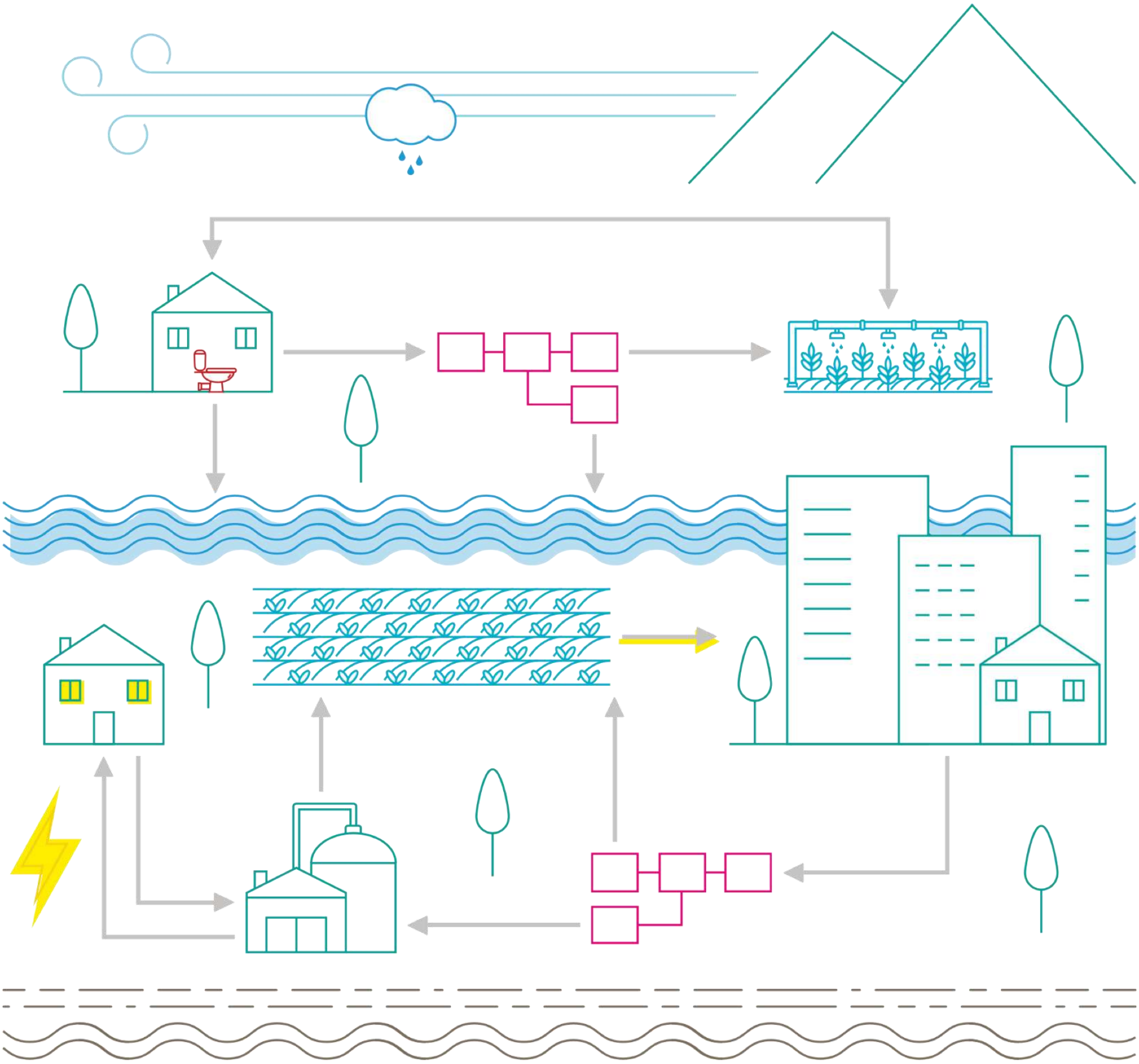

SANTIAGO documentation and technology data library

Functionalities, definitions and data for appropriateness profiles and transfer coefficients

Final Draft 2023

Spuhler Dorothee, Scheidegger Andreas, Roller Leandra, Fritzsche Julian, Willimann Cyril, Ilmanen Kukka, Basile Weber • Eawag, March 2023

Summary

SANTIAGO is a software (SANitation sysTem Alternative GeneratOr) that allows to evaluate the appropriateness of potential technologies, to build all valid system configurations from the appropriate technologies (typically more than 100'000 from a set of 90 technologies), to preselect a set of systems that is locally appropriate and diverse in terms of technical approach, and optionally to quantify nutrient, water, and total solid flows, recovery, and loss potentials as an indicator for sustainability. It comes together with a technology library, and a methodology to integrate these tools into a strategic planning process. The main advantage of using the software is the possibility to deal with a diverse and very large set of technologies and corresponding system configurations. Moreover, the software and its library provide international literature data and expert knowledge on technology appropriateness and substance flows and match it to the local context for more empirical decision-making. The library can easily be expanded to include future technology innovations and additional sanitation products. Using a software approach also allows to systematically consider uncertainties related to the technologies or the local context making it applicable at an early planning phase.

The documentation provides definitions and explanations required to understand the full functioning of SANTIAGO as well as all data and data sources to define the technology appropriateness profiles and transfer coefficients. It does not provide details on how to apply the software and how to integrate it with the planning process.

Disclaimer

This documentation is a complement to the SANTIAGO software: the SANitation sysTem Alternative GeneratOr. It provides definitions and explanations required to understand the full functioning of to the SANTIAGO software and SANTIAGO technology library including data references regarding technology appropriateness and transfer coefficients. SANTIAGO software and SANTIAGO technology library are open source and freely accessible on github:

> *Spuhler, D., and Scheidegger, A., (2021): SANTIAGO software, available here: https://github.com/SANTIAGO-sanitation-systems*

The SANTIAGO technology library repository also contains a number of example input files implemented based on this documentation. An additional repository provides a number of scripts to analyse SANTIAGO result in the R environment.

This document does not provide details on how to apply the software and how to integrate it with the planning process. For guidance on how to apply it a Wiki is available online:

> *Spuhler, D., Fritzsche, J. and Scheidegger, A., (2021): SANTIAGO software Wiki, available here: https://github.com/SANTIAGO-sanitation-systems/SANTIAGO.jl/wiki*

For guidance on how to use the software and how to integrate it with planning (e.g. Community-Led Urban Environmental Sanitation, CLUES (Lüthi et al., 2011), Sanitation 21 (Parkinson et al., 2014) please refer to the SaniChoice Practitioners Guide.

> *www.sanichoice.net/planning-with-sanichoice*

This version is based on a previous version from 2020 which was developed between 2019 and 2021 as part of the GRASP project ("Generation and Assessment of appropriate Sanitation systems for Planning") at the Eawag:

> *Spuhler, D. and Roller, L. (2021) Sanitation technology library: details and data sources for appropriateness profiles and transfer coefficients. ERIC: https://doi.org/10.25678/0000ss. Supplementary material for: Spuhler, D., Scheidegger, A., and Maurer, M. (2020) Ex-ante*

> *quantification of nutrient, total solids, and water flows in sanitation systems. https://doi.org/10.1016/j.jenvman.2020.111785*

The here presented version has been fully revised and amended with research documented in additional articles:

> *Spuhler, D., Scheidegger, A. and Maurer, M. 2021. Ex-ante quantification of nutrient, total solids, and water flows in sanitation systems. Journal of Environmental Management, 111785. DOI: https://doi.org/10.1016/j.jenvman.2020.111785.*
>
> *Spuhler, D., Scheidegger, A. and Maurer, M. 2020. Comparative analysis of sanitation systems for resource recovery: influence of configurations and single technology components. Water Research 186, 116281. https://doi.org/10.1016/j.watres.2020.116281.*
>
> *Spuhler, D., Germann, V., Kassa, K., Ketema, A.A., Sherpa, A.M., Sherpa, M.G., Maurer, M., Lüthi, C. and Langergraber, G. 2020. Developing sanitation planning options: a tool for systematic consideration of novel technologies and systems. Journal of Environmental Management 271. https://doi.org/10.1016/j.jenvman.2020.111004.*
>
> *Spuhler, D., Scheidegger, A. and Maurer, M. 2018. Generation of sanitation system options for urban planning considering novel technologies. Water Research 145, 259-278. https://doi.org/10.1016/j.watres.2018.08.021.*

Revision mainly concerns the definition of screening criteria and attributes as well as the data to quantify those.

Recommended citation:

Spuhler, D. Scheidegger, A., Roller, L., Fritzsche, J., Willimann, C., Ilmanen, K. (2022) SANTIAGO documentation and technology library: functionalities, definitions and data for appropriateness profiles and transfer coefficients. Continuously updated URL (work in progress): https://github.com/SANTIAGO-sanitation-systems/Sanitation-technology-library

Overview

This document is structured into two parts.

PART A: SANTIAGO documentation

This Part A documents the functionalities and the definitions underlying SANTIAGO. It contains seven chapters:

***Chapter 1: What is SANTIAGO** describes the motivation behind SANTIAGO, its scope, the requirements for its application as well as the outputs to be expected.*

***Chapter 2: Terms and definition** provides an overview on different terms and concepts used by SANTIAGO:*

***Chapter 3: How does SANTIAGO work** defines the different modules of the SANTIAGO algorithm. It does not provide user guidance on how to work with SANTIAGO. The latter is contained in the online Wiki on github.*

***Chapter 4: Defining technologies** provides the explanation how SANTIAGO defines the technologies and the technology data contained in the SANTIAGO technology library. It is required to understand the data provided in PART B as well as to define additional technologies to be included in the library.*

***Chapter 5: Defining the application case** explains briefly how to establish input data to run SANTIAGO software using the SANTIAGO technology for a specific case.*

***Chapter 6: Preparing data for SANTIAGO** explains which input data is required to run the SANTIAGO software and provides example files.*

***Chapter 7: Currently implemented** provides an overview of all the technologies, products, screening and other evaluation criteria as well as transfer coefficients that have been implemented in the current technology library. In addition, it contains an example for possible inflows into a sanitation system.*

PART B: Technology library

This Part B provides data sheets for all currently implemented technologies. In the datasheet, all original data used to describe the technology for SANTIAGO as well as literature references and assumptions are presented.

* Lüthi, C., Morel, A., Tilley, E. and Ulrich, L. (2011) Community-Led Urban Environmental Sanitation Planning (CLUES), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland. http://www.eawag.ch/forschung/sandec/gruppen/sesp/clues/index_EN.
* Parkinson, J., Lüthi, C. and Walther, D. (2014) Sanitation 21. A Planning Framework for Improving City-wide Sanitation Service, International Water Association (IWA), London.

* Lüthi, C., Morel, A., Tilley, E. and Ulrich, L. (2011) Community-Led Urban Environmental Sanitation Planning (CLUES), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland. http://www.eawag.ch/forschung/sandec/gruppen/sesp/clues/index_EN.
* Parkinson, J., Lüthi, C. and Walther, D. (2014) Sanitation 21. A Planning Framework for Improving City-wide Sanitation Service, International Water Association (IWA), London.

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Abbreviations

ABR	Anaerobic Baffled Reactor
FG	Functional Group
FG C	Functional Group Conveyance
FG D	Functional Group Reuse or Disposal
FG S	Functional Group Onsite Collection and Storage/Treatment
FG T	Functional Group Decentralized or Centralized treatment
FG U	Functional Group User Interface
GRASP	Generation and Assessment of appropriate Sanitation systems for Planning
H2O	Water, resource quantified by the substance flow model
MCDA	Multi-Criteria Decision Analysis
O&M	Operation & Maintenance
SANTIAGO	SANitaTIon system Alternative GeneratOr
SAS	System Appropriateness Score
SDM	Structured decision making
SFM	Substance Flow Model
TAF	Technology Appropriateness Filter
TAS	Technology Appropriateness Score
TC	Transfer Coefficient
TN	Total Nitrogen
TP	Total Phosphorus
TS	Total Solids

01 Part A: Documentation

— 1.1 WHAT IS SANTIAGO

1.1.1 Motivation and background

1.1.1.1 Sanitation, a global need and challenge

Sanitation describes the technologies and services needed to manage human waste (mainly urine and faeces) from its point of generation to the final reuse or disposal in a safe way (WHO, 2018) . Lack of sanitation is linked to reduced health and environmental degradation, and undermines social and economic development (Hutton and Varughese, 2016; WHO and UNICEF, 2000; 2013). The importance of sanitation has been recognized in the Millennium Development Goals, MDGs (UN, 2000a; b) and as a human right (UN, 2010).

The Sustainable Development Goals (SDGs) confirm the critical importance of water and sanitation for sustainable development, with explicit reference to management downstream, resource efficiency and participation of local communities (UN, 2014). In most of high-income countries, we benefit from great sanitation services and make great efforts to treat wastewaters and to prevent environmental pollution. However, at a global level considering rapidly growing urban centres in low-income areas, the situation has not been improving much recently.

> *55% of the global population did not use safely managed sanitation services in 2017 (UN, 2019), half of which was in cities (WHO and UNICEF, 2019) and 80% of wastewaters globally are discharged without any treatment at all.*

Existing sanitation services, especially in low-income areas are often limited to latrines or septic tanks without appropriate effluent treatment or emptying (Strande, 2014; WSP, 2014). Only 18% of the products from domestic on-site sanitation facilities are treated worldwide (UN-WATER, 2018). Systematic collection and safe disposal of wastewater and sludge are often missing (Strande, 2014; WSP, 2014), leading to 90% of urban wastewater globally being discharged without appropriate treatment (UNW-DPC, 2013).

One of the reasons for the high share of the population not having access to safely managed sanitation is that the unprecedented growth in urban areas of developing countries (informal settlements, slums, and small towns) often exceeds the capacities of administrations (Lüthi et al., 2012; Lüthi et al., 2010; UN-HABITAT, 2003). Pressure will most likely increase in the future, as 70% of the world population is projected to live in urban areas by 2050 and over 90% of urban growth will take place in developing countries (Birch et al., 2012; Dodman et al., 2013; UNFPA, 2007). In rapidly growing areas of developing countries, challenges of sanitation provisions are exasperated by high density, informality, and a lack of administrative and financial capacities for planning, implementing, and operating safe sanitation (Dodman et al., 2013; Dodman et al., 2017; Isunju et al., 2011; Ramoa et al., 2014; Tremolet et al., 2010; UN-HABITAT, 2012).

1.1.1.2 Failure of conventional approaches to sanitation system design

Conventional sanitation systems are based on a flush toilet, a sewered system, and hopefully a more or less sophisticated treatment (and recovery) plant at the end. The development of such system has helped the world to increase human health by reducing disease and making cities more liveable. On the other hand, this system is also a tragic failure (Wald, 2021) because it is not viable in many areas of the world leaving more than half of the global population without a toilet and sanitation system that safely manages body waste. The situation is particularly challenging in the developing urban areas where most of the population growth is currently taking place.

> *In these areas, conventional sanitation solutions are not appropriate and thus not viable because they require large amounts of water, energy, and space, expensive infrastructure, skilled staff for operation and maintenance, and long planning horizons (Davis et al., 2019; Dodman et al., 2017; Isunju et al., 2011; Tremolet et al., 2010; UNDESA, 2014)*

The abandonment or breakdown of sanitation infrastructures in developing urban areas is a common phenomenon (Barnes and Ashbolt, 2006), which indicates the failure of conventional approaches to sanitation planning and service provision (McConville, 2010). Planning approaches have a tendency to be top-down, technology-driven, and focussed on implementations of technology or regional master plans. This has led to inappropriate technology choices for local physical and social environments and the often-limited available human and financial resources for maintenance and operation (Kalbermatten et al., 1980; Kvarnström et al., 2011; Menck, 1973; Starkl et al., 2013; Tilley et al., 2014a). Additionally, conventional systems are also highly resource inefficient, as they lead to the pollution of large amounts of clean water, waste a lot of nutrients and energy, and promote the spread of medical residues in the environment.

1.1.1.3 Sustainable sanitation

Safe sanitation requires to address the entire system, from the toilet to containment and storage/treatment onsite, or conveyance, treatment and eventual safe end use or disposal off-site.

> *Sustainable sanitation systems should be locally appropriate in terms of technology, institutions and social acceptance, and economically viable in order to protect the human health and the environment (SuSanA, 2008). But to be in line with SDG 6, they should also be designed to closing water and nutrient loops at the lowest possible level.*

1.1.1.4 Sanitation Technology and System Innovations

The recognition of drawback of conventional sanitation system has triggered massive investments in the development of novel technologies (e.g. urine diversion dry toilets, composting toilets, briquetting) and system configurations (e.g. container-based sanitation) providing solutions for non-sewer sanitation and faecal sludge management.

> *Being independent from energy, water and sewer networks, these innovations are potentially more appropriate for developing urban areas. They also have the potential to enhance sustainability and resilience by reducing water requirements, being more adaptable for socio-demographic and environmental changes, and allowing recovery of nutrients, energy, and water resources (Drechsel et al., 2011; Larsen et al., 2016; Tilmans et al., 2015; Tobias et al., 2017).*

They also expand opportunities for private sector involvement in the collection and safe reuse of resources (Diener et al., 2014; Evans et al., 2013; Langergraber, 2014; Lüthi et al., 2009; Murray and Ray, 2010; Parkinson and Tayler, 2003; Schertenleib, 2005). The development of novel sanitation options has massively influenced the sanitation sector and the potential of alternative systems has also been recognized in high-income countries, where the focus is on optimising aging infrastructure. Although there are little to no full-scale implementation examples of those innovations, there exists today a global consensus that sanitation technology and system innovations need to find their way into practice (Larsen et al., 2016).

> *A sanitation system is a set of technologies which in combination treat and manage human waste and wastewater from the source of generation to the final point of reuse or disposal. This includes five functional groups (FGs): the user interface, collection and storage, conveyance, semi-centralized treatment, and reuse or disposal (Tilley et al., 2014b).*

Each technology should be appropriate to the context-specific health, environmental, economic and financial, socio-demographic, and institutional conditions. Moreover, given a certain choice of appropriate options, the preferred option should be the one that is most sustainable in terms of SDG6: the one that has the lowest water requirements, least emissions, and highest resource recovery potentials at the least costs. This strongly highlights the multi-criteria aspect of sanitation systems planning (Zurbrügg et al., 2009) and the importance of trade-offs and stakeholder preferences (e.g. (Lennartsson et al., 2009; Motevallian and Tabesh, 2011; Willetts et al., 2013).

1.1.1.5 Increase Planning Complexity

While novel technologies and innovative system configuration potentially enhance appropriateness, inclusiveness, and sustainability, they also increase planning complexity. How compatible are different technologies to be assembled into entire systems? And what is their performance in a given setting?

From a decision-making viewpoint, selecting a locally appropriate and sustainable sanitation system and its corresponding technologies is a complex multi-criteria decision-making problem (Bracken et al., 2005; Kvarnström and Petersens, 2004; Zurbrügg et al., 2009). Structured decision-making (SDM) helps tackle such problems by systematically comparing several decision options regarding the defined decision objectives in order to reveal trade-offs and balance for opposing interests using Multi-Criteria Decision Analysis (MCDA).

> SDM helps to structure the decision-making process and to deliver insights about what matters to diverse stakeholders and how well various objectives may be satisfied by different decision options (Gregory et al., 2012; Marttunen et al., 2017).

This leads to more strategic but also more informed and thus more accepted decisions. The facilitated participatory framework covers at least six steps generic to any decision-making process (Gregory et al., 2012): (1) understanding the decision context; (2) defining decision objectives and criteria; (3) identifying decision options/alternatives; (4) evaluating consequences of the options for decision objectives; (5) discussing the trade-offs and selecting for the preferred options; and (6) implementing and monitoring.

1.1.1.6 Strategic sanitation planning and structured decision making

Several sanitation planning frameworks that adopt SDM approaches for strategic sanitation planning have been developed (Schertenleib et al., 2021). Some of widely recognized examples include Community-Led Urban Environmental Sanitation (CLUES), (Lüthi et al., 2011a), Sanitation 21 (Parkinson et al., 2014), or City Sanitation Planning (CSP), (GoI, 2008; MOUD, 2008). Despite the continuous development of these theoretical foundations, there is a lack of putting them into practice (Kennedy-Walker et al., 2014; Ramôa et al., 2018; Starkl et al., 2013). Missing leadership and lack of knowledge of new approaches leads to the propagation of outdated solutions which are locally inappropriate (Kennedy-Walker et al., 2014; Lüthi and Kraemer, 2012; McConville, 2010).

1.1.1.1 Gap

To facilitate the adoption of SDM frameworks, recent research has focused on the development of tools to operationalize the different planning steps (Spuhler and Lüthi, 2020). Yet, most of the research focuses on the understanding of the problem (step 1 and 2 of SDM), (Peal et al., 2014; Robb et al., 2017; Strande et al., 2018) or the selection of a preferred option (step 5 of SDM), (Schütze et al., 2019), assuming that a set of options is already available. Yet, every decision support approach is only as good as the alternatives presented.

> *Typically, the creation of sanitation decision options (step 3 of SDM) is left over to engineers who lack data and systematic reproducible evaluation methods for considering the entire spectrum of currently available technologies and sustainability criteria (Spuhler and Lüthi, 2020). This introduces a whole range of shortcomings, such as insufficient knowledge and data leading to bias, opaque pre-selection processes based on experts' personal preferences and little local ownership.*

The lack of suitable methods for the systematic generation of locally appropriate sanitation systems is one of the biggest weaknesses in strategic urban sanitation planning (Gregory et al., 2012; Hajkowicz and Collins, 2007). In particular, considering simultaneously a broad and large range of conventional and novel options remains a challenge. Additionally, there is insufficient data to evaluate the sanitation options, particularly the novel options, according to the various sustainability criteria.

> *To make strategic decisions one needs to be aware of a large and diverse set of sanitation options at an early planning phase, and one needs to be able to compare their performance. This requires data about the performance of both individual technologies and entire system configurations regarding various sustainability criteria at an early stage when measurements are usually not available.*

1.1.2 Why SANTIAGO

Error! Not a valid link.has been developed to fill in the gap and provide a systematic method that enables the consideration of novel technologies despite lack of knowledge and data. SANTIAGO can predict transparently the appropriateness of potential technologies based on locally defined selection criteria. It can generate all possible system configurations. It can select from all the possible configurations a manageable number of sanitation system options, which are locally appropriate and diverse enough to highlight trade-offs. Finally, it is able to quantify resource recovery and emission potential for nutrients, water and total solids of sanitation technologies and systems.

1.1.2.1 Field Validation and Results

SANTIAGO was developed iteratively in collaboration with case studies in Nepal (2016/2017), Ethiopia (2016 and 2019), Peru (2019), and South Africa (2020) (Nisaa et al., 2021; Spuhler et al., 2020a; Spuhler et al., 2018). The case studies provided immediate feedback from users and evaluated the methodology from their perspective. They also were able to prove that SANTIAGO is capable of generating reasonable results. They also showed that there are some key characteristics that influence resource recovery in general. These key characteristics were used to develop a number of recommendations for the development and selection of sanitation technologies and systems for resource recovery (Spuhler et al., 2020b):

- Prioritize short systems that close the loop at the lowest possible level (fewer treatment steps results in fewer losses);
- Separate waste streams as much as possible. This does not necessarily lead to fewer treatment steps, still it allows for higher recovery potentials (e.g. through urine separation);
- Use storage and treatment technologies that can contain products with as few losses as possible and at the same time avoid technologies that leach (e.g. single pits) and technologies with high risk of volatilization into air (e.g. drying beds);
- Design sinks that optimise recovery and avoid sinks that simply dispose of substances;
- Combine various reuse options for different side streams such as the reuse of urine and the production of biofuel from faeces.

The results also led to three key conclusions which will guide future research. First, both the local appropriateness and resource recovery depend on technology interactions and system configurations and therefore both have to be evaluated for entire systems. Second, there exists no unequivocal set of factors determining appropriateness or resource recovery potential. And thirdly, local appropriateness, resource recovery and other important sustainability indicators can be contradictory. This highlights the need for an automated software that is able to generate all valid sanitation systems and predict the quantification of their appropriateness and resource recovery.

The case studies also showed that SANTIAGO can provide a number of additional benefits for planning practice (Spuhler et al., 2020a). For instance, inappropriate options are eliminated at the beginning, streamlining the process. SANTIAGO also enforces the consideration of entire systems and it suggests a technical option for each and every step in the sanitation value chain and each and every product. Moreover, the options space is expanded with systems that experts would not have thought of or did not even know about. The diversity of the set of options is guaranteed to help in revealing and discussing trade-offs during the further evaluation (e.g. costs versus hygiene).

1.1.2.2 The Aim of this Document

This documentation is a complement to the SANTIAGO software: the SANitation sysTem AlternatIve GeneratOr. It provides definitions and explanations required to understand the full functioning of the SANTIAGO software and SANTIAGO technology library including data references regarding technology appropriateness and transfer coefficients.

1.1.3 Scope of Application

1.1.3.1 What is SANTIAGO

SANTIAGO is a software proposed to provide a manageable and diverse set of locally appropriate sanitation system options for any decision-making or planning process. It provides the tools to operationalize step 3 (identification of decision options) and step 4 (evaluation of options) of a structured decision making (SDM) process. The aim is to enable a systematic and transparent consideration of large and diverse range of conventional and novel sanitation technologies and systems as well as locally relevant sustainability criteria at an early stage of planning.

SANTIAGO has been designed for the application to household generated wastewater products derived from faeces, urine, greywater in combination with stormwater and organic solid waste. However, SANTIAGO can be adapted to deal with any other similar problem such as drinking water supply (https://www.eawag.ch/en/research/humanwelfare/drinkingwater/compendium/) or municipal waste treatment (*Selecting Organic Waste Treatment Technologies. SOWATT* (Zabaleta et al., 2020)) as long as the respective technology libraries are defined in compatible format.

SANTIAGO helps to implement four steps:

1. **It evaluates the appropriateness of all potential technologies for a given case (e.g. a city or a neighbourhood) by comparing technology profiles to local conditions concerning user defined screening criteria.**
2. **It generates all possible system configurations from the appropriate technologies from the user interface to final reuse or disposal based on the compatibility of input and output products.**
3. **It proposes a set of sanitation system options that is diverse and of manageable number and appropriate for the case.**
4. **It quantifies resource recovery and loss potentials to compare the proposed systems in more detail.**

SANTIAGO requires the user to customize the existing technology library, provide data about the local conditions against which the technology appropriateness is evaluated, the inflows for the substance flows to be quantified, and the number of inhabitants. These are the elements that allow the user to customize SANTIAGO:

- The technology library consists of a set of technologies for five functional groups: the user interface (U), the onsite storage and treatment (S), conveyance (C), (semi-)centralized treatment (T), and reuse or disposal (D). Each technology is defined by the input products it can accept and the output products that it generates. This technology library will define the scope of SANTIAGO.
- The conditions of the application case are quantified in the form of a number of case attributes that represent relevant appropriateness screening criteria such as temperature, or water, energy, space and skills availability.
- The inflows are needed to define for each user interface, how much substance such as nutrients, water, or solids are entering the system to then quantify which fraction of this can be recovered or is lost by each system configuration.
- The number of inhabitants is used to scale the substance flows and recovery and loss ratios.

When SANTIAGO is customized to other applications than household wastewater, the systems templates need to also be customized. System configurations can be characterized by different system templates and each system can be assigned to one template. The system templates cover the diversity of all the options and sorting systems into the templates makes their number more manageable as typically for only a few dozens of technologies the number of system configurations can be more than 100’000. The SANTIAGO templates are based on a number of technical conditions (e.g. if effluent is transported offsite or if it is a wet or dry system) and the degree of decentralisation (onsite, decentralized, hybrid, offsite). By adapting these conditions, different templates can be defined.

1.1.3.1 What is SANTIAGO not?

SANTIAGO is not intended to replace any existing planning frameworks that address the entire Structured Decision Making (SDM) process (e.g. CLUES[1]) but to provide input in the form of the infrastructure decision options including data on their performance in regard to local appropriateness and resource recovery and loss potentials.

To facilitate the integration of SANTIAGO into any SDM procedure and to support engineers in obtaining suitable input data, we developed a procedure based on a number of interactive workshops. The screening criteria used to determine appropriateness include technical, physical, demographic, socio-cultural, legal and financial criteria as well as criteria concerning capacity and management. Thus, they consider different non-technical aspects. However, the finally presented sanitation options consider the technologies and their configurations solely from an infrastructure point of view. In most cases it might be relevant to also discuss other aspects such as different service delivery and financing arrangements. This then will also allow to look at other relevant evaluation options such as costs along with resource recovery and losses.

Moreover, SANTIAGO uses a number of simplifications to make the automation possible (see also *chapter 1.1.9 Assumptions and limitations*). Therefore, systems, that one wishes to consider as serious options, must be checked by an expert for plausibility. This plausibility check is the first step also for a detailed feasibility analysis where spatial aspects are going to be considered as they are not explicitly considered in SANTIAGO (only through the inclusion of physical criteria such as space availability or slope).

In summary, the main additional aspects not covered by SANTIAGO but important to consider in practice:

- The corresponding decision-making process and its steps and stakeholders;
- Additional aspects concerning the options such as different service delivery and financing arrangements;
- Other evaluation criteria than resource recovery such as costs;
- A plausibility check and a detailed feasibility analysis also considering spatial aspects.

1.1.4 SANTIAGO Steps

SANTIAGO integrates four algorithms (also depicted in Figure 1 on the left side):

1. **For the identification of all appropriate sanitation technologies in a technology library based on a list of criteria. These criteria should be independent from stakeholder preferences and thus non-negotiable and they can therefore be used to screen for appropriate technologies.**
2. **For the generation of all possible and valid sanitation system configurations (typically more than 100'000) using the appropriate technologies. A valid sanitation system is defined as a set of**

[1] Community-Led Urban Environmental Sanitation Planning. Available at: www.sandec.ch/clues

compatible technologies which, in combination, ensure that all sanitation products (e.g. excreta, sludge, blackwater) are either transferred, transformed, or end up in a sink.

3. **For the selection of the desired number of appropriate system configurations from all generated options. The selection covers the full diversity of the sanitation system options space defined by 19 system templates grouped into simple onsite, urine diversion, biofuel, or blackwater systems.**
4. **For the modelling of substance mass flows along entire system chains in order to quantify resource recovery potentials and environmental emissions for nutrients, organics, energy, and water.**

The diverse set of locally appropriate sanitation system options is the main output of SANTIAGO, which is passed over to the SDM process for further evaluation, discussion of trade-offs, and selection of the preferred options using any kind of facilitated MCDA method (steps 5 and 6 of SDM). Resource recovery and loss potentials provide some of the relevant performance indicators for this further evaluation. The options cover the technological aspect of the system only; aspects related to management and service delivery are to some extent considered in the appropriateness assessment.

1.1.5 SANTIAGO technology library

SANTIAGO also comes with a technology library that currently covers more than 90 conventional and novel technologies that can be combined in several 100'000 valid system configurations. The technologies are based on (Gensch et al., 2018; Mcconville et al., 2020; Spuhler et al., 2018; Tilley et al., 2014b) and (Spuhler, 2020). The library also provides the data for more than 30 screening criteria and the transfer coefficients for four substances (phosphorus, nitrogen, water, total solids) for each and every technology based on international literature and expert knowledge. Part B of this document contains a descriptive document that also contains all literature references (*— 2.4 References Part B*). An editable table format (JSON3) is provided online at github (see also *chapter 1.1.7 Where Is SANTIAGO Available*). Any new technology can be added to the table following the instructions provided in this document (*chapter 2.2.1Customization* of Technology Library).

1.1.6 Integration with Planning

To utilise the full strength of SANTIAGO, it should be integrated into a facilitated and participatory SDM process such as Community-Led Urban Environmental Sanitation (Lüthi et al., 2011a). The SaniChoice Practicioners' Guide for this integration is presented in:

> *www.sanichoice.net/planning-with-sanichoice*

The integration is illustrated in Figure 1. The main output is a diverse set of locally appropriate sanitation system options that is of manageable size. This set needs to be further evaluated in regard to the main decision objectives (e.g. costs, operation and managements scheme, etc.). Only afterwards it can be handed over to the SDM process for the discussion of trade-offs and the selection of the preferred option, using any kind of multi-criteria decision analysis (MCDA) method. The required inputs are:

1. **The set of potential technologies and data on their appropriateness and transfer coefficients (provided in this document)**
2. **The list of relevant and non-negotiable screening criteria (e.g. energy requirements) including their quantification for the application case and the desired number of options given by the SDM process.**

3. **Input mass flows for substance flow modelling and discussion of trade-offs and recovery potentials (provided by the SANTIAGO documentation).**

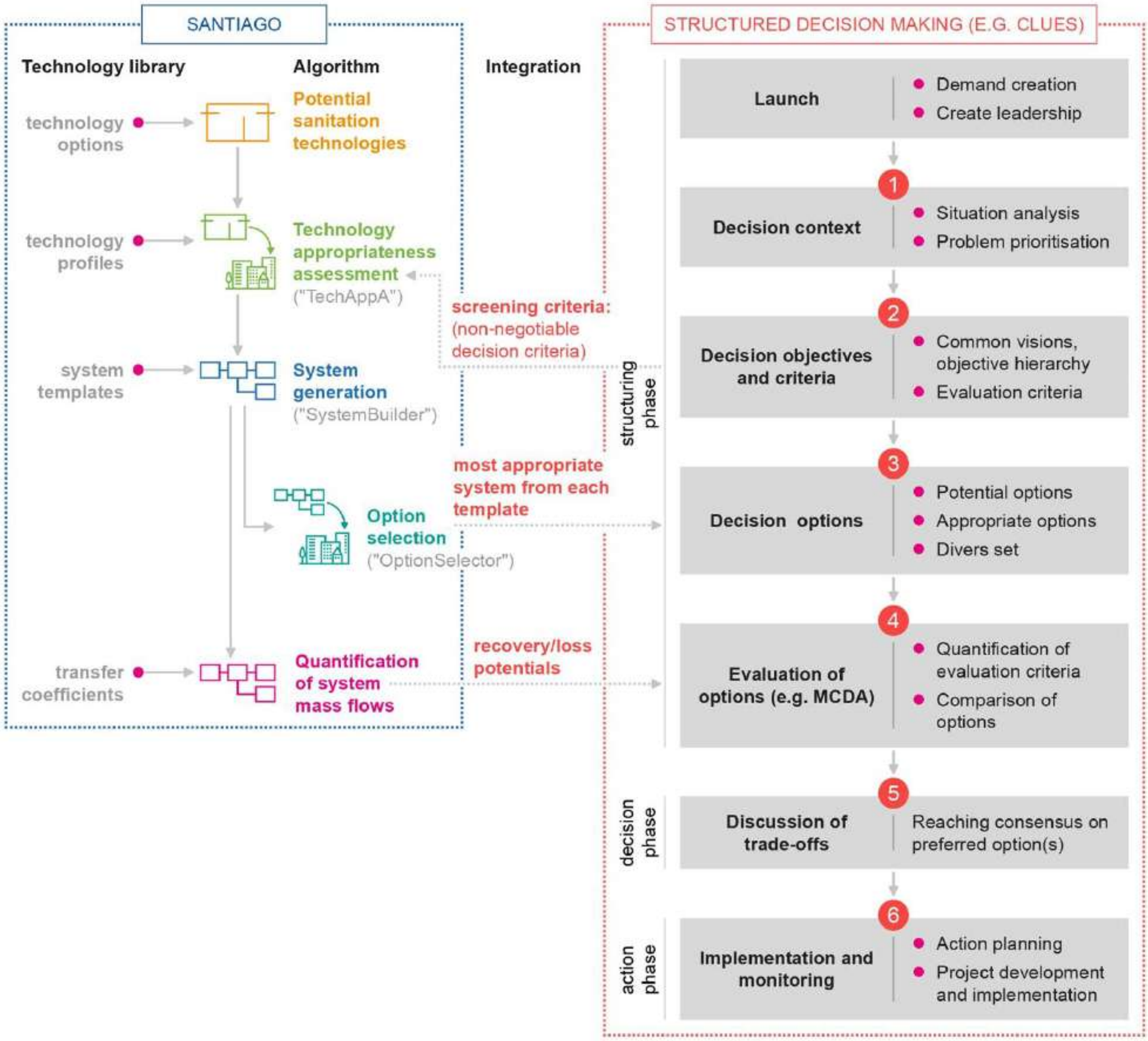


Figure 1 : Integration of the SANitation sysTem Alternative GeneratOr (SANTIAGO) and the Structured Decision Making (SDM) approach which happens at two stages. First, the decision objectives are used to derive screening criteria which allows assessment of the appropriateness of potential sanitation technologies for the given application case. The potential technologies are characterized in the technology library. Correspondingly the user characterizes the screening criteria for the given application case. Then, SANTIAGO generates all possible system configurations, calculates their appropriateness scores, and identifies the most appropriate system from each template to be handed over to the decision-making process. Optionally, it can also quantify resource recovery potentials and environmental emissions as inputs into further evaluations.

1.1.7 Where Is SANTIAGO Available

SANTIAGO is open source and freely accessible on github:

> *Spuhler, D., and Scheidegger, A., (2021): SANTIAGO software, available here: https://github.com/SANTIAGO-sanitation-systems*

The link not only contains SANTIAGO software repository (SANTIAGO.jl) but also the SANTIAGO technology library repository. It also contains an additional repository that provides a number of scripts to analyse SANTIAGO result in the R environment.

This document does not provide details on how to apply the software and how to integrate it with the planning process. For guidance on how to apply it a Wiki is available online:

> *Spuhler, D., Fritzsche, J. and Scheidegger, A., (2021): SANTIAGO software Wiki, available here: https://github.com/SANTIAGO-sanitation-systems/SANTIAGO.jl/wiki*

For guidance on how to integrate the software with planning (e.g. Community-Led Urban Environmental Sanitation, CLUES (Lüthi et al., 2011a), Sanitation 21 (Parkinson et al., 2014) please refer to the SaniChoice Practicioners' Guide.

> *www.sanichoice.net/planning-with-sanichoice*

1.1.8 SANTIAGO Advantages

The main advantage of using a software is the possibility to deal with large numbers and very diverse technologies and systems. Moreover, the software and its library allow to provide international literature data and expert knowledge. This can provide evidence about possible solutions and their potential performance at an early stage in the planning process for any application case in the world. The consequence is hopefully more informed decision-making. By providing a diverse set of options together with quantified information this can reveal trade-offs and thereby support a constructive dialogue among stakeholders to balance out conflicts of interest.

Another important advantage of SANTIAGO is that it uses generic definitions of technologies and products and therefore is also flexible to be adapted with new or better data or expanded with any future technology innovations.

> *The three main potential added values that we expect from the adoption of SANTIAGO in practice are:*
> *(1) To open up the options space and provide decision makers with sanitation system options that they might not have thought of based on experience alone and which are potentially not only more appropriate but also more sustainable*
> *(2) To increase the local acceptance for decisions by making them more evidence based and transparent. This hopefully contributes to better ownership and long-term operation and maintenance.*
> *(3) To enable the prioritisation of more appropriate and sustainable sanitation systems at an early planning phase. This hopefully helps to make new sanitation innovations more accessible for practitioners and to contribute to circular economy and the SDGs.*

1.1.9 Assumptions and limitations

It is important to note that the models used to produce the presented data are based on a number of simplifications that include very generic definitions of technologies and products. Consequently, the substance transfer coefficients (TC) which are defined for each technology and product are also impacted by these simplifications. Therefore, systems must be checked by an expert for plausibility when they are being seriously considered as planning options. An example is the treatment of faeces alone in a biogas reactor; it would not make much sense from an engineering perspective, while it would make sense if sludge and e.g. organics are also digested in the same reactor. Another example concerns transfer coefficients: soil loss in a single pit could be defined much more accurately if one would know whether the input product is moist (excreta with pour flush water) or dry (pure faeces). Consequently, the approach is suitable for strategic planning but not for detailed design and implementation of a specific sanitation system.

Modelling substance flows based only on TCs is clearly a simplification, as it excludes possible substance generation, (e.g. through biological fixation, see also (Spuhler et al., 2020c). For most technologies, this limitation is not relevant. A more detailed approach would substantially increase computational demand and the collection of comparable parameters from literature would also be difficult. Another simplification is the assumption of fault-free implementation, operation, and maintenance of the technologies.

Importantly, these simplifications allow the automation and generalization of the model application. Consequences of the simplifications are captured in the uncertainty calculations. The user is free to be more specific in the technology and product definition (e.g. make different types of single pits for different products), or to use more complicated TC models if more accuracy is needed (see also *chapter 2.2.1Customization* of Technology Library).

— 1.2 TERMS AND DEFINITIONS

1.2.1 Sanitation technologies

A sanitation technology is defined as any process, infrastructure, method or service that is designed to contain, transform or transport sanitation products. Here, it is characterized by its name, the input and output products and how they relate to each other as well as attributes describing its appropriateness. All implemented sanitation technologies can be found in *chapter 1.7.1 Currently implemented technologies*.

1.2.2 Sanitation Products

Some sanitation products are generated directly by humans (urine or faeces), others are required in the functioning of technologies (flush water to move excreta through sewers, etc.) and some are generated as a function of storage or treatment (sludge, effluent, etc.). All implemented sanitation products can be found in *chapter 1.7.2 Currently implemented products*.

1.2.3 Sanitation systems

A sanitation system is defined as a set of sanitation technologies which, in the given configuration, manage sanitation products from its point of generation to the final reuse or disposal. A sanitation system is valid if it contains only compatible technologies and every sanitation product either finds its way into a subsequent technology or a sink. Two sanitation technologies are compatible if the output product of one can be the input product of the other.

1.2.4 Functional groups

A sanitation system can also be defined as the sanitation value chain comprising of five functional groups (FG) that include technologies with similar functions: The user interface (U), the onsite collection and storage/treatment (S), the conveyance (C), the decentralized or centralized treatment (T), and the reuse or disposal (D).

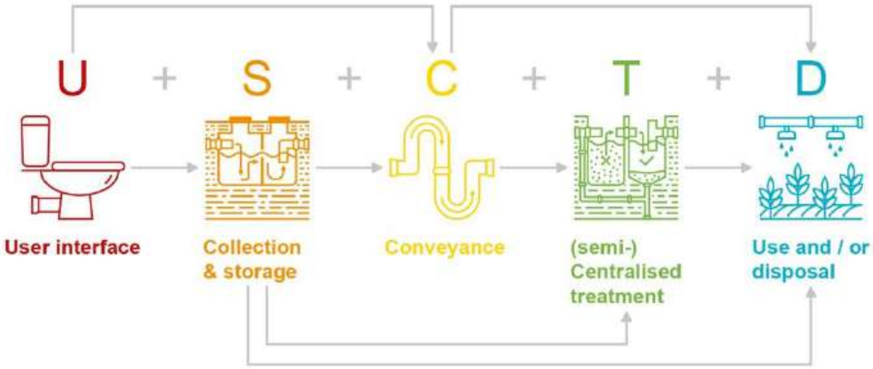


Figure 2: A valid sanitation system is a set of technologies which in combination manage sanitation products from the point of generation to a final point of reuse or disposal. Technologies contained in a system can be organized in five functional groups (FGs): source/ toilet user interface (U), on-site storage and treatment (S), conveyance (C), (semi-)centralized treatment (T), and reuse or disposal (D). Technologies belonging to U are sources, technologies belonging to D are sinks.

1.2.5 Sustainable sanitation

A sustainable sanitation system is one that not only provides appropriate technologies that protect human health and the environment but are also economically viable, socially acceptable, and institutionally applicable (SuSanA, 2008). This definition can be translated into five main objectives for sustainable sanitation: protection of health, protection of the environment and natural resources, economic viability, technological and institutional appropriateness, socio-cultural acceptance. The sustainability of sanitation systems depends on how technology interacts within a system as well as on how the technical system (hardware) interacts with other aspects such as the service delivery model and the enabling environment (favourable legal, political, and socio-economic conditions).

1.2.6 Appropriate technologies

An appropriate sanitation technology or system is one that provides a socially and environmentally acceptable level of service at affordable cost (Iwugo, 1979). This can be translated into technical, physical, demographic, socio-cultural, legal and financial criteria as well as in criteria concerning capacity and management.

1.2.7 Criteria

Criteria are used to assess and compare different sanitation systems in a consistent and transparent framework. SaniChoice differentiates between three different types of criteria: SaniChoice uses some criteria for pre-filtering certain technologies and sanitation systems, which are called **pre-conditions**. Criteria to assess the local appropriateness of technologies and sanitation systems and pre-select the most appropriate are named **screening criteria** and cover criteria that are non-negotiable, meaning they are independent from stakeholder preferences and can be quantified at an early planning phase. Screening criteria comprise most areas of appropriate technology: technical, physical and socio-cultural criteria as well as criteria concerning management and capacity. Criteria that are negotiable (not unanimously agreed and involving conflict of interests) are used in a later stage for the detailed evaluation of options and negotiation of trade-offs. These negotiable criteria are called **evaluation criteria**. SANTIAGO mainly uses screening criteria, which are described by corresponding technology and case attributes.

1.2.8 Attributes

A screening criterion always has a corresponding case attribute and a corresponding technology attribute per technology. These corresponding attributes are the variables that are identified for the criterion to measure and to report, either qualitatively or quantitatively, how well an option performs with respect to the criteria (Eisenführ et al., 2010). One example would be the socio-cultural screening criterion “Cleansing Method”: For the technology, it describes the performance of that technology given a specific type of anal cleansing method. For instance, a cistern flush toilet would perform 100% for water or soft tissue paper as anal cleansing material but would not function (0%) with hard and bulky cleansing materials, such as maize cobs. For the case, the attribute describes the use of different anal-cleansing methods in that location (case). It could be characterized by stating that 80% of the population use anal-cleaning water, 20% soft tissue paper and no hard cleansing material. All the attributes corresponding to a certain technology or an application case are called technology profile, respectively, application case profile.

1.2.9 Application case

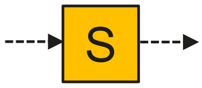
Application case refers to the spatial zone (e.g. village, different zones within a city) to which the SaniChoice procedure is applied to. They can be defined by physical, socio-demographic or political boundaries. These boundaries describe the local context based on which the local appropriateness of a sanitation system is determined.

1.2.10 System templates

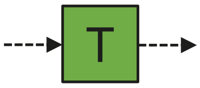
A sanitation system template defines a class of sanitation systems with similar conceptual characteristics. It can be defined by using different binary conditions based on characteristics such as if it is dry, wet, produces biofuel, uses urine diversion or based on its level of decentralisation (onsite, decentralized, offsite or hybrid). Each sanitation system can be assigned to one unique template. Detailed information on the use of system templates can be found in *chapter 1.3.6.1 System templates*.

1.2.11 Onsite, Decentralized and Offsite Technologies and Systems

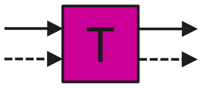
Treatment technologies can be assigned to functional groups based on their suitability for locations close to the toilet infrastructures (onsite) or at distant centralized treatment facilities (offsite):



a technology can only be used onsite, it is added to FG S (onsite collection and orage/treatment).



a technology can only be used offsite at (semi-)centralized treatment facilities, it is added to FG ((semi-)centralized treatment) and only input products that have been transported are allowed. previous technology in the FG C (conveyance) is required.



a technology can be used onsite and offsite, it is added to FG T and it allows input products that ave or have not been transported.

Based on these technology definitions the following four different types of sanitation are defined:

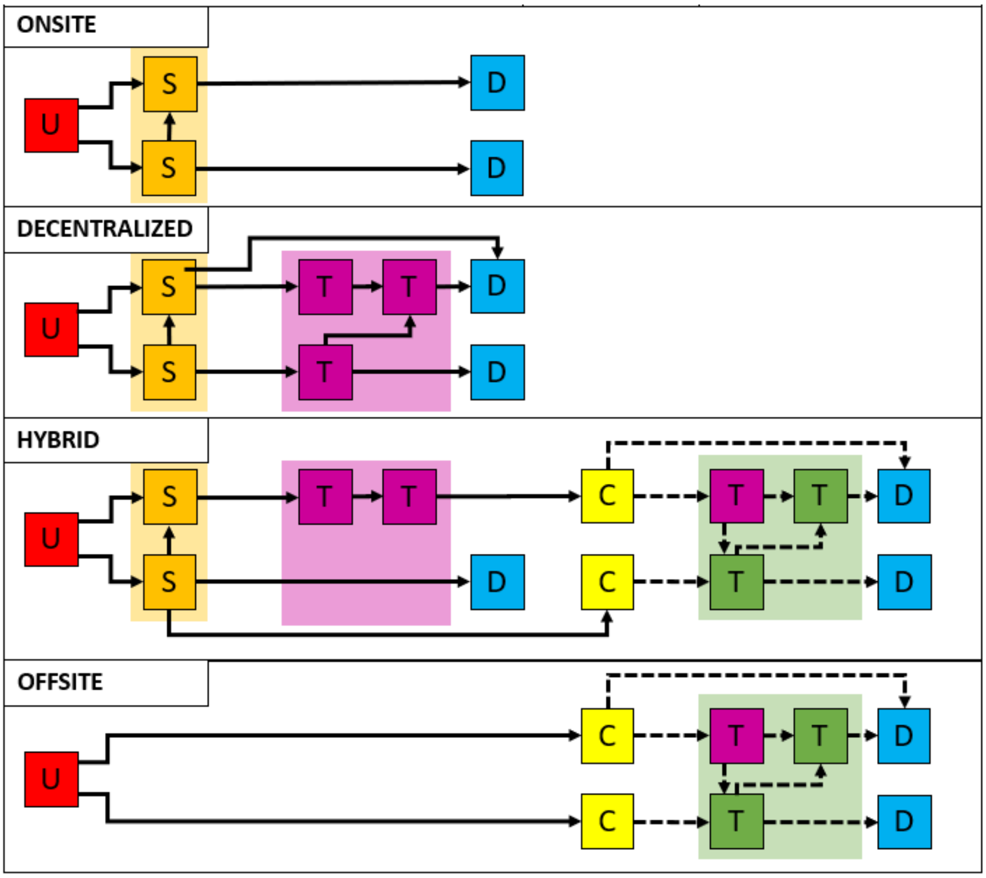


Figure 3. Schematic representation of four types of sanitation systems characterized by their spatial location. *Onsite* and *decentralized* systems are characterized by a lack of transport to an offsite location by a technology in FG C (conveyance). *Decentralized* systems are further defined as ones that do include decentralized technologies (FG T, purple). *Offsite* systems are defined to not include any onsite technologies of type FG S, while *hybrid* systems allow some processes to be onsite and others offsite. Technologies of FG T can accept input products from other FG T technologies and therefore create loops. The same is true for FG S technologies and these possible loops are denoted by transparent boxes. All products after an FG C technology are "transported" and denoted by dashed arrows.

1.2.12 Technology Appropriateness Scores

The Technology Appropriateness Score (TAS) is the result of evaluating the screening criteria for a specific technology within SaniChoice and expresses the confidence in how appropriate a technology is for a given application case. It is obtained by comparing a technology profile with the application case profile previously defined by the user. Each attribute is compared individually resulting in an attribute score. The aggregation of all attribute appropriateness scores via a geometric mean results in the TAS for the given case. The TAS can take values from 0 % to 100 % with 0 % being totally inappropriate and 100 % being totally appropriate.

1.2.13 System Appropriateness Scores

The System Appropriateness Score (SAS) is the result of evaluating the screening criteria for a specific sanitation system within SaniChoice and expresses the confidence in how appropriate a specific sanitation system (a set of compatible technologies) is for a given application case. It is obtained by aggregating the Technology Appropriateness Scores of the technologies used in the system (using a compromise between the geometric mean and the product of all scores). The SAS can take values from 0 % to 100 % with 0 % being totally inappropriate and 100 % being perfectly appropriate.

1.2.14 Substance flows

The substance flow refers to the mass inflow or outflow of a substance into a technology within a sanitation system. The substance flow is part of an input or output product, such as the mass flow of nitrogen (N) in the product of "blackwater". Possible substances can be nitrogen (N), phosphorus (P), water (H2O) and total solids (TS). The substance flow of an output product is calculated by multiplying the TCs with the sum of all substance inflows to the technology. The newly calculated substance flow in the output product can then be transferred into inflows into the subsequent technology.

1.2.15 Transfer coefficients

The transfer coefficient (TC) gives the fraction of the total substance that enters a technology with all input products, which is transferred into a specific output product. The TC for the substance s and the i-th output of a Tech (%) is the fraction of the sum of the input flows that leave the Tech through output i:

$$TC_{i,s} = \frac{out_{i,s}}{\sum_{j=1}^{n} in_{j,s}}$$

Where $out_{i,s}$ and $in_{j,s}$ refer to the mass of substance s in output product i and in input product j.

For instance, a septic tank is fed with the product "blackwater", which contains a certain amount of the substance nitrogen (N). The output products of the septic tank are defined as "sludge" and "effluent". The TC defines how much of the nitrogen is transferred to the sludge and how much is transferred to the effluent (e.g. 20% and 78%, respectively). Additionally, there are also losses of substances into air, soil and groundwater, or surface water, which have to be accounted for (e.g. 2% for nitrogen loss into air and 0% for soil and water loss). For every substance that is transferred into several output products, the sum of all TCs is equal to 1.

1.2.16 Loss potentials

The loss potentials are defined per substance and refer to the amount of substance transferred to air, soil and groundwater, and surface water over the whole sanitation system. It can be described either as a mass flow [kg/year] or as a ratio of the inflow into the system (%). The Loss Potential mass flow can be quantified as the sum of losses to air, soil and water for all technologies within a system. The Loss Potential ratio is determined as the fraction of the sum of losses compared to the initial substance flow entering the system via the source technology (functional group U). The Loss Potential ratio ranges from 0 (none lost) to 1 (all lost).

1.2.17 Recovery potentials

The recovery potential is defined for a whole sanitation system and refers to the amount of substance that can be recovered in the sink technology of a sanitation system (FG D). It can be described either as a mass flow [kg/year] or as a ratio of the inflow into the system (%). The Recovery Potential mass flow can be quantified as the difference between the mass inflow of the substance into the source technology (FG U) and the losses to air, soil and water for all technologies within a system. The Recovery Potential ratio is determined as the fraction of this recovered mass compared to the initial substance flow entering the system via the source technology (functional group U). The Recovery Potential ratio ranges from 0 (none recovered) to 1 (all recovered) and the sum of the recovery and loss potential ratio should equal 1.

— 1.3 HOW DOES SANTIAGO WORK

1.3.1 Disclaimer

This chapter is based on definitions and methods published in: (Spuhler et al., 2018; 2021)

1.3.2 SANTIAGO algorithms

SANTIAGO contains four algorithms to perform the above steps:

- the **Technology Appropriateness Filter TAF** that quantifies the appropriateness of potential technologies for a given application case;
- the **System Builder** that generates all valid system configurations from a set of potential and appropriate technologies;
- the **Option Selector** that selects a desired number of system configurations that is diverse and has a high appropriateness;

- and the **Substance Flow Model SFM** quantifies for a given amount of substance that enters the system how much is recovered or lost to soil, surface water, and air.

1.3.3 Required data

To run SANTIAGO, the set of potential technologies, the relevant screening criteria defining local appropriateness, the data for these criteria for the local application case, the number of inhabitants, and the desired number of system options are required.

1.3.3.1 Potential technologies

A sanitation technology is defined as any process, infrastructure, method or service that is designed to contain, transform or transport sanitation products (see also *chapter 1.2.1 Sanitation technologies* for a definition). SANTIAGO comes with a technology library that compiles data for over 90 conventional and novel technology options along the five functional groups User Interface (U), Onsite Collection and Storage/Treatment (S), Conveyance (C), Semi-centralized Treatment (T), and Reuse or Disposal (D).

Each technology is defined by its input and output products, its functional group, and the data for all screening criteria (the technology attributes) that apply for a given functional group. This data can be found in the technology library *chapter — 2.3 Currently implemented technologies* for all currently implemented technologies. If additional technologies are to be added to the library or existing ones modified *chapter 1.4.1 How to define technologies: functional groups, products* provides a helpful overview. Additionally, the relationship of the input and output products has to be defined. For instance, a technology could be defined as follows: a, b (OR) -> X -> d, e (AND). SANTIAGO then automatically generates all possible X variations: a -> X1 -> d, e; b -> X2 -> d, e; and a, b -> X3 -> d, e. The variations are further explained in *chapter 1.3.5.2 Technology Variations*.

The set of all input and output products contained in the technologies will define the scope of the sanitation system. E.g. if stormwater is considered then, not only toilet source needs to be looked at. It is important to consider, that when a technology is added with a new product, it has to be defined where its products are supposed to come from or go to and this has to be integrated in the existing set of technologies in order to be able to find the system configurations later with the System Builder.

The technology library (current format is JSON3) can be customized according to the above definitions. Customization includes adding, modifying, removing technologies, products, or criteria (see 2.2.1 Customization of Technology Library).

1.3.3.2 Screening criteria

The appropriateness of technologies is evaluated on the basis of screening criteria derived from the overall decision objectives for sustainable sanitation as defined by (SuSanA, 2008). Based on this definition, a sustainable sanitation system not only has to protect and promote human health by providing a clean environment and breaking the cycle of disease, but also has to be economically viable, socially and institutionally acceptable, technically appropriate, and protective of the environment and natural resources. The process to identify the list of screening criteria to be used for a given case is described in the SaniChoice Practicioners' Guide.

For each screening criterion, a pair of appropriateness attributes is required: a "technology attribute" and a "case attribute" (e.g. performance of a technology needing a certain energy supply, and energy availability in the given application case). The technology library currently contains the data and definitions for more than 30 criteria from five categories: technical, environmental and physical, socio-cultural, humanitarian, and criteria concerning capacity and management. The data for the corresponding case attribute has to be provided by the SANTIAGO user. The definitions for these criteria are available below in *chapter 1.7.3 Currently implemented screening criteria*.

1.3.3.3 Case data

The case data has to be provided by the user for each screening criteria ("case attribute") and compiled in a "case profile" that needs to correspond to the "technology profiles". Below we also provide guiding questions to establish the application case profiles (see the subchapter "Case question" for each criterion in *chapter 1.7.3 Currently implemented screening criteria*). Data required can generally be extracted from material collected through the planning process: baseline assessments, reports from previous projects, statistics, field visits, and key informant interviews. More sophisticated data collection methods, such as household surveys, should not be required for the application of SANTIAGO.

1.3.3.4 Inflows, number of users

To quantify resource recovery and loss potentials, the masses of inflowing substances need to be defined. The SANTIAGO technology library currently includes four substances and a number of sources. For each source and each substance, the mass of substance entering the system needs to be known per person. For instance, we can assume that a person produces 0.548 kg total phosphorus per year. Of course the masses vary depending on the diet of people, but if no local data is available, one can use an internationally valid estimate as provided in *chapter 1.7.6 Currently implemented inflows*. The substance flows and resulting resource recoveries and losses can then be scaled using the number of inhabitants within an area or adapted if local data is available.

1.3.3.5 Number of options

From a dozen of potential sanitation technologies, typically more than 100'000 valid systems can be generated. Many of them might be appropriate. On the other hand, the number of systems that can be managed by a typical SDM process strongly depends on the evaluation methods. In the case of a more sophisticated MCDA (e.g. using multiple−attribute value theory, MAVT), this number might be as high as 50. But the most often, especially in a simple context, as described in CLUES (Lüthi et al., 2011b), three to eight options are the most that can be dealt with (Gregory et al., 2012). SANTIAGO is designed to select a desired number of options using the system templates as an indicator for diversity. A good compromise in terms of size and diversity can be obtained by setting the number of options equal to the number of templates.

1.3.4 Appropriateness assessment

The first step to find an appropriate sanitation system is to identify those technologies among all potential ones that are appropriate for a specific case. For example, if no water can be supplied in the case, all technologies that require water supply can be excluded immediately.

The screening attributes cannot be described by a single value, as temporal and regional variabilities exist, and because of other uncertainties (e.g. data availability, future evolution, etc.). To account for these uncertainties, we use probability functions to parametrize the attributes. Each pair of technology and case attributes consists of one probability density function, e.g. the water availability for a given case, p(water availability); and one conditional probability function, e.g. the performance of a technology given a certain water availability P(performance/water availability); see also (Spuhler et al., 2018). One attribute function describes the requirements, and the other the conditions that have to be matched. Whether the density or the conditional probability function is used for the technology or the case is not important as long as both types of functions are a pair for each criterion.

The match of the two attribute functions defines the screening criteria appropriateness score between 0 and 100% either as:

$$AS_{t,c} = P(p) = \int P(p|c)\, p(c)\, dc\,,$$

if p(c) is a probability density function, or:

$$AS_{t,c} = P(p) = \sum_{c' \in \Omega} P(p|c)\, p(c')$$

if $P(c')$ is a probability distribution function.

By aggregating all criteria scores for a given technology and application case, the technology appropriateness score (TAS) is obtained (Spuhler et al., 2018). Again, it is a number between 0 and 100% that expresses the confidence in the appropriateness of the technologies and sanitation systems for a given application case:

$$TAS_t = \sqrt[n]{\prod_{c=1}^{n} AS_{t,c}}$$

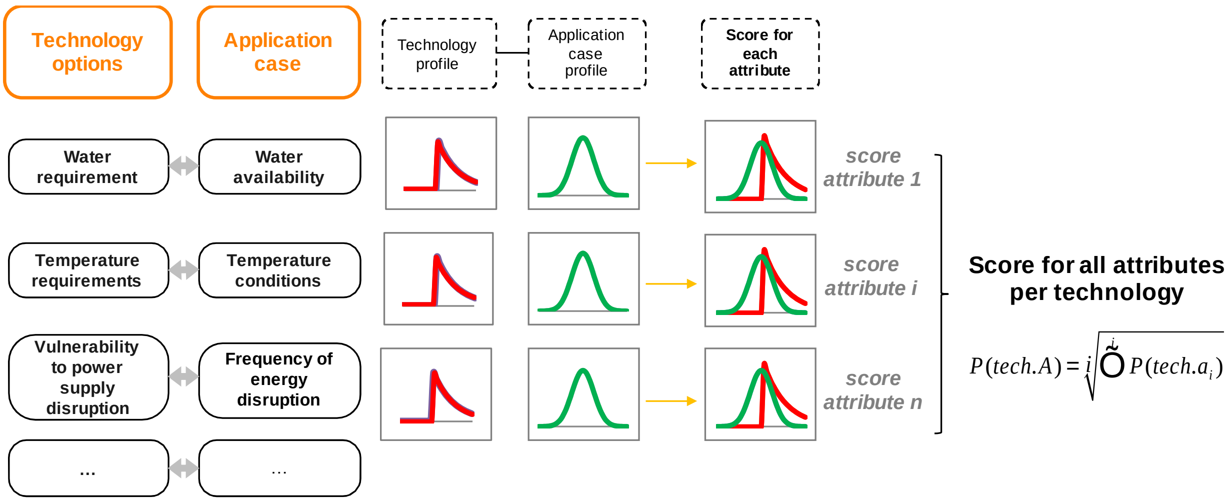


Figure 4 : Schematic representation of the comparison of technology profiles and application profiles, adapted from (Spuhler et al., 2018).

It is important to note that screening criteria are different from performance criteria in SDM and MCDA, as they are used to quantify the suitability of an option in a given context and not to identify the best option (Eisenführ et al., 2010). Consequently, screening criteria do not necessarily apply to all options under assessment, whereas performance criteria must do so. For instance, water availability should not influence the TASt of a Tech t that operates completely independently of the water availability. However, the TASt of this Tech t can still be compared to the TASx of another Tech x which is water reliant. Therefore, the aggregation function should allow for different numbers of criteria. We also require it to be equal to zero if at least one ASt,c is zero. The geometric mean fulfils these requirements (Langhans et al., 2014; Pollesch and Dale, 2015; Rowley et al., 2012).

Technologies with a $TAS = 0$ are totally inappropriate for the given case and are therefore excluded.

1.3.5 System builder

A sanitation system is defined as a set of technologies which, in combination, manage sanitation products from the point of generation to a final point of reuse or disposal (see definition in *chapter 1.2.3 Sanitation systems*). The technologies contained in a system can be organized in functional groups (FGs). We use the following FGs: toilet user interface (U), onsite collection and storage/treatment (S), conveyance (C), treatment (T), and reuse or disposal (D). A technology belonging to U is always a source, while a Tech belonging to D is always a sink. Additional sources, such as tabs, drainage, or organic solid waste collection bins can also be added and are assigned to a sub-group of U called Uadd. Each sanitation system comprises at least one source and one sink and a number of compatible technologies in such a way that all products end up in another technology or in a sink.

> *A sanitation system is valid if (1) it contains only compatible technologies and (2) every sanitation product either finds its way into a subsequent technology or a sink (Spuhler et al., 2018). Two sanitation technologies are compatible if the output product of one can be the input product of the other (Mauer et al. 2012).*

The System Builder (Spuhler et al., 2018; 2020d) is an algorithm that allows automatic generation of all valid sanitation system configurations from a set of potential technologies.

The set of all valid sanitation systems is constructed on the basis of the appropriate technologies, as illustrated in Figure 5**Error! Reference source not found.**. A Sanitation system is valid if it fulfils the following criteria:

- every output product of each Tech must be connected to another Tech that can take this product as its input,
- no Tech has inputs that are not connected to the output of another Tech.

These rules allow loops in a sanitation system. However, loops between Technologies are practically only possible if the infrastructures are situated close to each other. This leads to the additional constraint that loops are only allowed for the FG S or T either at the level of the premises (onsite) or at semi-centralized treatment facilities (offsite).

1.3.5.1 Transported products

The same product may occur onsite or offsite. In this case, it is treated as two different products for the generation of sanitation systems. For example, blackwater that is produced onsite (e.g. by a ‘septic tank’), cannot feed into a centralized Tech (e.g. ‘activated sludge’); it must first be transported by a transport Tech in FG C (e.g. ‘conventional sewer’). For the generation of sanitation systems we distinguish between products and transported products in building the systems (i.e. ‘blackwater’ and ‘transported blackwater’). Transported products are either output products of Techs in FG C or of Techs that accepted a transported input product.

1.3.5.2 Technology Variations

The generation of sanitation systems requires some assumptions and simplifications to be automated and generic enough to deal with all potential sanitation technologies. The main simplifications concern the way of how the input and output streams are related to each other. Some Technologies of the FG C take a varying number of input products that are then mixed together. To take this fact into consideration, the model defines a hierarchy of products according to their degree of pollution. When different products enter into such a Tech, the resulting output corresponds to the product which is defined to be the most polluted. For example, a conventional sewer fed with greywater and blackwater will produce blackwater. The same Tech fed with blackwater will also produce blackwater.

Another simplification concerns the generation of different Tech variations. The relations of different in- and out-products to each other is defined as either (i) any possible combination (‘OR’), (ii) their mutual exclusion (‘XOR’); or their compulsory co-existence (‘AND’). For example, a septic tank can have the following in-products: ‘blackwater’ OR ‘greywater’; and has the following out-products: ‘sludge’ AND ‘effluent’. This results in three possible combinations of in- and out-products: (i) blackwater, greywater -> effluent, sludge; (ii) blackwater -> effluent, sludge; (iii) greywater -> effluent, sludge. For the generation of sanitation systems we treat each of these possible combinations as a distinct technology variation.

Creating all possible combinations of Technologies is not feasible as a very large number of combinations exist. Moreover, only a very small fraction of these possible combinations are valid sanitation systems. The here proposed sanitation system builder provides an efficient heuristic design to create all valid sanitation systems (see details in the SI-B). The functioning of the algorithm is illustrated in Figure 5.

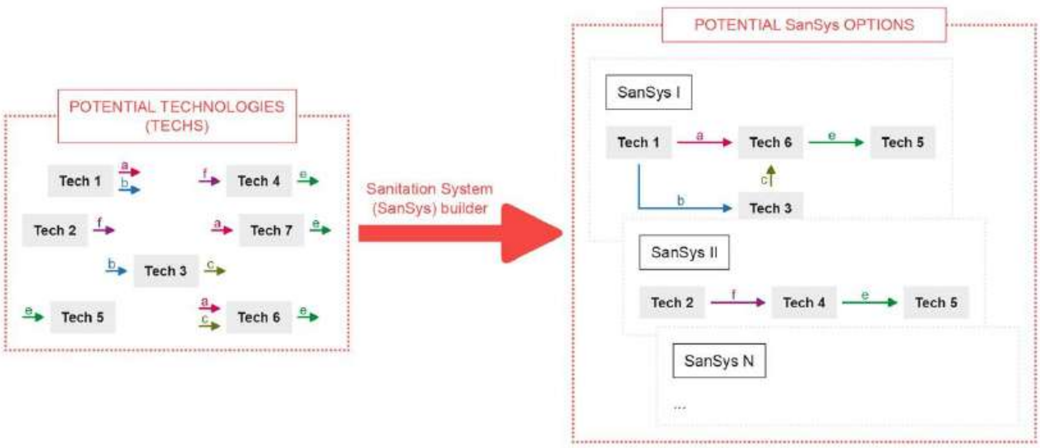


Figure 5 : Concept underlying the System Builder, adapted from (Spuhler et al., 2018; 2020d).

1.3.5.3 Quantifying system appropriateness

The sanitation System Appropriateness Score (SAS) is calculated by aggregating the TAS of every Tech of the system. Any aggregation function could be used. We propose a function that can either mimic the product of all TAS, the geometric mean, or a compromise between both:

$$SAS_S = \prod_{i=1}^{n.tech} TAS_t^{\frac{1}{\alpha\,(n.tech-1)+1}}$$

where $n.tech$ is the total number of technologies in a given system, and $\alpha \in [0,1]$.

A purely multiplicative aggregation ($\alpha = 0$) systematically penalizes sanitation systems with a large number of technologies (long systems). This contradicts the principle of allowing a broad range of sanitation systems in the decision option set. Using the geometric mean ($\alpha = 1$) is often not desirable either, because a simple system should be preferred over a complex (long) one with the same performance. The smaller the factor α that is chosen, the more are longer sanitation systems (i.e. sanitation system with a large number of technologies) penalized. The weight α is to be chosen in such a way that longer systems are not penalized over shorter, but a benefit is still provided for simpler systems over longer ones.

1.3.6 Option Selector

The set of all possible sanitation systems created with the System Builder may contain more than a hundred thousand systems. From these, we must select a sub-set of potentially applicable decision options that will serve as an input for decision-making. For this, we define three rules:

- The set contains the desired number of decision options. The absolute number of decision options depends on the user and its ability to handle small or larger numbers of decision options.
- The set entails a diverse range of options. The integration of a high variability of different options is important to open up the decision space for the stakeholders and to be able to reveal and discuss trade-offs and therefore increases the probability of finding a sustainable solution.
- The set contains locally appropriate options. The appropriateness is defined by the system appropriateness scores SAS.

To characterize the diversity, we use system templates. A system template defines a class of sanitation systems with similar conceptual characteristics (for a definition refer to *chapter 1.2.10 System templates*).

The optimal set of options in terms of size, appropriateness, and diversity is obtained by selecting the system with the highest SAS from each system template (Spuhler et al., 2018). In case more options can be managed, SANTIAGO uses a clustering algorithm (Spuhler et al., 2018) to pre-select more than one option from each template using system complexity and length as additional diversity indicators. In case fewer options need to be selected, the algorithm uses the 90% quantile of the SAS for each template to define which templates should be considered (Spuhler et al., 2018).

1.3.6.1 System templates

The Option Selector uses binary conditions (e.g. “produces biofuel”, “includes transport”) to define a set of system templates. Each sanitation system can be assigned to one unique template. To define system templates is rather complex as it has to be done based on a good understanding of technologies and generated systems. Therefore, the SANTIAGO package comes with a predefined template function based on a number of binary conditions and system templates (see Table 1). These classifications are partly inspired on the *Compendium of Sanitation Systems and Technologies* (Tilley et al., 2014b). The system templates differentiate between onsite, offsite (decentralised, or centralised) and hybrid sanitation systems. Onsite refers to systems that have treatment solely onsite at the location of the toilets (no conveyance technology (FG C) required). For offsite systems the output products of FG S are transported, and all treatment takes place at another location, while hybrid systems have treatment steps onsite and offsite. For further details refer to *chapter 1.2.11 Onsite, Decentralized and Offsite Technologies and Systems*.

Onsite, Decentralized and Offsite Technologies and Systems. It is possible to have sanitation systems that do not automatically fit into any template and that need to be considered separately by a user.

Table 1. System templates (ST) used to characterize the sanitation system options. The STs are adapted from (Spuhler et al., 2018). Each of the STs has a unique profile defined by a value for nine properties. And each of the sanitation systems can be assigned to one ST by testing the binary conditions for the system. ‘1’ means that the property is true (e.g. 'the system does not have dry material production”); 0 means that the property is false (e.g. “in this system there is no dry material”); and ‘not defined’ (n.d.) means that the property is not evaluated for this ST.

Group				Dry material (faeces or excreta)	Sludge	Sludge onsite or decentralised	Blackwater	Transported blackwater	Urine	Onsite storage and treatment (functional group S)	Decentralized and offsite storage and treatment (functional group T)	Transport of products	Biofuel	Biofuel onsite or decentralised	Biofuel production offsite	Biomass production	Urinal	Controlled open defecation
Dry	ST	**1.**	Onsite dry system with sludge production without biomass production	1	nd	1	0	0	0	1	0	0	0	nd	nd	0	0	0
		2.	Onsite dry system with sludge production and with biomass production	1	nd	1	0	0	0	1	0	0	0	nd	nd	1	0	0
		3.	Onsite dry system without sludge production without biomass production	1	nd	0	0	0	0	nd	0	0	0	nd	nd	0	0	0
		4.	Onsite dry system without sludge production and with biomass production	1	nd	0	0	0	0	1	0	0	0	nd	nd	1	0	0
		5.	Decentralized dry system without biomass production	1	nd	nd	0	0	0	nd	1	0	0	nd	nd	0	0	0
		6.	Decentralized dry system with biomass production	1	nd	nd	0	0	0	nd	1	0	0	nd	nd	1	0	0
		7.	Hybrid dry system without biomass production	1	nd	nd	0	0	0	1	nd	1	0	nd	nd	0	0	0
		8.	Hybrid dry system with biomass production	1	nd	nd	0	0	0	1	nd	1	0	nd	nd	1	0	0
		9	Centralized dry system without biomass production	1	nd	nd	0	0	0	0	nd	1	0	nd	nd	0	0	0
		10.	Centralized dry system with biomass production	1	nd	nd	0	0	0	0	nd	1	0	nd	nd	1	0	0
Blackwater	ST	**11.**	Onsite blackwater system without sludge with or without effluent transport	nd	nd	0	1	0	0	1	0	0	0	nd	nd	nd	0	0
		12.	Onsite blackwater system with sludge production without effluent transport	nd	nd	1	1	0	0	1	0	0	0	nd	nd	nd	0	0
	ST	**13.**	Decentralized blackwater system with sludge	nd	1	nd	1	0	0	nd	1	0	0	nd	nd	nd	0	0
	ST	**14.**	Decentralized blackwater system without sludge	nd	0	nd	1	0	0	nd	1	0	0	nd	nd	nd	0	0
	ST	**15.**	Hybrid blackwater system with sludge	nd	1	nd	1	nd	0	1	nd	1	0	nd	nd	nd	0	0
	ST	**16.**	Centralized blackwater system with sludge	nd	1	nd	1	nd	0	0	nd	1	0	nd	nd	nd	0	0
	ST	**17.**	Hybrid blackwater system without sludge	nd	0	nd	1	nd	0	1	nd	1	0	nd	nd	nd	0	0
	ST	**18.**	Centralized blackwater system without sludge	nd	0	nd	1	nd	0	0	nd	1	0	nd	nd	nd	0	0
Biofuel	ST	**19.**	Onsite dry system with biofuel production without effluent transport	1	nd	nd	0	0	0	1	0	0	nd	1	nd	nd	0	0
	ST	**20.**	Onsite blackwater system with biofuel production without effluent transport	0	nd	nd	1	nd	0	1	0	0	nd	1	nd	nd	0	0
	ST	**21.**	Decentralized dry system with biofuel production	1	nd	nd	0	0	0	nd	1	0	nd	1	0	nd	0	0
	ST	**22.**	Decentralized blackwater system with biofuel production	0	nd	nd	1	nd	0	nd	1	0	nd	1	0	nd	0	0

	ST	**23.**	Hybrid dry system with biofuel production	1	nd	nd	0	0	0	1	nd	1	1	nd	nd	nd	0	0
	ST	**24.**	Centralized dry system with biofuel production	1	nd	nd	0	0	0	0	nd	1	1	nd	nd	nd	0	0
	ST	**25.**	Hybrid blackwater system with biofuel production	0	nd	nd	1	nd	0	1	nd	1	1	nd	nd	nd	0	0
	ST	**26.**	Centralized blackwater system with biofuel production	0	nd	nd	1	nd	0	0	nd	1	1	nd	nd	nd	0	0
Urine	ST	**27.**	Onsite dry system with urine diversion without effluent transport	1	nd	nd	0	0	1	1	0	0	nd	nd	nd	nd	0	0
	ST	**28.**	Onsite blackwater system with urine diversion without effluent transport	0	nd	nd	1	0	1	1	0	0	nd	nd	nd	nd	0	0
	ST	**29.**	Decentralized dry system with urine diversion with or without effluent transport	1	nd	nd	0	0	1	nd	1	0	nd	nd	nd	nd	0	0
	ST	**30.**	Decentralized blackwater system with urine diversion with or without effluent transport	0	nd	nd	1	nd	1	nd	1	0	nd	nd	nd	nd	0	0
	ST	**31.**	Hybrid dry system with urine diversion	1	nd	nd	0	0	1	1	nd	1	nd	nd	nd	nd	0	0
	ST	**32.**	Centralized dry system with urine diversion	1	nd	nd	0	0	1	0	nd	1	nd	nd	nd	nd	0	0
	ST	**33.**	Hybrid blackwater system with urine diversion	0	nd	nd	1	nd	1	1	nd	1	nd	nd	nd	nd	0	0
	ST	**34.**	Centralized blackwater system with urine diversion	0	nd	nd	1	nd	1	0	nd	1	nd	nd	nd	nd	0	0
Others	ST.	**35.**	Urinal	0	nd	nd	0	0	1	nd	nd	nd	nd	nd	nd	nd	1	0
	ST	**36.**	Controlled open defecation in humanitarian context	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1
	ST	**37.**	Not defined	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Table 2: System templates using summarized binary conditions for the online tool www.sanichoice.net

Group				**Dry (no Flush water)**	**Wet (Blackwater)**	**Sludge production**	**Biomass Production**	**Biofuel Production**	**Urine Diversion**	**Onsite**	**Decentrlised**	**Hybrid**	**Centralized**
Dry	**ST**	**1.**	**Onsite dry system with sludge production without biomass production**	**1**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
		2.	**Onsite dry system with sludge production and with biomass production**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**
		3.	**Onsite dry system without sludge production without biomass production**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
		4.	**Onsite dry system without sludge production and with biomass production**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**
		5.	**Decentralized dry system without biomass production**	**1**	**0**	**ND**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
		6.	**Decentralized dry system with biomass production**	**1**	**0**	**ND**	**1**	**0**	**0**	**0**	**1**	**0**	**0**
		7.	**Hybrid dry system without biomass production**	**1**	**0**	**ND**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
		8.	**Hybrid dry system with biomass production**	**1**	**0**	**ND**	**1**	**0**	**0**	**0**	**0**	**1**	**0**
		9	**Centralized dry system without biomass production**	**1**	**0**	**ND**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

		10.	Centralized dry system with biomass production	1	0	ND	1	0	0	0	0	0	1
Blackwater	ST	11.	Onsite blackwater system without sludge with or without effluent transport	0	1	0	ND	0	0	1	0	0	0
		12.	Onsite blackwater system with sludge production without effuent transport	0	1	1	ND	0	0	1	0	0	0
	ST	13.	Decentralized blackwater system with sludge	0	1	1	ND	0	0	0	1	0	0
	ST	14.	Decentralized blackwater system without sludge	0	1	0	ND	0	0	0	1	0	0
	ST	15.	Hybrid blackwater system with sludge	0	1	1	ND	0	0	0	0	1	0
	ST	16.	Centralized blackwater system with sludge	0	1	1	ND	0	0	0	0	0	1
	ST	17.	Hybrid blackwater system without sludge	0	1	0	ND	0	0	0	0	1	0
	ST	18.	Centralized blackwater system without sludge	0	1	1	ND	0	0	0	0	0	1
Biofuel	ST	19.	Onsite dry system with biofuel production without effluent transport	1	0	ND	ND	1	0	1	0	0	0
	ST	20.	Onsite blackwater system with biofuel production without effluent transport	0	1	ND	ND	1	0	1	0	0	0
	ST	21.	Decentralized dry system with biofuel production	1	0	ND	ND	1	0	0	1	0	0
	ST	22.	Decentralized blackwater system with biofuel production	0	1	ND	ND	1	0	0	1	0	0
	ST	23	Hybrid dry system with biofuel production	1	0	ND	ND	1	0	0	0	1	0
	ST	24	Centralized dry system with biofuel production	0	1	ND	ND	1	0	0	0	0	1
	ST	25	Hybrid blackwater system with biofuel production	1	0	ND	ND	1	0	0	0	1	0
	ST	26	Centralized blackwater system with biofuel production	0	1	ND	ND	1	0	0	0	0	1
Urine	ST	27	Onsite dry system with urine diversion without effluent transport	1	0	ND	ND	ND	1	1	0	0	0
	ST	28	Onsite blackwater system with urine diversion without effluent transport	0	1	ND	ND	ND	1	1	0	0	0
	ST	29	Decentralized dry system with urine diversion with or without effluent transport	1	0	ND	ND	ND	1	0	1	0	0
	ST	30	Decentralized blackwater system with urine diversion with or without effluent transport	0	1	ND	ND	ND	1	0	1	0	0

	ST	**31**	**Hybrid dry system with urine diversion**	**1**	**0**	**ND**	**ND**	**ND**	**1**	**0**	**0**	**1**	**0**
	ST	**32**	**Centralized dry system with urine diversion**	**0**	**1**	**ND**	**ND**	**ND**	**1**	**0**	**0**	**0**	**1**
	ST	**33**	**Hybrid blackwater system with urine diversion**	**1**	**0**	**ND**	**ND**	**ND**	**1**	**0**	**0**	**1**	**0**
	ST	**34**	**Centralized blackwater system with urine diversion**	**0**	**1**	**ND**	**ND**	**ND**	**1**	**0**	**0**	**0**	**1**
Others	**ST.**	**35**	**Urinal**	**ND**	**ND**	**ND**	**ND**	**ND**	**1**	**ND**	**ND**	**ND**	**ND**
	ST	**36**	**Controlled open defecation in humanitarian context**	**ND**	**ND**	**1**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
	ST		**Not defined**	**ND**	**ND**			**ND**	**ND**	**ND**	**ND**	**ND**	**ND**

Table 3: Summarized characterisation of the currently implemented system templates (STS).

			Onsite	**Decentralized**	**Hybrid**	**Centralized**
Simple	**Dry**	**Without biomass production**	ST1 (with sludge) ST3 (without sludge)	ST5	ST7	ST9
		With biomass production	ST2 (with sludge) ST4 (without sludge)	ST6	ST8	ST10
Blackwater	**Wet**		ST11 (without sludge) ST12 (with sludge)	ST13 (without sludge) ST14 (with sludge)	ST15 (without sludge) ST17 (with sludge)	ST16 (without sludge) ST17 (with sludge)
Biofuel	**Dry**		ST19	ST21	ST23	ST24
	Wet		ST20	ST22	ST25	ST26
Urine diversion	**Dry**		ST27	ST29	ST31	ST32
	Wet		ST28	ST30	DZ33	ST34
Controlled open defection (humanitarian setting)			ST35			
Urinal only			ST36			
Not defined			ST37			

1.3.7 Substance Flow Model (SFM)

1.3.7.1 Approach

For the evaluation of trade-offs and the selection of the preferred sanitation system option, detailed information regarding the performance of various options can be useful. Nutrient emission or recovery potentials, water reuse or loss, and energy recovery potential are performance indicators that can matter in a multi-criteria selection of the preferred option. To analyse and quantify the flows of matter and energy into, within and out of the defined borders of a system, material flow analysis (MFA) or substance flow modelling (SFM) has proven to be a good option (Villeneuve et al., 2004).

We apply a simplified substance flow model to quantify substance flows of the sanitation systems. The flow paths are defined by the sanitation products that connect technologies within a system.

Using the transfer coefficients, the SFM algorithm propagates the entering mass of substance through the entire system, providing the percentage of substance mass transferred or lost, either to the soil, air, or water for each technology. In the sink technologies, substances are not transferred further but either lost or recovered for reuse. By summing up all losses and recoveries in the entire system, balances for resource recovery potentials and losses can be quantified. The uncertainty of the transfer coefficients is propagated using Monte Carlo providing the recovery and loss potentials, mean values and standard deviations. First tests showed (Spuhler et al., 2020d) that the standard deviations of the results remain in the order of magnitude of conventional material flow analysis studies for sanitation systems (Montangero and Belevi, 2008).

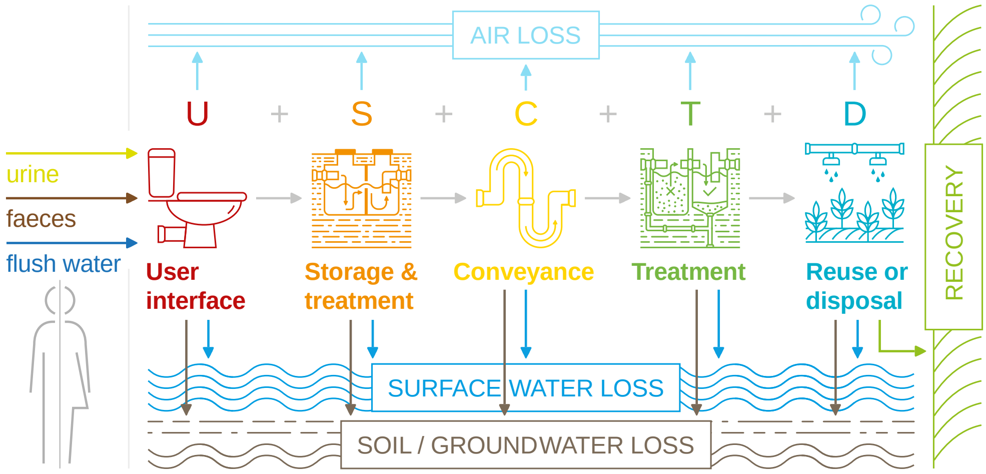


Figure 6: Concept underlying the Substance Model. The substances (phosphorus, nitrogen, total solids, water) enter the systems through the user interface (source, U) and are either transferred, lost to air, soil or surface water, or recovered at the sink level (reuse or disposal, D).

1.3.7.2 Transfer coefficients

Each technology needs to be characterised with a TC for each output flow and substance of interest. For a given substance, the TC for the i-th output flow of a technology (TC_i) is the fraction of the sum of the input flows that leave the technology through outflow i:

$$\mathrm{TC}_i = \frac{\mathrm{out}_i}{\sum_{j=1}^{n} in_j}$$

where n is the total number of inputs to this technology. The output flows are the output products as well as the losses to the environment - to air, soil/groundwater, and surface water. Input flows are defined only by the input products as we assume a system with no biological fixation. Thus, the sum of all TCs of a technology must always be 1 and all TCs positive.

Three types of TCs can be distinguished:

- Input-output TCs. For every output a TC needs to be defined; the number of outputs depends on the Tech.
- Input-loss TCs. Quantifying the fraction of substances transferred to air, soil or groundwater, and surface water. We only consider the losses (e.g. leaching of phosphorus from a single pit into the soil) and not the subsequent interactions (e.g. transfer of the same phosphorus from the soil to the surface water).
- Recovery TCs. Besides losses, sink technologies also have a TC to quantify the fraction of a substance that can be recovered (e.g. over 90% of phosphorus is recovered through the sink 'application of stored urine').

Figure 7 provides an example of the flows and the TCs for the technology single pit and the substance total phosphorus (TP). The example also shows the high variability of the data found in literature. Therefore, we need a systematic method to consider and model this uncertainty.

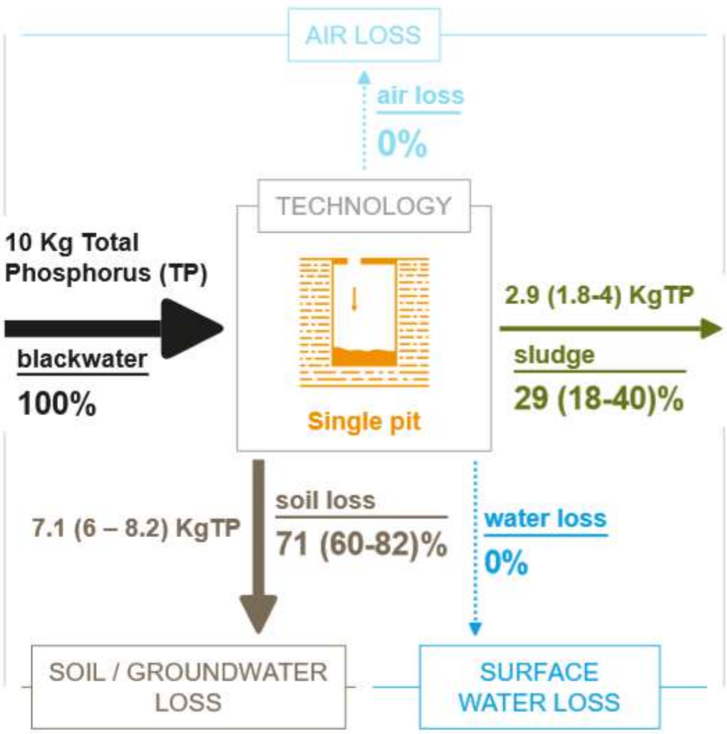


Figure 7: Illustration of the approach used to quantify transfer coefficients (TCs) using the example of total phosphorus (TP) pathways in a single pit. The TCs are estimated based on literature values in mass and in percentage as mean values. In parenthesis we provide the variability range resulting from the literature data points. From the 100% of phosphorus entering the single pit via blackwater, 29% are transferred to sludge and 71 % are lost to the soil. But these values can vary as much as between 18 to 40 and 60 to 82 % respectively.

1.3.7.3 Transfer Coefficient Uncertainty Propagation

Monte Carlo simulations are used to propagate the uncertainty of the TCs through the substance flow model and to quantify their effect on the resource recovery and loss ratios. The TCs for each Tech are sampled from their Dirichlet distribution and used to compute the mass flow of the entire sanitation system in repeated runs. We used a total of 300 runs which proved to be sufficient for stable results.

1.3.7.4 Mass flow calculations

The product connections between the technologies in each sanitation system define the flow paths of the substances (see also Figure 2). Transfer coefficients (TCs) define how much of substance entering a technology is transferred to one of the outputs products or lost to the environment. These TCs and the connections can be expressed in a matrix P, where Pi, is the fraction of the substance leaving Tech i that is transferred to Tech j. Additionally, we define a row vector $F^e(t)$, where the i-th element represents the external inflow to Tech i at time t (e.g. the dry toilet Tech receives 0.550 kg/year of phosphorus per one person). Based on this information, we can calculate the total inflow into Tech i at time t. We define a row vector (t) where the i-th element represents the sum of all inflows to Tech i at time t (e.g. the amount of phosphorus entering a single pit through excreta).

The mass flows at time t + 1 are obtained by

$$F_{t+1} = F_t * P + F_{t+1}^{ext}$$

If we assume a constant inflow $F_e(t)$ = F_{ext}, we have a steady state flow F that is calculated by

$$F = F \cdot P + F_{ext}$$

$$F = F_{ext} \cdot (I - P)^{-1}$$

The flow at steady state from node i to node j is consequently defined as

$$flow_{i,j} = F_i \cdot P_{i,j}$$

When considering the whole sanitation chain the model substance inflows into the source technologies (FG U) are transferred into the respective output products (e.g. urine, faeces, excreta or blackwater) using the transfer coefficients (TCs). From then on, the flow of the substances s through the system is calculated by multiplying the sum of all inflows to the technology by TCs in order to get the amount of substance in the output products. These are then transferred into inflows in the subsequent technology until the sink technologies (FG D) are reached.

The recovery potential of a sanitation system is defined by the mass flow that can be recovered from the sink technologies. The losses to air, soil and water for all technologies within a sanitation system are summed up and represent the mass flow of the total loss potential per environmental compartment $loss_{air/water/soil,s}$ [kg/cap/year]. It can also be quantified as the $Loss\ Potential\ ratio_{air/water/soil,s}$ [%] compared to the mass inflow $in_{FG\ U,s}$ entering the source technology by the following equation

$$Loss\ Potential\ ratio_{air/water/soil,s} = \frac{loss_{air/water/soil,s}}{in_{FG\ U,s}} = \frac{\sum_{all\ techs} loss_{air/water/soil,s}}{in_{FG\ U,s}}$$

In analogue, the total recovery potentials can be determined as both recovered mass flows $out_{FG\ D,s}$ [kg/cap/year] in the sink technology and as $Recovery\ Potential\ ratios_s$ [%] of mass inflow $in_{FG\ U,s}$ entering the system by the flowing equation

$$Recovery\ Potential\ ratio_s = \frac{out_{FG\ D,s}}{in_{FG\ U,s}} = \frac{in_{FG\ U,s} - \sum_{all\ techs} loss_{air,s} - \sum_{all\ techs} loss_{water,s} - \sum_{all\ techs} loss_{soil,s}}{in_{FG\ U,s}}$$

The recovery ratio depends solely on the transfer coefficients of the technologies. In comparison, the recovery mass flow is affected by the substance inflow into the sanitation system, which differs for different source technologies. For instance, a cistern flush toilet has a larger inflow of water (H2O) compared to a dry toilet. Therefore, a system with a cistern flush toilet might have a larger absolute water mass recovered, but a smaller recovery ratio of water than a sanitation system with a dry toilet.

Because we have different external inflows and transfer coefficients for each substance, the calculations are repeated separately for each substance that is to be modelled.

1.3.8 Results and Outputs

SANTIAGO provides the following results and outputs:

- Appropriateness Scores: for each technology and each screening criterion an appropriateness score between 0 and 100% is provided and describes how well the technology matches the local conditions for this screening criterion (e.g. space availability).
- Technology Appropriateness Scores: aggregating the individual appropriateness scores for all screening criteria determines the Technology Appropriateness Score, also a number between 0 and 100%. The TAS expresses the confidence in how appropriate this technology is for the local conditions.
- System options: SANTIAGO provides a list of all possible system configurations and their properties.
- System properties: The system properties for each system include a unique identifier, the included technologies and their product connections, the system template it belongs to and the system appropriateness score SAS based on the aggregation of the TASs. In addition, the system properties include the mass flow statistics including the substance mass flows per output product and the overall resource recovery and loss potential masses and ratios.
- A selection of diverse and appropriate sanitation system options and their properties according to the desired number of system options that one wishes to further evaluate.

— 1.4 DEFINING TECHNOLOGIES

To define a technology, following elements are required:

- A name
- The functional group it belongs to
- The input and output products and their relations
- The attribute functions and parameters for all relevant screening criteria (not all the screening criteria apply for all functional groups, but if it applies to a functional group, then all technologies within this functional group need an attribute for this criteria).
- The transfer coefficients into each output product and into the environmental compartments air, soil and water.
- Optionally a short description can be provided

1.4.1 How to define technologies: functional groups, products

The following list comprises the general input data needed to add a new technology to the technology library:

Name Unique and intuitive

Definition: Short description of the technology.

FG: User interface (U), onsite collection and storage/treatment (S), conveyance (C), (semi-) centralized treatment (T), use and/or disposal (D)

Treatment technologies can be sorted into different FG based on their suitability for locations close to the toilet infrastructures (onsite) or at distant centralized treatment facilities (offsite): If a technology can only be used onsite, it is added to FG S. If a technology can only be used offsite at (semi-)centralized treatment facilities, it is added to FG T and additionally it is defined that solely transported input products are allowed. If a technology can be used onsite and offsite, it is added to FG T and transported as well as not-transported input products are allowed.

Products: In- and output products of the technologies; for an overview of all currently implemented products and more information see *chapter 1.2.2 Sanitation Products*.

Relations: Required to generate the technology variations (see *chapter 1.3.5.2 Technology Variations*). Relation between the input products as well as between the output products:

'OR': **any possible combination** of products entering/leaving the technology

'XOR': **a mutual exclusion** with only one of the products entering/leaving the technology

'AND': **a compulsory co-existence** of all products entering/leaving the technology

For technologies in the FG C (conveyance): the order of output products separated by "**>**" indicates which output product is most/more dominant in case different products get mixed during conveyance. For example if blackwater AND greywater enter a conventional sewer, the output product will be considered to be transported blackwater (as blackwater > greywater).

1.4.2 Appropriateness Profiles

Additionally, to the data given above we also need to specify the appropriateness attributes for a technology in order to be able to calculate appropriateness scores. The functions to parametrize attributes given below are recommendations, but you can also use other probability density functions and/or conditional probability functions. In principle only two functions are required:

- The trapezoidal function: based on four values a, b, c, and d. If a=b and c=d then the functions correspond to the range functions. If b=c then it corresponds to the triangular functions.
- The categorical function: based on a pre-defined set of category names

> *It is important to remember that the technology and case functions for a given criteria must always be a pair of a conditional probably (performance function) and a probability distribution (condition function). For instance the technology has a performance given a certain temperature (performance function) and the temperature has a certain distribution over the year in a certain case (condition function).*

1.4.2.1 Possible attribute functions

In the following, we propose two functions (one continuous and one categorical) that should be sufficient for most of the data. However, if more accuracy is needed, any other probability function could be used.

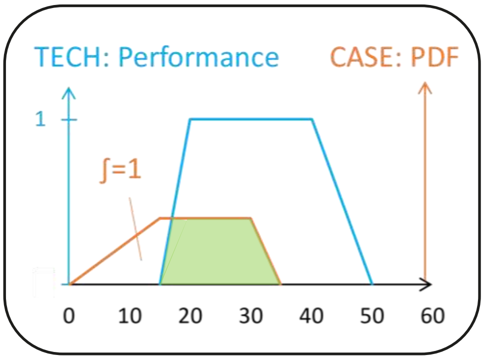
1.4.2.1.1 Trapezium Function: Continuous

The trapezium function can describe values where a linear interpolation between four data points (a = min, b = 1st optimum, c = 2nd optimum and d = max) is assumed. However, the trapezium function can be used in various ways depending on how the parameters are set.

Trapezium function in general → Trapez(a,b,c,d) , a<b<c<d

Example (Normal trapezium function as a performance and PDF function for “Temperature”):

The case area has a temperature range of 0 to 35°C. For most of the year the temperatures lie between 15 and 30°C.
PDF, Trapez:
(a=0, b=15, c=30, d=35)



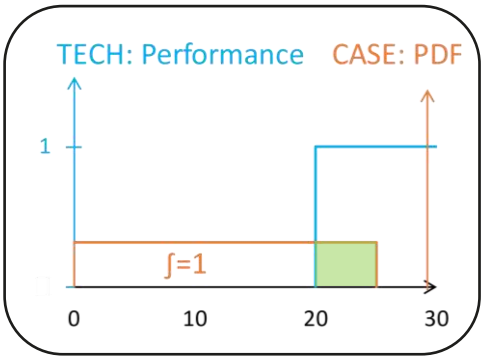
The technology starts working at 15°C, reaches its optimum at 20 to 40°C and does not work over 50°C.
Performance, Trapez:
(a=15, b=20, c=40, d=50)

Trapezium function as a range → Trapez(a,b,c,d), a=b<c=d

If the parameters are set a=b and c=d we can define a certain range as a function. This can be used for an interpolation between two data points (min and max value, e.g. “the available surface area ranges between 0 and 25 m^2”) → Trapez(a=b=0, c=d=25)

Example (Trapezium used as PDF and performance range function for “Surface Area”):

A maximum surface area of 25m² is available.
PDF, Range:
(a=b=0, c=d=25)



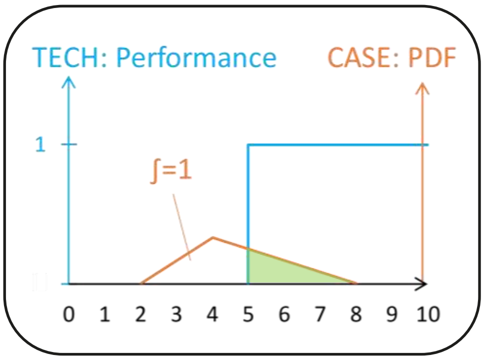
A minimal surface area of 20m² is required
Performance, Range:
(a=b=20, c=d=999)

Trapezium function as a triangle → Trapez(a,b,c,d), a<b=c<d

The triangle function can describe values where a linear interpolation between three points is assumed (min, medium and max value, e.g. “the groundwater ranges between 2 m and 8 m with an average of 4 m”) → Trapez(a=2, b=c=4, d=8)

Example (Trapezium used as PDF triangle function for “Groundwater Depth”):

The groundwater level varies between 2m and 8m with an average of 4m.
PDF, Triangle:
(a=2, b=c=4, d=8)



The technology only works with groundwater depths deeper than 5m.
Performance, Range:
(a=b=5, c=d=999)

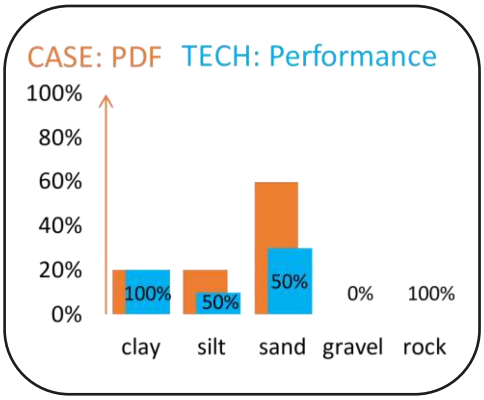
1.4.2.1.2 Discrete Function: Category

The category function allows us to give values to specific categories.

→ cat(category 1, category 2, category 3, …)

Example (Categorical function as PDF and performance function for “Soil Type”):

The soil in the area is 20% clay, 20% silt and 60% sand.
PDF, Categorical → ∑=1
(clay = 20%, silt = 20%,
sand = 60%, gravel = 0%,
rock = 0%)



The technology works 100% for clay and rock, but only 50% for silt and sand and does not work for gravel.
Performance, Categorical
(clay = 100%, silt = 50%,
sand = 50%, gravel = 0%,
rock = 100%)

1.4.3 Quantifying Transfer Coefficients

The Substance Flow Model (SFM) algorithm requires transfer coefficients for each technology and substance. The classical approach for quantifying transfer coefficients in material flow analysis is to make in-situ measurements to parametrize the transfer coefficients as a function of different parameters such as volume, temperature, etc. The problem is that in-situ measurements are often not possible and that the measurement results can be very different for different implementations of a technology. Therefore, we have chosen a more generic approach.

We use two different ways to determine transfer coefficients for the case where literature data is available and for the case of literature data being absent.

If literature data was available, we defined the expected value μ_i for TC_i as the median of the data points collected from the literature. In absence of literature data, we used expert judgement. For expert judgement, we collected information on the chemical and physical processes to make a best guess or contacted colleagues directly involved in the development of the technology to do that for us.

An exact definition is not possible, because TCs depend on many factors such as the environmental conditions, the design and implementation of a technology, the qualities and quantities of inputs, and because ignorance is common (especially for novel technologies). It is therefore important to consider uncertainties attached to the TCs. A suitable model is the Dirichlet distribution as it encodes the sum constraint that requires the sum of all TCs to be equal to 1. Thus, the probability density of the transfer coefficients $TC = [TC_1 \ldots TC_n]$ of a given Tech is:

$$TC \sim f(x) = \frac{1}{B(\alpha)} \prod_{i=1}^{n} x_i^{\alpha_i - 1},$$

where B is the Beta function and n is the number of TCs for a given Tech (Johnson et al., 1995). We define $\alpha_i = \mu_i \cdot k$, where μ_i is the expected value of TC_i and k is the concentration describing the variability range r_i of the TCs. The smaller the k, the larger the standard deviation of the observations. For a very small k, the marginal distributions become bimodal. The effect of k is visualized in Figure 8.

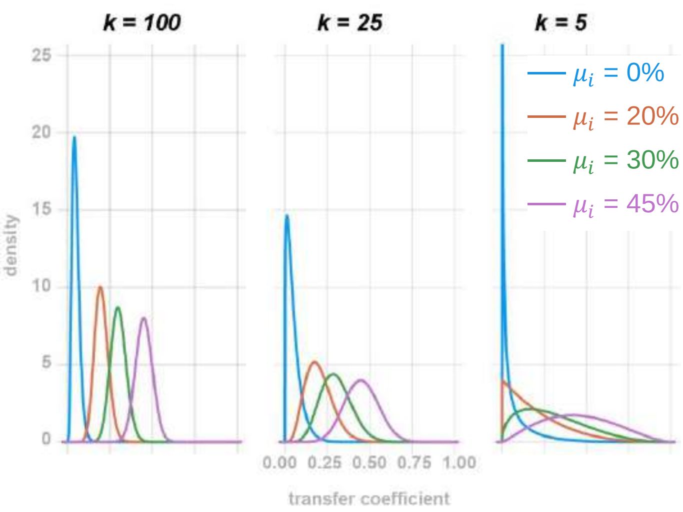


Figure 8: Three examples of concentration factors k for a set of four transfer coefficients μ_i (0%, 20%, 30% and 45%). For k = 100, the distributions are relatively narrow (small variability range of up to 10% expressed as standard deviation). For k = 5, the variability ranges are up to 40%.

To simplify the application of the approach, we define six generic values for k and use two different approaches to define k for a given TC: one for the case when literature data is present and based on the literature data variability; and one for the case of expert judgement based on the confidence in the judgement.

1.4.3.1 Concentration factors k based on literature observation

The range between the lowest and the highest values of all data points, the variability range r_i, is determined and used to define the concentration factor k with the help of Table 4. In the example presented in Figure 7, total phosphorus transferred to sludge in a single pit, we found TC values in the literature between 18 % and 40 %, resulting in r_i = 0.40-0.18 = 0.22 and thus k = 5. As the r_i for different TC_is of one Tech are not identical, we use the largest r_i to define k. Table 4 shows the k associated with each variability range r_i. The values are based on an approximation using 45 possible scenarios of TCs sets and their variability ranges.

1.4.3.2 Concentration factors k for TCs defined by expert judgement

We define the concentration factor k as a statement of the experts' confidence in two dimensions: (i) confidence in knowledge about the technology, and (ii) confidence in knowledge about the specific substance, as shown in Table 5. The knowledge about the technology is defined by the readiness level and its complexity. The knowledge in the substance is defined by a judgement how well the substance behaviour can be predicted.

Table 4: If literature data is present: Six standardized intervals are used to translate the variability of ranges observed in literature into the concentration factor k. The variability range of a transfer coefficient i (TCi) is defined by the range between the lowest and the highest value data points reported in literature.

Observed variability ranges in literature data	Concentration factor for the Dirichlet distribution (k)
[0, 0.1] (0-10%)	100
]0.1, 0.2] (10-20%)	25
]0.2, 0.4] (20-40%)	5
]0.4, 0.6] (40-60%)	2
]0.6, 0.8] (60-80%)	1
]0.8, 1] (80-100%)	0.5

Table 5: Based on the confidence in the expert judgement: Experts' knowledge about the technology and confidence in the substance are used to define the concentration factor k for transfer coefficients based on expert judgement. Confidence in the technology depends on different factors such as its development stage and the process used. Nitrogen and total solids have lower confidence, while phosphorus and water have medium and high confidence.

Concentration factor used in the Dirichlet distribution (k)		Confidence in knowledge about technology (technology readiness level)		
		Low	**Medium**	**High**
Confidence in substance	**Low**	1	2	5
	Medium	2	5	25
	High	5	25	100

— 1.5 DEFINING THE APPLICATION CASE

As mentioned earlier the integration of SANTIAGO with the planning process is defined in detail in The SaniChoice Practicioners' Guide:

> www.sanichoice.net/planning-with-sanichoice

Here we only refer to the minimal requirement information to use SANTIAGO. The two main steps are:

- Define which screening criteria are relevant from the list currently implemented in the technology library.
- Use existing data and literature to define the case profiles including all the attribute functions for the relevant criteria. How the appropriateness works is explained in *chapter 1.3.4 Appropriateness assessment*. *Chapter 1.4.2 Appropriateness Profiles* and the criteria definitions in *chapter 1.7.3 Currently implemented screening criteria* will tell you how to translate the data into functions. In the WIKI of SANTIAGO there are implemented case studies that can be used as templates for the case profiles.

  > https://github.com/santiago-sanitation-systems/Santiago.jl/wiki/5.-Input-Files

1.5.1 Inflows and Number of Options

In *chapter 1.3.3 Required data* we explained how to define the Inflows and the Number of Options. In *chapter 1.7.6 Currently implemented inflows* we provide some generic inflow masses that can be used by default. The Number of Options is best set to be equal to the number of templates applicable to the set of potential technologies. This provides a manageable number of sanitation systems that are based on diverse system templates.

— 1.6 PREPARING DATA FOR SANTIAGO

SANTIAGO requires the input data to be in the JSON3 format. Three files are required:

- A Technology with all the technology profiles
- An Application Case file with the case profile
- An Inflow File

Additional parameters such as the number of inhabitants are defined in the runfile when calling the functions.

In the Technology Library you will find example files to start with:

https://github.com/SANTIAGO-sanitation-systems/Sanitation-technology-library

In the WIKI of SANTIAGO you can find a best practice example and the instructions how to prepare own JSON files:

https://github.com/SANTIAGO-sanitation-systems/SANTIAGO.jl/wiki

— 1.7 CURRENTLY IMPLEMENTED

1.7.1 Currently implemented technologies

The following Table 6 provides an overview of the more than 90 technologies that have been implemented at this point in time. Additional sources, such as tabs, drainage, or organic solid waste collection bins can also be added and are assigned to a sub-group of U called Uadd.

A technology is defined by its functional group (FG), its unique identifier (ID), its input and output products as well as the relation between the input as well as the output products, its appropriateness profile and the TCs, which can be found for each technology in the technology factsheets in *Part B — 2.3 Currently implemented technologies*. A detailed description of each technology can be found online on SaniChoice based on (Gensch et al., 2018; Mcconville et al., 2020; Tilley et al., 2014b).

Table 6. List of currently implemented technologies sorted by their functional groups.

Uadd	U	S	C	T	D
Handwashing Facility	Cistern-Flush Toilet	Urine Storage Tank	Motorized Emptying and Transport of Urine	Urine Bank	Application of Urine and Nutrient Solutions
Kitchen Sink	Pour-Flush Toilet	Double Dehydration Vaults	Human-Powered Emptying and Transport of Urine	Struvite Precipitation	Application of Aurin
Organic Waste Bin	Dry Toilet	Single Faeces Storage Chamber	Motorized Emptying and Transport of Solids	Nitrification and Distillation of Urine	Application of Struvite or Dried Urine
Stormwater Collection	Urine Diversion Dry Toilet (UDDT)	Container-Based Toilet	Human-Powered Emptying and Transport of Solids	Alkaline Dehydration of Urine	Application of Dried Faeces
	Urine Diversion Flush Toilet (UDFT)	Single Pit	Conventional Gravity Sewer	Unplanted Drying Bed Sludge	Application of Compost and Biochar
	Urinal	Single Ventilated Improved Pit	Simplified Sewer	Planted Drying Bed	Application of Stabilized Sludge
	User Interface for Controlled Open Defecation	Double Ventilated Improved Pit	Solids-Free Sewer	Unplanted Drying Bed Dry	Fill and Cover

		Twin Pits for Pour-Flush Toilets	Stormwater Drainage	Sedimentation / Thickening Ponds	Biogas Combustion
		Composting chamber		Co-Composting	Briquettes as Fuel
		Fossa Alterna		Offsite Vermi-Composting	Co-Combustion
		Onsite Vermi-Composting		Black Soldier Fly Composting	Soak Pit
		Septic tank		Ladepa-Pelletizing	Leach Field
		Raised Latrine		Briquetting (Sanivation)	Irrigation
		Shallow Trench Latrine		Settler	Fish Pond
		Deep Trench Latrine		Imhoff Tank	Floating Plant Pond
		Chemical Toilet		Anaerobic Baffled Reactor (ABR)	Surface Water Disposal
		Storage Trench for Controlled Open Defecation		Upflow Anaerobic Sludge Blanket Reactor (UASB)	Surface Disposal and Storage
		Transfer Station		Biogas Reactor	Borehole Latrine
				Anaerobic Filter	
				Sequencing Batch Reactor (SBR)	
				Waste Stabilization Ponds (WSP)	
				Free-Water Surface Constructed Wetland	
				Horizontal Subsurface Flow Constructed Wetland	
				Vertical Flow Constructed Wetland	
				Aerated Pond	
				Trickling Filter	
				Activated Sludge	
				Lactic Acid Fermentation Treatment	
				Caustic Soda Treatment	
				Urea Treatment	
				Hydrated Lime Treatment	
				Microbial Fuel Cell (MFC)	
				Algae Cultivation	
				Membranes	
				Carbonisation	
				Mono-Incineration	

1.7.2 Currently implemented products

The definitions of the different sanitation products given in Table 7 are mostly based on those given in the *Compendium of Sanitation systems and Technologies* (Tilley et al., 2014b) and the supplementary *Guide to Sanitation Resource-Recovery Products & Technologies* (Mcconville et al., 2020). Further sources for the sanitation products are referenced in Table 7.

Table 7. List of currently implemented products defined by a unique identifier. Some products have an additional identifier where the prefix “transported” has been added. These identifiers refer to the same product, however assuming that prior conveyance of products has taken place and these products are only used in offsite treatment facilities. The differentiation between transported and not transported products is made to ensure a correct assembly of technologies by the sanitation system builder.

Product(s)	Identifier	Description	Reference
Anal cleansing water	anal_cleansing_water	Anal cleansing water is the water used to cleanse oneself after defecating and/or urinating. It is generated by those who use water, rather than dry material, for anal cleansing. The volume of water used per cleaning typically ranges from 0.5 L to 3 L.	(Mcconville et al., 2020)
Ash	ash	Incineration ash can be divided into two main categories: incinerator bottom ash (IBA) and air pollution control residue, commonly referred to as fly ash. IBA forms at the bottom of an incinerator from heavy components that are neither combustible nor volatile. These residues contain large proportions of phosphorous and potassium, which can fertilise the soil for agricultural purposes if the sludge is not chemically contaminated. It can also be used in construction materials such as roads.	(Mcconville et al., 2020)
Ash	transportedash		
Aurin	aurin	Aurin is the product of a series of urine treatment processes. It is a highly concentrated nutrient solution that compares well to commercial liquid fertilisers in terms of nutrient concentrations.	(Etter et al., 2015)
Aurin	transported_aurin		
Biogas	biogas	Biogas is the common name for the mixture of gases released from anaerobic digestion. Biogas is comprised of methane (50 to 75%), carbon dioxide (25 to 50%) and varying quantities of nitrogen, hydrogen sulphide, water vapour and other components. Biogas can be collected and burned for fuel (like propane).	(Tilley et al., 2014b)
Biogas	transportedbiogas		
Biochar	biochar	Biochar is a solid material obtained from pyrolysis, the thermochemical conversion of biomass in an oxygen-limited environment. Biochar derived from pyrolysis of sludge, faeces and/or organic waste may be applied to soils to improve soil properties and crop yields. Additionally, it acts as a carbon sink to reduce climate change impacts. Other applications include use as an adsorption material for filters, especially for water purification purposes, or as a feedstock for energy recovery. It is typically called “biochar” when it is used as a soil conditioner and “char” when it is used as a fuel.	(Mcconville et al., 2020)
Biochar	transportedbiochar		
Blackwater	blackwater	Blackwater is the mixture of urine, faeces and flushwater along with anal cleansing water (if water is used for cleansing) and/or dry cleansing materials. Blackwater contains the pathogens of faeces and the nutrients of urine that are diluted in the flushwater.	(Tilley et al., 2014b)
Blackwater	transportedblackwater		
Briquettes	briquettes	Briquettes are the product of a process developed by Sanivation in Naivasha, Kenia. Consisting of a mixture of dried, ground faecal matter and coal-dust, the briquettes are round and black. They burn longer than normal charcoal and produce less smoke.	(Spuhler and Roller, 2020) (Jones, 2017)
Briquettes	transportedbriquettes		
Brownwater	brownwater	Brownwater is the mixture of faeces and flushwater, and does not contain Urine. It is generated by Urine-Diverting Flush Toilets and, therefore, the volume depends on the volume of the flushwater used. The pathogen and nutrient load of faeces is not reduced, only diluted by the flushwater. Brownwater may also include anal cleansing water (if water is used for cleansing) and/or dry cleansing materials.	(Tilley et al., 2014b)
Brownwater	transported_brownwater		

Compost	compost	Compost is decomposed organic matter that results from a controlled aerobic degradation process. In this biological process, microorganisms (mainly bacteria and fungi) decompose the biodegradable waste components and produce this earth-like, odourless, brown/black material. Compost has excellent soil-conditioning properties and variable nutrient content. Because of leaching and volatilization, some of the nutrients may be lost, but the material is still rich in nutrients and organic matter. Generally, excreta or sludge should be composted long enough (2 to 4 months) under thermophilic conditions (55 to 60 °C) in order to be sanitized sufficiently for safe agricultural use. This temperature is not guaranteed in most composting chambers, but considerable pathogen reduction can normally be achieved.	(Tilley et al., 2014b)
Compost	transportedcompost		
Dried faeces	dried_faeces	Dried Faeces is faeces that has been dehydrated until it has become a dry, crumbly material. Dehydration takes place by storing faeces in a dry environment with good ventilation, high temperatures and/or the presence of absorbent material. Very little degradation occurs during dehydration and this means that the dried faeces are still rich in organic matter. However, faeces reduce by around 75% in volume during dehydration and most pathogens die off. There is a small risk that some pathogenic organisms can be reactivated under the right conditions, particularly, in humid environments.	(Tilley et al., 2014b)
Dried faeces	transporteddried_faeces		
Dried urine	dried_urine	Dried urine is a nutrient-rich solid fertiliser produced by dehydrating and concentrating human urine in an alkaline substrate (pH > 10). Alkaline urine dehydration, the technology used to obtain dried urine, can be implemented using different alkaline substrates, which determines the composition and physicochemical properties of the dried product. The dried urine captures nearly all of the fertilising nutrients in urine.	(Mcconville et al., 2020)
Dried urine	transporteddried_urine		
Effluent	effluent	Effluent is the general term for a liquid that leaves a technology, typically after blackwater or sludge has undergone solids separation or some other type of treatment. Effluent originates at either a collection and storage/treatment or a (semi-) centralized treatment technology. Depending on the type of treatment, the effluent may be completely sanitized or may require further treatment before it can be used or disposed of.	(Tilley et al., 2014b)
Effluent	transportedeffluent		
Excreta	excreta	Excreta consists of urine and faeces that is not mixed with any flushwater. Excreta is small in volume but concentrated in both nutrients and pathogens. Depending on the quality of the faeces, it has a soft or runny consistency.	(Tilley et al., 2014b)
Open Defecation Excreta	od_excreta	Excreta consists of urine and faeces that is not mixed with any flushwater. Excreta is small in volume but concentrated in both nutrients and pathogens. Depending on the quality of the faeces, it has a soft or runny consistency. The product was added to allow “Open Controlled Defecation” and “Shallow Trench Latrines” to be considered as technologies in FG S, since the screening criteria of the FG S are more suitable for these technologies than FG U.	Based on own judgement
Faeces	faeces	Faeces refers to (semi-solid) human excrement that is not mixed with urine or water. Depending on the diet, each person produces approximately 50 L per year of faecal matter. Fresh faeces contain about 80% water. Of the total nutrients excreted, Faeces contain about 12% N, 39% P, 26% K and have 10^7 to 10^9 faecal coliforms in 100 mL.	(Tilley et al., 2014b)

Flushwater		Flushwater is the water discharged into the User Interface to transport human excreta and anal cleansing material and/or clean the user interface. Freshwater, stormwater, recycled greywater or any combination of the three can be used as a flushwater source. The volume of flushwater used depends on the toilet but generally ranges from 2 to 15 L per flush.	(Tilley et al., 2014b)
Freshwater	freshwater	Freshwater is the water derived from a water source and is assumed to be uncontaminated.	Based on own judgement
Greywater	greywater	Greywater is the water generated from washing food, clothes and dishware, as well as from bathing, but not from toilets. It may contain traces of excreta (e.g. from washing diapers) and, therefore, also pathogens. Greywater accounts for approximately 65% of the wastewater produced in households with flush toilets.	(Tilley et al., 2014b)
Greywater	transportedgreywater		
Nutrient Solution	nutrient_solution	Liquid nutrient solutions refer to the concentrated liquid products obtained in either the feed stream or permeate streams from membrane filtration processes. Membrane distillation (MD) and forward osmosis (FO) are the most widely documented technologies to produce these nutrient solutions from urine and wastewater. The nutrient recovery products from membranes are primarily ammonia (NH_3), potassium (K) and phosphate (PO_4) solutions that can be used as liquid fertiliser or further processed in industry.	(Mcconville et al., 2020)
Nutrient Solution	transported_nutrient _solution		
Organics	organics	Organics refers to biodegradable plant material (organic waste) that must be added to some technologies for them to function properly (e.g. composting chambers). Organic degradable material can include but is not limited to, leaves, grass and market waste. Although other products in SaniChoice contain organic matter, the term organics refers to undigested plant material only.	(Tilley et al., 2014b)
Organics	transportedorganics		
Pellets	Pellets	Pellets are the product of the LaDePa (Latrine Dehydration and Pasteurization) machine and are brown and brittle. They are produced from faecal sludge and have a similar nutrient content to manure and compost, and similar calorific value to wood. As such they have suitable characteristics for reuse in agriculture and as a biofuel.	(Spuhler and Roller, 2020) Septien, 2018 #76}
Pellets	transportedpellets		
Pit Humus	pithumus	Pit humus is the term used to describe the nutrient-rich, hygienically improved, humic material that is generated in double pit technologies (double ventilated improved pit (VIP), fossa alterna, twin pits for pour flush) through dewatering and degradation. This earth-like product is also referred to as EcoHumus, a term conceived by Peter Morgan in Zimbabwe. The various natural decomposition processes taking place in alternating pits can be both aerobic and anaerobic in nature, depending on the technology and operating conditions. The main difference between pit humus and compost is that the degradation processes are passive and are not subjected to a controlled oxygen supply, C:N ratio, humidity and temperature. Therefore, the rate of pathogen reduction is generally slower and the quality of the product, including its nutrient and organic matter content, can vary considerably. Pit humus can look very similar to compost and have good soil conditioning properties, although pathogens may still be present.	(Tilley et al., 2014b)
Pit Humus	transportedpithumus		
Processed Sludge	processed_sludge	Sludge that has undergone some sort of treatment such as sedimentation, anaerobic, or aerobic digestion (see also sludge).	(Spuhler and Roller, 2020)
Processed Sludge	transported_processed		

	_sludge		
Secondary Effluent	secondary_effluent	Effluent that has undergone treatment for stabilisation and is expected to have better quality, than for example, septic tank effluent. Examples are aurin production, waste stabilization ponds (WSP) and horizontal subsurface flow constructed wetland (HSSFCW).	(Spuhler and Roller, 2020)
Secondary Effluent	transported_secondary _effluent		
Sludge	sludge	Sludge is a mixture of solids and liquids, containing mostly excreta and water, in combination with sand, grit, metals, trash and/or various chemical compounds. A distinction can be made between faecal sludge and wastewater sludge. Faecal sludge comes from onsite sanitation technologies, i.e. it has not been transported through a sewer. It can be raw or partially digested, a slurry or semisolid, and results from the collection and storage/treatment of excreta or blackwater, with or without greywater. For a more detailed characterization of faecal sludge refer to (Strande, 2014). Wastewater sludge (also referred to as sewage sludge) is sludge that originates from sewer-based wastewater collection and (semi-) centralized treatment processes. The Sludge composition will determine the type of treatment that is required and the end-use possibilities.	(Tilley et al., 2014b) (Strande, 2014)
Sludge	transportedsludge		
Transferred Sludge	transferred_sludge	Transferred sludge is sludge that has been transported to a transfer station for intermittent storage before being further transported for treatment. For instance, in densely populated sites, emptying has to be done with a smaller volume vehicle due to limited vehicular access. Storing the sludge in a transfer station allows usage of a larger vehicle for transporting it to a treatment site that lies out of the town.	Based on own judgement
Transferred Sludge	transportedtransferred_sludge		
Stabilized Sludge	stabilized_sludge	Stabilized sludge is the sludge that has undergone some sort of treatment similar to processed sludge but is expected to be of better hygienic quality. Stabilized sludge is obtained e.g. in drying beds or from lactic acid fermentation.	Based on own judgement
Stabilized Sludge	transported_stabilized _sludge		
Stabilized Urine	stabilized_urine	Stabilized urine is the urine that was kept in a urine bank and has been hydrolysed naturally over time, i.e. the urea has been converted by enzymes into ammonia and bicarbonate. It has a pH of approximately 9. Most pathogens cannot survive at this pH. After 6 months of storage, the risk of pathogen transmission is considerably reduced. Stored urine, if stored according to the guidelines from the World Health Organisation is a type of stabilized urine.	(Spuhler and Roller, 2020)
Stabilized Urine	transported_stabilized _urine		
Stored Faeces	stored_faeces	Faeces that were collected in a faeces storage chamber to be collected and transported to a treatment facility.	(Spuhler and Roller, 2020)
Stored Faeces	transported_stored _faeces		
Stored Urine	stored_urine	Urine that was collected in a urine storage tank to be collected and transported to a treatment facility.	(Spuhler and Roller, 2020)
Stored Urine	transportedstored_urine		
Stormwater	stormwater	Stormwater is the general term for the rainfall-runoff collected from roofs, roads and other surfaces before flowing towards low-lying land. It is the portion of rainfall that does not infiltrate into the soil.	(Tilley et al., 2014b)
Stormwater	transportedstormwater		

Struvite	Struvite	Struvite, sometimes also called magnesium ammonium phosphate hexahydrate (MAP), is a phosphate mineral that occurs naturally in sanitation systems. It is a common precipitate in, e.g. pipes and heat exchangers, and it can also be purposefully extracted from waste streams, for example, through the addition of magnesium to urine. Struvite precipitation can be applied to reduce phosphorus concentrations in effluents while at the same time generating a product that can be applied as a fertiliser or industrial raw material.	(Mcconville et al., 2020)
Struvite	transportedstruvite		
Urine	Urine	Urine is the liquid produced by the body to rid itself of urea and other waste products. In this context, the urine product refers to pure urine that is not mixed with faeces or water. Depending on diet, human urine collected from one person during one year (approx. 300 to 550 L) contains 2 to 4 kg of nitrogen. With the exception of some rare cases, urine is sterile when it leaves the body.	(Tilley et al., 2014b)
Urine	transportedurine		

1.7.3 Currently implemented screening criteria

Table 8: Overview of currently implemented screening criteria. The criteria marked by a star (*) are considered in a pre-evaluation as well as post-evaluation of selected systems and are not included in the appropriateness calculation. The first column provides links to chapters that contain more detailed information on the criterion including definitions and advice on how to quantify the case and technology attributes.

Screening Criteria	Case Attribute	Case Function	Technology Attribute	Technology Function	Applies to these FG	Units/Categories
Application Level*	NA	NA	Performance of technology given a certain application level	Performance Categorical	S,C,T,D	Household Neighbourhood City
Management Level*	NA	NA	Performance of technology given a certain management level	Performance Categorical	U,S,C,T,D	Household Shared Public
Development Phase*	NA	NA	Performance of technology given a certain development phase	Performance Categorical	U,S,C,T,D	Acute Stabilisation Development/recovery
Water Supply	Existing water supply types	PDF Categorical	Performance of technology given a certain water supply type	Performance Categorical	U	House Yard Public None
Water Volume	Available water volume for sanitary use	PDF Trapez	Required water volume for technology	Performance Trapez	S,C	[L/cap/day]
Electricity Supply	Availability and reliability of electricity supply	PDF Categorical	Performance of technology given different levels of electricity availability	Performance Categorical	S,T,D	Electricity Intermittent No electricity
Fuel Supply	Availability of fuel	PDF Categorical	Performance of technology for given fuel availability	Performance Categorical	C	Fuel No fuel
Frequency of Operation and	Capacity for O&M	Performance Categorical	Required frequency of labour to operate	PDF Categorical	U,S,C,T,D	Irregular Regular Continuous

Maintenance (O&M)			and maintain technology			
Pipe Supply	Availability of pipes	PDF Categorical	Performance of technology for certain pipe availability	Performance Categorical	S,C,T,D	No pipes Difficultly available Pipes
Pump Supply	Availability of pumps	PDF Categorical	Performance of technology for certain pump availability	Performance Categorical	S,C,T,D	No pumps Difficultly available Pumps
Concrete Supply	Availability of concrete	PDF Categorical	Performance of technology for certain concrete availability	Performance Categorical	U,S,C,T,D	Concrete Difficultly available No concrete
Spare Parts Supply	Availability of different types of spare parts	Performance Categorical	Proportion of spare part types that need to be replaced	PDF Categorical	U,S,C,T,D	Simple Technical Special
Temperature	Temperature range	PDF Categorical	Performance of technology given a certain temperature range	Performance Categorical	S,T,D	Very cold (< -10°C) Cold (-10 - 10°C) Temperate (10 - 20°C) Warm: (20 - 30°C) Hot: (>30°C)
Flooding	Flooding occurrence	PDF Categorical	Performance of the technology given a certain flooding risk	Performance Categorical	S,C,T,D	Flooding No flooding
Vehicular Access	Accessibility of households	PDF Categorical	Performance of the technology given access to certain types of vehicles	Performance Categorical	S	No access Difficult access Full access
Slope	Slope distribution	PDF Categorical	Performance of technology for given slope	Performance Categorical	C	Flat (<1%) Not flat (>1%)
Soil Type	Soil type occurrence	PDF Categorical	Performance of technology for given soil type/permeability	Performance Categorical	S,D	Clay Silt Sand Gravel Rock
Groundwater Depth	Groundwater depth	PDF Trapez	Required groundwater depth to avoid groundwater pollution	Performance Trapez	S,D	Distance from the surface to the groundwater table [m]
Excavation	Ease of excavation	PDF Categorical	Performance of technology if excavation is difficult	Performance Categorical	S,C,T,D	Easy Hard
Surface Area (Onsite)	Availability of area onsite	PDF Trapez	Required area for onsite toilet infrastructure	Performance Trapez	S	[m2/plot]
Surface Area (Offsite)	Availability of area offsite	PDF Trapez	Required area for treatment technologies	Performance Trapez	T	[m2/cap]
Drinking Water Exposure	Distance to drinking water sources	PDF Categorical	Risk of technology polluting a nearby water source	Performance Categorical	S,D	Close Not close
Construction Skills**	Level of construction skills in local workforce	PDF Categorical	Performance of technology for different levels of construction skills	Performance Categorical	U,S,C,T,D	Unskilled Skilled Professional

Design Skills**	Level of design skills in local workforce	PDF Categorical	Performance of technology for different levels of design skills	Performance Categorical	U,S,C,T,D	Unskilled Skilled Professional
Operation and Maintenance (O&M) Skills**	Level of O&M skills in local workforce	PDF Categorical	Performance of technology for different levels of O&M skills	Performance Categorical	U,S,C,T,D	Unskilled Skilled Professional
Cleansing Method	Population distribution of anal cleansing methods	PDF Categorical	Performance of technology for different anal cleansing materials	Performance Categorical	U	Washers Soft wipers Hard wipers
Lifetime	Expected lifetime	PDF Categorical	Possible lifetime of technology	Performance Categorical	S,T,D	Short (< 1 year) Medium (1-5 years) Long (>5 years)
Speed of Implementation For Toilet Structure	Expected speed of implementation	Performance Categorical	Probability of toilet being implemented in a certain time span	PDF Categorical	S	Rapid (< 3 days) Moderate (3 days to 2 weeks) Slow (> 2 weeks)
Speed of Implementation For Treatment	Expected speed of implementation	Performance Categorical	Probability of technology being implemented in a certain time span	PDF Categorical	T	Rapid (<= 1 week) Moderate (1 week - 3 months) Slow (> 3 months)
Scalability	Importance of scalability	PDF Categorical	Degree of difficulty to up-scale technology capacity	Performance Categorical	S,C,T	Easy Difficult
Construction Parts Supply	Availability of different types of construction parts	Performance Categorical	Proportion of parts required for construction	PDF Categorical	U,S,C,T,D	Simple Technical Special

**Alternative: One might also consider specific categories as ‘none’, ‘unskilled labour’, ‘mason’, ‘specially trained mason’, ‘construction engineer’, ‘supervisor’ or others. However, these professions do not ensure that all skills that might be needed are included and the skill level per category might differ from one region to the other. In SANTIAGO, a less detailed approach has been implemented.

1.7.3.1 Application Level

1.7.3.1.1 Why is it relevant?

Different sanitation technologies demand different levels of application: While some are appropriate for households or neighbourhoods, other technologies such as large, centralized wastewater treatment facilities can only be implemented on the city level. The application level is therefore an important proxy for technology appropriateness.

1.7.3.1.2 Definition

The application level is meant to provide additional information when comparing different locally appropriate sanitation system options in order to select the preferred one in the given case. Three spatial levels are defined under this heading:

- **Household:** implies that the technology is appropriate for one or several households.
- **Neighbourhood:** means that the technology is appropriate for anywhere between several and several hundred households.

- **City:** implies that the technology is appropriate at the city-wide level (either one unit for the whole city, or many units for different parts of the city).

This criterion does not apply to the technologies belonging to the user interface functional group (FG U) since their application level depends largely on the subsequent technologies.

1.7.3.1.3 Case questions

This is a case-independent criterion and there are therefore no case-specific questions.

1.7.3.1.4 Tech question

How suitable is the technology to a certain application level?

Fill in 1 to indicate a technology is suitable for a specific application level. Fill in 0.5 if the technology is less suitable and 0 if the technology is not suitable for a specific application level.

1.7.3.1.5 Additional notes

To define how suitable a technology is to a certain application level, we used the definitions of the *Compendium of Sanitation systems and Technologies* (Tilley et al., 2014b) and the *Compendium of Sanitation Technologies in Emergencies* (Gensch et al., 2018): Stars are used to indicate the appropriateness of any technology for the application level defined in the case. **: two stars means suitable (i.e. 100% performance), *: one star means less suitable (i.e. assumed 50% performance), no star: means not suitable (i.e. 0% performance).

1.7.3.2 Management Level

1.7.3.2.1 Why is it relevant?

Different sanitation technologies demand different levels of management: While some can be managed by the users themselves, other technologies require a more complex organization such as institutional or government run facilities to manage its operation. The management level is therefore an important proxy for technology appropriateness.

1.7.3.2.2 Definition

Management Level describes the organizational style best used for the operation and maintenance (O&M) of the given technology:

- **Household**: implies that the household, i.e. the family, is responsible for all O&M.
- **Shared**: means that a group of users (e.g. at a school, a community-based organization, or market vendors) handles the O&M by ensuring that a person or a committee is responsible for it on behalf of all users. Shared facilities are defined by the fact that the community of users decides who is allowed to use the facility and what their responsibilities are; it is a self-defined group of users.
- **Public**: implies institutional or government run facilities, and all O&M is assumed by the agency operating the facility. Usually, only users who can pay for the service are permitted to use public facilities.

The management level is meant to provide additional information when comparing different locally appropriate sanitation system options in order to select the preferred one in the given case. The technologies in the functional group User Interface (FG U) do not include a management level since maintenance is dependent on the subsequent technologies, and not simply on the user interface.

1.7.3.2.3 Case questions

This is a case-independent criterion and there are therefore no case-specific questions.

1.7.3.2.4 Tech question

How suitable is the technology to a certain management level?

Fill in 1 to indicate a technology is suitable for a specific management level. Fill in 0.5 if the technology is less suitable and 0 if the technology is not suitable for a specific management level.

1.7.3.2.5 Additional notes

To define how suitable a technology is to a certain management level, we used the definitions of the *Compendium of Sanitation systems and Technologies* (Tilley et al., 2014b) and the *Compendium of Sanitation Technologies in Emergencies* (Gensch et al., 2018): Stars are used to indicate the appropriateness of any technology for the management level defined in the case. **: two stars means suitable (i.e. 100% performance), *: one star means less suitable (i.e. assumed 50% performance), no star: means not suitable (i.e. 0% performance).

1.7.3.1 Development Phase

1.7.3.1.1 Why is it relevant?

Different sanitation technologies are suitable in different development phases: Some sanitation technologies are only suitable in the acute phase immediately following the cause of the emergency, while other technologies are not suitable for the acute and stabilisation phases of emergencies. “[Approximately identifying these phases can be helpful when evaluating technology appropriateness], however the division should be viewed as theoretical and simplified, modelled after singular disaster events. Real life is seldom so clearly defined.” (Gensch et al., 2018)

1.7.3.1.2 Definition

Qualitative estimates of the applicability of each technology given the phase of emergency in a specific case. It is based on three categories:

- **Acute**: refers to the humanitarian phase immediately following an emergency. It usually covers the first days up to the first few weeks, where effective short-term measures are applied to alleviate the emergency situation quickly until more permanent solutions can be found.
- **Stabilisation (or transition phase)**: refers to the phase starting after the first weeks of a crisis and can last several months or longer.
- **Development/Recovery**: refers to either a longer-term approach aiming to develop sanitation infrastructure in general (Development) or in a humanitarian context (Recovery), it refers to the phase where the aim is to rehabilitate infrastructure or implement long-lasting sanitation infrastructure and services.

The allocation of technologies to different humanitarian/development phases is mainly based on speed of implementation, budget and material requirements. It allows giving a first general orientation but may differ in a specific local situation.

1.7.3.1.3 Case questions

This is a case-independent criterion and there are therefore no case-specific questions.

1.7.3.1.4 Tech question

What is the applicability of a technology for a certain humanitarian/development phase?

Fill in 1 to indicate a technology is suitable for a specific development phase. Fill in 0.5 if the technology is less suitable and 0 if the technology is not suitable for the specific development phase

1.7.3.1.5 Additional notes

To define how suitable a technology is to a certain development phase, we used the definitions of the *Compendium of Sanitation Technologies in Emergencies* (Gensch et al., 2018): Stars are used to indicate the appropriateness of any technology for the applicability level defined in the case. **: two stars means suitable (i.e. 100% performance), *: one star means less suitable (i.e. assumed 50% performance), no star: means not suitable (i.e. 0% performance).

The recovery phase in emergencies and general development projects were combined into one category to avoid an artificial division between sanitation technologies suitable in humanitarian contexts and suitable for development contexts.

1.7.3.2 Water Supply

1.7.3.2.1 Why is it relevant?

Different sanitation technologies require water at a different spatial level: While some require a constant source of water at the location of the technology, other technologies can work with an intermittent water supply or even fully independent of water. The spatial level of the water supply is therefore an important proxy for technology appropriateness.

1.7.3.2.2 Definition

Qualitative estimate of the performance of each technology given a certain type of water supply available in a specific case. It is defined based on a scale of four categories taking into account different spatial levels:

- **House**: refers to an in-house water connection.
- **Yard**: refers to yard taps.
- **Public**: refers to public or community-managed standpipes.
- **None**: refers to no water supply.

The technology appropriateness is quantified based on the performance given a certain type of water supply.Type of water supply is only applied for technologies from the user interface (FG U) since this will consequently affect water availability further down the sanitation system. For example, cistern flush toilets require an in-house water supply while pour flush toilets can work with yard supply. Water supply does not account for the amount of water available. There is another criterion "water volume".

1.7.3.2.1 Case questions

How is the water supply distributed in your case area?

Allot the proportion (%) of households in the case area that have a certain type of water supply. The sum of all values must be 100%.

1.7.3.2.2 Tech question

What is the performance of the technology given a certain water supply type?

Allot the performance (between 0 and 100%) for each category based on how well the technology performs for the category.

1.7.3.2.3 Additional notes

Public or community-managed standpipes in this case mean that individual household sanitation facilities which rely on water are not appropriate. However, it should still be taken into account that community-managed sanitation blocks could rely on water if built next to extraction points (this would require a very skilled and careful operation in order not to pollute groundwater). On the other hand, regions that rely on public or community-managed standpipes mostly have a very low water consumption and are unlikely to use sanitation technologies that work with water.

An additional criterion describing the performance of technologies in case of water supply disruption could be added. However, it was not considered, because we assume that sanitation systems that rely on water are as inappropriate for an unreliable water supply as for no water supply (Loetscher and Keller, 2002).

1.7.3.3 Water Volume

1.7.3.3.1 Why is it relevant?

Different sanitation technologies demand different amounts of water to function: While some technologies do not require any, others are dependent on large volumes of water. Some technologies, such as pit latrines, might also be disturbed by larger water inputs. The water volume that can be handled by a technology is therefore an important proxy for technology appropriateness.

1.7.3.3.2 Definition

The water volume is defined in litres per person per day used for flushing and anal cleansing using following default values and 6 uses per day per person:

- **Anal cleaning water:** 0.3 to 3 litres per use
- **Pour flush toilet and urine diversion flush toilet:** 1 to 3 litres per use
- **Cistern flush toilet:** 6 to 10 litres per use

The technology appropriatenes accounts for the minimum water volumes required (e.g. for sewer, septic tank) and the maximum that a technology can handle (e.g. for pits).Water volume is defined for the collection and storage (FG S) and conveyance (FG C) technologies. Technologies of FG S and FG C that do not handle flushwater or blackwater will always be appropriate whatever the water volume considered.

1.7.3.3.3 Case questions

How much water volume is used for sanitary use (flushing and anal cleansing) in litres per person per day?

Option 1: Provide the minimal (A) and maximal value (D). If there is no clear minimum, allot the value 0. If there is no clear maximum, allot the value 999. Option 2: Up to four values can be allotted: the absolute minimum (A), the likely/typical minimum (B), the likely/typical maximum (C), and the absolute maximum (D).

Note: A must be smaller or equal than B must be smaller or equal than C must be smaller or equal than D.

1.7.3.3.4 Tech question

What is the performance of the technology given a certain water volume entering in litres per person and day (l/person/day)?

If the technology does not handle blackwater, provide 0 and 999 l/person/day for the minimal and maximal volume to avoid these technologies from being discarded. If the technology is able to handle blackwater, provide the minimum water volume required as an input for the technology to function. Alternatively, you can provide both the absolute minimum water volume required and the optimal minimum water volume (from which the technology performs 100%). If the technology has restrictions on the maximum amount of water volume it can handle, provide the absolute optimum (until which the technology performs 100%) and absolute maximum water volume it can deal with.

For filling in the tech library it might be helpful to think in terms of the four values (a,b,c,d) of the trapez function:

- a = min. value with performance >= 0%
- b = min. value with a performance of 100%
- c = d = 999 L/cap/day = max. value (unless technology has blackwater as an input and has restrictions on the maximum amount of water volume it can handle. Then allot explicit values for "c" and "d".).

1.7.3.3.5 Additional notes

The upper limit on the amount of water a given technology can handle is generally kept at a default value of 999 L/cap/day (few exceptions exist) because of two reasons. Firstly, since the SANTIAGO algorithm is based on the assumption that input and output products match, this inherently ensures that the FG S technologies for which high water volumes are problematic are not connected to FG U technologies that produce a lot of wastewater. Secondly, high water volumes and other associated problems are additionally accounted for with other criteria such as "Flooding" and "Groundwater Depth".

Many technologies have a minimum water requirement. These are considered by the “a” and “b” values. If the technologies do not require any water “a” and “b” can be characterized by 0 L/cap/d.

Some technologies further perform badly, if too much water enters them. These can be separated into two types of technologies:

- The first type only accepts input products with low water volume (faeces, urine, etc.) and no blackwater. For the first type it is assumed that no blackwater input equals a sufficiently low water volume input and no explicit maximum water input needs to be defined.

- The second type accepts blackwater as input and therefore the SANTIAGO algorithm can pair these technologies with FG U techs that introduce high volumes of water into the system (e.g. pour-flush, cistern-flush). Thus, the criterion “Water Volume” should reduce the performance of these technologies and hence their appropriateness when a user defines a case attribute with high water inputs. Therefore, an explicit limit of water volume the technology can handle needs to be defined. For the three affected technologies (single pit, single VIP, deep trench latrine) the following values “c=8 L/cap/d” and “d=33 L/cap/d” are allotted. This is based on the assumption that for these technologies the amount of blackwater generated by a pour-flush toilet would be acceptable, whereas a cistern flush toilet should be avoided. Consequently the maximum water volume is determined by considering that pour-flush systems only require 1-3 litres of flush water and multiplying this value with the average of 6 toilet visits per person per day. (Tilley et al., 2014b)

Alternative: A categorical function could be implemented, instead of a continuous one. However, a continuous function was chosen, because sufficient data could be found to estimate the lower and upper limits of water volumes for a technology. The benefit of a continuous function is that no category limits need to be pre-defined, and the minimum and maximum water limits can instead be defined individually for each case and technology.

1.7.3.4 Electricity Supply

1.7.3.4.1 Why is it relevant?

Different sanitation technologies require different levels of electricity supply: While some technologies don’t work without continuous electricity, other technologies are not dependent on electricity to function. The electricity supply is therefore an important proxy for technology appropriateness.

1.7.3.4.2 Definition

Qualitative estimate of the performance of each technology during normal operation and maintenance (e.g. for pumping, ventilation, aeration), given a certain energy supply in a specific case. It is based on a scale of three categories:

- **Continuous electricity**: power cuts are highly unlikely.
- **Intermittent electricity**: frequent power cuts are occurring.
- **No electricity**.

Electricity supply is defined for the onsite collection and storage/treatment (FG S), treatment (FG T), and reuse or disposal (FG D) technologies. Technologies for conveyance (FG C) such as sewers might need electricity depending on the slope and the pumps required, however, this is covered separately by other criteria ("Slope" and "Pump Supply").

1.7.3.4.3 Case questions

How is the electricity supply in the case for aeration, ventilation, pumping, or other power-consuming activities?

Allot the proportions (%) of the case area that have a certain electricity availability or the proportion (%) of months in the year where there is a certain electricity availability. The sum of all values must be 100%.

1.7.3.4.4 Tech question

What is the performance of the technology given a certain electricity supply?

Allot the performance (between 0 and 100%) for each category based on how well the technology performs for the category. To ensure consistency among the different technologies, their performance have been set on the following qualitative assumptions:
(electricity - intermittent - no electricity):

- → 100% - 100% - 100%: No electricity required.
- → 100% - 90% - 70%: Generally, technology can work without electricity, but it can improve the technology performance slightly (e.g. added ventilation system). Uninterrupted electricity supply performs slightly better.
- → 100% - 50% - 50%: Technology can work without electricity, however, under some conditions electricity is required (e.g. larger scale irrigation, pumps in sewers with too low slope).
- → 100% - 30% - 10%: Technology can work without electricity, but performance is far better with electricity (mainly related to mixing and recirculation pumps).
- → 100% - 0% - 0%: Constant source of electricity required.

1.7.3.4.5 Additional notes

Note that most technologies can be built in multiple configurations, e.g. an imhoff tank can be either built with pipes and pumps that require electricity or use pumping trucks that require fuel and vehicular access (Tilley et al., 2014b). Since SANTIAGO cannot account for if/else statements, the performance for 'no electricity' is set to 0.5. This way, we can partially account for the loss of configuration variability. The category 'intermittent' might be set to 0.5 as in the example (100%-50%-50%) above or to 0.75 depending on whether the operation of the technology is flexible enough to use electricity when it is available. For example, for the Imhoff Tank emptying can be implemented during times with electricity.

For FG S technologies the electricity requirements of emptying pumps are not considered here.

The reliability of electricity, i.e. the performance of a technology for power supply disruption is considered in the category 'intermittent electricity'. Several alternative technology configurations could be considered:

- Alternative 1: If more data were available one could describe it as a continuous function based on the available hours of electricity and the performance of technologies for these hours.
- Alternative 2: if data on the energy consumption were available could also be a categorical function describing the amount of electricity available and required (a fan probably needs less voltage than aeration in a big pond).

1.7.3.5 Fuel Supply

1.7.3.5.1 Why is it relevant?

Different sanitation transport technologies require different inputs of fuel during operation and maintenance: While some require fuel to be operated, other technologies can be used even in absence of any source of fuel. The fuel supply is therefore an important proxy for technology appropriateness.

1.7.3.5.2 Definition

The fuel supply is defined by two categories:

- **Fuel**: refers to if fuel is always available.
- **No fuel**.

The technology appropriateness is quantified based on the performance of a technology during normal operation (motorized transport in vehicles or with pumps) given a certain fuel supply.Fuel supply is defined for conveyance (FG C) technologies only.

1.7.3.5.3 Case questions

How is the fuel supply in the case?

Allot proportions (%) of the case area that have a certain fuel availability or the proportion (%) of months in the year when there is certain fuel availability. The sum of all values must be 100%.

1.7.3.5.4 Tech question

What is the performance of the technology given a certain fuel supply?

Allot the performance (between 0 and 100%) for the category 'no fuel' based on how well the technology performs in the absence of fuel. To avoid technologies from being discarded (as the possibility of electric vehicles exists or during lack of fuel motorized vehicles can be replaced temporarily by manual labour), one should refrain from entering the value 0% for 'no fuel'. For the category 'fuel' the performance is always 100%.

1.7.3.6 Frequency of Operation and Maintenance

1.7.3.6.1 Why is it relevant?

Different sanitation technologies require operation and maintenance at different frequency: While some can be operated with occasional cleaning and repair, others demand time-consuming operations that require permanent staff. The frequency of operation and maintenance is therefore an important proxy for technology appropriateness.

1.7.3.6.2 Definition

The frequency of operation and maintenance (O&M) is defined based on the extent of labour (type of task and time) required to maintain a certain technology. Maintenance considered is cleaning, repairing and/or replacing mechanical parts but NOT emptying/desludging. It is evaluated in three categories:

- **Irregular**: is used for technologies that require low maintenance, for operations such as occasional cleaning or eventual repair. No maintenance of odour seals, washing with detergents or monitoring is required.
- **Regular**: refers to more time-consuming operations such as regular cleaning, washing with detergents (e.g. the bowl with acid) or checking and replacing odour seals.
- **Continuous**: is used for technologies that require permanent staff (full-time job) for maintenance, repair, removing scum, etc.

1.7.3.6.3 Case questions

What is the availability of operation and maintenance (O&M) capacity in the case?

Allot for each category the feasibility (between 0 and 100%) to provide a certain frequency of O&M service.

Note: This is a ladder function, so if the application case can provide ‘continuous’ operation and maintenance levels, it can also provide ‘regular’ and ‘irregular’ levels (i.e. 100%). The values allotted to ‘irregular’ will always be equal to or higher than ‘regular’ and those allotted to ‘regular’ will be equal or higher than ‘continuous’.

1.7.3.6.4 Tech question

What type of operation and maintenance (O&M) is required to ensure the performance of the technology?

Allot the proportions (%) based on the technology requirements for each category of O&M frequency.

1.7.3.6.5 Additional notes

The desludging rate is not included in this criterion since it is measured in a different scale. Another idea to consider it would be to have a second criterion only for "emptying". A technology can require a lot of maintenance but very rarely desludging, e.g. Aerated Pond: "Permanent, skilled staff is required to maintain and repair aeration machinery and the pond must be desludged every 2 to 5 years." (Tilley et al., 2014b)

Alternative: One might also consider a criterion describing the hours of operation and maintenance per technology and year. However, this is very difficult to quantify and if the workload is per technology, all the technologies summed up within a system might exceed the workload specified for the case (if the case allows for up to 100 hours of O&M per year and all the technologies require 50 hours per year, the score for every technology would be good and the aggregated score for the system as well, even if all the technologies summed up would require more than 100 hours of operation and maintenance).

1.7.3.7 Pipe Supply

1.7.3.7.1 Why is it relevant?

Different sanitation technologies make varying use of pipes: While some do not require any, the design of other technologies can be adapted to work without pipes. Some technologies must be built with pipes to properly function. The availability of pipes for construction is therefore an important proxy for technology appropriateness.

1.7.3.7.2 Definition

Qualitative estimate of the performance of each technology given a certain pipe availability in a specific case. Pipes are mainly required for ventilation or transport/drainage associated with technologies. They can be made out of plastics or concrete. Alternative pipes such as bamboo are not considered here. It is based on a scale of three categories:

- **No pipes**.
- **Difficultly available**: pipes are difficult to source locally (high prices or fluctuating availability).
- **Pipes**: refers to if pipes are easily available.

Different technologies offer varying degrees of flexibility towards the usage of pipes. Certain technologies cannot be built without pipes. Certain ones usually use pipes, however, can also be designed without them. And others can be built entirely without pipes.

Pipe supply is defined for the onsite collection and storage/treatment (FG S), conveyance (FG C), treatment (FG T), and reuse and disposal (FG D) technologies and includes all pipes (e.g. drainage, ventilation, inlet, outlet).

1.7.3.7.3 Case questions

What is the local availability of pipes for the case?

Allot the proportions (%) of the case area that have a certain pipe availability. The sum of all values must be 100%.

1.7.3.7.4 Tech question

What is the performance of the technology given a certain pipe availability?

Allot the performance (between 0 and 100%) for each category. To ensure consistency among the different technologies, their performance have been set on the following qualitative assumptions:
(pipes - difficultly available - no pipes):

- → 100% - 100% - 100%: No pipes required OR pipe can be produced with local material (latter option usually refers to aboveground ventilation pipes).
- → 100% - 75% - 75%: Alternative configuration of technology without pipes is possible but usually performs slightly worse.
- → 100% - 75% - 50%: Inlet/outlet/T-shaped pipes required for the technology. It would be possible to find a workaround solution without pipes.
- → 100% - 50% - 0%: For drains and sewers where pipes are a necessity.

1.7.3.7.5 Additional notes

Alternative: This criterion could also be characterized based on the necessary pipe diameters. However, this is very hard to quantify both for the case and the technologies.

1.7.3.8 Pump Supply

1.7.3.8.1 Why is it relevant?

Different sanitation technologies make varying use of pumps: While some do not require any, the design of other technologies can be adapted to work without pumps. Some technologies must be built with pumps to properly function. The availability of pumps is therefore an important proxy for technology appropriateness.

1.7.3.8.2 Definition

Qualitative estimate of the performance of each technology given a certain pump availability in a specific case. The definition of pumps used here includes those required for emptying, discharge, mixing, overcoming elevations in sewer systems, and generating pressurized systems. It is based on a scale of three categories:

- **No pumps**.
- **Difficultly available**: pumps are difficult to source locally (high prices or fluctuating availability)
- **Pumps**: refers to if pipes are easily available.

Different technologies offer varying degrees of flexibility towards the usage of pumps. Certain technologies cannot be built without pumps. Some usually use pumps but can also be designed without them in certain circumstances (e.g. waste stabilisation ponds). Also, certain technologies require pumps in some circumstances (e.g. gravity sewers to overcome elevations).

Pump Supply is defined for the onsite collection and storage/treatment (FG S), conveyance (FG C), treatment (FG T), and reuse and disposal (FG D) technologies.

1.7.3.8.3 Case questions

What is the local availability of pumps for the case?

Allot the proportions (%) of the case area that have a certain pump availability.

1.7.3.8.4 Tech question

What is the performance of the technology given a certain pump availability?

Allot the performance (between 0 and 100%) for each category based on the following examples
(pumps - difficultly available - no pumps):

- → 100% - 100% - 100%: No pumps required.
- → 100% - 75% - 75%: Alternative configuration of technology without pumps is possible, but usually performs a bit worse (refers to mixing, emptying purposes).
- → 100% - 75% - 50%: For certain cases pumps are required for this technology, while for other cases they are not needed. (e.g. Pumps might be needed to overcome elevation. This depends on the slopes of the case or the designed depth of the technology.)
- → 100% - 50% - 0%: Pumps are required (e.g. for pressurized systems or discharge purposes).

1.7.3.8.5 Additional notes

In regard to emptying the pump supply only affects the performance of technologies in FG T and not in FG S. Technologies in FG S, which could be emptied with pumps, do not affect the technology performance for pump supply, as the actual emptying occurs in FG C via motorized or manual emptying. For technologies in FG T, which can be emptied by pumps, the pump supply does affect the technology performance. The reason is that after FG T no further emptying technologies can be added to the system and pumps are necessary at the treatment site.

Alternative: The criterion could be characterized by the pumping capacity of the pumps to specify what kind of pumps are available/necessary, but the available data is mostly not sufficient.

1.7.3.9 Concrete Supply

1.7.3.9.1 Why is it relevant?

Different sanitation technologies make varying use of concrete: While some do not require any, the design of other technologies can be adapted to work without concrete. Some technologies must be built with concrete to properly function. The availability of concrete is therefore an important proxy for technology appropriateness.

1.7.3.9.2 Definition

The concrete supply refers to concrete required to build the technology. The concrete supply is defined by three categories:

- **No concrete**.
- **Difficultly available**: concrete is difficult to source locally (high prices or fluctuating availability).
- **Concrete**: refers to if it is easily available.

Concrete supply is defined for all technologies regardless from their functional group and is important for technologies that need to be lined or sealed (e.g. biogas settler, sedimentation ponds). Some technologies could be built with locally available alternative materials (e.g. plastic liner) or a pre-fabricated version could be purchased, in which case the performance is assumed to be reduced for the categories "No concrete" and "Difficultly available".

1.7.3.9.3 Case questions

What is the local availability of concrete for the case?

Allot the proportions (%) of the case area that have a certain concrete availability. The sum of all values must be 100%.

1.7.3.9.4 Tech question

What is the performance of the technology given a certain concrete availability?

Allot the performance (between 0 and 100%) for each category based on the following examples
(concrete - difficultly available - no concrete):

- → 100% - 100% - 100%: No concrete is required.
- → 100% - 75% - 75%: Concrete slightly improves the performance of the technology.
- → 100% - 75% - 50%: The technology could be made from a locally available alternative material (e.g. plastic liner) or a pre-fabricated version could be purchased from the international market. However, concrete would be preferable e.g. due to a longer lifetime or available experience with concrete.
- → 100% - 50% - 0%: Concrete is required for the technology.

1.7.3.9.5 Additional notes

It is assumed that pre-fabricated materials that are not made from concrete often need to be imported and are therefore more expensive. Consequently, concrete is preferred compared to pre-fabricated units made from alternative materials.

Alternative: If data is available this attribute could also be used with a continuous function describing the amount of cement available/needed per technology.

1.7.3.10 Spare Parts Supply

1.7.3.10.1 Why is it relevant?

Different sanitation technologies require different kinds of spare parts: While some can be fixed with conventional parts, other technologies require more technical spare parts or even spare parts that need to be specifically constructed. The spare parts requirements are therefore an important proxy for technology appropriateness.

1.7.3.10.2 Definition

Qualitative estimate of the performance of each technology during operation given a certain spare parts availability in a specific case. Spare parts are defined as the parts to be replaced during maintenance and repair, including covers, siphons, membranes, etc. It is based on a scale of three categories:

- **Simple**: conventional parts generally locally available (e.g. simple metal or wood parts, covers, slabs).
- **Technical**: technical parts generally available (e.g. a siphon).
- **Special**: parts that need to be specifically manufactured (e.g. a membrane).

Spare parts supply is defined for all technologies regardless from their functional group.

1.7.3.10.3 Case questions

What level of accessibility do different types of spare parts have for the case?

Allot the performance (between 0 and 100%) for each category based on how easily such parts can be accessed in the case area.

Note: This is a ladder function, so if the application case can provide ‘special parts’, it can also provide ‘technical’ and ‘simple’ parts. The values allotted to ‘simple’ will always be equal to or higher than ‘technical’ and those allotted to ‘technical’ will be equal or higher than ‘special’.

1.7.3.10.4 Tech question

What are the different kinds of spare parts that are expected to fail during operation and need to be replaced in order for that technology to continue to function?

Allot the proportions (%) of the different types of parts of the technology.

1.7.3.10.5 Additional notes

This criterion does not refer to parts used during construction. These are considered in the criterion “Construction Parts Supply” in humanitarian contexts.

It has to be assessed individually what "locally accessible" means (regional/national level?) but it should be possible to bring spare parts easily and quickly to the facility.

Note that spare parts do not include chemicals here. The chemical supply could be considered in an additional criterion.

1.7.3.11 Temperature

1.7.3.11.1 Why is it relevant?

Different sanitation technologies function in different ranges of temperatures: While some function at any temperatures, the process of other technologies is hampered at particularly low or high temperatures. The effect of temperature on a technology is therefore an important proxy for technology appropriateness.

1.7.3.11.2 Definition

Semi/quantitative estimate of the performance of each technology for different temperature ranges. The criterion accounts for the effect of temperature on biological processes and soil infiltration. It is based on a scale of five categories (referring to daily mean temperatures):

- **Very cold**: refers to temperatures less than -10°C.
- **Cold**: refers to temperatures between -10 to 10°C.
- **Temperate**: refers to temperatures between 10 to 20°C.
- **Warm**: refers to temperatures between 20 to 30°C.
- **Hot**: refers to temperatures above 30°C.

Temperature is defined for the onsite collection and storage/treatment (FG S), treatment (FG T), and reuse or disposal (FG D) technologies.

1.7.3.11.3 Case questions

How is the temperature distributed over the year in your case area?

Allot the proportions (%) based on the number of days per year whose mean daily temperature lies in the respective ranges of each category.

1.7.3.11.4 Tech question

What is the performance of the technology given a certain temperature range?

Allot the performance (between 0 and 100%) for each category based on how well the technology performs for the given temperature range.

Note that technologies that primarily or partially rely on soil absorption (percolation) may have a decreased performance if the ground is frozen. Moreover, the application of many products (e.g. compost) is not viable if the ground is frozen and therefore, cannot take up nutrients. Technologies that follow this suit are allotted the following performance values: (very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1).

1.7.3.11.5Additional notes

This criterion looks at the performance of technologies for different temperature ranges. It is especially relevant for treatment technologies that rely on bacterial activity. Some of these technologies perform therefore better at higher than lower temperatures. Bacterial activity can sometimes occur even at 60°C. The effect of such high temperatures is not considered here as it is assumed that rarely daily average temperatures reach these levels.

Some technologies are unsuitable if the ground freezes and are therefore unsuitable during periods with less than - 10°C. It should be considered that several factors play a role in order for the ground to freeze, such as humidity, salt content and exposure time. The influence of these other factors is not considered here.

Alternative: The criterion could also be described as a continuous function with the case attribute referring to the minimum, mean and maximum daily average temperatures, while the technology would perform well in a specific temperature range. However, insufficient data was available to find the specific lower or upper temperature boundaries for a continuous function. Furthermore, a categorical function allows to distinguish the performance between different temperature zones. This represents reality better as technologies do perform differently in different temperature zones. For example, an unplanted drying bed can be installed in 'cold', 'temperate' and 'hot' climates, but it performs better in 'temperate' and 'hot' climates. (Tilley et al., 2014b) In addition, for the case profile the categorical option can represent the actual distribution of temperature over a year's time, whereas the continuous function could only provide minimum, mean and maximum temperatures.

1.7.3.12 Flooding

1.7.3.12.1 Why is it relevant?

Different sanitation technologies react differently to flooding: While some are not affected by flooding events, other technologies should not be used in flood-prone areas. The vulnerability of technologies to flooding is therefore an important proxy for technology appropriateness.

1.7.3.12.2 Definition

Qualitative estimate of the performance of each technology given a certain risk of flooding in a specific case. It is based on two categories:

- **No flooding**: describes conditions where surface flooding is a rare phenomenon.
- **Flooding**: describes conditions where intense rainfall and/or rise in levels of a neighbouring water body leads to flooding of surfaces.

There are three different types of floods.

1. Fluvial floods: occur when the water level in a river, lake or stream rises and overflows onto the surroundings. The water level rise could be due to excessive rain or snowmelt.
2. Pluvial floods: occur when heavy rainfall creates a flood independent of an overflowing water body, either due to an overwhelmed urban drainage system and/or due to a high proportion of sealed surfaces.
3. Flash floods can severely disrupt sanitation technologies; however, they are "sharp and sudden" i.e. difficult to predict/anticipate for a given region.

Fluvial and pluvial floods can be anticipated. Therefore the user can allot proportions to the categories 'flooding' and 'no flooding' based on the number of months pluvial or fluvial flooding is to be expected or not expected (e.g. monsoon season). In comparison, flash floods are difficult to predict and thus, are not considered for this criterion (sanitation systems, like other civil engineering projects, are not planned for rare extreme events).

Flooding is defined for the onsite collection and storage/treatment (FG S), conveyance (FG C), treatment (FG T), and reuse or disposal (FG D) technologies.

1.7.3.12.3 Case questions

What is the risk of flooding in this case?

Allot the proportions (%) based on the number of months per year when flooding can be expected for the case. The sum of all values must be 100%.

1.7.3.12.4 *Tech question*

What is the performance of the technology given a certain flooding risk?

Allot the performance (between 0 and 100%) for the category 'flooding' based on how well the technology performs when inundated, i.e. under flooding conditions. To avoid technologies from being discarded (as even in locations prone to flooding, technologies can be built on elevated surfaces unlikely to get flooded), one should refrain from entering the value 0% for 'flooding'. For the category 'no flooding' the performance is always 100%.

You can use the following examples
(no flooding - flooding):

- 100% - 100%: Technology performance is not affected by flooding.
- 100% - 80%/90%: Technology is in theory not affected by flooding, e.g. water-tight tank-based technologies or sufficiently large sewers that can handle stormwater and/or groundwater infiltration. However, in practice the performance of the technology can be hampered during flooding events. It also includes technologies in FG D that apply a certain product, since flooding could possibly lead to a low risk of pathogen transmission for the applied products.
- 100% - 50%: The technology performance can be severely disrupted by flooding events. However flood-preventive configurations of the technology are possible, such as raised structures or implementing embankments and other flood protective structures around the technology.
- 100% - 10%: Technologies that are impossible to operate during flooding or in the case of FG S and D technologies that lead to an unacceptable hygiene risk in case of flooding. A low performance of 10% is allotted to the category ‘flooding’ given that there exists the possibility that the technology could be built at elevated/ non-flooded plot areas of the flood-prone region, or one could operate the technology only during non-flooded times.

1.7.3.12.5 Additional notes

"If the project area is subject to regular flooding, alternatives based on soil absorption, or which are relying on stormwater drains for sewage collection, are unsuitable" (Loetscher and Keller, 2002). However, treatment technologies, which DO NOT rely on soil absorption, are generally designed to be watertight, i.e. are sealed against the ground. Therefore, it can be assumed that their functioning is not hampered significantly by flooding events (flooding = 90%).

Technologies can be built to have configurations that can withstand flooding (e.g. septic tanks could be built as raised septic tanks in flood-prone regions). If such a configuration is possible for a given technology, it is awarded a higher performance to account for this possibility (flooding = 50%).

1.7.3.13 Vehicular Access

1.7.3.13.1 Why is it relevant?

Different sanitation technologies require different levels of vehicular access during operation and maintenance: While some do not require any kind of vehicles, others depend on vehicles being able to access the location of the technologies for emptying and transport. The vehicular access is therefore an important proxy for technology appropriateness.

1.7.3.13.2 Definition

Semi-quantitative estimates of the performance of each technology during operation and/or maintenance given certain vehicular access in a specific case. This criterion refers to the need to empty onsite facilities by truck in dense areas. It is based on a scale of three categories:

- **No access**: vehicles cannot reach the site, because the road widths are less than 2 meters or the terrain is impossible to traverse.
- **Difficult access**: road widths are between 2-5 meters or terrain is difficult (no proper roads, hilly, etc.)
- **Full access**: road widths are over 5 meters which larger vehicles, such as a pumping truck, can use without any problem.

Note: Vehicular access can also be limited due to seasonal conditions (e.g. flooding during monsoon), however, this is not considered here and instead in the criterion "Flooding".

Vehicular access is only used for onsite and decentralized onsite collection and storage/treatment technologies (FG S).

1.7.3.13.3 Case questions

How accessible by motorized vehicles (e.g. pumping trucks) are the onsite locations for the planned toilets and treatment technologies?

Allot the proportions (%) of the case area that have certain vehicular accessibility.

1.7.3.13.4 Tech question

What is the performance of the technology given a certain type of vehicular access?

Allot the performance (between 0 and 100%) for each category based on how well the technology performs for the different categories of vehicular accessibility. You can use the following examples
(full access - difficult access - no access):

100% - 100% - 100%:	No vehicular access necessary. Includes cases where material requires no further treatment and could be used for example onsite as soil amendment.
→ 100% - 80% - 80%:	Vehicular access is not necessary, as manual transport is possible. However, motorized vehicles can slightly improve the operation efficiency (e.g. by handling

slightly larger loads of products such as dried faeces that do not require frequent emptying. In case of urine this often is treated onsite or transported manually and does not require vehicular transport.

→ 100% - 60% - 30%: Vehicular access is not necessary, as manual transport is possible. However, motorized vehicles can strongly improve the operation efficiency (e.g. as they can handle very large loads of material that are voluminous such as sludge and require frequent emptying).

→ 100% - 50% - 0%: Access for some type of motorized vehicles is necessary. Smaller non-motorized vehicles (e.g. Gulper) can navigate difficult terrain but they are less efficient in transporting the dug-out material.

→ 100% - 0% - 0%: Access for larger vacuum pumping trucks is necessary.

1.7.3.13.5 Additional notes

The criterion is only used to assess technologies in FG S, which are assumed to be onsite technologies. The assumption behind this choice is that vehicular access to the onsite facilities (plots) and not the offsite treatment facilities is the limiting factor. The reasoning is that these onsite technologies need to be emptied by desludging vehicles and the collected material can be treated close by or transported to an accessible offsite treatment facility. It has to be kept in mind that technologies of FG T can also be used as onsite technologies but are not limited by the criterion. To consider possible errors caused by this assumption, the four different sanitation system types (see *1.2.11 Onsite, Decentralized and Offsite Technologies and Systems)*

Onsite, Decentralized and Offsite Technologies and Systems Onsite are evaluated for the criterion “Vehicular Access”:

- **Onsite + Decentralized systems**: The criterion “Vehicular Access” penalizes FG S technology even though all processes happen onsite and consequently no transport and no vehicular access are required. If a user plans to implement the whole sanitation chain onsite or at a decentral location that only requires manual transport over short distances, they can set the case values to (no access = 1, difficult access = 0, full access = 0) and avoid this penalization.
- **Hybrid system:** The criterion “Vehicular Access” might penalize FG S technologies even though in some cases their output products enter onsite FG T or D technologies and no vehicular access is required. At the same the criterion does not penalize onsite technologies of type FG T or D, even though vehicular access might be required for these. For example, an onsite anaerobic baffled reactor would not have a reduced appropriateness even though vehicles would need to access it for sludge emptying.
- **Offsite system:** It is assumed that vehicular access to the offsite treatment facilities is not a limiting factor.

The assumption is made that for technologies that can be either emptied or displaced (e.g. pit latrine) the content is actually emptied.

Alternative: The criterion could be additionally applied for FG C technologies to reduce the appropriateness of sanitation systems that include motorized transport. However, then the appropriateness of such a system would be reduced twice: Once for the limited accessibility of the FG S technology and a second time for the technology motorized transport. Therefore, to avoid double-counting only FG S technologies are considered and the user must ensure that such systems are not implemented in case of ‘no access’. “Vehicular Access” is not implemented for FG T and D, because it is assumed that offsite facilities and disposal sites are in general accessible by vehicle. This assumption needs to be verified for the specific application case. The assumption also ignores the fact that technologies in FG T and D can be onsite or decentralized, where vehicular access might be relevant.

1.7.3.14 Slope

1.7.3.14.1 Why is it relevant?

Different sanitation technologies can be operated at different slopes: While some can function in particularly flat areas, other technologies require a certain gradient for proper functioning. The slope is therefore an important proxy for technology appropriateness.

1.7.3.14.2 Definition

Semi-quantitative estimates of the performance of each technology during operation and/or maintenance given a certain slope in a specific case. Slope can be an important aspect for all technologies but here it is considered relevant for conveyance technologies (FG C) only. In FG C, the slope is particularly important for piped technologies such as sewers whose function is greatly affected by flat slopes. Thus, this criterion is based on two categories:

- **Flat**: 0-1% gradient.
- **Not flat**: this includes everything from rolling to steep slopes (>1% gradient).

1.7.3.14.3 Case questions

How much of the area is flat in the case?

Allot the proportions (%) of the case area that have a slope that is greater or lower than 1%. The sum of all values must be 100%.

1.7.3.14.4 Tech question

What is the performance of the technology given a certain ground slope?

Allot the performance (between 0 and 100%) for the category 'flat' based on how well the technology performs if the slope is ‘flat’, i.e. <1%. To avoid technologies from being discarded (as even in flat slope, piped technologies could function with pumps), one should refrain from entering the value 0% for 'flat'. For the category 'not flat' the performance is always 100%.

1.7.3.14.5 Additional notes

The direction of the slope is not considered in this criterion. A more detailed feasibility study evaluating if the local slopes support a sewer system need to be conducted.

Following the approach of (Monvois et al., 2012), this criterion should allow to distinguish between if the natural hydraulic gradient is sufficient to let the wastewater flow through the sewerage system (>1°) or if it is too flat (<1°) because that would require additional digging. Doing so, one can specify the case constraints as means of fractions (20% of the area is ‘flat’, 80% is steep).

Several alternative characterizations were considered:

- Alternative 1: For this criterion, you might also consider categories such as verbal descriptions with defined boundary values, e.g. ‘plain (0-5.7°, 0-10%)’, ‘rolling (5.7-14°, 10-25%)’, ‘mountainous (14-31°, 25-60%)’ and ‘steep (>31°, >60%)’ as used by (Bustos, 2016). Since the main purpose is to evaluate suitability for a sewerage system, such a detailed analysis is considered unnecessary.
- Alternative 2: One could also quantify this attribute by exact numbers [% of gradient] and with a trapezium function, but the constraints for the case cannot be entered in fractions as before. A probability density function describing the prevailing slope distribution in the settlement has to be created for the case. Since one is interested in the proportion of the case area that is suitable for a sewerage system, the continuous function is less preferable than the categorical one.

1.7.3.15 Soil Type

1.7.3.15.1 Why is it relevant?

Different sanitation technologies can be operated at locations with different soil types: While some require the soil to be permeable for soil absorption, other technologies can function even in very rocky areas. Some technologies in turn are dependent on the cleansing capacity of the soil. The soil type is therefore an important proxy for technology appropriateness.

1.7.3.15.2 Definition

Qualitative estimates of the performance of each technology for operation given a certain soil type in a specific case. Soil type is mainly important for technologies depending on soil absorption during operation. Different soil types possess different permeability, thereby, some bear more risk for stagnation than others. Additionally, certain soils have better filtration characteristics or in other words a greater cleansing capacity for polluted effluents.

It is based on a scale of five categories:

- **Rock**: extremely low/ negligible permeability, would certainly lead to stagnation of polluted effluent towards surfaces. Also, the filtration or cleansing capacity is very limited. Here, we refer to a continuous rocky stratum.
- **Clay**: very low permeability, has a high risk of stagnation of polluted effluent towards surfaces. Since percolation is low, the filtration or cleansing capacity is also limited. It is assumed here that the clay has no fissures.
- **Silt**: low permeability, has a moderate risk of stagnation of polluted effluent towards surfaces. Silty soil offers adequate filtration or cleansing capacity.
- **Sand**: moderate permeability, offers good percolation of polluted effluent, along with good soil filtration or cleansing capacity.
- **Gravel**: high permeability, is considered best for percolation of polluted effluent. But the cleansing capacity of the soil or filtration power is very limited and likely to be insufficient.

Although the risk of percolation of polluted effluent and the abilities of different soils to filter it is somewhat considered as part of this criterion, the specific focus of percolation leading to pollution of drinking water sources is additionally looked at in a separate criterion "Drinking Water Exposure". Moreover, some technologies also need a certain soil type for construction, especially when concerning the stability of the technology underground, however, this is not a consideration here.

Soil type is used for onsite collection and storage/treatment (FG S), and reuse and disposal (FG D) technologies.

1.7.3.15.3Case questions

What is the soil type in the case area?

Allot the proportions (%) of the case area that consist of one of the given soil type categories. The sum of all values must be 100%.

1.7.3.15.4Tech question

What is the performance of the technology given a certain soil type/permeability?

Allot the performance (between 0 and 100%) for each category based on the following examples (clay – silt – sand – gravel – rock):

- → 100% - 100% - 100% - 100% - 100%: Technology is sealed and/or does not rely on soil absorption.
- → 70% - 90% - 100% - 90% - 70%: The technology can be designed to make use of soil percolation and filtration, in order to lower the desludging rates, but does not necessarily have to (e.g. raised latrines).
- → 25% - 50% - 100% - 50% - 25%: Soil percolation and filtration are desirable for this technology as it results in lower desludging rates. (e.g. pit latrines).
- → 0% - 25% - 100% - 25% - 0%: The functionality of the technology primarily depends on soil percolation and filtration. (e.g. soak pits, leach fields).

1.7.3.15.5Additional notes

According to (Loetscher and Keller, 2002) coarse or medium sand does not provide a sufficient level of filtration and can lead to high risks of groundwater contamination. However, to simplify for this criterion it is assumed that 'sand' has a sufficiently good cleansing capacity.

1.7.3.16 Groundwater Depth

1.7.3.16.1 Why is it relevant?

Different sanitation technologies demand different groundwater depths to function: While some might pollute the groundwater and should not be built in case of high groundwater levels, other technologies are fully sealed and independent from the groundwater depth. The groundwater depth is therefore an important proxy for technology appropriateness.

1.7.3.16.2 Definition

Quantitative estimates of the performance of each technology for construction and operation given a certain groundwater depth in a specific case. The groundwater depth is estimated in meters distance from the surface. For the case the focus lies on the lowest distance from the surface or the highest groundwater table over a year's time. This criterion is mainly important if the technology can pollute the groundwater by infiltration.

If any given technology is built to be sealed against the ground, it is assumed that it functions successfully (100% performance) given any level of groundwater depth. In reality, not all such sealed technologies may be recommended for areas with high groundwater tables, however, this is not considered here. The actual soil absorption capacity of a technology is not considered here but instead in the criterion “Soil Type”.

Groundwater depth is defined for the onsite collection and storage/treatment (FG S), and reuse and disposal (FG D) technologies. Conveyance (FG C) and treatment technologies (FG T) are assumed to be sealed against the ground.

1.7.3.16.3 Case questions

What is the local groundwater depth (=distance from the surface to the groundwater table)?

Option 1: Provide the minimal (A) and maximal value (D). If there is no clear minimum, allot the value 0. If there is no clear maximum, allot the value 999.

Option 2: Up to four values can be alloted: the absolute minimum (A), the likely/typical minimum (B), the likely/typical maximum (C), and the absolute maximum (D).Note: A must be smaller or equal than B must be smaller or equal than C must be smaller or equal than D.

1.7.3.16.4Tech question

What is the performance of the technology given a certain groundwater depth?

Provide the minimum groundwater depth at which the technology can function. Alternatively, you can provide both the absolute minimum groundwater depth at which the technology can function and the optimal minimum groundwater depth at which the technology performs at 100%. It might be helpful to think in terms of the four values (a,b,c,d) of the trapez function:

- a = min. value with performance >= 0%
- b = min. value with performance of 100%
- c = d = 999m = max. value

Note: A minimum vertical safety distance of three meters is assumed between the point of infiltration (e.g. the bottom of a pit) and the groundwater table as suggested by (Monvois et al., 2012).

1.7.3.16.5 Additional notes

"Wastewater that infiltrates the soil or comes from leakages can constitute a pollution risk for the groundwater table. A groundwater table is not compatible with technologies that use infiltration of water into the soil or where there is a risk of leakage if this table is situated less than 3 meters away from the point of infiltration (e.g. the bottom of a pit). The intervention of a (hydro-) geologist may be required to establish if there is a risk of groundwater table contamination" (Monvois et al., 2012). (Loetscher and Keller, 2002) set the threshold at 5 m below surface, if water is abstracted locally from the groundwater, and at 2 m below surface, if the water supply is transported in pipes to the location. For SANTIAGO, we set the minimum vertical distance for technologies that rely on soil absorption to 3 meters.

This criterion considers the possible pollution of the groundwater by infiltrating technologies as well as the structural stability of underground structures in regard to the groundwater table. It is an addition to the criterion “Drinking Water Exposure” that covers the sensitivity of the regional water supply to polluted groundwater. “Groundwater Depth” does not consider the effect of groundwater on the soil absorption capacity of a technology, as this is part of the criterion "Soil Type".

1.7.3.17 Excavation

1.7.3.17.1 Why is it relevant?

Different sanitation technologies demand different amounts of excavation: While some can be built above ground in the case of challenging soil conditions, other technologies are imperatively dependent on the process of excavation during construction. The ease of excavation is therefore an important proxy for technology appropriateness.

1.7.3.17.2 Definition

Qualitative estimate of the performance of a technology given how easy it is to excavate soil in a specific case. The ease of excavation is important for technologies that have to be constructed below ground. It is based on two categories:

- **Easy**: can be excavated without special machinery.
- **Hard**: needs special machinery and equipment for instance in rocky ground conditions.

Excavation is defined for the onsite collection and storage/treatment (FG S), conveyance (FG C), treatment (FG T), and reuse and disposal (FG D) technologies. Technologies belonging to the user interface (FG U) are linked to the FG S technologies and excavation is therefore not a relevant criterion.

1.7.3.17.3 Case questions

What is the ease of excavation in the case?

Allot the proportions (%) of the case area that can be excavated easily or with more difficulty. The sum of all values must be 100%.

1.7.3.17.4 Tech question

What is the performance of the technology given a certain level of difficulty in excavation?

Allot the performance (between 0 and 100%) for the category 'hard' based on how well the technology performs if excavation is difficult. To avoid technologies from being discarded (as excavation though difficult, is always possible), one should refrain from entering the value 0% for 'hard'. For the category 'easy' the performance is always 100%. You can use the following examples
(easy – hard):

- → 100% - 100%: No excavation required.
- → 100% - 75%: Shallow excavation required (<3m deep) or one of multiple configurations is underground and therefore requires excavation.
- → 100% - 50%: Deeper excavation required (>=3m deep) or shallow and wide excavation (e.g. as for simplified sewers).
- → 100% - 25%: Deep (>=3m deep) and wide excavation necessary (e.g. as for a conventional sewer)

1.7.3.18 Surface Area (Onsite)

1.7.3.18.1 Why is it relevant?

Different onsite sanitation technologies require different amounts of surface area: While some can be built on a very small footprint relative to the number of users, other technologies demand a large plot of land that might not be available in a certain case. The surface area onsite is therefore an important proxy for technology appropriateness.

1.7.3.18.2 Definition

The surface area (onsite) refers to the space available for onsite technology construction. Is is evaluated in m2 per unit. The unit could be at the household level or the community level.

It must be noted that when multiple technologies from FG S are part of a system, the SANTIAGO algorithm does NOT apply the surface area restrictions to the cumulative sum of all the areas of individual technologies. E.g. if for the case a 5 m^2 plot is available, SANTIAGO individually compares the area required by a certain technology against this number. However, if two or more technologies are recommended as part of the system (e.g. urine storage tanks in addition to dehydration vaults), it does NOT compare the sum of their areas against the 5 m^2 restriction.

Surface area (onsite) is defined for the onsite collection and storage/treatment technologies (FG S) only.

1.7.3.18.3 Case questions

How much surface area (m^2) is available in the case onsite per unit of planned technology (e.g. one double pit)?

Option 1: Provide the minimal (A) and maximal value (D). If there is no clear minimum, allot the value 0. If there is no clear maximum, allot the value 999.

Option 2: Up to four values can be allotted: the absolute minimum (A), the likely/typical minimum (B), the likely/typical maximum (C), and the absolute maximum (D).

Note: A must be smaller or equal than B must be smaller or equal than C must be smaller or equal than D.

1.7.3.18.4 Tech question

What is the degree of feasibility of the technology given a certain surface area available in the case in m^2 per unit?

Provide the minimum surface area required for the technology to perform 100%. Alternatively, you can provide both the absolute minimum surface area required for technology to function and the optimal minimum at which the technology performs best.

Note: A maximum surface area requirement does not apply to technologies and therefore, a default value of 999 m^2 is assumed. It might be helpful to think in terms of the four values (a,b,c,d) of the trapez function:

- a = min. value with performance >= 0%
- b = min. value with performance of 100%
- c = d = 999 m^2 = max. value

1.7.3.18.5 Additional notes

Note that in SANTIAGO, if space is required underground, it still has the same space requirements as if it were aboveground.

Defining the surface area requirements for different technologies is challenging. The following very simplified strategy was implemented to classify groups of collection and storage/treatment FG S technologies with similar surface area requirements:

→ *Movable technologies with very low surface area requirements (container-based): (a = 0 m², b = 0.5 m²)*

These technologies can basically be put anywhere and possibly do not require any permanent space at all. A space requirement starting at a = 0 m² is therefore proposed. There are many different variations of container-based toilets and urine storage tanks, so common sense can be applied here to define a small value of 0.5 m² as a requirement for 100% performance.

→ *Technologies with low surface area requirements: (a = b = 1 m²)*

These technologies are all based on storing excreta below the user interface and therefore have similar surface area requirements as the user interface above. The value of 1 m² is based on a recommendation for single pits (Tilley et al., 2014b). The same value is assumed to be valid for the single VIP, the borehole latrine and the single faeces storage chamber.

The chemical toilet and deep trench latrine can also be constructed with a small footprint (Gensch et al., 2018) and are therefore added to this class.

→ *Techs with medium surface area requirements: (a = b = 2 m²)*

The technologies (fossa alterna, double VIP, double dehydration vault) are based on storing excreta below the user interface, but making use of alternating chambers. Therefore, their surface area requirements are similar and assumed to be (at least) twice the area of the single chamber technologies of 1 m².

The same value of 2 m² is assumed for worm-based toilet, because they require additional 0.7 to 1 m² for the vermifilter (Gensch et al., 2018). The composting chamber is assumed to be of similar size as a vermicompost, but could also be significantly larger. Finally raised latrines also require more space since there needs to be some kind of elevated structure with stairs.

→ *Techs with high surface area requirements: (a = b = 5 m²)*

The values for septic tanks and twin pits for pour flush are based on the following references (Monvois et al., 2012) and (Gensch et al., 2018).

→ *Techs with surface areas that highly depend on the number of users: (a = 35 m², b = 35 m²)*

For shallow trench latrines, 0.25 m²/cap/day are required (Gensch et al., 2018). Assuming they are used at minimum for 2 weeks by 10 people, we get at a surface area requirement of 35 m². The same value is used for the open defecation field, though space requirements could be even larger there. These assumptions are very generic and further feasibility studies by a user are required.

There are several other criteria that are related to the surface area and could be considered either additionally or as a replacement for the surface area:

- Alternative: One might also consider a criterion describing the population density. This is especially important for technologies that rely on on-site soil absorption (Loetscher and Keller, 2002). However, it is very hard to quantify at what threshold a technology relying on soil absorption is inappropriate for a certain population density.
- Alternative 2: Another criterion one might consider is one describing the total population size, because e.g. activated sludge is not very feasible for a small population size (<2000 inhabitants) due to economies of scale (Loetscher and Keller, 2002). However, the reason is most probably because these kinds of technologies are

too expensive. In SANTIAGO, costs are covered with a separate criterion and a criterion describing the population size is therefore not needed.

1.7.3.19 Surface Area (Offsite)

1.7.3.19.1 Why is it relevant?

Different offsite sanitation technologies require different amounts of surface area: While some can be built on a small footprint, other technologies demand a large plot of land that might not be available in a certain case. The surface area offsite is therefore an important proxy for technology appropriateness.

1.7.3.19.2 Definition

The surface area (offsite) refers to the space available for technology construction offsite at a centralized location and is evaluated in m^2 per person. Surface area (offsite) is defined for the treatment technologies (FG T) only.

It must be noted that when multiple technologies from FG T are part of a system, the SANTIAGO algorithm does NOT apply the surface area restrictions to the cumulative sum of all the areas of individual technologies. E.g. if for the case a 5 m^2 plot is available, SANTIAGO individually compares the area required by a certain technology against this number. However, if two or more technologies are recommended as part of the system (e.g. waste stabilisation ponds in addition to a drying bed), it does NOT compare the sum of their areas against the 5 m^2 restriction.

1.7.3.19.3 Case questions

How much total surface area per capita (m^2/cap) is available offsite for decentralized and centralized treatment technologies for the case?

Option 1: Provide the minimal (A) and maximal value (D). If there is no clear minimum, allot the value 0. If there is no clear maximum, allot the value 999.

Option 2: Up to four values can be allotted: the absolute minimum (A), the likely/typical minimum (B), the likely/typical maximum (C), and the absolute maximum (D).

Note: A must be smaller or equal than B must be smaller or equal than C must be smaller or equal than D.

1.7.3.19.4 Tech question

What is the degree of feasibility of the technology given a certain surface area available offsite (decentralized and centralized sites) in m^2 per capita?

Provide the minimum surface area required for the technology to perform 100%. Alternatively, you can provide both the absolute minimum surface area required for technology to function and the optimal minimum at which the technology performs best.

Note: A maximum surface area requirement does not apply to technologies and therefore, a default value of 999 m^2 is assumed.) It might be helpful to think in terms of the four values (a,b,c,d) of the trapez function:

- a = min. value with performance >= 0%
- b = min. value with performance of 100%

- c = d = 999 m^2 = max. value

1.7.3.19.5 Additional notes

Defining the surface area requirements for technologies is challenging and depends on many factors, such as the actual technology configuration, its scale, etc. Therefore, SANTIAGO cannot calculate the actual area requirements of a sanitation technology and only provides the minimally required surface area. In real life, the same technology might be far larger. The range is chosen as broad as possible to ensure that no technology is discarded unnecessarily. A detailed feasibility study by the user is necessary to determine the actual surface area per technology.

In addition, as previously mentioned in the criterion definition, the SANTIAGO algorithm can only check whether any technology individually exceeds the available surface area. It is therefore recommended that a user adds the surface areas of all technologies for a plausibility check.

While “Surface Area (Offsite)” includes the word “offsite”, it actually refers to the area required by the treatment technologies in FG T according to the SANTIAGO algorithm. The treatment technologies can be either implemented close to the toilets themselves (decentralized system) or further away at (semi-)centralized facilities (offsite system) (see also *chapter 1.2.11 Onsite, Decentralized and Offsite Technologies and Systems*). Therefore, for this criterion the user needs to quantify the area where they expect to implement the treatment facilities. This can be close to the toilets themselves or further away. It is further possible that the treatment technologies are spread over several locations. These can all be onsite, all offsite or a hybrid system with a mix of both. For all of these cases the user can add all the areas together and then divide them by the proposed number of users. However, after the appropriateness assessment, any selected sanitation system requires another plausibility check examining how the technologies are distributed between the different locations and if that matches the available surface at these locations.

It is further assumed that the surface area required by technologies in FG U, C and D are negligible compared to technologies in FG S and C. This requires another plausibility check as some, e.g. fish ponds, also need significant space.

Note that in SANTIAGO, if space is required underground, it still has the same space requirements as if it were aboveground.

1.7.3.20 Drinking Water Exposure

1.7.3.20.1 Why is it relevant?

Different sanitation technologies can be used in varying proximity to drinking water sources: While some rely on soil absorption or might possibly leak into the groundwater and could potentially pollute drinking water, other technologies can be used in close proximity to water sources. The drinking water exposure is therefore an important proxy for technology appropriateness.

1.7.3.20.2 Definition

Quantitative estimation of the performance of the technology given a certain water source proximity. This is important for technologies that rely on soil absorption and might pose a risk to nearby drinking water sources. It is based on two categories:

- **Close**: refers to a distance less than 30 meters to the closest drinking water source (e.g. a groundwater well).
- **Not close**: refers to a distance of more than 30 meters from the closest drinking water source.

Drinking water exposure is defined for the onsite collection and storage/treatment (FG S), and reuse and disposal technologies (FG D). The sites where such technologies are to be implemented are referred to here as 'implementation sites'.

1.7.3.20.3 Case questions

How many of the implementation sites can pollute nearby drinking water sources (e.g. groundwater wells)?

Allot proportions (%) based on the number of implementation sites that are 30m closer or not closer from drinking water sources (e.g. groundwater well). Implementation sites could be either at the household or the community level. The sum of all values must be 100%.

1.7.3.20.4 Tech question

What is the performance of the technology with respect to preventing the risk of pollution given a drinking water source is closer than 30 meters?

Allot performance (between 0 and 100%) for the category 'close' based on how likely it is for the technology to infiltrate polluted effluent into the soil. To avoid technologies from being discarded (as infiltration of polluted effluent into drinking water sources can indeed be prevented), one should refrain from entering the value 0% for 'close'. For the category 'not close' the performance is always 100%.

1.7.3.20.5 Additional notes

The category ‘not close’ does not consider the water requirements of a technology as this is covered in the criteria “Water Supply” and “Water Volume”.

The limit of 30 m distance between containment facilities and water sources is based on the Sphere Standards (Association, 2018).

Alternative: This criterion could also be used as a continuous function on the distance to the next water source in meters instead of categories. It mostly depends on the data available for both the case and the technologies.

1.7.3.21 Construction Skills

1.7.3.21.1 Why is it relevant?

Different sanitation technologies require different skills for their initial construction: While some can be entirely built with very limited skill, other technologies require highly trained professionals for the construction of certain parts of the technology. The availability of construction skills is therefore an important proxy for technology appropriateness.

1.7.3.21.2 Definition

Qualitative estimation of the performance of each technology given a certain construction skills availability in a specific case. This differs from the criterion 'Design Skills' as correct implementation of the technology needs both effective design and effective construction. Construction skills refer to the skills required for the construction of sanitation technologies and is defined by three categories:

- **Unskilled labour**: casual/daily labourer such as mason, artisan, or craftsman.
- **Skilled labour**: plumber, technician (maintenance, lab, IT), mechanic, electrician, trained mason/artisan/craftsman.
- **Professional**: highly qualified engineer, architect, planner, or supervisor.

Construction skills is defined for all technologies regardless from their functional group. It is not representative of the entire local workforce but only the one that will be involved in the implementation of sanitation technologies.

1.7.3.21.3Case questions

What is the availability of different levels of construction skills in the case?

Allot proportions (%) based on the construction skill set of the workforce in the case area. The sum of all values must be 100%.

1.7.3.21.4Tech question

What is the performance of the technology given a certain availability of construction skills?

Allot for each category the performance of a technology (between 0 and 100%) for a given skill level of the available workforce.

Note: This is a ladder function, so if a technology performs 100% with ‘unskilled labour’, it will also perform well (i.e. 100%) with ‘skilled’ and ‘professional’ labour. The values allotted to ‘professional’ will always be equal to or higher than ‘skilled’ and those allotted to ‘skilled’ will be equal or higher than ‘unskilled’.

1.7.3.21.5Additional notes

Alternative: One might also consider specific categories as ‘none’, ‘unskilled labour’, ‘mason’, ‘specially trained mason’, ‘construction engineer’ and ‘supervisor’. However, these professions do not ensure that all skills that might be needed are included and the skill level per category might differ from one region to the other. In SANTIAGO, a less detailed approach has been implemented.

1.7.3.22 Design Skills

1.7.3.22.1Why is it relevant?

Different sanitation technologies require different skills for their design: While some can be designed with very limited knowledge, other technologies require the design skills of highly trained professionals to ensure proper functioning. The availability of design skills is therefore an important proxy for technology appropriateness.

1.7.3.22.2Definition

Qualitative estimation of the performance of each technology given a certain design skills availability in a specific case. This differs from the criterion 'Construction Skills' as implementation needs both effective design and effective construction. It is based on a scale of three categories:

- **Unskilled labour**: casual/daily labourer such as mason, artisan, or craftsman.
- **Skilled labour**: plumber, technician (maintenance, lab, IT), mechanic, electrician, trained mason/artisan/craftsman.
- **Professional**: highly qualified engineer, architect, planner, or supervisor.

Design skills is defined for all technologies regardless from their functional group. It is not representative of the entire local workforce but only the one that will be involved in the design of sanitation technologies.

1.7.3.22.3Case questions

What is the availability of different levels of design skills in the case?

Allot proportions (%) based on the design skill set of the workforce in the case area.

1.7.3.22.4Tech question

What is the performance of the technology given a certain availability of design skills?

Allot for each category the performance of a technology (between 0 and 100%) for a given skill level of the available workforce.

Note: This is a ladder function, so if a technology performs 100% with ‘unskilled labour’, it will also perform well (i.e. 100%) with ‘skilled’ and ‘professional’ labour. The values allotted to ‘professional’ will always be equal to or higher than ‘skilled’ and those allotted to ‘skilled’ will be equal or higher than ‘unskilled’.

1.7.3.22.5Additional notes

Alternative: One might also consider specific categories as ‘none’, ‘unskilled labour’, ‘mason’, ‘specially trained mason’, ‘planning engineer’ and ‘supervisor’. However, these professions do not ensure that all skills that might be needed are included and the skill level per category might differ from one region to the other. In SANTIAGO, a less detailed approach has been implemented.

1.7.3.23 Operation and Maintenance (O&M) Skills

1.7.3.23.1Why is it relevant?

Different sanitation technologies require different skills for operation and maintenance: While some can be operated with a very limited set of skills, other technologies require highly specialized training to ensure endured functioning. The availability of operation and maintenance skills is therefore an important proxy for technology appropriateness.

1.7.3.23.2Definition

Qualitative estimation of the performance of each technology given a certain operation and maintenance (O&M) skills availability in a specific case. It is based on a scale of three categories:

- **Unskilled**: casual/daily labourer such as pit digger, sanitary worker, pit emptier.
- **Skilled**: plumber, technician (maintenance, lab, IT), mechanic, electrician, trained mason/artisan/craftsman. Also includes basic administrative and finance skills.
- **Professional**: highly qualified collection supervisor, treatment supervisor, chemist, and administrator (including finance).

O&M skills is defined for all technologies regardless from their functional group. It is not representative of the entire local workforce but only the one that will be involved in the operation and maintenance of sanitation technologies.

1.7.3.23.3Case questions

What is the availability of different levels of operation and maintenance skills (O&M) in the case?

Allot proportions (%) based on the O&M skill set of the workforce in the case area.

1.7.3.23.4Tech question

What is the performance of the technology given a certain operation and maintenance (O&M) skills availability?

Allot for each category the performance of a technology (between 0 and 100%) for a given skill level of the available workforce. The sum of all values must be 100%.

Note: This is a ladder function, so if a technology performs 100% with 'unskilled labour', it will also perform well (i.e. 100%) with 'skilled' and 'professional' labour. The values allotted to 'professional' will always be equal to or higher than 'skilled' and those allotted to 'skilled' will be equal or higher than 'unskilled'.

1.7.3.23.5Additional notes

Alternative: One could also define specific categories, such as 'none', 'unskilled labour', 'specially trained labour', 'technician', 'supervisor', 'administrator', 'engineer' and 'scientist'. However, these professions do not ensure that all skills that might be needed are included and the skill level per category might differ from one region to the other. In SANTIAGO, a less detailed approach has been implemented.

1.7.3.24 Cleansing Method

1.7.3.24.1Why is it relevant?

Different sanitation technologies can be used by people preferring different cleansing methods: While some technologies can be used with anal cleansing water as well as dry cleansing material, some technologies only function perfectly with one type of cleansing method. The cleansing method is therefore an important proxy for technology appropriateness.

1.7.3.24.2Definition

Qualitative estimation of the performance of each technology given a certain cleansing method in the specific case. It is based on a scale of three categories:

- **Washer**: refers to the use of anal cleansing water.
- **Soft wipers**: refers to the use of toilet paper or other soft materials.

- **Hard wipers**: refers to the use of any other, mostly hard and bulky material such as maize cobs.

Cleansing method is defined for the user interface (FG U) technologies only.

1.7.3.24.3 Case questions

Which anal cleansing methods are used by the population?

Allot proportions (%) based on the share of the population using each of the proposed cleansing methods. The sum of all values must be 100%.

1.7.3.24.4 Tech question

What is the performance of the technology given a certain anal cleansing material?

Allot the performance (between 0 and 100%) for each category based on how well the technology performs for the different anal cleansing materials.

1.7.3.24.5 Additional notes

The criterion “Cleansing Method” is only defined for the user interface (FG U). This is based on the assumption that some kind of pre-screening is implemented before any technology in FG S, C, T and D, which screens out dry cleansing material.

1.7.3.25 Lifetime

1.7.3.25.1 Why is it relevant?

The criterion was chosen as relevant for humanitarian contexts by experts in a study by (Jain and Ilmanen, 2021). Some technologies have short design lifetimes and are therefore appropriate in the short-term or in a transition period. This is especially relevant for technologies in the initial phases of a humanitarian crisis, where interim solutions and short lifetimes of technologies are acceptable whereas in the long-term other technologies might be more appropriate. The lifetime is therefore an important proxy for technology appropriateness in humanitarian contexts.

1.7.3.25.2 Definition

The criterion lifetime has been developed specifically and is only applicable for humanitarian contexts.

It is defined by the semi-quantitative estimates of how appropriate each technology is given an expected lifespan in a specific case. It is based on the following three categories (based on expert judgement):

- **Short**: refers to a lifetime of less than one year.
- **Medium**: refers to a lifetime ranging from over one year to up to five years.
- **Long**: refers to a lifetime of over five years.

The criterion is defined for technology for storage and treatment (FG S), (Semi-)centralized treatment (FG T) and reuse or disposal (FG D).

If a technology has a long service life, it can be also used for shorter periods of time. This assumption is not correct for all technologies due to their long start-up time or required minimum storage time. The minimum lifetime of a technology (e.g. due to the minimum storage time for composting chambers) is not taken into consideration in this criterion. However, start-up times are considered separately in “Speed of Implementation”.

If this criterion is used for screening technologies by implementing an appropriateness calculation, stakeholders need to agree on a preferred scalability. If this is not the case the criterion should not be considered as a screening criterion and instead looked at in more detail in the evaluation phase when evaluating appropriate options and when negotiating a preferred option with all stakeholders.

1.7.3.25.3Case questions

What lifetime is a technology required to last in the case?

Allot proportions (%) based on how acceptable the given service lifetimes are for the case. E.g. if a short lifetime is acceptable, 100% should be allotted to the category 'short'. The sum of all values must be 100%.

Note: If the lifetime does not matter for the case, this criterion must be excluded from consideration.

1.7.3.25.4Tech question

What is the performance of technology given a certain expected design lifetime?

Allot for each category the performance (between 0 and 100%) based on how appropriate the technology is for the different proposed lifetimes.

Note: This is a ladder function, so if a technology performs 100% if a ‘long’ service lifetime is expected’, it will also perform well (i.e. 100%) for ‘medium’ or ‘shorter’ lifetimes. The values allotted to ‘short’ will always be equal to or higher than ‘medium’ and those allotted to ‘medium’ will be equal or higher than ‘long’.

1.7.3.25.5Additional notes

Some technologies are only meant for the short-term but end up being used for far longer timespans. This is considered in the form of performance values between 0 and 100%.

For FG D 'technologies'/concepts that include the application of stored and treated material, the storage and treatment time are accounted for in FG S and FG T.

Several alternative technology configurations were considered:

- Alternative 1: A PDF function could be used to describe the possible lifetime of a technology. This alternative was discarded, because several technologies could be used equally in the short- or long-term and should have therefore achieved appropriateness scores of 100%. However, with a PDF function such a technology could only be described by (short = 0.3, medium = 0.4, long = 0.3) and consequently the appropriateness score of such a technology might have been reduced.
- Alternative 2: A performance function without a ladder function could be used to describe the performance of technology. This alternative was discarded, because for most technologies no data was available, on its

performance for short (<1a) or medium lifetimes (1-5a). The assumption that a technology with a long service life can also be used for a shorter lifetime by abandoning it was deemed realistic.

1.7.3.26 Speed of Implementation For Toilet Structure

1.7.3.26.1 Why is it relevant?

The criterion was chosen as relevant for humanitarian contexts by experts in a study by (Jain and Ilmanen, 2021). The initial response to a humanitarian crisis requires a quick implementation of adequate sanitary facilities. To account for this the speed of implementation of toilet structures is considered an important proxy for technology appropriateness in humanitarian contexts.

1.7.3.26.2 Definition

The criterion has been developed specifically and is only applicable for humanitarian contexts.

Semi-quantitative estimates of the performance of each technology given the preference for the time within which functional toilets are required in a specific case. It is based on the following three categories:

- **Rapid**: refers to when implementation is possible under three days.
- **Moderate**: refers to an implementation time between three days to two weeks.
- **Slow**: refers to an implementation time longer than two weeks.

Toilet coverage with safe onsite containment is a priority and often comes prior to the implmentation of the entire treatment chain. It is relevant to use this criteria in an acute response phase. The quality of implementation of the technology is assumed to be the same for all of the aforementioned speeds, i.e. for example, 'rapid' in no way equates to fast sub-standard construction.

The speed of implementation can be judged based on many factors such as the complexity of construction and skills required, local availability of materials, concrete curing time, etc.

This criterion refers to the speed of implementation of onsite collection and storage/treatment technologies (FG S) only (it is assumed that construction of the superstructure, i.e. technologies belonging to the user interface are not the time-limiting agent here).

1.7.3.26.3 Case questions

How acceptable are the following speeds of implementation for finishing the toilet structure?

Allot for each category values between 0 and 100% based on the desire for a given speed of implementation.

Note: This is as a ladder function, i.e. values allotted to category 'rapid' will always be equal to or higher than 'moderate' and those allotted to 'moderate' will be equal or higher than 'slow'. This reflects reality as for example, if a 'moderate' speed is acceptable to the user, it automatically implies that 'rapid' speed is acceptable with equal or higher preference.

The following case can realistically never be a possibility: (rapid=0, moderate=0.5, slow=1), as it would imply that a rapid speed of implementation is not desirable whereas a slow one is. This is principally undesirable for infrastructure projects.

1.7.3.26.4 Tech question

How quickly can this technology be implemented?

Allot proportions (%) based on how quickly the treatment technology can be implemented. E.g. if a rapid implementation in less than a week is possible, 100% should be allotted to the category 'rapid'.

1.7.3.26.5 Additional notes

Here, the speed with which a technology can be implemented is judged based on multiple considerations, such as whether a technology requires more complex materials that might not be locally accessible in a humanitarian context. Technologies can be rapidly implemented (rapid = 1, moderate = 0, slow = 0) if prefabricated units are available and can be easily transported to the location. The speed of implementation is reduced if concrete is used as generally a minimum time of 7 days is required for the curing of concrete. The speed of implementation is further reduced if the construction or design are complex and require time (e.g. digging is required or ventilation system needs to be designed) as this can cause a delay when setting up the technology. Finally, technologies that require a start-up time (e.g. for the biological activity to reach its full potential) are considered as 'slowly' implemented.

1.7.3.27 Speed of Implementation For Treatment

1.7.3.27.1 Why is it relevant?

The criterion was chosen as relevant for humanitarian contexts by experts in a study by (Jain and Ilmanen, 2021). In a humanitarian crisis sanitary facilities are implemented that require treatment of the collected material (e.g. emptying and treatment of excreta in a latrine). To avoid contaminating the camp and surrounding area with these output products they need adequate treatment. Therefore, a faecal sludge treatment system needs to be developed before the storage technologies are completely filled. Certain technologies might require too much time to design and construct to be adequate in a humanitarian context. To account for this the speed of implementation of treatment is considered an important proxy for technology appropriateness in humanitarian contexts.

1.7.3.27.2 Definition

The criterion has been developed specifically and is only applicable for humanitarian contexts.

Semi-quantitative estimates of the performance of each technology given the preference for time within which a functional treatment system is required in a specific case. It is based on the following three categories created to facilitate comparison between different technologies:

- **Rapid**: refers to implementation within a few days to up to one week.
- **Moderate**: refers to an implementation time between a few weeks up to three months.
- **Slow**: refers to an implementation time longer than three months.

A treatment system is considered to be functional after its expected construction time and start-up time if any is required (e.g. for biological processes). In the implementation phase, functional treatment system comes often after having reached toilet coverage and safe onsite containment. Therefore, it is relevant to consider this criteria more in the stabilization phase of humanitarian context. This criterion is applicable to (semi-) centralized treatment technologies (FG T) only. A treatment system is considered to be functional after its expected construction time and start-up time if any is required (e.g. for biological processes).

The speed of implementation can be judged based on many factors such as the local availability of materials as well as prefabricated units, concrete curing time, required start up time, etc.

1.7.3.27.3 Case questions

How acceptable are the following speeds of implementation for realising a functional faecal sludge treatment technology?

Allot for each category values between 0 and 100% based on the desire for a given speed of implementation.

Note: This is as a ladder function, i.e. values allotted to category 'rapid' will always be equal to or higher than 'moderate' and those allotted to 'moderate' will be equal or higher than 'slow'. This reflects reality as for example, if a 'moderate' speed is acceptable to the user, it automatically implies that 'rapid' speed is acceptable with equal or higher preference.

The following case can realistically never be a possibility: (rapid=0, moderate=0.5, slow=1), as it would imply that a rapid speed of implementation is not desirable whereas a slow one is. This is principally undesirable for infrastructure projects.

1.7.3.27.4 Tech question

How quickly can this technology be implemented?

Allot proportions (%) based on how quickly the treatment technology can be implemented. E.g. if a rapid implementation in less than a week is possible, 100% should be allotted to the category 'rapid'.

1.7.3.27.5 Additional notes

A user enters preferences at what point of time the storage (FG S) volumes need to be emptied the first time and/or a functioning treatment system of the faecal sludge/blackwater is necessary.

Here, the speed with which a technology can be implemented is judged based on multiple considerations, such as whether a technology requires more complex materials that might not be locally accessible in a humanitarian context. Technologies can be rapidly implemented (rapid = 1, moderate = 0, slow = 0) if prefabricated units are available and can be easily transported to the location. The speed of implementation is reduced if concrete is used as generally a minimum time of 7 days is required for the curing of concrete. The speed of implementation is further reduced if the construction or design are complex and require time as this can cause a delay when setting up the technology. Finally, technologies that require a start-up time (e.g. for the biological activity to reach its full potential) are considered as 'slowly' implemented.

1.7.3.28 Scalability

1.7.3.28.1 Why is it relevant?

The criterion was chosen as relevant for humanitarian contexts by experts in a study by (Jain and Ilmanen, 2021). Planning sanitation facilities during a humanitarian crisis is difficult since the future is often unpredictable and changes happen fast. To at least account for a changing number of users, for example due to a rising number of refugees, the criterion "Scalability" was developed. It is supposed to judge whether a technology can adapt to such a change in population size and considered therefore an important proxy for technology appropriateness in humanitarian contexts.

1.7.3.28.2 Definition

The criterion has been developed specifically and is only applicable for humanitarian contexts.

Qualitative estimates of the performance of each technology with reference to its scalability given the expected increases in population size for a specific case. It is based on two categories:

- **Easy**: refers to if the technology can be easily up-scaled to accommodate changing number of users.
- **Difficult**: refers to difficulty in achieving the above.

Scalability is either possible due to a flexible design that allows for larger inputs or a modular design where units can be added to extend capacity. The focus is on the technological feasibility to scale up and limitations such as space or economics are not considered. The criterion only considers if a technology can be up-scaled and not whether it can be downscaled.

If this criterion is used for screening, stakeholders need to agree on the importance of scalability. If this is not the case the criterion should not be used for screening but considered in more detail when evaluating and discussing trade-offs of options appropriate options with all stakeholders.

The criterion is implemented for storage and treatment (FG S), conveyance (FG C) and (Semi-) centralized treatment (FG T) technologies.

1.7.3.28.3Case questions

How important is it for the case that the treatment capacity can be easily extended (to accommodate an increase in population)?

Allot the proportions (%) based on the importance of scalability for the case. The sum of both values must be 100%.

1.7.3.28.4Tech question

What is the performance of the technology if its capacity needs to be scaled up?

Allot the performance (between 0 and 100%) for the category 'difficult' based on how well the capacity of the technology can be extended. To avoid technologies from being discarded (as it is always possible to scale-up by building a new unit of the technology), one should refrain from entering the value 0% for 'difficult'. For the category 'easy' the performance is always 100%.

You can use the following examples
(easy – difficult):

- → 100% - 100%: Treatment capacity of a technology can be easily extended. Alternatively, a technology in FG S can be replicated quickly and allows therefore easy upscaling.
- → 100% - 80%: Technology can be extended or replicated, but there are some drawbacks.
- → 100% - 50%: Technology is complete and difficult to extend. However, it might be able to accept changing (flow/load) inputs and therefore to some degree an increasing number of users. The technology can be scaled up by building an additional unit though this is not always easy.
- → 100% - 30%: Technology is complete and very difficult to extend. Building an additional unit is sometimes possible, but very difficult due to long start-up times, complex designs, difficult construction, etc..

1.7.3.29 Construction Parts Supply

1.7.3.29.1 Why is it relevant?

The criterion has been developed and implemented specifically for humanitarian contexts, where accessibility of construction materials might be limited or special prefabricated parts might cause delays and higher costs due to the required transportation. Different sanitation technologies require different kinds or parts that might make them more or less suitable in humanitarian contexts with limited accessibility to construction materials. For cases that are not in humanitarian contexts, it is assumed that the parts required to build the technology are available and only spare parts limit the technology appropriateness. The construction parts supply is considered an important proxy for technology appropriateness in humanitarian contexts.

1.7.3.29.2 Definition

Construction parts supply is applied specifically for humanitarian contexts, where accessibility of construction materials might be limited or special prefabricated parts might cause delays and higher costs due to the required transportation. It is a qualitative estimate of the feasibility of the construction of technology given a certain construction parts availability in a specific case. It is based on a scale of three categories:

- **Simple**: conventional parts generally locally available (e.g. simple metal or wood parts, covers, slabs).
- **Technical**: technical parts generally available (e.g. a siphon).
- **Special**: parts that need to be specifically manufactured (e.g. a membrane).

1.7.3.29.3 Case questions

What level of accessibility do different types of parts (required for construction) have for the case?

Allot the performance (between 0 and 100%) for each category based on how easily such parts can be accessed in the case area. This has to be filled in as a ladder function: ‘simple’ construction parts’ value is always higher or equal to ‘technical’ which is always higher or equal to ‘special’, the most limiting category.

1.7.3.29.4 Tech question

What are the different kinds of parts that are required to build this technology?

Allot the proportions (%) of the different types of parts of the technology.

1.7.3.29.5 Additional notes

The technology attributes for this criterion have similar proportions to the criterion “Spare Parts Supply” though in some cases “Construction Parts Supply” receive higher proportions for 'simple' parts as more of them are required to initially construct the technology.

It has to be assessed individually what "locally accessible" means (regional/national level?) but it should be possible to bring parts quickly to the construction site.

1.7.4 Currently implemented additionally evaluation criteria

The technology library also includes data for a number of additional evaluation criteria which should allow to further compare system options identified with SANTIAGO. These criteria however are not used for the technology appropriateness filter of SANTIAGO as they are only very rough estimates and not suitable for screening as not independent from preferences and trade-offs. The currently implemented additional evaluation criteria are Capital Expenditure (Capex) Requirements, Operational Expenditure (Opex) Requirements and Technical Maturity.

1.7.4.1 Capital Expenditure (Capex) Requirements

1.7.4.1.1 Why is it relevant?

Different sanitation technologies demand different capital expenditures: While some require only little upfront investment, other technologies require large quantities of material, a lot of labour and a large area of land. This leads to high costs. The capital expenditure requirements are therefore an important proxy for technology appropriateness.

1.7.4.1.2 Definition

The capital expenditure requirement level presents an indication of the expected level of investment costs that will arise from the implementation of a given technology. It is based on the estimation of required resources using expert judgement. Three types of required resources are considered, namely, material, labour, and land. The criterion investment requirements can indicate the investment cost levels when considered together with local market prices for different resources.

The judgement is made by comparing technologies per functional group. For technologies from the functional group U and S, the judgement is made based on one typical unit and not per user. For technologies belonging to functional groups C, T, and D, the judgement is made for applications of comparable scale and per user. For each technology, the quantities of material, labour, and land are individually judged and allotted a value 1, 2, or 3 indicating low, medium, high, respectively. The final score for any technology is then determined based on the sum of points from the above three parameters assuming that they all have the same weight.

- **Low cost (3 points)**: means that only small amounts of material, labour and land are required.
- **Medium cost (4 to 6 points)**: implies that medium amounts of material and/or labour and/or land are required.
- **High cost (7 to 9 points)**: implies that large amounts of material and/or labour and/or land are required.

The capex (and opex) requirement level are not meant to provide sufficient information to select a certain technology. It merely provides additional information for comparing different sanitation system configuration options. It must be looked at together with other criteria such as resource recovery, emissions, or appropriateness. A key consideration is also that the final costs not only depend on local market prices but also on economies of scale and who of the stakeholders will pay for the costs depending on different technologies. Thus, for a detailed evaluation and selection of the most preferred option, investment and operation requirement levels are not enough but a context-specific cost estimation will be required based on local unit prices, financial arrangements, and economies of scale.

1.7.4.1.3 Case questions

This is a case-independent criterion and there are therefore no case-specific questions.

1.7.4.1.4 Tech question

What is the capital expenditure (Capex) requirement level of the technology?

Fill in by adding 1 to the category that applies.

1.7.4.2 Operation Expenditure (Opex) Requirements

1.7.4.2.1 Why is it relevant?

Different sanitation technologies cause different expenditures during operation: While some can be operated with a tight budget, the operation of other technologies causes substantial costs due to material, labour or electricity/fuel requirements. Operation Expenditure Requirements are therefore an important proxy for technology appropriateness.

1.7.4.2.2 Definition

The operation expenditure requirement level presents an indication of the expected level of investment costs that will arise from the implementation of a given technology. It is based on the estimation of required resources using expert judgement. Three types of required resources are considered, namely, material, labour, and electricity/fuel. The criterion operation requirements can indicate the operation cost levels when considered together with local market prices for different resources.

The judgement is made by comparing technologies per functional group over a lifetime of 10 years. For technologies from the functional group U and S, the judgement is made based on one typical unit and not per user. For technologies belonging to functional groups C, T, and D, the judgement is made for applications of comparable scale and per user. For each technology, the quantities of material, labour, and electricity/fuel are individually judged and allotted a value 1, 2, or 3 indicating low, medium, high, respectively. The final score for any technology is then determined based on the sum of points from the above three parameters assuming that they all have the same weight.

- **Low cost (3 points)**: means that only small amounts of material, labour and electricity/fuel are required.
- **Medium cost (4 to 6 points)**: implies that medium amounts of material and/or labour and/or electricity/fuel are required.
- **High cost (7 to 9 points)**: implies that large amounts of material and/or labour and/or electricity/fuel are required.

The opex (and capex) requirement level is not meant to provide sufficient information to select a certain technology. It merely provides additional information for comparing different sanitation system configuration options. It must be looked at together with other criteria such as resource recovery, emissions, or appropriateness. A key consideration is also that the final costs not only depend on local market prices but also on economies of scale and who of the stakeholders will pay for the costs depending on different technologies. Thus, for a detailed evaluation and selection of the most preferred option, investment and operation requirement levels are not enough but a context-specific cost estimation will be required based on local unit prices, financial arrangements, and economies of scale.

1.7.4.2.3 Case questions

This is a case-independent criterion and there are therefore no case-specific questions.

1.7.4.2.4 Tech question

What is the operation expenditure (Opex) requirement level of the technology?

Fill in by adding 1 to the category that applies.

1.7.4.3 Technical Maturity

1.7.4.3.1 Why is it relevant?

Sanitation technologies differ in how established and therefore technically mature they are: While some have only been applied in pilot projects and few contexts, other technologies have proved to be operational in many contexts. The technical maturity is therefore an important proxy for technology appropriateness.

1.7.4.3.2 Definition

The technical maturity presents an indication of how well-established the technology is. It indicates how certain the information on its performance is and how much practical experience there exists related to it. It is based on three different levels derived based on the technology readiness level (TRL):

- **Low**: implies that the technology has been applied in pilot projects, i.e. TRL 5. Technologies with a TRL lower than the pilot scale are not considered here.
- **Medium**: implies that the technology is emerging and has been demonstrated in one or more different contexts, i.e. TRL 6 to 8.
- **High**: implies that the technology is established and operational in one or more contexts, i.e. TRL 9.

The technical maturity level is meant to provide additional information when comparing different locally appropriate sanitation system options to select the preferred one in the given case.

1.7.4.3.3 Case questions

This is a case-independent criterion and there are therefore no case-specific questions.

1.7.4.3.4 Tech question

What is the technical maturity of the technology?

Fill in by adding 1 to the categories that apply.

1.7.5 Currently implemented substances and transfer coefficients

1.7.5.1 Currently implemented substances

So far, we have defined transfer coefficients for four substances that typify different properties: total phosphorus (TP), total nitrogen (TN), total solids (TS), and water (H2O). All four substances are relevant as indicators for resource recovery and pollution potential. Both phosphorus and nitrogen have value and crucial significance: as important macronutrients, there are resources to be recovered; and as environmental pollutants, there are emissions to be minimised. Total solids can be used as a proxy for energy that could be recovered, for example, in the form of briquettes or biochar, as well as for organic matter that could be recovered as soil amendment. If discharged into the environment, total solids also has significant pollution potential. Water is under increasing pressure in many urban areas and has become a scarce commodity which should be either saved or reused.

For TN and TS, the behaviour is also more difficult to predict than for TP and water. Water is a special case because the inflowing masses vary significantly depending on the source (e.g. dry toilet versus cistern-flush toilet) and from a sustainability perspective, both the requirement and the recovered masses are interesting.

We are aware that these are not the only performance indicators required for the evaluation of the main decision criteria. However, to align decisions with the SDGs, the optimized use of natural resources and the minimisation of losses to the environment (both services provided by many technology innovations) become more relevant than ever.

There are two main general interests in the *SanitationSystemMassFlow* model. First, knowledge on the substance flow and emissions to the environment is gained. And secondly, options and potentials of the different sanitation systems for recovery and reuse of these substances are better understood.

In the following, the interest in the used substances, their sources, fates in the treatment process, and transfer coefficients are described in more detail.

1.7.5.2 Phosphorus

1.7.5.2.1 Interest and reuse potential

Phosphorus (P) is an essential nutrient for plant growth and may cause algae bloom in water bodies, leading to excessive oxygen consumption and oxygen free zones (Tchobanoglous et al., 2009). As phosphates are not reduced like organic matter, but remain in the cycle, the discharge of effluents from sanitation systems containing P can be problematic. Because P is an important plant nutrient, the recovery of P from sanitation systems can be financially attractive and achieved through different methods (e.g. irrigation with effluent, composting of sludge, or struvite production (Etter et al., 2011; Jönsson et al., 2004).

1.7.5.2.2 Sources of P in wastewater and chemical characteristics

In raw wastewater P is found in different forms as organic phosphates, inorganic orthophosphates, and polyphosphates. While organic phosphates have physiological origin, inorganic phosphates originate mainly from detergents and other household chemicals (von Sperling, 2007). Humans excrete 30 to 50% of P in faeces and the other 50 to 70% in urine (Montangero and Belevi, 2007; Rose et al., 2015). As detergents can account for up to 50% of P in wastewater, it is vital to know if greywater enters a treatment system or not (von Sperling, 2007).

Orthophosphates, such as PO_3^-, HPO_4^{2-}, $H_2PO_4^-$ and H_3PO_4, are directly available for biological metabolism, in which of these forms they occur depends on the pH (Montangero and Belevi, 2007). Polyphosphates are complex molecules, which slowly transform to the orthophosphate forms through hydrolysis and can then be consumed by microorganisms (Tchobanoglous et al., 2009; von Sperling, 2007).

The bigger part (~75%) of phosphorus in raw domestic sewage is soluble, comprised of the inorganic forms, as well as part of P bound to soluble organic matter. The remaining ~25% are organic P bound to particulate organic matter (Tchobanoglous et al., 2009; von Sperling, 2007).

1.7.5.2.3 Treatment process

Phosphorus is required as a growth nutrient for microorganisms that stabilise organic matter during treatment (von Sperling, 2007). Consequently, biological removal of phosphorus is based on the removal of phosphate accumulating organisms. Removal of phosphorus by physical-chemical processes after biological treatment can polish the effluent and result in very low P (Sasse, 1998; von Sperling, 2007). Transformation or storage of P (e.g. in compost) are additional ways of treatment, with the aim of recovery.

1.7.5.2.4 Determination of transfer coefficients for P

For the *SanitationSystemMassFlow* model, we use Total phosphorus (TP) to describe the flows of P through sanitation systems because most of the consulted research literature on the TCs for P in sanitation technologies uses TP as a measurement. A few literature examples also look at another type of phosphorus. In these cases, estimations were transformed to TP. The uncertainties that come with this procedure are considered in the corresponding concentration factor.

1.7.5.3 Nitrogen

1.7.5.3.1 Interest and reuse potential

Just like phosphorus, nitrogen (N) is a fundamental nutrient for plant growth and a potential pollutant of water bodies, leading to algae growth and eutrophication (Mudrack and Kunst, 2003). Adverse impacts on humans are caused by nitrite (NO_2^-) in drinking water, as it can cause illness (methemoglobinemia). In the form of free ammonia gas (NH_3), it is toxic to fish (von Sperling, 2007). During nitrogen conversions in wastewater treatment processes, nitrous oxide (N_2O) is produced (Kampschreur et al., 2009). N_2O emission are not discussed further here but accounted for by air losses of total nitrogen.

Nitrogen is also a valuable fertiliser. During composting and drying of faeces and sludge, a high percentage of nitrogen volatises (Meinzinger, 2010). The rest remains retained in the biosolid. High N recoveries can be achieved by direct recovery from urine.

1.7.5.3.2 Sources of N in wastewater and chemical characteristics

Nitrogen can take on different oxidation stages in water, the changes between which are often brought about by bacteria. Additionally, the changes in oxidation stages vary with the availability of free oxygen in the water, i.e. aerobic or anaerobic conditions (Tchobanoglous et al., 2009). The chemistry of nitrogen in wastewater treatment is, thus, fairly complex.

In domestic wastewater, N is mainly found as organic nitrogen and ammonia. About 80 to 90% of N in domestic wastewater originates from urine as urea; the remaining 10 to 20% come from faeces and are mainly in the form of proteinaceous matter (Montangero and Belevi, 2007; Rose et al., 2015). Urea is rapidly hydrolysed to ammonia and is detectable in small quantities only in sewage. In aquatic solutions, ammonia exists in two forms: ammonium ions (NH_4^+) and ammonia (NH_3) as shown in the equilibrium reaction in:

$$NH_4^+ \leftrightarrow NH_3 + H^+$$

The distribution of ammonia forms here is dependent on the pH. At pH = 9.25, the reaction is in equilibrium, while, at a higher pH, it is displaced to the right and more gaseous ammonia is released (Tchobanoglous et al., 2009). In typical raw domestic sewage., the pH ranges around 7 and consequently ammonia is predominantly present as NH_4^+ (von Sperling, 2007).

1.7.5.3.3 Treatment process

Nitrogen from wastewater undergoes two main processes during treatment, i.e. nitrification and denitrification. Nitrification is a two-step process in which ammonia is first oxidised to nitrite and then to nitrate (Tchobanoglous et al., 2009). The oxidation is carried out by two groups of autotrophic bacteria under aerobic conditions as they consume oxygen. Denitrification occurs under anoxic conditions. Consequently, if essential nitrogen removal is required, the treatment needs to comprise a mixture of aerobic and anaerobic conditions (Sasse, 1998).

1.7.5.3.4 Determination of transfer coefficients for N

Different forms of nitrogen can be and are measured in wastewater treatment monitoring, often according to the treatment process and prevailing form of N. A short overview of the commonly measured forms of N is given here (von Sperling, 2007):

Organic nitrogen (No):	Nitrogen in the form of proteins, amino acids and urea
Ammonia:	Ammonium ions (NH_4^+) and ammonia gas (NH_3), produced by the decomposition of organic nitrogen
Nitrite:	NO_2^-, product of first oxidation stage of ammonia, basically not found in raw sewage
Nitrate:	NO_3^-, final product of ammonia oxidation, basically not found in raw sewage
Total Nitrogen:	Includes organic nitrogen, ammonia, nitrite and nitrate
Total Kjeldahl nitrogen (TKN):	Organic nitrogen and ammonia together

For the *SanitationSystemMassFlow* model, Total nitrogen (TN) is used to describe the flows of N through sanitation systems. Many of the studies considered for the determination of TCs, however, did not measure TN, but did measure other forms of N. If TN and an additional form of N were measured in one literature source, the ratio of these two was determined and applied to other literature for the same or similar treatment processes in order to convert all values found in the literature to TN. Ratio estimations were made based on the measured form of N and personal knowledge of the nitrogen pathway in the respective technology. The uncertainties that come with this procedure are represented by the corresponding concentration factor.

1.7.5.4 Total Solids

1.7.5.4.1 Interest and reuse potential

Excessive discharge of total solids (TS) into water bodies induces microbial growth and can, thus, lead to a lowering of the dissolved oxygen availability in water. Aquatic life is negatively impacted and eutrophication may occur. Because of this, determining flows of TS in sanitation systems is important. Moreover, TS can be used as indicator for energy content or for organic carbon content, which is a valuable soil amendment. For both relationships, TS-energy and TS-organics, other factors, especially the volatile and fixed matter content are important. The subchapter "*Energy in wastewater*" goes into detail about the relation of TS and energy.

1.7.5.4.2 Sources of Total Solids in wastewater and chemical characteristics

The term Total Solids (TS) comprises all matter in wastewater which is not water and which remains after evaporation and drying (Hauser, 1996). Besides faeces, urine and paper from toilet usage, food residues and wash waters have to be considered.

Total solids can be further divided by size and state into Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) (Sasse, 1998). TSS includes settleable, as well as non-settleable suspended solids retained by filtration and is often used as an indicator for the performance of wastewater treatment plants (Tchobanoglous et al., 2009). An alternative way of describing the different fractions of TS is by distinguishing them into Volatile Solids (VS) and Fixed Solids (FS). VS burn off or volatilise when heating up to temperatures of around 550°C and are considered the organic matter fraction of wastewater (Tchobanoglous et al., 2009). FS still contains a combustible part (inorganic solids) and inert mineral (ash), see also Figure 9.

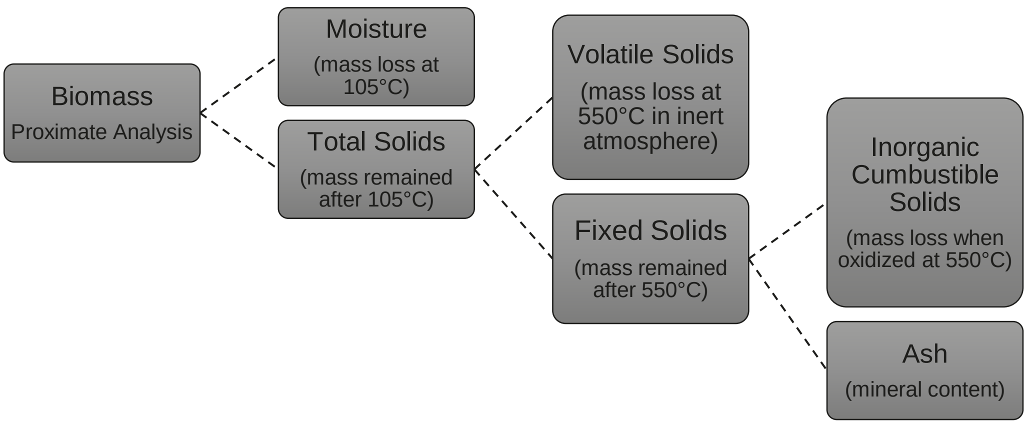


Figure 9. Procedure for determination of biomass volatile solids, fixed solids and ash (Sahito et al., 2013)

1.7.5.4.3 Treatment process

In primary treatment especially, suspended solids get removed through the physical process of sedimentation (50 to 70% of TSS) (Scholz, 2006). A major part of this is organic matter in suspension. As a result, primary sludge contains a big VS fraction, which is the fraction interesting for fertilisation or energy recovery. In secondary treatment, the solids content in wastewater is further reduced through biochemical processes carried out by different kinds of microorganisms (Hauser, 1996; von Sperling, 2007). There are different setups for secondary treatment, all aiming at establishing contact of the microorganisms with the wastewater through biofilms, mixing or guided flow paths (von Sperling, 2007).

1.7.5.4.4 Determination of transfer coefficients for TS

The literature mostly reports on measurements of the removal efficiencies of TSS. To obtain values for TS pathways, studies measuring TS, as well as TSS removal ratios, were used to establish a "removal ratio" between these. The ratios were then applied to other data to calculate transfer coefficients for TS (see, for example, the calculation 13.2.1 in the "Septic Tank" technology factsheet in *chapter 02 - Part B: Technology factsheets*). The uncertainties that result from this procedure are represented by the corresponding uncertainty factor.

Another difficulty that was encountered relates to the consumption of solids by microorganisms. As the used concept of transfer coefficients does not include a "removal" of substance but only describes their transfer into output products, compromises had to be made. In most cases the amount of solids taken up by microorganisms was considered as transferred to sludge. In composting and dehydration technologies, it was considered as air loss.

1.7.5.4.5 Energy from wastewater

There are different ways energy can be gained from wastewater. Biogas is produced in anaerobic digestion of wastewater sludge and can be used for electricity production or as heating energy. Other technologies for thermal processing of faeces or faecal sludge in mono- and co-combustion include pelletising or briquetting (Werther and Ogada, 1999).

To estimate the energy that can be gained through the combustion of biomass solid fuels, the composition of the fuel is of importance. While volatile and fixed solids contribute to the calorific value, high ash and moisture content have a negative effect (Sheng and Azevedo, 2005; Yin, 2011).

The following equation can be used to calculate the gross calorific value (GCV) of biomass, based on the amount of fixed and volatile solid content minus ash (Sahito et al., 2013).

$$\mathrm{GCV}\ [\mathrm{MJ/kg}] = 0.21575\ (\mathrm{VS}) + 0.07492\ (\mathrm{FS}) - 0.08426\ (\mathrm{ash})$$

In the case of faecal sludge, ash originates, for example, from indigestible nutrients and sand from pit linings and increases slagging and fouling (Hafford et al., 2017; Rose et al., 2015). The moisture content of the fuel again depends on the drying technology.

The heating value of faecal sludge varies considerably, depending on initial composition, storage duration and containment types (Strande et al., 2014). It has, for example, been shown that anaerobic digestion of faecal sludge reduces the readily degradable organic fraction into ash and lowers the calorific value (Andriessen et al., 2019). Dried faeces or sewage sludge, therefore, have a higher calorific value than anaerobic digested sludge (Hafford et al., 2017).

In the same way, energy recovery in the form of biogas, which is based on methane production from anaerobic digestion, works best from primary sludge. Most organic matter is contained in settleable solids, collects here and can be digested (Shizas and Bagley, 2004; Zhang and Li, 2017).

1.7.5.5 Water

1.7.5.5.1 Interest and reuse potential

Wastewater reuse is an important part of urban water cycles. In about 80% of the towns in Africa, Asia and Latin America, use wastewater, non- or partially treated, for irrigation (Meinzinger, 2010). This due to the scarcity of fresh water, high prices, or convenience. Fertilisers are also expensive, and the nutrients and organic matter contained in the wastewater are an added value. Moreover, the availability can be linked to water consumption (Meinzinger, 2010). As treated wastewater still contains pathogens, it should be handled with care (Sasse, 1998) and treated according to the purpose (e.g. if used for irrigation, nutrient content is not a problem). Guidelines on the usage of treated wastewater are published by various organisations, such as the WHO (von Sperling, 2007). To plan the irrigation options with reclaimed water, the quantities available after losses in the sanitation systems are important to know better.

1.7.5.5.2 Sources of water and chemical characteristics

Water in sanitation systems can originate from various sources within households: toilet flushing, bathing, wash water, kitchen sinks and so on. Depending on the country, type of toilet, culture and habit, different flows are to be expected. Additionally, there is stormwater, which may infiltrate into sanitation systems and influence the flow rates. In this study, only flush water is considered as entering the system.

1.7.5.5.3 Treatment process

In most treatment technologies considered in this study, there is little change in the amount of water flow. Some is retained when solid and liquid phase are separated. The biggest losses of water are due to evapotranspiration and infiltration.

1.7.5.5.4 Determination of transfer coefficients for water

Little data was found on the pathway of water in sanitation technologies, most likely because as mentioned before, there is almost no change in quantity. If technologies are open to the atmosphere, evaporation may occur. Infiltration into soil due to leakages is another pathway but is not well documented. Consequently, a lot of TC used in this study are based on expert judgement.

1.7.6 Currently implemented inflows

For the four implemented substances, we also defined inflows for currently implemented toilet sources using values from international literature. These inflow values are average literature from all over the world and therefore are quite generic. For the application in a specific case, those values could be adjusted to account for the local diet and flush water usages.

Table 9: Overview of estimated inflow substance masses based on international literature per person and year. TP: total phosphorus, TN: total nitrogen, TS: total solids, H2O: water. The amount of TP, TN, and TS are the same for all sources; only

the water inflow masses depend on the flush volume. The assumed amount of flushing water is 2L/day/person for the pour flush toilet and 60 L/day/person for the cistern flush toilet.

Inflows in kg year^{-1} for 1 person equivalent	Total phosphorus	Total nitrogen	Total solids	Water
Cistern Flush Toilet	0.548	4.55	32.12	22’447.1
Pour Flush Toilet	0.549	4.56	32.13	1’277.1
Dry Toilet	0.550	4.57	32.14	547.1
Urine Diverting Dry Toilet	0.551	4.58	32.15	547.1
Urine Diverting Flush Toilet	0.552	4.59	32.16	22’447.1
Urinal	0.370	4.00	21.54	510.98
Controlled Open Defecation (humanitarian)	0.554	4.61	32.18	547.1

Table 10: Detailed overview on raw data and used literature to estimate inflow substance masses. *Retained values

		g/P/d	Kg/P/Year	Reference
TP	**Urine**		**0.365***	(Vinnerås, 2002; Vinnerås et al., 2006)
			0.3	(Jönsson et al., 2004)
	Faeces		**0.183***	(Vinnerås, 2002; Vinnerås et al., 2006)
			0.1	(Jönsson et al., 2004)
	Total	1	0.365	(von Sperling, 2007)
			0.548*	(Vinnerås, 2002; Vinnerås et al., 2006)
			0.4	(Jönsson et al., 2004)
TN	**Urine**		**4***	(Vinnerås, 2002; Vinnerås et al., 2006)
		11	4.015	(Rose et al., 2015)
			2.3	(Vinnerås, 2002; Vinnerås et al., 2006)
	Faeces		**0.55***	(Vinnerås, 2002; Vinnerås et al., 2006)
		1.8	0.657	(Rose et al., 2015)
			0.3	(Jönsson et al., 2004)
	Total	8	*2.92*	(von Sperling, 2007)
			4.55*	(Vinnerås, 2002; Vinnerås et al., 2006)

			4.672	(Rose et al., 2015)
			2.6	(Jönsson et al., 2004)
TS	**Urine**	59	**21.535***	(Rose et al., 2015) dry weight
		14	5.11	(Rose et al., 2015) summary
		45.4	16.571	(Meinzinger, 2010), Annex B
	Faeces	29	**10.585***	(Rose et al., 2015) dry weight
		32	11.68	(Rose et al., 2015) summary
		40.4	14.746	(Meinzinger, 2010), Annex B
	Total	180	*65.7*	(von Sperling, 2007)
			32.12*	(Rose et al., 2015),from dry weight
			16.79	(Rose et al., 2015) 2015 summary
			31.317	(Jönsson et al., 2004)
H_2O	**Urine**		529	(Vinnerås et al., 2006)
		1399.9	**510.98***	(Rose et al., 2015)
	Faeces		40	(Vinnerås et al., 2006)
		99	**36.135***	(Rose et al., 2015)
	Total		*569*	(Vinnerås et al., 2006)
			547.11*	(Rose et al., 2015)
Flushwater	**Dry toilet**		0	
	Pour flush		2555	
			547.5	
			730*	2 litres, own experience of Nepal, only once per day
	cistern flush		**21900***	10 litres, own experience, 5+1 times per day
	UDDT		0	

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02 Part B: Technology factsheets

— 2.1 OVERVIEW

In this Part B, the detailed data behind the SANTIAGO technology library are available. It is a compilation of (Gensch et al., 2018; Mcconville et al., 2020; Tilley et al., 2014) and many other references to establish appropriateness attributes and transfer coefficients. The condensed JSON format is available here:

www.github.com/santiago-sanitation-systems/Sanitation-technology-library

Based on the here presented examples of data, the SANTIAGO user can develop or adjust the JSON library to modify or add Technologies or appropriateness attributes.

— 2.2 EXPLAINING THE TECHNOLOGY SHEETS

The SANTIAGO technology library is based on different technology sheets. Each technology has a sheet containing the quantified technology attributes and transfer coefficients including the data sources and assumptions behind them. The PDF sheets are to be read according to the following overview:

Table 11: Overview of the technology sheet PDFs.

FUNCTIONAL GROUP	Functional Group of the Technology (see *chapter 1.2.4 Functional groups*): user interface (U), collection and storage/treatment (S), conveyance (C), (semi-)centralized treatment (T), use and/or disposal (D)
NUMBER	Number identifying technology in the technology list
UNIQUE IDENTIFIER	Code that uniquely identifies each technology
DATA COMPILER	All persons who compiled the data in the technology sheet
REVIEWER	All persons who reviewed the technology sheet
INPUT PRODUCT	Input products of the technology; for an overview of all products and more information see *chapter 1.2.2 Sanitation Products*.
OUTPUT PRODUCT	Output products of the technology; for an overview of all products and more information see *chapter 1.2.2 Sanitation Products*.
RELATIONS	Describes the relation between the input and between the output products: ‘OR’: any possible combination of products entering/leaving the technology ‘XOR’: a mutual exclusion with only one of the products entering/leaving the technology ‘AND’: a compulsory co-existence of all products entering/leaving the technology For technologies in the FG C (conveyance): the order of output products separated by “>” indicates which output product is most/more dominant in case different products get mixed during conveyance. For example if blackwater AND greywater enter a

	conventional sewer, the output product will be considered to be transported blackwater (as blackwater > greywater).
COMMENTS	Additional comments
EXTENDED PROPERTIES	Includes evaluation criteria of a technology that are not part of the appropriateness assessment.

Appropriateness Attributes

Overview of the quantified screening criteria for the technology including the underlying assumptions and data sources. Each Screening Criterion has a unique identifier (e.g. “water_supply” for criterion “Water Supply”). It is further defined by its Type “*Performance*/*PDF*” and its Function Type “*Categorical/Trapez*”. For a further explanation of the attributes and functions refer to *chapter 1.4.2 Appropriateness Profiles*.

For trapez functions the unit and for categorical functions the possible categories are given in column “UNITS/CATEGORIES”. The actual quantified attribute values can be found in the column “PARAMETERS”, while the reasoning for these values is explained in the following column “DATA SOURCE/ASSUMPTIONS”.

Some attributes are not considered appropriate for certain functional groups and are marked as “FALSE” and “NA”. For example, technologies in the functional group user interface (FG U) do not need to be evaluated according to the acceptable “Water Volume” (“water_vol_cont”).

Table 12: Example of screening criteria with the underlying assumptions and data sources.

ATTRIBUTE	TYPE AND FUNCTION	ATTRIBUTE USED FOR THIS TECHNOLOGY [TRUE/FALSE]	UNITS/ CATEGORIES	PARAMETERS	DATA SOURCE/ ASSUMPTIONS	REVIEW DONE
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 0, public = 0, none = 0)	"Requires a constant source of water“, "Requires less water than a traditional Cistern Flush Toilet“ (Tilley, E. et al. (2014)) It is assumed that UDFTs are not appropriate if there is no in-house water supply.	yes
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA		NA
…	…	…	…	…	…	…

Transfer coefficients

Overview of the quantified transfer coefficients as well as the concentration factor for the Dirichlet distribution (k) for the output products of the technology. The technology sheet includes the calculations to determine these transfer coefficients as well as their underlying data sources. For further information on the quantification refer to *chapter 1.4.3 Quantifying Transfer Coefficients*.

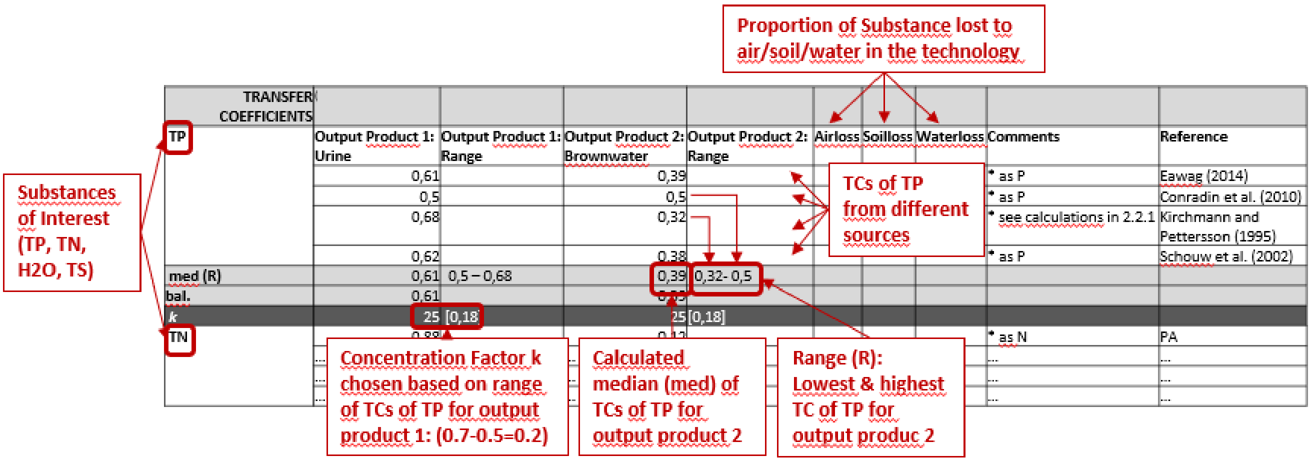

Figure 10: Example of transfer coefficients in the technology factsheets.

Table 13: Example of additional calculations to the transfer coefficients in the technology factsheets.

Additional Information: Calculation 2.2.1

	N [kg N/P*a]		P [kg P/P*a]		TC_TN	TC_TP
	Median	Range	Median	Range		
Urine	3,4	2.5 - 4.3	0,85	0.7 - 1.0	0,85	0,68
Faeces	0,6	0.5-0.7	0,4	0.3 - 0.5	0,15	0,32

Data from: Kirchmann and Pettersson (1995)

Calculation:

TC_TN Urine =

Mass N in Urine [kg N/P*a]/

Total Mass N (in Urine & Faeces) [kg N/P*a]

0,85 = 3,4 / (3,4 + 0,6)

TC_TN Faeces = Mass N in Faeces

[kg N/P*a]/

Total Mass N (in Urine & Faeces) [kg N/P*a]

0,15 = 0,6 / (3,4 + 0,6)

TC_TP Urine =

Mass P in Urine [kg P/P*a]/

Total Mass P (in Urine & Faeces) [kg P/P*a]

0,68 = 0,85 / (0,85 + 0,4)

TC_TP Faeces = Mass P in Faeces

[kg P/P*a]/

Total Mass P (in Urine & Faeces) [kg P/P*a]

0,32 = 0,4 / (0,85 + 0,4)

Abbreviations:

TP:	Total Phosphorus
TN:	Total Nitrogen
H2O:	Water
TS:	Total Solids
med:.	Median
(R):	Range
bal.:	Balanced Results
k: … []	Concentration factor [and range it was based on]
PA:	Personal Assessment by Author
EJ:	Expert Judgement
Comment: *as…	Chemical form in which the substance was described in the reference
calculations X.X	Further calculations based on information in the source found in the Additional Information

Calculations

The TCs were calculated with the following equation

$$TC_{i,s} = \frac{out_{i,s}}{\sum_{j=1}^{n} in_{j,s}}$$

Where:

- → $out_{i,s}$ = mass of substance s in output product i
- → $in_{j,s}$ = mass of substance s in input product j
- → s = substance of interest

The TCs from different sources are aggregated by determining the median of all found TCs. In some cases the different medians for the TCs of different output products do not sum up to 1. For such cases the results are balanced with the equation below and the balanced results should have a sum of 1.

$$bal.median_{op,1} = \frac{median_{op,1}}{\sum_{i=1}^{n} median_{op,i}}$$

Where:

- → $median_{op,i}$ = median of output product i
- → $bal.median_{op,1}$= balanced median of output product i

The concentration factor for the Dirichlet distribution k can be determined in two ways: Firstly, if literature data is present, it is determined based on the range of values, which we define as the difference between the lowest and the highest TC value mentioned in all sources (see Table 4). Secondly, if the TCs are determined by expert judgement, then the concentration factor k is based on the confidence of the expert (see Table 5).

2.2.1 Customization of Technology Library

Customization includes adding, modifying, removing technologies, products, or criteria:

Technologies can be added by entering all required data for a technology sheet (products, appropriateness criteria, TCs) (see *chapter — 2.2 ExplaIning the technology sheets*). The same way several more detailed versions of the same technology can be set up by copying the original version and adapting it to the personal specifications (e.g. make different types of single pits for different products).

Similarly the generic technology data can be adapted to the specific technologies one wishes to use by changing the appropriateness profiles according to *chapter 1.4.2 Appropriateness Profiles* and the criteria definition in *chapter 1.7.3 Currently implemented screening criteria* or to use more complicated or better validated TC models if more accuracy is needed.

Finally, it is also possible reduce the number of technologies to ones that are applicable for the case study and reduce the computation time of the programme.

— 2.3 CURRENTLY IMPLEMENTED TECHNOLOGIES

A technology is defined by its functional group (FG), its unique identifier (ID), its input and output products as well as the relation between the input as well as the output products, its appropriateness profile and the TCs. A detailed description of each technology can be found online on SaniChoice based on (Gensch et al., 2018; Mcconville et al., 2020; Tilley et al., 2014). A technology belonging to functional group toilet user interface (U) is always a source and does not have any input products (NA), while a Tech belonging to FG reuse or disposal (D) is always a sink and does not have an output product (NA). Additional sources, such as tabs, drainage, or organic solid waste collection bins can also be added and are assigned to a sub-group of U called Uadd.

Table 14: List of currently implemented technologies defined by a unique identifier (ID). The table also contains information on the functional group (FG) of the technology, the input and output products of the technology as well as the relations between the input products as well as the output products.

FG	Name	Unique Identifier (ID)	Input products	Output products	Relations
Uadd	Handwashing Facility	handwashing_facility	freshwater For Santiago: NA	greywater	Input: NA Output: NA
Uadd	Kitchen Sink	kitchen_sink	freshwater For Santiago: NA	greywater	Input: NA Output: NA
Uadd	Organic Waste Bin	organic_waste_bin	organics For Santiago: NA	organics	Input: NA Output: NA
Uadd	Stormwater Collection	stormwater_collection	stormwater For Santiago: NA	stormwater	Input: NA Output: NA
U	Cistern-Flush Toilet	cistern_flush	urine, faeces, flushwater, anal_cleansing_water For Santiago: NA	blackwater	Input: OR, For Santiago: NA Output: NA

U	Pour-Flush Toilet	pour_flush	urine, faeces, flushwater, anal_cleansing_water For Santiago: NA	blackwater	Input: OR, For Santiago: NA Output: NA
U	Dry Toilet	dry_toilet	urine, faeces, anal_cleansing_water For Santiago: NA	excreta	Input: OR, For Santiago: NA Output: NA
U	Urine Diversion Dry Toilet (UDDT)	uddt	urine, faeces For Santiago: NA	urine, faeces	Input: OR, For Santiago: NA Output: AND
U	Urine Diversion Flush Toilet (UDFT)	udft	urine, faeces, flushwater, anal_cleansing_water For Santiago: NA	blackwater, urine	Input: OR, For Santiago: NA Output: AND
U	Urinal	urinal	urine For Santiago: NA	urine	Input: NA Output: NA
U	User Interface for Controlled Open Defecation	u_controlled_od	urine, faeces For Santiago: NA	od_excreta	Input: NA Output: NA
S	Urine Storage Tank	urine_storage_tank	urine	stored_urine	Input: NA Output: NA
S	Double Dehydration Vaults	double_dehydration_vaults	faeces	dried_faeces	Input: NA Output: NA
S	Single Faeces Storage Chamber	single_faeces_storage_chamber	faeces	stored_faeces	Input: NA Output: NA
S	Container-Based Toilet	container_based_toilet	faeces	stored_faeces	Input: NA Output: NA
S	Single Pit	single_pit	faeces, excreta, blackwater	sludge	Input: OR Output: NA
S	Single Ventilated Improved Pit	single_vip	faeces, excreta, blackwater	sludge	Input: OR Output: NA
S	Double Ventilated Improved Pit	double_vip	faeces, excreta	pithumus	Input: OR Output: NA
S	Twin Pits for Pour-Flush Toilets	twin_pits_pour_flush	blackwater	pithumus	Input: NA Output: NA
S	Composting chamber	composting_chamber	faeces, excreta, organics	compost, effluent	Input: OR Output: AND
S	Fossa Alterna	fossa_alterna	faeces, excreta, organics	pithumus	Input: OR Output: NA
S	Onsite Vermi-Composting	onsite_vermi_composting	faeces, excreta, organics, blackwater	effluent, compost	Input: OR Output: AND
S	Septic tank	septic_tank	blackwater, greywater	sludge, effluent	Input: OR Output: AND
S	Raised Latrine	raised_latrine	faeces, excreta	sludge	Input: OR Output: NA
S	Shallow Trench Latrine	shallow_trench_latrine	faeces, excreta	sludge	Input: OR Output: NA
S	Deep Trench Latrine	deep_trench_latrine	faeces, excreta, blackwater	sludge	Input: OR Output: NA
S	Chemical Toilet	chemical_toilet	faeces, excreta	sludge	Input: OR Output: NA
S	Storage Trench for Controlled Open Defecation	s_controlled_od	od_excreta	sludge	Input: NA Output: NA
S	Transfer Station	transfer_station	sludge	transferred_sludge	Input: NA Output: NA
C	Motorized Emptying and Transport of Urine	motorized_emptying_urine	urine, stored_urine, stabilized_urine, concentrated_urine, dried_urine, struvite	NA [for SaniChoice, use x]	Input: OR Output: urine > stored_urine > stabilized_urine >

C					concentrated_urine > dried_urine > struvite
C	Human-Powered Emptying and Transport of Urine	human-powered_emptying_urine	urine, stored_urine, stabilized_urine, concentrated_urine, dried_urine, struvite	NA [for SaniChoice, use x]	Input: OR Output: urine > stored_urine > stabilized_urine > concentrated_urine > dried_urine > struvite
C	Motorized Emptying and Transport of Solids	motorized_emptying_solids	sludge, transferred_sludge, processed_sludge, pithumus, dried_faeces, stabilized_sludge, stored_faeces, organics, compost, pellets, briquettes, biochar, ash	NA [for SaniChoice, use x]	Input: OR Output: sludge > transferred_sludge > processed_sludge > pithumus > dried_faeces > stabilized_sludge > stored_faeces > organics > compost > pellets > briquettes > biochar > ash
C	Human-Powered Emptying and Transport of Solids	human-powered_emptying_solids	sludge, transferred_sludge, processed_sludge, pithumus, dried_faeces, stabilized_sludge, stored_faeces, organics, compost, pellets, briquettes, biochar, ash	NA [for SaniChoice, use x]	Input: OR Output: sludge > transferred_sludge > processed_sludge > pithumus > dried_faeces > stabilized_sludge > stored_faeces > organics > compost > pellets > briquettes > biochar > ash
C	Conventional Gravity Sewer	conventional_sewer	blackwater, effluent, greywater, secondary_effluent, stormwater	NA [for SaniChoice, use x]	Input: R Output: blackwater > effluent > greywater > secondary_effluent > stormwater
C	Simplified Sewer	simplified_sewer	blackwater, effluent, greywater, secondary_effluent	NA [for SaniChoice, use x]	Input: OR Output: blackwater > effluent > greywater >

					secondary_effluent
C	Solids-Free Sewer	solids-free_sewer	effluent, greywater, secondary_effluent	NA [for SaniChoice, use x]	Input: OR Output: effluent > greywater > secondary_effluent
C	Stormwater Drainage	stormwater_drainage	greywater, stormwater	NA [for SaniChoice, use x]	Input: OR Output: greywater > stormwater
T	Urine Bank	urine_bank	transportedurine, transportedstored_urine	transportedstabilized_urine	Input: OR Output: NA
T	Struvite Precipitation	struvite_precipitation	urine, transportedurine, greywater, transportedgreywater	struvite, transportedstruvite, effluent, transportedeffluent	Input: OR Output: AND
T	Nitrification and Distillation of Urine	nitrification_distillation_urine	transportedurine, transportedstored_urine	transportedconcentrated_urine, transportedsecondary_effluent	Input: OR Output: AND
T	Alkaline Dehydration of Urine	alkaline_dehydration_of_urine	transportedurine, transportedstored_urine	transporteddried_urine	Input: OR Output: NA
T	Unplanted Drying Bed Sludge	unplanted_drying_bed_sludge	sludge, transportedsludge, transportedtransferred_sludge	stabilized_sludge, transportedstabilized_sludge, effluent, transportedeffluent	Input: OR Output: AND
T	Planted Drying Bed	planted_drying_bed	sludge, transportedsludge, transportedtransferred_sludge	stabilized_sludge, transportedstabilized_sludge, effluent, transportedeffluent	Input: OR Output: AND
T	Unplanted Drying Bed Dry	unplanted_drying_bed_dry	stored_faeces, transportedstored_faeces pithumus, transportedpithumus	dried_faeces, transporteddried_faeces	Input: OR Output: AND
T	Sedimentation / Thickening Ponds	sedimentation-thickening_ponds	transportedsludge, transportedtransferred_sludge	transportedprocessed_sludge, transportedeffluent	Input: OR Output: AND
T	Co-Composting	co-composting	stored_faeces, transportedstored_faeces, pithumus, transportedpithumus, sludge, transportedsludge, , transportedtransferred_sludge, processed_sludge, transportedprocessed_sludge, organics, transportedorganics	compost, transportedcompost	Input: OR Output: AND
T	Offsite Vermi-Composting	offsite_vermi_composting	stored_faeces, transportedstored_faeces, pithumus, transportedpithumus, sludge, transportedsludge, transportedtransferred_sludge, blackwater, transportedblackwater, organics, transportedorganics	compost, transportedcompost, effluent, transportedeffluent	Input: OR Output: AND
T	Black Soldier Fly Composting	black_soldier_fly_composting	transportedstored_faeces, transportedpithumus, transportedsludge, transportedtransferred_sludge, transportedorganics	transportedcompost	Input: OR Output: NA
T	Ladepa-Pelletizing	ladepa_pelletizing	transportedstored_faeces, transportedsludge, transportedtransferred_sludge, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	transportedpellets	Input: OR Output: NA

T	Briquetting (Sanivation)	briquetting	transporteddried_faeces, transportedstored_faeces, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	transportedbriquettes	Input: OR Output: NA
T	Settler	settler	blackwater, transportedblackwater	effluent, transportedeffluent, sludge, transportedsludge	Input: OR Output: AND
T	Imhoff Tank	imhoff_tank	blackwater, transportedblackwater, greywater, transportedgreywater	effluent, transportedeffluent, sludge, transportedsludge	Input: OR Output: AND
T	Anaerobic Baffled Reactor (ABR)	abr	blackwater, transportedblackwater, greywater, transportedgreywater	effluent, transportedeffluent, sludge, transportedsludge	Input: OR Output: AND
T	Upflow Anaerobic Sludge Blanket Reactor (UASB)	uasb	blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge, pithumus, transportedpithumus	effluent, transportedeffluent, processed_sludge, transportedprocessed_sludge, biogas, transportedbiogas	Input: OR Output: AND
T	Anaerobic Filter	anaerobic_filter	blackwater, transportedblackwater, greywater, transportedgreywater, effluent, transportedeffluent	effluent, transportedeffluent, sludge, transportedsludge	Input: OR Output: AND
T	Sequencing Batch Reactor (SBR)	sbr	blackwater, transportedblackwater, greywater, transportedgreywater, sludge, transportedsludge, transportedtransferred_sludge	processed_sludge, transportedprocessed_sludge, effluent, transportedeffluent	Input: OR Output: AND
T	Waster Stabilization Ponds (WSP)	wsp	transportedblackwater, transportedgreywater, transportedeffluent, transportedstormwater	transportedsludge, transportedsecondary_effluent	Input: OR Output: AND
T	Free-Water Surface Constructed Wetland	free-water_wetland	effluent, transportedeffluent, greywater, transportedgreywater, stormwater, transportedstormwater	secondary_effluent, transportedsecondary_effluent	Input: OR Output: AND
T	Horizontal Subsurface Flow Constructed Wetland	horizontal_wetland	blackwater, transportedblackwater, effluent, transportedeffluent, greywater, transportedgreywater, stormwater, transportedstormwater	secondary_effluent, transportedsecondary_effluent	Input: OR Output: AND
T	Vertical Flow Constructed Wetland	vertical_wetland	blackwater, transportedblackwater, effluent, transportedeffluent, greywater, transportedgreywater, stormwater, transportedstormwater	secondary_effluent, transportedsecondary_effluent	Input: OR Output: AND
T	Aerated Pond	aerated_pond	transportedblackwater, transportedgreywater, transportedeffluent	transportedsludge, transportedsecondary_effluent	Input: OR Output: AND
T	Trickling Filter	trickling_filter	transportedblackwater, transportedgreywater, transportedeffluent	transportedsludge, transportedsecondary_effluent	Input: OR Output: AND
T	Activated Sludge	activated_sludge	transportedblackwater, transportedgreywater, transportedeffluent	transportedsludge, transportedsecondary_effluent	Input: OR Output: AND
T	Lactic Acid Fermentation Treatment	lactic_acid_fermentation_treatment	stored_faeces, transportedstored_faeces, blackwater,	stabilized_sludge , transportedstabilized_sludge	Input: OR Output: AND

			transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge		
T	Caustic Soda Treatment	caustic_soda_treatment	stored_faeces, transportedstored_faeces, blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge	stabilized_sludge , transportedstabilized_sludge, effluent, transportedeffluent	Input: OR Output: AND
T	Urea Treatment	urea_treatment	stored_faeces, transportedstored_faeces, blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge	stabilized_sludge , transportedstabilized_sludge	Input: OR Output: AND
T	Hydrated Lime Treatment	hydrated_lime_treatment	stored_faeces, transportedstored_faeces, blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge	stabilized_sludge , transportedstabilized_sludge, secondary_effluent, transportedsecondary_effluent	Input: OR Output: AND
T	Microbial Fuel Cell	microbial_fuel_cell	transportedurine, transportedeffluent, transportedgreywater	transportedsecondary_effluent	Input: OR Output: NA
T	Algae Cultivation	algae_cultivation	transportedurine, transportedblackwater, transportedeffluent, transportedgreywater	transportedsecondary_effluent	Input: OR Output: NA
T	Membrane Filtration	membrane_filtration	transportedurine, transportedeffluent, transportedgreywater	transportedconcentrated_urine	Input: OR Output: NA
T	Carbonisation	carbonisation	transportedstored_faeces, transporteddried_faeces, transportedsludge, transportedprocessed_sludge, transportedtransferred_sludge	transportedbiochar	Input: OR Output: NA
T	Mono-Incineration	mono_incineration	transportedstored_faeces, transporteddried_faeces, transportedsludge, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	transportedash	Input: OR Output: NA
T	Biogas Reactor	biogas_reactor	blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge, stored_faeces, transportedstored_faeces, pithumus, transportedpithumus, organics, transportedorganics	processed_sludge, transportedprocessed_sludge, biogas, transportedbiogas	Input: OR Output: AND
D	Application of Urine and Nutrient Solutions	application_of_urine	stored_urine, transportedstored_urine, stabilized_urine, transportedstabilized_urine	NA	Input: OR Output: NA
D	Application of Concentrated Urine	application_concentrated_urine	concentrated_urine, transportedconcentrated_urine	NA	Input: OR Output: NA
D	Application of Struvite or Dried Urine	application_struvite_driedurine	struvite, transportedstruvite, dried_urine, transporteddried_urine	NA	Input: OR Output: NA
D	Application of Dried Faeces	application_of_dried_faeces	dried_faeces, transporteddried_faeces	NA	Input: OR Output: NA
D	Application of Compost and Biochar	application_of_compost_biochar	compost, transportedcompost, pithumus, transportedpithumus, biochar, transportedbiochar, ash, transportedash	NA	Input: OR Output: NA

D	Application of Stabilized Sludge	application_of_sludge	processed_sludge, transportedprocessed_sludge, stabilized_sludge, transportedstabilized_sludge, pithumus, transportedpithumus, pellets, transportedpellets, briquettes, transportedbriquettes	NA	Input: OR Output: NA
D	Fill and Cover	fill_and_cover	stored_faeces, transportedstored_faeces, dried_faeces, transporteddried_faeces, pithumus, transportedpithumus, stabilized_sludge, transportedstabilized_sludge	NA	Input: OR Output: NA
D	Biogas Combustion	biogas_combustion	biogas, transportedbiogas	NA	Input: OR Output: NA
D	Briquettes as Fuel	briquettes_as_fuel	briquettes, transportedbriquettes	NA	Input: OR Output: NA
D	Co-Combustion	co_combustion	transportedstored_faeces, transporteddried_faeces, transportedsludge, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	NA	Input: OR Output: NA
D	Soak Pit	soak_pit	effluent, secondary_effluent, greywater, urine, stored_urine, stabilized_urine	NA	Input: OR Output: NA
D	Leach Field	leach_field	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, greywater, transportedgreywater urine, transportedurine, stored_urine, transportedstored_urine	NA	Input: OR Output: NA
D	Irrigation	irrigation	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, stormwater, transportedstormwater	NA	Input: OR Output: NA
D	Fish Pond	fish_pond	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, greywater, transportedgreywater, stormwater, transportedstormwater	NA	Input: OR Output: NA
D	Floating Plant Pond	floating_plant_pond	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, greywater, transportedgreywater, stormwater, transportedstormwater	NA	Input: OR Output: NA
D	Surface Water Disposal	water_disposal	secondary_effluent, transportedsecondary_effluent, stormwater, transportedstormwater	NA	Input: OR Output: NA
D	Surface Disposal and Storage	surface_disposal_and_storage	dried_faeces, transporteddried_faeces, processed_sludge, transportedprocessed_sludge, stabilized_sludge, transportedstabilized_sludge, pithumus, transportedpithumus, compost, transportedcompost	NA	Input: OR Output: NA
D	Borehole Latrine	borehole_latrine	faeces, excreta, blackwater	NA	Input: OR

— 2.4 REFERENCES PART B

* Gensch, R., Jennings, A., Renggli, S. and Reymond, P. (2018) Compendium of Sanitation Technologies in Emergencies, German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA), Berlin, Germany. https://www.eawag.ch/en/department/sandec/projects/sesp/water-sanitation-and-hygiene-in-emergencies/.

* Mcconville, J., Niwagaba, C., Nordin, A., Ahlström, M., Namboozo, V. and Kiffe, M. 2020. Guide to Sanitation Resource-Recovery Products & Technologies : a supplement to the Compendium of Sanitation Systems and Technologies. http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-p-109420.

* Tilley, E., Ulrich, L., Lüthi, C., Reymond, P. and Zurbrügg, C. (2014) Compendium of Sanitation Systems and Technologies - 2nd revised edition, Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland. https://www.eawag.ch/en/department/sandec/publications/compendium/.

— 2.5 TECH FACTSHEETS

In the following pages, all the technology factsheets with its calculations, assumptions and references are listed.

Handwashing Facility

General Information	Values	Data Source
FUNCTIONAL GROUP	Uadd	-
UNIQUE IDENTIFIER (ID)	handwashing_facility	-
DATA COMPILER	Basile Weber	-
INPUT PRODUCT	freshwater For Santiago: NA	 Spuhler, D et al. (2021)
OUTPUT PRODUCT	greywater	Gensch, R. et al. (2018) -> U.7
RELATIONS	Input: NA Output: NA	 Spuhler, D et al. (2021)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 1, city = 1)	Gensch, R. et al. (2018)
management_level	(household = 1, neighbourhood = 1, city = 1)	Gensch, R. et al. (2018)
capex_req_level	3	Spuhler, D et al. (2021)
opex_req_level	3	Spuhler, D et al. (2021)
technical_maturity	3	Spuhler, D et al. (2021)
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 1, public = 1, none = 0)	"A handwashing station has to include a constant source of water and soap. If water is not available, an alcohol-based hand sanitiser (or ash) may be used as an alternative." (Gensch et al. (2018))	
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.8, regular = 0.4, continuous = 0.2)	"Water containers need to be refilled and soap needs to be restocked constantly in public facilities and distributed where handwashing is in private shelters. With piped water, there needs to be a plumber available for minor maintenance work and repairs." (Gensch et al. (2018))	
pipe_supply	Performance, Categorical	FALSE	no pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, no concrete = 1)	no concrete needed	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple =1, technical = 0, special = 0)	"Soap bars and plastic buckets for handwashing stations are usually cheap and locally available" (Gensch et al. (2018))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access	NA	NA	NA
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No special skills needed. (Spuhler, D. et al. (2021))	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No special skills needed. (Spuhler, D. et al. (2021))	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	No special skills needed. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)		
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple =1, technical = 0, special = 0)	"Soap bars and plastic buckets for handwashing stations are usually cheap and locally available" (Gensch et al. (2018))	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Greywater	Range	Airloss	Soilloss	Waterloss	Comments/Specifications	Reference
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

Influent

	Value [kg/pers/yr]	Range	Comments/Specifications	Reference	
					Spuhler et al. (2021)
TP	-	-	negligible	Olupot et al. (2021), Spuhler et al. (2021)	
med (R)	**0**	-	0	0	
k		-	-	-	
TN	-	-	negligible	Spuhler et al. (2021)	
	0.009	0.0003-0.043	16.5 mg N/L	Olupot et al. (2021)	
med (R)	**0**	-	0	0	
k		-	-	-	
H2O	547.5	365-730	1-2L/pers/day for handwashing only	Gensch et al. (2018)	
med (R)	**547.5**	-	0	0	
k		-	-	-	
TS	0.33	0.14-0.657	613.8 mg TS/L [256.8-1200]	Olupot et al. (2021)	

med (R)	**0.33**	-	0	0
k		-	-	-

References

Gensch, R., Jennings, A., Renggli, S. and Reymond, P. 2018. Compendium of Sanitation Technologies in Emergencies. GWN, Eawag, GWC and SuSanA. Berlin, Germany. ISBN: 978-3-906484-68-6

Spuhler, D., de Morais Lima, P., Fritzsche, J., Ilmanen, K., Jain, A., van Sloten, M., & Willimann, C. (2021). SaniChoice Project Team. Department Sanitation, Water and Solid Waste for Development Countries (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland.

Olupot et al. (2020) Development and appraisal of handwash-wastewater treatment system for water recycling as a resilient response to COVID-19. Journal of Environmental Chemistry Engineering 9, 106113. https://doi.org/10.1016/j.jece.2021.106113

Sink		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	Uadd	-
UNIQUE IDENTIFIER (ID)	sink	-
DATA COMPILER	Basile Weber	-
INPUT PRODUCT	freshwater For Santiago: NA	Spuhler et al. (2021)
OUTPUT PRODUCT	greywater	Spuhler et al. (2021)
RELATIONS	Input: NA Output: NA	Spuhler et al. (2021)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	5	Spuhler et al. (2021)
opex_req_level	3	Spuhler et al. (2021)
technical_maturity	3	Spuhler et al. (2021)
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Spuhler et al. (2021)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 0.75, public = 0.5, none = 0)	Distance between stoves and sinks should be minimized for ease of use, hand washing hygiene and to minimize circulation movement between appliances, mostly if the kitchen is shared (e.g. common kitchen in a refugee camp)	
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.8, regular = 0.4, continuous = 0.2)		
pipe_supply	Performance, Categorical	FALSE	no pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available	(no concrete = 1, difficultly available = 1, no concrete = 1)	no concrete needed	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple =0.75, technical = 0.25, special = 0)	Sink can be made locally with concrete (providing that sand and cement are available), fibreglass, porcelain or stainless steel. Wooden or metal moulds can be used to produce several units quickly and efficiently. Prefabricated units made from plastic are also available Sink can be made from simple local material. However, further technical parts (e.g. siphon with a water seal) are required. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access	NA	NA	NA
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	Although it's possible to directly infiltrate the effluent in the soil through a drainage channel or a soak pit if the sink is located outside, it's assumed that at least a plumber is needed as well for a proper installation: the plumber will ensure that all valves are connected and sealed properly, therefore, minimizing leakage. (Spuhler, D. et al. (2021))	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	The design skills needed for the technology are the same as the construction skills needed. Here are also moderate skills of a specialist like a plumber necessary. (Spuhler, D. et al. (2021))	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	Because there are no mechanical parts, sink are quite robust and rarely require repair. Despite the fact that it is a waterbased technology, it should be cleaned regularly to maintain hygiene and prevent the buildup of stains. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)		
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple =0.75, technical = 0.25, special = 0)	Sink can be made locally with concrete (providing that sand and cement are available), fibreglass, porcelain or stainless steel. Wooden or metal moulds can be used to produce several units quickly and efficiently. Prefabricated units made from plastic are also available Sink can be made from simple local material. However, further technical parts (e.g. siphon with a water seal) are required. (Spuhler, D. et al. (2021))	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Greywater	Range	Airloss	Soilloss	Waterloss	Comments/Specifications	Reference
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

Influent in low water consumption context

	Value [kg/pers/yr]	Range	Comments/Specifications	Reference
TP	0.08	0.04-0.12	4-14 mg/l non-phosporus detergent	Morel and Diener (2006)
	1.48	0.41-2.55	42-280 mg/L phosporus detergent	Morel and Diener (2006)
	1.12		67% of 4.6 g/p/d : average pollution loads in greywater compared to total loads in domestic WW	Lindstrom (2000), Morel and Diener (2006)
med (R)	**0.89**	-	average	0
k		-	-	-
TN	0.26	0.05-0.46	5-50 mg/l	Morel and Diener (2006)
	0.58		12% of 13.2 g/p/d: average pollution loads in greywater compared to total loads in domestic WW	Lindstrom (2000), Morel and Diener (2006)
med (R)	**0.42**		0	0
k		-	-	-
H2O	9125	7300-10'950	20-30 L/p/d including kitchen, bathroom and laundry greywater for low-income areas with water scarcity	Morel and Diener (2006)
med (R)	**9125**	-	0	0
k		-	-	-
TS	5.475		150 mg/l	Morel and Diener (2006)
	6.64		26% of 70 g TSS /p/d average pollution loads in greywater compared to total loads in domestic WW	Lindstrom (2000), Morel and Diener (2006)
med (R)	**6.06**	-	0	0
k		-	-	-

References

Morel, A. and Diener, S. (2006) Greywater Management in Low and Middle-Income Countries, Review of different treatment systems for households or neighbourhoods. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland.

Spuhler, D., de Morais Lima, P., Fritzsche, J., Ilmanen, K., Jain, A., van Sloten, M., & Willimann, C. (2021). SaniChoice Project Team. Department Sanitation, Water and Solid Waste for Development Countries (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland.

Lindstrom, C., 2000. Greywater, what it is, how to treat it, how to use it.

Organic Waste Bin		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	Uadd	-
UNIQUE IDENTIFIER (ID)	organic_waste_bin	-
DATA COMPILER	Basile Weber	-
INPUT PRODUCT	organics For Santiago: NA	Spuhler, D. et al. (2021)
OUTPUT PRODUCT	organics	Spuhler, D. et al. (2021)
RELATIONS	Input: NA Output: NA	Spuhler, D. et al. (2021)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Spuhler, D. et al. (2021)
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Spuhler, D. et al. (2021)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public	(house = 1, yard = 1, public = 1, none = 1)	no water needed	
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continuous = 0)	only requires frequent emptying	
pipe_supply	Performance, Categorical	FALSE	no pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, no concrete = 1)	no concrete needed	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple =1, technical = 0, special = 0)	any type of bin or bucket are locally available	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access	NA	NA	NA
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No special skills needed. (Spuhler, D. et al. (2021))	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No special skills needed. (Spuhler, D. et al. (2021))	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	No special skills needed. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)		
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple =1, technical = 0, special = 0)	any type of bin or bucket are locally available	

Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")						
	Organics	**Range**	**Airloss**	**Soilloss**	**Waterloss**	**Comments/Specifications**	**Reference**
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

Influent					
	Value [kg/pers/yr]	**Range**	**Comments/Specifications**	**Reference**	Spuhler et al. (2021)
TP	0.78	0,55-1.01	0.46-0.85% w/w of 118,8 kg organics/p/d	Fung et al. (2018), Kaza et al. (2022)	
	1.18	0,2-2,85	0.1-2.4% w/w of 118,8 kg organics/p/d	Manu et al. (2021), Kaza et al. (2022)	
med (R)	**0.98**				
k					
TN	5.46	1,31-11,4	1,1-9,6% w/w of 118,8 kg organics/p/d	Manu et al. (2021), Kaza et al. (2022)	
	4.67		3,93% w/w of 118,8 kg organics/p/d	Vakalis et al (2016), Kaza et al. (2022)	
med (R)	**5.065**				
k					
H2O	65.3	35.6-95	30-80% w/w of 118,8 kg organics/p/d	Zabaleta et al. (2020), Kaza et al. (2022)	
	92.08	71.3-112.86	60-95% w/w of 118,8 kg organics/p/d	Vögeli et al. (2014), Kaza et al. (2022)	
	83.16		70% w/w of 118,8 kg organics/p/d	Chua et al (2014), Kaza et al. (2022)	
med (R)	**87.62**	35.6-112.86			
k					

References

Spuhler, D., de Morais Lima, P., Fritzsche, J., Ilmanen, K., Jain, A., van Sloten, M., & Willimann, C. (2021). SaniChoice Project Team. Department Sanitation, Water and Solid Waste for Development Countries (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland.

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Stormwater Collection

General Information	Values	Data Source
FUNCTIONAL GROUP	Uadd	-
UNIQUE IDENTIFIER (ID)	stormwater_collection	-
DATA COMPILER	please fill!	-
INPUT PRODUCT	stormwater For Santiago: NA	Spuhler, D. et al. (2021)
OUTPUT PRODUCT	stormwater	Spuhler, D. et al. (2021)
RELATIONS	Input: NA Output: NA	Spuhler, D. et al. (2021)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Spuhler, D. et al. (2021)
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Spuhler, D. et al. (2021)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public	(house = 1, yard = 1, public = 1, none = 1)		
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continuous = 0)	annual or biannual cleaning of storage tank, remove material from screen	
pipe_supply	Performance, Categorical	FALSE	no pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, no concrete = 0.8)	since it exists many different technologies to collect stormwater, we decided here to avoid being too restrictive	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple =1, technical = 0, special = 0)	since it exists many different technologies to collect stormwater, we decided here to avoid being too restrictive	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access	NA	NA	NA
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.4, skilled = 1, professional = 1)	The necessary construction skills of a stormwater collection facility is assumed to be rather moderate than high.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.4, professional = 1)	"Design of Stormwater Drainage needs to be done by a skilled and experienced engineer." (Emersan) High level skills for design necessary.	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Solid waste must be removed from stormwater channels on a regular basis and particularly before the start of a rainy season or expected rainfall events to assure proper functioning. After the rains it may be necessary to empty sediments from storage tanks and channels, after the water flow has decreased below the self-cleansing velocity. Structural damages also need to be tended to on a regular basis. These can occur especially in channels with high gradients and runoff velocities." (Emersan) Low operation and maintenance skills required.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)		
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple =1, technical = 0, special = 0)	since it exists many different technologies to collect stormwater, we decided here to avoid being too restrictive.	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stormwater	Range	Airloss	Soilloss	Waterloss	Comments/Specifications	Reference
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

Influent

	Value [kg/pers/yr]	Range	Comments/Specifications	Reference
TP	-	-	negligible	Spuhler, D. et al. (2021)
			0.36 mg P/L for high urban areas	Fletcher et al. (2004)
med (R)	**0**	-		

k		-	-	-
TN	-	-	negligible	Spuhler, D. et al. (2021)
			2.5 mg N/L fir high urban areas	Fletcher et al. (2004)
med (R)	**0**	-		
k		-	-	-
H2O	170138.9	122'500-437'500	tropical climate (2000mm/yr), 7200 cap/km2, runoff coefficient=0.6125	
	68055.6	49'000-175'000	temperate climate (800mm/yr), 7200 cap/km2, runoff coefficient=0.6125	
	17014	12'250-43'750	dry climate (200mm/yr), 7200 cap/km2, runoff coefficient=0.6125	
med (R)	**85069.5**	12'250-437'500	average	
k				

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Fung et al. (2022) Estimated energy and nutrient composition of different sources of food waste and their potential for use in sustainable swine feeding programs. Translational Animal Science 3:359-368. doi: 10.1093/tas/txy099

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Cistern-Flush Toilet

General Information	Values	Data Source
FUNCTIONAL GROUP	U	-
UNIQUE IDENTIFIER (ID)	cistern_flush	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	urine, faeces, flushwater, anal_cleansing_water For Santiago: NA	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	blackwater	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR, For Santiago: NA Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018) -> U.4 Flush Toilet Cistern toilets could also be considered as less suitable in the acute emergency phase, as a pipe system needs to be set up. (Spuhler, D. et al. (2021))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical		house yard public none	(house = 1, yard = 0, public = 0, none = 0)	"The cistern flush toilet must be connected to a constant source of water for flushing." (Tilley, E. et al. (2014)) It is assumed that cistern flush toilets are not appropriate if there is no in-house water supply. (Spuhler, D. et al. (2021))	Yes (AJ)
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.7, regular = 0.3, continuous = 0)	"Although flushwater continuously rinses the bowl, the toilet should be scrubbed clean regularly to maintain hygiene and prevent the buildup of stains. Maintenance is required for the replacement or repair of some mechanical parts or fittings." (Tilley, E. et al. (2014)) Usually there's not often need for reparation. The design is similar but it contains more technical parts than a pour flush toilet, thats why its frequency of it is asumed a little higher. (Spuhler, D. et al. (2021))	YES
pipe_supply	Performance, Categorical	FALSE	no pipes difficultly available pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps difficultly available pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"The cistern flush toilet is usually made of porcelain and is a mass-produced, factory-made User Interface." (Tilley, E. et al. (2014)) If there is no concrete available it's still possible to build up the toilet. If you have the porcelain user interface and any material similar to concrete like clay it should easily be possible to build the superstructure of the user interface. Based on this we make the assumption, that the technology can be built with and without concrete. (Spuhler, D. et al. (2021))	YES
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 1, special = 0)	"The cistern flush toilet is usually made of porcelain and is a mass-produced, factory-made User Interface." (Tilley, E. et al. (2014)) "A cistern flush toilet should not be considered unless all of the connections and hardware accessories are available locally." (Tilley, E. et al. (2014)) "Cannot be built and/or repaired locally with available materials" (Tilley, E. et al. (2014)) We assume that the only case where the reparation can be done easily is when a screw is missing or something similar to that. The value for technical spare parts is based on the assumption that also the reparation or replacement of parts like a siphon can be possible. There ist no big difference to the pour flush toilet despite of the flushing mechanism (cistern) that makes it a little bit more technical. (Spuhler, D. et al. (2021))	YES
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding no flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy hard	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"A good plumber is required to install a flush toilet. The plumber will ensure that all valves are connected and sealed properly, therefore, minimizing leakage."(Tilley, E. et al. (2014)) For the construction of the technology is a specialist like a plumber or similar necessary. (Spuhler, D. et al. (2021))	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	The design skills needed for the technology are the same as the construction skills needed. Here are also moderate skills of a specialist like a plumber necessary. (Spuhler, D. et al. (2021))	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"the toilet should be scrubbed clean regularly to maintain hygiene and prevent the buildup of stains. Maintenance is required for the replacement or repair of some mechanical parts or fittings." (Tilley, E. et al. (2014)) The operation of the technology needs no special skills. The maintenance includes the regular cleaning of the user interface that can be done by everyone and the reperation or replacement of technical parts on the technology that has to be done by a specialist like a plumber. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 0)	"Flush toilets are also unsuitable where bulky materials (e.g. maize cobs) are used for anal cleansing." (Loetscher, T. & Keller, J. (2002)) Cleaning material can only be used if it's small and light enough or if they are soluble in water like paper. Any other material is unsuitable and the use of it would cause clogging. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.5, special = 0.5)	"The cistern flush toilet is usually made of porcelain and is a mass-produced, factory-made User Interface." (Tilley, E. et al. (2014)) "A cistern flush toilet should not be considered unless all of the connections and hardware accessories are available locally." (Tilley, E. et al. (2014)) "Cannot be built and/or repaired locally with available materials" (Tilley, E. et al. (2014)) We assume that specially manufactured parts, such as pre-fabricated User interfaces are necessary to construct the cistern flush toilet. (Spuhler, D. et al (2021))	YES

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Blackwater	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

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Pour-Flush Toilet

General Information	Values	Data Source
FUNCTIONAL GROUP	U	-
UNIQUE IDENTIFIER (ID)	pour_flush	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	anal_cleansing_water For Santiago: NA	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	blackwater	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR, For Santiago: NA Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 1, public = 0.5, none = 0)	Under the assumption that water carriers suffice for pour flush toilets, the performance for house and yard connection equals 1. Water carriers can also be filled up at public or community-managed standpipes, but the distance is mostly further and therefore the effort much bigger. Therefore, the score for public equals 0.5 (only half the performance). (Spuhler, D. et al. (2021)) "Water carriers suffice for pour-flush toilets" (Loetscher & Keller (2002))	Yes (AJ)
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.8, regular = 0.2, continuous = 0)	"Because there are no mechanical parts, pour flush toilets are quite robust and rarely require repair. Despite the fact that it is a waterbased toilet, it should be cleaned regularly to maintain hygiene and prevent the buildup of stains." (Tilley, E. et al. (2014)) Simple design, usually requires repair not very often, but still should be cleaned more or less regularly to prevent buildup of stains and therefore clogging. (Spuhler, D. et al. (2021))	yes
pipe_supply	Performance, Categorical	FALSE	no pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, no concrete = 1)	Concrete is mostly used for the superstructure of the toilet and is very practical for building the toilets. However, if no concrete is available, the superstructure can still be built with stone, brick, clay or similiar materials. Concrete is not essential for this technology. The construction process is faster if a mould is used that can be filled with concrete, compared to the performance if built with anything else but concrete. (Spuhler, D. et al. (2021))	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple =0.2, technical = 0.8, special = 0)	"Requires materials and skills for production that are not available everywhere" (Tilley, E. et al. (2014)) Requires a siphon with a water seal. (Spuhler, D. et al. (2021))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access	NA	NA	NA
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"A good plumber is required to install a flush toilet. The plumber will ensure that all valves are connected and sealed properly, therefore, minimizing leakage."(Tilley, E. et al. (2014)) This information refers to the cistern-flush toilet. But since both of them are a flush toilet and that they are very similar in design, it's assumed that herefore at least a plumber is needed as well for a proper installation. (Spuhler, D. et al. (2021))	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	The design skills needed for the technology are the same as the construction skills needed. Here are also moderate skills of a specialist like a plumber necessary. (Spuhler, D. et al. (2021)) "The water seal at the bottom of the pour flush toilet or pan should have a slope of at least 25°." (Tilley, E. et al. (2014))	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Because there are no mechanical parts, pour flush toilets are quite robust and rarely require repair. Despite the fact that it is a waterbased toilet, it should be cleaned regularly to maintain hygiene and prevent the buildup of stains." (Tilley, E. et al. (2014))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 0)	"Flush toilets are also unsuitable where bulky materials (e.g. maize cobs) are used for anal cleansing." (Loetscher, T. & Keller, J. (2002)) Cleaning material can only be used if it's small and light enough or if they are soluble in water like paper. Any other material is unsuitable and the use of it would cause clogging. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special		"Requires materials and skills for production that are not available everywhere" (Tilley, E. et al. (2014)) "Squatting slabs can be made locally with concrete (providing that sand and cement are available), fibreglass, porcelain or stainless steel. Wooden or metal moulds can be used to produce several units quickly and efficiently. Prefabricated pedestals and squatting slabs made from plastic are also available, as are water seal devices that can be attached to squatting slabs." (Gensch, R. et al. (2018)) Slabs can be made from simple local material. However, further technical parts (e.g. siphon with a water seal) are required. (Spuhler, D. et al. (2021))	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Blackwater	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0	_	-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

References

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Dry Toilet						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	U	-				
UNIQUE IDENTIFIER (ID)	dry_toilet	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	urine, faeces, anal_cleansing_water For Santiago: NA	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	excreta	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR, For Santiago: NA Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	NA	NA				
management_level	NA	NA				
capex_req_level	3	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 1, public = 1, none = 1)	"Does not require a constant source of water". Water required for washing hands is not considered here, but as a separate Uadd Technology (Hand Washing facility). (Tilley, E. et al. (2014))	Yes (AJ)
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continuous = 0)	"The sitting or standing surface should be kept clean and dry to prevent pathogen/disease transmission and to limit odours. There are no mechanical parts; therefore, the dry toilet should not need repairs except in the event that it cracks." (Tilley, E. et al. (2014)) No special maintenance required. Even if dry toilet is not maintained properly, the performance is still ensured. However, hygienic conditions probably suffer. (Spuhler, D. et al. (2021))	yes
pipe_supply	Performance, Categorical	FALSE	no pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, no concrete = 1)	"The Vietnamese dry toilet works as a batch process. It consists of two chambers of 0.3 cubic metres each, built above the ground with a squatting slab with two holes on top of the chambers. This system is constructed with concrete, stone or unbaked brick. " (Kaczala, F. (2006)) Vietnamese dry toilets refer to urine diversion toilets. However, it is assumed that dry toilets can also be built with locally available building materials (stone, brick, clay etc.) and therefore not only relies on concrete available for construction. The construction process is faster if a mould is used that can be filled with concrete, compared to the performance if built with anything else but concrete. (Spuhler, D. et al. (2021))	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"There are no mechanical parts; therefore, the dry toilet should not need repairs except in the event that it cracks." - (Tilley, E. et al. (2018)) Dry toilets have a very simple design and no special parts. (Spuhler, D. et al. (2021))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access	NA	NA	NA
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled	(unskilled = 1, skilled = 1, professional = 1)	"Can be built and repaired with locally available materials" (Tilley, E. et al. (2014))	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No special design considerations, very simple design. (Spuhler, D. et al. (2021))	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"There are no mechanical parts; therefore, the dry toilet should not need repairs except in the event that it cracks." (Tilley, E. et al. (2014))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)	Any cleansing method can be used, not vulnerable to clogging. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy	NA	NA	NA

construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Pedestals and squatting slabs can be made locally with concrete (provided that sand and cement are available). Fibreglass, porcelain, plastic and stainless steel versions may also be available. Wooden or metal moulds can be used to produce several units quickly and efficiently.", "Can be built and repaired with locally available materials" (Gensch, R. et al. (2018)) "There are no mechanical parts; therefore, the dry toilet should not need repairs except in the event that it cracks." - (Tilley, E. et al. (2014))	yes		

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Excreta	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	0.99	-	0.01	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	0.99	-	0.01	0	0		-
k	25	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

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Urine Diversion Dry Toilet

General Information	Values	Data Source
FUNCTIONAL GROUP	U	-
UNIQUE IDENTIFIER (ID)	uddt	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	urine, faeces For Santiago: NA	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	urine, faeces	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR, For Santiago: NA Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 1, public = 1, none = 1)	"A urine-diverting dry toilet (UDDT) is a toilet that operates without water [...]" (Tilley, E. et al. (2014)) Water required for washing hands is not considered here, but as a separate Uadd Technology (--> Hand Washing facility). (Spuhler, D. et al. (2021))	Yes (AJ)
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"All of the surfaces should be cleaned regularly to prevent odours and to minimize the formation of stains. [...]. An odour seal also requires occasional maintenance. It is critical to regularly check its functioning." (Tilley, E. et al. (2014))	yes
pipe_supply	Performance, Categorical	FALSE	no pipes difficultly available pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps difficultly available pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"The UDDT is simple to design and build, using such materials as concrete and wire mesh or plastic." (Tilley, E. et al. (2014)) Concrete is not necessary needed but it might ease the construction if some is available. (Spuhler, D. et al. (2021))	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Tilley, E. et al. (2014)) No need for technical or special parts is expected. (Spuhler, D. et al. (2021))	yes
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding no flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy hard	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"The UDDT is simple to design and build, using such materials as concrete and wire mesh or plastic". (Tilley, E. et al. (2014))	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"The UDDT is simple to design and build, using such materials as concrete and wire mesh or plastic". (Tilley, E. et al. (2014))	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"A UDDT is slightly more difficult to keep clean compared to other toilets because of both the lack of water and the need to separate the solid faeces and liquid urine. An odour seal also requires occasional maintenance. It is critical to regularly check its functioning". (Tilley, E. et al. (2014)) Still, no specific knowledge is required. (Spuhler, D. et al.(2021))	yes
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)	Similar to a dry toilet. Any cleansing method can be used, not vulnerable to clogging. (Spuhler, D. et al. (2021))	
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA

speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials". (Tilley, E. et al. (2014))	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Urine	Range	Faeces	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.61	-	0.39	0	0	0	* as P	Tilley, E. et al. (2014)
	0.68	-	0.32	0	0	0	* see calculations in 2.2.1	Kirchmann, H. & Pettersson, S. (1995)
	0.5	-	0.5	0	0	0	* as P	Conradin, K. et al. (2010)
	0.62	-	0.38	0	0	0	* as P	Schouw, N. L. et al. (2002)
med (R)	0.62	0,5 - 0,7	0.38	0	0	0		-
k	25	[0,2]	-	-	-	-		Spuhler, D. et al. (2021)
TN	0.88	-	0.12	0	0	0	* as N	Tilley, E. et al. (2014)
	0.85	-	0.15	0	0	0	* see calculations in 2.2.1	Kirchmann, H. & Pettersson, S. (1995)
	0.8	-	0.2	0	0	0	* as N	Conradin, K. et al. (2010)
	0.87	-	0.13	0	0	0	* as N	Schouw, N. L. et al. (2002)
med (R)	0.86	0,5 - 0,7	0.14	0	0	0		-
k	100	[0,1]	-	-	-	-		Spuhler, D. et al. (2021)
H2O	0.86	-	0.14	0	0	0	* see calculations in 2.2.2	Rose, C. et al. (2015)
	0.93	-	0.07	0	0	0	* see calculations in 2.2.3	Vinnerås, B. et al. (2006)
med (R)	0.9	0,86-0,93	0.11	0	0	0	Spuhler et al. (2021)	-
k	100	[0.07]	-	-	-	-		Spuhler, D. et al. (2021)
TS	0.61	-	0.39	0	0	0	* see calculations in 2.2.2	Rose, C. et al. (2015)
	0.66	-	0.34	0	0	0	* see calculations in 2.2.3	Vinnerås, B. et al. (2006)
med (R)	0.64	0,33-0,34	0.37	0	0	0		-
k	100	[0,01]	-	-	-	-		Spuhler, D. et al. (2021)

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Urine Diversion Flush Toilet		Urine Divertion Flush Toilet
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	U	-
UNIQUE IDENTIFIER (ID)	udft	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	blackwater, urine	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	blackwater, urine	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR, For Santiago: NA Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	3	Spuhler, D. et al. (2021)
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Same values as for a UDDT are assumed by Spuhler, D. et al. (2021) based on Gensch, R. et al. (2018): U.2 Urine-Diverting Dry Toilet (UDDT).

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 0, public = 0, none = 0)	"Requires a constant source of water" "Requires less water than a traditional Cistern Flush Toilet" (Tilley, E. et al. (2014)) It is assumed that UDFTs are not appropriate if there is no in-house water supply. (Spuhler, D. et al. (2021))	Yes (AJ)
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Is prone to misuse and clogging" (Tilley, E. et al. (2014)) Therefore needs to be maintained regularly. Usually there's not often need for reparation. The design is similar but it contains more technical parts than other toilets which can potentially fail. Regular frequency of operation and maintenance. (Spuhler, D. et al. (2021))	yes
pipe_supply	Performance, Categorical	FALSE	no pipes difficultly available pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps difficultly available pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Adapted from cistern flush toilet, since they both require concrete in a similar way. (Tilley, E. et al. (2014)); (Spuhler, D. et al. (2021))	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.7, special = 0.3)	"Limited availability; cannot be built or repaired locally" (Tilley, E. et al. (2014)) Might require technical spare parts (e.g. siphon) or even specially manufactured piping and odour seals. (Spuhler, D. et al. (2021))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding no flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy hard	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Since this technology requires separate pipes for urine and brownwater collection, the plumbing is more complicated than for Cistern Flush Toilets. Particularly, the proper design and installation of the urine pipes is crucial, and requires expertise." (Tilley, E. et al. (2014))	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Since this technology requires separate pipes for urine and brownwater collection, the plumbing is more complicated than for Cistern Flush Toilets. Particularly, the proper design and installation of the urine pipes is crucial, and requires expertise." (Tilley, E. et al. (2014))	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Labour-intensive maintenance. In some cases manual removal may be required." (Tilley, E. et al. (2014))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 0)	Similar to a pour flush toilet. "Flush toilets are also unsuitable where bulky materials (e.g. maize cobs) are used for anal cleansing." (Loetscher, T. & Keller, J. (2002)) Cleaning material can only be used if it's small and light enough or if they are soluble in water like paper. Any other material is unsuitable and the use of it would cause clogging. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.3, special = 0.7)	"Limited availability; cannot be built or repaired locally" (Tilley, E. et al. (2014)) "Since this technology requires separate pipes for urine and brownwater collection, the plumbing is more complicated than for Cistern Flush Toilets." (Tilley, E. et al. (2014)) We assume that due to its dual plumbing it requires even more specially manufactured piping compared to a cistern flush toilet. (Spuhler, D. et al. (2021))	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Urine	Range	Brownwater	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.61	-	0.39	0	0	0	* as P	Tilley, E. et al. (2014)
	0.68	-	0.32	0	0	0	* see calculations in 2.2.1	Kirchmann, H. & Pettersson, S. (1995)
	0.5	-	0.5	0	0	0	* as P	Conradin, K. et al. (2010)
	0.62	-	0.38	0	0	0	* as P	Schouw, N. L. et al. (2002)
med (R)	0.61	0,5 - 0,7	0.39	0	0	0		-
k	25	[0,2]	-	-	-	-		Spuhler, D. et al. (2021)
TN	0.88	-	0.12	0	0	0	* as N	Tilley, E. et al. (2014)
	0.85	-	0.15	0	0	0	* see calculations in 2.2.1	Kirchmann, H. & Pettersson, S. (1995)
	0.8	-	0.2	0	0	0	* as N	Conradin, K. et al. (2010)
	0.87	-	0.13	0	0	0	* as N	Schouw, N. L. et al. (2002)
med (R)	0.86	0,5 - 0,7	0.14	0	0	0		-
k	100	[0,1]	-	-	-	-		Spuhler, D. et al. (2021)
H2O	0.86	-	0.14	0	0	0	* see calculations in 2.2.2	Rose, C. et al. (2015)
	0.93	-	0.07	0	0	0	* see calculations in 2.2.3	Vinnerås, B. et al. (2006)
med (R)	0.9	0,86-0,93	0.1	0	0	0	Spuhler et al. (2021)	-
k	100	[0.07]	-	-	-	-		Spuhler, D. et al. (2021)
TS	0.61	-	0.39	0	0	0	* see calculations in 2.2.2	Rose, C. et al. (2015)
	0.66	-	0.34	0	0	0	* see calculations in 2.2.3	Vinnerås, B. et al. (2006)
med (R)	0.635	0,33-0,34	0.365	0	0	0		-
k	100	[0,01]	-	-	-	-		Spuhler, D. et al. (2021)

Additional Information

2.2.1 (Data from: Kirchmann, H. & Pettersson, S. (1995))

	N [kg/P*a] (Median)	Range	P[kg/P*a] (Median)	Range	TC_TN	TC_TP
Urine	3.4	2.5 - 4.3	0.85	0.7 - 1.0	0.85	0.68
Faeces	0.6	0.5-0.7	0.4	0.3 - 0.5	0.15	0.32
Calculation					TC_TN Urine = Mass N in Urine [kg/P*a]/ Total Mass N (in Urine and Faeces) [kg/P*a] TC_TN Faeces = Mass N in Faeces [kg/P*a]/ Total Mass N (in Urine and Faeces) [kg/P*a]	TC_TP Urine = Mass P in Urine [kg/P*a]/ Total Mass P (in Urine and Faeces) [kg/P*a] TC_TP Faeces = Mass P in Faeces [kg/P*a]/ Total Mass P (in Urine and Faeces) [kg/P*a]

2.2.2 (Data from: Rose, C. et al. (2015))

k	100	[0,01]	-	-	-	-

Additional Information

2.2.1 (Data from: Kirchmann, H. & Pettersson, S. (1995))

	N [kg/P*a] (Median)	Range	P[kg/P*a] (Median)	Range	TC_TN	TC_TP
Urine	3.4	2.5 - 4.3	0.85	0.7 - 1.0	0.85	0.68
Faeces	0.6	0.5-0.7	0.4	0.3 - 0.5	0.15	0.32
Calculation					TC_TN Urine = Mass N in Urine [kg/P*a]/ Total Mass N (in Urine and Faeces) [kg/P*a] TC_TN Faeces = Mass N in Faeces [kg/P*a]/ Total Mass N (in Urine and Faeces) [kg/P*a]	TC_TP Urine = Mass P in Urine [kg/P*a]/ Total Mass P (in Urine and Faeces) [kg/P*a] TC_TP Faeces = Mass P in Faeces [kg/P*a]/ Total Mass P (in Urine and Faeces) [kg/P*a]

2.2.2 (Data from: Rose, C. et al. (2015))

Calculation					H2O Faeces = Water content Faeces [kg/cap*a] / Water content Total [kg/cap*a] H2O Urine = Water content Urine [kg/cap*a]/ Water content Total[kg/cap*a]	TS Faeces = Dry weight Faeces [kg/cap*a] / Dry weight Total [kg/cap*a] TS Urine = Dry weight Urine [kg/cap*a]/ Dry weight Total[kg/cap*a]

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).
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Urinal						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	U	-				
UNIQUE IDENTIFIER (ID)	urinal	-				
DATA COMPILER	SaniChoice Project Team	-				
INPUT PRODUCT	urine For Santiago: NA	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	urine	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: NA Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	NA	NA				
management_level	NA	NA				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 1, public = 1, none = 0.5)	"Waterless urinals do not require a constant source of water". (Tilley, E. et al. (2014)) "Water-saving or waterless technologies should be favoured" (Tilley, E. et al. (2014)). "Particularly, in waterless urinals, calcium- and magnesium-based minerals and salts can precipitate and build up in pipes and on surfaces where urine is constantly present. Washing the bowl with a mild acid (e.g., vinegar) and/or hot water can prevent the build-up of mineral deposits and scaling." (Tilley, E. et al. (2014)) It is assumed that to ensure proper maintenance, at least basic water supply might be necessary. (Spuhler, D. et al. (2021)	Yes (AJ)
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Maintenance is simple, but should be done frequently, especially for waterless urinals". (Tilley, E. et al. (2014))	yes
pipe_supply	Performance, Categorical	FALSE	no pipes difficultly available pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps difficultly available pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Adapted from Cistern Flush Toilet. The technology can be built with and without concrete. The performance with concrete is assumed to be the same. (Spuhler, D. et al. (2021))	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Tilley, E. et al. (2014)) No need for technical or special parts is expected. (Spuhler, D. et al. (2021))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding no flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy hard	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Waterless urinals are available in a range of styles and complexities". (Tilley, E. et al. (2014)) Some plumbing knowledge is necessary. (Spuhler, D. et al. (2021))	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Waterless urinals are available in a range of styles and complexities". (Tilley, E. et al. (2014)) Some plumbing knowledge is necessary. (Spuhler, D. et al. (2021))	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Maintenance is simple, but should be done frequently, especially for waterless urinals". (Tilley, E. et al. (2014))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)	Since an urinal has only urine as input no cleansing method is needed. In other words, it is possible in every case. (Spuhler, D. et al. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Tilley, E. et al. (2014))	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Urine	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0	_	-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	0.99	-	0.01	0	0	* Assumption: Losses occur in storage, very little volatilization of ammonia	Spuhler, D. et al. (2021)
med (R)	0.99	-	0.01	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* Assumption: Losses occur in storage	Spuhler, D. et al. (2021)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

References

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Loetscher, T., & Keller, J. (2002). A decision support system for selecting sanitation systems in developing countries. *Socio-Economic Planning Sciences* , *36* (4), 267–290. https://doi.org/10.1016/S0038-0121(02)00007-1

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User Interface for Controlled Open Defecation		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	U	-
UNIQUE IDENTIFIER (ID)	u_controlled_od	-
DATA COMPILER	Kukka Ilmanen	-
INPUT PRODUCT	urine, faeces For Santiago: NA	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	od_excreta	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: NA Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	NA	NA
management_level	NA	NA
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	No technical components. Spuhler, D. et al. (2021)
development_phase	(acute = 1, stabilisation = 0, development/recovery = 0)	Gensch, R. et al. (2018) -> U.6 Shallow Trench Latrine This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. It is assumed to have the same development phase values as Shallow Trench Latrines. (Spuhler, D. et al. (2021))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	TRUE	house yard public none	(house = 1, yard = 1, public = 1, none = 1)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
pipe_supply	Performance, Categorical	FALSE	no pipes difficultly available pipes	NA	NA	NA
pump_supply	Performance, Categorical	FALSE	no pumps difficultly available pumps	NA	NA	NA
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	FALSE	flooding no flooding	NA	NA	NA
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	FALSE	easy hard	NA	NA	NA
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

cleansing_method	Performance, Categorical	TRUE	Washers Soft wipers Hard wipers	(washers = 1, soft wipers = 1, hard wipers = 1)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. (Spuhler, D. et al. (2021))	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Open Defecation Excreta	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. No losses occur.	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0	-	-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TN	1	-	0	0	0	* This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. No losses occur.	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
H2O	1	-	0	0	0	* This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. No losses occur.	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)
TS	1	-	0	0	0	* This is a dummy technology only implemented to have a technology in FG U that can be the input into the technologies Controlled open defecation and Shallow trench latrines. No losses occur.	Spuhler, D. et al. (2021)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler, D. et al. (2021)

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Spuhler, D., de Morais Lima, P., Fritzsche, J., Ilmanen, K., Jain, A., van Sloten, M., & Willimann, C. (2021). SaniChoice Project Team. Department Sanitation, Water and Solid Waste for Development Countries (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland.

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Urine Storage Tank						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	S	-				
UNIQUE IDENTIFIER (ID)	urine_storage_tank	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	urine	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	stored_urine	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: NA Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 0.5)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	3	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Values for urine storage tank and single faeces storage chamber are assumed to be similar. --> Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"When urine cannot be used immediately or transported using a Conveyance technology (i.e., Jerrycans, see C.1), it can be stored onsite in containers or tanks." (Compendium) No additional water needed. Santiago algorithm ensures this technology is connected to FG U techs that have urine diversion, therefore, default maximum value of 999L/cap/day remains since upper bound of water entering the system is not an issue. (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"May require frequent emptying (depending on tank size)" (Compendium) "When the storage tank is emptied, the sludge will usually be emptied along with the urine, but if a tap is used and the tank is never fully emptied, it may require desludging. The desludging period will depend on the composition of the urine and the storage conditions. Mineral and salt build-up in the tank or in connecting pipes can be manually removed (sometimes with difficulty) or dissolved with a strong acid (24% acetic)." (Compendium) All together regular OM can be expectet.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.75, difficultly available = 0.75, concrete = 1)	"Mobile storage tanks should be made of plastic or fibreglass, but permanent ones can be comprised of concrete or plastic." (Compendium) Concrete not necessary, but can perform a bit better for long-term solutions.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, hot = 1)	"Urine storage tanks can be installed indoors, outdoors, above ground and below ground depending on the climate, space available, and soil." (Compendium) If installed below ground the technology should be feasible in cold climates as well.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding= 1)	"Low risk of pathogen transmission" (Compendium) There should be no problem with frequent flooding. The tank should be watertight anyway.	yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.8, difficult = 0.8, full = 1)	"If the storage tank is emptied using a vacuum truck [...]" (Compendium) At a large scale a vacuum truck might be required. At smaller distances can be transported manually. Large volumes of urine are produced and might need to be transported. However, since it can also be used locally, it is assumed that motorized vehicles can only slightly improve the operation efficiency.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, rock = 1)	Technology does not rely on soil absorbtion. No difference between soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	Technology does not rely on soil absorbtion. Water depth has no influence on the performance of the technology.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"Urine storage tanks can be installed indoors, outdoors, above ground and below ground depending on the climate, space available, and soil." (Compendium) Excavation needed in colder climates.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 0, b = 0.5, c = 999, d = 999)	"Small land area required" (Compendium). As the technology is movable, it is assumed that it can be used starting from space requirements of zero m2/plot! Since there are many different variations of urine storage tank, common sense is applied here to define 0.5 m2/plot as the minimum space required for 100% performance (Eawag, 2021).	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Simple and robust technology" (Compendium) "Low risk of pathogen transmission" (Compendium) Exposure to drinking water has no influence on the performance of the technology.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Simple and robust technology" (Compendium) "Can be built and repaired with locally available materials" (Compendium) Some very basic skills are necessary to fulfil the design requirements.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Mobile storage tanks should be made of plastic or fibreglass, but permanent ones can be comprised of concrete or plastic. Metal should be avoided as it can easily be corroded by the high pH of stored urine. Over time, a layer of organic sludge and precipitated minerals (primarily calcium and magnesium phosphates) will form on the bottom of the tank. Any tank used for urine storage should have an opening large enough so that it can be cleaned and/or pumped out. If the storage tank is directly connected with a pipe to the toilet or urinal, care should be taken to minimize the length of the pipe since precipitates will accumulate. Pipes should have a steep slope (> 1%), no sharp angles, and large diameters (up to 110 mm for underground pipes). They should be easily accessible in case of blockages. To minimize odours and nitrogen loss, the tank should be filled from the bottom, i.e., the urine should flow down through a pipe and be released near the bottom of the tank. This will prevent the urine from spraying and avoid the backflow of air." (Compendium)	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"If the storage tank is emptied using a vacuum truck (see C.3), the inflow of air must be maintained at a sufficient rate to ensure that the tank does not implode due to the vacuum. A viscous sludge will accumulate on the bottom of the storage tank. When the storage tank is emptied, the sludge will usually be emptied along with the urine, but if a tap is used and the tank is never fully emptied, it may require desludging. The desludging period will depend on the composition of the urine and the storage conditions. Mineral and salt build-up in the tank or in connecting pipes can be manually removed (sometimes with difficulty) or dissolved with a strong acid (24% acetic)." (Compendium) Even though OM contains not very difficult tasks, there are a few things to take in account. Moderate OM skills are recommended.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"all urine should be stored for at least 1 month before use (see WHO guidelines for specific storage and application guidelines)." (Compendium) Therefore, lifetimes of less than 1 month are in theory not suitable, but limitations of technologies for short lifetimes are not considered here. In general, the concept of storing urine does not have a lifetime and can therefore be used at anytime. The actual storage devices, such as urine containers and tanks, can be replaced easily. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.5, moderate = 0.5, slow = 0)	"They can be replicated quickly given enough space is available." "Single Vault UDDTs can be constructed with local materials, e.g. bamboo, wood, corrugated iron, tarpaulin, plastic buckets and jerricans." (Single Vault UDDT- Emersan Compendium) "Mobile storage tanks should be made of plastic or fibreglass, but permanent ones can be comprised of concrete or plastic." (Emersan Compendium) Single faeces storage chamber and urine storage tanks are awarded same values since they both elements of a Single Vault UDDT and values are based on the literature available for Single Vault UDDT/Urine Storage Tank. (Akanksha Jain, Eawag 2021)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The number of urine storage containers and tanks can be changed to scale the technology up. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stored Urine	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* 28% of P settle in storage, see 6.2	Etter et al. (2011)
	1	-	0	0	0	* 20% of P settle in storage, see 6.2	Maurer et al. (2006)
med (R)	1.00	-	0	0	0	-	-
k	100	-	-	-	-		PA
TN	0.98	-	0.02	0	0	* 1% of N precipitate/volatize in storage	Etter et al. (2011)
	0.99	-	0.01	0	0	* 1% of N precipitates/volatizes in storage	Maurer et al. (2006)
	0.98	-	0.02	0	0	* "volatilization is marginal"	Udert et al. (2006)
med (R)	0.98	0,98-0,99	0.02	0	0		-
k	100	[0,01]	-	-	-		PA
H2O	0.98	-	0.02	0	0		Maurer et al. (2006)
med (R)	0.98	-	0.02	0	0		-
k	100	-	-	-	-		PA
TS	1	-	0	0	0	*2% of TS settle in storage, see 6.2	Maurer et al. (2006)

med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		Spuhler et al. (2021)

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

Loetscher, T., & Keller, J. (2002). A decision support system for selecting sanitation systems in developing countries. *Socio-Economic Planning Sciences , 36* (4), 267–290. https://doi.org/10.1016/S0038-0121(02)00007-1

Spuhler, D., de Morais Lima, P., Fritzsche, J., Ilmanen, K., Jain, A., van Sloten, M., & Willimann, C. (2021). SaniChoice Project Team. Department Sanitation, Water and Solid Waste for Development Countries (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland.

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Etter, B., et al. (2011). "Low-cost struvite production using source-separated urine in Nepal." Water Research 45(2): 852-862.

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Udert, K. M., et al. (2006). "Fate of major compounds in source-separated urine." Water Science and Technology 54(11-12): 413–420.

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Double Dehydration Vaults						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	S	-				
UNIQUE IDENTIFIER (ID)	double_dehydration_vaults	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	faeces	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	dried_faeces	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: NA Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)				
capex_req_level	8	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"Dehydration vaults are especially appropriate for water-scarce and rocky areas or where the groundwater table is high" (Compendium). No additional water required. This technology is not impacted by flooding and/or high groundwater tables. The only possible way high water volumes could enter this technology would be by means of a FG U technology that introduces high amount of water into the system (i.e., due to anal cleansing or flush water). Maximum values (c & d) are assumed to remain 999 L/cap/day since the FG U technology that will be connected with this tech according to santiago algorithm, based on input-output products will never be a technology that leads to high water volumes entering dehydration vaults (because blackwater/anal cleansing water is not an input for dehydration vaults). For e.g. Cistern flush sytems willl never be the recommended FG U tech for dehydration vaults. (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Key operation and maintenance tasks include regular emptying and replacing of urine collection containers (if urine is not drained away), cleaning, checking availability of hygiene items, water and dry cleansing materials, conducting minor repairs and advising on proper use. Ample supply of cover material must be secured. Accumulated faeces beneath the toilet should occasionally be pushed to the sides of the chamber." (Emersan)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	"A vent pipe is required to remove humidity from vaults and control flies and odours" (Emersan Compendium) "Connection pipes [for urine]" (Emersan Compendium) Ventilation pipes can be produced with local material. The pipes to connect user interface and storage containers are though necessary.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	"Manual removal of dried faeces is required" (Compendium) No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Can be built and repaired with locally available materials" (Compendium) "They should be made of sealed brickwork or concrete to ensure that surface runoff cannot enter." (Compendium) Concrete not necessary. However, availability of concrete could ease the construction.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium) "They should be made of sealed brickwork or concrete to ensure that surface runoff cannot enter." (Compendium) Concrete not necessary. However, availability of concrete could ease the construction.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.6, temperate = 0.8, warm = 1, hot = 1)	"The WHO recommends a minimum storage time of 6 months if ash or lime are used as cover material (alkaline treatment), otherwise the storage should be for at least 1 year for warm climates (>20 °C average) and for 1.5 to 2 years for colder climates" (Compendium) Performance decreases for lower temperatures.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	"They are also suitable in areas that are frequently flooded because they are built to be watertight." (Compendium)	Yes

vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.8, narrow = 0.8, full = 1)	"If used in an urban context, this technology relies on a transport service for the dried faeces (and urine) since urban users normally do not have an interest and/or opportunity to use it locally." (Compendium) "faeces in the first vault dry and decrease in volume", emptying every 6 months upto 2 years. (Emersan Compendium) Dried faeces have low volume and require infrequent emptying, so that a motorized transport service only slightly improves the performance of the technology. Large volumes of urine are produced and might need to be transported. However, since it can also be used locally, it is assumed that motorized vehicles can only slightly improve the operation efficiency.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.7, silt = 0.9, sand = 1, gravel = 0.9, rock = 0.7)	"They are also suitable in areas that are frequently flooded because they are built to be watertight." (Compendium) "If reuse is not intended and soil conditions allow, urine can be in filtrated directly into the ground, avoiding regular urine management and may increase user acceptance." (Emersan) Technology can be built to rely on soil percolation and filtration, but does not necessarily have to.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 3, c = 999 d = 999)	"Dehydration vaults are especially appropriate for water-scarce and rocky areas or where the groundwater table is high." (Compendium) Usually does not affect the groundwater, however, it can be built to rely on soil absorption and therefore might affect the groundwater.	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	They can be built above ground indoor or outdoor. No excavation needed.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 2, b = 2, c = 999, d = 999)	Based on a comparison of different technologies, we derive the space requirements of double dehydration vaults to be (at least) twice the space of the space requirements of a single pit. This is based on the assumption that the excreta ends up in two alternating chambers below the user, instead of just one chamber. There are no further significant differences in terms of space requirements between a single pit and double dehydration vaults and therefore, using twice the space (2m2/plot) is justified (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0.5, not close = 1)	"They are also suitable in areas that are frequently flooded because they are built to be watertight." (Compendium) Since the vaults are built watertight there is no danger of drinking water contamination. Technology can be built to rely on soil percolation and filtration, but does not necessarily have to. This could then contaminate groundwater.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	To ensure proper function of some important attributes of the technology such as water tightness at least moderate construction skills are needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Whenever the material is intended to be applied onto fields without further treatment, it is recommended to separately collect and dispose of the dry cleansing materials. Occasionally, the faeces that have accumulated beneath the toilet should be pushed to the sides of the chamber. Care should be taken to ensure that no water or urine gets into the dehydration vault. If this happens, extra ash, lime, soil or sawdust can be added to help absorb the liquid. To empty the vaults, a shovel, gloves and possibly a facemask (cloth) should be used to avoid contact with the dried faeces." (Compendium) "Care should be taken to ensure that no water or urine gets into the dehydration vault. If this happens, extra ash, lime, soil or sawdust can be added to help absorb the liquid. To empty the vaults, a shovel, gloves and possibly a facemask (cloth) should be used to avoid contact with the dried faeces." (Compendium) Lots of things to take in account. High design skills needed.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	Adapted from single faeces storage chamber due to similar setup.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"The life-span of a UDDT is expected, under normal circumstances, to be at least 15 years." (Rieck C. et al. (2011)) "Long lifespan and low/no operating costs if self-emptied" (Emersan Compendium)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.3, moderate = 0.7, slow = 0)	Values point towards slightly longer speeds of implementation than single faeces storage chamber because its a similar technology but with dual tanks, i.e., double the efforts and consequently more time required for implementation. (Akanksha Jain, Eawag 2021)	yes

speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"Capacity limited by vault size", "The capital costs for constructing a Double Vault UDDT may vary depending on availability and costs of local materials and prefabricated slabs/toilet seats but are generally low to moderate." (Emersan) Technology is complete and it's not easy to extend the vault size, however it is possible to build new units. This depends on the availability of construction material. It has a lower performance compared to single faeces storage chambers, because more material and space are required. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stored Urine	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* as P	Stintzing, A. et al. (2004)
med (R)	1.00	-	0	0	0		-
k	100	-	-	-	-		PA
TN	0.5	-	0.5	0	0	* as N	Stintzing, A. et al. (2004)
med (R)	0.50	-	0.50	0	0		-
k	25	-	-	-	-		PA
H2O	0.2	-	0.8	0	0		Esrey and et al. (1998)
	0.25	-	0.75	0	0		Rieck et al. (2012)
med (R)	0.225	0,2-0,25	0.775	0	0		-
k	100	[0,05]	-	-	-		PA
TS	0.85	-	0.15	0	0	*Organic matter containment: 70% (assumption for TS= 85%)	Regmi (2005)
med (R)	0.85	-	0.15	0	0		-
k	5	-	-	-	-		PA

References

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Esrey, S. A., et al. (1998). Ecological sanitation. Stockholm, Department for Natural Resources and the Environment: 92 s.

Regmi, M. R. (2005). "A sustainable approach towards rural development: Dry toilets in Nepal." Water Science and Technology 52(12): 19.

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Single Faeces Storage Chamber

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	single_faeces_storage_chamber	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	faeces	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	stored_faeces	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: NA Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0.5, neighbourhood = 1, city = 0)	Gensch, R. et al. (2018)
management_level	(household = 0.5, shared = 1, public = 1)	Gensch, R. et al. (2018)
capex_req_level	4	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Gensch, R. et al. (2018)
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"The Single Vault UDDT is a Container-Based Toilet (S.10) that operates without water" (Emersan). "As no water is needed for operation it is a viable solution for water scarce areas" (Emersan). This technology is not impacted by flooding and/or high groundwater tables. The only possible way too high water volumes could enter this technology would be by means of a FG U technology that introduces high amount of water into the system (i.e., due to anal cleansing or flush water). Maximum values (c & d) are assumed to remain 999 L/cap/day since the FG U technology that will be connected with this tech according to santiago algorithm, based on input-output products, will never be a technology that leads to high water volumes entering single faeces storage chamber (because blackwater is not a defined input). For e.g. Cistern flush sytems willl never be the recommended FG U tech for single faeces storage chamber. (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No need for electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Key operation and maintenance (O & M) tasks include regular emptying and replacing of collection containers, cleaning, checking availability of hygiene items, soap, cover material, dry cleansing materials and water for handwashing and anal cleansing, conducting minor repairs and advising on proper use. Care should be taken to ensure that no water or urine gets into the faeces container. If this happens, extra cover material can be added to help absorb the liquid. Service personnel should wear proper personal protective equipment including a mask, gloves, boots, an apron or protective suit. Division of O & M responsibilities between users and potential service providers need to be clearly defined." (Emersan) Regular maintenance required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	"All connection pipes should be as short as possible with no sharp bends and installed with at least a 1 % slope.", "A vent pipe is suggested to remove humidity from the vaults and control flies and odours." (Emersan) Ventilation pipes can be produced with local material. The pipes to connect user interface and storage containers are though necessary.	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps are required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Single Vault UDDTs can be constructed with local materials, e.g. bamboo, wood, corrugated iron, tarpaulin, plastic buckets and jerricans" (Emersan) No concrete required.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Single Vault UDDTs can be constructed with local materials, e.g. bamboo, wood, corrugated iron, tarpaulin, plastic buckets and jerricans. Depending on local availability potential cover/drying material that can be used include ash, lime, sawdust, dried soil or dried agricultural waste products. Urine diversion toilet seats or squatting pans can be obtained or produced locally." (Emersan) All material and consequent spare parts are simple and should be found locally.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.7, cold = 0.9, temperate = 1, warm = 1, hot = 1)	Can be used in every climate. If urine is to be infiltrated in the soil, lower temperatures might not allow the leachate to infiltrate (Emersan). Since this is only one possible configuration, the performances are better than for other technologies relying on percolation.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	"Single Vault UDDTs are suitable for floodprone areas", "They are adaptable to anticipated disruptions and hazardous events: toilets can be serviced more frequently prior to anticipated events, or additional collection devices can be provided for times when servicing might be difficult." (Emersan)	Yes

vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.8, difficult = 0.8, full = 1)	"Manual removal of faeces (and urine) containers required", "The collected urine and faeces must be emptied on a regular basis." (Emersan) Manual removal of containers is possible and vehicular access is not required. However motoritzed transport can improve the performance slightly due to the regular transport of the not-voluminous faeces. Large volumes of urine are produced and might need to be transported. However, since it can also be used locally, it is assumed that motorized vehicles can only slightly improve the operation efficiency.	yes	
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA	
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.7, silt = 0.9, sand = 1, gravel = 0.9, rock = 0.7)	"If reuse is not intended and soil conditions allow, urine can be in filtrated directly into the ground, avoiding regular urine management and may increase user acceptance." (Emersan) The technology can be built to rely on soil percolation and filtration, but does not necessarily have to.	yes	
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"Single Vault UDDTs are suitable for floodprone, high water table and rocky areas" (Emersan)	yes	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	"Single Vault UDDTs are suitable for floodprone, high water table and rocky areas" (Emersan) No excavation is required as the vaults are above ground.	yes	
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 1, b = 1, c = 999, d = 999)	Based on a comparison of different technologies, we derive the space requirements of a single faeces storage chamber to be very similar to a single pit (as the excreta is also ends up in a chamber below the user) and use the same minimum space requirement of 1m2/plot (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.		
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Containers should be sealable" (Emersan) Faeces should not get into contact with the soil. Urine might be discharged into the soil, but this would be part of another technology. In this storage chamber urine is solely stored.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	Technical skills required for construction.	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Adapted from double dehydration vaults due to similar setup.	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Requires well-trained service personnel" (Emersan).	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Single Vault UDDTs can be temporary solutions, making them more attractive in situations with landownership issues that do not permit permanent structures." (Emersan), "The life-span of a UDDT is expected, under normal circumstances, to be at least 15 years." (Rieck C. et al. (2012)) The technology can be used for a short lifetime, but mostly it is expected to have a long lifetime.	yes	
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.5, moderate = 0.5, slow = 0)	"They can be replicated quickly given enough space is available." "Single Vault UDDTs can be constructed with local materials, e.g. bamboo, wood, corrugated iron, tarpaulin, plastic buckets and jerricans." (Single Vault UDDT- Emersan Compendium) Single faeces storage chamber and urine storage tanks are awarded same values since they both elements of a Single Vault UDDT and values are based on the literature available for Single Vault UDDT. (Akanksha Jain, Eawag 2021)	yes	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"They can be replicated quickly given enough space is available." (Emersan)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Single Vault UDDTs can be constructed with local materials, e.g. bamboo, wood, corrugated iron, tarpaulin, plastic buckets and jerricans. [...] Urine diversion toilet seats or squatting pans can be obtained or produced locally." (Emersan) Can be constructed from locally available material.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stored Faeces	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	* Nutrients besides N are contained	Jönsson et al. (2004)
med (R)	1	-	0	0	0	-	-
k	25	-	-	-	-	-	PA
TN	0.8	-	0.2	0	0	* at constant air moisture, loss of N is low	Jönsson et al. (2004)
med (R)	0.8	-	0.2	0	0		-
k	5	-	-	-	-	-	PA
H2O	0.7	-	0.3	0	0		PA
med (R)	0.7	-	0.3	0	0		-
k	5	-	-	-	-	-	PA
TS	0.85	-	0.1	0	0	*Assumption: similar to dehydration vault	Regmi (2005)
med (R)	0.9	-	0.1	0	0		-
k	5	-	-	-	-	-	PA

References

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Container-Based Toilet

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	container_based_toilet	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces	Gensch, R. et al. (2018)
OUTPUT PRODUCT	stored_faeces	Gensch, R. et al. (2018)
RELATIONS	Input: NA Output: NA	Gensch, R. et al. (2018)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Gensch, R. et al. (2018)
management_level	(household = 0.5, shared = 1, public = 1)	Gensch, R. et al. (2018)
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	6	Spuhler, D. et al. (2021)
technical_maturity	3	Gensch, R. et al. (2018)
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 0.5)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"Dry Technology" (Emersan). This technology is not impacted by flooding and/or high groundwater tables. The only possible way too high water volumes could enter this technology would be by means of a FG U technology that introduces high amount of water into the system (i.e., due to flush water). Maximum values (c & d) are assumed to remain 999 L/cap/day since the FG U technology that will be connected with this tech according to santiago algorithm, based on input-output products, will never be a technology that leads to high water volumes entering container-based toilet (because blackwater is not an input). For e.g. Cistern flush sytems willl never be the recommended FG U tech for container-based toilet. (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No need for electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.7, continous = 0.3)	"Key O & M tasks include the regular emptying, cleaning and replacing of the collection containers (depending on the size of the container and the number of users), by either the user or a collector/service provider. Containers require careful cleaning by trained staff in a designated cleaning area that can safely manage the hazardous cleaning water. Each Container-Based Toilet needs to be supplied with the appropriate anal cleansing material." (Emersan) Maintenance is required very often.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No need for pipes.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"No need for permanent structures, thereby accommodating the needs of mobile, or transient residents" (Emersan) "Container-Based Toilets are either prefabricated containers or can be a mixture of both prefabricated containers and a locally-made box for holding the container." (Emersan) No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0, special = 0.5)	"Container-Based Toilets are either prefabricated containers or can be a mixture of both prefabricated containers and a locally-made box for holding the container." (Emersan) Some specially manufactured spare parts by the manufacturares might be necessary. If they are locally-made also simple spare parts can work.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, hot = 1)	Assumed to be suitable for all temperatures.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	"Suitable where constraints such as risk of flooding, high water table, rocky ground or collapsing soil exist" (Emersan)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.3, difficult = 0.6, full = 1)	"The containers are then transported by Manual or Motorised Transport to the treatment or resource recovery centres where the contents can be safely managed." (Emersan) Manual transport is possible, but due to regular transport requirements motorized transport performs a lot better.	yes
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, rock = 1)	Not affected by soil type.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"Suitable where constraints such as risk of flooding, high water table, rocky ground or collapsing soil exist" (Emersan)	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No excavation needed.	yes

surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 0, b = 0.5, c = 999, d = 999)	As the technology is movable, it is assumed that it can be used starting from space requirements of zero m2/plot! Since there are many different variations of container based toilets, common sense is applied here to define 0.5 m2/plot as the minimum space required for 100% performance (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Suitable where constraints such as risk of flooding, high water table, rocky ground or collapsing soil exist" (Emersan) There is no contamination of drinking water to be expected.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	"No need for permanent structures, thereby accommodating the needs of mobile, or transient residents" (Emersan) "Container-Based Toilets are either prefabricated containers or can be a mixture of both prefabricated containers and a locally-made box for holding the container." (Emersan) Low construction skills should be sufficient.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The division of operation and maintenance (O & M) tasks and responsibilities between users and potential service providers need to be clearly defined and considered in the planning process." (Emersan) "The size of the Container-Based Toilet vault must be chosen according to the anticipated number of users and the collection capacity and interval. The size of the collection container should not exceed 50–60 L to ensure easy and manual removal and transport. Containers should be fully sealable and equipped with handles to ensure safe handling, intermediate storage (if required), storage and transport. A simple cubical can be constructed within the home to increase privacy. Where squatting is preferred, a wooden box can be built to create a platform for the user over the container." (Emersan) "Container-Based Toilets are either prefabricated containers or can be a mixture of both prefabricated containers and a locally-made box for holding the container." (Emersan) No specific knowledge necessary, but determining the size of the vault requires at	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Key O & M tasks include the regular emptying, cleaning and replacing of the collection containers (depending on the size of the container and the number of users), by either the user or a collector/service provider. Containers require careful cleaning by trained staff in a designated cleaning area that can safely manage the hazardous cleaning water. Each Container-Based Toilet needs to be supplied with the appropriate anal cleansing material." (Emersan) "Requires well-trained user and service personnel for use, maintenance, servicing and monitoring" (Emersan) "Container-Based Toilets are either prefabricated containers or can be a mixture of both prefabricated containers and a locally-made box for holding the container." (Emersan).	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Container-Based Toilets can be an appropriate solution in all phases of an emergency, provided a company or other organisation is ensuring regular collection, transport and emptying.", "Container-Based Toilets are moderately expensive to implement. However, they can be implemented rapidly and once managed well can be used sustainably in the long-term." (Emersan) "Life span of 5+ years" (Hakspiel, D. et al. (2018))	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 1, moderate = 0, slow = 0)	"Container-Based Toilets can be implemented relatively quickly and distributed by hand, if stocks are readily available. They do not need a permanent structure" (Emersan Compendium) "The entire construction, assembly, and installation process takes approximately 3 days and trained staff should be able to produce 4 toilets per person per day" (Hakspiel, D. et al. (2018))	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"No need for permanent structures, thereby accommodating the needs of mobile, or transient residents.", (Emersan) Technology can be easily scaled-up as long as new containers are available.	yes

construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Container-Based Toilets are either prefabricated containers or can be a mixture of both prefabricated containers and a locally-made box for holding the container. The holding box and the cubicles can be made from wood, woven mats, ferro-cement or metal sheets. Toilet seats or squatting pans can be obtained or produced locally or prefabricated alternatives may be used. Some models of Container-Based Toilets require a bag-type lining, a supplier of these will need to be secured." (Emersan) Mostly locally-made. It is assumed that specially-made prefabricated containers are only used if a local supplier exists.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20221010.xlsm")

	Excreta	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	No P assumed to be lost.	Spuhler et al. (2021)
	1	-	0	0	0	* Nutrients besides N are contained	Jönsson et al. (2004)
med (R)	1.00	-	0	0	0	-	-
k	100	-	-	-	-		
TN	0.43	0.16 - 0.7	0.57	0	0	* as N	Jacks et al. (1999)
	0.99	-	0.01	0	0	* 1% of N precipitates/volatizes in urine	Maurer et al. (2006)
	0.6		0.4	0	0	*5 days-emission of Ntot+NH3 in aerobic	Osada et al. (2001)
	0.7	0.67-0.81	0.3	0	0	*7-10 days-emission of Ntot+NH3 in	Sommer et al. 2001
	0.8	-	0.2	0	0	* at constant air moisture, loss of N is low	Jönsson et al. (2004)
med (R)	0.7	0.43-0.99	0.3	0	0		-
k	2	[0.56]		-	-		
H2O	0.9	0.8 - 1	0.1	0	0	*PA	Spuhler et al. (2021)
med (R)	0.9	0.8 - 1	0.1	0	0		-
k	5	[0.2]	-	-	-		
TS	1	-	0	0	0	* PA, no TS losses assumed due to frequent emptying (weekly/biweekly)	Spuhler et al. (2021)
	0.96	0.95-0-97	0.04	0		0.71 VSS in 50 days, >0.95 VSS in 7 days (assumption: VSS=0.8-0.9*TS)	Regmi (2005)
med (R)	0.98	0.95-1	0.02	0	0		-
k	100	[0.05]	-	-	-		

Additional Information

Even though the container based toilet can be sealed, it is assumed that ammonia volatilization and denitrification takes place. The values were therefore adapted from "raised_latrine" (same assumptions). Also no blackwater should be diverted into this technology.

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Single Pit

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	single_pit	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces, excreta, blackwater	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	sludge	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 0)	Tilley, E. et al. (2014)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Gensch, R. et al. (2018)
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Tilley, E. et al. (2014)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 8, d = 33)	- Minimal volume: can be used without flushing water (a,b = 0) - Maximal volume: can be used with pour-flush toilet (1-3 l/use) and anal cleansing water (0.3-3 l/use) assuming 6 visits per persons per day	yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electriciy needed	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	"There is no daily maintenance associated with a single pit apart from keeping the facility clean. However, when the pit is full it can be a) pumped out and reused or b) the superstructure and squatting plate can be moved to a new pit and the previous pit covered and decommissioned, which is only advisable if plenty of land area is available." (Compendium) "Depending on how deep they are dug, some pits may last 20 or more years without emptying." (Compendium) Irregular frequency of OM can be expected.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Can be built and repaired with locally available materials" (Compendium) "Pit lining materials can include brick, rotresistant timber, bamboo, concrete, stones, or mortar plastered onto the soil." (EmersanCompendium) But concrete is not specifically needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	A single pit can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"Pits are susceptible to failure and/or overflowing during floods." (Compendium) "[...] A raised pit can also be constructed in an area where flooding is frequent in order to keep water from flowing into the pit during heavy rain." (Compendium) All technologies where raised configurations are possible get a 50% performance for category "flooding". (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.3, difficult = 0.6, full = 1)	"However, when the pit is full it can be a) pumped out and reused or b) the superstructure and squatting plate can be moved to a new pit and the previous pit covered and decommissioned, which is only advisable if plenty of land area is available." (Compendium) Pumps might be needed depending on the configuration of the technology. In cases where pumps are needed a pumping truck can be used as well. Single Pits need to be emptied frequently, so that motorized emptying and transport can improve the performance strongly.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel = 0.5, rock = 0.25)	"As the single pit fills, two processes limit the rate of accumulation: leaching and degradation. Urine and water percolate into the soil through the bottom of the pit and wall, while microbial action degrades part of the organic fraction." (Compendium) "They are not suited for rocky or compactede soils (that are difficult to dig), or for areas that flood frequently." (Compendium) Soil percolation and filtration is desired resulting in lower desludging rates.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 6, b = 9, c = 999, d = 999)	"Leachate can contaminate groundwater" (Compendium) "When it is not possible to dig a deep pit or the groundwater level is too high, a raised pit can be a viable alternative: the shallow pit can be extended by building the pit upwards with the use of concrete rings or blocks." (Compendium) "Typically, the pit is at least 3 m deep and 1 m in diameter." (Compendium) If the technology is constructed in areas with a high groundwater table the risk for contamination is higher and some further design and effort is needed. It is assumed that a pit is at least 3 m deep and optimally 6 m deep. A vertical safety distance of 3 meters is applied.	yes

excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"The volume of the pit should be designed to contain at least 1,000 L." (Compendium) "When it is not possible to dig a deep pit or the groundwater level is too high, a raised pit can be a viable alternative: the shallow pit can be extended by building the pit upwards with the use of concrete rings or blocks. A raised pit can also be constructed in an area where flooding is frequent in order to keep water from flowing into the pit during heavy rain. Another variation is the unlined shallow pit that may be appropriate for areas where digging is difficult." (Compendium) Excavation for a bigger volume needed. If excavation is not possible other solutions are an option. But these lead to further design and effort	yes	
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 1, b = 1, c = 999, d = 999)	"Typically, the pit is at least 3 m deep and 1 m in diameter. If the pit diameter exceeds 1.5 m, there is an increased risk of collapse." (Compendium). Based on this, we derive a minimum space requirement of 1m2/plot for a single pit (Eawag, 2021). Note that this only involves the pit and not any visual protection. A superstructure could require more space.		
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"Leachate can contaminate groundwater" (Compendium) "A minimum horizontal distance of 30m between a pit and a water source [...] is normally recommended to limit exposure to microbial contamination." (Compendium) Technology must not be exposed to a drinking water source.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Can be built and repaired with locally available materials" (Compendium) Even though high design skills are recommended, moderate or even low construction skills should be sufficient. The only case where moderate construction skills are necessary needed is to install technical components such as a pump. But there are lots of configurations without technical components.	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"If the pit is to be reused, it should be lined. Pit lining materials can include brick, rot-resistant timber, concrete, stones, or mortar plastered onto the soil. If the soil is stable (i.e., no presence of sand or gravel deposits or loose organic materials), the whole pit need not be lined. The bottom of the pit should remain unlined to allow for the infiltration of liquids out of the pit. As liquid leaches from the pit and migrates through the unsaturated soil matrix, pathogenic germs are absorbed to the soil surface. In this way, pathogens can be removed prior to contact with groundwater. The degree of removal varies with soil type, distance travelled, moisture and other environmental factors and, thus, it is difficult to estimate the distance necessary between a pit and a water source. A minimum horizontal distance of 30 m is normally recommended to limit exposure to microbial contamination. (Compendium) Lots of things to take in account and different configurations possible depending on the circumstances. High design skills recommended, moderate design skills could be sufficient for simple variations.	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"There is no daily maintenance associated with a single pit apart from keeping the facility clean. However, when the pit is full it can be a) pumped out and reused or b) the superstructure and squatting plate can be moved to a new pit and the previous pit covered and decommissioned, which is only advisable if plenty of land area is available." (Compendium) Pumps might be needed depending on the configuration of the technology. In cases where pumps are needed a pumping truck can be used as well. If there are no technical components such as pumps low OM skills should be sufficient.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 0.5, long = 0)	"Expected lifetime: 1-3 yrs", "Short lifetime (can be <1 year)", "New land required for each new latrine after one fills up" (BCG, 2014) for pit latrines in refugee camps.	yes	
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 1, moderate = 0, slow = 0)	"Single Pit Latrines can be constructed quickly with local materials during the acute phase of an emergency." "minimal materials and minimal skills for construction are needed."(Emersan Compendium)	yes	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Single Pit Latrines can be constructed quickly with local materials during the acute phase of an emergency.", (Emersan) "It can be replicated quickly and implemented at scale given sufficient space." (Single VIP - Emersan)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0		-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	25	[0.18]	-	-	-		PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA
med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

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Single Ventilated Improved Pit

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	single_vip	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces, excreta, blackwater	Tilley, E. et al. (2014)
OUTPUT PRODUCT	sludge	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: NA	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 8, d = 33)	"The only design difference to a Single Pit Latrine is the ventilation." (Emersan) "Large quantities of water should not be poured down the toilet (from the shower, etc.). Water can, however, be used for anal cleansing." (Monvois et al. -> A01 Simple Unventilated Pit Latrine) No additional water needed but a high water consumption should be prevented. This is a technology that is negatively impacted if very high water-volumes enter it (performance is reduced). Since blackwater is an input to this technology, Santiago algorithm CAN pair these technologies with FG U techs that introduce high volumes of water into the system (e.g., Cistern flush). Thus, our criterion (WATER REQ) should bring down the performance of this tech and hence its appropriateness when a user defines a case attribute with high water inputs. Or in other words, if user defines	yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electriciy needed	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continous = 0)	"To keep the single VIP free of flies and odours, regular cleaning and maintenance is required. Dead flies, spider webs, dust and other debris should be removed from the ventilation screen to ensure a good flow of air." (Compendium) Maintenance is between regular and irregular.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Can be built and repaired with locally available materials" (Compendium) "Pit lining materials can include brick, rotresistant timber, bamboo, concrete, stones, or mortar plastered onto the soil." (EmersanCompendium) But concrete is not specifically needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium) "The only design difference to a Single Pit Latrine is the ventilation." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	A single VIP can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"Pits are susceptible to failure and/or overflowing during floods." (Compendium) "[...] A raised pit can also be constructed in an area where flooding is frequent in order to keep water from flowing into the pit during heavy rain." (Compendium) All technologies where raised configurations are possible get a 50% performance for category "flooding". (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.3, difficult = 0.6, full = 1)	"The only design difference to a Single Pit Latrine is the ventilation." (Emersan) "However, when the pit is full it can be a) pumped out and reused or b) the superstructure and squatting plate can be moved to a new pit and the previous pit covered and decommissioned, which is only advisable if plenty of land area is available." (Compendium -> S.2 Single Pit) Pumps might be needed depending on the configuration of the technology. In cases where pumps are needed a pumping truck can be used as well. Single Pits need to be emptied frequently, so that motorized emptying and transport can improve the performance strongly	yes
slope	Performance, Categorical	FALSE	flat	NA	NA	NA

soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel = 0.5, rock = 0.25)	"The only design difference to a Single Pit Latrine is the ventilation." (Emersan) "As the single pit fills, two processes limit the rate of accumulation: leaching and degradation. Urine and water percolate into the soil through the bottom of the pit and wall, while microbial action degrades part of the organic fraction." (Compendium -> S.2 Single Pit) "They are not suited for rocky or compactede soils (that are difficult to dig), or for areas that flood frequently." (Compendium) Soil percolation and filtration is desired resulting in lower desludging rates.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 6, b = 9, c = 999, d = 999)	"Leachate can contaminate groundwater" (Compendium) "When it is not possible to dig a deep pit or the groundwater level is too high, a raised pit can be a viable alternative: the shallow pit can be extended by building the pit upwards with the use of concrete rings or blocks." (Compendium) "Typically, the pit is at least 3 m deep and 1 m in diameter." (Compendium) If the technology is constructed in areas with a high groundwater table the risk for contamination is higher and some further design and effort is needed. It is assumed that a pit is at least 3 m deep and optimally 6 m deep. A vertical safety distance of 3 meters is applied.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"The volume of the pit should be designed to contain at least 1,000 L." (Compendium) "When it is not possible to dig a deep pit or the groundwater level is too high, a raised pit can be a viable alternative: the shallow pit can be extended by building the pit upwards with the use of concrete rings or blocks. A raised pit can also be constructed in an area where flooding is frequent in order to keep water from flowing into the pit during heavy rain. Another variation is the unlined shallow pit that may be appropriate for areas where digging is difficult." (Compendium) Excavation for a bigger volume needed. If excavation is not possible other solutions are an option. But these lead to further design and effort.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 1, b = 1, c = 999, d = 999)	Based on a comparison of different technologies, we derive the space requirements of a single VIP to be very similar to a single pit (as the excreta is also ends up in a chamber below the user) and use the same minimum space requirement of 1m2/plot (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"Leachate can contaminate groundwater" (Compendium) "A minimum horizontal distance of 30m between a pit and a water source [...] is normally recommended to limit exposure to microbial contamination." (Compendium) Technology must not be exposed to a drinking water source.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Can be built and repaired with locally available materials" (Compendium) Even though high design skills are recommended, moderate or even low construction skills should be sufficient. The only case where moderate construction skills are necessary needed is to install technical components such as a pump. But there are lots of configurations without technical components.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The only design difference to a Single Pit Latrine is the ventilation." (Emersan) "The vent pipe should have an internal diameter of at least 110 mm and reach more than 300 mm above the highest point of the toilet superstructure. [...] Care should be taken that objects, such as trees or houses, do not interfere with the air stream. The vent works best in windy areas, but where there is little wind, its effectiveness can be improved by painting the pipe black. [...] The mesh size of the fly screen must be large enough to prevent clogging with dust and allow air to circulate freely. Aluminium screens, with a hole-size of 1.2 to 1.5 mm, have proven to be the most effective. [...] As liquid leaches from the pit and migrates through the unsaturated soil matrix, pathogenic germs are sorbed to the soil surface. In this way, pathogens can be removed prior to contact with groundwater. The degree of removal	yes

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"To keep the single VIP free of flies and odours, regular cleaning and maintenance is required. Dead flies, spider webs, dust and other debris should be removed from the ventilation screen to ensure a good flow of air." (Compendium). "The latrine should be cleaned with disinfectant, emptying should preferably be carried out by a professional." (Monvois et al. -> A02 Ventilated Improved Pit Latrine (VIP))	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 0.5, long = 0)	"Expected lifetime: 1-3 yrs", "Short lifetime (can be <1 year)", "New land required for each new latrine after one fills up" (BCG, 2014) for pit latrines in refugee camps.	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.9, moderate = 0.1, slow = 0)	"...can be considered a viable solution in all phases of an emergency.""The only design difference to a Single Pit Latrine is the ventilation." (Emersan Compendium) A slightly lower value is allotted to the category "Rapid" (90%) than a Single Pit Latrine as the complexity of construction if slightly higher owing to the ventilation system that needs to be established.	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"It can be replicated quickly and implemented at scale given sufficient space." (Emersan)	yes
construction_parts	PDF, Categorical	TRUE	simple technical	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0		-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	25	[0.18]	-	-	-		PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA
med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

Additional Information

Copied from "single pit". It is assumed, that both the technologies carry the same transfer coefficients, as the reference of "Jacks et al. (1999)" already deals with ventilated improved pits.

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Montangero, A. and H. Belevi (2007). "Assessing nutrient flows in septic tanks by eliciting expert judgement: a promising method in the context of developing countries." Water Res 41(5): 1052-1064.

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Group, T. B. C. (2014). "Improving Sanitation in Refugee Camps." United Nations High Commissioner for Refugees (UNHCR), The UN Refugee Agency; Boston Consulting Group (BCG).

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Double Ventilated Improved Pit

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	double_vip	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces, excreta	Tilley, E. et al. (2014)
OUTPUT PRODUCT	pithumus	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: NA	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 8, d = 33)	"The double VIP has almost the same design as the Single VIP (S.3) with the added advantage of a second pit [...]." (Compendium) "The only design difference to a Single Pit Latrine is the ventilation." (Emersan -> S.4 Single Ventilated Improved Pit (VIP)) "Large quantities of water should not be poured down the toilet (from the shower, etc.). Water can, however, be used for anal cleansing." (Monvois et al. -> A01 Simple Unventilated Pit Latrine) No additional water needed but a high water consumption should be prevented. - Minimal volume: can be used without flushing water (a,b = 0) - Maximal volume: can be used with pour-flush toilet (1-3 l/use) and anal cleansing water (0.3-3 l/use) assuming 6 visits per persons per day	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continous = 0)	"To keep the double VIP free of flies and odours, regular cleaning and maintenance is required. Dead flies, spider webs, dust and other debris should be removed from the ventilation screen to ensure a good flow of air. The out of service pit should be well sealed to reduce water infiltration and a proper alternating schedule must be maintained." (Compendium) Maintenance is between regular and irregular.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	"After the resting time, the soil-like material is manually emptied (it is dug out, not pumped out), so vacuum truck access to the pits is not necessary." (Compendium) No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Can be built and repaired with locally available materials" (Compendium) "Pit lining materials can include brick, rotresistant timber, bamboo, concrete, stones, or mortar plastered onto the soil." (EmersanCompendium) But concrete is not specifically needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	A double VIP can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"Pits are susceptible to failure and/or overflowing during floods." (Compendium) "[...] A raised pit can also be constructed in an area where flooding is frequent in order to keep water from flowing into the pit during heavy rain." (Compendium) All technologies where raised configurations are possible get a 50% performance for category "flooding". (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.8, difficult = 0.8, full = 1)	"After the resting time, the soil-like material is manually emptied (it is dug out, not pumped out), so vacuum truck access to the pits is not necessary." (Compendium) The emptying and transport is slightly improved by motorized transport as the dug-out material can be transported more efficiently.	yes
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel = 0.5, rock = 0.25)	"The double VIP has almost the same design as the Single VIP (S.3) with the added advantage of a second pit [...]." (Compendium) "The only design difference to a Single Pit Latrine is the ventilation." (Emersan -> S.4 Single Ventilated Improved Pit (VIP)) "As the single pit fills, two processes limit the rate of accumulation: leaching and degradation. Urine and water percolate into the soil through the bottom of the pit and wall, while microbial action degrades part of the organic fraction." (Compendium -> S.2 Single Pit) "They are not suited for rocky or compactede soils (that are difficult to dig), or for areas that flood frequently." (Compendium) Soil percolation and filtration is desired resulting in lower desludging rates.	yes

groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 6, b = 9, c = 999, d = 999)	"Leachate can contaminate groundwater" (Compendium) "The double VIP has almost the same design as the Single VIP (S.3) with the added advantage of a second pit [...]." (Compendium) "When it is not possible to dig a deep pit or the groundwater level is too high, a raised pit can be a viable alternative: the shallow pit can be extended by building the pit upwards with the use of concrete rings or blocks." (Compendium -> S.3 Single VIP) "Typically, the pit is at least 3 m deep and 1 m in diameter." (Compendium) If the technology is constructed in areas with a high groundwater table the risk for contamination is higher and some further design and effort is needed. It is assumed that a pit is at least 3 m deep and optimally 6 m deep. A vertical safety distance of 3 meters is applied.	yes	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"The double VIP has almost the same design as the Single VIP (S.3) with the added advantage of a second pit [...]." (Compendium) "The volume of the pit should be designed to contain at least 1,000 L." (Compendium -> S.3 Single VIP) "When it is not possible to dig a deep pit or the groundwater level is too high, a raised pit can be a viable alternative: the shallow pit can be extended by building the pit upwards with the use of concrete rings or blocks. A raised pit can also be constructed in an area where flooding is frequent in order to keep water from flowing into the pit during heavy rain. Another variation is the unlined shallow pit that may be appropriate for areas where digging is difficult." (Compendium -> S.3 Single VIP) Excavation for a bigger volume needed. If excavation is not possible other solutions are an option. But these lead to further design and effort	yes	
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 2, b = 2, c = 999, d = 999)	Based on a comparison of different technologies, we derive the space requirements of a double VIP to be (at least) twice the space of the space requirements of a single pit. This is based on the assumption that the excreta ends up in two alternating chambers below the user, instead of just one chamber. There are no further significant differences in terms of space requirements between a single pit and a double VIP and therefore, using twice the space (2m2/plot) is justified (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.		
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"Leachate can contaminate groundwater" (Compendium) "The double VIP has almost the same design as the Single VIP (S.3) with the added advantage of a second pit [...]." (Compendium) "A minimum horizontal distance of 30m between a pit and a water source [...] is normally recommended to limit exposure to microbial contamination." (Compendium -> S.3 Single VIP) Technology must not be exposed to a drinking water source.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Can be built and repaired with locally available materials" (Compendium) Even though high design skills are recommended, moderate or even low construction skills should be sufficient. The only case where moderate construction skills are necessary needed is to install technical components such as a pump. But there are lots of configurations without technical components.	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The double VIP has almost the same design as the Single VIP (S.3) with the added advantage of a second pit [...]." (Compendium) "The superstructure may either extend over both holes or it may be designed to move from one pit to the other. In either case, the pit that is not being filled should be fully covered and sealed to prevent water, garbage and animals, or people from falling into the pit. The ventilation of the two pits can be accomplished using one ventilation pipe moved back and forth between the pits, or each pit can be equipped with its own dedicated pipe. The two pits in the double VIP are continually used and should be well lined and supported to ensure longevity." (Compendium) Lots of things to take in account and different configurations possible depending on the circumstances. High design skills recommended, moderate design skills could be sufficient for simple configurations.	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"To keep the single VIP free of flies and odours, regular cleaning and maintenance is required. Dead flies, spider webs, dust and other debris should be removed from the ventilation screen to ensure a good flow of air." (Compendium) "The double VIP has almost the same design as the Single VIP (S.3) with the added advantage of a second pit [...]." (Compendium) "the latrine should be cleaned with disinfectant, emptying should preferably be carried out by a professional." (Monvois et al. -> A02 Ventilated Improved Pit Latrine (VIP))	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Pits designed to last 25 to 30 years are not uncommon and a design life of 15 to 20 years is perfectly reasonable. The longer a pit lasts, the lower will be the average annual economic cost and the greater the social benefits from the original input (WHO 1992)." (Double Pits | SSWM Toolbox) "Because double pits are used alternately, their life is virtually unlimited" (Compendium)	yes	

speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.8, moderate = 0.2, slow = 0)	A slightly lower value is allotted to the category "Rapid" (80%) than a Single VIP as the complexity of construction if slightly higher, owing to the implementation of ventilation system + double pits (double the efforts and consequently time). (Akanksha Jain, Eawag 2021) "Twin pit systems include double Ventilated Improved Pits (VIP), and the fossa alterna (FA)." (Twin pit systems- Emersan Compendium) Same values are allotted to both Fossa Alterna and Double VIPs because of the text above. Other important text from Emersan Compendium that bear some relevance for this technology and criteria: "The slab can be fabricated on-site with a mould and cement. In the acute emergency phase, pre-fabricated plastic slabs may be used." "As the second pit only comes into operation when the first pit is full, which may take between 6 to 24 months, Twin Pit Dry Systems are recommended as longer-term solutions in prolonged emergency situations."	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"Easier excavation than single pit systems, [but] double the space and materials required" (Emersan) Technology is complete and it's not easy to extend the pit size, however it is possible to build new units. It has a lower performance compared to single pit latrines, because more material and space are required. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Pit Humus	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0		-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	5	[0.18]					PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA
med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

Additional Information

Copied from "single pit" because the treatment is assumed to be similar. The k-factors were decreased if not already at minimum value.

References

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Montangero, A. and H. Belevi (2007). "Assessing nutrient flows in septic tanks by eliciting expert judgement: a promising method in the context of developing countries." Water Res 41(5): 1052-1064.

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Twin Pits for Pour-Flush Toilets						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	S	-				
UNIQUE IDENTIFIER (ID)	twin_pits_pour_flush	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	blackwater	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	pithumus	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: NA Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)				
capex_req_level	8	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 8, b = 20, c = 21, d = 33)	"As this is a water-based (wet) technology, the full pits require a longer retention time (two years is recommended) to degrade the material before it can be excavated safely." (Compendium) Since it is a water-based technology a minimum of water volume entering the pits is necessery. Calculations for minimum water required are based on following assumptions: Pour flush toilets require 1-3L of flush water for every flush and anal cleansing water 0.3-3L/use (Compendium) assuming 6 toilet visits (or flushes) per person per day. The performance of the technology is depending on a minimum but not on a maximum of water consumption even though high amount of inflitration water should be optimally avoided.	yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continous = 0)	"The pits must be regularly emptied (after the recommended two year resting time), and care must be taken to ensure that they do not flood during rainy seasons. Emptying is done manually using long handled shovels and proper personal protection." (Compendium) Maintenance is between regular and irregular.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.75, difficultly available = 0.75, pipes = 1)	"The twin pits for pour flush technology can be designed in various ways; the toilet can be located directly over the pits or at a distance from them." (Compendium) "Alternatively, the Flush toilet could also be connected to the pit in use by a single straight pipe" (Emersan Compendium) Flush toilets are either above the pits or connected to via pipes. The configuration with pipes performs slightly better due to distance between pits	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	"The dewatered, solid material is manually emptied from the pits (it is dug, not pumped out)"(Compendium) "Emptying is done manually [it is dug not pumped out], e.g. using long handled shovels and proper personal protective equipment or emptying can be done with mobile desludging machines" (Emersan Compendium) Pumps are not required	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Can be built and repaired with locally available materials" (Compendium) "The pit lining can be made of concrete or bricks among other materials" (Emersan Compendium) But concrete is not specifically needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium) "The latrine superstructure can be made from local materials, such as bamboo, grass matting, cloth or wood, plastic or metal sheeting (though this often heats up the interior)." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	Twin pits can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	"This technology is not suitable for areas with a high groundwater table or where there is frequent flooding." (Compendium) A low performance of 10% is allotted to the category "flooding" given that there exists the possibility that twin pits pour flush technology could be built at elevated/ non-flooded plot areas of the flood-prone region. (Akanksha Jain)	Yes

vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.8, difficult = 0.8, full = 1)	"The dewatered, solid material is manually emptied from the pits (it is dug, not pumped out), therefore, space is not required for vacuum trucks to access them." (Compendium) "Emptying is done manually [it is dug not pumped out], e.g. using long handled shovels and proper personal protective equipment or emptying can be done with mobile desludging machines" (Emersan Compendium) The emptying and transport is slightly improved by motorized transport as the dug-out material can be transported more efficiently.	yes
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel = 0.5, rock = 0.25)	"In order for the pits to drain properly, the soil must have a good absorptive capacity; clay, tightly packed or rocky soils are not appropriate." (Compendium) Soil percolation and filtration is desired resulting in lower desludging rates.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 6, b = 9, c = 999, d = 999)	"This technology is not suitable for areas with a high groundwater table or where there is frequent flooding." (Compendium) "There is a risk of groundwater pollution when pits are located in areas with a high or variable water table, and/or fissures or cracks in the bedrock" (Compendium) It is assumed that a pit is at least 3 m deep and optimally 6 m deep. A vertical safety distance of 3 meters is applied.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Excavation for a bigger volume needed. If excavation is not possible other solutions are an option. But these lead to further design and effort. A bigger volume than for a single pit is necessary, but we assume the performance is the same.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 5, b = 5, c = 999, d = 999)	Emersan: "It is recommended that the twin pits are constructed at least 1 m apart to minimise cross-contamination between the maturing pit and the one in use. Pits should be constructed over 1 m from any structural foundation as leachate can negatively impact structural supports." It is assumed that the space requirements of the separate components of a twin pit for pour and flush setup resembles the size requirements of a single pit, meaning that 1m2 is allotted to each the toilet and the two pits. Due to the required distance between the two pits and further walls, it is assumed that the whole twin pit for pour and flush requires at least 5m2/plot (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"As soil and groundwater properties are often unknown, it is difficult to estimate the distance necessary between a pit and a water source. It is normally recommended to have a minimum horizontal distance of 30 m between them to limit exposing the water source to microbial contamination." (Compendium)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Can be built and repaired with locally available materials" (Compendium) Moderate construction skills are recommended, low construction skills could be sufficient.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"The pits should be of an adequate size to accommodate a volume of waste generated over one or two years. […] It is recommended that the twin pits be constructed 1 m apart from each other to minimize cross-contamination between the maturing pit and the one in use. It is also recommended that the pits be constructed over 1 m from any structural foundation as leachate can negatively impact structural supports. Water within the pit can impact its stability. Therefore, the full depth of the pit walls should be lined to prevent collapse and the top 30 cm should be fully mortared to prevent direct infiltration and to support the superstructure. To ensure that only one of the two pits is used at any time, the idle pipe of the junction connecting to the outof-use pit should be closed (e.g. with cement or bricks). Alternatively, the Pour Flush Toilet could also be directly connected to the pit in use by a single straight pipe	yes

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"The pits must be regularly emptied (after the recommended two year resting time), and care must be taken to ensure that they do not flood during rainy seasons. Emptying is done manually using long handled shovels and proper personal protection." (Compendium) Moderate OM skills can ensure propper operation but low OM skills could be sufficient.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Because double pits are used alternately, they can have a long life" (Emersan) "Expected lifetime: ~5 years with supersize communal pits (10m3 +; 10+ years if twin vaults are alternated & emptied", "Longevity: If pit is large enough with sufficient leaching, can last ~5 years; "Empty-able" pits can be re-used; No trash increases lifespan of pits (up to 25% of basic latrine= trash)" (Pour-flush to pit | BCG, 2014)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0, moderate = 0.5, slow = 0.5)	"If possible, materials should be used that are locally available. The pit lining can be made of concrete or bricks among other materials. Moreover, piping is needed." (Emersan Compendium) "The pits are either constructed with a porous material, in open-joint brick lines (like a honeycomb, to facilitate the liquid to flow out) or with perforated concrete tubes (i.e. pre-fabricated)." (SSWM) Given that concrete could be used for construction and/or masonry brick structures need to be built, curing itself would take some time. Plus, the construction is underground (i.e., digging required). All these elements point towards longer speeds of implementation and it is unlikely that this technology be implemented in <3 days. (Akanksha Jain, Eawag 2021)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"Twin Pits for Pour Flush are appropriate for areas where it is not possible to continuously build new pit latrines or regular desludging might be an issue and where there is water available and desired for flushing. It is recommended not to concentrate pits in a small area as the soil may not have sufficient capacity to absorb the liquid and the ground could become water-logged (oversaturated)" (Emersan) A unit of technology is complete and it is difficult to increase the pit size, because it is designed specifically. The alternative option would be to build new units, which is difficult in close proximity due to limited soil absorption. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium) "The latrine superstructure can be made from local materials, such as bamboo, grass matting, cloth or wood, plastic or metal sheeting (though this often heats up the interior)." (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Pit Humus	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0		-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	5	[0.18]					PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA
med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

Additional Information

Copied from "single pit" since both an anaerobic and a aerobic digestion can occur and therefore the transfer coefficients are assumed to be similar to the ones of a single pit. Some of the k-factors were decreased if they weren't already the minimum possible value.

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Composting Chamber		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	composting_chamber	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces, excreta, organics	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	compost, effluent	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS	"Depending on the design, the composting chamber should be emptied every 2 to 10 years."	Spuhler, D. & Roller, L. (2020)
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute=0, stabilisation=1, development/recovery=1)	"The priority of 1st phase options is the speed of response, and it is essential that 1st phase technologies to contain excreta can be installed quickly. Normally, UD technology and composting toilets are associated with 2nd phase responses, particularly in flood prone areas. However, novel solutions to rapid onset floods have been tried and tested in Latin America." (Oxfam Policy & Practice, 2009)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"Since this technology is compact and waterless, it is especially suited in areas where land and water are limited, or when there is a need for compost." (Compendium) "This technology cannot be used for the collection of anal cleansing water or greywater; if the reactor becomes too wet, anaerobic conditions will cause odour problems and improper degradation." (Compendium) No additional water needed. This technology is not impacted by flooding and/or high groundwater tables. The only possible way high water volumes could enter this technology would be by means of a FG U technology that introduces high amount of water into the system (i.e., due to anal cleansing or flush water). Maximum values (c & d) are assumed to remain 999 L/cap/day since the FG U technology that will be connected with this tech according to santiago algorithm, based on input-output products, will never be a technology that leads to high water volumes entering composting chamber (because blackwater/anal cleansing water is not a defined input product for composting chamber). For e.g. Cistern flush sytems willl never be the recommended FG U tech for composting chamber (due to input-output mismatch). (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.9, no elec	"A composting chamber can be designed in various configurations [...] More complex designs can include a small ventilation fan or a mechanical mixer." (Compendium) Depending on the configuration the technology must not run with electricity. However, the technology performs better if ventilation or mixing can be applied. For mixing and ventilation intermittent electricity is not suitable.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	The composting chamber has to be emptied and the quality of the compost has to be checked regularly every several weeks and the chamber must be emptied every several years. In dependence of the operation of the composting process there might also other maintanance actions be necessary such as watering or turning over the material.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficutly available = 1, pipe	The composting chamber contains a ventilation pipe, air ducts as well as an excess liquid drain. (Compendium) These components might work the best if they are built with pvc pipes but its not necessary. If there are no pipes available it should also be possible to build it with other (local) material such as bamboo or similar.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficutly available = 1, pu	"A composting chamber can be designed in various configurations [...] More complex designs can include a small ventilation fan or a mechanical mixer." (Compendium) Depending on the configuration the technology can have a pump for mixing, but it does not affect performance.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, no concrete = 1)	According to Crennan (2007) there is need for concrete to build up the technology. Even though its easier to build the technology with concrete it's also possible to build it with other (weather-proof) material like clay.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.5, special = 0.5)	"This technology usually requires four main parts: (1) a reactor (storage chamber); (2) a ventilation unit to provide oxygen and allow gases (CO2, water vapour) to escape; (3) a leachate collection system; and (4) an access door to remove the mature product. [...] A composting chamber can be designed in various configurations. [...] Ventilation channels (air ducts) under the heap can be beneficial for aeration. More complex designs can include a small ventilation fan, a mechanical mixer, or multiple compartments to allow for increased storage and degradation time. [...] A drainage system is important to ensure the removal of leachate. [...] May require some specialized parts and electricity." (Compendium) The technology can be designed in various configurations. Some of them require specially-manufactured parts, while any system requires some kind of technical parts for mixing and ventilation.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 0	"There are four factors that ensure the good functioning of the system: [...] internal (heap) temperature of 40 to 50 °C" (Compendium) Retention time during winter months was double the retention time in summer, therefore we adapted a performance (=1) in summer and a performance (=0.5) in winter. The ambient temperatures were measured as -20 to 0 °C in winter (performance 0.5 for "very cold") and 10 to 30° in summer. It is assumed that a composting chamber works up to ambient temperatures of up to 60 °C because the composting chamber still works if the pile temperature is at this level. (McCartney, 2005)	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	"It can also be installed in rocky areas, or where the groundwater table is high." (Compendium) The technology is neither based on soil absorption nor relying on stormwater drains for sewage collection. That means that the performance is not directly affected by flooding.	yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.8, difficult = 0.8, full = 1)	There is no need for any special vehicle to empty the chamber and it can easily be done manual. However, a vehicle can be used to empty the chamber. If a vehicle might be useful depends on the dimension of the chamber. If it is designed for a big load of material a vehicle like an excavator might ease the operating work.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, rock	The compost in the chamber is not lying directly on the ground what means that there is no contact of the substrate in the chamber to the soil. (Compendium) Technology does not rely on soil absorbtion. No difference between soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	The compost in the chamber is not lying directly on the ground and exiting liquids leave the system by a drainage. (Compendium) That means that no content of the chamber should reach the ground and that the groundwater is not affected by the technology.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"A composting chamber can be designed in various configurations and constructed above or below ground, indoors or with a separate superstructure." (Compendium) Excavation is not necessary needed since its possible to build the superstructure above ground. However, can be built underground.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 2, b = 2, c = 999, d = 999)	The space area requirements of composting chambers are derived based on a comparable approach with other technologies. Its space requirements are certainly similar to a single pit (1m2/plot), as it also requires just one chamber below the user where the excreta ends up. However, composting chambers generally require a bit more space than other technologies based on one chamber (Eawag, 2021). It is therefore assumed that composting chambers require at least 2m2/plot (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	The compost in the chamber is not lying directly on the ground and exiting liquids leave the system by a drainage. (Compendium) The technology doesnt rely on soil absorbtion and no content of the chamber should reach the ground. That means that the groundwater is not affected by the technology.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Requires expert design and construction" (Compendium) To build up the technology a skilled labour with technical knowledge is necessary.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium) "If the composting chamber is well designed, the users will not have to handle the material during the first year. A well-functioning composting chamber should not produce odours." (Compendium) To ensure that the system is well planned and runs properly it should be designed by an expert planner or an engineer.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Requires well-trained user or service personnel for monitoring and maintenance" (Compendium) "Although simple in theory, composting chambers are not that easy to operate. The moisture must be controlled, the C:N ratio must be well balanced and the volume of the unit must be such that the temperature of the compost pile remains high to achieve pathogen reduction. After each defecation, a small amount of bulking material is added to absorb excess liquid, improve the aeration of the pile and balance the carbon availability. Turning the material from time to time will boost the oxygen supply. A squeeze test can be made to check the moisture level within the chamber. When squeezing a handful of compost, it should not crumble or feel dry, nor should it feel like a wet sponge. Rather, the compost should leave only a few drops of water in one's hand. If the material in the chamber becomes too compact and humid, additional bulking material should be added." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Long Service Life" (Composting Chamber | SSWM Toolbox). Meant for long-term service life "May require a year or more of maturation before being safe to use." (Compost | SLU Compendium) The fact that a storage time of less than one year is unsuitable is not considered in the criterion 'Lifetime'. (Kukka Ilmanen, Eawag 2021)	yes

speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0, moderate = 0.2, slow = 0.8)	"This technology usually requires four main parts: (1) a reactor (storage chamber); (2) a ventilation unit to provide oxygen and allow gases (CO2, water vapour) to escape; (3) a leachate collection system; and (4) an access door to remove the mature product." Compendium The above goes to show that design and construction requires special attention and efforts to achieve good quality (technical complexity is higher). This points towards slower speeds of implementation (largely expected to be > 2 weeks)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"A design value of 300 L/person/year can be used to calculate the required chamber volume." (Compendium) "Although simple in theory, composting chambers are not that easy to operate. The moisture must be controlled, the C:N ratio must be well balanced and the volume of the unit must be such that the temperature of the compost pile remains high to achieve pathogen reduction. After each defecation, a small amount of bulking material is added to absorb excess liquid, improve the aeration of the pile and balance the carbon availability. The immediate coverage of the fresh faeces with an additive material also lowers nuisances caused by odour or flies. Turning the material from time to time will boost the oxygen supply." (Compendium) In general, a composting chamber has a designed specific volume per person and it is complex to construct a further unit so that scaling up the technology is difficult. However, if composting chambers are designed large enough and the abovementioned conditions can be fulfilled, it is possible to increase the amount of input material into a composting chamber. This requires the availability of further bulking material, additive material and material with sufficient carbon content to be added to the system. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.5, special = 0.5)	"This technology usually requires four main parts: (1) a reactor (storage chamber); (2) a ventilation unit to provide oxygen and allow gases (CO2, water vapour) to escape; (3) a leachate collection system; and (4) an access door to remove the mature product. [...] A composting chamber can be designed in various configurations. [...] Ventilation channels (air ducts) under the heap can be beneficial for aeration. More complex designs can include a small ventilation fan, a mechanical mixer, or multiple compartments to allow for increased storage and degradation time. [...] A drainage system is important to ensure the removal of leachate. [...] May require some specialized parts and electricity." (Compendium) The technology can be designed in various configurations. Some of them require specially-manufactured parts, while any system requires some kind of technical parts for mixing and ventilation.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Compost	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.95	-	0.05	0	0	0	* as P	Stintzing et al. (2004)
	1	-	0	0	0	0	* see calculations in 11.2.1	Yadav et al. (2012)
	0.99	-	0.01	0	0	0	* as P	Meinzinger (2010)
med (R)	0.99	0.95 -1	0.01	0	0	0		-
k	100	[0.05]	-	-	-	-		PA
TN	0.7	0,5-0,9	0	0.3	0	0	* as N	Stintzing et al. (2004)
	0.67	-	0	0.33	0	0	* see calculations in 11.2.1	Yadav et al. (2012)
	0.65	-	0	0.35	0	0	* as N	Meinzinger (2010)
	0.3	-	0	0.7	0	0	* max N losses through volatilization	Heinonen-Tanski and van Wijk-Sijbesma (2005)
		-	0.05		0	0		PA
med (R)	0.66	0,3-0,9	0.05	0.34	0	0		-
bal.	0.63	-	0.05	0.32	0	0		-
k	2	[0.6]	-	-	-	-		PA
H2O	0.65	0.59 - 0.7	0	0.35	0	0	* moisture content should be 50- 60%, compare with calculations in 11.2.2	Winblad, U. et al. (2004)
	0.54	-	0	0.46	0	0	Spuhler et al. (2021)	Yadav et al. (2012)
	0.7	-	0	0.3	0	0	*moisture content should be 60%, see calculation in 11.2.2	Zavala and Funamizu (2005)
		-	0.05		0	0		PA
med (R)	0.65	0.54-0.8	0.05	0.35	0	0		-
bal.	0.63	-	0.05	0.32	0	0		-
k	5	[0.26]	-	-	-	-		PA
TS	0.33	0.1- 0.6	0.05	0.62	0	0	*reduction is achieved by organic matter consumption by bacteria	Zavala and Funamizu (2005)
med (R)	0.33	0.1 -0.6	0.05	0.62	0	0		-
k	2	[0.5]	-	-	-	-		PA
Additional Information								
2.2.3	(Data from Yadav et al. (2012))							
	Faecal Slurry	**Bulking Material***	**Compost**					
Moisture %	92	45	50					
k	5	[0.26]	-	-	-	-		
TS	0.33	0.1- 0.6	0.05	0.62	0	0	*reduction is achieved by organic matter consumption by bacteria	
med (R)	0.33	0.1 -0.6	0.05	0.62	0	0		
k	2	[0.5]	-	-	-	-		
Additional Information								
2.2.3	(Data from Yadav et al. (2012))							
	Faecal Slurry	**Bulking Material***						
Moisture %	92	45	50					

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Fossa Alterna

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	fossa_alterna	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces, excreta, organics	Tilley, E. et al. (2014)
OUTPUT PRODUCT	pithumus	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: NA	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"Waterless double pit technology" (Compendium). "The Fossa Alterna should be used for urine, but water should not be added" (Compendium). "It is especially suitable to water-scarce environments" (Compendium). Maximum values (c & d) are assumed to remain 999 L/cap/day since the disruption of this tech due to high water volumes, i.e., due to either flooding or high groundwater tables is considered with two separate criteria "Flooding" and "Groundwater Depth". Additionally, the FG U technology that will be connected with this tech according Santiago algorithm, based on input-output products will never be a technology that leads to high water volumes entering fossa alterna (because blackwater is not a defined input product). For e.g. Cistern flush sytems willl never be the recommended FG U tech for fossa alterna. (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.3, regular = 0.7, continous = 0)	"When the first pit is put into use, a layer of leaves should be put onto the bottom of the pit. Periodically, more leaves should be added to increase the porosity and oxygen availability. Following the addition of faeces to the pit, a small amount of soil, ash, and/or leaves should be added. Occasionally, the mounded material beneath the toilet hole should be pushed to the sides of the pit in order to optimise the use of space. [...] Depending on the dimensions of the pits, the contents should not be emptied more often than once a year." (Compendium) Rather regular than irregular maintenance is required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	"The material is manually emptied from the Fossa Alterna (it is dug out, not pumped out); thus, vacuum truck access to the pits is not necessary." (Compendium) No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Can be built and repaired with locally available materials" (Compendium) "Pit lining materials can include brick, rotresistant timber, bamboo, concrete, stones, or mortar plastered onto the soil." (EmersanCompendium) But concrete is not specifically needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	A single pit can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"The Fossa Alterna is not suited for rocky or compacted soils (that are difficult to dig) or for areas that flood frequently, except if the pits are raised." (Compendium) Raised configurations of fossa alterna are also possible for flood prone areas (Borges Pedro et al., 2020) All technologies where raised configurations are possible get a 50% performance for category "flooding". (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.8, difficult = 0.8, full = 1)	"The material is manually emptied from the Fossa Alterna (it is dug out, not pumped out); thus, vacuum truck access to the pits is not necessary." (Compendium) The emptying and transport is slightly improved by motorized transport as the dug-out material can be transported more efficiently.	yes
slope	Performance, Categorical	FALSE	flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel = 0.5, rock = 0.25)	"The Fossa Alterna is not suited for rocky or compacted soils (that are difficult to dig) or for areas that flood frequently, except if the pits are raised." (Compendium) Soil percolation and filtration is desired resulting in lower desludging rates.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 6, b = 9, c = 999, d = 999)	"In flood-prone areas and where the groundwater table is too high, the Fossa Alterna could be raised or built entirely above ground to avoid water intrusion and groundwater pollution." (Compendium) If the technology is constructed in areas with a high groundwater table the risk for contamination is higher and some further design and effort is needed. It is assumed that a pit is at least 3 m deep and optimally 6 m deep. A vertical safety distance of 3 meters is applied.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"The Fossa Alterna is not suited for rocky or compacted soils (that are difficult to dig) or for areas that flood frequently, except if the pits are raised." (Compendium)	yes

surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 2, b = 2, c = 999, d = 999)	Based on a comparison of different technologies, we derive the space requirements of a fossa alterna to be (at least) twice the space of the space requirements of a single pit. This is based on the assumption that the excreta ends up in two alternating chambers below the user, instead of just one chamber. There are no further significant differences in terms of space requirements between a single pit and a fossa alterna and therefore, using twice the space (2m2/plot) is justified (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"In flood-prone areas and where the groundwater table is too high, the Fossa Alterna could be raised or built entirely above ground to avoid water intrusion and groundwater pollution." (Compendium) If the technology is constructed close to a drinking water source the risk for contamination is higher and some further design and effort is needed.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Can be built and repaired with locally available materials" (Compendium) Moderate construction skills are recommended, low construction skills could be sufficient.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"The Fossa Alterna technology will only work properly if the two pits are used sequentially and not concurrently. Therefore, an adequate cover for the out of service pit is required. A UDDT (U.2) can be used with the Fossa Alterna, but only in circumstances when the soil cannot sufficiently absorb the urine or when the urine is highly valued for application. To reduce the smells even further, a ventilation pipe can be added. If space is abundant and emptying not desired, the Arborloo (D.1) can be an alternative Disposal option. Pits should not be lined if used as an Arborloo." (Compendium) Several things to take in account and different configurations possible depending on the circumstances. Since the design requires little lower design skills than a double VIP, moderate design skills are sufficient.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"When the first pit is put into use, a layer of leaves should be put onto the bottom of the pit. Periodically, more leaves should be added to increase the porosity and oxygen availability. Following the addition of faeces to the pit, a small amount of soil, ash, and/or leaves should be added. Occasionally, the mounded material beneath the toilet hole should be pushed to the sides of the pit in order to optimise the use of space. Unlike a Single or Ventilated Pit (S.2, S.3) which will be covered or emptied, the material in the Fossa Alterna is meant to be used as a soil conditioner. Therefore, it is extremely important that no garbage is put into the pit. Emptying the Fossa Alterna is easier than emptying other pits; the pits are shallower and the addition of soil, ash, and/or leaves means that the contents are less compact. The material that is removed is not offensive and presents a reduced threat of contamination. Depending on the dimensions of the pits, the contents should not be emptied more often than once a year." (Compendium) Moderate OM skills can ensure propper operation but low OM skills could be sufficient	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Because double pits are used alternately, their life is virtually unlimited" (Compendium) "May require a year or more of maturation before being safe to use." (Pit Humus | SLU Compendium) The fact that a storage time of less than one year is unsuitable is not considered in the criterion 'Lifetime'. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.8, moderate = 0.2, slow = 0)	A slightly lower value is allotted to the category "Rapid" (80%) than a Single VIP as the complexity of construction is slightly higher, owing to the implementation of ventilation system + double pits (double the efforts and consequently time). (Akanksha Jain, Eawag 2021) "Twin pit systems include double Ventilated Improved Pits (VIP), and the fossa alterna (FA)." (Twin pit systems- Emersan Compendium) Same values are allotted to both Fossa Alterna and Double VIPs because of the text above. Other important text from Emersan Compendium that bear some relevance for this technology and criteria: "The slab can be fabricated on-site with a mould and cement. In the acute emergency phase, pre-fabricated plastic slabs may be used." "As the second pit only comes into operation when the first pit is full, which may take between 6 to 24 months, Twin Pit Dry Systems are recommended as longer-term solutions in prolonged emergency situations."	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"Easier excavation than single pit systems, [but] double the space and materials required" (Twin Pit Dry System - Emersan) Technology is complete and it's not easy to extend the pit size, however it is possible to build new units. This depends on the availability of material and space. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Pit Humus	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0	-	-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	5	[0.18]					PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA
med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

Additional Information

Copied from "single pit" because the treatment is assumed to be similar. The k-factors were decreased if not already at minimum value.

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Deep Trench Latrine						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	S	-				
UNIQUE IDENTIFIER (ID)	deep_trench_latrine	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	faeces, excreta, blackwater	Gensch, R. et al. (2018)				
OUTPUT PRODUCT	sludge	Gensch, R. et al. (2018)				
RELATIONS	Input: OR Output: NA	Gensch, R. et al. (2018)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 1, city = 0)	Gensch, R. et al. (2018)				
management_level	(household = 0, shared = 0.5, public = 1)	Gensch, R. et al. (2018)				
capex_req_level	7	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	"A Deep Trench Latrine is a widely-used communal latrine option for emergencies" (Gensch, R. et al. (2018)).				
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 0)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 8, d = 33)	"No water needed for operation" (Emersan). No additional water required. This is a technology that is negatively impacted if very high water-volumes enter it (performance is reduced). Since blackwater is an input to this technology, Santiago algorithm CAN pair these technologies with FG U techs that introduce high volumes of water into the system (e.g., Cistern flush). Thus, our criterion (WATER REQ) should bring down the performance of this tech and hence its appropriateness when a user defines a case attribute with high water inputs. Or in other words, if user defines water requirements that allow the FG U tech "Cistern flush toilets" to be selected, then any system which Santiago recommends that combines cistern flush toilets with any of the above four techs–SHOULD have a reduced appropriateness (this reduced appropriateness will be by means of our criterion (WATER REQ). Therefore, an optimal and maximum upper limit of water volume the	yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No need for electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.6, continous = 0.4)	"The general operation and maintenance (O & M) measures therefore include regular cleaning, routine operational tasks such as checking availability of water, hygiene items, soap and dry cleansing materials, providing advice on proper use, conducting minor repairs and monitoring of trench filling level. O & M also includes daily covering of excreta with a 10 cm layer of soil to minimise odour and prevent fly breeding." (Emersan) Very labour intensive technology with need for regular or maybe even coninous OM.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No need for pipes.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"If possible, locally available construction materials should be used. The latrine superstructure can be made from local materials, such as bamboo, wood, plastic or metal sheeting (though this often heats up the interior). The trench lining can be made from bricks, timber, sand bags or temporary lining materials such as bamboo poles or matting." (Emersan) No need for concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"If possible, locally available construction materials should be used. The latrine superstructure can be made from local materials, such as bamboo, wood, plastic or metal sheeting (though this often heats up the interior). The trench lining can be made from bricks, timber, sand bags or temporary lining materials such as bamboo poles or matting. Some relief agencies have rapid response kits for slabs and superstructure which can be used where there are few resources locally." (Emersan) The technology is supposed to be constructed with locally available material, so a need for technical or special parts should not occure.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	A deep trench latrine can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	"Unsuitable for areas with high water-table, unstable soil, rocky ground or prone to flooding" (Emersan) A low performance of 10% is allotted to the category "flooding" given that there exists the possibility that deep trench latrines could be built at elevated/ non-flooded plot areas of the flood-prone region. (Akanksha Jain)	Yes

vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.3, difficult =0.6, full = 1)	"Accessibility for desludging vehicles C.2 should be considered. If desludging is not an option the latrines should be decommissioned X.6 when the trench is filled up to 0.5 m below the top of the trench." (Emersan) Vehicular access is not necessary needed but gives more options for decommission of the products especially as regular emptying is required.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel = 0.5, rock = 0.25)	"Unsuitable for areas with high water-table, unstable soil, rocky ground or prone to flooding" (Emersan) "Special attention should be paid to [...] ground conditions and soil permeability. Poorly permeable soil will increase the rate at which the pit fills." (Emersan) Soil percolation and filtration is desired.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 4.5, b = 6, c = 999, d = 999)	"Unsuitable for areas with high water-table, unstable soil, rocky ground or prone to flooding" (Emersan) "The depth (usually between 1.5 to 3 m) may vary depending on local soil conditions and required speed of implementation. A maximum trench length of 6 m is recommended, providing for six cubicles." (Emersan)	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard =0.75)	"The depth (usually between 1.5 to 3 m) may vary depending on local soil conditions and required speed of implementation. A maximum trench length of 6 m is recommended, providing for six cubicles." (Emersan) Volume of excavation is not that big. In areas where excavation is hard the construction is still possible but therefore it gets more labour intensive.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 1, b = 1, c = 999, d = 999)	Deep trench latrines can also be constructed on a small footprint ("Trenches should be around 0.8– 0.9 m wide" (Emersan)). Based on a comparison of different technologies, we derive the space requirements of a deep trench to be similar to a single pit and use the same minimum space requirement of 1m2/plot (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"As with all pit-based systems, groundwater contamination can be an issue and soil properties such as the permeability of the soil and groundwater level should be properly assessed X.3 to identify the minimum distance to the next water source and limit exposure to microbial contamination." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	"Inexpensive and quick to construct" (Emersan) Simple construction that does not need moderate or high construction skills.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Proper drainage should be provided for around the trench to ensure runoff and prevent flooding. When the trench is complete, slabs are placed over it. Prefabricated self-supporting plastic slabs can increase the speed of construction, if available. Alternatively, wooden planks can be secured across the trench (leaving out every third or fourth plank for defecation) until wooden or concrete slabs can be produced locally. The slabs can be fitted with pedestal toilets where users do not squat. Separate trench latrines for men and women should be considered. The trench lifespan (the time required to fill it to within half a metre of the top) is a function of the trench volume, divided by the number of users and estimated excreta volume generated per person. On average, solids accumulate at a rate of 3–5 L/person/month and up to 5–7.5 L/person/month if dry cleansing materials are used." (Emersan) Even though several of things have to be considered the design is pretty simple.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Deep Trench Latrines are usually built as communal latrine blocks. The general operation and maintenance (O & M) measures therefore include regular cleaning, routine operational tasks such as checking availability of water, hygiene items, soap and dry cleansing materials, providing advice on proper use, conducting minor repairs and monitoring of trench filling level. O & M also includes daily covering of excreta with a 10 cm layer of soil to minimise odour and prevent fly breeding. As trenches are often misused for solid waste disposal, which can complicate later emptying, awareness raising measures X.12 should be a part of installation programmes. If desludging is not an option the latrines should be decommissioned X.6 when the trench is filled up to 0.5 m below the top of the trench." (Emersan) The only crucial thing is determining when to decommission the latrine.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 0.5, long = 0)	"Deep Trench Latrines can be a viable solution in the acute phase of an emergency provided that the technology is acceptable to the users" (Emersan) A deep trench latrine can be used in the short-term. It is often also in use for more than a year. (Kukka Ilmanen, Eawag 2021)	yes	
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 1, moderate = 0, slow = 0)	"It can be quickly implemented(within 1–2 days)" (Emersan Compendium)	yes	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Deep Trench Latrines can be replicated fast and implemented at scale given that enough space is available." (Emersan)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"If possible, locally available construction materials should be used. The latrine superstructure can be made from local materials, such as bamboo, wood, plastic or metal sheeting (though this often heats up the interior). The trench lining can be made from bricks, timber, sand bags or temporary lining materials such as bamboo poles or matting. Some relief agencies have rapid response kits for slabs and superstructure which can be used where there are few resources locally." (Emersan) Can be constructed from locally available material.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0		-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	25	[0.18]	-	-	-		PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA
med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

Additional Information

Copied from "single pit". Some of the k-factors were decreased if they weren't already the minimum possible value.

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Onsite Vermi-Composting

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	onsite_vermi_composting	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces, excreta, organics, blackwater	Gensch, R. et al. (2018)
OUTPUT PRODUCT	effluent, compost	Gensch, R. et al. (2018)
RELATIONS	Input: OR Output: AND	Gensch, R. et al. (2018)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Gensch, R. et al. (2018)
management_level	(household = 1, shared = 1, public = 0)	Gensch, R. et al. (2018)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	2	"The Worm-Based Toilet is an emerging technology that has been used successfully in rural, peri-urban and camp settings" (Emersan).
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 8, c = 33, d = 60)	"Water-based Technology" (Emersan). "They are particularly appropriate in contexts where water is available and used for flushing. The toilets should only be cleaned with water and a brush, and should be flushed (min. 200 mL) after every use including urination" (Emersan). - Absolute mimimal volume: can be used without flushing water, e.g cacarousel (a=0) - Typical minimal and maximal volume: can be used with pour-flush toilet (1-3 l/use) and anal cleansing water (0.3-3 l/use) assuming 6 visits per persons per day - Maximal volume: can be used with cistern flush toilet (10 l/use) assuming 6 visits per persons per day. Even though onsite vermicompost can handle more water, big amount of flushing water should be avoided to keep the moisture content satisfactory for the worms.	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elect	No need for electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.2, regular = 0.8, continous = 0)	"The system thus needs emptying less frequently than traditional pit systems." (Emersan) "General operation and maintenance (O & M) measures include regular cleaning of toilets, advice on proper use, minor repairs, regular checking of the well-being of the worms and the monitoring of the filling of the tank. These toilets require emptying approximately every 5 years." (Emersan)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.7	Inlet pipe to connect flush toilet with composting pit required (Emersan)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, p	No need for pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Worm-Based Toilets can be constructed from locally available materials. The offset tank can be made from various materials including concrete rings, masonry and brickwork." (Emersan) Concrete may be helpful but it is definitely feasible without concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Worm-Based Toilets can be constructed from locally available materials. The superstructure should contain a roof and a door for privacy. A pour flush pan is also required. The offset tank can be made from various materials including concrete rings, masonry and brickwork. The most important material is the worms." (Emersan) The worms can be found locally and are not considered as special.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.2, cold = 0.5, temperate =	"As the effluent enters the soil, a certain inafiltration capacity is required." (Compendium) As the leachate might not percolate into the soil, lower temperatures might be less appropriate. Moreover, the worms will also decrease in performance or eventually even die if the ambient temperature is too low.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"Recent research studies suggest that the effluent from worm-based systems can be considered safer than the effluent from septic tanks and that the vermi compost generated can be considered safer than faecal sludge. However, more research is required to confirm this." (Emersan) Raised designs possible for flood prone regions (Tiger worm toilets, OXFAM)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 1, difficult = 1, full = 1)	"The vermicompost should be removed from the edges of the tank with a small spade [...] The harvested vermicompost can be buried on-site." (Emersan) No trucks or vehicles needed.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0, silt = 0.25, sand = 1, gravel = 0.	"The effluent infiltrates into the soil [...]." (Emersan) The technology primarily relies on soil percolation and filtration to function properly.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 1, b = 1, c = 999, d = 999)	"As the toilets can be built half above and half below the ground they can be used in areas with relatively high water tables (approx. 1 m). As the effluent enters the soil, a certain in filtration capacity is required." (Emersan)	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"As the toilets can be built half above and half below the ground they can be used in areas with relatively high water tables (approx. 1 m). As the effluent enters the soil, a certain in filtration capacity is required." (Emersan) Shallow excavation required.	
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 2, b = 2, c = 999, d = 999)	The space area requirements of the worm based toilet are derived based on a comparable approach with other technologies. It does not require alternating chambers, but an additional tank: "The surface area of the household tank for the vermifilter varies from 0.7 m2 to 1 m2 depending on the number of users." (Emersan). It is assumed that the space requirements of the toilet itself are similar to a single pit (1m2/plot), but at least an additional space of 1m2/plot are required for the vermifilter. It is therefore assumed that the worm based toilet requires at least 2m2/plot (Eawag, 2021). The space requirements are therefore similar to toilets with alternating chambers. Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0.5, not close = 1)	"Recent research studies suggest that the effluent from worm-based systems can be considered safer than the effluent from septic tanks and that the vermi compost generated can be considered safer than faecal sludge. However, more research is required to confirm this." (Emersan) There might be a remaining risk of groundwater contamination and therefore it is not recommended to construct the technology close to a drinkingwater source.	yes
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Worm-Based Toilets can be constructed from locally available materials. The superstructure should contain a roof and a door for privacy. A pour flush pan is also required. The offset tank can be made from various materials including concrete rings, masonry and brickwork." (Emersan) Basic technical knowledge to build it.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Ideally the toilets are emptied by the household after they have been un-used for one week, allowing the fresh faeces to be converted into vermi compost. The vermi compost should be removed from the edges of the tank with a small spade, then the vermi compost from the middle should be spread across the surface to create a bedding later. The harvested vermi compost can be buried on-site. When sensitising the users, it should be highlighted that only water, faeces, urine and possibly toilet paper should go into these toilets. The toilets should only be cleaned with water and a brush, and should be flushed after every use including urination. If emptying by the households is not an option (due to acceptabilityissues or other reasons) other options involving local service providers need to be identified." (Emersan) "The bottom of the tank is exposed to the soil. The tank contains 40 cm of drainage material (gravel or stones), 10 cm of organic bedding material (woodchips, coconut husks or compost) and the worms. The lid to this tank needs to fit extremely well, but should not be sealed. This is then connected to the pour flush system." (Emersan)	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"The vermi compost is generated at the top of the system and is a dry humus-like material, which, compared with untreated excreta, is relatively easy and safe to empty." (Emersan) "O & M is still a grey area as the systems which have been built have not been emptied yet." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Low emptying frequency (> 5 years of use)." (Emersan) Meant for long-term service life, if the emptying happens every 5 years or even less frequent. "May require a year or more of maturation before being safe to use." (Compost | SLU Compendium) The fact that a storage time of less than one year is unsuitable is not considered in the criterion 'Lifetime'. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0, moderate = 0.2, slow = 0.8)	Technical complexity is on the higher side (based on Emersan Compendium). "Worm-Based Toilets can be constructed from locally available materials. The offset tank can be made from various materials including concrete rings, masonry and brickwork. The most important material is the worms (100 g per person). They can be found locally, bought from vermicomposting or vermiculture businesses, or imported." Given that concrete could be used for construction and/or masonry brick structures need to be built, curing itself would take some time. Plus, the construction is underground (i.e., digging required). Additionally, worms may have to imported. All these elements point towards longer speeds of implementation and it is unlikely that this technology be implemented in <3 days. (Akanksha Jain, Eawag 2021)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"The surface area of the household tank for the vermifilter varies from 0.7 m2 to 1 m2 depending on the number of users.", "Worm-Based Toilets are a viable solution if long-term household sanitation is required [...] and in camp communities that have a strategy of implementing household systems" (Emersan) Onsite worm based toilets are often implemented at a household scale and designed for a specific number of users in these households. Therefore, scaling up by increasing the size of one unit is not feasible. However, the technology can be scaled up by building new units for other households. "Worm-Based Toilets can be constructed from locally available materials. [Worms] can be found locally, bought from vermicomposting or vermiculture businesses, or imported." (Emersan) Since they can be set-up with locally available material and do not require special parts, building new units should not be difficult.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Worm-Based Toilets can be constructed from locally available materials. The superstructure should contain a roof and a door for privacy. A pour flush pan is also required. The offset tank can be made from various materials including concrete rings, masonry and brickwork. The most important material is the worms. They can be found locally, bought from vermicomposting or vermiculture businesses, or imported." (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Compost	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	0	* see calculations in 12.2.2	Yadav et al. (2010)
	1	-	0	0	0	0	* includes prior composting, see calculations in 12.2.1	Yadav et al. (2012)
	1	-	0	0	0	0	* increase of TP content	Hait and Tare (2011)
	0.233	-	0.767	0	0	0	removeal efficency for PO4-P	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
	0.5		0	0	0.5	0	removeal efficency for PO4-P, with sand and gravel drainage layer	Koslengar, Konate and Karambiri (2020), BW
med (R)	1.00	(0.23-1)	0.00	0.00	0.00	0.00		-
bal.	0.75		0.15	0.00	0.10	0.00		-
k	1	[0.77]	-	-	-	-		PA
TN	0.68	-	0	0.32	0	0	* see calculations in 12.2.2	Yadav et al. (2010)
	0.64	-	0	0.36	0	0	* as TN	Benitez et al. (1999)
	0.5	-	0	0.5	0	0	* includes prior composting, see calculations in 12.2.1	Yadav et al. (2012)
	1	-	0	0	0	0	* increase of TN content	Hait and Tare (2011)
	1	-	0	0	0	0	* increase of TN content	Gupta and Garg (2008)
	0.05	-	0.95	0	0	0	effluent removal efficency for NH3-N	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
	0.198	-	0.802	0	0	0	Spuhler et al. (2021)	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
med (R)	0.64	(0.2-1)	0	0	0	0		-
bal.	0.6	-	0.25	0.15	0	0		-
k	1	[0.8]	-	-	-	-		PA
H2O	0.49		0.51		0	0	* includes prior composting, see calculations in 12.2.1	Yadav et al. (2012)
	0.53		0.47				* see calculations in 12.2.2	Yadav et al. (2010)
	0.2		0.8				estimated based on drawing	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
	0.1	0,02-0,2					Reduction in the total wet mass of faeces	Furlong et al. (2015)
	0.1925	0,17-0,21	0.8075				conversion ratio (1:0.55) * moisure (35%)	Koslengar, Konate and Karambiri (2020)
				0.05			assumption that almost no evaporation occur (closed tank)	Spuhler et al. (2022)
med (R)	0.2	(0.1-0.53)	0.655	0.05	0	0		
bal.	0.3		0.65	0.05				
k	2	[0.43]						
TS	0.5			0.5			* see calculations in 12.2.2	Yadav et al. (2010)
	0.53		0.47				* see calculations in 12.2.2	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
	0.2		0.8				estimated based on drawing	Zhao et al. (2010)

	0.1	0,02-0,2					Reduction in the total wet mass of faeces	Koslengar, Konate and Karambiri (2020)
	0.1925	0,17-0,21	0.8075				conversion ratio (1:0.55) * moisure (35%)	
				0.05			assumption that almost no evaporation occur (closed tank)	
med (R)	0.2	(0.1-0.53)	0.655	0.05	0	0		
bal.	0.3		0.65	0.05				
k	2	[0.43]						
TS	0.5			0.5			* see calculations in 12.2.2	

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Septic Tank

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	septic_tank	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	blackwater, greywater	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	sludge, effluent	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 1, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	8	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 8, b = 33, c = 60, d = 120)	"There is sufficient water available (water consumption of at least 30L/person/day)." (Monvois et al. (2012)) The performance of the technology is depending on a minimum but not on a maximum of water consumption. - mimimal volumes with pour flush toilet flushing water (1-3 l/use) and anal cleansing water (0.3-3 l/use) assuming 6 visits per persons per day - Maximal volume: can be used with cistern flush toilet (10-20 l/use) assuming 6 visits per persons per day.	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electri	"No electrical energy is required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Desludging is required for Septic Tanks and frequency will depend on the volume of the tank relative to the input of solids, the amount of indigestible solids, and the ambient temperature, as well as usage, system characteristics and the requirements of the relevant authority. Well-functioning systems will require emptying every two to five years. [...] The most common cause of failure of Septic Tanks is the failure of the in filtration system. Tanks connected to under-designed disposal systems will require emptying more frequently." (Emersan) "Scum and sludge levels need to be monitored to ensure that the tank is functioning well. [...] Septic tanks should be checked from time to time to ensure that they are watertight." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 0.75, p	T-shaped inlet and outlet pipes are recommended to reduce scums and solids that are discharged. (Compendium)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pu	"No electrical energy is required" (Compendium) There is no need for pumps to buildup the technology. (Compendium)	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"A Septic Tank is a watertight chamber made of concrete, fibreglass, PVC or plastic [...]." (Compendium) "A Septic Tank can be made of local bricks, cement blocks or stone and thus can be constructed on site using local materials. Prefabricated tanks are available in fibreglass, PVC or plastic." (Emersan) Concrete can be replaced by alternative options, but these might perform worse due to lifetime, import of pre-fabrication options or more local experience with concrete construction.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	"Simple and robust technology" (Compendium) "A Septic Tank can be made of local bricks, cement blocks or stone and thus can be constructed on site using local materials. [...] The most common cause of failure of Septic Tanks is the failure of the in filtration system. " (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.7, cold = 0.8, temperate = 1	"They can be implemented in every type of climate, although the efficiency will be lower in colder climates (as an aerobic digestion occurs more efficiently at higher temperatures)." (Emersan) Performance in colder temperatures decreased.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.6, no flooding = 1)	"Even though septic tanks are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding." (Compendium) Raised configurations of septic tank are also possible for flood prone areas (Borges Pedro et al., 2020) All technologies where raised configurations are possible get a 50% performance for category "flooding". Septic tank also gets a slightly higher performance, i.e, 60% since it is built to be water tight. (Akanksha Jain)	Yes

vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0, difficult = 0, full = 1)	"A septic tank is appropriate where there is a way of dispersing or transporting the effluent. [...] Instead, the septic tanks should be connected to some type of Conveyance technology, through which the effluent is transported to a subsequent Treatment or Disposal site. [...] Because the septic tank must be regularly desludged, a vacuum truck should be able to access the location." (Compendium)	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, rock	Technology does not rely on soil absorbtion. No difference between soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"Even though septic tanks are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding." (Compendium) However, even though there is a remaining risk of groundwater contamination, a septic tank should be built watertight and therefore should not affect the groundwater.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"Small land area required (can be built underground)" (Compendium) If built underground, excavation can be necessary.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 5, b = 5 , c = 999 , d = 999)	The surface area required: 5m2 for septic tanks (Monvois et al. 2012). The value of 5m2/plot is used here, making septic tank a technology with a larger footprint on the plot compared to other technologies such as pit latrines.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Even though septic tanks are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding." (Compendium) Septic tanks should be watertight.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Simple and robust technology" (Compendium) There are no technical parts to be installed and the design is pretty simple. There are prefabricated tanks are available in fibreglass, PVC or plastic. (Emersan)	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	To design a septic tank some important considerations must be done and the design is depending on several parameter that have to be noted. (Compendium) Therefore at least moderate design skills are needed.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"The most common cause of failure of Septic Tanks is the failure of the in filtration system. " (Emersan) "Scum and sludge levels need to be monitored to ensure that the tank is functioning well. [...] Septic tanks should be checked from time to time to ensure that they are watertight." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"long service life", "Well-functioning systems will require emptying every two to five years." (Emersan) Meant for long-term service life, if the emptying itself happens every 2-5 years. "For the civil works a life expectancy of 25 years is assumed. Pipework and the manhole cover are expected to last for 15 years." (Septic Tank | Griesauer, C. (2014)) In a study by Berg on the CLARA planning tool the expected lifetimes for septic tanks were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0, moderate = 0.5, slow = 0.5)	"A Septic Tank can be made of local bricks, cement blocks or stone and thus can be constructed on site using local materials. Prefabricated tanks are available in fibreglass, PVC or plastic." (Emersan Compendium) Design and construction requires attention to ensure water tightness and proper functioning of septic tank (i.e., too high solids are not discharged into effluent). Since there is transport of effluent required (Either soil infiltration or conevyance technology- a subsequent pipe network or infiltration system needs to exist. All these components could lead to slower speeds of implementation. (Akanksha Jain, Eawag 2021)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA

scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"The design of a septic tank depends on the expected number of users, the water used per capita, average annual temperature, desludging frequency and wastewater characteristics." (Emersan) "Construction costs of septic tanks are relatively low compared to other water based systems. However, they are much more expensive than for dry or composting toilets and unlikely to be affordable for poorer people in society. " (Septic Tank | SSWM Toolbox) Technology is designed for a specific number of users and not easy to extend. However, new septic tanks can be built to extend the system. These new ones are more complicated and costly to build than dry pit latrines and therefore more difficult to scale-up. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	"Simple and robust technology" (Compendium) "A Septic Tank can be made of local bricks, cement blocks or stone and thus can be constructed on site using local materials. Prefabricated tanks are available in fibreglass, PVC or plastic.", "The most common cause of failure of Septic Tanks is the failure of the in filtration system. " (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.19	11 - 27 %	0.81	0	0	0	* general P pathways	Montangero and Belevi (2007)
	0.23	-	0.77	0	0	0	* general TP removal	Hamader and Javorszky (2014)
	0.4	-	0.6	0	0	0	* general TP removal	Polprasert and Rajput (1982)
	0.1	-	0.9	0	0	0	* P removal at HRT 24 - 48h	Siegrist (2017)
	0.256	-	0.7444	0	0	0	* P removal at HRT 24h	Nasr and Mikhaeil (2013)
	0.3	-	0.7	0	0	0	* PO4 at HRT 20h	Rahman et al. (1999)
	0.6	-	0.4	0	0	0	* TP removal at HRT 48h	Wanasen (2003)
	0.269	-	0.731	0	0	0	* P removal at HRT 48h	Nasr and Mikhaeil (2013)
	0.33	-	0.67	0	0	0	* PO4 at HRT 46h	Rahman et al. (1999)
	0.47	-	0.53	0	0	0	* TP removal at HRT 24h	Wanasen (2003)
	0.293	-	0.707	0	0	0	* P removal at HRT 72h	Nasr and Mikhaeil (2013)
	0.33	-	0.67	0	0	0	* PO4 at HRT 73h	Rahman et al. (1999)
	0.65	-	0.35	0	0	0	* PO4 at HRT 114h	Rahman et al. (1999)
med (R)	0.30	(0,1 - 0,65)	0.70	0	0	0		-
k	2	[0.55]	-	-	-	-	Spuhler et al. (2021)	PA
TN	0.095	5 - 14 %	0.905	0	0	0	* general N pathways	Montangero and Belevi (2007)
	0.08	-	0.92	0	0	0	* general TN removal	Polprasert and Rajput (1982)
	0	-	1	0	0	0	* N removal at HRT 24 - 48h	Siegrist (2017)
	0.177	-	0.823	0	0	0	* TKN removal at HRT 24h, increase of ammonia concentration	Nasr and Mikhaeil (2013)
	0.16	-	0.84	0	0	0	* NO3 removal at HRT 20h	Rahman et al. (1999)
	0.24	-	0.76	0	0	0	* TKN removal at HRT 24h	Wanasen (2003)
	0.208	-	0.792	0	0	0	* TKN removal at HRT 48h, increase of ammonia	Nasr and Mikhaeil (2013)
	0.2	-	0.8	0	0	0	* NO3 removal at HRT 46h	Rahman et al. (1999)
	0.44	-	0.56	0	0	0	* TKN removal at HRT 48h	Wanasen (2003)
	0.268	-	0.732	0	0	0	* TKN removal at HRT 72h, increase of ammonia concentration	Nasr and Mikhaeil (2013)
	0.35	-	0.65	0	0	0	* NO3 removal at HRT 67h	Rahman et al. (1999)
	0.48	-	0.52	0	0	0	* general TN pathways	Hamader and Javorszky (2014)
	0.46	-	0.54	0	0	0	* NO3 removal at HRT 114h	Rahman et al. (1999)
	0.16	-	0.84	0	0	0	* NO3 removal at HRT 20h	-
	0.24	-	0.76	0	0	0	* TKN removal at HRT 24h	-
	0.208	-	0.792	0	0	0	* TKN removal at HRT 48h, increase of ammonia concentration	PA
	0.2	-	0.8	0	0	0	* NO3 removal at HRT 46h	Howard (2007)
	0.44	-	0.56	0	0	0	* TKN removal at HRT 48h	-
	0.268	-	0.732	0	0	0	* TKN removal at HRT 72h, increase of ammonia concentration	PA
	0.35	-	0.65	0	0	0	* NO3 removal at HRT 67h	Álvarez et al. (2008)
	0.48	-		0	0	0	* general TN pathways	Seabloom et al. (2005)
	0.46	-	0.54	0	0	0	* NO3 removal at HRT 114h	Polprasert and
	0.35	30 - 40%	0.65	0	0	0	* at HRT 24 - 48h; TSS removal 60–80% (TS removal 30-40%, estimated using 13.2.1.)	Siegrist (2017)
	0.33	-	0.68	0	0	0	* single baffle septic tank; TSS removal at HRT 24h: 65% (~TS 32.5%, estimated using 13.2.1.)	Nasr and Mikhaeil (2014)
	0.25	-	0.75	0	0	0	* TS removal at HRT 24h	Nasr and Mikhaeil (2013)
	0.25	-	0.75	0	0	0	* TSS removal at HRT 20h: 50% (~TS 25%, estimated using 13.2.1.)	Rahman et al. (1999)
	0.24	-	0.76	0	0	0	* TSS removal of conventional septic tank at HRT 24h: 47% (~TS 24%, estimated using	Wanasen (2003)
	0.34	-	0.66	0	0	0	* single baffle septic tank; TSS removal: 69% (~TS 34%, estimated using 13.2.1.)	Nasr and Mikhaeil (2014)
	0.27	-	0.73	0	0	0	* TS removal at HRT 48h	Nasr and Mikhaeil (2013)
	0.18	-	0.82	0	0	0	* TSS removal at 46h: 36% (~TS 18%, estimated using 13.2.1.)	Rahman et al. (1999)
	0.38	-	0.62	0	0	0	* TSS removal of conventional septic tank at HRT 48h: 76% (~TS 38%, estimated using	Wanasen (2003)
	0.37	-	0.63	0	0	0	* single baffle septic tank; TSS removal: 73% (~TS 0,37, estimated using 13.2.1.)	Nasr and Mikhaeil (2014)
	0.38	-	0.62	0	0	0	* TS removal at HRT 72h	Nasr and Mikhaeil (2013)
	0.35	-	0.65	0	0	0	* TSS removal at HRT 73h: 70% (~TS 35%, estimated using 13.2.1.)	Rahman et al. (1999)
	0.20	-	0.80	0	0	0	* TSS removal at HRT 114h: 40% (~TS 20%, estimated using 13.2.1.)	Rahman et al. (1999)
med (R)	0.33	(0,18 - 0,51)	0.67	0	0	0		-
k	5	[0.33]	-	-	-	-	-	PA

Additional Information

13.2.1 Relationship TS:TSS removal in septic tanks

TS removal	38%	27%	24.60%	46%			
TSS removal	65.30%	58.30%	55%	70%			
Ratio TS:TSS removal	58.19%	46.31%	44.73%	65.71%	AVERAGE:	53.74%	
Reference	Nasr and Mikhaeil (2013)	Nasr and Mikhaeil (2013)	Nasr and Mikhaeil (2013)	Polprasert and Rajput (1982)			

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Raised Latrine

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	raised_latrine	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	faeces, excreta	Gensch, R. et al. (2018)
OUTPUT PRODUCT	sludge	Gensch, R. et al. (2018)
RELATIONS	Input: OR Output: NA	Gensch, R. et al. (2018)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 1, city = 0)	Gensch, R. et al. (2018)
management_level	(household = 1, shared = 1, public = 1)	Gensch, R. et al. (2018)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Gensch, R. et al. (2018)
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 0.5)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"As no water is needed for operation it is also a solution for water scarce areas" (Emersan). This technology is not impacted by flooding and/or high groundwater tables. The only possible way high water volumes could enter this technology would be by means of a FG U technology that introduces high amount of water into the system (i.e., due to anal cleansing or flush water). Maximum values (c & d) are assumed to remain 999 L/cap/day since the FG U technology that will be connected with this tech according to santiago algorithm, based on input-output products, will never be a technology that leads to high water volumes entering raised latrines (because blackwater is not a defined input). For e.g. Cistern flush sytems willl never be the recommended FG U tech for raised latrines. (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No need for electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continuous = 0)	"Operation and maintenance (O & M) requirements depend on which latrine design is used. Raised Latrines with a sealed containment facility fill up quickly and need regular emptying or replacement of storage facility and subsequent management of collected sludge. O & M tasks also include regular cleaning, conducting routine operational tasks (e.g. checking of availability of water, hygiene items, soap), providing advice on proper use, conducting minor repairs and monitoring the fill level." (Emersan) Maintenance is between regular and irregular.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	Only ventilation pipes require (Emersan) Ventilation pipes can be produced from local material	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Raised latrine is aboveground and does not require emptying with a pump.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"If possible, materials should be used that are readily available and that can be sourced rapidly. The superstructure can be made from materials including bamboo, grass matting, wood, plastic or metal sheeting (though this often heats up the interior). The lining can be of concrete rings, bricks, stones, timber or sand bags. Several companies have developed variations of prefabricated Raised Latrines that can be delivered and assembled quickly." (Emersan) No concrete specifically needed	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"If possible, materials should be used that are readily available and that can be sourced rapidly. The superstructure can be made from materials including bamboo, grass matting, wood, plastic or metal sheeting (though this often heats up the interior). The lining can be of concrete rings, bricks, stones, timber or sand bags. Several companies have developed variations of prefabricated Raised Latrines that can be delivered and assembled quickly." (Emersan) Material should be locally available and be sourced rapidly when it needs to be replaced, so it cannot be too complicated.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, hot = 1)	Raised latrines do not rely on percolation and are therefore suitable for all climates (Emersan).	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	"Raised Latrines are particularly suitable for flood prone areas" (Emersan)	Yes

vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0, difficult = 0.5, full = 1)	"Raised Latrines with a sealed containment facility fill up quickly and need regular emptying or replacement of storage facility and subsequent management of collected sludge. [...] Public Raised Latrines tend to have a high sludge accumulation rate and will require frequent emptying. If regular desludging is needed, availability of and accessibility for desludging vehicles must be considered " (Emersan) Vehicular Access of at least smaller desludging vehicles is required and due to the frequency of emptying full access allowing pumping trucks perform the best	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.7, silt = 0.9, sand = 1, gravel = 0.9, rock = 0.7)	"For Raised Latrines partly below ground, groundwater contamination can be an issue and soil properties and the groundwater level should be assessed (X.3) to identify the minimum distance to the next water source and limit exposure to microbial contamination." (Emersan) The technology can be built to rely on soil percolation and filtration, but does not necessarily have to.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 3, c = 999, d = 999)	"Raised Latrines are particularly suitable for areas where the water table is high","For Raised Latrines partly below ground, groundwater contamination can be an issue and soil properties and the groundwater level should be assessed (X.3) to identify the minimum distance to the next water source and limit exposure to microbial contamination." (Emersan) Could affect the groundwater if built underground.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	"Raised Latrines are particularly suitable for flood prone areas, areas where pit digging is difficult" (Emersan)	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 2, b = 2, c = 999, d = 999)	The space area requirements of the raised latrine are derived based on a comparable approach with other technologies. Its space requirements are certainly similar to a single pit (1m2/plot), as it also requires just one chamber below the user where the excreta ends up. However, due to elevated structure, additional space is required (e.g. to construct stairs). It is assumed that the space requirements of the toilet itself are similar to a single pit (1m2/plot), but at least an additional space of 1m2/plot are required due to the elevated structure. It is therefore assumed that the raised latrine requires at least 2m2/plot (Eawag, 2021). The space requirements are therefore similar to toilets with alternating chambers. Note that this does not involve any visual protection. A superstructure could require more space.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0.5, not close = 1)	"For Raised Latrines partly below ground, groundwater contamination can be an issue and soil properties and the groundwater level should be assessed (X.3) to identify the minimum distance to the next water source and limit exposure to microbial contamination." (Emersan) Two different configurations partly below and above ground. Could contaminate groundwater.	yes
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Raised Latrines must be equipped with stairs or a ramp and corresponding handrails and, if necessary, structural support at the back" (Emersan). Requires more construction skills than facilities not raised.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Raised Latrines with pits partially below ground need pit lining (> 0.5 m) to ensure that the pit remains stable. To reduce odours and flies the latrine should be equipped with a ventilation pipe. Drainage should be considered around the latrine so that rainwater does not enter the pit" (Emersan). Some considerations necessary.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"O&M tasks also include regular cleaning, conducting routine operational tasks (e.g. checking of availability of water, hygiene items, soap), providing advice on proper use, conducting minor repairs and monitoring the fill level" (Emersan). Simple O&M. Monitoring fill level is the most crucial aspect.	yes
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA

lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"They can be considered a viable solution in all stages of an emergency provided the technology is acceptable to the users" (Emersan) The lifetime of a raised latrine depends on the pit volume and accumulation rate. If regular emptying is possible the latrine can be used for a long time similarly to a pit latrine. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.8, moderate = 0.2, slow = 0)	"They can be considered a viable solution in all stages of an emergency provided the technology is acceptable to the users." "They can be replicated quickly and implemented at scale if enough space is available." (Emersan Compendium) A slightly lower value is allotted to the category "Rapid" (80%) than a Single VIP as the complexity of construction is slightly higher, owing to the implementation of ventilation system + raised structure (more efforts for constructing stairs, holding tanks, etc. and consequently more time). (Akanksha Jain, Eawag 2021)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"They can be replicated quickly given enough space is available." (Emersan)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0, special = 0.2)	"If possible, materials should be used that are readily available and that can be sourced rapidly. The superstructure can be made from materials including bamboo, grass matting, wood, plastic or metal sheeting (though this often heats up the interior). The lining can be of concrete rings, bricks, stones, timber or sand bags. Several companies have developed variations of prefabricated Raised Latrines that can be delivered and assembled quickly." (Emersan) Can be constructed from locally available material or prefabricated units can be used.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Airloss	Soilloss	Waterloss	Comments/Specifications	Reference
TP	1	-	0	0	0	No P assumed to be lost.	PA
med (R)	1.00	-	0	0	0	_	-
k	5	[0.22]	-	-	-		PA
TN	0.43	0.16 - 0.7	0.57	0	0	* as N	Jacks et al. (1999)
	0.31	0.22-0.4	0.69	0	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.37	0,16-0,7	0.63	0	0		-
k	2	[0.54]	-	-	-		PA
H2O	0.85	0.75 - 1	0.15	0	0	high variability depending on soil permeability	PA
med (R)	0.85	(0.05 - 0.3)	0.15	0	0		-
k	5	[0.25]	-	-	-		PA
TS	1		0	0	0	No TSS losses assumed.	PA
med (R)	1.00	0.5 - 0.7	0	0	0		-
k	1	[0.2]	-	-	-		PA

Additional Information — **Spuhler et al. (2021)**

Copied from "single pit" and adapted. Some of the literature used to calculate the transfer coefficients for “single pit” dealt with blackwater as an input solely. Since the raised latrine does not have blackwater as an input, we removed the literature values (Montangero and Belevi (2007)) that dealt with blackwater as an input product. We assume raised latrines are sealed against the ground and therefore have no soil losses. The soil losses are allocated to sludge.

References

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Shallow Trench Latrine

General Information	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	shallow_trench_latrine	-
DATA COMPILER	Akanksha Jain, Kukka Ilmanen	-
INPUT PRODUCT	faeces, excreta	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	sludge	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 1, city = 0.5)	Gensch, R. et al. (2018)
management_level	(household = 0, shared = 0, public = 1)	Gensch, R. et al. (2018)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Gensch, R. et al. (2018)
development_phase	(acute = 1, stabilisation = 0, development/recovery = 0)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	According to (Emersan) it belongs into the 'Dry' technologies. Water is only required for handwashing, which is neglected here. Maximum values (c & d) are assumed to remain 999 L/cap/day since the disruption of this tech due to high water volumes, i.e., due to either flooding or high groundwater tables is considered with two separate criteria "Flooding" and "Groundwater Depth". Additionally, the FG U technology that will be connected with this tech according to Santiago algorithm based on input-output products, will never be a technology that leads to high water volumes entering shallow trench latrines (because blackwater is not a defined input). For e.g. Cistern flush sytems willl never be the recommended FG U tech for shallow trench latrines (due to input-output mismatch). (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity required	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.3, continous = 0.7)	"In order to ensure security, proper use and the opening and closing of defecation trenches there should be an attendant at all times." (Emersan) Very labour intensive technology with need for (regular or) continous OM.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficulty available = 1, pipes = 1)	No pipes required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficutly available = 1, pumps = 1)	No pumps required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Simple digging tools are needed for Shallow Trench Latrines, such as shovels and picks. In order to assure privacy screening should be provided. This can be done with plastic canvas or materials such as bamboo, fabrics and others. Shovels for users can be provided to allow each user to cover their excreta with soil." (Emersan) No need for concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Simple digging tools are needed for Shallow Trench Latrines, such as shovels and picks. In order to assure privacy screening should be provided. This can be done with plastic canvas or materials such as bamboo, fabrics and others. Shovels for users can be provided to allow each user to cover their excreta with soil." (Emersan) The required materials should all be locally available and not require technical or special spare parts.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. [...]." (Liu et al. (2018)) A shallow trench latrine can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	The hygiene risk if a defecation field/trench latrine is flooded is considered as unacceptable. A low performance of 10% is allotted to the category "flooding" given that there exists the possibility that shallow trench latrines could be built at elevated/ non-flooded plot areas of the flood-prone region. (Akanksha Jain)	Yes

vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 1, difficult = 1, full = 1)	"After each defecation, faeces should be covered with soil. After one trench section is full, the soil with excreta should be treated with on-site disinfection such as lime treatment or should be taken away to a treatment facility. When closing one defecation trench section, privacy screens and simple slabs (if applicable) need to be moved to the next trench section." (Emersan) Vehicular access is not necessary, as trenches are decommissioned.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel = 0.5, rock = 0.25)	"Deep trench latrines are unsuitable for areas with high water-table, unstable soil, rocky ground or prone to flooding" (Emersan) "Special attention should be paid to [...] ground conditions and soil permeability. Poorly permeable soil will increase the rate at which the pit fills." (Emersan) It is assumed that shallow trench latrines requires similar soil absorption capacities as deep trench latrines. Soil percolation and filtration is desired.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 3.2, b = 3.2, c = 999, d = 999)	"Shallow trenches should be around 20–30 cm wide and 15 cm deep" (Emersan) 3m difference between latrine depth and GW table are added for safety	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	No deep excavation required. (only upto 15cm)	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 35, b = 35, c = 999, d = 999)	As the space requirements of shallow trench latrines strongly depend on the number of users, some assumptions are required here. In general, "the area needed is approximately 0.25 m2/person/day" (Emersan). Assuming that at least 10 people need to be able to use the shallow trench latrine for a mininum of two weeks, we estimate the minimum space requirements for shallow trench latrines to be 35 m2/plot (Eawag, 2021) and thus a lot larger than other technologies of this functional group.	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"Shallow Trench Latrines should be located where they are less likely to be public health hazards" (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No specific skills needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	Design requires expert identification of an appropriate location, considering the following aspects: "The area chosen should be at least 50 m from food production, storage and preparation areas (e.g. kitchens, markets), water sources, water storage and treatment facilities but close enough to ensure safety of and accessibility for users. Defecation fields should be downhill of settlements, camps and water sources to avoid contamination" (Emersan). No other design skills necessary.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	No specific skills needed.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 0, long = 0)	"A Shallow Trench Latrine is only recommended as temporary solution for the acute emergency response and is not a suitable long-term sanitation solution.", "Short lifespan" (Emersan)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 1, moderate = 0, slow = 0)	"Can be built immediately" (Emersan)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The shallow trench latrine can be increased by digging new trenches. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0		-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	5	[0.18]	-	-	-		PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA

med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

Additional Information

Copied from "single pit". Some of the k-factors were decreased if they weren't already the minimum possible value.

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Chemical Toilet

	Values	Data Source
FUNCTIONAL GROUP	S	-
UNIQUE IDENTIFIER (ID)	chemical_toilet	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	faeces, excreta	Gensch, R. et al. (2018)
OUTPUT PRODUCT	sludge	Gensch, R. et al. (2018)
RELATIONS	Input: OR Output: NA	Gensch, R. et al. (2018)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 1, city = 0)	Gensch, R. et al. (2018)
management_level	(household = 0, shared = 0, public = 1)	Gensch, R. et al. (2018)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	6	Spuhler, D. et al. (2021)
technical_maturity	3	Gensch, R. et al. (2018)
development_phase	(acute = 1, stabilisation = 0, development/recovery = 0)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"A small amount of water and chemicals are mixed to make the flush water" (Emersan). As the technology does not handle blackwater, the entire possible range of water volume is considered to avoid the technology being discarded (Spuhler et al. 2021)	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No need for electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.2, continous = 0.8)	"The toilets require regular cleaning and checking of water for handwashing and anal cleansing, hygiene items, soap and dry cleansing materials. Where there is a high number of users it is advised to have an attendant to guarantee maintenance and cleaning. It is recommended to have one attendant for every 10 cubicles." (Emersan)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultlty available = 1, pipes = 1)	No need for pipes (only ventilation pipe, which can be made from local material or is part of prefabricated cubicle)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"The Chemical Toilet is designed as a complete prefabricated cubicle [...]." (Emersan) No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.5, special = 0.5)	"The Chemical Toilet comes as complete prefabricated plastic unit either available in-country from existing suppliers or can be flown in." (Emersan) Assumed that spare parts for these units need to be accessed from the producer and mostly cannot be replaced with locally produced parts.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.75, temperate = 1, warm = 1, hot = 1)	"larger holding tanks with anti-freeze are available" (Emersan) Can add chemicals up to -40°C ambient temperature, though the performance is lower since need additional chemicals up to freezing point of 0°C (TheTodayTalk 2019)	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	"Chemical Toilets are appropriate for the acute response phase of an emergency and are particularly suitable for flood prone affected areas, where pit digging is difficult, within urban areas and where low water and non-permanent solutions are required." (Emersan)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0, difficult = 0.5, full = 1)	"If 75–100 people are using one toilet per day then they should be emptied daily using a Motorised Emptying and Transport." (Emersan) Vehicular access for some type of motorized vehicles is necessary. Smaller vehicles (e.g. Gulper) are an option and can navigate difficult terrain but are less efficient.	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, rock = 1)	Not relying on soil absorbtion and therefore not affected by soil type.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"Chemical Toilets are appropriate for the acute response phase of an emergency and are particularly suitable for flood prone affected areas, where pit digging is difficult, within urban areas and where low water and non-permanent solutions are required." (Emersan) Low risk for contamination and therefore suitable for areas with a high groundwater table.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	"Chemical Toilets are appropriate [...] where pit digging is difficult, [...]." (Emersan) Not affected by excavation.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 1, b = 1, c = 999, d = 999)	This toilet can also be constructed on a small footprint. Based on a comparison of different technologies, we derive the space requirements of a chemical toilet to be similar to a single pit and use the same minimum space requirement of 1m2/plot (Eawag, 2021). Note that this does not involve any visual protection. A superstructure could require more space.	yes
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Chemical Toilets are appropriate for the acute response phase of an emergency and are particularly suitable for flood prone affected areas, where pit digging is difficult, within urban areas and where low water and non-permanent solutions are required. As excreta is well contained and well isolated with minimal risk of contamination, it is a good solution where there is a risk of cholera." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	"The Chemical Toilet comes as complete prefabricated plastic unit either available in-country from existing suppliers or can be flown in." (Emersan)	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"[...]. Standard cubical size is usually about 110 cm square by 210 cm, large enough for one person, and have washable floors, ventilation screens and ventilation pipes. Modifications to the standard design are available on the market with a variety of different user interfaces such as urinals, squatting pans, pedestal toilets and with wheelchair access and handwashing stations in the cubical. Larger holding tanks (< 200 L) and winterised models with anti-freeze are also available. Toilets must be located in areas that can be accessed by desludging vehicles and motorised emptying vehicles. The final disposal of sludge is a critical issue and a safe option should be identified before considering Chemical Toilets." (Emersan) "The chemical solution commonly used is glutaraldehyde, formaldehyde or caustic soda (sodium hydroxide). More environmentally friendly enzyme mixes have also been developed." (Emersan). Most design skills are outsourced to the company constructing the prefabricated toilet. However, some basic understanding of the system is necessary.	yes

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Chemical Toilets come with a basic pump flush that operates using the hand or foot or as dry systems without flush. If 75–100 people are using one toilet per day then they should be emptied daily Using a Motorised Emptying and Transport. The toilets require regular cleaning and checking of water for handwashing and anal cleansing, hygiene items, soap and dry cleansing materials. Some chemicals in the sludge can harm the biological activity in certain treatment facilities such as an aerobic Baffled Reactors or Biogas Reactors." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 0, long = 0)	"meant for short term" (Emersan)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 1, moderate = 0, slow = 0)	"The Chemical Toilet, commonly referred to as a 'portaloo', can be used as an immediate solution in the acute response phase of an emergency." "immediate solution" (Emersan) "in Dominican republic inside 2days arrival" (Harvey, 2007) The implementation time could be slightly slower, if chemical toilets are not locally available and need to be transported there. This is neglected here. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Can be mobilised rapidly" (Emersan) The chemical toilets can be up- and downscaled rapidly by changing the number of available cubicles. It should be mentioned that this depends on the local availability of further chemical toilets. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0, special = 1)	"The Chemical Toilet comes as complete prefabricated plastic unit either available in-country from existing suppliers or can be flown in." (Emersan) Assumed that these units need to be accessed from the producer.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.99	-	0.01	0	0		PA
med (R)	0.99	-	0.01	0	0		-
k	25	-	-	-	-		PA
TN	0.9	-	0.1	0	0		PA
med (R)	0.95	-	0.05	0	0		-
k	5	-	-	-	-		PA
H2O	1	-	0	0	0	sealed tank with chemical toilet fluid	PA
med (R)	1	-	0	0	0		-
k	25	-	-	-	-		PA
TS	0.95	-	0.05	0	0		PA
med (R)	0.95	-	0.05	0	0		-
k	25	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Storage Trench for Controlled Open Defecation						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	S	-				
UNIQUE IDENTIFIER (ID)	s_controlled_od	-				
DATA COMPILER	Akanksha Jain, Kukka Ilmanen	-				
INPUT PRODUCT	od_excreta	Spuhler, D. et al. (2021)				
OUTPUT PRODUCT	sludge	Gensch, R. et al. (2018)				
RELATIONS	Input: NA Output: NA	Spuhler, D. et al. (2021)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 1, city = 0.5)	Gensch, R. et al. (2018)				
management_level	(household = 0, shared = 0, public = 1)	Gensch, R. et al. (2018)				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Gensch, R. et al. (2018)				
development_phase	(acute = 1, stabilisation = 0, development/recovery = 0)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	According to (Emersan) it belongs into the 'Dry' technologies. Water is only required for handwashing, which is neglected here. Maximum values (c & d) are assumed to remain 999 L/person/day, firstly since the aspect of high water volumes disrupting this technology is considered with a separate criterion"Flooding", and secondly since this technology could be mobilized to a non-flooded plot area, the upper limit on incoming water is a non-issue (Akanksha Jain).	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity required	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0, continuous = 1)	"An attendant should be on site at all times in order to ensure security, continuous user orientation, proper use and the opening and closing of defecation strips." (Emersan)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficutly available = 1, pipes = 1)	No pipes required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficutly available = 1, pumps = 1)	No pumps required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Materials are needed for proper screening and demarcation of the area. This can be done with plastic canvas or materials such as bamboo or fabrics. Wooden or metal posts are required as well as shovels and picks to set up the posts." (Emersan) No concrete required	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Materials are needed for proper screening and demarcation of the area. This can be done with plastic canvas or materials such as bamboo or fabrics. Wooden or metal posts are required as well as shovels and picks to set up the posts.", "Can be built and repaired with locally available materials" (Emersan) No special materials required	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. [...]." (Liu et al. (2018)) A defecation field can be set up in any climate, but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	The hygiene risk if a defecation field is flooded is considered as unacceptable. A low performance of 10% is allotted to the category "flooding" given that there exists the possibility that open defecation fields could be built at elevated/ non-flooded plot areas of the flood-prone region. (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0.3, difficult = 0.6, full = 1)	"O & M also includes regular treatment of faeces with lime, their removal and burial or transport to a disposal site." (Emersan) Vehicular access is not necessary, as manual transport is possible. However, motorized vehicles can strongly improve the operation efficiency (e.g. as they can handle very large loads of sludge that require frequent emptying).	yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0, silt = 0.5, sand = 1, gravel = 0.5, rock = 0)	If the soil does not allow the liquid to infiltrate, ponding of contaminated material would pose a serious health risk. Soil percolation and filtration therefore should be guaranteed.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 3, b = 3, c = 999, d = 999)	No flushwater and no excavation therefore limited infiltration of effluent, so that groundwater depth should not be a limiting factor. However, there is a risk of contamination of groundwater if the groundwater table is high. A safety distance of three meters is applied.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No excavation required.	yes

surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 35, b = 35, c = 999, d = 999)	As the space requirements of open defecation fields strongly depend on the number of users, some assumptions are required here. The assumptions are based on the space requirements of shallow trench latrines: "the area needed is approximately 0.25 m2/person/day" (Emersan). This is justified due to the similar nature of the two technologies. Assuming that at least 10 people need to be able to use the open defecation field for a mininum of two weeks, we estimate the minimum space requirements for open defecation fields to be 35 m2/plot (Eawag, 2021) and thus a lot larger than other technologies of this functional group.	yes
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"The area chosen should be at least 50 m from [...] water sources" (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No specific skills needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	Design requires expert identification of an appropriate location, considering the following aspects: "The area chosen should be at least 50 m from food production, storage and preparation areas (e.g. kitchens, markets), water sources, water storage and treatment facilities but close enough to ensure safety of and accessibility for users. Defecation fields should be downhill of settlements, camps and water sources to avoid contamination" (Emersan). No other design skills necessary.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	No specific training needed for maintaining. But they can be "Difficult to manage" (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 0, long = 0)	"Controlled Open Defecation is not considered an improved sanitation technology and should be used only as an extreme short-term measure before other sanitation options are ready to use." (Emersan)	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 1, moderate = 0, slow = 0)	"Rapid implementation" (Emersan)	yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The defecation field can be increased by demarking new areas. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.29	0,18 - 0,4	0	0.71	0	* as P	Montangero and Belevi (2007)
med (R)	0.29	(0.18 - 0.4)	0	0.71	0		-
k	5	[0.22]	-	-	-		PA
TN	0.18	0,09-0,27	0	0.82	0	* as N	Montangero and Belevi (2007)
	0.18	0.15 - 0.2	0.55	0.27	0	* as N	Jacks et al. (1999)
	0.2	-	0.6	0.2	0	* TC Soilloss: N reaching the groundwater	Nyenje et al. (2013)
med (R)	0.18	0,09-0,27	0.55	0.27	0		-
k	25	[0.18]	-	-	-		PA
H2O	0.15	0.05 - 0.3	0.15	0.7	0	*PA; high variability depending on soil permeability	PA
med (R)	0.15	(0.05 - 0.3)	0.15	0.70	0		-
k	5	[0.25]	-	-	-		PA
TS	0.6	0.5 - 0.7	0	0.4	0	*TSS retainment range: 0.7-0.9 (Assumption for TS: 0.5 - 0.7)	Montangero and Belevi (2007)
med (R)	0.60	0.5 - 0.7	0	0.40	0		-
k	5	[0.2]	-	-	-		PA
							Spuhler et al. (2021)

Additional Information

Copied from "single pit". Some of the k-factors were decreased if they weren't already the minimum possible value.

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Transfer Station and Storage						
	Values	Data Source				
FUNCTIONAL GROUP	S	-				
UNIQUE IDENTIFIER (ID)	transfer_station	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	sludge	Tilley, E. et al. (2014)				
OUTPUT PRODUCT	transferred_sludge	Tilley, E. et al. (2014)				
RELATIONS	Input: NA Output: NA	Tilley, E. et al. (2014)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	6	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0.5, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	Can be used for all types of water consumption.	Yes
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	Assumed that there is no electricity needed.	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Screens must be frequently cleaned to ensure a constant flow and prevent back-ups. Sand, grit and on solidated sludge must also be periodically removed from the holding tank. There should be a well-organized system to empty the transfer station; if the holding tank fills up and overflows, it is no better than an overflowing pit. The pad and loading area should be regularly cleaned to minimize odours, flies and other vectors from becoming nuisances." (Compendium) Regular maintenance required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes are required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps required (pumping trucks required)	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, no concrete = 1)	No data found. It is assumed, that underground holding tanks are mostly constructed with concrete, because they should be watertight (Compendium). However, other materials are also possible, but these tanks are mostly bought from a specialized dealer in prefabricated HDPE holding tanks and have therefore a lower performance.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Transfer stations can be equipped with digital data recording devices to track quantity, input type and origin, as well as collect data about the individuals who dump there. In this way, the operator can collect detailed information and more accurately plan and adapt to differing loads." (Compendium) No technical spare parts are usually required. However, the use of technical equipment might improve the performance of the technology.	Yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0.25, temperate = 0.75, warm = 1, hot = 1)	Assumed to be similar to a biogas reactor.	Yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	Assumed to be similar to a biogas reactor.	Yes
vehicular_acces	Performance, Categorical	TRUE	no access difficult full	(no access = 0, difficult = 1, full = 1)	"A vacuum truck is required to empty transfer stations when they are full." (Compendium)	Yes
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, rock = 1)	Not relying on soil absorbtion and therefore not affected by soil type.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 3, c = 999, d = 999)	"The holding tank must be well constructed to prevent leaching and/or surface water infiltration." (Compendium) If it is propper built there should not be any problem at a place with a high groundwater table. But since there is still a remainig risk of contamination, one must be very careful in areas with a high groundwater table.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	" The dumping point should be built low enough to inimize spills when labourers manually empty their sludge carts." (Compendium) Underground holding tanks are (mostly) built underground and therefore require excavation. However, the excavation is not as big as for a sewer, comparable to the excavation of a soak pit.	yes
surface_area_onsite	Performance, Trapez	TRUE	[m2/plot]	(a = 1, b = 1, c = 999, d = 999)	Depending on the transfer time. Can be as small as a normal pit.	yes
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0.5, not close = 1)	"The holding tank must be well constructed to prevent leaching and/or surface water infiltration." (Compendium) If it is propper built there should not be any problem at a place close to a drinking water source. But since there is still a remainig risk of contamination, one must still be very careful in areas close to drinking water.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.1, professional = 1)	"Requires expert design and construction" (Compendium) Assumed to be comparable with the skills for a solids-free/simplified sewer.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.1, professional = 1)	"Requires expert design and construction" (Compendium) Assumed to be comparable with the skills for a solids-free/simplified sewer.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Screens must be frequently cleaned to ensure a constant flow and prevent back-ups. Sand, grit and consolidated sludge must also be periodically removed from the holding tank. " (Compendium) The required operation and maintenance skills are low-level.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	Construction can last long	yes
speed_implement_toilet	PDF, Categorical	TRUE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	(rapid = 0.3, moderate = 0.5, slow = 0.2)	"Requires expert design and construction" (Compendium) Since expert design and construction skills are required a rather moderate implememtation time is assumed. The location also has to be chosen carefully (PA)	Yes
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 0.5, difficiult = 1)	The scalability of a transfer station is limited. Other transfer stations could be built to enhance the capacity (PA).	Yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Transfer stations can be equipped with digital data recording devices to track quantity, input type and origin, as well as collect data about the individuals who dump there. In this way, the operator can collect detailed information and more accurately plan and adapt to differing loads." (Compendium) No technical spare parts are usually required. However, the use of technical equipment might improve the performance of the technology.	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Transferred Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.99	-	0.01	0	0		PA
med (R)	0.99	-	0.01	0	0		-
k	5	-	-	-	-		PA
TN	0.95	-	0.05	0	0		PA
med (R)	0.95	-	0.05	0	0		-
k	5	-	-	-	-		PA
H2O	0.95	-	0.05	0	0		PA
med (R)	0.95	-	0.05	0	0		-
k	5	-	-	-	-		PA
TS	0.95	-	0.05	0	0		PA
med (R)	0.95	-	0.05	0	0		-
k	5	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Motorized Emptying and Transport of Urine						
	Values	Data Source				
FUNCTIONAL GROUP	C	-				
UNIQUE IDENTIFIER (ID)	motorized_emptying_urine	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	urine, stored_urine, stabilized_urine, concentrated_urine, dried_urine, struvite	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	NA [Ifor SaniChoice, use x]	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: urine > stored_urine > stabilized_urine > concentrated_urine > dried_urine > struvite	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 0.5)	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	8	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	Motorised emptying and transport of urine involves transport of urine alone, from technologies that store it separately. The general problems associated with conveyance technologies, especially those that use pumps such as this one, is that the sludge is too thick and difficult to transport. This is not an issue here and there the full range of continuous function (0-999 L/cap/day) is considered (i.e., full range has 100% performance) (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 0.1)	Pumping trucks rely on fuel for operation, however they might also be run with electricity or a manual option could be possible though with a lot lower performance. To avoid discarding technologies based on their need for fuel, 10% is awarded for 'no fuel'.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.5, continuous = 0.5)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain. Therefore, older trucks are often used, but the savings are offset by the resulting high maintenance and fuel costs that can account for more than two thirds of the total costs incurred by a truck operator. Truck owners must be conscientious to save money for the purchase of expensive replacement parts, tires and equipment. The lack of preventive maintenance is often the cause for major repairs." (Compendium) Pumping trucks require regular maintenance that can be quite time-consuming, almost continuous	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No water pipes necessary for this technology.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	The motorized pumping trucks contain an installed pump and are independent of the pumps covered by pump supply. They usually cannot be replaced by a normal pump, but need special equipment for the trucks.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete necessary for this technology.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.5, special = 0.5)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain." (Compendium) If something breaks, technical as well as possibly specially manufactured spare parts that are produced by the manufactureres, are necessary for this technology.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.1, no flooding=1)	There is significant hazard associated with walking or driving a vehicle through a flood. Given so, the performance of this technology is surely reduced for the category of "Flooding". A performance of 10% is allotted to the category "Flooding" given the possibility that the desludging time can be adjusted, and the service is performed after the flooding event is over and waters have receded. (Akanksha Jain) It is assumed that it is equally risky for human-powered transport and motorized transport to operate during flooding and therefore, all technologies related to the two are allotted same performance values. (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	TRUE	flat not flat	(flat = 1, not flat = 1)	Pumping trucks do not rely on a hydraulic gradient for conveyance - Maximum performance on every slope, however: "A very steep gradient can pose problems for vacuum trucks." (Monvois et al. 2012)	yes
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Pumping trucks do not need any kind of excavation digging - Maximum performance for every type	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain. Therefore, older trucks are often used, but the savings are offset by the resulting high maintenance and fuel costs that can account for more than two thirds of the total costs incurred by a truck operator. Truck owners must be conscientious to save money for the purchase of expensive replacement parts, tires and equipment. The lack of preventive maintenance is often the cause for major repairs." Even though pumping trucks probably aren't constructed onsite, a skilled technician is necessary to maintain the truck.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	Construction and design skills are equivalent	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Truck owners must be conscientious to save money for the purchase of expensive replacement parts, tires and equipment. The lack of preventive maintenance is often the cause for major repairs." (Compendium) Mechanic skills are required	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The emptying can be scaled-up by buying more trucks or using the existing ones more frequently. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.3, special = 0.7)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain." (Compendium) "The required materials – a vehicle, a tank and a pump – are usually available locally. Second-hand trucks are often used, which can reduce costs but often also reduce efficiency.", "Not all parts and materials may be locally available" (Emersan) To get pump trucks one can either add pumps to a truck or buy specially-manufactured pumping tracks. The latter are used more often, so that specially-manufactured parts are more likely to be required.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA
TN	0.96	-	0.02	0	0.02	* Ammonia volatilization	Udert et al. (2006)
med (R)	0.96	-	0.02	0	0.02		-
k	100	-	-	-	-		PA
H2O	0.97	-	0.01	0	0.02		PA
med (R)	0.97	-	0.01	0	0.02		-
k	100	-	-	-	-		PA
TS	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Human-Powered Emptying and Transport of Urine						
	Values	Data Source				
FUNCTIONAL GROUP	C	-				
UNIQUE IDENTIFIER (ID)	human-powered_emptying_urine	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	urine, stored_urine, stabilized_urine, concentrated_urine, dried_urine, struvite	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	NA [Ifor SaniChoice, use x]	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: urine > stored_urine >	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 0)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	3	Spuhler, D. et al. (2021)				
opex_req_level	5	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	Human-powered emptying and transport of urine involves transport of urine alone, from technologies that store it separately. The general problems associated with conveyance technologies, especially those that use pumps such as this one, is that the sludge is too thick and difficult to transport. This is not an issue here and there the full range of continuous function (0-999 L/cap/day) is considered (i.e., full range has 100% performance) (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 1)	No fuel is required.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Manually operated sludge pumps require daily maintenance (cleaning, repairing and disinfection). Workers who manually empty latrines should clean and maintain their protective clothing and tools to prevent contact with the sludge." (Compendium) Regular maintenance is necessary to maintain hygienic requirements.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes are required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Can be done by shoveling or with manual hand-held pumps. These latter manual pumps are not included in pump supply, as they cannot handle large volumes.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete necessary	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Simple hand pumps can be built and repaired with locally available materials", " Some devices may require specialized repair (welding)" (Compendium) Most devices can be built and repaired with low-tech materials. Some require more technical repair such as welding.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.1, no flooding=1)	There is significant hazard associated with walking or driving a vehicle through a flood. Given so, the performance of this technology is surely reduced for the category of "Flooding". A performance of 10% is allotted to the category "Flooding" given the possibility that the desludging time can be adjusted, and the service is performed after the flooding event is over and waters have receded. (Akanksha Jain) It is assumed that it is equally risky for human-powered transport and motorized transport to operate during flooding and therefore, all technologies related to the two are allotted same performance values. (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	TRUE	flat not flat	(flat = 1, not flat = 1)	Does not rely on a hydraulic gradient.	yes
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Medium-level skills (a gulper can be purchased from a specialized dealer or be constructed by a skilled craftsman)"(Monvois et al. (2012)) Requires moderate construction and design skills if not purchased by a specialized dealer.	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Medium-level skills (a gulper can be purchased from a specialized dealer or be constructed by a skilled craftsman)" (Monvois et al. (2012)) Requires moderate construction and design skills if not purchased by a specialized dealer.	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Low-level skills (for the handling and maintenance of materials)" (Monvois et al. (2012)) The operation and maintenance does not require special skills.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA	
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The emptying can be scaled-up by scaling-up the business and conducting more frequent emptying. (Kukka Ilmanen, Eawag 2021)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Human-powered emptying of pits, vaults and tanks can be done in one of two ways: 1) using buckets and shovels, or 2) using a portable, manually operated pump specially designed for sludge (e.g., the Gulper, the Rammer, the MDHP or the MAPET)." (Compendium) "Simple hand pumps can be built and repaired with locally available materials. [...] Hand pumps can be locally made with steel rods and valves in a PVC casing." (Compendium) "In principle, hand pumps and hand carts can often be constructed using locally available material such as steel and PVC pipes. Prefabrication is also possible. For some pumps, additional piping is needed. Other tools such as buckets and shovels should be available locally." (Emersan) Overall, buckets, shovels and some simple pumps can be built locally.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA
TN	0.95	-	0.03	0	0.02	* Ammonia volatilization	Udert et al. (2006)
med (R)	0.95	-	0.03	0	0.02		-
k	100	-	-	-	-		PA
H2O	0.97	-	0.01	0	0.02		PA
med (R)	0.97	-	0.01	0	0.02		-
k	100	-	-	-	-		PA
TS	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Motorized Emptying and Transport of Solids

	Values	Data Source
FUNCTIONAL GROUP	C	-
UNIQUE IDENTIFIER (ID)	motorized_emptying_solids	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	sludge, transferred_sludge, processed_sludge, pithumus, dried_faeces, stabilized_sludge, stored_faeces, organics, compost, pellets, briquettes, biochar, ash	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA [Ifor SaniChoice, use x]	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: sludge > transferred_sludge >	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 1, city = 0.5)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	8	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 7, c = 999, d = 999)	"Depending on the Collection and Storage technology, the sludge can be so dense that it cannot be easily pumped. In these situations it is necessary to thin the solids with water so that they flow more easily, but this may be inefficient and costly." (Compendium) Given the above source, the optimal minimum water requirement for this technology was set by assuming that atleast pour-flush sytems should ideally be present to generate a sludge fluid enough to be pumped. A value of "b"=7L/cap/day was calculated based on the following assumptions: 7 toilet visits/person/day and 1L/flush for pour flush tech (Compendium) The minimum water requirement is still kept at 0L/cap/day assuming that the water required to thin out the "too-solid" sludge can be found locally, however, given the unit of "L/capita/day" it may be too less to be accountable. Handling too high water volumes	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 0.1)	Pumping trucks rely on fuel for operation, however they might also be run with electricity or a manual option could be possible though with a lot lower performance. To avoid discarding technologies based on their need for fuel, 10% is awarded for 'no fuel'.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.5, continuous = 0.5)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain. Therefore, older trucks are often used, but the savings are offset by the resulting high maintenance and fuel costs that can account for more than two thirds of the total costs incurred by a truck operator. Truck owners must be conscientious to save money for the purchase of expensive replacement parts, tires and equipment. The lack of preventive maintenance is often the cause for major repairs." (Compendium) Pumping trucks require regular maintenance that can be quite time-consuming, almost continuous.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No water pipes necessary for this technology.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	The motorized pumping trucks contain an installed pump and are independent of the pumps covered by pump supply. They usually cannot be replaced by a normal pump, but need special equipment for the trucks.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete necessary for this technology.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.5, special = 0.5)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain." (Compendium) If something breaks, technical as well as possibly specially manufactured spare parts that are produced by the manufactureres, are necessary for this technology.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA

flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.1, no flooding=1)	There is significant hazard associated with walking or driving a vehicle through a flood. Given so, the performance of this technology is surely reduced for the category of "Flooding". A performance of 10% is allotted to the category "Flooding" given the possibility that the desludging time can be adjusted, and the service is performed after the flooding event is over and waters have receded. (Akanksha Jain) It is assumed that it is equally risky for human-powered transport and motorized transport to operate during flooding and therefore, all technologies related to the two are allotted same performance values. (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	TRUE	flat not flat	(flat = 1, not flat = 1)	Pumping trucks do not rely on a hydraulic gradient for conveyance - Maximum performance on every slope, however: "A very steep gradient can pose problems for vacuum trucks." (Monvois et al. 2012)	yes
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Pumping trucks do not need any kind of excavation digging - Maximum performance for every type	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain. Therefore, older trucks are often used, but the savings are offset by the resulting high maintenance and fuel costs that can account for more than two thirds of the total costs incurred by a truck operator. Truck owners must be conscientious to save money for the purchase of expensive replacement parts, tires and equipment. The lack of preventive maintenance is often the cause for major repairs." (Compendium) Even though pumping trucks probably aren't constructed onsite, a skilled technician is necessary to maintain the truck.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	Construction and design skills are equivalent	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	" Truck owners must be conscientious to save money for the purchase of expensive replacement parts, tires and equipment. The lack of preventive maintenance is often the cause for major repairs." (Compendium) Mechanic skills are required	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The emptying can be scaled-up by buying more trucks or using the existing ones more frequently. (Kukka Ilmanen, Eawag 2021)	yes

construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.3, special = 0.7)	"Most pump trucks are manufactured in North America, Asia or Europe. Thus, in some regions it is difficult to locate spare parts and a mechanic to repair broken pumps or trucks. New trucks are very expensive and sometimes difficult to obtain." (Compendium) "The required materials – a vehicle, a tank and a pump – are usually available locally. Second-hand trucks are often used, which can reduce costs but often also reduce efficiency.", "Not all parts and materials may be locally available" (Emersan) To get pump trucks one can either add pumps to a truck or buy specially-manufactured pumping tracks. The latter are used more often, so that specially-manufactured parts are more likely to be required.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA
TN	0.96	-	0.02	0	0.02	* Ammonia volatilization	Udert et al. (2006)
med (R)	0.96	-	0.02	0	0.02		-
k	100	-	-	-	-		PA
H2O	0.97	-	0.01	0	0.02		PA
med (R)	0.97	-	0.01	0	0.02		-
k	100	-	-	-	-		PA
TS	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Human-Powered Emptying and Transport of Solids

	Values	Data Source
FUNCTIONAL GROUP	C	-
UNIQUE IDENTIFIER (ID)	human-powered_emptying_solids	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	sludge, transferred_sludge, processed_sludge, pithumus, dried_faeces, stabilized_sludge, stored_faeces, organics, compost, pellets, briquettes, biochar, ash	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA [Ifor SaniChoice, use x]	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: sludge > transferred_sludge > processed_sludge > pithumus > dried_faeces > stabilized_sludge > stored_faeces > organics > compost > pellets > briquettes > biochar > ash	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 1, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	"Human-powered emptying of pits, vaults and tanks can be done in one of two ways: 1) using buckets and shovels, or 2) using a portable, manually operated pump" (Compendium) If the sludge is too thick/solid, it is possible manually shovel it. Therefore, unlike motorized transport (where pumping is must), an optimal water requirement (value "b") need not be defined for human-powered transport. Although handling too high water volumes is not ideal for this technology, we choose to ignore this aspect, and a default value of 999L/cap/day is still assumed (Desludging frequency can always be increased to handle large volumes). (Akanksha Jain) Note: Technologies "Motorized transport dry" and "Human powered transport dry" were filled in conjunction, and their TechCase attribute values should be looked at together.	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 1)	No fuel is required.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Manually operated sludge pumps require daily maintenance (cleaning, repairing and disinfection). Workers who manually empty latrines should clean and maintain their protective clothing and tools to prevent contact with the sludge." (Compendium) Regular maintenance is necessary to maintain hygienic requirements.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes are required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Can be done by shoveling or with manual hand-held pumps. These latter manual pumps are not included in pump supply, as they cannot handle large volumes.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete necessary	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Simple hand pumps can be built and repaired with locally available materials", " Some devices may require specialized repair (welding)" (Compendium) Most devices can be built and repaired with low-tech materials. Some require more technical repair such as welding.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.1, no flooding=1)	There is significant hazard associated with walking or driving a vehicle through a flood. Given so, the performance of this technology is surely reduced for the category of "Flooding". A performance of 10% is allotted to the category "Flooding" given the possibility that the desludging time can be adjusted, and the service is performed after the flooding event is over and waters have receded. (Akanksha Jain) It is assumed that it is equally risky for human-powered transport and motorized transport to operate during flooding and therefore, all technologies related to the two are allotted same performance values. (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	TRUE	flat not flat	(flat = 1, not flat = 1)	Does not rely on a hydraulic gradient.	yes

soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA	
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Medium-level skills (a gulper can be purchased from a specialized dealer or be constructed by a skilled craftsman)"(Monvois et al. (2012)) Requires moderate construction and design skills if not purchased by a specialized dealer.	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Medium-level skills (a gulper can be purchased from a specialized dealer or be constructed by a skilled craftsman)" (Monvois et al. (2012)) Requires moderate construction and design skills if not purchased by a specialized dealer.	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Low-level skills (for the handling and maintenance of materials)" (Monvois et al. (2012)) The operation and maintenance does not require special skills.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA	
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The emptying can be scaled-up by scaling-up the business and conducting more emptying. (Kukka Ilmanen, Eawag 2021)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Human-powered emptying of pits, vaults and tanks can be done in one of two ways: 1) using buckets and shovels, or 2) using a portable, manually operated pump specially designed for sludge (e.g., the Gulper, the Rammer, the MDHP or the MAPET)." (Compendium) "Simple hand pumps can be built and repaired with locally available materials. [...] Hand pumps can be locally made with steel rods and valves in a PVC casing." (Compendium) "In principle, hand pumps and hand carts can often be constructed using locally available material such as steel and PVC pipes. Prefabrication is also possible. For some pumps, additional piping is needed. Other tools such as buckets and shovels should be available locally." (Emersan) Overall, buckets, shovels and some simple pumps can be built locally.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA
TN	0.96	-	0.02	0	0.02	* Ammonia volatilization	Udert et al. (2006)
med (R)	0.96	-	0.02	0	0.02		-
k	100	-	-	-	-		PA
H2O	0.97	-	0.01	0	0.02		PA
med (R)	0.97	-	0.01	0	0.02		-
k	100	-	-	-	-		PA
TS	0.98	-	0	0	0.02		PA
med (R)	0.98	-	0	0	0.02		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Conventional Gravity Sewer

	Values	Data Source
FUNCTIONAL GROUP	C	-
UNIQUE IDENTIFIER (ID)	conventional_sewer	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	blackwater, effluent, greywater, secondary_effluent, stormwater	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA [Ifor SaniChoice, use x]	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: blackwater > effluent >	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)
capex_req_level	8	Spuhler, D. et al. (2021)
opex_req_level	8	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 50, b = 100, c = 999, d = 999)	"The sewer must be designed, however, so that it maintains self-cleansing velocity (i.e., a flow that will not allow particles to accumulate). For typical sewer diameters, a minimum velocity of 0.6 to 0.7 m/s during peak dry weather conditions should be adopted. This requires a daily water consumption rate of more than 100 L per person per day." "Local drinking water consumption is at least 50L/person/day (this varies according to the gradient and diameter of the network)." (Monvois et al. (2012)) Based on the above two sources and values, a min. water requirement was set at 50L/cap/day and an optimal water requirement was set at 100L/cap/day. (Akanksha Jain) An upper bound to how much water the sewers can handle is not considered here, as this is more a design aspect. Note: Performance values of all sewer technologies (Conventional-Simplified-SolidsFree) are filled together, in accordance with each other and should be viewed together.	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 1)	A sewer does not rely on fuel for operation.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.3, regular = 0.7, continuous = 0)	"Manholes are used for routine inspection and sewer cleaning. Debris (e.g., grit, sticks or rags) may accumulate in the manholes and block the lines. To avoid clogging caused by grease, it is important to inform the users about proper oil and grease disposal. Common cleaning methods for conventional gravity sewers include rodding, flushing, jetting and bailing. Sewers can be dangerous because of toxic gases and should be maintained only by professionals, although, in well-organised communities, the maintenance of tertiary networks might be handed over to a well-trained group of community members. Proper protection should always be used when entering a sewer." (Compendium) Proper and regular maintenance is required. However, maintenance is only required for routine inspections or in the event of blocking.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	" Commonly used materials are concrete, PVC, ar	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficultly available = 0.75, pumps = 1)	"A constant downhill gradient must be guaranteed along the length of the sewer to maintain self-cleansing flows, which can require deep excavations. When a downhill grade cannot be maintained, a pumping station must be installed." (Compendium) It depends on the local slope distribution if pumps are necessary or not. We therefore, set the performance for no pumps to 0.5 and for difficultly available to 0.75. Also check the comments of the attribute "electricity supply" and "slope"	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	" Commonly used materials are concrete, PVC, ar	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	Besides pipes, concrete or material for manholes, no technical spare parts are required. Concrete and pipes are already covered in the attributes above. However, special tools might be necessary to repair sewer systems, therefore some technical parts might be necessary.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA

flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.9, no flooding=1)	Ideally, sewers should be unaffected by ongoing flooding events. They are built to be leak proof and designed to handled certain amount of storm water and/or groundwater infiltration. However, in reality ofcourse their performance can be hampered during flooding events. A 10% reduction in performance in considered for Conventional Gravity Sewers, i.e. Flooding is allotted a performance of 90%. This is because they can comparitively handle large volumes and are better equipped to deal with flooding than simplified or solids free sewers (both of which are allotted a performance of 80%) (Akanksha Jain) Note: Performance values of all sewer technologies (Conventional-Simplified-SolidsFree) are filled together, in accordance with each other and should be viewed together.	Yes	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA	
slope	Performance, Categorical	TRUE	flat not flat	(flat = 0.2, not flat = 1)	"A constant downhill gradient must be guaranteed along the length of the sewer to maintain self-cleansing flows, which can require deep excavations." (Compendium) A slope steeper than 1% is recommended (Monvois et al. 2012). However, if the slope is less than 1%, a conventional gravity sewer can still be used with pumps. Also check attribute "pumps" and "electricity supply"	yes	
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA	
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.25)	"Requires deep excavations" (Compendium)Deep	yes	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Planning, construction, operation and maintenance require expert knowledge. " (Compendium)	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Planning, construction, operation and maintenance require expert knowledge. " (Compendium)	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0, professional = 1)	"Planning, construction, operation and maintenance require expert knowledge. " (Compendium)	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA	
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	"Difficult and costly to extend as a community changes and grows" (Emersan) A sewer network can be expensive and difficult to construct especially below existing infrastructure. Therefore, it is possible but difficult to extend the sewer network.	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.6, technical = 0.4, special = 0)	"Commonly used materials are concrete, PVC, vitrified clay and ductile or cast-iron pipes. Excavation requires an excavator or numerous workers with shovels, depending on soil properties." (Emersan) Mostly a sewer system consists of pipes, which are assumed to be simple locally available parts. Technical parts might be required for machinery to excavate or pumps in areas with low gradient.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.9	-	0	0.1	0	* PA based on H2O, assuming P in particulate form is contained in solids	PA
med (R)	0.90	-	0	0.10	0		-
k	5	-	-	-	-		PA
TN	0.85	-	0.05	0.1		*PA based on H2O	PA
med (R)	0.85	-	0.05	0.10			-
k	5	-	-	-	-		PA
H2O	0.8	-	0	0.2	0	*Italy	Howard (2007)
	0.95	-	0	0.05	0	*Germany	Reynolds and Barrett (2003)
	0.95	-	0	0.05	0	*UK	Howard (2007)
	0.70	-	0	0.3	0	* PA for developing countries	PA
med (R)	0.88	(0.7 - 0.95)	0	0.12	0		-
k	5	[0.25]	-	-	-		PA
TS	0.9	-	0	0.1	0	*PA based on H2O	PA
med (R)	0.90	-	0	0.10	0		-
k	5	-	-	-	-		Spuhler et al. (2021)

References

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Simplified Sewer

	Values	Data Source
FUNCTIONAL GROUP	C	-
UNIQUE IDENTIFIER (ID)	simplified_sewer	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	blackwater, effluent, greywater, secondary_effluent	Tilley, E. et al. (2014)
OUTPUT PRODUCT	NA [Ifor SaniChoice, use x]	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: blackwater > effluent >	Tilley, E. et al. (2014)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 1, city = 0.5)	Tilley, E. et al. (2014)
management_level	(household = 0.5, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 40, b = 60, c = 999, d=999)	"Local drinking water consumption is at least 40 to 50L/person/day (this varies according to the gradient and diameter of the network)." (Monvois et al. (2012)) "They should be considered as an option where there is a sufficient population density (about 150 people per hectare) and a reliable water supply (at least 60 L/person/day)." (Compendium) Based on the above two sources and values, a min. water requirement was set at 40L/cap/day and an optimal water requirement was set at 60L/cap/day. (Akanksha Jain) An upper bound to how much water the sewers can handle is not considered here, as this is more a design aspect. Note: Performance values of all sewer technologies (Conventional-Simplified-SolidsFree) are filled together, in accordance with each other and should be viewed together.	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 1)	No fuel required.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.7, continuous = 0.3)	"Requires repairs and removals of blockages more frequently than a Conventional Gravity Sewer", "Alternatively, a private contractor or users committee can be hired to do the maintenance." (Compendium) Maintenance can extend to a full time job.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	Pipes are required. However, the pipes have a	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficultly available = 0.75, pumps = 1)	In some cases pumping stations are necessary (if gradient not sufficient) (Monvois et al. (2012)).	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete is needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	Besides pipes or material for manholes, no technical spare parts are required. Pipes are already covered in the attribute "PIPE.SUPPLY". However, special tools might be necessary to repair sewer systems, therefore some technical parts might be necessary.	yes
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.8, no flooding=1)	Ideally, sewers should be unaffected by ongoing flooding events. They are built to be leak proof and designed to handle a certain amount of storm water and/or groundwater infiltration. However, in reality ofcourse their performance can be hampered during flooding events. A 20% reduction in performance in considered for Simplified Sewers and Solids free sewers, i.e. Flooding is allotted a performance of 80%. This is because they can comparitively handle lesser volumes than conventional gravity sewers (which are better equipped to deal with flooding than these technologies, e.g. combined sewers) (Akanksha Jain) Note: Performance values of all sewer technologies (Conventional-Simplified-SolidsFree) are filled together, in accordance with each other and should be viewed together.	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	TRUE	flat not flat	(flat = 0.5, not flat = 1)	"A gradient of 0.5% is usually sufficient." (Compendium) Monvois et al. (2012) recommend a minimum gradient of 1% to let the wastewater flow. The performance for flat areas is therefore 0.5. However, further calculations have to be carried out to evaluate the efficiency of a simplified sewer system.	yes
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Simplified sewer systems are not buried as deep as conventional sewer systems, but they still rely on excavation (Compendium). Shallow and wide excavation necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"High-level skills (technical engineering firm)" (Monvois et al. (2012)) "Requires expert design and construction" (Compendium) The design and construction still is slightly easier than for the conventional sewer.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"High-level skills (technical engineering firm)" (Monvois et al. (2012)) "Requires expert design and construction" (Compendium) The design and construction still is slightly easier than for the conventional sewer.	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Medium-level skills (people with experience of management and maintenance)" (Monvois et al. (2012))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"Can be extended as a community grows" (Emersan) A sewer network can be expensive and difficult to construct especially below existing infrastructure, but a simplified sewer is easier to extend than a conventional one.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"PVC pipes are recommended for the Simplified Sewer. Inspection chambers can be constructed using bricks with mortared cover to avoid the influx of unwanted products, such as stormwater, soil or grit. Plastic junction boxes can be pre-fabricated. Concrete should not be used in simplified sewerage, as it will corrode quickly." (Emersan) "Can be built and repaired with locally available materials" (Simplified-and-Condominial-Sewers | SSWM Toolbox)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.9	-	0	0.1	0		PA
med (R)	0.9	-	0	0.1	0		-
k	25	-	-	-	-		PA
TN	0.85	-	0.05	0.1	0		PA
med (R)	0.85	-	0.05	0.1	0		-
k	25	-	-	-	-		PA
H2O	0.9	-	0	0.1	0		PA
med (R)	0.9	-	0	0.1	0		-
k	25	-	-	-	-		PA
TS	0.9	-	0	0.1	0		PA
med (R)	0.9	-	0	0.1	0		-
k	25	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Solids-Free Sewer

	Values	Data Source
FUNCTIONAL GROUP	C	-
UNIQUE IDENTIFIER (ID)	solids-free_sewer	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	effluent, greywater, secondary_effluent	Tilley, E. et al. (2014)
OUTPUT PRODUCT	NA [Ifor SaniChoice, use x]	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: effluent > greywater > secondary_effluent	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 1, city = 0.5)	Tilley, E. et al. (2014)
management_level	(household = 0.5, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Same values allotted as all other sewer based technologies in the Emersan Compendium (Akanksha Jain) Not suitable (0) for acute emergency phase. Less suitable (+) for stabilisation emergency phase. Suitable (++) for recovery emergency phase. (Gensch, R. et al. (2018))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 7, b = 30, c = 999, d = 999)	"Can be used where water supply is limited" "Does not require a minimum gradient or flow velocity" (Compendium). "As opposed to simplified sewers, a solids free sewer can also be used where domestic water consumption is limited" "With sewered pour-flush toilets the total wastewater flow will normally be low, in the region of 30-80 litres per capita per day." (Otis & Mara, (1985)) Based on the above three sources, the optimal water requirement was set at 30L/cap/day whereas the minimum water requirement was calculated assuming a limited domestic water consumption for e.g. where a pour-flush system is used as a user interface. Assuming 7 toilet visits/person/day and 1L/flush for pour flush tech (Compendium), we set a minimum water requirement of 7L/cap/day. (Akanksha Jain) An upper bound to how much water the sewers can handle is not considered here, as this is more a design aspect. Note: Performance values of all sewer technologies (Conventional-Simplified-SolidsFree) are filled together, in accordance with each other and should be viewed together	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 1)	No fuel required.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Interceptors require regular desludging to prevent clogging" (Compendium) "Requires repairs and removals of blockages more frequently than a conventional gravity sewer" (Compendium) Since usually no solids are transported, clogging should occur less often than for a simplified sewer.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	Pipes are required. However, the pipes have a smaller diam	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Usually no pumps are required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete necessary.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Solids-Free Sewer | SSWM Toolbox)	yes
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.8, no flooding=1)	Ideally, sewers should be unaffected by ongoing flooding events. They are built to be leak proof and designed to handle a certain amount of storm water and/or groundwater infiltration. However, in reality ofcourse their performance can be hampered during flooding events. A 20% reduction in performance in considered for Simplified Sewers and Solids free sewers, i.e. Flooding is allotted a performance of 80%. This is because they can comparitively handle lesser volumes than conventional gravity sewers (which are better equipped to deal with flooding than these technologies, e.g. combined sewers) (Akanksha Jain) Note: Performance values of all sewer technologies (Conventional-Simplified-SolidsFree) are filled together, in accordance with each other and should be viewed together	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	TRUE	flat not flat	(flat = 1, not flat = 1)	"Does not require a minimum gradient or flow velocity " (Compendium)	yes
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Solids-free sewers are not buried as deep as conventional sewers. They still require excavation, but since no hydraulic gradient has to be maintained and even negative slopes are allowed, the excavation might be easier compared to the simplified sewer (Compendium). Shallow and wide excavations necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA

drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) The design and construction skills required are similar to the construction and design skills of the simplified sewer.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) The design and construction skills required are similar to the construction and design skills of the simplified sewer.	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Requires repairs and removals of blockages more frequently than a conventional gravity sewer", "Interceptors require regular desludging to prevent clogging" (Compendium) The operation and maintenance is easier than the one of a simplified sewer system. No mechanical cleaning equipment is required.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"This technology is a flexible option that can be easily extended as the population grows." (Emersan) A sewer network can be expensive and difficult to construct especially below existing infrastructure, but a solids-free sewer is easier to extend than a conventional one.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Solids-Free Sewer | SSWM Toolbox)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.9	-	0	0.1	0		PA
med (R)	0.9	-	0	0.1	0		-
k	25	-	-	-	-		PA
TN	0.85	-	0.05	0.1	0		PA
med (R)	0.85	-	0.05	0.1	0		-
k	25	-	-	-	-		PA
H2O	0.9	-	0	0.1	0		PA
med (R)	0.9	-	0	0.1	0		-
k	25	-	-	-	-		PA
TS	0.9	-	0	0.1	0		PA
med (R)	0.9	-	0	0.1	0		-
k	25	-	-	-	-		PA

References

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Stormwater Drainage						
	Values	**Data Source**				
FUNCTIONAL GROUP	C	-				
UNIQUE IDENTIFIER (ID)	stormwater_drainage	-				
DATA COMPILER	SaniChoice Project Team	-				
INPUT PRODUCT	greywater, stormwater	Gensch, R. et al. (2018)				
OUTPUT PRODUCT	NA [lfor SaniChoice, use x]	Gensch, R. et al. (2018)				
RELATIONS	Input: OR Output: greywater > stormwater	Gensch, R. et al. (2018)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0.5, neighbourhood = 1, city = 1)	Gensch, R. et al. (2018)				
management_level	(household = 0.5, shared = 0.5, public = 1)	Gensch, R. et al. (2018)				
capex_req_level	7	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Gensch, R. et al. (2018)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	TRUE	[L/cap/day]	(a = 0, b = 0, c = 999, d = 999)	Collects rainwater only, not affected by case attribute values where the user defines sanitary water consumption. (Akanksha Jain)	Yes
electricity_supply	Performance, Categorical	FALSE	electricity intermittent no electricity	NA	NA	NA
fuel_supply	Performance, Categorical	TRUE	fuel no fuel	(fuel = 1, no fuel = 1)	No fuel required.	yes
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.3, regular = 0.7, continuous = 0)	"Solid waste must be removed from stormwater channels on a regular basis and particularly before the start of a rainy season or expected rainfall events to assure proper functioning. After the rains it may be necessary to empty sediments from a channel, after the water flow has decreased below the self-cleansing velocity. Structural damages also need to be tended to on a regular basis. These can occur especially in channels with high gradients and runoff velocities." (Emersan) Regular maintenance required, but the technology still performs with irregular maintenance, just not as good.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes, but lining material required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps required. Open surface flow.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"For lined stormwater channels, lining r	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Basic tools are needed for cleaning secondary channels, such as shovels and rakes." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	FALSE	very cold cold temperate warm hot	NA	NA	NA
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=1, no flooding=1)	"Stormwater drainage can be implemented in areas with regular flooding and/or greywater production and where there is no conventional sewerage." (Emersan)	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	TRUE	flat not flat	(flat = 0.5, not flat = 1)	"Constructing stormwater channels for drainage can be challenging in areas with flat terrain due to the lack of gradient, as well as in steep areas , where run-off velocities become high and difficult to control." (Emersan) It is assumed, that a gradient of at least 0.5% is necessary in order to divert stormwater efficiently.	yes
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"Stormwater channels should always be	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled 0.5, professional = 1)	The necessary construction skills of a stormwater drainage is assumed to be rather moderate than high.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Design of Stormwater Drainage needs to be done by a skilled and experienced engineer." (Emersan) High level skills for design necessary.	

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Solid waste must be removed from stormwater channels on a regular basis and particularly before the start of a rainy season or expected rainfall events to assure proper functioning. After the rains it may be necessary to empty sediments from a channel, after the water flow has decreased below the self-cleansing velocity. Structural damages also need to be tended to on a regular basis. These can occur especially in channels with high gradients and runoff velocities." (Emersan) Low operation and maintenance skills required.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	FALSE	short (< 1 year) medium (1-5 years) long (>5 years)	NA	NA	NA
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	A drainage network can be extended by adding new channels to it. However, the existing channels might not be sufficiently large to accept additional stormwater into the drainage network. The consequence could be overflooding. If the drainage network is above ground it is easier to extend then sewers below the ground. Extending the nextwork is possible, but drawbacks exist. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"For lined stormwater channels, lining materials are needed. These can be prefabricated drain elements, cement or local materials such as wood. For unlined channels the ground can be reinforced with chicken wire and plants.", "Can be built with local materials" (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	X	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0		PA
med (R)	1	-	0	0	0		-
k	25	-	-	-	-		PA
TN	1	-	0	0	0		PA
med (R)	1	-	0	0	0		-
k	25	-	-	-	-		PA
H2O	1	-	0	0	0		PA
med (R)	1	-	0	0	0		-
k	25	-	-	-	-		PA
TS	1	-	0	0	0		PA
med (R)	1	-	0	0	0		-
k	25	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Urine Bank		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	urine_bank	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedurine, transportedstored_urine	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	transportedstabilized_urine	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 1, city = 1)	Compared to small urine storage tanks, application on the city level is possible with urine banks. (Tilley, E. et al. (2014))
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Same value as Urine Storage Tank (Tilley, E. et al. (2014))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	No electricity required.	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continuous = 0)	"To avoid faecal contamination, special precautions must be taken during instances of diarrhoea and when children or unaccustomed adults use the toilet.", "Urine collection pipes need to be checked for precipitates and bottom sludge needs either to be used separately or mixed with the urine before reuse. It should be regularly checked that the urine tanks are not ventilated." (SSWM) Irregular to regular maintenance.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes required.	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Usually no pumps are required.	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Urine is very corrosive and therefore tanks should be made of resistant material, e.g. plastic or high quality concrete, while metals should be avoided " (SSWM)	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	No special or technical spare parts required.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm =	High temperatures increase the pathogen removal and therefore decreases the necessary storage time (SSWM).	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	For this technology the criterion "flooding" is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Depending on the design, excavation might be necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.1, b = 0.1, c = 999, d = 999)	The space requirements of urine banks are difficult to define as they strongly depend on the number of users. Some assumptions need to be made. "The storage guidelines for urine correspond to the temperature of storage and the intended crop for which it would be used as fertilizer, but all urine should be stored for at least 1 month before use (see WHO guidelines for specific storage and application guidelines)" (Compendium). "On average, a person generates about 1.2 L of urine a day" (Compendium). To estimate the minimum space requirements, we assume that the urine needs to be stored for at least 1 month. At least two tanks need to ensure that one tank can be filled while the other remains untouched during the storage time. This results in at least 72 liters of storage per person. It is assumed that this results in minimum space requirements of 0.1 m2/cap for a urine bank (Eawag, 2021).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.7, skilled = 1, professional = 1)	No special design or construction skills necessary.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.7, skilled = 1, professional = 1)	No special design or construction skills necessary.	

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.7, skilled = 1, professional = 1)	No special O&M skills required.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"All urine should be stored for at least 1 month before use (see WHO guidelines for specific storage and application guidelines)." (Compendium) Therefore, lifetimes of less than 1 month are in theory not suitable, but limitations of technologies for short lifetimes are not considered here. In general, the concept of storing urine does not have a lifetime and can therefore be used at anytime. The actual technology (the storage devices, such as urine tanks) can be replaced easily and do not limit the lifetime of the technology. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=1, moderate=0, slow=0)	"Mobile storage tanks should be made of plastic or fibreglass (prefab), but permanent ones can be comprised of concrete or plastic." (Compendium) Simply a storage device, no time required for implementation i.e., very quick implementation. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	The number of urine storage containers and tanks can be changed to scale the technology up. Same value as for Urine Storage Tank (FG S) are chosen. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"The storage tanks can be made of any watertight material, such as glass fibre reinforced plastic, PE, PP or PVC, but they can also be made of rubber bladders or reinforced concrete (von Münch and Winker, 2011). Usually the tanks are placed on reinforced concrete slabs." (Griesauer, C. (2014)) It is assumed that the parts required for urine banks are locally available.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stabilized Urine	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0		PA
med (R)	1	-	0	0	0		-
k	25	-	-	-	-		PA
TN	0.95	0.92 - 0.98	0.05	0	0		PA
med (R)	0.95	(0.92 - 0.98)	0.05	0	0		-
k	100	[0.06]	-	-	-		PA
H2O	0.96	-	0.04	0	0		PA
med (R)	0.96	-	0.04	0	0		-
k	25	-	-	-	-		PA
TS	1	-	0	0	0		PA
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		PA

References

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Griesauer, C. (2013). Contribution to the development of cost functions for the CLARA simplified planningtool:(water sources, purification & distribution), na.

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Struvite Precipitation						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	struvite_precipitation	-				
DATA COMPILER	SaniChoice Project Team	-				
INPUT PRODUCT	urine, transportedurine, greywater, transportedgreywater	McConville, J. et al. (2020)				
OUTPUT PRODUCT	struvite, transportedstruvite, effluent, transportedeffluent	McConville, J. et al. (2020)				
RELATIONS	Input: OR Output: AND	McConville, J. et al. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	McConville, J. et al. (2020)				
management_level	(household = 0, shared = 0.5, public = 1)	McConville, J. et al. (2020)				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	5	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	Phosphorus recovery can be considered not to be a priorty in the acute and stabilisation phases of an emergency, however since the complexity of this technology is low, and can be built with locally available materials it can be considered as a good option for recovery phases. (Akanksha Jain, based on McConville, J. et al. (2020))				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"The system can operate with or without electricity" (SLU).	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	EJ (SLU).	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	EJ (SLU).	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficultly available = 0.5, pumps = 1)	Meyer et al. (2011)	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	EJ (SLU).	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	EJ (SLU).	yes
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.2, cold = 0.4, temperate = 0.6, warm = 0.8, hot = 1)	Darwish, M. et al. (2016)	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	Germann, V. (2019)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No excavation needed.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.03, b = 0.03, c = 999, d = 999)	"Common reactors for struvite crystallisation are upflow fluidised bed reactors and air-agitated reactors." (Struvite Precipitation | SLU Compendium) Surface area assumed to be equal to an UASB.	
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Requires expertise. "Common reactors for struvite crystallisation are upflow fluidised bed reactors and air-agitated reactors" (SLU).	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Requires expertise. "Common reactors for struvite crystallisation are upflow fluidised bed reactors and air-agitated reactors" (SLU).	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0, professional = 1)	Requires expertise. "Struvite recovery is controlled by the solution's supersaturation point, pH, molar ratio of nutrients (Mg:NH4:PO4), temperature, reaction time and mixing conditions. To ensure a high recovery rate, these factors have to be monitored closely" (SLU).	yes
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA

lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Life time of the reactor, its equipment and of the pumps is assumed to be 10 y." (Struvite production |Griesauer, C. (2014)). In a study by Griesauer on the CLARA planning tool the expected lifetimes of parts were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.5, moderate=0.5, slow=0)	If the materials can be made available locally fast, then implementation does not require much time at all. From the VUNA Handbook, it looks like the entire setup is made from prefab units. Lower probability is allotted to the category "rapid" (50%) because materials required for operation are quite specialised and therefore may be difficult to procure in a short time, i.e., less than a week. (Akanksha Jain, based on text in SLU Compendium and VUNA Handbook)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Struvite precipitation is a process used to recover phosphorus (P) from either urine or concentrated wastewater. Struvite precipitation occurs under specific pH conditions when concentrations of magnesium (Mg), phosphate (PO43-) and ammonium (NH4+) are close to an equimolar ratio of 1:1:1." (Struvite Precipitation | SLU Compendium) If the struvite reactor is large enough, one needs to change the pH and increase the amount of added Mg salts to scale up the technology.(Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Reactors for struvite precipitation can be constructed with local materials and be operated in batches." (Struvite Precipitation | SLU Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Struvite	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.93	-	0.07	0	0	0	* P recovery >90%	Etter et al. (2014)
	0.9	-	0.1	0	0	0	* as P, see calculation in 21.2.1	Etter et al. (2011)
	0.98	-	0.02	0	0	0	* as P	Maurer et al. (2006)
med (R)	0.93	0,9 - 0,98	0.07	0	0	0		-
k	100	[0,08]	-	-	-	-		PA
TN	0.04	-	0.96	0	0	0	* N recovery <5%	Etter et al. (2014)
	0.02	-	0.98	0	0	0	* as N, see calculation in 21.2.1	Etter et al. (2011)
	0.03	-	0.97	0	0	0	* as N	Maurer et al. (2006)
	0.01	-	0.99	0	0	0	* as Ammonia	Udert et al. (2006)
med (R)	0.03	0,01-0,04	0.97	0	0	0		-
k	100	[0,02]	-	-	-	-		PA
H2O	0.02	-	0.98	0	0	0	* PA based on 2% volume reduction stated by:	Maurer et al. (2006)
med (R)	0.02	-	0.98	0	0	0		-
k	100	-	-	-	-	-		PA
TS	0.05	-	0.95	0	0	0	Spuhler et al. (2021)	Etter et al. (2011)
med (R)	0.05	-	0.95	0	0	0		-
k	25	-	-	-	-	-		PA

Additional Information

21.2.1 Data from: Etter et al. (2011)

	Inflow	After storage	Effluent	Struvite	TC precipitation_Storage	TC Struvite
P [g/m³]	388	278	28	250	0.72	0.9
N [g/m³]	5436	5421	5308	128	1	0.02
Calculation					TC_Storage= Substance Mass after storage / Substance Mass influent	TC_Struvite= Substance Mass in Struvite / Substance Mass after storage

21.2.2 Data from: Etter et al. (2011)

	TS [mg/L]	TC effluent
Start	10.78	
After 1 day	10.28	0.95

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Nitrification and Distillation of Urine		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	nitrification_distillation_urine	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedurine, transportedstored_urine	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	transportedconcentrated_urine, transportedsecondary_effluent	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0.5, neighbourhood = 1, city = 0.5)	McConville, J. et al. (2020)
management_level	(household = 0.5, shared = 1, public = 0.5)	McConville, J. et al. (2020)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	8	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	"Complexity of construction is High" (McConville, J. et al. (2020). According to the Emersan Compendium the appropriateness of a technology to a given phase is determined based on the following three factors: applicability, speed of implementation, and material requirements. (Gensch, R. et al. (2018)) Implementation of this technology can be thought of in the recovery phases but given the lack of locally available special equipment and therefore, possibly slow speed of implementation, this technology can be considered unsuitable for acute and stabilisation phases of emergencies. In addition to this, the primary purpose of this technology is to produce a liquid fertiliser, which is perhaps not a priority in emergency situations. (Akanksha Jain) "

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"Requires electricity, especially for efficient distillation and for the required automatic control nitrification" (Mcconville, J., et al. (2020)).	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.3, continuous = 0.7)	The operation and maintenance of the technology can be quite time consuming.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	Pipes are required.	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly = 0.5, pumps = 1)	Air pumps are required.	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Concrete is usually not required.	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.6, special = 0.1)	from old library	
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, hot = 1)	The process is independent from the ambient temperature and should be adaptable in various climates.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	For this technology the criterion "flooding" is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No excavation necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.03, b = 0.03, c = 999, d = 999)	"Current nitrification and distillation systems can treat up to 200 L of urine per day" (Mcconville, J., et al. (2020)). "One person generates 1.2 L of urine per day" (Compendium). "The complete installation of the system has a footprint of approximately 5 m2, whereas the room accommodating it should not be smaller than 10 m2 to ensure proper access and ventilation" (Mcconville, J., et al. (2020)). Based on these assumptions, we derive a minimum space requirement of 0.03 m2/cap (Eawag, 2021): 5m2 / (200 L/d / 1.2 L/P/d) = 0.03 m2/P	
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA

construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	High technical complexity requires expertise in construction. "The system consists of the following parts: a urine storage tank, nitrification column with automatic control, activated carbon filter, intermediate storage tank, vacuum distiller and final product storage tanks. The critical components are the nitrification column acting as a bioreactor, the activated carbon column and the distillation unit" (Mcconville, J., et al. (2020)).	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	High technical complexity requires expertise in design. "The system consists of the following parts: a urine storage tank, nitrification column with automatic control, activated carbon filter, intermediate storage tank, vacuum distiller and final product storage tanks. The critical components are the nitrification column acting as a bioreactor, the activated carbon column and the distillation unit" (Mcconville, J., et al. (2020)).	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Maintenance involves calibration of the pH probe and rinsing of pipes twice a year. General maintenance of piping system and pumps, as well as inspections twice a year, should be done throughout the system's service life. Formation of ammonia gas in the headspace ofn urine tanks can be toxic when inhaled. High nitrite concentrations in the reactor can lead to the formation of volatile noxious compounds, which are harmful to humans and the environment. Operators should use masks and appropriate protective equipment if the urine storage tank has to be opened" (Mcconville, J., et al. (2020)).	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	In a study on the sustainability assessment of urine concentration technologies the lifetime of different parts that make up the nitrification distillation process were collected and used for an economic analysis. Lifetime of different parts are assumed to be 25 years for toilets, 50 years for pipes, 20 years for process control & electricity, 15 years for pump and machines, 10 years for the ion-exchange vessel, the plastic vessels and boxes. (Gunnarsson, M. (2021)) In this study the assumed lifetimes of the different parts exceed 5 years of lifetime.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.5, moderate=0.5, slow=0)	If the materials can be made available locally fast, then implementation does not require much time at all. From the VUNA Handbook, it looks like the entire setup is made from prefab units. Lower probability is allotted to the category "rapid" (50%) because materials required for operation are quite specialised and therefore may be difficult to procure in a short time, i.e., less than a week. (Akanksha Jain, based on text in Mcconville, J., et al. (2020) Compendium (Tech Name: Nitrification and distillation of urine) and VUNA Handbook)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"It is theoretically possible to scale the technology down for household use or scale it up by having multiple installations citywide." (Nitrification and Distillation of Urine | Mcconville, J., et al. (2020) Compendium) A single unit has a complex design and cannot be extended easily, however if the material is available it is possible to extend the treatment capacity by adding further installations.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.6, special = 0.1)	"The system consists of the following parts: a urine storage tank, nitrification column with automatic control, activated carbon filter, intermediate storage tank, vacuum distiller and final product storage tanks. The critical components are the nitrification column acting as a bioreactor, the activated carbon column and the distillation unit.", "The treatment unit necessitates sufficient air space and ventilation, like any technical equipment placed in a building." (Nitrification and Distillation of Urine | Mcconville, J., et al. (2020) Compendium) Technical and special parts are required to construct the system. The values are copied from the spare parts supply in the old library and might need to be adapted.	yes

Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")							
	Concentrated Urine	**Range**	**Secondary Effluent**	**Airloss**	**Soilloss**	**Waterloss**	**Comments**	**Reference**
TP	1	-	0	0	0	0		Udert et al. (2015)

	0.99	-	0	0.01	0	0		PC with Bastian Etter
med (R)	0.99	0.99 - 1	0	0.01	0	0		-
k	100	[0.01]	-	-	-	-		PA
TN	0.97	-	0	0.03	0	0		Udert et al. (2015)
	0.99	-	0	0.01	0	0		PC with Bastian Etter
med (R)	0.99	0.97 - 0.99	0	0.02	0	0		-
k	100	[0.02]	-	-	-	-		PA
H2O	0.04	-	0.96	0	0	0	95 - 97% of water are removed	Udert et al. (2015)
	0.075	-	0.925	0	0	0		PC with Bastian Etter
med (R)	0.06	0.04 - 0.075	0.94	0	0	0		-
k	100	[0.035]	-	-	-	-		PA
TS	0.35	-	0	0.65	0	0	* up to 90% of organic matter content is degraded; Organic matter makes up between 65% and 85% of urine dry solids (Rose et al) -> TC airloss range 0.58 - 0.76	Udert et al. (2015)
	0.4	-	0	0.6	0	0		PC with Bastian Etter
med (R)	0.375	0.35 - 0.4	0	0.625	0	0	Spuhler et al. (2021)	-
k	5	[0.05]	-	-	-	-		PA

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Alkaline Dehydration of Urine

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	alkaline_dehydration_of_urine	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedurine, transportedstored_urine	McConville, J. et al. (2020)
OUTPUT PRODUCT	transporteddried_urine	McConville, J. et al. (2020)
RELATIONS	Input: NA Output: AND	McConville, J. et al. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 1, neighbourhood = 1, city = 0.5)	McConville, J. et al. (2020)
management_level	(household = 1, shared = 1, public = 1)	McConville, J. et al. (2020)
capex_req_level	4	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	2	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	Urine treatment alone is perhaps not a priority in emergencies. Additionally, it usually requires an electricity supply for operation. However, it can be assembled using off-the-shelf materials and could be a potentially good option for recovery phases since complexity of operation is low (Spuhler, D. et al. (2021)).

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"Usually requires an electricity supply" (Mcconville, J., et al. (2020)).	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.2, regular = 0.8, continous = 0)	Expert judgement (Senecal-Smith, J. (2021))	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	Expert judgement (Senecal-Smith, J. (2021))	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Expert judgement (Senecal-Smith, J. (2021))	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Expert judgement (Senecal-Smith, J. (2021))	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	Expert judgement (Senecal-Smith, J. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, h	Expert judgement (Senecal-Smith, J. (2021))	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	Expert judgement (Senecal-Smith, J. (2021))	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Expert judgement (Senecal-Smith, J. (2021))	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.2, b = 0.3, c = 999, d = 999)	Expert judgement (Senecal-Smith, J. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Urine dehydration rates can be increased by: (1) increasing the surface area of drying substrate; (2) increasing air-flow; (3) increasing air temperature; and (4) reducing air humidity. Warming the inlet air, by either solar or other means, would increase dehydration rate by increasing the water-holding capacity of air" (Mcconville, J., et al. (2020)). Relatively simple system which can be constructed by skilled workers.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The operating conditions dictate how often the alkaline substrate needs to be replaced" (Mcconville, J., et al. (2020)). "Urine dehydration rates can be increased by: (1) increasing the surface area of drying substrate; (2) increasing air-flow; (3) increasing air temperature; and (4) reducing air humidity. Warming the inlet air, by either solar or other means, would increase dehydration rate by increasing the water-holding capacity of air" (Mcconville, J., et al. (2020)). Simple systems can be designed with a certain understanding of the underlying chemical processes. Specialized knowledge is necessary to design efficient systems.	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Maintenance should include: (1) cleaning the pipes with an alkaline solution (to prevent biofilm building up); (2) regularly changing the dehydration substrate; and (3) checking the system components (fans)" (Mcconville, J., et al. (2020)). Relatively simple tasks that can be done by unskilled workers. Adapting the system to the ambient air conditions in the initial phase might require more skills.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	It is assumed that the concept can be applied over a short- or long-term, since the technology is easy to construct and use. It mainly depends on sufficient electricity for ventilation and access to alkaline substances. Both are no impediment for a long lifetime. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.5, moderate=0.5, slow=0)	If the materials can be made available locally fast, then implementation does not require much time at all. The entire setup is made from prefab units (Simha et al.). Lower probability is allotted to the category "rapid" because materials required for operation are quite specialised and therefore may be difficult to procure in a short time, i.e., less than a week.(Akanksha Jain, based on text in Mcconville, J., et al. (2020) Compendium)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"It is a two-step, on-site treatment technology. First, fresh human urine collected from a urine-diverting toilet or urinal is added to an alkaline substrate (e.g., lime or wood ash). [...] Subsequently, the alkaline urine and substrate mixture is dehydrated by forced ventilation to yield a dry end product.", "For helminth eggs, a thermal treatment (≥42°C for 5 days) or a storage treatment in a sealed container (111 days at 20°C or 79 days at 35°C) is recommended in order to meet the WHO and U.S. EPA guidelines for unrestricted reuse of excreta in agriculture.", "Compact and fits into existing bathrooms with minimal retrofitting." (Alkaline Dehydration of Urine | Mcconville, J., et al. (2020) Compendium) The dehydration units appear to be small so to scale up the technology one could build more units with ventilators and access more alkaline substances. For large scale treatment plants, heating elements or additional ventilators could be implemented to reduce the treatment time and therefore increase the capacity. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"The treatment unit can be assembled by the user using off-the-shelf materials, since it does not require sophisticated components." It further requires alkaline substances: "Locally sourced substrate could be ash, biochar and/or lime." (Alkaline Dehydration of Urine | Mcconville, J., et al. (2020) Compendium) It is assumed that the parts for the treatment unit as well as the alkaline substances are locally available.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Dried Urine	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0		Expert judgement (Senecal-Smith, J. (2021))
med (R)	1	-	0	0	0		-
k	2	-	-	-	-		PA
TN	0.9	-	0.1	0	0		Expert judgement (Senecal-Smith, J. (2021))
med (R)	0.9	-	0.1	0	0		-
k	2	-		-	-		PA
H2O	0.05	-	0.95	0	0		Expert judgement (Senecal-Smith, J. (2021))
med (R)	0.05	-	0.95	0	0		-
k	1	-		-	-		PA
TS	0.98	-	0.02	0	0		Expert judgement (Senecal-Smith, J. (2021))
med (R)	0.98	-	0.02	0	0		-
k	5	-		-	-		PA

References

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Unplanted Drying Bed Sludge						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	unplanted_drying_bed_sludge	-				
DATA COMPILER	SaniChoice Project Team	-				
INPUT PRODUCT	sludge, transportedsludge, transportedtransferred_sludge	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	stabilized_sludge, transportedstabilized_sludge, effluent, transportedeffluent	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0.5, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"No electrical energy required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Simple operation, only infrequent attention required" (Compendium) "Dried sludge can be removed after 10 to 15 days, but this depends on the climate conditions." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	"The bottom of the drying bed is lined with perforated pipes to drain the leachate away that percolates through the bed."(Compendium) Therefore pipes are needed for the technology.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"The bed frame is usually made from concrete or a plastic liner with the bottom surfaces slightly sloped in order to facilitate percolation and drainage." (Spuhler, n.d.) "The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." (Emersan) It is assumed that concrete has a longer lifetime and locals have more experience with it than with plastic liners. Therefore, the performance is slightly better with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Drying beds require the availability of gravel and sand of the correct grain size. Furthermore, piping for the drainage is needed. To remove dried sludge, shovels and rakes are required as well as personal protective equipment for the workers. The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." (Emersan) "Can be built and repaired with locally available materials" (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.3, cold = 0.5, temperate = 1, warm = 1, hot = 1)	"This is a low-cost option that can be installed in most hot and temperate climates." (Compendium) Sludge application rates of 100 to 250 kg/m2/year have been reported in warm tropical climates. In colder climates, such as northern Europe, rates up to 80 kg/m2/year are typical. (Compendium -> T.15 Planted Drying Beds) Yearly average temperatures in Europe are assumed to be cold.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"Excessive rain or high humidity may prevent the sludge from properly drying.","If installed in wet climates, the facility should be covered by a roof and special caution should be given to prevent the inflow of surface runoff." (Emersan) It's assumed that a special caution must be given to prevent the inflow of surface runoff at places where there is regular flooding as well. old library: a=0,b=0,c=6,d=12 days per year -> strongly affected This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Especially for bigger application the construction of the technology relies on excavation. On rocky resp. gravelly ground there could be difficulties with excavation that is needed for the construction. Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.05, b = 0.05, c = 999, d = 999)	"There must be sufficient space available for creation of the treatment plant (50m²/1000 inhabitants)" (Monvois et al. 2012).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium) The construction can be done with moderate construction skills. But if there are high skills available the performance could be better due to better construction.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) "Both the incoming and dried sludge are pathogenic; [...]." (Compendium) Because there is a high risk of contamination with pathogens a proper desingn is very important.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Simple operation, only infrequent attention required" (Compendium) Once the process is designed with high skills the operation and maintenance is pretty easy and does not require special skills. But therefore it is important the labourer follow the rules of the process design.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	Simple and durable installation." (Solar drying | SLU Compendium) Durable solution that can be used in the short- or long-term (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	"The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." "Can be built and repaired with locally available materials" (Emersan Compendium) Construction is quite simple however, since bricks and/or concrete is used for construction, minimum 7 days curing is required- and since no prefab units are available, probability is allotted only to moderate category and not rapid. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"To improve drying and percolation, sludge application can alternate between two or more beds. The number of beds needed is a function of the frequency of sludge arrivals and the number of days necessary for drying in the local climate, to which a few days must be added for sludge removal." (Emersan) Additional drying beds can be easily added, if sufficient land area is available. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stabilized Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.7		0.3	0	0	0	* TP recovery in paved drying beds	Nikiema et al. (2014)
	0.53	0.48-0.58	0.46	0	0	0	* TP removal given	Kuffour (2010)
med (R)	0.62	(0.48 - 0.7)	0.38	0	0	0		-
k	5	[0.22]	-	-	-	-		PA
TN	0.6	-	0.3	0.1	0	0	* TN recovery in sludge, paved drying beds	Nikiema et al. (2014)
	0.61	-	0.39	0	0	0	* see calculations in 22.2.1	Cofie et al. (2006)
	0.5	-	0.2	0.3	0	0	* NH4 removal rates given (0.4 - 0.6)	Montangero and Strauss (2002)
	0.70	-	0.1	0	0	0	* Removals of different N compounds given (0.2-0.4)	Kuffour (2010)
	0	-	0	0.1	0	0		PA
	0.52	-	0	0.48	0	0	* Net TN loss due to volatilization, solar drying, no effluent, differences due to tillage and temp	O'Shaughnessy et al. (2008)
	0.55	0.41-0.7	0.15	0.3	0	0	* TN of sludges decreased by 30-59% through air drying	Ryan und Keeney (1975)
med (R)	0.58	0.41-0.7	0.18	0.30	0	0		-
bal.	0.53	-	0.18	0.29	0	0		-
k	5	[0.4]	-	-	-	-		PA
H2O	0.2	-	0.55	0.25	0	0	Spuhler et al. (2021)	Strande et al. (2014)
	0.58	0.32-0.79	0.22	0.2	0	0	* see calculations in 22.2.2	Montangero and Strauss (2002)
	0.14	-	0	0.86	0	0	* solar drying, no effluent	O'Shaughnessy et al. (2008)
med (R)	0.20	(0.14 - 0.79)	0.39	0.25	0	0		-
bal.	0.31	-	0.39	0.30	0	0		-
k	2	[0.65]	-	-	-	-		PA
TS	0.8	-	0.2	0	0	0	* see calculations in 22.2.1	Cofie et al. (2006)
	0.78	-	0.22	0	0	0	* 95% removal SS (TS=0.78, estimated from ratio in 22.2.3)	Montangero and Strauss (2002)
	0	-	0	0.04	0	0		PA
med (R)	0.79	(0.75 -0.78)	0.21	0.04	0	0		-
bal.	0.75	-	0.21	0.04	0	0		-
k	100	[0.03]	-	-	-	-		PA

Additional Information

k	2	[0.65]	-	-	-	-	

TS	0.8	-	0.2	0	0	0	* see calculations in 22.2.1
	0.78	-	0.22	0	0	0	* 95% removal SS (TS=0.78, estimated from ratio in 22.2.3)
	0	-	0	0.04	0	0	
med (R)	0.79	(0.75 -0.78)	0.21	0.04	0	0	
bal.	0.75	-	0.21	0.04	0	0	
k	100	[0.03)	-	-	-	-	

Additional Information

	Moisture content		H2O Sludge	
Incoming	0.95			
Dried sludge high moisture	0.75		0.79	
Dried sludge medium moisture	0.6		0.63	
Dried sludge low moisture	0.3		0.32	
			0.58	
Calculation			H2O Sludge = Moisture content in dried sludge/ moisture content in incoming sludge	
22.2.3	Data from Cofie et al. (2006)			
	Removal		**Ratio TS:SS removal**	
TS		0.8		
TSS		0.97		0.82
Calculation			Ratio= TS removal/ TSS removal	

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Planted Drying Bed

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	planted_drying_bed	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	sludge, transportedsludge, transportedtransferred_sludge	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	stabilized_sludge, transportedstabilized_sludge, effluent, transportedeffluent	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"No electrical energy required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Trained staff for operation and maintenance is required to ensure proper functioning. The drains must be maintained and the effluent properly collected and disposed of. The plants should have grown sufficiently before applying the sludge. The acclimation phase is crucial and requires much care. The plants should be periodically thinned and/or harvested. After 3 to 5 years the sludge can be removed." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	"A planted drying bed is similar to an Unplanted Drying Bed [...]." (Compendium) "The bottom of the unplanted drying bed is lined with perforated pipes to drain the leachate away that percolates through the bed."(Compendium -> T.14 Unplanted Drying Beds) Therefore pipes are needed for the technology.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"A planted drying bed is similar to an Unplanted Drying Bed [...]." (Compendium) "The bed frame (of an unplanted drying bed) is usually made from concrete or a plastic liner with the bottom surfaces slightly sloped in order to facilitate percolation and drainage." (Spuhler, n.d.) "The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." (Emersan) It is assumed that concrete has a longer lifetime and locals have more experience with it than with plastic liners. Therefore, the performance is slightly better with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Planted drying beds require availability of gravel and sand with the right grain size. Local plants can be used. Furthermore, piping is needed for drainage and ventilation. To remove dried sludge, shovels and rakes are required as well as personal protective equipment (PPE). The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom", "Can be built and repaired with locally available materials" (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.3, cold = 0.5, temperate = 1, warm = 1, hot = 1)	"A planted drying bed is similar to an Unplanted Drying Bed [...]." (Compendium) "This is a low-cost option that can be installed in most hot and temperate climates." (Compendium) Sludge application rates of 100 to 250 kg/m2/year have been reported in warm tropical climates. In colder climates, such as northern Europe, rates up to 80 kg/m2/year are typical. (Compendium -> T.15 Planted Drying Beds) Yearly average temperatures in Europe are assumed to be cold.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"A planted drying bed is similar to an Unplanted Drying Bed [...]." (Compendium) "If installed in wet climates, the facility should be covered by a roof and special caution should be given to prevent the inflow of surface runoff." (Compendium -> T.14 Unplanted Drying Beds) old library: a=0,b=0,c=6,d=12 days per year -> strongly affected This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Especially for bigger application the construction of the technology relies on excavation. On rocky resp. gravelly ground there could be difficulties with excavation that is needed for the construction. Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.05, b = 0.05, c = 999, d = 999)	"There must be sufficient space available for creation of the treatment plant (50m²/1000 inhabitants)" (Monvois et al. 2012).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium)	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium)	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Trained staff for operation and maintenance is required to ensure proper functioning. The drains must be maintained and the effluent properly collected and disposed of." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Sludge drying reed beds can be continuously used for a couple of years before sludge removal is required. [...] Literature reports accumulation periods of 5–12 years with annual sludge accumulation rates of 0.08–0.2 m/y" (Sludge drying reed bed | Griesauer, C. (2014)) Accumulation periods of more than 5 years suggests that this technology can be used for a longer period of time. "The whole sludge drying reed bed is expected to last for 30 years" (Sludge drying reed bed | Griesauer, C. (2014) In a study by Griesauer on the CLARA planning tool the expected lifetimes were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	"The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." "Can be built and repaired with locally available materials" (Emersan Compendium) Construction is quite simple however, since bricks and/or concrete is used for construction, minimum 7 days curing is required- and since no prefab units are available, probability is allotted only to moderate category and not rapid. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"On average, a 6 month start-up is recommended" (Planted Drying Beds - Strande et al. 2014) The planted drying bed capacity can be increased by increasing the number of drying beds. Due to a long start-up time to get the macrophytes acclimatised it will take time to add further planted drying beds. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stabilized Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.97	-	0.03	0	0	0	* as PO4-P	{Kengne, 2014 #1433}
med (R)	0.97	-	0.03	0	0	0		-
k	5	PA	-	-	-	-		PA
TN	0.385	0.35-0.42	0.615	0	0	0	* as TKN	{Kengne, 2014 #1433}
	0.905	0.82-0.99	0.095	0	0	0	* as TKN	{Kengne, 2014 #1433}
	0.9	-	0.1	0	0	0	* as TKN	{Kengne, 2014 #1433}
	0.79	-	0.21	0	0	0	* as TKN	{Kengne, 2014 #1433}
	0.85	0.7-0.99	0.15	0	0	0	* as TKN	{Kengne, 2014 #1433}
	0.84	0.692-0.993	0.16	0	0	0	* as TKN	{Kengne, 2014 #1433}
med (R)	0.85	0.35-0.99	0.15	0	0	0		-
k	1	[0.64]	-	-	-	-		PA
H2O	0.025	-	0.025	0.95	0	0	* 95% volume reduction within a year, assumed by evapotranspiration, TCs in sludge and effluent split of remaining H2O	{Kengne, 2014 #1433}
	0.175	-	0.65	0.175	0	0	* 65% of the liquid passed as leachate, 35% lost as ET or retained in sludge, allocate half of it for both	{Kengne, 2014 #1433}
med (R)	0.100	0.025-0.175	0.34	0.56	0	0		-
k	25	[0.15]	-	-	-	-	Spuhler et al. (2021)	PA
TS	0.77	0.66-0.88	0.23	0	0	0	* as TS	{Kengne, 2014 #1433}
	0.925	-	0.075	0	0	0	* as TS, from 37.2.1	{Kengne, 2014 #1433}
	0.85	-	0.15	0	0	0	* as TS	{Kengne, 2014 #1433}
	0.31	0.15-0.47	0.69	0	0	0	* as TS	{Kengne, 2014 #1433}
	0.8	0.74-0.86	0.2	0	0	0	* as TS	{Kengne, 2014 #1433}
	0.85	0.706-0.999	0.15	0	0	0	* as TS	{Kengne, 2014 #1433}
	0.39	-	0.61	0	0	0	* from 37.2.2	{Kengne, 2014 #1433}
	0.97	-	0.03	0	0	0	* as TS	{Kengne, 2014 #1433}
med (R)	0.825	0.31-0.999	0.175	0	0	0		-
bal.	0.82	-	0.18	0	0	0		-
k	1	[0.69]	-	-	-	-		PA

Additional Information

	0.8	0.74-0.86	0.2	0	0	0	* as TS
	0.85	0.706-0.999	0.15	0	0	0	* as TS
	0.39	-	0.61	0	0	0	* from 37.2.2
	0.97	-	0.03	0	0	0	* as TS
med (R)	0.825	0.31-0.999	0.175	0	0	0	
bal.	0.82	-	0.18	0	0	0	
k	1	[0.69]	-	-	-	-	

Additional Information

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Unplanted Drying Bed Dry						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	unplanted_drying_bed_dry	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	stored_faeces, transportedstored_faeces pithumus, transportedpithumus	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	dried_faeces, transporteddried_faeces	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0.5, stabilisation = 0.5, development/recovery = 1)	Same values given as Unplanted drying beds with sludge (Gensch, R. et al. (2018))				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"No electricity required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Simple operation, only infrequent attention required" (Compendium) "Dried sludge can be removed after 10 to 15 days, but this depends on the climate conditions." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	"The bottom of the drying bed is lined with perforated pipes to drain the leachate away that percolates through the bed."(Compendium) Therefore pipes are needed for the technology.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"The bed frame is usually made from concrete or a plastic liner with the bottom surfaces slightly sloped in order to facilitate percolation and drainage." (Spuhler, n.d.) "The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." (Emersan) It is assumed that concrete has a longer lifetime and locals have more experience with it than with plastic liners. Therefore, the performance is slightly better with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Drying beds require the availability of gravel and sand of the correct grain size. Furthermore, piping for the drainage is needed. To remove dried sludge, shovels and rakes are required as well as personal protective equipment for the workers. The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." (Emersan) "Can be built and repaired with locally available materials" (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.3, cold = 0.5, temperate = 1, warm =	"This is a low-cost option that can be installed in most hot and temperate climates." (Compendium) Sludge application rates of 100 to 250 kg/m2/year have been reported in warm tropical climates. In colder climates, such as northern Europe, rates up to 80 kg/m2/year are typical. (Compendium -> T.15 Planted Drying Beds) Yearly average temperatures in Europe are assumed to be cold.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"If installed in wet climates, the facility should be covered by a roof and special caution should be given to prevent the inflow of surface runoff." (Compendium) It's assumed that a special caution must be given to prevent the inflow of surface runoff at places where there is regular flooding as well. old library: a=0,b=0,c=6,d=12 days per year -> strongly affected This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Especially for bigger application the construction of the technology relies on excavation. On rocky resp. gravelly ground there could be difficulties with excavation that is needed for the construction. Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.05, b = 0.05, c = 999, d = 999)	"There must be sufficient space available for creation of the treatment plant (50m²/1000 inhabitants)" (Monvois et al. 2012). Assumption: The same space requirements are applied for "unplanted dry bed sludge" and "unplanted drying bed dry" (Eawag, 2021).	

0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium) The construction can be done with moderate construction skills. But if there are high skills available the performance could be better due to better construction.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) "Both the incoming and dried sludge are pathogenic; [...]." (Compendium) Because there is a high risk of contamination with pathogens a proper desing is very important.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Simple operation, only infrequent attention required" (Compendium) Once the process is designed with high skills the operation and maintenance is pretty easy and does not require special skills. But therefore it is important the labourer follow the rules of the process design.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	Simple and durable installation." (Solar drying | SLU Compendium) Durable solution that can be used in the short- or long-term (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	"The bed itself can be constructed with cement and bricks or concrete and needs to be sealed at the bottom." "Can be built and repaired with locally available materials" (Emersan Compendium) Construction is quite simple however, since bricks and/or concrete is used for construction, minimum 7 days curing is required- and since no prefab units are available, probability is allotted only to moderate category and not rapid. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"To improve drying and percolation, sludge application can alternate between two or more beds. The number of beds needed is a function of the frequency of sludge arrivals and the number of days necessary for drying in the local climate, to which a few days must be added for sludge removal." (Emersan) Additional drying beds can be easily added, if sufficient land area is available. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Dried Faeces	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0		PA
med (R)	1	-	0	0	0		-
k	25	-	-	-	-		PA
TN	0.8	-	0.2	0	0		PA
med (R)	0.8	-	0.2	0	0		-
k	5	-	-	-	-		PA
H2O	0.4	-	0.6	0	0		PA
med (R)	0.4	-	0.6	0	0		-
k	5	-	-	-	-		PA
TS	0.9	-	0.1	0	0		PA
med (R)	0.9	-	0.1	0	0		-
k	5	-	-	-	-		PA

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Sedimentation / Thickening Ponds

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	sedimentation_thickening_ponds	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	transportedsludge, transportedtransferred_sludge	Tilley, E. et al. (2014)
OUTPUT PRODUCT	transportedprocessed_sludge, transportedeffluent	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.5, no electricity = 0.5)	"No electrical energy is required if there is no pump" (Emersan) Depending on the design pumps might be necessary.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"The maintenance is not intensive. The discharging area must be maintained and kept clean to reduce the potential of disease transmission and nuisance (flies and odours). Solid waste that is discharged along with the sludge must be removed from the screen at the inlet of the ponds. The thickened sludge must be mechanically removed (with a frontend loader or other specialised equipment) after it has sufficiently thickened; alternatively, it can be pumped if it is still sufficiently liquid." (Emersan)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	Liquid outlet pipes might be necessary. (Emersan)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.75, difficultly available = 0.75, pumps = 1)	"The thickened sludge must be mechanically removed (with a frontend loader or other specialised equipment) after it has sufficiently thickened; alternatively, it can be pumped if it is still sufficiently liquid." (Emersan) Depending on the design, pumps might be necessary.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0, difficultly available = 0.5, concrete = 1)	"This is standard civil engineering work, requiring digging and concrete." (Emersan) Usually concrete is required.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"This is standard civil engineering work, requiring digging and concrete. Key items are the sludge removal equipment.", "The thickened sludge must be mechanically removed (with a frontend loader or other specialised equipment) after it has sufficiently thickened; alternatively, it can be pumped if it is still sufficiently liquid." , "Can be built and repaired with locally available materials"(Emersan) Technical spare parts might be necessary for the sludge removal equipment.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.1, cold = 0.5, temperate = 1, warm = 1, hot = 1)	"This is a low-cost option that can be installed in most hot and temperate climates." (SSWM) The functioning of the technology might not be guaranteed for temperatures under 0 °C. If the temperature is permanently below 0 °C, the sludge would probably freeze.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.6, no flooding = 1)	Assumed to be similar to a WSP regarding flood proneness. "Both the incoming and thickened sludge are pathogenic", "Excessive rain may prevent the sludge from properly settling and thickening." (Emersan) Should avoid floods spreading the pathogenic sludge This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. Process wise, flooding or entry of surface run-off can be considered to be more critical for drying beds than ponds and wetlands, therefore technologies of the latter two type are awarded a slightly higher performance of 60% (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.006, b = 0.006, c = 999, d = 999)	0.006 m2/cap are required. From Table 8 in Heinss et al. 1998. Based on the following assumptions: 8-week cycle (4 weeks loading + 4 weeks consolidating; 6 cycles annually); two parallel settling tanks.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium).	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium).	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"The thickened sludge is still infectious, although it is easier to handle and less prone to splashing and spraying. Trained staff for operation and maintenance is required to ensure proper functioning" (Compendium).	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Desludging every 2 to 4 or 8 to 12 months for settling tanks or sedimentation ponds respectively." (Thickening Ponds | SSWM Toolbox) The ponds can be used with lifetimes shorter than 1 year. It is assumed that a long lifetime is also possible, since the ponds can be emptied and reused. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	"This is standard civil engineering work, requiring digging and concrete. " (Emersan Compendium) Construction is quite simple however, since bricks and/or concrete is used for construction, minimum 7 days curing is required- and since no prefab units are available, probability is allotted only to moderate category and not rapid. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	The technology can be upscaled by increasing the pond size or the number of ponds. These ponds require large areas to be excavated, which might require machinery and can therefore limit the scalability of the technology. The technology can be upscaled as long as sufficient space is available and excavation is possible. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials"(Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Processed Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.34	0.1 - 0.65	0.66	0	0	0		PA
	0.36	-	0.64	0	0	0	* TP removal in	Ingallinella et al. (2002)
med (R)	0.35	0.1 - 0.65	0.65	0	0	0		-
k	2	[0.55]	-	-	-	-		PA
TN	0.3	-	0.7	0	0	0	* See calculations	Strauss et al. (2000)
	0.31	-	0.69	0	0	0	* See calculations in 24.2.1	Koné and Strauss (2004)
	0.39	-	0.61	0	0	0	* TN removal in septage pond	Ingallinella et al. (2002)
	-	-	-	0.1	-	-		PA
med (R)	0.31	(0.3-0.39)	0.69	0.1	0	0		-
bal.	0.24	-	0.66	0.1	0	0		-
k	25	[0.09]	-	-	-	-		PA
H2O	0.05	-	0.95	0	0	0	* supernatant flows of settling/thic	Montangero and Strauss (2002)
	-	-	-	0.03	-	-		PA
med (R)	0.05	-	0.95	0.03	0	0		-
bal.	0.03	-	0.94	0.03	0	0	Spuhler et	-
k	25	-	-	-	-	-		PA
TS	0.324	-	0.676	0	0	0	* TSS: 60% removal	Conradin et al. (2010)
	0.513	-	0.487	0	0	0	* TSS: 95% removal (Estimarion TS to sludge:	Montangero and Strauss (2002)
med (R)	0.42	(0.324 - 0.523)	0.58	0	0	0		-
k	25	[0.19]	-	-	-	-		PA

Additional Information

24.2.1 Data from: Koné and Strauss (2004)

	Influent	Effluent	TC Effluent	TC Sludge
NH4-N [mg/L]	150	104	0.69	0.31
Calculation			TC_Effluent = Ammonia content in Effluent/ Ammonia content in Influent	

24.2.2 Data from: Strauss et al. (2000)

	Influent	Effluent	TC Effluent	TC Sludge
k	25	[0.19]	-	-

Additional Information

24.2.1 Data from: Koné and Strauss (2004)

	Influent	Effluent	TC Effluent	TC Sludge
NH4-N [mg/L]	150	104	0.69	0.31
Calculation			TC_Effluent = Ammonia content in Effluent/ Ammonia content in Influent	

24.2.2 Data from: Strauss et al. (2000)

	Influent	Effluent	TC Effluent	TC Sludge

References

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Co-Composting						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	co-composting	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	stored_faeces, transportedstored_faeces, pithumus, transportedpithumus, sludge, transportedsludge, , transportedtransferred_sludge, processed_sludge, transportedprocessed_sludge, organics, transportedorganics	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	compost, transportedcompost	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output:	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	5	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0.5, stabilisation = 0.5, development/recovery = 1)	"Because of the high level of organisation and labour needed to sort organic waste, manage the facility and monitor treatment efficiency, this technology is unlikely to be practical in the acute response phase. However, it can be considered a viable option in the stabilisation and recovery phases of an emergency." (Gensch, R. et al. (2018))				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"No electrical energy required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.5, continuous = 0.5)	"The mixture must be carefully designed so that it has the proper C:N ratio, moisture and oxygen content. If facilities exist, it would be useful to monitor helminth egg inactivation as a proxy measure of sterilization. A well-trained staff is necessary for the operation and maintenance of the facility. Maintenance staff must carefully monitor the quality of the input material, and keep track of the inflows, outflows, turning schedules, and maturing times to ensure a high quality product. Forced aeration systems must be carefully controlled and monitored. Turning must be periodically done with either a front-end loader or by hand. Robust grinders for shredding large pieces of solid waste (i.e., small branches and coconut shells) and pile turners help to optimize the process, reduce manual labour, and ensure a more homogenous end product." (Compendium) Depending on the design, full-time labour might be required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.75, difficultly available = 0.75, concrete = 1)	"A sealed or impervious composting pad (the surface where the heaps are located) must be constructed to collect the leachate which can then be reintegrated into the piles or treated.", "The compost pad can be made out of concrete, or well-compressed clay." (Emersan) The composting facility does not necessarily have to be built with concrete, but it can be useful to avoid leaching into the ground and concrete might perform a bit better than well-compressed clay when it comes to impermeability.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and maintained with locally available materials", "If required, a cover/roof can be made from local materials such as bamboo, grass matting, or wood, plastic or metal sheeting." (Emersan) Simple spare parts suffice.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 0.9, warm	Assumed to be similar to a composting chamber. "Windrow piles should be at least 1 m high and insulated with a 30 cm layer of compost, soil, or grass soil to promote an even distribution of heat. In colder climates heaps work best at 2.5 m high and 5 m wide." (Emersan). In colder climates windrows need to be larger to generate more heat.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.9, no flooding=1)	"Depending on the climate and available space, the facility may need to be covered." (Emersan) "Since moisture plays an important role in the composting process, covered facilities are especially recommended where there is heavy rainfall." (Compendium) old library: a=0,b=0,c=6,d=12 days per year -> strongly affected Two configurations of this technology are possible, in-vessel (could be classified as "tank") and open windrows. The latter is generally housed, i.e., it has a roof and superstructure surrounding it. Although flooding would be harmful, appropriate configuration can be chosen from flood prone areas and therefore, only a 10% reduction in performance is made. Same values allotted to the other composting technology "Vermicomposting"	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA

soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Usually does not need excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.04, b = 0.04, c = 999, d = 999)	3000kg of compost can be treated in a centralized facility of 770m2 (Jain & Ilmanen, 2006). From this, we derive minimum space requirements of 0.04 m2/cap (Eawag, 2021).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	"Relatively straightforward to set up and maintain with appropriate training" (Compendium) The construction is quite simple.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and operation by skilled personnel" (Compendium) Moderate to high skills required for design and maintenance.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Requires expert design and operation by skilled personnel" (Compendium) Moderate to high skills required for design and maintenance.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Life time of the processing machinery and vehicles is assumed to be 12 y. The top layer of the asphalt pad [used as lining material for the base] is expected to be replaced every 15 y. All other infrastructure (pond, the base of the asphalt pad and the building) is expected to have a life time of 30 years." [Assessments in Ethiopia expect 10 years lifetime for the mechanical equipment.] (Composting | Griesauer, C. (2014) In a study by Griesauer on the CLARA planning tool the expected lifetimes of all parts for a windrow composting system were larger than 5 years. "May require a year or more of maturation before being safe to use." (Compost | SLU Compendium) Since the product needs to be stored for minimum a year, lifetimes of less than 1 year are in theory not suitable, but limitations of technologies for short lifetimes are not considered here. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.7, slow=0.3)	" Co-Composting facilities can be constructed using locally available material. The compost pad can be made out of concrete, or well-compressed clay. If required, a cover/roof can be made from local materials such as bamboo, grass matting, or wood, plastic or metal sheeting. Prefabricated composting vessels of different sizes are available on the market." "Because of the high level of organisation and labour needed to sort organic waste, manage the facility and monitor treatment efficiency, this technology is unlikely to be practical in the acute response phase. However, it can be considered a viable option in the stabilisation and recovery phases of an emergency." (Emersan Compendium) Since high level of organisation and labour is required to sort organic waste, it would be difficult to realise this technology in a short time frame. Prefab units aid in the cause of improving speed of implementation, therefore, probabilities are allotted at 70% to "moderate" and 30% to "slow" category. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"In open windrow Co-Composting, the mixed material (sludge and organic waste) is piled into long heaps called windrows and left to decompose." (Emersan) "The whole composting area should be lined by a concrete or asphalt base, and a pond should be constructed to collect runoff, which is high in nutrients und should therefore not be directly discharged." (Griesauer, C. (2014)) To scale up the composting the number of windrows or piles can be increased as long as sufficient area lined with concrete or asphalt is available and has a gradient towards the constructed pond. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and maintained with locally available materials", "If required, a cover/roof can be made from local materials such as bamboo, grass matting, or wood, plastic or metal sheeting." (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Compost	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.99	-	0	0.01	0	* full P pathways	Belevi (2002)
	0.99	-	0	0.01	0	* full P pathways	Meinzinger (2010)
	0.99	-	0	0.01	0	* see calculation in 27.2.1	Leitzinger (2001)
med (R)	0.99	-	0	0.01	0		-
k	100	-	-	-	-		PA
TN	0.69	-	0.3	0.01	0	* full N pathways	Belevi (2002)
	0.65	-	0.35	0	0	* full N pathways	Meinzinger (2010)
	0.65	-	0.28	0.06	0.01	* see calculation in 27.2.1	Leitzinger (2001)

	0.3	-	0.6	0.1	0	* N loss as high as 70%	Heinonen-Tanski and van Wijk-Sijbesma (2005)
med (R)	0.65	0.3-0.69	0.33	0.04	0.01		-
bal.	0.63	-	0.32	0.04	0.01		-
k	5	[0.39]	-	-	-		PA
H2O	0.9	-	0.05	0.05	0	PA: moisture content is to be maintained throughout	
med (R)	0.9	-	0.05	0.05	0		-
k	5	-	-	-	-		Spuhler et al. (2021)
TS	0.61	-	0.36	0.03	0	* Derived from pathways for masses	Belevi (2002)
med (R)	0.61	-	0.36	0.03	0		-
k	5	-	-	-	-		PA

Additional Information

27.2.1 Data from: Leitzinger (2001)

	Incoming N [t/year]	Outgoing N [t/year]	Incoming P [t/year]	Outgoing P [t/year]	TC_TN	TC_TP
From Markets	534		267			
From Households	1005		182			
From Poultry Farms	7		6			
From Breweries	177		44			
From Sawmills	172		3			
To Atmosphere- Airloss		534		0	0.28	0

Additional Information

27.2.1 Data from: Leitzinger (2001)

	Incoming N [t/year]	Outgoing N [t/year]	Incoming P [t/year]	Outgoing P [t/year]	TC_TN	TC_TP
From Markets	534		267			
From Households	1005		182			
From Poultry Farms	7		6			
From Breweries	177		44			
From Sawmills	172					
To Atmosphere- Airloss		534		0	0.28	0

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Offsite Vermi-Composting

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	offsite_vermi_composting	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	stored_faeces, transportedstored_faeces, pithumus, transportedpithumus, sludge, transportedsludge, transportedtransferred_sludge, blackwater, transportedblackwater, organics, transportedorganics	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	compost, transportedcompost, effluent, transportedeffluent	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 1, city = 1)	Gensch, R. et al. (2018)
management_level	(household = 0, shared = 0.5, public = 1)	Gensch, R. et al. (2018)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	"Vermifiltration can be applied in all emergency phases provided there is access to worms. Vermicomposting requires a high level of organisation and labour to sort organic waste, manage the facility and monitor treatment efficiency and is therefore unlikely to be practical in the acute response phase of emergency situations. However, it can be considered a viable option in the stabilisation and recovery phases where there is an available source of well-sorted organic solid waste and space." (Gensch, R. et al. (2018))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.9, no electricity = 0.7)	"Turning must be periodically done with either a front-end loader or by hand using a pitch fork or shovel. [...] Recirculation, if required for improved effluent quality, would require a pump." (Emersan) Installation of a pump would require electrical energy. A pump managed with intermittent electricity could be used for periodic instead of continous recirculation, when electricity is available. Intermittent electricity would therefore peform better than no electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.9, regular = 0.1, continous = 0)	"A Vermifilter has low mechanical and manual maintenance requirements, and where gravity-operated requires no energy inputs." (Emersan)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No need for pipes.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.75, difficultly available = 0.75, pumps = 1)	"A Vermifilter has low mechanical and manual maintenance requirements, and where gravity-operated requires no energy inputs. Recirculation, if required for improved effluent quality, would require a pump." (Emersan) Another technology configuration with pumps is possible and performs slightly better	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Vermi composting tanks can be made from local materials (bricks or concrete). Vermifilters require enclosed reactors made from durable materials that eliminate vermin entry, usually plastic or concrete." (Emersan) Tanks and reactors can be made from concrete, but also from alternative material. Concrete is assumed to perform better.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and maintained with locally available materials", "Vermicomposting tanks can be made from local materials (bricks or concrete). Vermifilters require enclosed reactors made from durable materials that eliminate vermin entry, usually plastic or concrete. Filter material for the vermifilter can be sawdust, straw, coir, bark mulch or peat. Worms are required, and three species to date have been successfully used: Eisenia fetida, Eudrilus eugeniae and Eisenia andrei." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.2, cold = 0.5, temperate = 1, warm = 1, hot = 1)	As the worm-based toilet, the performance is limited if the temperatures are very cold since the worms might eventually even die.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"Vermi filtration happens in a water-tight container" (Emersan) "Simple robust technology" (Emersan) There should not exist a risk for drinking water contamination. "Effluent produced during the vermi filtration process can be directly in filtrated into the soil, or further treated through evapotranspiration in a planted system." (Emersan) These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain) Same values allotted to the other composting technology "Co-composting"	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Septien, 2021	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.04, b = 0.04, c = 999, d = 999)	the material of over 3000 households can be treated in a centralized facility of 770m2 (Eawag, 2006). From this, we derive minimum space requirements of 0.04 m2/cap (Jain & Ilmanen, 2021). This value underlies the assumption that space requirements of co-composting and vermicomposting facilities are similar (Emersan: "The design of a Vermi composting facility is similar to Co-Composting.").	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Simple robust technology" (Emersan) Can be built and maintained with locally available materials" (Emersan) Low construction skills should be sufficient and moderate construction skills could increase the quality of the construction.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"In separating solid and liquid fractions the quality of the effluent is increased. Ventilation must be sufficient to ensure an aerobic environment for the worms and microorganisms, while also inhibiting entry of unwanted flies. The temperature within the reactor needs to be maintained within a range suitable for the species of compost worms used. The specific design of a vermifilter will depend on the characteristics and volume of sludge. Vermi composting or vermifilters can be combined with other treatments - for example, the digestate from an aerobic digestion could be vermifiltered to achieve solids reduction and increase pathogen elimination. Effluent produced during the vermi filtration process can be directly in filtrated into the soil, or further treated through evapotranspiration in a planted system." (Emersan) High design skills are highly recommended.	yes

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Vermi composting requires a high level of organisation and labour to sort organic waste, manage the facility and monitor treatment efficiency and is therefore unlikely to be practical in the acute response phase of emergency situations." (Emersan) "A Vermi composting facility requires well-trained maintenance staff to carefully monitor quality and quantity of the input material and worm health as well as manage moisture and oxygen content" (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Vermicompost should be stored for at least a year before use." (Emersan) Since the product needs to be stored for minimum a year, lifetimes of less than 1 year are in theory not suitable, but limitations of technologies for short lifetimes are not considered here. (Kukka Ilmanen, Eawag 2021) "The design of a vermicomposting facility is similar to co-composting using vessels, but with the addition of earthworms" (SLU Compendium) Similarly to co-composting vermicomposting can work well at lifetime of more than 5 years. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.8, slow=0.2)	"Vermicomposting tanks can be made from local materials (bricks or concrete). Vermifilters require enclosed reactors made from durable materials that eliminate vermin entry, usually plastic or concrete. It is possible to find worms in the local environment, buy them from vermicomposting or vermifilter businesses or import them. Prefabricated composting vessels of different sizes are available on the market." "Vermifiltration can be applied in all emergency phases provided there is access to worms. Vermicomposting requires a high level of organisation and labour to sort organic waste, manage the facility and monitor treatment efficiency and is therefore unlikely to be practical in the acute response phase of emergency situations. However, it can be considered a viable option in the stabilisation and recovery phases where there is an available source of well-sorted organic solid waste and space." (Emersan Compendium) Since high level of organisation and labour is required to sort organic waste or vermicomposting, it would be difficult to realise this technology in a short time frame. Prefab units aid in the cause of improving speed of implementation. Additionally, here, vermifiltration is also considered which can be implemented quicker since sorting of waste is not applicable here. Therefore, probabilities are allotted at 80% to "moderate" and 20% to "slow" category. Which is slightly better than co-composting and this is due to consideration of quicker implementation for vermifiltration. (Akanksha Jain) Vermifiltration can be implemented quickly, however, depends on the availability of materials, hence, "rapid" category gets a performance of 50% (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"The design of a vermicomposting facility is similar to co-composting using vessels, but with the addition of earthworms. Vermifilters consist of enclosed reactors containing filter media and worms. These are used on a small scale in worm-based toilets. In vermifiltration systems, the solids (excreta, sludge and toilet paper) are trapped on top of the filter, where they are processed into humus by the worms and bacteria while the liquid passes through the filter. [...] The specific design of a vermifilter will depend on the characteristics and volume of sludge." (Vermicomposting and Vermifiltration | SLU Compendium) A vermicompost should be easy to extend, if new worms are added and could be easily scalable. A vermifilter is designed specifically and might be more difficult to extend. Instead more vermifilter units could be built. To account for both technologies a value of 80% is chosen. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and maintained with locally available materials", "Vermicomposting tanks can be made from local materials (bricks or concrete). Vermifilters require enclosed reactors made from durable materials that eliminate vermin entry, usually plastic or concrete. Filter material for the vermifilter can be sawdust, straw, coir, bark mulch or peat. Worms are required, and three species to date have been successfully used: Eisenia fetida, Eudrilus eugeniae and Eisenia andrei." (Emersan) "Worms can be harvested from vermicompost using mechanical process such as sieving with a wire mesh or with a rotating cylindrical screen. [...] Worms will reproduce in the vermicompost; thus, if properly operated, worms can be harvested and sold, making a net profit. However, in cases where worms die in the process and/or the compost needs to be reseeded with worms, it is important to know in advance where replacement worms can be sourced." (Worms | SLU Compendium)" (Worms | SLU Compendium) The worms, as well as the technical parts, such as the wire mesh or rotating cylindrical screen are assumed to be available locally	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Compost	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0	0	* see calculations in 12.2.2	Yadav et al. (2010)
	1	-	0	0	0	0	* includes prior composting, see calculations in 12.2.1	Yadav et al. (2012)
	1	-	0	0	0	0	* increase of TP content	Hait and Tare (2011)
	0.233	-	0.767	0	0	0	removeal efficency for PO4-P	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
med (R)	1	0.23-1	0.77	0	0	0		-
bal.	0.81	-	0.19	0	0	0		-
k	1	[0.77]	-	-	-	-		PA
TN	0.68	-	0	0.32	0	0	* see calculations in 12.2.2	Yadav et al. (2010)
	0.64	-	0	0.36	0	0	* as TN	Benitez et al. (1999)
	0.5	-	0	0.5	0	0	* includes prior composting, see calculations in 12.2.1	Yadav et al. (2012)
	1	-	0	0	0	0	* increase of TN content	Hait and Tare (2011)
	1	-	0	0	0	0	* increase of TN content	Gupta and Garg (2008)
	0.05	-	0.95	0	0	0	effluent removal efficency for NH3-N	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
	0.2	-	0.8	0	0	0	effluent removal efficency for NO3-N	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
med (R)	0.57	(0.2-1	0	0	0	0	Spuhler et al. (2021)	-
bal.	0.565	-	0.25	0.18	0	0		-
k	1	[0.8]	-	-	-	-		PA
H2O	0.49	-	0	0.51	0	0	* includes prior composting, see calculations in 12.2.1	Yadav et al. (2012)
	0.53	-	0	0.47	0	0	* see calculations in 12.2.2	Yadav et al. (2010)
	0.7	-	0	0.3	0	0	* moisture is contained at 70%	Gupta and Garg (2008)

	0.2	-	0.8	0	0	0	estimated based on drawing	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
med (R)	0.51	0.2-0.7	0.8	0.47	0	0		-
bal.	0.48	-	0.2	0.32	0	0		-
k	2	[0.5]	-	-	-	-		PA
TS	0.5	-	0	0.5	0	0	* see calculations in 12.2.2	Yadav et al. (2010)
	0.541	-	0	0.459	0	0	* Manure	Lalander et al. (2015)
	0.824	-	0.176	0	0	0	value for TSS	Amoah, P., Gbenatey Nartey, E. and Schrecongost, A. 2016.
med (R)	0.54	0.5 - 0.824	0.18	0.48	0	0		-
	0.7	-	0	0.3	0	0	* moisture is contained at 70%	PA
	0.2	-	0.8	0	0	0	estimated based on drawing	
med (R)	0.51	0.2-0.7	0.8	0.47	0	0		
bal.	0.48	-	0.2	0.32	0	0		
k	2	[0.5]	-	-	-	-		
TS	0.5	-	0	0.5	0	0	* see calculations in 12.2.2	
	0.541	-	0	0.459	0	0	* Manure	
	0.824	-		0	0	0	value for TSS	
med (R)	0.54	0.5 - 0.824	0.18	0.48	0	0		
Calculation				TC_Vermicompost= Substance mass in vermicompost / Substance mass in faecal slurry				

12.2.2 Data from: Yadav et al. (2010)

	Faeces	Vermicompost	TC Vermicompost
Moisture %	0.8	0.43	0.5375
TN [mg/g dry weight]	0.41	0.28	0.682926829
P as P2O5 [mg/g dry weight]	0.11	0.235	2.136363636
Calculation			TC_Vermicompost= Substance mass in vermicompost / Substance mass in faecal slurry

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Black Soldier Fly Composting		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	black_soldier_fly_composting	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedstored_faeces, transportedpithumus, transportedsludge, transportedtransferred_sludge, transportedorganics	McConville, J. et al. (2020)
OUTPUT PRODUCT	transportedcompost	McConville, J. et al. (2020)
RELATIONS	Input: OR Output: NA	McConville, J. et al. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0.5, neighbourhood = 1, city = 1)	McConville, J. et al. (2020)
management_level	(household = 1, shared = 1, public = 1)	McConville, J. et al. (2020)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	6	Spuhler, D. et al. (2021)
technical_maturity	2	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	High technical complexity for production of Larvae, rearing of flies requires environmental control and trained personnel. However, if larvae growth can be maintained, this technology can be very beneficial as it can handle large volumes of organic wastes in a very short amount of time and can generate high-protein feed which can be sold and used. (Akanksha Jain, based on McConville, J. et al. (2020)) Given the technical complexity in establishing a working flies rearing facility this technology is not suitable for acute phase and less suitable (50% performance) for stabilisation phase. However, since it can handle organic waste fast and efficiently, its applicabtion can be considered to some extent in stabilisation phase and definitely in the recovery phases of emergencies. Innovative technologies such as this could potentially be the ideal sustainable solution in emergencies. (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.8, no electricity = (	Expert Judgement (Lalander, C. 2021)	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.25, regular = 0.25, continous = 0.5)	Expert Judgement (Lalander, C. 2021)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	Expert Judgement (Lalander, C. 2021)	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Expert Judgement (Lalander, C. 2021)	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Expert Judgement (Lalander, C. 2021)	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.2, special = 0.1)	Expert Judgement (Lalander, C. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0, temperate = 0, warm = 1, h	Expert Judgement (Lalander, C. 2021)	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	Expert Judgement (Lalander, C. 2021)	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Expert Judgement (Lalander, C. 2021)	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.02, b = 0.03, c = 999, d = 999)	Assumed values for the calculation: Opimal space requirements: 5 t/d on 900 m^2 (Dortmans, B. et al. (2021)) Minimal space requirements: 1 t/d on 250 m^2 (Dortmans, B. et al. (2021)) faecal sludge production per person and year: 50 kg/pers*a (Vinneras, B. (2006))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	Depends on whether the goal is solely treatment or the production of larvae to sell them as animal feed. More sophisticated systems require specialized facilites (e.g. for rearing). However, also more simple systems can be implemented, mostly based on manual labor and not specialized technology. Constructing a small-scale facility should not require much specialized knowledge.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	Depends on whether the goal is solely treatment or the production of larvae to sell them as animal feed. More sophisticated systems require specialized facilites (e.g. for rearing). However, also more simple systems can be implemented, mostly based on manual labor and not specialized technology. Even for designing a small-scale facility, a certain understanding of the life-cycle of BSFL is required and therefore limited to highly skilled personell.	

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Care should be taken to ensure that the waste is neither too dry nor too wet, lest the larvae fail to feed" (SLU). "BSFL treatment requires access to eggs, either purchased or reared. Rearing of flies require environmental control and trained personnel" (SLU). Even small-scale facilites that do not rear eggs on-site require skilled workers that understand the requirements of BSFL.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Under optimal conditions, it takes three weeks for BSFL to grow from an egg to reach the final larval stage, in which the larvae crawl out of the residue in the search for a dry and dark place to pupate.", "BSFL can be easily dried for longer storage." (Larvae | SLU Compendium) The larvae require three weeks to grow after which they pupated and grow into Black Soldier Flies that can lay further eggs and the process can be repeated indefinite times. This is an emerging technology, so there is no empirical data on the possible lifespan of the technology. It is assumed to be applicable for the long-term. (Kukka Ilmanen, Eawag 2021) "May require a year or more of maturation before being safe to use." (Compost | SLU Compendium) Since the product needs to be stored for minimum a year, lifetimes of less than 1 year are in theory not suitable, but limitations of technologies for short lifetimes are not considered here. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	"the treatment units can be assembled using relatively cheap, locally available materials, such as metallic sheets." "Rearing of flies require environmental control and trained personnel." "Usually, 4 to 10-day-old larvae are used for treatment. They are removed from the BSFL rearing units and placed onto the waste in the treatment units. The number of larvae used depends on the amount of waste per surface area. The larvae are usually fed incrementally over a period of about 3 weeks, until they have grown large enough to be harvested." (SLU Compendium) Setting up not too difficult, however, rearing of flies would take time and therefore, the technology cannot be realised with a "rapid" speed of implementation (less than a week) (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Treatment of waste using BSFL can be carried out at both household and municipal levels." (SLU Compendium) "[Horizontal scaling up is possible by adding more decentral treatment sites (e.g. at household level) that treat smaller amounts of local organic waste and accept BSF larvae reared at a larger central site]" (Bram Dortmans, Eawag 2021) Scaling up can be done easily by extending the number of treatment sites or households using BSF treatment. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"BSFL technology has low investment costs, as the treatment units can be assembled using relatively cheap, locally available materials, such as metallic sheets.", "BSFL treatment usually takes place in boxes, bins or containers measuring 60 to 100 cm × 40 to 80 cm × 17 to 30 cm. [..] using a mesh. For small-scale systems, the growth chambers can be built with ramps [...] A drainage system or ventilation is required when working with wet material such as household waste or pig manure, or if the system is operated in a humid climate. [...] It is necessary for large-scale facilities to rear BSFL at the treatment site to ensure continuous production of larvae. [...] BSFL treatment requires access to eggs, either purchased or reared. Rearing of flies require environmental control and trained personnel." (SLU Compendium) Mostly locally available material are required, such as containers, ramps, mesh, etc. Some technical parts might be required for the drainage or ventilation system. BSFL eggs are assumed to be locally available though in some places they might need to be imported. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Compost	Range	Airloss	Soilloss	Waterloss	Comment	Reference
TP	0.75	0.6 - 0.9	0.25	0	0		Expert Judgement (Lalander, C. 2021)
med (R)	0.75	0.6 - 0.9	0.25	0	0		-
k	2	[0.3]	-	-	-		PA
TN	1	-	1	0	0		Expert Judgement (Lalander, C. 2021)
med (R)	1	-	1	0	0		-
k	2	-	-	-	-		PA
H2O	0.55	0.5 - 0.6	0.45	0	0		Expert Judgement (Lalander, C. 2021)
med (R)	0.55	0.5 - 0.6	0.45	0.45	0.45		-
k	1	[0.1]	-	-	-		PA
TS	0.5	0.4 - 0.6	0.5	0	0		Expert Judgement (Lalander, C. 2021)
med (R)	0.5	0.4 - 0.6	0.5	0	0		-
k	5	[0.2]	-	-	-		PA

References

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Expert Judgement (Lalander, C. 2021)

Mcconville, J., et al. (2020). "Guide to Sanitation Resource-Recovery Products & Technologies : a supplement to the Compendium of Sanitation Systems and Technologies."

Vinnerås, B., et al. (2006). "The characteristics of household wastewater and biodegradable solid waste—A proposal for new Swedish design values." Urban Water Journal 3(1): 3-11.

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Ladepa-Pelletizing

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	ladepa_pelletizing	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedstored_faeces, transportedsludge, transportedtransferred_sludge, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	transportedpellets	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0, city = 1)	Septien, S. (2021)
management_level	(household = 0, shared = 0, public = 1)	Septien, S. (2021)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	1	Septien, S. (2021)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Specialised equipment needs to be purchased/rented specifically from designers (Particle Separation Systems). The methodology is quite complex (extrusion, patented drying mechanisms, etc.). It is primarily used to generate pelletised soil amender- which unlikely to be a priority during emergencies. Implementation of this technology can be thought of in the recovery phases but given the lack of locally available special equipment and therefore, possibly slow speed of implementation, this technology can be considered unsuitable for acute and stabilisation phases of emergencies. (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continuous = 0)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficulty available = 0, pipes = 1)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficulty available = 1, pumps = 1)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0, difficulty available = 0, concrete = 1)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.4, special = 0.3)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0, temperate = 0, warm = 0, h	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	For this technology the criterion "flooding" is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)		
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.0004, b = 0.0004, c = 999, d = 999)	Adapted from Personal Communication wit Santia	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.3, skilled = 1, professional = 1)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Expected design lifetime is 10 years" (Personal Communication wit Santiago Septien (Septien, S. 2021))	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0, slow=1)	"6 months are required to construct and set-up a functional technology" (Personal Communication wit Santiago Septien (Septien, S. 2021))	yes

scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.4, special = 0.3)	Adapted from Personal Communication wit Santiago Septien (Septien, S. 2021)	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Pellets	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.99	-	0.01	0	0	*Drying did not affect the nutrient content and calorific value of the dry bone of faecal sludge	Septien et al. (2018)
	0.99	-	0.01	0	0		PC with Rein
med (R)	0.99	-	0.01	0	0		-
k	100	-	-	-	-		PA
TN	0.95	-	0.05	0	0	*Drying did not affect the nutrient content and calorific value of the dry bone of faecal sludge	Septien et al. (2018)
	0.99	-	0.01	0	0		PC with Rein
med (R)	0.97	0.95 - 0.99	0.03	0	0		-
k	100	[0.04]	-	-	-		PA
H2O	0.25	-	0.75	0	0	*Reduction from 80% moisture to 20%	Septien et al. (2018)
	0.225	-	0.775	0	0		PC with Rein
med (R)	0.24	0.225 - 0.25	0.76	0	0		-
k	100	[0.025]	-	-	-		PA
TS	0.99	-	0.01	0	0	*Drying did not affect the nutrient content and calorific value of the dry bone of faecal sludge	Septien et al. (2018)
	0.99	-	0.01	0	0		PC with Rein
med (R)	0.99	-	0.01	0	0		Spuhler et al. (2021)
k	100	-	-	-	-		PA

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Septien, S., et al. (2018). "'LaDePa' process for the drying and pasteurization of faecal sludge from VIP latrines using infrared radiation." South African journal of chemical engineering 25: 147–158.

Septien, S., et al. (2018). Evolution of faecal sludge chemical and physical characteristics during drying.

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Briquetting

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	briquetting	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transporteddried_faeces, transportedstored_faeces, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	transportedbriquettes	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	From Sanivation Website: The plant has capacity to serve 10,000 people and produce 350 tons of fuel per month. The plant intakes fecal sludge from exhauster trucks and outputs biomass fuels to replace firewood in industrial boilers. Appears to be a centralized technology which is best applied on a high level.
management_level	(household = 0, shared = 0.5, public = 1)	From Sanivation Website: The plant has capacity to serve 10,000 people and produces 350 tons of fuel per month. The plant intakes fecal sludge from exhauster trucks and outputs biomass fuels to replace firewood in industrial boilers. Appears to be a centralized technology which is best managed on a high level.
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	2	Sanivation successfully piloted this approach and is currently expanding. We assume medium maturity. See here: https://www.cdc.gov/globalhealth/stories/transforming_waste_to_fuel.html#:~:text=Sanivation%20uses%20innovative%2C%20low-cost,source%20for%20cooking%20or%20heating.&text=The%20briquettes%20burn%20more%20cleanly,and%20risk%20of%20respiratory%20disease.%20(CDC%20-%3E%20Sanivation
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Can yield a cheap and effective low cost fuel alternative. Briquetting process has proved to be very helpful especially for women (e.g., Refugees in Ugandan Camps). Mud briquetting does not require complex or expensive equipment. Source: United Nations High Commissioner for Refugees. (2013). Innovation: Briquette-making project helps protect women in Ugandan camp. UNHCR. https://www.unhcr.org/news/makingdifference/2013/8/520500559/innovation-briquette-making-project-helps-protect-women-ugandan-camp.html In recovery phases large scale briquetting could be implemented with proper solid waste management and briquetting machines. (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	energy required according to old library	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0, continous = 1)	based on old library but needs a re-check A sanivation treatment plant employs 30-50 people. (Sanivation, n.d.) Need for continous work of several workers is assumed.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.1, pipes = 1)	Need for pipes is assumed	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly available = 0.1, pumps =	Need for pumps is assumed	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0, difficultly available = 0.1, concrete = 1)	Need for concrete is assumed	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.2, special = 0.1)	from old library	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0, temperate = 0.25, warm =	Sanivation uses innovative, low-cost solar treatment technologies to transform fecal waste into briquettes [...] (CDC, 2017) since the process is based on solar treatment technologies it probably runs much more efficient in hot areas with lots of sun.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	For this technology the criterion “flooding” is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	It is assumed that there is no need for excavation.	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.01, b = 0.12, c = 999, d = 999)	According to Sanivation (n.d.) there is 3 - 5 acres of land space needed to build up a sanivation treatment plant that serves 100,000-2,000,000 people.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	Professional construction skills are assumed to be very useful but skilled construction skills should be sufficient under certain circumstances such as very good design and good preparation of the construction site	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Professional design skills are assumed to be needed in any case	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.1, professional = 1)	Professional OM skills are assumed to be very highly recommended	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	Treatment tank, Mixer, Barrels and dolly cart all have a lifespan of 10 years. (Hakspiel, D. et al. (2018))	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.5, moderate=0.5, slow=0)	"Increases speed of toilet deployment: Faster to deploy a toilet unit than digging a pit latrine.", "Lead time: Time required for initial system deployment, including waste processing plant, is higher than traditional solutions." (Hakspiel, D. et al. (2018)) While the appropriate container-based toilets can be implemented quickly, the treatment system itself takes some time to set up. Patent technology (Sanivation), if materials are made available locally fast then implementation does not require much time at all. Lower probability is allotted to the category "rapid" (50%) because materials required for operation are quite specialised and therefore may be difficult to procure in a short time, i.e., less than a week. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"The faecal sludge is collected and transported to a central processing site twice a week, where it is treated using a solar thermal treatment process. Once free of pathogens, the treated faeces are combined with a high carbon co-waste product, such as charcoal dust, to make solid fuel briquettes. ", The Implementation Guide actively promotes an expansion stage, in which more toilets can be deployed as part of the system. (Hakspiel, D. et al. (2018)) It is assumed that by a briquetting facility can be scaled up by increasing the high carbon co-waste product and collecting faeces from more toilets. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.3, special = 0.2)	"The system that Sanivation uses in Kakuma heats a heating fluid that is continuously pumped through a closed circuit of pipes running through an insulated jacket. The insulated jacket surrounds a tank into which faecal sludge is loaded. The heating system is semi-automated with temperature sensors measuring the fluid and sludge temperatures and a controller activating a circulation pump accordingly. Safety mechanisms, including pressure relief valves and temperature alarms, are incorporated into the design to maximize operator safety and to minimize the potential for user error. [...] The system can be built offsite and assembled in a standard shipping container for ease of transportation and rapid deployment." (Hakspiel, D. et al. (2018)) [Manufacturing of the treatment tank and drying racks can be local (in an industrial city), whereas the grinding wheel mixer and roller press are manufactured abroad and need to be imported.] (Hakspiel, D. et al. (2018)) The treatment process requires technical parts as well as some specially manufactured parts that need to be imported.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Briquettes	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0		PC with Sanivation
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		PA
TN	0.95	-	0.05	0	0		PC with Sanivation
	0.9	-	0.1	0	0	* N volatilization is related to air temperature	PA
med (R)	0.93	0.9 - 0.95	0.08	0	0		-
bal.	0.93	-	0.07	0	0		-
k	25	[0.05]	-	-	-		PA
H2O	0	-	1	0	0		PC with Sanivation
	0.14	-	0.86	0	0	Assumption: moistrue content briquetts ~5%. Dried Faeces with moisture 20% -> 5% = TC_Airloss 0.75. FS with moisture 80% -> 5% = TC_Airloss 0.9325	PA
med (R)	0.14	0 - 0.14	0.93	0	0		-
bal.	0.07	-		0	0		-
k	5	[0.14]	-	-	-		PA
TS	0.99	-	0.01	0	0		PC with Sanivation
med (R)	0.99	-	0.01	0	0		Spuhler et al. (2021)
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Settler

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	settler	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	blackwater, transportedblackwater	Tilley, E. et al. (2014)
OUTPUT PRODUCT	effluent, transportedeffluent, sludge, transportedsludge	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.75, no electricity = 0.5)	"Large primary clarifiers are often equipped with mechanical collectors that continually scrape the settled solids towards a sludge hopper in the base of the tank, from where it is pumped to sludge treatment facilities. A sufficiently sloped tank bottom facilitates sludge removal. Scum removal can also be done either manually or by a collection mechanism." (Compendium) Settlers can be equipped with collectors that require electrical energy. The performance is slightly improved if a mechanical collector is installed, as it does not have to be done by hand. If electric scrappers are used, 'intermittent electricity' can work a bit better than 'no electricity', since one can choose to only empty when electricity is available.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"In settlers that are not designed for anaerobic processes, regular sludge removal is necessary to prevent septic conditions and the build-up and release of gas which can hamper the sedimentation process by re-suspending part of the settled solids. Sludge transported to the surface by gas bubbles is difficult to remove and may pass to the next treatment stage. Frequent scum removal and adequate treatment/disposal, either with the sludge or separately, is also important." (Compendium) Regular desludging and scum removal is necessary.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	"...a good inlet and outlet construction with an efficient distribution and collection system (baffles, weirs or T-shaped pipes) is important." (Compendium)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.75, difficultly available = 0.75, pumps = 1)	"desludging can be done using Manual Emptying and Transport (C.1), Motorised Emptying and Transport (C.2) or by gravity using a bottom outlet. [...]The main operation and maintenance costs are related to the removal of primary sludge and the cost of electricity if pumps are required for discharge (in absence of a gravity flow option)." (Emersan) Pumps can be required for emptying depending on the design. It is assumed that building a gravity-driven configuration performs worse than one with pumps.	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"A Settler can be made of concrete, sand, gravel,cement, steel, as well as fibreglass, PVC or plastic, and are available as prefabricated units." (Emersan) It is assumed that concrete has a higher performance than the other materials due to the local experience with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"A Settler can be made of concrete, sand, gravel, cement, steel, as well as fibreglass, PVC or plastic, and are available as prefabricated units.", "...and also on the local availability and thus costs of materials (sand, gravel, cement, steel) or prefabricated modules and labor costs." (Emersan) Technical spare parts might be needed, if it is a pre-fabricated module or if pumps are used for emptying.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, hot = 1)	The settling efficiency of the settler does not particularly rely on the overall temperature, but the temperature variations and uniformity within the tank ({Goula, 2008 #1376}). Since the settler does not rely on bacterial activity either, all temperature values are assumed to be suitable.	yes

flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Depending on the design, excavation might be necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.05, b = 0.05, c = 999, d = 999)	From Mang, H.-P. & Li, Z. (2010) on biogas settlers: "Only 0.5-1m2 per m3 daily flow are needed, compared to 25-30 m2 /m3 /d flow in aerobic ponds and constructed wetlands." We calculate the ratio of the minimum space requirements between biogas settlers and constructed wetlands: 30 m2/m3/d / 0.5 m2/m3/d = 60. The space requirements of the settler are therefore 60x smaller than the space requirements of constructed wetlands. Using our value of 3 m2/cap for constructed wetlands (from Table 1.3, Dotro et al. 2017), we calculate space requirements of 0.05 m2/cap for the biogas settler (Eawag, 2021).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Simple and robust technology" (Compendium) There are no technical parts to be installed and the design is pretty simple. A casual labourer should be sufficient. Futhermore there are prefabricated tanks are available in fibreglass, PVC or plastic. (Emersan)	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Settlers are typically designed for a hydraulic retention time of 1.5–2.5 hours. Less time is needed if the BOD level should not be too low for the following biological step. The tank should be designed to ensure satisfactory performance at peak flow. In order to prevent eddy currents and short-circuiting, as well as to retain scum inside the basin, a good inlet and outlet construction with an efficient distribution and collection system (baffles, weirs or T-shaped pipes) is important." (Emersan) The design has to be carried out in accordance with a few factors.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	Usually no operation and maintenance is needed except regular scum and sludge removal.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	There are different types of settlers, but in general long lifetimes are expected. For example, settlers with additional lamellae, such as tube settlers have "twenty to twenty-five year service life, provided proper maintenance is performed, [and plate settlers have] longer lifespan due to material of construction." (Brentwood, 2020)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.7, moderate=0.3, slow=0)	"A Settler can be made of concrete, sand, gravel, cement, steel, as well as fibreglass, PVC or plastic, and are available as prefabricated units." (Compendium) With prefabricated structures implementation should be very quick, however, slightly lower performance allotted to category "rapid" (70%) since if concrete is to be used for construction, minimum curing time of 7 days would be needed. (Akanksha Jain)	yes

scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"The tank should be designed to ensure satisfactory performance at peak flow.", "They can be independent tanks or integrated into combined treatment units.", "To enhance the performance of Settlers inclined plates (lamellae) and tubes can be installed which increase the settling area, or chemical coagulants can be used." (Emersan) The settlers have been specifically designed with a certain volume for certain inputs, so one cannot simply increase their size. However, new settlers can be build and integrated into combined treatment units. Furthermore, the treatment capacity can be increased slightly by adding lamellae, tubes or chemical coagulants.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	"A Settler can be made of concrete, sand, gravel, cement, steel, as well as fibreglass, PVC or plastic, and are available as prefabricated units." (Emersan) Can be constructed from locally available material. However, we assume that some technical parts are required to pump out sludge from the tank. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.7	0.6 - 0.8	0.3	0	0	0	* as TP	{Domokos, 2005
med (R)	0.7	0.6 - 0.8	0.3	0	0	0		-
k	5	[0.2]	-	-	-	-		PA
TN	0.15	-	0.85	0	0	0	* denitrified	{Guerrero, 2013
	0.43	-	0.57	0	0	0	* denitrified	{Guerrero, 2013
	0.17	-	0.83	0	0	0	* denitrified	{Guerrero, 2013
med (R)	0.17	0.15 - 0.43	0.83	0	0	0		-
k	5	[0.28]	-	-	-	-		PA
H2O	0.04	-	0.95	0.01	0	0		PA (adapted from ABR)
med (R)	0.04	-	0.95	0.01	0	0		-
k	5	-	-	-	-	-		PA
TS	0.234	0.195 - 0.273	0.766	0	0	0	* from 34.2.1	{Conradin, 2010 #973}
	0.228	0.191 - 0.265	0.772	0	0	0	* from 34.2.2	{Fuchs, 2014
med (R)	0.23	0.191 - 0.273	0.77	0	0	0		-
k	100	[0.082]	-	-	-	-	Spuhler et	PA

Additional Information

34.2.1	Data from: {Conradin, 2010 #973}⍰	
	Min. Removal [%]	**Max. Removal [%]**
TSS	50	70
Ratio TSS:TS (from	0.39	0.39
TS (from TSS)	19.5	27.3
34.2.2	Data from: {Fuchs, 2014 #1421}	
	Min. Removal [%]	**Max. Removal [%]**
TSS	49	68
Ratio TSS:TS (from horizontal_wetland)	0.39	0.39
TS (from TSS)	19.11	26.52

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Imhoff Tank

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	imhoff_tank	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	blackwater, transportedblackwater, greywater, transportedgreywater	Tilley, E. et al. (2014)
OUTPUT PRODUCT	effluent, transportedeffluent, sludge, transportedsludge	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Same values allotted as for a Settler. Emersan -> T.1 Settler (Gensch, R. et al. (2018))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.75, no electricity = 0.5)	Pumps for emptying are necessary and these pumps might require electricity to work. However, if the pumps are in the form of mobile pumps or vacuum trucks, they can work without electricity. It is assumed that generally, electric pumps perform better, as they do not require vehicular access and can be installed at the best location. If electric pumps are used intermittent electricity can work a bit better than no electricity, since one only empties when electricity is available. If electric pumps are used, 'intermittent electricity' can work a bit better than 'no electricity', since one can choose to only empty when electricity is available.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Operation and maintenance are possible at low cost, if trained personnel are in charge. Flow paths have to be kept open and cleaned out weekly, while scum in the settling compartment and the gas vents has to be removed daily if necessary. Stabilized sludge from the bottom of the digestion compartment should be removed according to the design. A minimum clearance of 50 cm between the sludge blanket and the slot of the settling chamber has to be ensured at all times." (Compendium) Regular maintenance is required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficulty available = 0.5, pipes = 1)	"T-shaped pipes or baffles are used at the inlet and the outlet to reduce velocity and prevent scum from leaving the system" (Emersan) "For desludging, a pipe and pump have to be installed or access provided for vacuum trucks and mobile pumps." (Compendium) Pipes are required for this technology.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficulty available = 0.75, pumps = 1)	"The Imhoff tank is usually built underground with reinforced concrete. It can, however, also be built above ground, which makes sludge removal easier due to gravity, although it still requires pumping up of the influent." (Emersan) "For desludging, a pipe and pump have to be installed or access provided for vacuum trucks and mobile pumps." (Compendium) "Sludge is ideally removed by hydraulic pressure, not requiring any pumping but only a sludge removal pipe controlled by a valve. This is possible if a natural gradient exists, so that a head of min. 1.5 m at the level of the valve can be achieved (Texas Water Commission, 1991)." (Griesauer, C. (2014)) Some type of pump is required for pumping up the influent, if the imhoff tank is built (partly) above ground. In other configurations the hydraulic pressure is sufficient or pumping could be achieved in the form of a mobile pump or a vacuum truck.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0, difficulty available = 0.5, concrete = 1)	"The Imhoff tank is usually built underground with reinforced concrete. It can, however, also be built above ground, which makes sludge removal easier due to gravity, although it still requires pumping up of the influent. Small prefabricated Imhoff tanks are also available on the market." (Compendium) Concrete is assumed to be necessary.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Operation and maintenance are possible at low cost, if trained personnel are in charge" (Compendium) "Requires expert design, but can be constructed with locally available material.", "Simple to construct and to operate." (SSWM Toolbox) Low tech spare parts are assumed, however, if the pump breaks, more technical parts are necessary.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"Imhoff tanks can be used in warm and cold climates.", " In colder climates longer sludge retention time and, therefore, a greater volume is needed." (Compendium) Lower performance for temperatures lower than temperate.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"As the tank is very high (7-9.5m), it can be built underground if the groundwater table is low and the location is not flood prone." (Compendium) These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Imhoff tanks are usually built underground and require a deep excavation (Compendium). One configuration is built underground.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.004, b = 0.004, c = 999, d = 999)	Cruz et al. 2005 on imhoff tanks: "A 1,000 population would need a 100 m3 /day tank with a (...) total surface area of 3.75 m2" This results in a minimum space requirement of 0.004 m2/cap. This value is considered appropriate here.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) Similar to a WSP.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) Similar to a WSP.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Operation and maintenance are possible at low cost, if trained personnel are in charge." (Compendium) Trained personnel is necessary.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Sludge needs to be dug out every 1 to 5 years and discharged properly" (Imhoff Tank | SSWM Toolbox) "For the civil works a life expectancy of 25 years is assumed. Pipework and the manhole cover are expected to last for 15 years. [Country specific assessments show that reinvestment was required every 20 to 25 years.]" (Imhoff Tank |Griesauer, C. (2014)). In a study by Griesauer on the CLARA planning tool the expected lifetimes for imhoff tanks were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.7, moderate=0.3, slow=0)	"The Imhoff tank is usually built underground with reinforced concrete" "Small prefabricated Imhoff tanks are also available on the market." (Compendium) With prefabricated structures implementation should be very quick, however, slightly lower performance allotted to category "rapid" (70%) since if concrete is to be used for construction, minimum curing time of 7 days would be needed. (Akanksha Jain)	yes

scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"Dimensioning of the anaerobic digestion compartment depends mainly on sludge production per population equivalent, on the targeted degree of sludge stabilisation (linked to the desludging frequency) and the temperature." (Imhoff Tank | SSWM Toolbox) "Small prefabricated Imhoff tanks are also available on the market." (Compendium) Imhoff tanks are either prefabricated or specifically designed, so that it is not easy to change their size after they have been built. Therefore, scaling up by increasing the size of one unit is not feasible. "Suitable for small settlements and house clusters" (Imhoff Tank | SSWM Toolbox) However, the technology is meant for smaller settlement and house clusters, so if new settlements are built for new users the technology can be scaled up by building new prefabricated units. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	"Requires expert design, but can be constructed with locally available material.", "Simple to construct and to operate." (Imhoff Tank | SSWM Toolbox) An imhoff tank can be constructed mostly with simple locally available material. However, we assume that some technical parts are required to pump out sludge from the tank. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.11	-	0.89	0	0	0	* 11.51% removal of	{Ghrabi, 2011
med (R)	0.11	-	0.89	0	0	0		-
k	25	-	-	-	-	-		PA
TN	0.44	-	0.56	0	0	0	* as TN	{Ghrabi, 2011
	0.3	-	0.7	0	0	0	* as TN	{Ávila, 2017
med (R)	0.37	0.3 - 0.44	0.63	0	0	0		-
k	5	[0.14]	-	-	-	-		PA
H2O	0.04	-	0.95	0.01	0	0		PA (adapted from ABR)
med (R)	0.04	-	0.95	0.01	0	0		-
k	5	-	-	-	-	-		PA
TS	0.18	0.078 - 0.273	0.82	0	0	0	* from 32.2.1	{Mikelonis, 2010
	0.24	0.2 - 0.27	0.76	0	0	0	* from 32.2.2	{McLean, 2009
	0.25	-	0.75	0	0	0	* from 32.2.3	{Ghrabi, 2011
	0.31	0.24 - 0.38	0.69	0	0	0	* from 32.2.4	{Ávila, 2017
med (R)	0.25	0.078 - 0.38	0.75	0	0	0	Spuhler et	-
k	5	[0.302]	-	-	-	-		PA

Additional Information

32.2.1	Data from: {Mikelonis, 2010 #1406}	
	Removal [%] (Min. value)	**Removal [%] (Max. value)**
TSS	20	70
Ratio TSS:TS (from horizontal_wetland)	0.39	
TS (from TSS)	7.8	27.3

32.2.2	Data from: {McLean, 2009 #1407}	
	Removal [%] (Min. value)	**Removal [%] (Max. value)**
TSS	50	70
Ratio TSS:TS (from horizontal_wetland)	0.39	
TS (from TSS)	19.5	27.3

32.2.3	Data from: {Ghrabi, 2011 #1408}
	Removal [%]
TSS	63.3
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	24.687

32.2.4	Data from: {Ávila, 2017 #1409}	
	Removal [%] (Min. value)	**Removal [%] (Max. value)**
TSS	61	97
Ratio TSS:TS (from	0.39	
TS (from TSS)	23.79	37.83

32.2.5	Data from: {Ávila, 2017 #1409}			
	Influent	**Effluent Imhoff Tank**	**Removal [%]**	**Average Removal [%]**
TN (Period I)	68	46	32.3529412	29.96560028
TN (Period II)	60	46	23.3333333	
TN (Period III)	76	50	34.2105263	

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Anaerobic Baffled Reactor

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	abr	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	blackwater, transportedblackwater, greywater, transportedgreywater	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	effluent, transportedeffluent, sludge, transportedsludge	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0.5, neighbourhood = 1, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 0.5, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0.5, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.75, no electricity = 0.5)	"No electrical energy is required" (Compendium) "The main operation and maintenance costs are related to the removal of primary sludge and the cost of electricity if pumps are required for discharge (in the absence of a gravity flow option)." (Emersan) Technology can work without electricity and it would only be required for the desludging of the ABR with a fixed pump. (A vacuum truck for emptying the ABR would be an alternative option without electricity). It is assumed that an installed pump using electricity do perform slightly better than the gravity-driven emptying or the one with a vacuum truck. If electric pumps are used, 'intermittent electricity' can work a bit better than 'no electricity', since one can choose to only empty when electricity is available.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continuous = 0)	"Scum and sludge levels need to be monitored to ensure that the tank is functioning well. Process operation in general is not required, and maintenance is limited to the removal of accumulated sludge and scum every 1 to 3 years.", "ABR tanks should be checked from time to time to ensure that they are watertight." (Compendium) Maintenance has to be done regularly but not very often.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	Inlet and outlet pipes are required (Emersan)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.75, difficultly available = 0.75, pumps = 1)	"A pump might be required for discharging the treated wastewater where gravity flow is not an option." (Emersan) Pumps can be required for emptying depending on the design (e.g. gravity-driven emptying). It is assumed that building a gravity-driven configuration performs worse than one with pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"There are many materials that can be used in the construction of an ABR. Metal, concrete, and plastic are primarily used depending on the setting." ({Nguyen, 2010 #1377}) Concrete is one of the possible materials to construct an ABR. It is assumed to perform a bit better, as it can seal the ABR effectively against the ground and locals have usually experience working with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"An ABR can be made of concrete, fibreglass, PVC or plastic, and prefabricated units are available. A pump might be required for discharging the treated wastewater where gravity flow is not an option." (Emersan) The ABR is mechanically simple (({Nguyen, 2010 #1377}) and requires only few technical spare parts. If the pump breaks, more technical parts are necessary. Technical spare parts might be needed, if it is a pre-fabricated module.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"ABRs can be installed in every type of climate, although the efficiency is lower in colder climates." (Compendium) Assumed to be similar to an Imhoff Tank.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"The system should have an emergency bypass system to protect against flooding during high water usage." (({Nguyen, 2010 #1377}) "Even though ABRs are designed to be watertight, it is not recommended to construct them inareas with high groundwater tables or where there is frequent flooding. Alternatively prefabricated modules can be placed above ground." (Emersan) Usually, flooding can pose a problem if the ABR is built underground. These values are allotted to all “tank” based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"...most commonly installed underground..." (Compendium) Excavation might be necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.15, b = 0.15, c = 999, d = 999)	Expert judgement by Nanchoz Zimmermann (personal communication, April 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) Similar to an Imhoff Tank.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) Similar to an Imhoff Tank.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1	Operation and maintenance includes desludging and checking for leaks - rather easy.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Long service life" (Compendium) "For the civil works a life expectancy of 25 years is assumed. Pipes and the manhole cover are expected to last for 15 years." (ABR |Griesauer, C. (2014)). In a study by Griesauer on the CLARA planning tool the expected lifetimes for ABRs were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.2, slow=0.8)	"An ABR can be made of concrete, fibreglass, PVC or plastic, and prefabricated units are available." "Roughly, an ABR for 20 households can take up to several weeks to construct. If reinforced fibre plastic ABR prefabricated modules are used the time required for construction is much less (3–4 days). Once in operation, three to six months (up to nine in colder climates) are needed for the biological environment to become established and maximum treatment efficiency to be reached. ABRs are thus not appropriate for the acute response phase and are more suitable for the stabilisation and recovery phases as a longer-term solution." "To reduce start-up time, the ABR can be inoculated with anaerobic bacteria, e.g. by adding Septic Tank sludge, or cow manure." "Long start up time" (Compendium) Since a long start up time is required, probabilities are mostly allotted to category "slow" (80%) however, some probability is also allotted to moderate category to account for the improvement in speed of implementation as prefab units are available. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	"Scale/scalability (level 4 of 5 meaning difficult to scale): Not modular i.e. scale up only possible at design stage" (Abbott, J. et al. (2019)) "ABRs should consist of at least four chambers (as per BOD load); more than six chambers are not recommended.", "The hydraulic retention time should not be less than eight hours, and 16–20 hours is a preferred range." (Emersan) "With increasing wastewater volumes, the up-flow area has to be increased accordingly, and the total reactor volume cannot be adjusted by increasing the reactor depth, as this would lead to increased velocities. Therefore ABRs for high wastewater volumes would require very large, shallow tanks, which makes their construction uneconomical" (Gutterer et al., 2009) ABR are designed specifically and it is not recommended to add further chambers or increase the volume size of a chamber. However, new ABRs can be built (e.g. attached to new toilets). These require a new design and complex concrete constructions so that ABRs are assigned a scalability performance of 30%. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	"An ABR can be made of concrete, fibreglass, PVC or plastic, and prefabricated units are available. A pump might be required for discharging the treated wastewater where gravity flow is not an option." (Emersan) The ABR is mechanically simple and can be constructed mostly with locally available material. However, we assume that some technical parts are required to pump out sludge from the tank. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.31	-	0.69	0	0	0	* TP pathways	Hamader and Javorszky (2014)
	0.45	0.39 - 0.51	0.55	0	0	0	* TP removal, range depends on number of baffles	Koottatep et al. (2018)
	0.33	0.3 - 0.36	0.67	0	0	0	* TP removal, depends on HRT	Nasr et al. (2009)
med (R)	0.33	0.3-0.51	0.67	0	0	0		-
k	5	[0.21]	-	-	-	-		PA
TN	0.32	-	0.68	0	0	0	* TKN pathways	Hamader and Javorszky (2014)
	0.28	0.15 - 0.41	0.72	0	0	0	* TKN removal, range depends on number of baffles	Koottatep et al. (2018)
	0.29	0.21 - 0.37	0.71	0	0	0	* TKN removal, depends on HRT; Ammonia concentration increases	Nasr et al. (2009)
med (R)	0.29	0.15 - 0.41	0.71	0	0	0		-
k	5	[0.26]	-	-	-	-		PA
H2O	0.04	-	0.95	0.01	0	0		PA

med (R)	0.04	-	0.95	0.01	0	0		-
k	25	-	-	-	-	-		PA
TS	0.57	-	0.43	0	0	0	* TSS Removal 73%; TC_Effluent TS=0.57 estimated with ratio from calculations in 25.2.1	Hamader and Javorszky (2014)
	0.65	0.63 - 0.66	0.35	0	0	0	Spuhler et al. (2021)	Koottatep et al. (2018)
	0.58	0.53 - 0.63	0.42	0	0	0	*TSS Removal: 69 – 82%; TC_Effluent TS=0.53 - 0.63 estimated with ratio from calculations in 25.2.1	Nasr et al. (2009)
med (R)	0.58	0.53 -0.66	0.42	0	0	0		-
k	25	[0.13]	-	-	-	-		PA

Additional Information

25.2.1 Data from: Koottatep et al. (2018)

	TS	TSS	Ratio TS:TSS removal
Removal	0.66	0.86	0.77
	0.65	0.83	0.78
	0.55	0.71	0.77
Median			0.77
Calculation		Ratio = Removal TS / Removal TSS	

Additional Information

25.2.1 Data from: Koottatep et al. (2018)

	TS	TSS	Ratio TS:TSS removal
Removal	0.66	0.86	0.77
	0.65	0.83	0.78
	0.55	0.71	0.77
Median			0.77
Calculation			

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Upflow Anaerobic Sludge Blanket Reactor		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	uasb	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge, pithumus, transportedpithumus	Tilley, E. et al. (2014)
OUTPUT PRODUCT	effluent, transportedeffluent, processed_sludge, transportedprocessed_sludge, biogas, transportedbiogas	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	"Long start-up time" (Tilley, E. et al. (2014)) Rather unsuitable for acute and stabilisation emergency phases, complex operation, expensive equipment required. (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.5, no electricity = 0)	"A constant source of electricity is required" (Compendium) "Power supply interruptions have minimal effect" (NaWaTech Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	Operation and maintenance includes monitoring and infrequent desludging. (Compendium) Regular O&M required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.75, difficultly available = 0.75, pipes = 1)	"Critical elements for the design of UASB reactors are the influent distribution system, the gas-solids separator, and the effluent withdrawal design." (Compendium) Inlet and outlets pipes are not specifically required as other inlet and outlet systems can be created, but pipes might be useful before the inlet and after the outlet systems.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly available = 0.5, pumps = 1)	Since the wastewater has to be pushed up the UASB, a pump is required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0, difficultly available = 0.5, concrete = 1)	"Commonly used construction material is Reinforced Cement Concrete." (SSWM Toolbox) Assuming concrete is used to build the reactor	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.4, special = 0.4)	"Not all parts and materials may be locally available ", "Critical elements for the design of UASB reactors are the influent distribution system, the gas-solids separator, and the effluent withdrawal design. The gas that rises to the top is collected in a gas collection dome and can be used as energy (biogas)." (Compendium) Technical as well as some specially manufacture spare parts for the influent, effluent and gas systems are required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	Assumed to be similar to an Imhoff Tank.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.9, no flooding=1)	These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Depending on the design, excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA

surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.03, b = 0.03, c = 999, d = 999)	Requires at least 0.03 m2/cap. From Table 1.3 (Dotro et al. 2017)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) High construction and design skills.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) High construction and design skills.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The UASB is a Centralized Treatment technology that must be operated and maintained by professionals." (Compendium) High O&M skills required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Life time of pipes, the 3-phase separator, the inlet distribution system and the steel gratings and steps is assumed to be 10 y. [...] The reactors are expected to have a life time of 25 years." (UASB | Griesauer, C. (2014) In a study by Griesauer on the CLARA planning tool the expected lifetimes for UASBs were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0, slow=1)	"Long start-up time", "A UASB is not appropriate for small or rural communities without a constant water supply or electricity. The technology is relatively simple to design and build, but developing the granulated sludge may take several months" (Compendium) Long start up time and no prefab structure, implementation can only be done corresponding to the timeframe of "slow" category. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"Scale/scalability (level 2 of 5 meaning easy to scale): More settlement tanks and filters could be added in sets of three in parallel" (Upflow Filters | Abbott, J. et al. (2019)) A UASB can be scaled up by building new units.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.4, special = 0.4)	"Not all parts and materials may be locally available ", "Critical elements for the design of UASB reactors are the influent distribution system, the gas-solids separator, and the effluent withdrawal design. The gas that rises to the top is collected in a gas collection dome and can be used as energy (biogas)." (Compendium) The UASB requires technical as well as some specially manufactured parts for the influent, effluent and gas systems.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Processed Sludge	Range	Secondary Effluent	Biogas	Airloss	Soilloss	Waterloss	Comments/Specifications	Reference
TP	0.9	-	0.1	0	0	0	0	* as TP	{Tian, 2015 #1423}
	0.98	0.97 - 0.99	0.02	0	0	0	0	* as TP from dairy wastewater - with steel elements	{Jędrzejewska-Cicińska, 2010 #1425}
	0.714	0.577 - 0.851	0.286	0	0	0	0	* as TP from dairy wastewater- without steel, see 35.2.2	{Jędrzejewska-Cicińska, 2010 #1425}
med (R)	0.90	0.577 - 0.99	0.10	0	0	0	0		-
k	2	[0.413]	-	-	-	-	-		PA
TN	0.74	-	0.26	0	0	0	0	* as TN (annamox)	{Tian, 2015 #1423}
	0.7	-	0.3	0	0	0	0	* greater than 70% (annamox)	{Yokota, 2018 #1424}
	0.87	-	0.13	0	0	0	0	* as TN, without recirculation	{Tang, 2010 #1426}
	0.82	-	0.18	0	0	0	0	* as TN, without recirculation	{Tang, 2010 #1426}
	0.79	-	0.21	0	0	0	0	* as TN, without recirculation	{Tang, 2010 #1426}
	0.87	-	0.13	0	0	0	0	* as TN, without recirculation	{Tang, 2010 #1426}
	0.84	-	0.16	0	0	0	0	* as TN, without recirculation	{Tang, 2010 #1426}
	0.83	-	0.17	0	0	0	0	* as TN, without recirculation	{Tang, 2010 #1426}
	0.6	-	0.37	0.03	0	0	0	adapted from biogas_settler)	PA
med (R)	0.82	0.7 - 0.87	0.18	0.03	0	0			-

bal.	0.8	-	0.17	0.03	0	0	0		-
k	25	[0.17]	-	-	-	-	-		PA (see SBR)
H2O	0.93	0.85 - 1	0.02	0	0.05	0	0	See SBR	PA
med (R)	0.93	-	0.02	0	0.05	0	0		-
k	5	[0.15]	-	-	-	-	-		PA
TS	0.35	-	0.65	0	0	0	0	* from 35.2.1	{Musa, 2019 #1422}
	0.36	-	0.64	0	0	0	0	* from 35.2.1	{Musa, 2019 #1422}
	0.37	-	0.63	0	0	0	0	* from 35.2.1	{Musa, 2019 #1422}
	0.22	-	0.78	0	0	0	0	* from 35.2.1	{Musa, 2019 #1422}
	0.17	-	0.83	0	0	0	0	* from 35.2.1	{Musa, 2019 #1422}
	0.17	-	0.83	0	0	0	0	* from 35.2.1	{Musa, 2019 #1422}
	-	-	-	0.5	-	-	-	* at least 50% of the dry matter content is converted to methane (CH4) and carbon dioxide (CO2)	Al Seadi et al. (2013)
	-	-	0.08	-	-	-	-	* see calculations in 28.2.1; TSS: 0.13 (estimation	Sibooli (2013)
	-	-	0.19	-	-	-	-	* as TS reduction in wastewater	Erni et al. (2011)
	-	-	-	0.4	-	-	-	*Organic matter combustion 40-90%; TS assumption 25-	Rose et al. (2015)
	0.41	-	-	-	-	-	-	* balances remainders adapted from biogas_settler)	PA
med (R)	0.35	0.17 - 0.37	0.65	0.45	0	0	0		-
bal.	0.2	-	0.5	0.3	0	0	0		-
k	25	[0.2]	-	-	-	-	-		PA

Additional Information

35.2.1	Data from: {Musa, 2019 #1422}					
Ratio TSS:TS (from horizontal_wetland)	0.39	0.39	0.39	0.39	0.39	0.39
TS (from TSS)	35.1	35.88	37.05	21.84	17.16	16.77

35.2.2	Data from: {Jędrzejewska-Cicińska, 2010 #1425}	
	Min. Removal [%]	**Max. Removal [%]**
Removal with steel	0.97	0.99
Removal without steel (minimum - divided by 1.164)	0.833333333	0.850515464
Removal without steel (maximum -divided by 1.681)	0.577037478	0.588935158
Removal range without steel	(0.577-0.851)	

"Phosphorus removal efficiency in a UASB reactor packed with steel elements was higher by 16.4–68.1% than

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Biogas Reactor			Biogas Reactor			
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	biogas_reactor	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	blackwater, transportedblackwater, sludge, transportedsludge,	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	processed_sludge, transportedprocessed_sludge, biogas, transportedbiogas	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	6	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	"Biogas Reactor technology is appropriate for treating household wastewater as well as wastewater from institutions such as hospitals and schools. It is not suitable for the acute response phase, as the biological environment needs time to establish itself." (Gensch, R. et al. (2018))				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	" No electrical energy required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Organic waste used as substrate should be shredded and mixed with water or digestate prior to feeding. Gas equipment should be carefully and regularly cleaned so that corrosion and leaks are prevented. Grit and sand that have settled to the bottom should be removed." (Compendium) Regular maintenance required.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	"The pressure can be used to transport the biogas through pipes." (Compendium) Inlet/Outlet pipes and connection pipes required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Biogas reactors can be brick-constructed domes or prefabricated tanks" (Compendium) Concrete is not needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.6, special = 0.2)	"If the reactor is properly designed and built, repairs should be minimal" (Compendium) "A Biogas Reactor can be made out of bricks, cement, steel, sand, wire for structural strength (e.g. chicken wire), waterproof cement additive (for sealing), water pipes and fittings, a valve and a prefabricated gas outlet pipe. Prefabricated solutions include geo-bags, reinforced fibre plastic modules, and router moulded units and are available from specialist suppliers." (Emersan) Technical spare parts will be necessary to replace pipes, valves, etc, if it was built locally. Some simple materials, such as chicken wire might also be necessary. Special spare parts might be required for the prefabricated solutions.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0.25, temperate = 0.75, warm = 1, hot = 1)	"Limited gas production below 15 °C" (Compendium) "Biogas Reactors are less appropriate for colder climates as the rate of organic matter conversion into biogas becomes very low." (Emersan) "Biogas plants that produce gas from excreta do not function well in cold temperatures either because the amount of gas produced drops precipitously with the temperature. They cannot be recommended where the temperature in the plant will drop below 5°C." {Leblanc, 2019 #1402} Performance decreases from 15° C to lower temperatures.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"Even though Biogas Reactors are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding." (Emersan) "Biogas reactors can be brick-constructed domes or prefabricated tanks, installed above or below ground" (Emersan) old library: a=0,b=0,c=6,d=12 days per year -> strongly affected These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA

slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"Biogas reactors can be brick-constructed domes or prefabricated tanks, installed above or below ground" (Emersan) Depending on the design (above or below ground), excavation might be necessary.	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.4, b = 0.4, c = 999, d = 999)	About 1.2 - 1.6 m3/cap are needed for a biogas reactor. Assuming a depth of max. 3m of smaller reactors (Eawag, 2021), we define a minimum space requirement of 0.4 m2/cap. "Requires minimum space of of 1.5m x 6m for digester" (BCG, 2014) The number of users is assumed to be a minimum of 5 households upto commercial use.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and skilled construction" (Compendium)	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and skilled construction" (Compendium)	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"The digestate is partially sanitized but still carries a risk of infection. Depending on its end-use, further treatment might be required. There are also dangers associated with the flammable gases that, if mismanaged, could be harmful to human health." (Compendium) "If the reactor is properly designed and built, repairs should be minimal. To start the reactor, it should be inoculated with anaerobic bacteria, e.g., by adding cow dung or Septic Tank sludge. Organic waste used as substrate should be shredded and mixed with water or digestate prior to feeding. Gas equipment should be carefully and regularly cleaned so that corrosion and leaks are prevented. Grit and sand that have settled to the bottom should be removed. Depending on the design and the inputs, the reactor should be emptied once every 5 to 10 years." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Robust technology with a long service life", "Depending on the design and the inputs, the reactor should be emptied and cleaned every 5 to 10 years." (Emersan) "[For Fixed-Dome or Floating Drum Digesters] structure lasts 20+ years" and "[For Plug-Flow Tubular Digesters] structure lasts 5-10 years, more prone to breaking" (BCG, 2014) If the desludging rate lasts at least 5 years, the lifetime of the technology is expected to be more than 5 years and a long service life is expected.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.2, slow=0.8)	"A Biogas Reactor can be made out of bricks, cement, steel, sand, wire for structural strength (e.g. chicken wire), waterproof cement additive (for sealing), water pipes and fittings, a valve and a prefabricated gas outlet pipe. Prefabricated solutions include geo-bags, reinforced fibre plastic modules, and router moulded units and are available from specialist suppliers." "It is not suitable for the acute response phase, as the biological environment needs time to establish itself." "To start the reactor, it should be inoculated with anaerobic bacteria (e.g. by adding cow dung or Septic Tank sludge)." (Compendium) Since a long start up time is required, probabilities are mostly allotted to category "slow" (80%) however, some probability is also allotted to moderate category to account for the improvement in speed of implementation as prefab units are available. (Akanksha Jain)	yes

scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	"Scale/scalability (level 4 of 5 meaning difficult to scale): Not easily scalable for a decentralised model; Prefabricated digesters come in a variety of sizes but likely maximum 8m³ would be efficient for "household" type scale, otherwise you look to develop a centralised type plant; Size of biogas reactor (digester) need to be aligned with volume of influent i.e. toilet blocks not individual latrine; A 4m3 digester serves a kitchen shared by six families. This would need to be scaled accordingly" (Abbott, J. et al. (2019)) Biogas reactors can only be upscaled by building new units. This option is limited since new biogas reactors needed to fit with the existing spatial distribution of latrines.	yes		
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.4, special = 0.3)	"A Biogas Reactor can be made out of bricks, cement, steel, sand, wire for structural strength (e.g. chicken wire), waterproof cement additive (for sealing), water pipes and fittings, a valve and a prefabricated gas outlet pipe. Prefabricated solutions include geo-bags, reinforced fibre plastic modules, and router moulded units and are available from specialist suppliers." (Emersan) Simple materials, such as concrete, as well as technical parts including pipes, valve, etc. are needed to construct a local biogas reactor. Alternatively, biogas reactors can be specially manufactured and prefabricated.	yes		

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Biogas	Range	Processed Sludge	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	1	0	0	0		Bachmann et al. (2015)
med (R)	0	-	1	0	0	0		-
k	100	-	100	-	-	-		PA
TN	0.03	-	0.97	0	0	0		PA
med (R)	0.03	-	0.97	0	0	0		-
k	100	-	100	-	-	-		PA
H2O	0.01	-	0.99	0	0	0		PA
med (R)	0.01	-	0.99	0	0	0		-
k	100	-	100	-	-	-		PA
TS	0.5	-	0.5	0	0	0	* at least 50% of the	Wellinger, A. et al.
	0.4	0.25 - 0.5	0.6	0	0	0	*Organic matter	Rose et al. (2015)
	0.34	-	0.66	0	0	0		Minale and Worku
	0.29	0.25 - 0.33	0.71	0	0	0	* anaerobic	Bachmann et al. (2015)
med (R)	0.34	0.29 - 0.5	0.66	0	0	0		-
bal.	0.38	-	0.62	0	0	0	Spuhler et	-
k	25	[0.21]	25	-	-	-		PA

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Anaerobic Filter

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	anaerobic_filter	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	blackwater, transportedblackwater, greywater, transportedgreywater,	Tilley, E. et al. (2014)
OUTPUT PRODUCT	effluent, transportedeffluent, sludge, transportedsludge	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0.5, neighbourhood = 1, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 0.5, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0.5, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.75, no electricity = 0.5)	"No electrical energy is required" (Emersan), "The main operation and maintenance (O & M) costs are related to the removal of primary sludge and the cost of electricity if pumps are required for discharge (in absence of a gravity flow option)." (Emersan) Electricity is required for pumps that backflush or discharge. It is possible to imagine alternative solutions, e.g. a gravity flow option for discharge, though this might perform less well than an installed pump using electricity. If electric pumps are used, 'intermittent electricity' can work a bit better than 'no electricity', since one can choose to only empty when electricity is available.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.7, continuous = 0.3)	"Scum and sludge levels need to be monitored to ensure that the tank is functioning well. Over time, solids will clog the pores of the filter. As well, the growing bacterial mass will become too thick, break off and eventually clog pores. When the efficiency decreases, the filter must be cleaned. This is done by running the system in reverse mode (backwashing) or by removing and cleaning the filter material. Anaerobic filter tanks should be checked from time to time to ensure that they are watertight." (Compendium) Regular, almost continuous maintenance is required.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	Inlet and outlet pipes are required (Emersan)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.75, difficultly available = 0.75, pumps = 1)	"The main operation and maintenance (O & M) costs are related to the removal of primary sludge and the cost of electricity if pumps are required for discharge (in absence of a gravity flow option)." (Emersan) Pumps can be required for emptying depending on the design. It is assumed that building a gravity-driven configuration performs worse than one with pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"An AF can be made of concrete, sand, gravel, cement, steel, as well as fibreglass, PVC or plastic, and thus can be found as a prefabricated solution." (Emersan) Concrete is one of the possible materials to construct an AF. It is assumed to perform a bit better, as it can seal the AF effectively against the ground and locals have usually experience working with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"An AF can be made of concrete, sand, gravel, cement, steel, as well as fibreglass, PVC or plastic, and thus can be found as a prefabricated solution. Compared to an ABR, additional filter material is necessary, while a pump is not used to empty the sludge. (Emersan) "Filter materials commonly used include gravel, crushed rocks or bricks, cinder, pumice, shredded glass or specially formed plastic pieces (even crushed PVC plastic bottles can be used)." (Emersan) The AF mainly requires a replacement of the filter material, for which different materials are suitable. It is expected that these materials are locally available.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"Anaerobic filters can be installed in every type of climate, although the efficiency is lower in colder climates. " (Compendium) Similar to an ABR.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"Even though AFs are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding. Alternatively, prefabricated modules can be placed above ground." (Emersan) As the ABR, the anaerobic filter should have an emergency bypass if built underground so no problems with flooding occur. These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA

slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Depending on the configuration, anaerobic filters are built underground and therefore require excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.4, b = 0.4, c = 999, d = 999)	Monvois et al. 2012: "The footprint is estimated to be around 0.5 m2/person." To account for uncertainties, we assume a minimum space requirement of 0.4 m2/cap here (Eawag, 2021).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) Similar to an ABR.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) Similar to an ABR.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	Similar to an ABR, but filter material also has to be cleaned. A little bit more elaborate.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Long service life" (Compendium) "An AF requires a start-up period of 6-9 months to reach full treatment capacity as the slow growing anaerobic biomass first needs to be established on the filter media." (Emersan) The start up period suggests that a short lifetime might not be suitable, but this is considered in the criterion "Speed of implementation for treatment".	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.2, slow=0.8)	"An AF can be made of concrete, sand, gravel, cement, steel, as well as fibreglass, PVC or plastic, and thus can be found as a prefabricated solution." "AFs are not suitable for the acute response phase because the biological environment within the AF takes time to establish. The AF is more suitable for the stabilisation and recovery phases and as a longer-term solution" "Maintenance: An AF requires a start-up period of six to nine months to reach full treatment capacity as the slow growing anaerobic biomass first needs to be established on the filter media. To reduce start-up time, the filter can be inoculated with anaerobic bacteria, e.g. by spraying Septic Tank sludge onto the filter material." (Compendium) Since a long start up time is required, probabilities are mostly allotted to category "slow" (80%) however, some probability is also allotted to moderate category to account for the improvement in speed of implementation as prefab units are available. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	"The hydraulic retention time (HRT) is the most important design parameter influencing filter performance and a HRT of 12–36 hours is recommended." (Emersan) AFs are designed for a specific Hydraulic Retention Time and it is not recommended to add further chambers or increase the volume size of a chamber. However, new AFs can be built (e.g. attached to new toilets). These require a new design and complex concrete constructions so that AFs are assigned a scalability performance of 30%. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"An AF can be made of concrete, sand, gravel, cement, steel, as well as fibreglass, PVC or plastic, and thus can be found as a prefabricated solution. Typical filter material should ideally range from 12 to 55 mm in diameter. The size of materials decrease from bottom to top. Filter materials commonly used include gravel, crushed rocks or bricks, cinder, pumice, shredded glass or specially formed plastic pieces (even crushed PVC plastic bottles can be used)." (Emersan) The material required to construct an AF (concrete, gravel,...) is usually locally available.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.53	0.28 - 0.78	0.47	0	0	0	* as PO4-P	{Keating, 2016
med (R)	0.53	0.28 - 0.78	0.47	0	0	0		-
k	5	[0.5]	-	-	-	-		PA
TN	0.15	-	0.85	0	0	0	* as TN	{Conradin, 2010 #973}
med (R)	0.15	-	0.85	0	0	0		-
k	2	-	-	-	-	-		PA
H2O	0.04	-	0.95	0.01	0	0		PA (adapted from ABR)
med (R)	0.04	-	0.95	0.01	0	0		-
k	2	-	-	-	-	-		PA
TS	0.15	-	0.85	0	0	0	* from 38.2.1	{Kang, 2003

	0.12	-	0.88	0	0	0	* from 38.2.2	{Kang, 2003
	0.2	-	0.8	0	0	0	* from 38.2.3	{Kang, 2003
	0.23	-	0.77	0	0	0	* from 38.2.4	{Kang, 2003
med (R)	0.15	0.12 - 0.23	0.85	0	0	0		-
bal.	0.18	-	0.82	0	0	0	Spuhler et	-
k	25	[0.11]	-	-	-	-		PA

Additional Information

38.2.1	Data from: {Kang, 2003 #1434}
HRT [d] = 1	**Min. Removal [%]**
TSS	39
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	15.21
38.2.2	Data from: {Kang, 2003 #1434}
HRT [d] = 0.5	**Min. Removal [%]**
TSS	30
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	11.7
38.2.3	Data from: {Kang, 2003 #1434}
HRT [d] = 2	**Min. Removal [%]**
TSS	52
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	20.28
38.2.4	Data from: {Kang, 2003 #1434}
HRT [d] = 3	**Min. Removal [%]**
TSS	59
horizontal_wetland)	0.39
TS (from TSS)	23.01

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Sequencing Batch Reactor

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	sbr	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	blackwater, transportedblackwater, greywater, transportedgreywater, sludge, transportedsludge, transportedtransferred_sludge	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	processed_sludge, transportedprocessed_sludge, effluent, transportedeffluent	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems (from SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29).
management_level	(household = 0, shared = 0, public = 1)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems (from SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29).
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	3	"The Sequencing Batch Reactor (SBR) process has been successfully applied to more than 1,300 plants in the U.S., Canada, and Europe within the last 25 years." From SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems. (Gensch, R. et al. (2018))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"high electricity consumption (pumping and aeration", "requires continous supply of energy" (NaWaTech Compendium) For aeration a constant energy supply is required.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0, continuous = 1)	"Since the heart of the SBR system is the controls, automatic valves, and automatic switches, these systems may require more maintenance than a conventional activated sludge system." {EPA, 1999 #1385} More O&M than activated sludge.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	Inlet and outlet pipes as well as connecting pipes between tanks are required	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly available = 0.5, pumps = 1)	"Mechanical equipment, such as pumps, aerates and mixers" (NaWaTech Compendium) "Budget level costs include such as the blowers, diffusers, electrically operated valves, mixers, sludge pumps, decanters, and the control panel. " {EPA, 1999 #1385} Desludging pumps are necessary.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0, difficultly available = 0.5, concrete = 1)	"The SBR tank is typically constructed with steel or concrete." {EPA, 1999 #1385}	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.4, special = 0.4)	"Mechanical equipment, such as pumps, aerates and mixers","costly mechanical parts", "highly mechanised equipment (control panel" (NaWaTech Compendium) Diffusers, electrically operated valves, mixers, control panels and other parts are necessary {EPA, 1999 #1385}.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	Assumed to be similar to an ABR.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.9, no flooding=1)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems (from SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29). old library: a=0,b=0,c=6,d=60 days per year -> affected These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes

vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems (from SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29). As for other treatment technologies, the configuration built underground is mostly more practical because the water does not need additional pumping. However, we assume that it can be also built above ground.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.12, b = 0.12, c = 999, d = 999)	Requires at least 0.12 m2/cap. Table 1.3 (Dotro et al. 2017)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems (from SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29).	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems (from SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29).	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.5, professional = 1)	Adapted from activated sludge, since the Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems (from SSWM: https://sswm.info/step-nawatech/module-1-nawatech-basics/appropriate-technologies-0/sequence-batch-reactor-%28sbr%29).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"For the civil works a life expectancy of 25 years is assumed. Mechanical and electrical components are expected to last for 10 years." [A specific assessment in Ethiopia showed a 25 year lifetime before reinvestment was required.] (SBR |Griesauer, C. (2014)). In a study by Griesauer on the CLARA planning tool the expected lifetimes for SBRs were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.5, slow=0.5)	Same as Activated Sludge Technology since this is just a variant of the same (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"For small treatment plants the SBR setup has the advantage of avoiding redundant system components compared to conventional activated sludge plants and the modular structure allows for a simple upscaling of the treatment plant (DWA, 2009). The possibility to change cycle times provides operational flexibility without requiring any constructive measures (DWA, 2009; WSP, 2007). Hydraulic and organic shock loads can be tolerated well (WSP, 2007), because during the filling stage the SBR tank itself acts as an equalisation basin (US-EPA, 1999)." (Griesauer, C., (2014)) "Resistant against shock-loads and applicable for a large range of organic and hydraulic loading rates." (NaWaTech Compendium) A SBR is able to deal with higher levels of organic and hydraulic loading rates and therefore a small to medium increase in the number of users. To scale up the operation cycle times can be adapted. For larger upscaling an additional reactor could be constructed. (Kukka Ilmanen,	yes

construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.5, special = 0.3)	"Mechanical equipment, such as pumps, aerators and mixers", "costly mechanical parts", "highly mechanised equipment (control panel)" (NaWaTech Compendium) Diffusers, electrically operated valves, mixers, control panels and other parts are necessary {EPA, 1999 #1385}. An SBR requires a lot of technical parts. Additionally, we assume that the controlling system might require even some parts from special manufacturers. (Kukka Ilmanen, Eawag 2021)	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Processed Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.88	-	0.12	0	0	0	* pathways for PO4-P	Hamader and Javorszky (2014)
	0.74	-	0.26	0	0	0	* see calculations in 26.2.1	Wilderer et al. (2000)
	0.73	0.44 - 0.98	0.27	0	0	0	* TC_effluent given (=1 – PO4-P removal) see calculations in 26.2.2	Bernal-Martínez et al. (2000)
med (R)	0.74	0.44 - 0.98	0.26	0	0	0		-
k	2	[0.54]	-	-	-	-		PA
TN	0.22	-	0.14	0.64	0	0	* pathways for TN	Hamader and Javorszky (2014)
	0.26	-	0.06	0.68	0	0	* Effluent TC: see calculations in 26.2.1; other values estimated based on removal distribution ratio in 26.2.5	Wilderer et al. (2000)
	0.23	-	0.19	0.58	0	0	* TC_effluent given (=1 - NH4-N removal) see calculations in 26.2.2; other values estimated based on removal distribution ration in 26.2.5	Bernal-Martínez et al. (2000)
	0.25	-	0.05	0.7	0	0	* Aerobic granular sludge SBR; TC_TN pathways given	Lochmatter et al. (2014)
	0.29	0.27 - 0.3	0.1	0.61	0	0	* continuous influent SBR, calculations see 26.2.4	Xylem (2015)
med (R)	0.25	0.22 - 0.3	0.10	0.64	0	0		-
bal.	0.24	-	0.12	0.64	0	0		-
k	2	[0.08]	-	-	-	-		PA
H2O	0.02	0 - 0.05	0.93	0.05	0	0		PA
med (R)	0.02	0 - 0.05	0.93	0.05	0	0	Spuhler et al. (2021)	-
k	25	[0.05]	-	-	-	-		PA
TS	0.64	-	0.36	0	0	0	*Given is TSS to sludge: 0.82; TS estimated from ratio in 26.2.6	Hamader and Javorszky (2014)
	0.75	-	0.25	0	0	0	* TSS to sludge: 0.95; TS estimated from ratio in 26.2.6	Keller et al. (2001)
	0.78	-	0.22	0	0	0	* PIG SLURRY	Zhu et al. (2006)
med (R)	0.75	0.64 - 0.78	0.25	0	0	0		-
k	25	[0.14]	-	-	-	-		PA

Additional Information

26.2.1	Data from: Wilderer et al. (2000)					
	TN [mg/L]		**TP [mg/L]**		**TC_Effluent**	
	Influent	**Effluent**	**Influent**	**Effluent**	**TN**	**TP**
Min	25	44320	5	0.6	0.18	0.12
Ave	62	44328	44418	44410	0.2	0.26
Max	87	20	17	44320	0.23	0.26
TC Median					0.2	0.26

26.2.2	Data from: Bernal-Martínez et al. (2000)	
Sludge Age days	**PO4-P removal [%]**	**NH4- N removal [%]**
3	0.53	-
6	0.44	0.48
16	0.95	1
23	0.98	0.94
Mean	0.73	0.81

26.2.3	Data from: Keller et al. (2001)		
	Influent [mg/L]	**Effluent [mg/L]**	**TC_effluent**
TSS	260	13	0.05
TN	54	44233	0.11
TP	35247	0.17	0.02
Calculation			TC_Effluent= Content Effluent / Content Influent

26.2.4	Data from: Xylem (2015)			
	0h	**4h**	**6h**	**Average**
TC_TN to effluent	0.17	0.087	0.055	0.1
TC_TN to sludge	0.3	0.27	0.29	0.29
TC_TN to Gas	0.53	0.65	0.66	0.61
26.2.5				

Ratio TC_Sludge: TC_Airloss (for TN pathway estimations)			
Data Source	**TC_Sludge**	**TC_Airloss**	
Hamader and Javorszky (2014)	0.22	0.64	
Lochmatter et al. (2014)	0.25	0.7	
Xylem (2015)	0.29	0.61	
Mean	0.25	0.65	
Removal Distribution (%)	0.28	0.72	
26.2.6	Data from: Zhu et al. (2006)		
TS removal [%]	**TSS removal [%]**	**Ratio**	
0.782	0.995	0.786	
Calculation		Ratio= TS Removal/ TSS removal	

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Waste Stabilization Ponds						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	wsp	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	transportedblackwater, transportedgreywater,	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	transportedsludge, transportedsecondary_effluent	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	7	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"No electrical energy is required" (Compendium/Emersan)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Scum that builds up on the pond surface should be regularly removed. Aquatic plants (macrophytes) that are present in the pond should also be removed as they may provide a breeding habitat for mosquitoes and prevent light from penetrating the water column." (Compendium) Regular maintenance is required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	Inlet and outlet pipes (Emersan)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	"No electrical energy is required", "natural wind mixing" (Emersan) "Sludge can be removed using a raftmounted sludge pump, a mechanical scraper at the bottom of the pond or by draining and dewatering the pond and removing the sludge with a front-end loader." (Emersan) No pumps are needed. Sludge pumps can though be used to remove the sludge. There are two other options for desludging without pumps (mechanical sccraper, draining&dewatering) that are assumed to perform equally well.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"To prevent leaching into the groundwater, the ponds should have a liner. The liner can be made from clay, asphalt, compacted earth, or any other impervious material." (Compendium) Technology should be watertight, but the liner does not appear to be made from concrete. No concrete required.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.6, technical = 0.4, special = 0)	"To prevent leaching into groundwater, the ponds should have a liner, which can be made from clay, asphalt, compacted earth, or any other impervious material.", "Facultative ponds' [...] efficiency may be improved with the installation of mechanical aerators.","Sludge can be removed using a raftmounted sludge pump, a mechanical scraper at the bottom of the pond or by draining and dewatering the pond and removing the sludge with a front-end loader." (Emersan) Only local low tech material is required, however further aerations, scrapers and pumps can be added that might need technical spare parts.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"In the psychrophilic temperature region, digestion becomes slower when temperatures decrease below 15°C, but never stops." The temperature can even be as low as -45° (G. E. ALEXIOU* AND D. D. MARA (2003)) It is assumed there's no change in performance for higher temperatures	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.6, no flooding = 1)	"The pond system must be protected from general flooding, for ponds, inlet and outlet devices, and other features can be damaged or destroyed by floodwaters and accompanying debris. Floodwaters containing large amounts of sediments may, through deposition and erosion, completely destroy an inadequately protected waste stabilization pond." (WHO, 1987) "It should be verified whether the land is floodable and the maximum flood levels, for definition of the height of the embankments" (Sperling (2007)) WSPs need to be built flood proof and therefore require more effort if frequent flooding occurs. But they can be built in a way that protects them against flooding. This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. Process wise, flooding or entry of surface run-off can be considered to be more critical for drying beds than ponds and wetlands, therefore technologies of the latter two type are awarded a slightly higher performance of 60% (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"Anaerobic ponds are built to a depth of 2 to 5 m..." (Compendium) Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 10, b = 10, c = 999, d = 999)	From European Commission (2002).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium) It is assumed that the construction is slightly less difficult than for example a conventional sewer.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) The designer needs to account for retention time, wastewater flow, slope, soil type etc. (Sperling (2007))	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	" Scum that builds up on the pond surface should be regularly removed. Aquatic plants (macrophytes) that are present in the pond should also be removed as they may provide a breeding habitat for mosquitoes and prevent light from penetrating the water column. " (Compendium) Maintenance does not require specially skilled labour.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"WSPs are not suitable for the acute response phase due to the long implementation time needed and are more appropriate for the stabilisation and recovery phases and as a longer-term solution." (Emersan) The fact that WSPs are not suitable for short lifetimes due to the long implementation time is not considered in the criterion 'Lifetime' and instead part of the criterion 'Speed of Implementation'. (Kukka Ilmanen, Eawag 2021) "Life time of the pump, pipes and of baffle walls is assumed to be 10 y. [...] The ponds are expected to have a life time of 25 years." [Assessments in Ethiopia expect 20 years lifetime for most parts and the civil works associated with the pond may serve up to 40 years.] (WSP | Griesauer, C. (2014) In a study by Griesauer on the CLARA planning tool the expected lifetimes for WSPs were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0, slow=1)	"WSPs are not suitable for the acute response phase due to the long implementation time needed and are more appropriate for the stabilisation and recovery phases and as a longer-term solution." (Compendium) Long start up time (anaerobic pond) and no prefab structure, implementation can only be done corresponding to the timeframe of "slow" category. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	"Scale/scalability (of anaerobic lagoon is level 5 of 5 meaning difficult to scale): Centralised treatment process, scale up possible by adding new treatment units (e.g. anaerobic lagoons) in parallel; [...] Smaller sized anaerobic lagoons could be constructed according to context but the minimum scale is still a 'centralised system'; A key advantage of the anaerobic lagoons is that the 1.5 year solids residence time provides sufficient time to build phase 2 treatment and finish the treatment train over a period in which all waste is contained" (Abbott, J. et al. (2019)) A case study on anaerobic lagoons in Cox Bazaar showed that they are very difficult to scale. These lagoons represent the first anaerobic pond in a Waste Stabilisation Pond System and WSPs are therefore very difficult to scale. It is possible to scale up the technology by adding further anaerobic, facultative and maturations ponds and using them in parallel. However, due to their size these can be difficult to excavate and construct. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.6, technical = 0.4, special = 0)	"Mechanical equipment is necessary to dig ponds. To prevent leaching into groundwater, the ponds should have a liner, which can be made from clay, asphalt, compacted earth, or any other impervious material.", "Facultative ponds' [...] efficiency may be improved with the installation of mechanical aerators.", "Sludge can be removed using a raftmounted sludge pump, a mechanical scraper at the bottom of the pond or by draining and dewatering the pond and removing the sludge with a front-end loader." (Emersan) Mechanical equipment required for digging and constructing the WSP. Aerators, scrapers, pumps can be added to the design, which require technical parts.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Secondary Effluent	Airloss	Soilloss	Waterloss	Comments/	Reference
TP	0.56	-	0.44	0	0	0	* TP pathways	Hamader and
	0.37	0.32 - 0.41	0.63	0	0	0		Xian-Hua (1994)
med (R)	0.56	0.32- 0.56	0.44	0	0	0		-
bal.	0.47	-	0.53	0	0	0		-
k	5	[0.24]	-	-	-	-		PA
TN	0.24	-	0.28	0.48	0	0	* TN pathways	Hamader and
	0.2	-	0.2	0.6	0	0	* TN removal	Conradin et al. (2010)
	0.22	-	0.33	0.45	0	0	* N removal	Ho et al. (2017)
	0.25	-	0.24	0.51	0	0	* Ammonia removal	Soares et al. (1996)
med (R)	0.24	0.2-0.25	0.28	0.48	0	0		-
bal.	0.24	-	0.26	0.50	0	0		-
k	2	[0.05]	-	-	-	-		PA
H2O	0.05	-	0.9	0.05	0	0	*PA	
med (R)	0.05	-	0.90	0.05	0	0		-
k	5	-	-	-	-	-	Spuhler et	PA
TS	0.43	-	0.59	0	0	0	* TSS removal:	Hamader and
	0.35	-	0.68	0	0	0	*TSS removal	Conradin et al. (2010)
	0.45	-	0.55	0	0	0	* TS removal	Alcocer et al. (1993)
med (R)	0.43	0.35 -0.45	0.59	0	0	0		-
bal.	0.42	-	0.58	0	0	0		-
k	25	[0.1]	-	-	-	-		PA

Additional Information

29.2.1	Data from: Alcocer et al. (1993)		
	Removal Efficiency	**TC_Effluent**	**Ratio TS:TSS removal**
TS	0.45	0.55	
TSS	0.6	0.4	0.75
TDS	0.43	0.57	
Calculation		TC_Effluent = 1- Removal efficiency	Ratio= Removal TS / Removal TSS
29.2.2	Data from:Hamader and Javorszky (2014)		
	TC Sludge	**TC Effluent**	**TC Airloss**
Removal	0.24	0.28	0.48
Removal Distribution	33%	67%	
Calculation	Removal to sludge= TC_Sludge / (TC_Sludge + TC_Airloss)		Removal to airloss= TC_Airloss / (TC_Sludge + TC_Airloss)

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Free-Water Surface Constructed Wetland		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	free-water_wetland	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	effluent, transportedeffluent, greywater, transportedgreywater, stormwater, transportedstormwater	Tilley, E. et al. (2014)
OUTPUT PRODUCT	secondary_effluent, transportedsecondary_effluent	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0.5, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0.5, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	8	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Assumption the same values apply for free-water wetlands. (Gensch, R. et al. (2018))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"No electrical energy is required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Regular maintenance should ensure that water is not short-circuiting, or backing up because of fallen branches, garbage, or beaver dams blocking the wetland outlet. Vegetation may have to be periodically cut back or thinned out." (Compendium) Regular maintenance.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	"Wastewater can be fed into the wetland, using weirs or by drilling holes in a distribution pipe, to allow it to enter at evenly spaced intervals." Inlet and outlet pipes for effluent required. (Compendium)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"The channel or basin is lined with an impermeable barrier (clay or geo-textile) covered with rocks, gravel and soil and planted with native vegetation (e.g., cattails, reeds and/or rushes)." (Compendium) Technology should be watertight, but the liner does not appear to be made from concrete. No concrete required.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium) No technical or special parts are required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"This technology is best suited for warm climates, but can be designed to tolerate some freezing and periods of low biological activity." (Compendium) Assumed to be comparable to a WSP.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.6, no flooding = 1)	Assumed to be comparable to a WSP. "Constructed wetlands are also used as a flood protection measure." (Stefanakis, 2019) This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. Process wise, flooding or entry of surface run-off can be considered to be more critical for drying beds than ponds and wetlands, therefore technologies of the latter two type are awarded a slightly higher performance of 60% (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 3, b = 3, c = 999, d = 999)	The same value as for the horizontal flow wetland is applied here, as both "require a large land area" (Compendium) and differences in terms of space requirements are expected to be insignificant due to the similar nature of the technologies (Eawag, 2021).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium) See WSP.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) See WSP.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	O&M includes declogging and eventual cutting back of vegetation (Compendium).	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Long service life" (Emersan) A long service life similar to the horizonal subsurface flow constructed wetland is assumed. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0, slow=1)	"In principle, Constructed Wetlands can be built using locally available material, however, availability of sand and gravel (with required grain size distribution and cleanliness) is often a problem. Additional materials include a liner or clay, wetland plants, and a syphon or pump for intermittent loading. They are typically not suit able for pre-fabrication." "Wetland plants take time to become established, therefore the start-up time for Constructed Wetlands is quite long. Thus this technology is not suitable for the acute response phase but for the stabilisation and recovery periods and as a longer-term solution." (Emersan Compendium) Long start up time and no prefab structure, implementation can only be done corresponding to the timeframe of "slow" category. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	It is assumed that new wetland beds can be added though it requires a long start-up time. Similar scalability as for vertical wetlands is assumed.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Secondary Effluent	Range	Soilloss	Airloss	Waterloss	Comments	Reference
TP	0.512	-	0.488	0	0	* as TP removal efficiency	{Vymazal, 2007 #103}
	0.66	-	0.34	0	0	* as TP removal efficiency	{Vymazal, 2010 #1436}
	0.51	-	0.49	0	0	* as TP removal efficiency	{Vymazal, 2010 #1436}
	0.65	-	0.35	0	0	* as TP removal efficiency	{Vymazal, 2010 #1436}
	0.5	-	0.5	0	0	* as TP removal efficiency	{Vymazal, 2010 #1436}
med (R)	0.51	0.5 - 0.66	0.49	0	0		-
k	25	[0.16]	-	-	-		PA
TN	0.588	-	0.412	0	0	* as TN removal efficiency	{Vymazal, 2007 #103}
	0.55	-	0.45	0	0	* as TN removal efficiency	{Vymazal, 2010 #1436}
	0.53	-	0.47	0	0	* as TN removal efficiency	{Vymazal, 2010 #1436}
	0.59	-	0.41	0	0	* as TN removal efficiency	{Vymazal, 2010 #1436}
	0.42	-	0.58	0	0	* as TN removal efficiency	{Vymazal, 2010 #1436}
med (R)	0.55	0.42 - 0.59	0.45	0	0		-
k	25	[0.17]	-	-	-		PA
H2O	0.8	0.95 - 0.73	0	0.16	0	Adapted from "horizontal_wetland"	Spuhler et al. (2021)
	0.82	0.75 - 0.97	0	0.15	0	Adapted from "horizontal_wetland"	PA
	-	-	0.03	-	-	Adapted from "horizontal_wetland"	PA
med (R)	0.8	0.73 - 0.97	0	0.16	0		-
bal.	0.81	-	0.03	0.16	0		-
k	5	[0.24]	-	-	-		PA
TS	0.7	-	0.3	0	0	* from 40.2.2	{Vymazal, 2010 #1436}
	0.735	-	0.265	0	0	* from 40.2.3	{Vymazal, 2010 #1436}
med (R)	0.72	0.7 - 0.735	0.28	0	0		-
k	100	[0.035]	-	-	-		PA

Additional Information

Usually the removal efficiency stands for the fraction of the substance retained in the sludge. However, since constructed wetlands do not carry sludge as an output product (but biomass), the removal rate represents the soil loss. It has to be taken into account that if the resulting biomass of a wetland is used for alternative

40.2.2	Data from: {Vymazal, 2010 #1436}
HLR [cm/d]	*3.1
	Removal [%]
TSS	77
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	*30.03
40.2.3	Data from: {Vymazal, 2010 #1436}
HLR [cm/d]	*3.3
	Removal [%]
TSS	68
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	26.52

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Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Horizontal Subsurface Flow Constructed Wetland

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	horizontal_wetland	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	blackwater, transportedblackwater, effluent, transportedeffluent, greywater,	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	secondary_effluent, transportedsecondary_effluent	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: AND	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0.5, neighbourhood = 1, city = 0.5)	Tilley, E. et al. (2014)
management_level	(household = 0.5, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	8	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"No electrical energy is required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"During the first growing season, it is important to remove weeds that can compete with the planted wetland vegetation. With time, the gravel will become clogged with accumulated solids and bacterial film. The filter material at the inlet zone will require replacement every 10 or more years. Maintenance activities should focus on ensuring that primary treatment is effective at reducing the concentration of solids in the wastewater before it enters the wetland. Maintenance should also ensure that trees do not grow in the area as the roots can harm the liner." (Compendium) Regular maintenance.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	"A wide inlet zone should be used to evenly distribute the flow. A well-designed inlet that allows for even distribution is important to prevent short-circuiting. The outlet should be variable so that the water surface can be adjusted to optimize treatment performance." Inlet and outlet pipes for effluent required. (Compendium)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps required	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"The bed should be lined with an impermeable liner (clay or geotextile) to prevent leaching.", "Small, round, evenly sized gravel is most commonly used to fill the bed" (Compendium) Technology should be watertight, but the liner does not appear to be made from concrete. No concrete required.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials and local labourers" (Horizontal subsurface flow CW | SSWM Toolbox) No technical or special parts are required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	"This technology is best suited for warm climates, but can be designed to tolerate some freezing and periods of low biological activity." (Compendium) Assumed to be comparable to a WSP.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.6, no flooding = 1)	Assumed to be comparable to a WSP. "Constructed wetlands are also used as a flood protection measure." (Stefanakis, 2019) This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. Process wise, flooding or entry of surface run-off can be considered to be more critical for drying beds than ponds and wetlands, therefore technologies of the latter two type are awarded a slightly higher performance of 60% (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Assuming that shallow and wide excavation is necessary.	yes

surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 3, b = 3, c = 999, d = 999)	Requires at least 3 m2/cap. From Table 1.3 (Dotro et al. 2017)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) The construction is slightly more elaborate than a free-water wetland.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) The construction is slightly more elaborate than a free-water wetland.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Regular maintenance should ensure that water is not short-circuiting, or backing up because of fallen branches, garbage, or beaver dams blocking the wetland outlet. Vegetation may have to be periodically cut back or thinned out." (Compendium) For maintenance, low skills suffice.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Long service life" (Emersan) "Some constructed wetlands have now been in continuous operation for over 20 years and these plants are still producing good treatment results" (Hoffmann et al. (2011)) "Life expectancy for the pumps and pump equipment is assumed to be 10 y. [...] All other items such as filter material, plant cover, liner, drain pipes in the filter, manholes, piping between the beds and the pump station are expected to last for 25 years." [Assessments in Ethiopia expect 20 years lifetime, in Kenia 20-25 years and a study in Morocco suggests a replacement of the filter material every 8-15 years.] (HFCW | Griesauer, C. (2014) In a study by Griesauer on the CLARA planning tool the expected lifetimes for HFCWs were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0, slow=1)	"In principle, Constructed Wetlands can be built using locally available material, however, availability of sand and gravel (with required grain size distribution and cleanliness) is often a problem. Additional materials include a liner or clay, wetland plants, and a syphon or pump for intermittent loading. They are typically not suit able for pre-fabrication." "Wetland plants take time to become established, therefore the start-up time for Constructed Wetlands is quite long. Thus this technology is not suitable for the acute response phase but for the stabilisation and recovery periods and as a longer-term solution." (Emersan Compendium) Long start up time and no prefab structure, implementation can only be done corresponding to the timeframe of "slow" category. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	"The design of a horizontal subsurface flow constructed wetland depends on the treatment target and the amount and quality of the influent. It includes decisions about the amount of parallel flow paths and compartmentation. The removal efficiency of the wetland is a function of the surface area (length multiplied by width), while the cross-sectional area (width multiplied by depth) determines the maximum possible flow." (Compendium) It is assumed that new wetland beds can be added though it requires a long start-up time and needs to be designed well. Similar scalability as for vertical wetlands is assumed.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials and local labourers" (Horizontal subsurface flow CW | SSWM Toolbox)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Secondary Effluent	Range	Soilloss	Airloss	Waterloss	Comments/	Reference
TP	0.589	-	0.411	0	0	* as TP removal efficiency	{Vymazal, 2007 #103}
	0.5	-	0.5	0	0	* as TP removal efficiency	{Vymazal, 2010 #1436}
med (R)	0.54	0.5 - 0.589	0.46	0	0		-
k	100	[0.089]	-	-	-		PA
TN	0.577	-	0.423	0	0	* as TN removal efficiency	{Vymazal, 2007 #103}
	0.57	-	0.43	0	0	* as TN removal efficiency	{Vymazal, 2010 #1436}
	0.67	-	0.33	0	0	* as TN removal efficiency	{Vymazal, 2010 #1436}
	-	-	-	0.12	-	* NH3 volatilization of CW treating swine manure	Poach et al. (2002)
med (R)	0.58	0.57 - 0.67	0.42	0.12	0		-
bal.	0.46	-	0.42	0.12	0		-
k	100	[0.1]	-	-	-		PA
H2O	0.8	0.95 - 0.73	0	0.16	0	* ET rates given	Headley et al. (2012)

	0.82	0.75 - 0.97	0	0.15	0	* ET rates given	Consoli et al. (2018)
	-	-	0.03	-	-		PA
med (R)	0.81	0.73 - 0.97	0.03	0.16	0		Spuhler et al. (2021)
bal.	0.81	-	0.03	0.16	0		-
k	5	[0.24]	-	-	-		
TS	0.66	-	0.34	0	0	* TSS removal = 80 - 95 %, TS estimated from ratio in 30.2.1	Conradin et al. (2010)
	0.71	-	0.29	0	0	* TSS removal 75%; TS estimated from ratio in 30.2.1	{Vymazal, 2010 #1436}
med (R)	0.69	0.66 - 0.71	0.32	0	0		-
bal.	0.68	-	0.32	0	0		-
k	100	[0.05]	-	-	-		PA

Additional Information

Usually the removal efficiency stands for the fraction of the substance retained in the sludge. However, since constructed wetlands do not carry sludge as an output product (but biomass), the removal rate represents the soil loss. It has to be taken into account that if the resulting biomass of a wetland is used for alternative products,

30.2.1	Data from Chandrakanth et al. (2016)	
	Relation TS - TSS – TDS in lab scale experiment CW	**Ratio to TS**
Removal TS	0.1563	
Removal TSS	0.4	0.39
Removal TDS	0.1111	1.41

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Vertical Flow Constructed Wetland		
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	vertical_wetland	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	blackwater, transportedblackwater, effluent, transportedeffluent, greywater,	Tilley, E. et al. (2014)
OUTPUT PRODUCT	secondary_effluent, transportedsecondary_effluent	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0.5, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0.5, shared = 0.5, public = 1)	Tilley, E. et al. (2014)
capex_req_level	8	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"Because of the mechanical dosing system, this technology is most appropriate where trained maintenance staff, constant power supply, and spare parts are available." (Compendium) Constant power supply should be provided.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.3, regular = 0.7, continuous = 0)	"Less clogging than in a Horizontal Subsurface Flow Constructed Wetland" (Compendium) Clogging and therefore maintenance should happen less often than for a Horizontal Subsurface Flow Constructed Wetland.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	"A ventilation pipe connected to the drainage system can contribute to aerobic conditions in the filter." Inlet and outlet drainage pipes for effluent are required. (Compendium) Additionally ventilation pipes might be necessary.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficultly available = 0.75, pumps = 1)	"In vertical filter beds wastewater is intermittently applied (either by pump or self-acting syphon device) ", "Therefore, vertical filters always need pumps or at least siphon pulse loading, whereas horizontal flow constructed wetlands can be operated without pumps (if topography allows).", "Electricity pumps may be necessary", "Even distribution on a filter bed requires a well-functioning pressure distribution with pump or siphon." (SSWM Toolbox) The mechanical dosing system does not necessarily require a pump, however a pump will perform better than as syphon device.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Each filter should have an impermeable liner and an effluent collection system." (Compendium) Technology should be watertight, but it is not stated that the liner is made from concrete. It is assumed that similar to the other wetland technologies, no concrete is required.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.6, special = 0.1)	"Not all parts and materials may be locally available", "Because of the mechanical dosing system, this technology is most appropriate where trained maintenance staff, constant power supply, and spare parts are available.", "Each filter should have an impermeable liner and an effluent collection system. A ventilation pipe connected to the drainage system can contribute to aerobic conditions in the filter. Structurally, there is a layer of gravel for drainage (a minimum of 20 cm), followed by layers of sand and gravel." (Compendium) "High quality filter material is not always available and expensive", (SSWM Toolbox) Simple material or possibly special material is required for the filter. Technical parts are required for the ventilation, dosing and drainage system.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.6, cold = 0.8, temperate = 1, warm = 1, hot = 1)	The performance depending on the temperature is assumed to be comparable to other wetlands. However, less space is required for warmer climates (annual average >20° C) (SSWM Toolbox) "Not very tolerant to cold climates", "In cold climates (annual average < 10°C), an area of 4 m2/p.e. is necessary. In warmer climates (annual average > 20°C), 1.2 m2/p.e. is enough, if the filter is designed correctly (HOFFMANN et al. 2011)." (SSWM Toolbox)	yes

flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.6, no flooding = 1)	Assumed to be comparable to a WSP. "Constructed wetlands are also used as a flood protection measure." (Stefanakis, 2019) This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. Process wise, flooding or entry of surface run-off can be considered to be more critical for drying beds than ponds and wetlands, therefore technologies of the latter two type are awarded a slightly higher performance of 60% (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 1.2, b = 1.2, c = 999, d = 999)	Requires at least 1.2 m2/cap. From Table 1.3 (Dotro et al. 2017)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction, particularly, the dosing system" (Compendium) High construction and design skills necessary.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	" Requires expert design and construction, particularly, the dosing system" (Compendium) High construction and design skills necessary.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	The operation and maintenance is not very elaborate.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Long service life" (Emersan) "Life expectancy for the pumps and pump equipment and for the siphon is assumed to be 10 y. [...] All other items such as filter material, plant cover, liner, drain pipes in the filter, manholes, piping between the beds and the pump station are expected to last for 25 years."[Assessments in Ethiopia expect 20 years lifetime, in Kenia 20-25 years and a study in Morocco suggests a replacement of the filter material every 8-15 years.] (VFCW | Griesauer, C. (2014) In a study by Griesauer on the CLARA planning tool the expected lifetimes for VFCWs were larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0, slow=1)	"In principle, Constructed Wetlands can be built using locally available material, however, availability of sand and gravel (with required grain size distribution and cleanliness) is often a problem. Additional materials include a liner or clay, wetland plants, and a syphon or pump for intermittent loading. They are typically not suit able for pre-fabrication." "Wetland plants take time to become established, therefore the start-up time for Constructed Wetlands is quite long. Thus this technology is not suitable for the acute response phase but for the stabilisation and recovery periods and as a longer-term solution." (Emersan Compendium) Long start up time and no prefab structure, implementation can only be done corresponding to the timeframe of "slow" category. (Akanksha Jain)	yes

scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	"Scale/scalability: CW have a relatively large footprint area per volume treated; The CW technology can be scaled up to municipal scale however the area required will be the limiting factor; Care is need at larger scale to ensure good distribution of influent and avoid short circuiting; Large-scale CW are normally made up of smaller CW beds with alternating use" (Abbott, J. et al. (2019)) It is assumed that new wetland beds can be added though it requires a long start-up time and needs to be designed well (avoid sort-circuiting).	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.5, special = 0.1)	"Not all parts and materials may be locally available", "Because of the mechanical dosing system, this technology is most appropriate where trained maintenance staff, constant power supply, and spare parts are available.", "Each filter should have an impermeable liner and an effluent collection system. A ventilation pipe connected to the drainage system can contribute to aerobic conditions in the filter. Structurally, there is a layer of gravel for drainage (a minimum of 20 cm), followed by layers of sand and gravel." (Compendium) "High quality filter material is not always available and expensive" (SSWM Toolbox) Simple material or possibly special material is required for the filter. Technical parts are required for the ventilation and drainage system.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Secondary Effluent	Range	Soilloss	Airloss	Waterloss	Comments	Reference
TP	0.405	-	0.595	0	0	* as TP removal efficiency	{Vymazal, 2007 #103}
	0.44	-	0.56	0	0	* as TP removal efficiency	{Vymazal, 2010 #1436}
med (R)	0.42	0.405 - 0.44	0.58	0	0		-
k	100	[0.035]	-	-	-		PA
TN	0.554	-	0.446	0	0	* as TN removal efficiency	{Vymazal, 2007 #103}
	0.57	-	0.43	0	0	* as TN removal efficiency	{Vymazal, 2010 #1436}
med (R)	0.56	0.554 - 0.57	0.44	0	0		-
k	100	[0.016]	-	-	-		PA
H2O	0.8	0.95 - 0.73		0.16	0	Adapted from "horizontal_wetland"	PA
	0.82	0.75 - 0.97		0.15	0	Adapted from "horizontal_wetland"	PA
	-	-	0.03	-	-	Adapted from "horizontal_wetland"	PA
med (R)	0.81	0.73 - 0.97	0.03	0.16	0		-
bal.	0.81	-	0.03	0.16	0		-
k	5	[0.24]	-	-	-		PA
TS	0.653	-	0.347	0	0	* from 39.2.2	Spuhler et al. (2021)
med (R)	0.65	-	0.35	0	0		-
k	1	-	-	-	-		PA

Additional Information

Usually the removal efficiency stands for the fraction of the substance retained in the sludge. However, since constructed wetlands do not carry sludge as an output product (but biomass), the removal rate represents the soil loss. It has to be taken into account that if the resulting biomass of a wetland is used for alternative products,

39.2.2	Data from: {Vymazal, 2010 #1436}
	Removal [%]
TSS	89
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	34.71

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Aerated Pond

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	aerated_pond	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	transportedblackwater, transportedgreywater,	Tilley, E. et al. (2014)
OUTPUT PRODUCT	transportedsludge, transportedsecondary_effluent	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Adapted from Waste stabilisation ponds (WSP), since the configuration is similar to a large extent. (Akanksha Jain based on Gensch, R. et al. (2018))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"High energy consumption, a constant source of electricity is required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.5, continuous = 0.5)	"Permanent, skilled staff is required to maintain and repair aeration machinery and the pond must be desludged every 2 to 5 years." (Compendium) Regular to continuous maintenance is required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	In- and outlet pipes are required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps are necessary.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"To prevent leaching, the pond should have a liner. This can be made from clay, asphalt, compacted earth, or any other impervious material. A protective berm should be built around the pond, using the fill that is excavated, to protect it from runoff and erosion." (Compendium) Technology should be watertight, but the liner does not appear to be made from concrete. No concrete required.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.6, technical = 0.4, special = 0)	"Not all parts and materials may be locally available", "To prevent leaching, the pond should have a liner. This can be made from clay, asphalt, compacted earth, or any other impervious material.", "Mechanical aerators provide oxygen and keep the aerobic organisms suspended and mixed with water to achieve a high rate of organic degradation.", " It is especially important that electricity service is uninterrupted and that replacement parts are available to prevent extended downtimes that may cause the pond to turn anaerobic." (Compendium) Technical spare parts are required and should be accessible quickly. Some simple spare parts might also be required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.7, cold = 0.9, temperate = 1, warm = 1, hot = 1)	"Aerated lagoons can function in a larger range of climates than Waste Stabilization Ponds (T.5) " , " As well, because oxygen is introduced by the mechanical units and not by light-driven photosynthesis, the ponds can function in more northern climates" (Compendium) Performance in lower temperatures is assumed to be higher than the performance of a WSP.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.6, no flooding = 1)	It is assumed that aerated ponds are as prone to flooding as WSPs. This is a technology that is necessarily built on the ground surface and its raised configuration is not possible. (e.g., all pond-based, wetlands, drying beds etc.). Note: All pond-based/wetland/drying bed technologies are allotted similar performance values. Their functioning can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. Process wise, flooding or entry of surface run-off can be considered to be more critical for drying beds than ponds and wetlands, therefore technologies of the latter two type are awarded a slightly higher performance of 60% (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA

soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Assuming that shallow and wide excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 1.5, b = 1.5, c = 999, d = 999)	From European Commission (2001).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Requires expert design and construction" (Compendium) Construction and design is slightly more elaborate than for a WSP.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) Construction and design is slightly more elaborate than for a WSP.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Requires operation and maintenance by skilled personnel" (Compendium) O&M is more elaborate than for a WSP.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Pond must be desludged every 2 to 5 years" (Emersan) The large desludging rate suggests that the technology is meant for a long service life.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	"Not all parts and materials may be locally available" "An aerated pond is a large, mixed, aerobic reactor." (Compendium) Construction simple however, since bricks and/or concrete is used for construction, minimum 7 days curing is required- and since no prefab units are available, probability is allotted only to moderate category and not rapid. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"Requires expert design and construction", "Resistant to organic and hydraulic shock loads" (Compendium) To scale up the technology for a larger number of new users further ponds can be built and used in parallel, if sufficient land is available. Compared to waste stabilization pond systems, they need fewer ponds which need to be dug less deep (2-5m). This allows easier upscaling. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.6, technical = 0.4, special = 0)	"Not all parts and materials may be locally available", "To prevent leaching, the pond should have a liner. This can be made from clay, asphalt, compacted earth, or any other impervious material.", "Mechanical aerators provide oxygen and keep the aerobic organisms suspended and mixed with water to achieve a high rate of organic degradation.", "It is especially important that electricity service is uninterrupted and that replacement parts are available to prevent extended downtimes that may cause the pond to turn anaerobic." (Compendium) A liner is required for an aerated pond and can be built with locally available material. Mechanical equipment required for digging and constructing the Aerated Pond. Aerators and pumps will require technical parts.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Secondary Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.494	-	0.506	0	0	0	* as TP	{Kakiichi, 1990
	0.864	-	0.136	0	0	0	* as TP	{Kakiichi, 1990
	0.891	-	0.109	0	0	0	* as TP	{Kakiichi, 1990
	0.19	-	0.81	0	0	0	* as TP	{Hannah, 1986
med (R)	0.68	0.19 - 0.891	0.32	0	0	0		-
k	1	[0.701]	-	-	-	-		PA
TN	0.68	-	0.32	0	0	0	* as TKN	{Del Nery, 2002
	0.5	-	0.5	0	0	0	* as TKN	{Oleszkiewicz, 1986
	0.43	-	0.57	0	0	0	* as TN	{Koottatep, 1993
	0.652	-	0.348	0	0	0	* as TN	{Kakiichi, 1990
	0.908	-	0.092	0	0	0	* as TN	{Kakiichi, 1990
	0.942	-	0.058	0	0	0	* as TN	{Kakiichi, 1990
	0.02	-	0.98	0	0	0	* as TKN	{Hannah, 1986
med (R)	0.65	0.02 - 0.942	0.35	0	0	0		-
k	0.5	[0.922]	-	-	-	-	Spuhler et	PA
H2O	0.0011	-	0.9989	0	0	0	adapted from "activated	
	0.001	-	0.9988	0.00015	0	0		PA
med (R)	0	-	1	0	0	0		-

k	0.5	[0.99]	-	-	-	-	PA
TS	0.33	-	0.67	0	0	0 * from 36.2.1	{Hannah, 1986
	0.22	0.21 - 23	0.78	0	0	0 * from 36.2.2	{Abdel-Shafy, 2011
med (R)	0.28	0.21 - 0.33	0.72	0	0	0	-
k	25	[0.12]	-	-	-	-	PA

Additional Information

36.2.1	Data from: {Hannah, 1986 #1431}
	Min. Removal [%]
TSS	85
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	33.15

36.2.2	Data from: {Abdel-Shafy, 2011 #1432}	
	Min. Removal [%]	**Max. Removal [%]**
TSS	53.1	57.8
Ratio TSS:TS (from horizontal_wetland)	39%	39%
TS (from TSS)	20.709	22.542

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Trickling Filter

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	trickling_filter	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	transportedblackwater, transportedgreywater,	Tilley, E. et al. (2014)
OUTPUT PRODUCT	transportedsludge, transportedsecondary_effluent	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"Requires a constant source of electricity and constant wastewater flow", "A low-energy (working with gravity) trickling system can be designed, but in general, a continuous supply of power and wastewater is required." (Emersan)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.7, continuous = 0.3)	" A skilled operator is required to monitor the filter and repair the pump in case of problems. The sludge that accumulates on the filter must be periodically washed away to prevent clogging and keep the biofilm thin and aerobic. High hydraulic loading rates (flushing doses) can be used to flush the filter. Optimum dosing rates and flushing frequency should be determined from the field operation. The packing must be kept moist. This may be problematic at night when the water flow is reduced or when there are power failures. Snails grazing on the biofilm and filter flies are well known problems associated with trickling filters and must be handled by backwashing and periodic flooding." (Compendium) Regular up to continuous maintenance required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	A feed pipe and other pipes are necessary (Compendium).	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly available = 0.5, pumps = 1)	"Energy is required to operate the pumps feeding the Trickling Filter." (Emersan) Pumps for backflushing as well as to feed the trickling filter are required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0, difficultly available = 0.5, concrete = 1)	"The under-drainage system of trickling filters, consists of v- shaped or half round channels, cast in the concrete floor during its construction. These drains are covered by the concrete blocks." (Sengupta) The surrounding reactor and especially the floor with the underdrainage system are usually made from concrete. Concrete is considered as necessary for this technology. Further crushed concrete can be used as filter material, but since other filter materials perform equally well, concrete is not considered a requirement for the filter material.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.5, special = 0.2)	"monitor the filter and repair the pump in case of problems." (Emersan) "Not all parts and materials may be locally available " (Compendium) The filter material can either be made from local materials as rocks or gravel, or from special pre-formed plastic filter media. Technical spare parts are needed for the dosing system, the pumps and the drainage system. Some specially manufactured parts might be required for the dosing system. (Kukka Ilmanen, Eawag 2021)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	The performance depending on the temperature (in F°) is represented by a slope between 0.34 up to 0.62, but the performance is primarily depending on the wastewater temperature and only secondarily on the ambient temperature. {Schroepfer, 1952 #1379} Assumed to be comparable to an imhoff tank.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.9, no flooding=1)	These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA

soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Depending on the design, excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.15, b = 0.15, c = 999, d = 999)	Requires at least 0.15 m2/cap. From Table 1.3 (Dotro et al. 2017)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction, particularly, the dosing system" (Compendium) High construction and design skills necessary.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction, particularly, the dosing system" (Compendium) High construction and design skills necessary.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Requires operation and maintenance by skilled personnel" (Compendium) Moderate O&M skills necessary.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"It is a viable solution during the stabilisation and recovery phase of an emergency when a longer-term solution is required." (Emersan)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.5, slow=0.5)	"Not all parts and materials may be locally available" "A Trickling Filter is usually part of a wastewater treatment plant as a secondary or tertiary treatment step and is applicable only in water-borne systems. It is a viable solution during the stabilisation and recovery phase of an emergency when a longer-term solution is required." (Emersan)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"The hydraulic and nutrient loading rate (i.e. how much wastewater can be applied to the filter) is determined based on wastewater characteristics, type of filter media, ambient temperature, and discharge requirements.", "Can be operated at a range of organic and hydraulic loading rates" (Emersan) Trickling filters are designed specifically and can neither be extended easily nor easily be replicated. However, they can accept changing (flow/load) inputs to some degree and therefore a slight increase in the number of users. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.5, special = 0.1)	"Not all parts and materials may be locally available", "A skilled operator is required full-time to monitor the filter and repair the pump in case of problems." (Emersan) [The filter material can either be made from local materials as rocks or gravel, or from special pre-formed plastic filter media.] (Emersan) Technical parts are needed for the pumps and the drainage system. Some specially manufactured parts might be required for the dosing system. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")							
	Sludge	**Range**	**Secondary Effluent**	**Airloss**	**Soilloss**	**Waterloss**	**Comments**	**Reference**
TP	0.13	0.1 - 0.15	0.87	0	0	0	*TP removal	{Conradin, 2010 #973}
	0.15	-	0.85	0	0	0	*as PO4-P	{Vacker, 1967
	0.22	-	0.78	0	0	0	*as PO4-P	{Vacker, 1967
	0.15	-	0.85	0	0	0	*as PO4-P	{Vacker, 1967
	0.17	-	0.83	0	0	0	*as PO4-P	{Vacker, 1967
	0.02	-	0.98	0	0	0	*as PO4-P	{Vacker, 1967
	0.17	-	0.83	0	0	0	*as PO4-P	{Vacker, 1967
	0.22	-	0.78	0	0	0	*as PO4-P	{Vacker, 1967
	0.21	-	0.79	0	0	0	*as PO4-P	{Vacker, 1967
	0.12	-	0.88	0	0	0	*as PO4-P	{Vacker, 1967
	0.14	-	0.86	0	0	0	*as PO4-P	{Vacker, 1967
	0.17	-	0.83	0	0	0	*as PO4-P	{Vacker, 1967
	0.09	-	0.91	0	0	0	*as PO4-P	{Vacker, 1967
	0.16	-	0.84	0	0	0	*as PO4-P	{Vacker, 1967
	0.16	-	0.84	0	0	0	Spuhler et al. (2021)	{Vacker, 1967
	0.14	-	0.86	0	0	0	*as PO4-P	{Vacker, 1967
	0.18	-	0.82	0	0	0	*as PO4-P	{Vacker, 1967
	0.15	-	0.85	0	0	0	*as PO4-P	{Vacker, 1967

	0.14	-	0.86	0	0	0	*as PO4-P	{Vacker, 1967
	0.13	-	0.87	0	0	0	*as PO4-P	{Vacker, 1967
med (R)	0.15	0.02 - 0.22	0.85	0	0	0		-
k	25	[0.2]	-	-	-	-		PA
TN	0.63	-	0.37	0	0	0	*TN removal	{Forbis-Stokes,
	0.18	0 - 0.35	0.82	0	0	0	*TN removal	{Conradin, 2010 #973}
	0.67	-	0.33	0	0	0	* from 31.2.2	{Dai, 2013 #1383}
med (R)	0.63	0 - 0.67	0.37	0	0	0		-
k	1	[0.67]	-	-	-	-		PA
H2O	0.02	0 - 0.05	0.93	0.05	0	0		PA (see SBR)
med (R)	0.15	0.02 - 0.22	0.85	0	0	0		-
k	25	[0.2]	-	-	-	-		PA
TN	0.63	-	0.37	0	0	0	*TN removal	{Forbis-Stokes,
	0.18	0 - 0.35	0.82	0	0	0	*TN	{Aslam,
	0.67	-	0.33	0	0	0	* from	{Aslam,
med (R)	0.63	0 - 0.67	0.37	0	0	0		-
k	5	[0.36]	-	-	-	-		PA

Additional Information

31.2.1	Data from: {Forbis-Stokes, 2018 #1380}					
	Influent trickling filter	**Effluent trickling filter**	**TC Effluent**	**Removal [%]**	**Relation Turbidity - TSS**	**Ratio TSS:TS**
Turbidity [NTU]	980	13	0.01326531	986734694		
TSS (from formula)	1506	22	0.01460823	985391766		
TS				384302789		
Calculation			TC_Effluent = effluent_trickling_filter/influent_trickling_filter	Removal = (1-TC_Effluent)*100	ln (TSS)=0.979 ln (Turb)+0.574 {Al-Yaseri, 2013 #1381}	0.39

31.2.2	Data from: {Dai, 2013 #1383}			
	Influent [mg/l]	**Effluent [mg/l]**	**TC Effluent**	**Removal [%]**
TN	84	28	0.333333333	0.66666667
Calculation		TC_Effluent = (Effluent/Influent)*100		Removal = 1- TC_Effluent

31.2.3	Data from: {Aslam, 2017 #1384}	
	Removal [%] (Min. value)	**Removal [%] (Max. value)**
TSS	38	56
TDS	20	36
Ratio TSS:TS (from horizontal_wetland)	0.39	
TS (from TSS)	14.82	21.84
TS (from TDS)	44255	50.76

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Activated Sludge						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	activated_sludge	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	transportedblackwater, transportedgreywater,	Tilley, E. et al. (2014)				
OUTPUT PRODUCT	transportedsludge, transportedsecondary_effluent	Tilley, E. et al. (2014)				
RELATIONS	Input: OR Output: AND	Tilley, E. et al. (2014)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	8	Spuhler, D. et al. (2021)				
opex_req_level	7	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"High energy consumption, a constant source of electricity is required" (Compendium)	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.2, continuous = 0.8)	"The mechanical equipment (mixers, aerators and pumps) must be constantly maintained. As well, the influent and effluent must be constantly monitored and the control parameters adjusted, if necessary, to avoid abnormalities that could kill the active biomass and the development of detrimental organisms which could impair the process (e.g., filamentous bacteria)." (Compendium) O&M is almost a full-time job.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	Pipes are necessary for aeration. Pipes are needed for inlet, outlet and for return activated sludge	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly available = 0.5, pumps = 1)	For recirculation a pump will be required.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Usually the Activated Sludge reactor is made of plastic or concrete." (Emersan) Assuming concrete performs better than plastic due to its lifetime and local experience with construction with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.7, special = 0.1)	"Not all parts and materials may be locally available ", "Usually the Activated Sludge reactor is made of plastic or concrete. The aerators consist of stainless steel or plastic and a membrane of rubber seal. For the potential subsequent membrane process either ceramic, polymeric, or composite membranes can be used. The material used has an impact on fouling propensity in IMBRs. Different pre-fabricated models are available." (Emersan) Technical spare parts are required. Specially manufactured aeration or monitoring equipment is assumed to be rarely necessary.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	Assumed to be similar to an Imhoff Tank. "Activated Sludge processes are appropriate in almost every climate, but treatment capacity is reduced in colder environments." (Emersan)	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.9, no flooding=1)	"An activated sludge process is only appropriate for a Centralized Treatment facility with a well-trained staff, constant electricity and a highly developed management system that ensures that the facility is correctly operated and maintained. Because of economies of scale and less fluctuating influent characteristics, this technology is more effective for the treatment of large volumes of flows." (Compendium) . These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	Depending on the design, excavation is necessary.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.12, b = 0.12, c = 999, d = 999)	Requires at least 0.12 m2/cap. From Table 1.3 (Dotro et al. 2017)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) High construction and design skills.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Requires expert design and construction" (Compendium) High construction and design skills.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Highly trained staff is required for maintenance and trouble-shooting." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	Activated Sludge Plants are implemented in wastewater treatment plants around the world and have usually a lifetime of more than 5 years. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=0.5, slow=0.5)	"Speed of construction and set up: All treatment units are prefabricated tanks so quick to deploy (2 weeks to set up); Commissioning takes time (30days?) to introduce sludge and get process (microorganisms) functioning" (Abbott, J. et al. (2019)) "Several weeks are needed to establish the microorganisms required for a stable biological process" (Emersan) and that is after the reactors have been built and the aeration system has been built." "Not all parts and materials may be locally available" (Compendium) Prefab units improve the speed of implementation however, since several weeks are required for microbial communities to establish, probablities are allotted to both categories "moderate" and "slow" (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.8)	"Scale/scalability (level 2 of 5 meaning scalable: Compact equipment and layout. All treatment units are in prefabricated, so layout is flexible [...] Additional tanks can be added in parallel" (Abbott, J. et al. (2019)) Activated Sludge Plants can be scaled up by adding additional tanks.	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.5, special = 0.3)	"Not all parts and materials may be locally available " (Compendium) "Usually the Activated Sludge reactor is made of plastic or concrete. The aerators consist of stainless steel or plastic and a membrane of rubber seal. For the potential subsequent membrane process either ceramic, polymeric, or composite membranes can be used. The material used has an impact on fouling propensity in IMBRs. Different pre-fabricated models are available." (Emersan) An Activated Sludge System requires a lot of technical parts. Additionally, we assume that the controlling system and the membrane process might require even some parts from special manufacturers. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Sludge	Range	Secondary Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.77	-	0.23	0	0	0	* 77.4% TP removal	{Hsu, 1998 #1410}
	0.92	-	0.08	0	0	0	* 92.4% TP removal,	{Thomas, 1965
	0.8	-	0.2	0	0	0	* as TP	{Commission, 1970
med (R)	0.8	0.77 - 0.92	0.2	0	0	0		-
k	25	[0.15]	-	-	-	-		PA
TN	0.67	-	0.33	0	0	0	* 67.4% TN removal	{Hsu, 1998 #1410}
	0.9	-	0.1	0	0	0	* as TN	{Samiotis, 2018
med (R)	0.79	0.67 - 0.9	0.21	0	0	0		-
k	5	[0.23]	-	-	-	-		PA
H2O	0.0011	-	0.9989	0	0	0	* from 33.2.2	{EDWIGE, 2015 #1415}
	0.001	-	0.9988	0.00015	0	0	* from 33.2.4 (1/2 of airloss	{Wanner, 2004 #1418}
med (R)	0.001	-	1	0	0	0		-
k	2	-	-	-	-	-		PA
TS	0.34	-	0.66	0	0	0	* from 33.2.1	{Guven, 2019
	0.37	-	0.63	0	0	0	Spuhler et al. (2021)	{Hsu, 1998 #1410}
med (R)	0.36	0.34 - 0.37	0.64	0	0	0		-
k	100	[0.03]	-	-	-	-		PA

Additional Information

33.2.1	Data from: {Guven, 2019 #1417}
	Removal [%]
TSS	88
Ratio TSS:TS (from horizontal_wetland)	0.39
TS (from TSS)	34.32

33.2.2	Data from: {EDWIGE, 2015 #1415}					
	2010	**2011**	**2012**	**2013**	**Average**	**Calculation**
Water_volume_influent [m3/d]	1081.58	1096.82	1179.3	1171.03	1132.1825	
water_volume_sludge [m3/d]	1.38	1.21	1.12	1.27	1.245	

TC_H20_sludge [%]	0.127591117	0.110318922	0.094971593	0.108451534	0.1099646	TC_H2O_Sludge = Water_volume_sludge/water_volume_influent
33.2.3	Data from: {Hsu, 1998 #1410}					
	Removal [%]					
TSS	94					
Ratio TSS:TS (from horizontal_wetland)	0.39					
TS (from TSS)	36.66					
33.2.4	Data from: {Wanner, 2004 #1418}					
Evaporation of water [kg/m3]	0.15					
Assumption: 1000kg H2O = 1 m3 H2O						
Evaporation of water [m3/m3]	0.00015					

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Lactic Acid Fermentation

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	lactic_acid_fermentation	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	stored_faeces, transportedstored_faeces, blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge	Gensch, R. et al. (2018)
OUTPUT PRODUCT	stabilized_sludge , transportedstabilized_sludge	Gensch, R. et al. (2018)
RELATIONS	Input: OR Output: AND	Gensch, R. et al. (2018)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 1, city = 0)	Gensch, R. et al. (2018)
management_level	(household = 0, shared = 0, public = 1)	Gensch, R. et al. (2018)
capex_req_level	4	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	2	Gensch, R. et al. (2018)
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 0)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.3, no electricity = (	"To achieve a homogeneous mix within the vessel a recirculation pump is required. The type of pump depends on the thickness of the sludge. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump." (Emersan) Mixing can also be done manual, but therefore is much more effort needed and the performance could still not be the same as if done electrical.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Regular maintenance of pumps is required, especially due to the corrosive nature of the treated sludge." (Emersan)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No need for pipes.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.25, difficultly available = 0.5, pumps	"To achieve a homogeneous mix within the vessel a recirculation pump is required. The type of pump depends on the thickness of the sludge. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump." (Emersan) Mixing can also be done manually, but therefore is much more effort needed and the performance would be worse without pumps, so that 'difficultly available' is chosen to be 50% (pump required) and 'no pumps' is set to an especially low value of 25% performance.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"AF Treatment needs a vessel, preferably sealable as LAB are most efficient under an aerobic conditions. However, LAB are aero-tolerant and therefore open tanks can be used if no sealed vessel is available." (Emersan) There is no information found what type of material the vessel could be made of, but since the vessel needs to be sealed it could be concrete. It is assumed that alternative vessels need to either be imported (metal), have shorter lifetimes (plastic, wood) and that locals have experience working with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	"LAF Treatment needs a vessel, preferably sealable as LAB are most efficient under an aerobic conditions. However, LAB are aero-tolerant and therefore open tanks can be used if no sealed vessel is available. To achieve a homogeneous mix within the vessel a recirculation pump is required. The type of pump depends on the thickness of the sludge. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump. In addition, an initial supply of milk and a probiotic drink is needed to prepare the LAB molasses. To monitor the pH level and pathogens in the vessel a water testing kit is needed.", "Simple process which uses readily available material: molasses and LAB" (Emersan) To repair and replace the pumps technical parts might be required. To maintain the vessel locally available materials might be required	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, h	Assumed to be appropriate for all temperatures.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding =0.9, no flooding = 1)	"It is recommended that the LAF process is carried out under batch conditions in sealed vessels (container or bladder). " (Emersan) If constructed with a sealed vessel the technology should be watertight, what means that there should be no risk in area prone to flooding. These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	Yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	There is no information on need for excavation for the technology. Excavation might be necessary (one configuration).	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.007, b = 0.007, c = 999, d = 999)	It is recommended that the LAF process is carried out under batch conditions in sealed vessels (container or bladder) (Emersan). The same value as for hydrated lime treatment is used as it follows the same operating principle (adding treatment solution to a tank and mixing it) (SaniChoice Team 2021: Best Guess).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	Even though the design is complex the construction should be possible with basic skills (e.g. for the installation of pumps).	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"It is recommended that the LAF process is carried out under batch conditions in sealed vessels (container or bladder). The vessel size may vary depending on the amount and frequency of sludge generated. LAB is cultured in an inoculum before being added to the fresh sludge. The inoculum for the first batch is a mixture of milk (99.8 %) and LAB from, for example, Yakult (0.02 %) that has been mixed and stored at room temperature for 48 hours. For subsequent batches the treated sludge can be used as an inoculum. For the biological process, the inoculum is initially added to the tank in the ratio of 10 % of the overall sludge wet weight. The fresh faecal sludge is pumped into the vessel and recirculated to get a homogenous mix of fresh sludge and the inoculum. The sludge is then stored over a period of 2 weeks monitoring the pH daily to ensure a sanitised sludge is produced." (Emersan) "For each new batch of faecal sludge an initial amount of sludge from the previous batch should remain in the reactor vessel as an inoculant for LAB production in the sludge." (Emersan)	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Molasses, milk or the LAB do not pose any significant health risk. However, proper personal protective equipment (PPE) should still be considered when handling the treated sludge as the final product may not be sufficiently treated and may still contain pathogens." "Maintenance of pump is required" (Emersan).	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"short treatment time (around 2 weeks)" (Emersan) Due to the short treatment time a lifetime of less than 1 year is possible. Emerging technology, so that no data on its longevity is available, but it is assumed that the concept of sanitisation with lactic acid can also be applied in the long-term. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=1, moderate=0, slow=0)	"Lactic Acid Bacteria (LAB) are easily obtainable and can be made from molasses, milk and probiotic drinks." (Emersan Compendium) Implementation very quick since only a vessel and LAB are required, both of which are generally locally available (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"[Lactic acid fermentation] LAF Treatment needs a vessel, preferably sealable as LAB are most efficient under anaerobic conditions. However, LAB are aero-tolerant and therefore open tanks can be used if no sealed vessel is available.", "LAF Treatment may be a suitable treatment option particularly for the acute response phase due to its short treatment time (around 2 weeks), a relatively simple process and use of readily available materials." (Emersan) If a LAF vessel is designed large enough, one needs to simply increase the amount of LAF to scale up the technology. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"LAF Treatment needs a vessel, preferably sealable as LAB are most efficient under an aerobic conditions. However, LAB are aero-tolerant and therefore open tanks can be used if no sealed vessel is available. To achieve a homogeneous mix within the vessel a recirculation pump is required. The type of pump depends on the thickness of the sludge. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump." (Emersan) To construct the vessel simple locally available materials should be enough. Technical parts are required to provide pumps for mixing.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stabilized Sludge	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1					As the fermentation is performed in sealed containers, there should be no change in nutrient content, nor added value of the sludge	{Scheinemann et al. 2015}
	1						McConville et al. (2020)
	0.99	-	0.01	0	0		Spuhler et al. (2022)
med (R)	0.99	0.99-1	0.01	0	0		-
k	25	[0,01]	-	-	-		
TN	0.8	-	0.2	0	0		PA from Dorothee
	0.9	0,85-0,97	0.1	0	0		Kelova et al. (2021)
med (R)	**0.95**	**0,85-0,97**	**0.05**	**0.00**	**0.00**		-
k	5	[0,12]	-	-	-		
H2O	0.99	-	0.01	0	0		PA from Dorothee
	0.95		0.05	0	0		Kelova et al. (2021)
med (R)	**0.97**		**0.03**	**0.00**	**0.00**		-
k	25	[0,03]	-	-	-		
TS	0.95	-	0.05	0	0		PA from Dorothee
	0.9		0.1	0	0		Spuhler et al. (2021)
	0.94		0.06	0	0		
	1		0	0	0	VSS	Kelova et al. (2021)
med (R)	**0.95**	**0,9-0,1**	**0.06**	**0.00**	**0.00**		-
k	25	[0,1]	-	-	-		

References

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Caustic Soda Treatment

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	caustic_soda_treatment	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	stored_faeces, transportedstored_faeces, blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge	Gensch, R. et al. (2018)
OUTPUT PRODUCT	stabilized_sludge , transportedstabilized_sludge, effluent, transportedeffluent	Gensch, R. et al. (2018)
RELATIONS	Input: OR Output: AND	Gensch, R. et al. (2018)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 1, city = 0)	Gensch, R. et al. (2018)
management_level	(household = 0, shared = 0, public = 1)	Gensch, R. et al. (2018)
capex_req_level	4	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	2	Gensch, R. et al. (2018)
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 0)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.3, no elec	"For an even distribution of caustic soda in the tank it is mixed into the sludge either manually or using a mixing pump. The type of pump required depends on the consistency of the sludge. A separate pump is needed for removing the treated effluent from the tank and a shovel or vacuum pump for the removal of solid material." "Effect [of caustic soda] can be enhanced by ensuring complete mixing"(Emersan) Mixing can be done manually, but performance is far better with electric mixing so that intermittent electricity is assigned a value of 0.3. At least intermittent electricity for pumping the treated effluent is required.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continuous = 0)	"Caustic Soda is corrosive due to its high alkalinity, therefore a regular maintenance of pumps is required. During storage, caustic soda must be kept dry at all times because it absorbs and reacts with water. " (Emersan) Regular maintenance required.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipe	No need for pipes.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly available = 0.5, p	"For an even distribution of caustic soda in the tank it is mixed into the sludge either manually or using a mixing pump. The type of pump required depends on the consistency of the sludge. A separate pump is needed for removing the treated effluent from the tank and a shovel or vacuum pump for the removal of solid material." (Emersan)	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Caustic Soda Treatment needs a reactor vessel that can either be an above ground tank (between 1–30m3) or a pit below ground with tarpaulin lining." (Emersan) There is no information found what type of material the vessel could be made of, but since the vessel needs to be sealed it could be concrete. It is assumed that alternative vessels need to either be imported (metal), have shorter lifetimes (plastic, wood) and that locals have experience working with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	"For an even distribution of caustic soda in the tank it is mixed into the sludge either manually or using a mixing pump. The type of pump required depends on the consistency of the sludge. A separate pump is needed for removing the treated effluent from the tank and a shovel or vacuum pump for the removal of solid material.","In addition a water testing kit[...], personal protective equipment (PPE) [..], steady supply of caustic soda is also required.", "Simple process which uses a material that is available in most countries" (Emersan) To repair and replace the pumps technical parts might be required. To maintain the vessel or provide testing kits and PPE locally available materials might be required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, wa	Assumed to be appropriate for all temperatures.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"Caustic Soda Treatment can either take place above ground in a separate tank or below ground. In areas with a high groundwater level or in flood prone areas it is recommended to always use above ground tanks.", "Sealable container/vessel" (Emersan) If constructed with a sealed vessel the technology should be watertight, what means that there should be minimal risk in area prone to flooding. These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA

groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	"Caustic Soda Treatment needs a reactor vessel that can either be an above ground tank (between 1–30 m3) or a pit below ground with tarpaulin lining" (Emersan). We assume that the technology works perfectly in above ground tank and excavation therefore is not a limiting factor.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.007, b = 0.007, c = 999, d = 999)	"Caustic Soda Treatment needs a reactor vessel that can either be an above ground tank (between 1–30 m3) or a pit below ground with tarpaulin lining. An additional smaller container is needed for the preparation of the caustic soda solution (e.g. 200 L plastic drum)" (Emersan). The same value as for hydrated lime treatment is used as it follows the same operating principle (adding treatment solution to a tank and mixing it) (SaniChoice Team 2021: Best Guess).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	Relatively basic tanks/containers for batch process required. Pumps require basic knowledge for installation. "Caustic Soda Treatment can either take place above ground in a separate tank or below ground. In areas with a high groundwater level or in flood prone areas it is recommended to always use above ground tanks. Separate tanks may be needed for the preparation of the soda solution slurry and for the post-neutralisation of the treated effluent respectively" (Emersan).	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	Requires expertise. "The optimum dosage to reach the recommended pH of 12 is around 26 g of soda per litre of faecal sludge. The exact amount, however, depends on the characteristics of blackwater or sludge. Its effect can be enhanced by ensuring complete mixing, a longer contact time and a higher dosage of caustic soda" (Emersan).	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Regular maintenance of pumps is required. During storage, caustic soda must be kept dry at all times because it absorbs and reacts with water. Due to potential health risks when handling caustic soda (see below) skilled and trained personnel must follow respective health and safety protocols and wear proper PPE" (Emersan).	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"The Caustic Soda Treatment process should be undertaken as a batch process and can be used to treat both solid and liquid sludge. After treatment, pH decrease towards neutral usually within 24 hours." (Emersan) Due to the short treatment time a lifetime of less than 1 year is possible. Emerging technology, so that no data on its longevity is available, but it is assumed that the concept of treatment with caustic soda can also be applied in the long-term. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=1, moderate=0, slow=0)	"Simple process which uses a material that is available in most countries" (Emersan Compendium) Implementation very quick since only a vessel and caustic soda is required, both of which are generally locally available (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Caustic Soda Treatment is particularly suitable for the rapid response phase due to its short treatment time, simple process and use of readily available materials.", "Its effect can be enhanced by ensuring complete mixing, a longer contact time and a higher dosage of caustic soda." (Emersan) To scale up more sludge/blackwater needs to be treated and simply the amount of available caustic soda should be increased. It needs to be made sure that even though a larger amount of input material is treated, sufficient mixing and a long enough contact time are achieved. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Caustic Soda Treatment needs a reactor vessel that can either be an above ground tank (between 1–30 m3) or a pit below ground with tarpaulin lining. An additional smaller container is needed for the preparation of the caustic soda solution (e.g. 200 L plastic drum). For an even distribution of caustic soda in the tank it is mixed into the sludge either manually or using a mixing pump. The type of pump required depends on the consistency of the sludge. A separate pump is needed for removing the treated effluent from the tank and a shovel or vacuum pump for the removal of solid material." (Emersan) To construct the vessel simple locally available materials should be enough. If pumps are used for mixing and emptying, technical parts are required.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stabilized Sludge	Range	Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.65	0,4-0,9	0.21	0.125	0.025	0	TCs from hydrated lime treatment	PA
	0.74		0.26	0				Longo et al (2015)

	0.775		0.1	0.1			tertiary treatment analysis done on 24hr composite trickling filter effluent	Al-Rehaili and Misbahuddin (2001), PA
med (R)	0.675	-	0.2	0.1	0.025	0		-
k	2	-	-	-	-	-		PA
TN	0.28		0.52	0.2	0			Nurul Hanira et al. (2015), PA
	0.33		0.57	0.1				Longo et al (2015), PA
med (R)	0.305		0.545	0.15	0	0		-
k	5		-	-	-	-		PA
H2O	0.145	0,04-0,25	0.8	0.03	0.025	0	TC from hadrated lime treatment	PA
med (R)	0.145	-	0.8	0.03	0.025	0		-
k	5	-	-	-	-	-		PA
TS	0.4	-	0.4	0.15	0.05	0		PA
	0.72		0.28	0				Longo et al (2015)
	0.47		0.53				Spuhler et al. (2021)	Al-Rehaili and Misbahuddin (2001)
med (R)	0.47	0,4-0,72	0.4	0.1	0.03	0		
k	5	[0,32]	-	-	-	-		

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Urea Treatment		Urea Treatment				
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	urea_treatment	-				
DATA COMPILER	SaniChoice Project Team	-				
INPUT PRODUCT	stored_faeces, transportedstored_faeces, blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge	Gensch, R. et al. (2018)				
OUTPUT PRODUCT	stabilized_sludge , transportedstabilized_sludge	Gensch, R. et al. (2018)				
RELATIONS	Input: OR Output: AND	Gensch, R. et al. (2018)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 1, city = 0.5)	McConville, J. et al. (2020)				
management_level	(household = 0, shared = 0.5, public = 1)	McConville, J. et al. (2020)				
capex_req_level	4	Spuhler, D. et al. (2021)				
opex_req_level	7	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 1, stabilisation = 0, development/recovery = 0)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0, no electricity = 0)	"Urea Treatment needs a lockable vessel (e.g. a closed tank or portable bladder) and a recirculation pump to achieve a homogeneous sludge- urea mix. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump." (Emersan) Continous electricity supply is necessary.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Regular maintenance of pumps used for mixing is required." (Emersan)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pipes. (Eawag own judgement, 2021)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0, difficultly available = 0.5, pumps = :	"A pump is used to circulate the sludge within the storage vessel to ensure adequate contact between the urea and sludge", "Urea Treatment needs a lockable vessel (e.g. a closed tank or portable bladder) and a recirculation pump to achieve a homogeneous sludge- urea mix. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump." (Emersan) Pump supply is necessary.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Urea Treatment needs a lockable vessel (e.g. a closed tank or portable bladder)" (Emersan) There is no information found what type of material the vessel could be made of, but it could be concrete. It is assumed that alternative vessels need to either be imported (metal), have shorter lifetimes (plastic, wood) and that locals have experience working with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.6, special = 0)	"Urea Treatment needs a lockable vessel (e.g. a closed tank or portable bladder) and a recirculation pump to achieve a homogeneous sludge- urea mix. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump. In addition, a steady supply of urea is needed. Urea is a conventional, widely used and affordable chemical fertilizer that should be available in most local contexts. In addition, a water testing kit (particularly for pH and E. coli) is needed to control pH levels in the urea sludge mix and to test the level of treatment efficacy." (Emersan) "[...] urea are required and urea is generally available and affordable." To repair and replace the pumps technical parts might be required	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.2, cold = 0.3, temperate = 0.5, warm	Nordin A. & Vinnerås B. (2015) Nordin A. et al. (2015) Nordin, A. et al. (2009) (1) Nordin A. et al. (2009) (2) Vinnerås B. t al. (2008)	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"It is recommended that treatment is undertaken in a sealed vessel [...]." (Emersan) "Potential health risks if not handled properly" (Emersan) It seems like there is a small health risk if the technology is constructed in an area prone to flooding. However, if the technology is constructed completely watertight there should be no problem with flooding. These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Expert judgement (Nordin, A. (2021))	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA

surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.2, b = 0.4, c = 999, d = 999)	defined by the flow to be treated thus related to the dilution with flush water, collection time and storage time where the latter is temeprature and dosage dependent. Figures given here cover the range from undiluted human excreta to using 5 L flush water per day, and gives values assuming treating waste collected per month at a storage time of less than 1 month, assuming a square cubicle. Area can be decreased further by changing wih to height ratio of cubicle. (Nordin, A. (2021))		
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Urea Treatment needs a lockable vessel (e.g. a closed tank or portable bladder) and a recirculation pump to achieve a homogeneous sludge- urea mix. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump." (Emersan) "Urea may be hazardous when it comes on contact with skin or eyes (irritant), ingestion or inhalation and may be combustible at high temperatures." (Emersan) The installation of technical components might require a skilled labourer. Further is a propper construction highly recommended since there might be serious health risks if not.	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"The process depends on temperature and partial pressures of ammonia gas above the liquid. Hence, ventilation and head space also influences the process conditions. It is recommended that treatment is undertaken in a sealed vessel to minimise the amount of ammonia gas that escapes and to force the equilibrium towards soluble ammonia. The treatment should be done as a batch process to ensure consistent sanitisation in the sludge." (Emersan) "Urea is usually added at a ratio of 2 % of the overall sludge wet weight. Urea is initially placed in the storage vessel (e.g. bladder/closed tank) and then faecal sludge is pumped into the vessel. The size of the vessel may vary depending on the amount and frequency of the sludge to be treated. A pump is used to circulate the sludge within the storage vessel to ensure adequate contact between the urea and sludge. Urea decomposition requires a minimum of 4 days, hence a retention time in the closed vessel of approximately 1 week is recommended." (Emersan)	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Due to potential health risks when handling urea (see below) the process requires skilled personnel following health and safety protocols and wearing proper personal protective equipment (PPE)." (Emersan) "Urea may be hazardous when it comes on contact with skin or eyes (irritant), ingestion or inhalation and may be combustible at high temperatures. Ammonia gas is toxic and precautions are needed when removing sludge from the tank. PPE (for example masks, gloves, aprons and long-sleeved clothing) must be worn when handling urea to prevent irritation to eyes, skin, and the respiratory system." (Emersan) To avoid health risks of the OM staff at least moderate OM skills are recommended.		
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Treatment time ≈ 1 week (4–8 days)" (Emersan) Due to the short treatment time a lifetime of less than 1 year is possible. Emerging technology, so that no data on its longevity is available, but it is assumed that the concept of treatment with urea can also be applied in the long-term. (Kukka Ilmanen, Eawag 2021)	yes	
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA	
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=1, moderate=0, slow=0)	"Ammonia sanitisation may be a suitable treatment option both for emergency situations and established treatment systems, due to its short treatment time, relatively simple process and the use of locally available materials" (SLU Compendium) Implementation very quick since only a closed vessel and urea is required, both of which are generally locally available (Akanksha Jain)	yes	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Urea Treatment may be a suitable treatment option for the acute emergency phase due to its short treatment time (around 1 week), a relatively simple process and use of readily available materials" (Emersan) If a urea treatment vessel is designed large enough, one needs to simply increase the amount of urea to scale up the technology. (Kukka Ilmanen, Eawag 2021)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	"Urea Treatment needs a lockable vessel (e.g. a closed tank or portable bladder) and a recirculation pump to achieve a homogeneous sludge- urea mix. For liquid sludge, a diaphragm pump may be used, whereas thicker sludge may need a screw pump or a vacuum pump. In addition, a steady supply of urea is needed. Urea is a conventional, widely used and affordable chemical fertilizer that should be available in most local contexts." (Emersan) To construct the vessel simple locally available materials should be enough. If a pumping system is used for mixing, technical parts are required.	yes	
Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")						
	Stabilized Sludge	**Range**	**Airloss**	**Soilloss**	**Waterloss**	**Comments**	**Reference**

TP	1	-	0	0	0		A. Nordin (2021)
med (R)	1	-	0	0	0		-
k	2	-	-	-	-		PA
TN	0.96	-	0.04	0	0		A. Nordin (2021)
med (R)	0.96	-	0.04	0	0		-
k	2	-	-	-	-		PA
H2O	0.98	-	0.02	0	0		A. Nordin (2021)
med (R)	0.98	-	0.02	0	0		-
k	5	-	-	-	-		PA
TS	1	-	0	0	0		A. Nordin (2021)
med (R)	1	-	0	0	0		-
k	1	-	-	-	-		PA

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Hydrated Lime Treatment

General Information	Values	Data Source
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	hydrated_lime_treatment	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	stored_faeces, transportedstored_faeces, blackwater, transportedblackwater, sludge, transportedsludge, transportedtransferred_sludge	Gensch, R. et al. (2018)
OUTPUT PRODUCT	stabilized_sludge , transportedstabilized_sludge, secondary_effluent, transportedsecondary_effluent	Gensch, R. et al. (2018)
RELATIONS	Input: OR Output: AND	Gensch, R. et al. (2018)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0, neighbourhood = 1, city = 0.5)	McConville, J. et al. (2020)
management_level	(household = 0, shared = 0, public = 1)	McConville, J. et al. (2020)
capex_req_level	4	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 0)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.9, no electricity = 0.7)	"For an even distribution of hydrated lime throughout the sludge, constant mixing is required (either manually or with a mixing pump). The type of pump required depends on the consistency of the sludge. A separate pump is needed to remove the treated effluent from the tank and a shovel or vacuum pump to remove the solid material." (Emersan) Depending on the configuration electricity is needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.6, continous = 0.4)	If there are no machines running the process it could be quite labour intensive. If the system is automatized with machines such as pumps the process gets less labour intensive but then maintenance of the machines is required. In both cases regular to continous OM is assumed.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pipes.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficultly available = 0.75, pumps = 1)	"For an even distribution of hydrated lime throughout the sludge, constant mixing is required (either manually or with a mixing pump). The type of pump required depends on the consistency of the sludge. A separate pump is needed to remove the treated effluent from the tank and a shovel or vacuum pump to remove the solid material." (Emersan) Depending on the configuration a pump is needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"Hydrated Lime Treatment needs a reactor vessel. A smaller additional container is needed to prepare the lime slurry (e.g. a 200 L plastic drum)." (Emersan) There is no information found what type of material the vessel could be made of, but it could be concrete. It is assumed that alternative vessels need to either be imported (metal), have shorter lifetimes (plastic, wood) and that locals have experience working with concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	"Simple process which uses commonly available material" (Emersan) " A smaller additional container is needed to prepare the lime slurry (e.g. a 200 L plastic drum). For an even distribution of hydrated lime throughout the sludge, constant mixing is required (either manually or with a mixing pump). The type of pump required depends on the consistency of the sludge. A separate pump is needed to remove the treated effluent from the tank and a shovel or vacuum pump to remove the solid material. In addition a water testing kit (particularly for pH, E.coli, total suspended solids and turbidity) is needed as well as personal protective equipment (PPE) including masks, gloves, boots, apron or suit and respective chemicals (hydrated lime, magnesium sulphate if needed)." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, warm = 1, hot = 1)	Assumed to be appropriate for all temperatures.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	"If the tank is located below ground, care should be taken to ensure it is absolutely water tight to avoid the leakage of highly alkaline effluent into the soil. In areas with high groundwater level or in flood prone areas it is recommended to use above ground tanks." (Emersan) These values are allotted to all "tank" based technologies. These treatment technologies and their corresponding tanks are built to be water-tight. Additionally, their raised configurations are possible in flood prone areas. The impact of criterion flooding is therefore not considered to be as severe and only a 10% reduction in performance is allotted. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA

excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"Hydrated Lime Treatment should be carried out in a leak-proof cistern or tank, If the tank is located below ground, care should be taken to ensure it is absolutely water tight to avoid the leakage of highly alkaline effluent into the soil. In areas with high groundwater level or in flood prone areas it is recommended to use above ground tanks." (Emersan) Excavation might be needed but is mostly not necessary needed.	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.007, b = 0.007, c = 999, d = 999)	Based on calculations (SaniChoice Team 2021) that are based on technical drawings from a case study (Octopus, 2019).	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Hydrated Lime Treatment should be carried out in a leak-proof cistern or tank, If the tank is located below ground, care should be taken to ensure it is absolutely water tight to avoid the leakage of highly alkaline effluent into the soil. In areas with high groundwater level or in flood prone areas it is recommended to use above ground tanks. Separate tanks may be needed for preparation of the lime slurry and for post-neutralisation of the treated effluent respectively." (Emersan) Since it is a technology with a complex design it is important that it is properly constructed. At least moderate construction skills are recommended.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Hydrated Lime Treatment should be carried out in a leak-proof cistern or tank, If the tank is located below ground, care should be taken to ensure it is absolutely water tight to avoid the leakage of highly alkaline effluent into the soil. In areas with high groundwater level or in flood prone areas it is recommended to use above ground tanks. Separate tanks may be needed for preparation of the lime slurry and for post-neutralisation of the treated effluent respectively." (Emersan) "Hydrated lime is a powder and corrosive to skin, eyes and lungs. Therefore, adequate PPE must be worn when handling hydrated lime to prevent irritation to eyes, skin, respiratory system, and gastrointestinal tract. Protection from fire and moisture must also be ensured. Lime is an alkaline material that reacts strongly with moisture." (Emersan)	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Lime is corrosive in nature due to its alkalinity and regular maintenance of the pumps used for mixing will be required. Due to the potential health risks when handling hydrated lime, skilled staff are required who follow appropriate health and safety protocols." (Emersan)	yes
0	0	FALSE	0	NA		NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Short treatment time (6 log removal of E-coli in < 1day i.e. pathogen count is 1 million times smaller)" (Emersan) Due to the short treatment time a lifetime of less than 1 year is possible. It is assumed that the concept of sanitisation with hydrated lime can also be applied in the long-term. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=1, moderate=0, slow=0)	"Lime sanitisation is a simple process and uses readily available materials." (SLU Compendium) Implementation very quick since only a vessel and lime is required, both of which are generally locally available (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"Hydrated Lime Treatment is particularly suitable for the rapid response phase due to its short treatment time, simple process and use of readily available materials." (Emersan) "Scale/scalability [for lagoons]: Easily replicable simple excavated lagoons; Scale up could be achieved by installing additional treatment units in parallel. However, this site must have space for increasing capacity", "Scale/scalability [for concrete tanks]: Scale up could be achieved by installing treatment units in parallel; Structures are concrete so are less simple to scale up than excavated lagoons", "Scale up of 'in-barrel' mixing is simple and will not require much more area. Barrels can also be stacked" (Abbott, J. et al. (2019)) If the mixing happens in lagoons or in barrels it is simple to extend the treatment capacity. In case of concrete tanks upscaling requires building more of these. To scale up more sludge/blackwater needs to be treated and simply the amount of available lime should be increased. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Simple process which uses commonly available material" (Emersan) "A smaller additional container is needed to prepare the lime slurry (e.g. a 200 L plastic drum). For an even distribution of hydrated lime throughout the sludge, constant mixing is required (either manually or with a mixing pump). The type of pump required depends on the consistency of the sludge. A separate pump is needed to remove the treated effluent from the tank and a shovel or vacuum pump to remove the solid material. " (Emersan) Simple construction parts are required to build the reactor. Additional containers for the lime slurry need to be provided or constructed. If pumps are used for mixing and emptying, technical parts are required.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Stabilized Sludge	Range	Secondary Effluent	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.6	-	0.1	0.25	0.05	0		PA
	0.65	0.4-0.9						Parker et al (1975)
	0.68	0,6-0,77	0.32	0	0	0		Mazlum and Ikizoglu (2018)
med (R)	0.65	0,4-0,9	0.21	0.125	0.025	0		-
k	2	[',5]	-	-	-	-		PA

TN	0.3	-	0.3	0.35	0.05	0		PA
	0.6		0.2	0.2	0	0		Mazlum and Ikizoglu (2018), , Puijenbroek, Beusenand Bouwman (2019)
med (R)	0.45	0,3-0,6	0.25	0.275	0.025	0		-
k	5	[0,3]	-	-	-	-		PA
H2O	0.25	-	0.65	0.05	0.05	0		PA
	0.04	-	0.95	0.01	0	0		PA (adapted from ABR)
med (R)	0.145	0,04-0,25	0.8	0.03	0.025	0		-
k	5	[0,21]	-	-	-	-		PA
TS	0.45		0.3	0.2	0.05			PA
	0.65	0.45-0.9	0.35	0	0	0	Spuhler et al. (2021)	Parker et al (1975)
	0.75	0.6-0.93	0.25	0	0	0	TSS reduction	Gold et al. (2016)
med (R)	0.65	0,45-0,9	0.3	0.05	0	0		-
k	2	[0,45]	-	-	-	-		PA

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Microbial Fuel Cell		Microbial Fuel Cell
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	microbial_fuel_cell	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedurine, transportedeffluent, transportedgreywater	McConville, J. et al. (2020)
OUTPUT PRODUCT	transportedsecondary_effluent	McConville, J. et al. (2020)
RELATIONS	Input: OR Output: NA	McConville, J. et al. (2020)
COMMENTS		

Pre-Filter Criteria	Values	Data Source
applicability_level	(household = 0.5, neighbourhood = 1, city = 1)	McConville, J. et al. (2020)
management_level	(household = 0.5, shared = 1, public = 1)	McConville, J. et al. (2020)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	1	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	"MFCs are applicable in many settings due to their ambient operating conditions and the possibility of integration with existing treatment technologies. MFCs can be integrated into other treatment technologies at all levels, including domestic, centralised or industrial treatment." "At a domestic scale, the MFCs can be incorporated into existing septic tanks." "Possibility of integration with other existing wastewater treatment technologies." "Low operation and maintenance costs." (McConville, J. et al. (2020)) "MFCs are an expensive technology due to electrode and membrane materials." (McConville, J. et al. (2020)) Although LOWER cost alternatives are present but not tested. This technology has low technical maturity and is not well established, however, it shows promise since it can integrated well with existing technologies to achieve better pollutant removal (i.e, with septic tanks). And since its expensive as well- therefore, it can be considered rather unsuitable in the acute and stabilisation phases- but good option for recovery phases. (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	Rather than requiring electricity, MFCs produce electricity: "MFCs can produce clean electricity directly from organic matter in wastewater" (SLU).	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	Santoro, C. et al. (2017)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0, pipes = 1)	Palanisamy, G. et al. (2019)	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Włodarczyk, P. & Włodarczyk, B. (2018)	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Expert Judgement (McConville, J. 2021)	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.4, special = 0.3)	Expert Judgement (McConville, J. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0.2, temperate = 1, warm = 1, hot = 0.5)	Feng, Q. et al. (2016); Gonzalez-Martínez, A. et al. (2018); Tkach, O. et al (2017)	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	Expert Judgement (McConville, J. 2021)	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Expert Judgement (McConville, J. 2021)	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.00025, b = 0.00045, c = 999, d = 999)	Expert Judgement: It varies depending on the number, the purpose and volume. Some experiments used anode with a surface area of 30 cm2, while 15 cm2 for the cathode. Others that has volume of 200 mL used each with a surface area of 25 cm2. (McConville, J. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"The simplest MFC is composed of single cathode and anode compartment separated by a cation exchange membrane with graphite/platinum electrodes" (SLU). Installation requires skilled electricians.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"The main design parameters are the number of chambers, wastewater composition and the selection of electrode material. The performance of MFCs depends on parameters such as pH, temperature, substrate, type of bacteria and internal resistance. Depending on choice of integration, the optimum design factors can vary. Adequate attention should be given to matching the MFC to the local conditions" (SLU). Requires expertise.	

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Operators should ensure that organic loading rate and microbial activity are kept at optimal levels for efficient functioning of the MFC components. Monitoring the feedstock concentration and feeding rate, as well as the power generation is crucial" (SLU). Requires skilled workers who understand MFCs.		
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	In a study on Single Chamber Microbial Fuel Cells a lifetime of 10 years was assumed. (Christgen, B. et al. (2015)) Based on this study it can be assumed that the lifetime of Microbial Fuel cells exceed 5 years. Even if the electrodes should fail before 5 years have passed, they can be replaced and the technology can continue to function.	yes	
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA	
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.5, moderate=0.5, slow=0)	Does not require much- Anode Cathode and membrane materials, can be integrated with other technologies really well and easily. Should be able to be implemented fast, however, the limiting factor could be the local availability of such materials and therefore the probability allotted to "rapid" category is reduced (50%) (Akanksha Jain, based on text from SLU Compendium)	yes	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 1)	"[Microbial Fuel Cells] (MFCs) can be integrated into other treatment technologies at all levels, including domestic, centralised or industrial treatment. At a domestic scale, the MFCs can be incorporated into existing septic tanks." (Microbial Fuel Cell | SLU Compendium) MFCs can be integrated into other treatment technologies to reduce the energy requirements and remove wastewater pollutants. The scalability depends on the technology it is integrated into. It is assumed that the MFCs themselves can be upscaled by increasing the number of electrodes and membranes in-between compartments. (Kukka Ilmanen, Eawag 2021)	yes	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0, special = 1)	"The simplest MFC is composed of single cathode and anode compartment separated by a cation exchange membrane with graphite/platinum electrodes. The single-compartment MFC removes the need for the cathodic chamber by exposing the cathode directly to air. " (Microbial Fuel Cell | SLU Compendium) MFCs mainly consists of electrodes and membranes, which probably need to be imported and the membranes will need to be specially manufactured.	yes	

Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")						
	Secondary Effluent	**Range**	**Airloss**	**Soilloss**	**Waterloss**	**Comments**	**Reference**
TP	0.1	0.05 - 0.15	0	0.9	0		Munoz-Cupa et al. (2020)
med (R)	0.1	-	0	0	0		-
k	100	[0.1]	-	-	-		PA
TN	0.4	0.3 - 0.5	0	0.6	0		Fischer et al. (2011)
med (R)	0.4	-	0	0	0		-
k	100	[0.2]	-	-	-		PA
H2O	1	-	0	0	0		Palanisamy et al. (2019)
med (R)	1	-	0	0	0		-
k	100	-	-	-	-		PA
TS	0.1	0.05 - 0.15	0.1	0.8	0		Palanisamy et al. (2019)
med (R)	0.1	-	0.1	0.8	0		-
k	100	[0.1]	-	-	-		PA

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Algae Cultivation						
General Information	**Values**	**Data Source**				
FUNCTIONAL GROUP	T	-				
UNIQUE IDENTIFIER (ID)	algae_cultivation	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	transportedurine, transportedblackwater,	McConville, J. et al. (2020)				
OUTPUT PRODUCT	transportedsecondary_effluent, organics	McConville, J. et al. (2020)				
RELATIONS	Input: OR Output: NA	McConville, J. et al. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	McConville, J. et al. (2020)				
management_level	(household = 0, shared = 0.5, public = 1)	McConville, J. et al. (2020)				
capex_req_level	7	Spuhler, D. et al. (2021)				
opex_req_level	6	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	"Low energy requirements."" Low operation and maintenance costs." (SLU)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.5, no electricity = 0.5)	"If open-pond systems are used, sufficient space will be needed for construction. Closed photo-bioreactors require less space; however, they may require an energy source for artificial lighting" (SLU). Trade-off between space and energy use. Systems without electricity must be expected to perform worse.	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.7, regular = 0.2, continous = 0.1)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.9, difficultly available = 0.9, pipes = 1)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.9, difficultly available = 0.9, pumps = 1)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.8, difficultly available = 0.9, concrete = 1)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.6, technical = 0.4, special = 0)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0, temperate = 1, warm = 1, hot = 0)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.25, no flooding = 1)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Expert Judgement (Ruas, G. & Serejo, M. L. (2021))	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.72, b = 2.88, c = 999, d = 999)	"Large space requirements" (SLU). Best Guess (Spuhler, D. et al. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	Depends on the complexity of the system and whether open or closed systems are used. Skilled workers could suffice in simpler, open systems.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"The selection of the most appropriate cultivation system should consider the microalgae strain used, the geographical location and the desired product" (SLU). "Effluent characteristics (such as turbidity, chemical oxygen demand/biochemical oxygen demand (COD/BOD) and nitrogen and phosphorus concentrations) and selection of the microalgae species (e.g., Spirulina spp., cyanobacteria or naturally occurring species) are critical in reactor design and operations" (SLU). Requires expertise.	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Efficiency of the system is enhanced by optimising operating parameters such as hydraulic retention time, temperature, mixing, CO2 availability and cultivation mode. At times, fertiliser addition may be required to boost the nitrogen and phosphorus concentrations" (SLU). Successful operation requires skilled personell, even when deploying simpler systems.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	In a study by the Oak Ridge National Laboratory a lifetime of approximately 30 years is assumed for an engineering and cost analysis. (Schoenung, S.M et al. (2018)) Based on this it can be assumed that the lifetime of the algae ponds are larger than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.3, moderate=0.7, slow=0)	Open systems (Ponds) and closed systems possible (tubular photo-bioreactors, flat plate reactors and bag systems.) Ponds would entail typical civil engineering construction works of digging and concrete, Photobioreactors would be prefabricated and thus could be implemented faster. Since the more commonly adopted option is to have ponds, and this would require brickwork/concrete, higher probabilities are allotted to moderate category (curing time min 7 days). Some probability is also allotted to rapid in the event that prefab units are used. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	It is assumed that an algae pond can be easily extended by increasing the size of the pond and adding more algae. Extending the pond requires some digging that might limit the upscaling. They are assumed to have similar scalability values to aerated ponds. Furthermore, the scalability depends on how easily new algae can be sourced or their number multiplied. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.6, special = 0)	"There are two major types of large-scale algae culture systems, open ponds and closed photo-bioreactors. Algae are cultivated in suspension or on attached systems like algal turf scrubbers.[...] There are three types of closed systems: tubular photo-bioreactors, flat plate reactors and bag systems.[...] Common harvesting methods include sedimentation, flocculation, centrifugation and filtration. Drying of microalgae can be done by centrifuge, freeze drying or sun drying." (Algae Cultivation | SLU Compendium) Open systems are assumed to require similar materials to aerated ponds. Closed systems require an energy source and can be more complex, requiring more technical parts. Furthermore, the harvesting and drying of algae requires more complex technical parts. It is assumed that the algae themselves are locally available.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Effluent	Range	Organics	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.32	0.25 - 0.39	0.46	0	0.022	0		Ruas (2018), Ruas (2020), Serejo
	0.643							Bhatia et al. (2022)
	0.12		0.88				TDP removal	Ji et al. (2018), Acién
	0.9						soluble P removal	Ferrari Silveira et al.
	0.27							Xu et al. (2017)
	0.29						PO4-P removal	Usha et al. (2016)
med (R)	0.305	0,12-0,64	0.675	0	0.02	0		
k	2	[0.52]	-	-	-	-		
TN	0.17	0.13 - 0.21	0.3	0.44	0.09	0		Ruas (2018), Ruas (2020), Serejo
	0.5							Bhatia et al. (2022)
	0.2						TDP removal	Ji et al. (2018)
	0.18							Xu et al. (2017)
	0.25						TKN removal	Ferrari Silveira et al.
	0.35						NO3-N removal	Usha et al. (2016)
			0.76				Spuhler et al. (2021)	Acién et al. (2018)
med (R)	0.23	0,17-0,5	0.53	0.24	0	0		
k	5	[0.33]	-	-	-	-		
H2O	0.91	-	0.05	0.04	0	0		Krustok (2016), PA
	0.939	0,89-0,99	0.001	0.06			see H2O calculation	Spuhler et al. (2022)
med (R)	0.9245	0,89-0,99	0.03	0.05	0	0		
k	25	[0.1]	-	-	-	-		
TS	0.6	0.5 - 0.7	0.2	0.2	0	0		Krustok (2016), PA
	0.64		0.14	0.2			TSS in mircoalgae	Acién et al. (2018),
med (R)	0.63		0.17	0.2	0	0		
k	25	[0.2]	-	-	-	-		

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

	Effluent	Range	Organics	Airloss	Soilloss	Waterloss	Comments
med (R)	0.9245	0,89-0,99	0.03	0.05	0	0	
k	25	[0.1]	-	-	-	-	
TS	0.6	0.5 - 0.7	0.2	0.2	0	0	
	0.64		0.14	0.2			TSS in mircoalgae
med (R)	0.63		0.17	0.2	0	0	
k	25	[0.2]	-	-	-	-	

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

Xu et al. (2017) Effects of influent C/N ratios and treatment technologies on integral biogas upgrading and pollutants removal from synthetic domestic sewage Sci. Rep., 7 (2017), p. 10897, 10.1038/s41598-017-11207-y

Usha et al. (2016) Removal of nutrients and organic pollution load from pulp and paper mill effluent by microalgae in outdoor open pond. Bioresource Technology 214, 856.860. https://doi.org/10.1016/j.biortech.2016.04.060

Ancién Fernández et al. (2018) Recovery of Nutrients From Wastewaters Using Microalgae

Gouveia et al. (2016) Microalgae biomass production using wastewater: Treatment and costs Scale-up considerations

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P., & Zurbrügg, C. (2014). *Compendium of Sanitation Systems and Technologies—2nd revised edition* . Swiss Federal Institute of Aquatic Science and Technology (EAWAG).

Membrane Filtration		Membrane Filtration
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	membrane_filtration	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedurine	McConville, J. et al. (2020)
OUTPUT PRODUCT	transportedconcentrated_urine	McConville, J. et al. (2020)
RELATIONS	Input: OR Output: NA	McConville, J. et al. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	McConville, J. et al. (2020)
management_level	(household = 0, shared = 0.5, public = 1)	McConville, J. et al. (2020)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	7	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	"Due to the high technical complexity and capital investments of current membrane technology, it is most applicable at higher management levels in centralised systems." "When membranes eventually foul costly replacements and/or hazardous regeneration chemicals will be necessary." (McConville, J. et al. (2020)) Given above, this technology is not considered to be very appropriate for emergency situations. Membrane Filtration is considered only appropriate for development projects or the recovery phase of an emergency. (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no electricity = 1)	"The osmotic process of the FO membranes is a naturally occurring phenomenon that does not require any external energy provided the draw solute is available without energy input. Depending on the physical driving forces used in other membrane processes (e.g., pressure, heat or electricity), the operation of membranes may require a considerable amount of energy input." (SLU). Electricity requirements therefore depend on the deployed system.	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.2, regular = 0.8, continous = 0)	PA by Matthias van Sloten and proven by Priscila de Morais Lima.	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.5, pipes = 1)	Expert judgement (McConville, J. 2021)	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.8, difficultly available = 0.8, pumps = 1)	Expert judgement (McConville, J. 2021)	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Expert judgement (McConville, J. 2021)	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.5, special = 0.5)	PA by Matthias van Sloten and proven by Priscila de Morais Lima.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate = 1, warm = 1, hot = 1)	Expert judgement (McConville, J. 2021)	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.8, no flooding = 1)	Should be possible to be built waterproof what means that flooding should not be a problem but maybe could cause some more effort to build. (PA by Matthias van Sloten)	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Expert judgement (McConville, J. 2021)	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0.5, b = 1, c = 999, d = 999)	This depends on the wastewater flow of course. For a single household with not many people, it could be less than 1 m3. These are very rough estimates - it of course in also a function of the depth of the filter as much as the surface ares. (McConville, J. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	Depends on the complexity of the implemented system, but requires highly skilled workers to construct the highly technical systems.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"The main design aspects of membranes include the feed and draw solutions, draw solute recovery process, membrane material, orientation and placement within the treatment process" (SLU). High technical complexity. Requires expertise.	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	Depends on the complexity of the implemented system, but requires skilled workers to handle the high technical complexity.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"high technical complexity and capital investments of current membrane technology" (Membranes | SLU Compendium) It is assumed that due to the high capital investment costs membranes are implemented as long-term solutions. Therefore, even though membranes can have lifetimes of 3 or less years, it is assumed that old membranes can be replaced and the technology itself has a lifetime of more than 5 years. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0.5, moderate=0.5, slow=0)	"Membrane technology is widely applicable to a number of waste streams and can easily be integrated into existing treatment options as discussed above." Does not require much- Draw Solution and membrane materials, can be integrated with other technologies really well and easily. Should be able to be implemented fast, however, the limiting factor could be the local availability of such materials and therefore the probability allotted to "rapid" category is reduced (50%) (Akanksha Jain, based on text from SLU Compendium)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	"Membrane technology is widely applicable to a number of waste streams and can easily be integrated into existing treatment options as discussed above." (Membranes | SLU Compendium) Membranes often exist in compact modules that are added as an additional step to other treatment processes. As long as sufficient membrane modules are available the treatment capacity can be increased by increasing their number. Depending on the module types and how these modules are connected to the overall system adding further modules can be difficult. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.4, special = 0.6)	"The main design aspects of membranes include the feed and draw solutions, draw solute recovery process, membrane material, orientation and placement within the treatment process.", "highly technical complexity" (Membranes | SLU Compendium) Membrane filtration requires special membranes as well as technical parts. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Concentrated Urine	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.3	0.2 - 0.4	0	0.7	0		McConville, J. (2021)
med (R)	0.3	0.2 - 0.4	0	0.7	0		-
k	2	[0.2]	-	-	-		PA
TN	0.3	0.1 - 0.5	0.05	0.65	0		McConville, J. (2021)
med (R)	0.3	0.1 - 0.5	0.05	0.65	0		-
k	2	[0.4]	-	-	-		PA
H2O	0.95	0.9 - 1	0.05	0	0		McConville, J. (2021)
med (R)	0.95	0.9 - 1	0.05	0	0		-
k	5	[0.1]	-	-	-		PA
TS	0.15	0 - 0.3	0.1	0.75	0		McConville, J. (2021)
med (R)	0.15	0 - 0.3	0.1	0.75	0		-
k	1	[0.3]	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Mcconville, J., et al. (2020). "Guide to Sanitation Resource-Recovery Products & Technologies : a supplement to the Compendium of Sanitation Systems and Technologies."

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Carbonisation		Carbonisation
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	carbonisation	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedstored_faeces, transporteddried_faeces, transportedsludge,	McConville, J. et al. (2020)
OUTPUT PRODUCT	transportedbiochar	McConville, J. et al. (2020)
RELATIONS	Input: OR Output: NA	McConville, J. et al. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0.5, neighbourhood = 0.5, city = 1)	McConville, J. et al. (2020)
management_level	(household = 0.5, shared = 0.5, public = 1)	McConville, J. et al. (2020)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	This tech has highly complex and would be difficult to establish in the acute and stabilisation phases of an emergency. Additionally, carbonisation of sludge is usually done at a centralised level, where sludge can be dried prior to the thermal treatment. This would not be ideal for emergencies where generally, onsite treatment technologies need to be implemented. However, it can allow for significant energy and nutrient recovery and has a very fast treatment time- therefore, could potentially be a good option for recovery phases. (Akanksha Jain, based on McConville, J. et al. (2020))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.75, no electricity = 0.5)	Electricity is required "if mechanical equipment is used for feedstock loading, air pollution control and process control/ monitoring equipment". Simple systems do not require electricity, but perform worse.	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.1, regular = 0.7, continous = 0.2)	Zabaleta et al. (2018)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	Zabaleta et al. (2018)	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	Zabaleta et al. (2018)	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Zabaleta et al. (2018)	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	Zabaleta et al. (2018)	
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.7, cold = 0.8, temperate = 1, warm = 1, hot = 1)	Zabaleta et al. (2018)	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	Zabaleta et al. (2018)	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	NA	NA	NA
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1 hard = 1)	Zabaleta et al. (2018)	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0,014, b = 0.025, c = 999, d = 999)	assuming 0.25kg/cap day feedstock and reactor of 40kg capacity using 2.25m2 (Expert Judgement (Zurbrügg, C. (2021)))	
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	System based on batch processes (without conveyor belts) should be fairly easy to construct. However, due to safety concerns associated with the operation, skilled workers should be employed.	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Each carbonisation technique uses different temperatures, heating duration, or reactor pressure to produce different quantities and qualities of the end products" (SLU). "A gas filtering system, such as a bag filter, should be incorporated into the reactors to reduce harmful environmental gas emissions" (SLU). Requires expertise.	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Accidental introduction of air into the pyrolysis reactor, for example, through leaks in the reactor, may create unstable combustion and result into explosions or fires. Regular inspection and maintenance of filter bags and safety devices are a necessity to minimise accident occurrences" (SLU). Tasks are relatively basic, but due to safety concerns, skilled workers should be employed.	
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	20 years assumed	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	Chamber made from bricks or concrete, would require minimum 7 days for curing. No microbial process involved, therefore no reduction in speed because of time needed for communities to establish. (Akanksha Jain)	yes
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.3)	complex design -> more difficult to scale, flexibility with input --> similar to mono-incineration	

construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0, technical = 0.7, special = 0.3)	"The batch reactor will consist of a pipe closed to one end with a vessel dished end (curved shape). This requires less material than a flat end and is easier to manufacture than a hemispherical end. The top is equipped with a flange and closed with a lid that can be screwed to the flange, allowing easy accessibility to the inside of the reactor. This way, the reactor can be easily opened, filled, and tightly closed. A graphite sealing ring allows the reactor to be hermetically sealed. The electric heating is provided by a cylindrical heating mantle surrounding the vessel. The external temperature is controlled with a regulator connected to the heating mantle. An energy meter is connected to the heating mantle to measure the energy consumed during the reaction. The inner temperature and pressure as well as power consumption will be recorded over time on a computer during the reactions. The maximum allowable pressure is controlled with an overpressure valve that releases the pressure when going higher than a certain limit. The steam released is directed to the outside with a stainless steel pipe. At the end of the reaction, after letting the reactor cooling down, the residual pressure will be released thanks to a drain valve and the residual gases directed to the outside through a plastic pipe." (Robbiani, Z. (2013)) The batch reactor requires several parts that might possibly need to be specially manufactured. Around the vessel electrical heating needs to be ensured and control equipment inside and outside of the vessel is necessary.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Biochar	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0		Zielinska et al. (2015)
med (R)	1	-	0	0	0		-
k	2	-	-	-	-		PA
TN	0.03	-	0.97	0	0		Krueger et al. (2020)
med (R)	0.03	-	0.97	0	0		-
k	2	-	-	-	-		PA
H2O	0.01	-	0.99	0	0		Zurbrügg, C. (2021)
med (R)	0.01	-	0.99	0	0		-
k	5	-	-	-	-		PA
TS	0.99	-	0.01	0	0		Zurbrügg, C. (2021)
med (R)	0.99	-	0.01	0	0		-
k	1	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Mono-Incineration		Mono-Incineration
General Information	**Values**	**Data Source**
FUNCTIONAL GROUP	T	-
UNIQUE IDENTIFIER (ID)	mono_incineration	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	transportedstored_faeces, transporteddried_faeces, transportedsludge, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	transportedash	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	McConville, J. et al. (2020)
management_level	(household = 0, shared = 0.5, public = 1)	McConville, J. et al. (2020)
capex_req_level	7	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	McConville, J. et al. (2020)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, inermittent = 1, no electricity = 1)	Expert judgement (McConville, J. et al. 2021)	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.2, regular = 0.7, continous = 0.1)	Expert judgement (McConville, J. et al. 2021)	
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(No pipes = 1, Difficulty available = 1, Pipes = 1)	Expert judgement (McConville, J. et al. 2021)	
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(No pumps= 1, Difficulty available = 1, Pumps= 1)	Expert judgement (McConville, J. et al. 2021)	
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Expert judgement (McConville, J. et al. 2021)	
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	Expert judgement (McConville, J. et al. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.7, cold = 0.8, temperate = 1, warm = 1, hot = 1)	Expert judgement (McConville, J. et al. 2021)	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	Expert judgement (McConville, J. et al. 2021)	
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	FALSE	clay silt sand gravel rock	(Rock = 1, Clay = 1, Silt = 1, Sand = 1, Gravel = 1)	Expert judgement (McConville, J. et al. 2021)	
groundwater_depth	Performance, Trapez	FALSE	water depth [m]	NA	NA	NA
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Expert judgement (McConville, J. et al. 2021)	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	TRUE	m2/pers	(a = 0,014, b = 0.025, c = 999, d = 999)	assuming 0.25kg/cap day feedstock and reactor of 40kg capacity using 2.25m2 (Expert Judgement (Zurbrügg, C. (2021)))	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	FALSE	Close Not close	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	Expert judgement (McConville, J. et al. 2021)	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 0.9, professional = 1)	Expert judgement (McConville, J. et al. 2021)	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.8, skilled = 1, professional = 1)	Expert judgement (McConville, J. et al. 2021)	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"the lifetime of typical incinerators (20-30 years)" (National Research Council (US) 2000) It is assumed that sludge incinerators have similar lifetimes to a normal incinerator. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	TRUE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	(rapid=0, moderate=1, slow=0)	Chamber made from bricks or concrete, would require minimum 7 days for curing. No microbial process involved, therefore no reduction in speed because of time needed for communities to establish. (Akanksha Jain)	
scalability	Performance, Categorical	TRUE	easy difficult	(easy = 1, difficult = 0.5)	Mono-incineration requires a complex installation that can neither be easily increased in size nor replicated. However, it is assumed that a large enough incinerator has some flexibility in regard to the input loading. (Kukka Ilmanen, Eawag 2021)	yes
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	Expert judgement (McConville, J. et al. 2021)	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Ash	Range	Airloss	Soilloss	Waterloss	Comments Specifications	Reference
TP	1	-	0	0	0	Expert judgement	McConville, J. et al. (2021)
med (R)	1	-	0	0	0		-
k	2	-	-	-	-		PA
TN	0.03	0 - 0.06	0.97	0	0	Expert judgement	McConville, J. et al. (2021)
med (R)	0.03	-	0.97	0	0		-
k	2	[0.06]	-	-	-		PA
H2O	0.01	-	0.99	0	0	Expert judgement	McConville, J. et al. (2021)
med (R)	0.01	-	0.99	0	0		-
k	1	-	-	-	-		PA
TS	0.99	0.9 - 1	0.01	0	0	Expert judgement	McConville, J. et al. (2021)
med (R)	0.99	-	0.01	0	0		-
k	5	[0.1]	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Spuhler, D., & Roller, L. (2020). *Sanitation technology library: Details and data sources for appropriateness profiles and transfer coefficients* . Eawag - Swiss Federal Institute of Aquatic Science and Technology.

Mcconville, J., et al. (2020). "Guide to Sanitation Resource-Recovery Products & Technologies : a supplement to the Compendium of Sanitation Systems and Technologies."

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Application of Urine		Application of Urine				
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	application_of_urine	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	stored_urine, transportedstored_urine, stabilized_urine, transportedstabilized_urine	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	3	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no ele	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continous = 0)	"Over time, some minerals in urine will precipitate (especially, calcium and magnesium phosphates). Equipment that is used to collect, transport or apply urine (i.e., watering cans with small holes) may become clogged over time. Most deposits can easily be removed with hot water and a bit of acid (vinegar), or in more extreme cases, manually chipped off." (Compendium) "Urine application does not need special equipment, and thus additional costs for urine application are low. However, urine application can be labour intensive." (SLU Compendium) Frequency of maintanance is low but the application needs a lot of work.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Urine application does not need special equipment, and thus additional costs for urine application are low [...]." (SLU Compendium) No special equipment means also that no technical or special spare parts are needed.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. The absence, or poor growth of crops (limiting uptake of manure nutrients and water), winter weather, and winter soil conditions generally exacerbate off-site losses of manure-derived pollutants." (Liu et al. (2018)) The application of stored urine is still possible on cold temperatures but the soil will not be able to absorb all of the nutritients and they would be washed away to surface waters or to the groundwater.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	All technologies associated with "Application of a certain product" are awarded performance values in accordance with each other. Generally, these products are aimed to be safe for use, however, they do carry a "low risk of pathogen transmission" (Compendium). In the event of flooding, surrounding areas of where these products are applied therefore bear some risk. Also, the social acceptance of these products can be low and people would not prefer flood waters to spread these products everywhere. Hence, their performance is reduced by 10% or 20% depending on the relative risk of pollution between different products (e.g., stabilized sludge riskier than stored urine). (Akanksha Jain). Stored urine is considered to be quite a safe product therefore allotted a performance of 90%.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, r	The application of stored urine is not based on soil absorption. No difference between different soil types. Stored urine can be brought on the field on every type of soil.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"Urine poses a minimal risk of infection, especially when it has been stored for an extended period of time. Yet, urine should be carefully handled and should not be applied to crops less than one month before they are harvested. This waiting period is especially important for crops that are consumed raw [...]." (Compendium) Because there is a remaining risk of contamination you should make safe that it is sterile before you applicate stored urine in an area with a high groundwater level.	yes

excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Urine poses a minimal risk of infection, especially when it has been stored for an extended period of time. Yet, urine should be carefully handled and should not be applied to crops less than one month before they are harvested. This waiting period is especially important for crops that are consumed raw [...]." (Compendium) Because there is a remaining risk of contamination you should make safe that it is sterile before you applicate stored urine close to a drinking water source.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No construction needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"There is no standard recommendation for dilution, and existing recommendations vary widely, usually between ratios of 1:3 to 1:10, depending on the soil and the type of vegetables. Keep in mind that dilution increases the total volume and thus labour and transport needs. If diluted urine is used in an irrigation system, it is referred to as "fertigation" (see R.19). During the rainy season, urine can be applied directly into small holes near plants, it is then diluted naturally." (SLU Compendium) "Urine poses a minimal risk of infection, especially when it has been stored for an extended period of time. Yet, urine should be carefully handled and should not be applied to crops less than one month before they are harvested. This waiting period is especially important for crops that are consumed raw [...]." (Compendium) High design skills are recommended to applicate the urine correct and to prevent contamination.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	OM skills required are low.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	The concept of applying stored urine does not have a lifetime and can therefore be used at anytime. The storage of urine itself takes place in the FG S or T. (Kukka Ilmanen, 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Urine application does not need special equipment, and thus additional costs for urine application are low [...]." (SLU Compendium) No special equipment means that no technical or special parts are needed to apply stored urine.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.97	-	0	0.02	0.01		PA
med (R)	0.97	-	0	0.02	0.01		-
k	100	-	-	-	-		PA
TN	0.94	0.9 - 0.99	0.05	0	0	* sophisticated spreading techniques	Udert et al. (2006)
	0.89	0	0.11	0	0	* Cattle manure	Vertregt and Rutgers
	-	-	-	0.01	0.01		PA
med (R)	0.91	0.89-0.99	0.07	0.01	0.01		-
k	25	[0.1]	-	-	-		PA
H2O	0.98	-	0	0.01	0.01		PA
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TS	0.98	-	0	0.01	0.01		PA
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
							Spuhler et al. (2021)

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Vertregt, N. and B. Rutgers (1987). Ammonia Volatilization from Urine Patches in Grassland. Animal Manure on Grassland and Fodder Crops. Fertilizer or Waste? H. G. Van Der Meer, R. J. Unwin, T. A. Dijk and G. C. Ennik. Dordrecht, Springer Netherlands: 361–363.

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Liu, J., et al. (2018). "A review of regulations and guidelines related to winter manure application." Ambio 47(6): 657-670.

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Application of Concentrated Urine		Application of Concentrated Urine
	Values	**Data Source**
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	application_concentrated_urine	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	concentrated_urine, transportedconcentrated_urine	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 1, city = 1)	McConville, J. et al. (2020)
management_level	(household = 1, shared = 1, public = 1)	McConville, J. et al. (2020)
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	Same values allotted as treatment technology aurin production (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.8, regular = 0.2, continous = 0)	The only material you need for the application of Aurin is a watering can or aomething similar. No further maintenance needed. "At a large scale, this liquid fertiliser requires appropriate equipment for spreading on agricultural fields." (SLU Compendium -> R.2 Concentrated Urine) For the special equipment on a large scale some regular maintenance might be necessary.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	The only material you need for the application of Aurin is a watering can. No special spare parts are needed on a small scale. "At a large scale, this liquid fertiliser requires appropriate equipment for spreading on agricultural fields." (SLU Compendium -> R.2 Concentrated Urine) For the special equipment on a large scale technical spare parts might be necessary.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. The absence, or poor growth of crops (limiting uptake of manure nutrients and water), winter weather, and winter soil conditions generally exacerbate off-site losses of manure-derived pollutants." (Liu et al. (2018)) The application of Aurin is still possible on cold temperatures but the soil will not be able to absorb all of the nutritients and they would be washed away to surface waters or to the groundwater.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=0.9, no flooding=1)	All technologies associated with "Application of a certain product" are awarded performance values in accordance with each other. Generally, these products are aimed to be safe for use, however, they do carry a "low risk of pathogen transmission" (Compendium). In the event of flooding, surrounding areas of where these products are applied therefore bear some risk. Also, the social acceptance of these products can be low and people would not prefer flood waters to spread these products everywhere. Hence, their performance is reduced by 10% or 20% depending on the relative risk of pollution between different products (e.g., stabilized sludge riskier than stored urine). (Akanksha Jain). Aurin is considered to be quite a safe product therefore allotted a performance of 90%.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	The application of Aurin is not based on soil absorption. No difference between different soil types. Aurin can be brought on the field on every type of soil.	yes

groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	Aurin is sterile and free of heavy metals, hormons and medicaments. It is safe to applicate everywhere. Accepted as commercial fertiliter by the Federal Office for Agriculture of Siwtzerland. (Etter et al.) If applicated in areas with high a groundwater level it is very important not to applicate too much to prevent infiltration of nutritients to the groundwater.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	Aurin is sterile and free of heavy metals, hormons and medicaments. It is safe to applicate everywhere. Accepted as commercial fertilizer by the Federal Office for Agriculture of Siwtzerland. (Vuna) If applicated in areas close to a drinking water source it is very important not to applicate too much to prevent infiltration of nutritients to the drinking water.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No construction needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	The only things that have to be considered are the amount of Aurin applicated and that it is not applicated on frozen, completely dried out or soaked ground.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	The only material you need for the application of Aurin is a watering can (Vuna). No OM skills needed on a small scale. "At a large scale, this liquid fertiliser requires appropriate equipment for spreading on agricultural fields." (SLU Compendium -> R.2 Concentrated Urine) Moderate OM skills needed on a large scale.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	The concept does not have a lifetime and can therefore be used at anytime. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.8, technical = 0.2, special = 0)	The only material you need for the application of Aurin is a watering can. No special spare parts are needed on a small scale. "At a large scale, this liquid fertiliser requires appropriate equipment for spreading on agricultural fields." (SLU Compendium -> R.2 Concentrated Urine) For spreading on a large scale special technical equipment might become necessary.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.98	-	0	0.01	0.01		PA
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TN	0.96	-	0.02	0.01	0.01	*"low volailization due to nitrification"	PA
med (R)	0.96	-	0.02	0.01	0.01		-
k	100	-	-	-	-		PA
H2O	0.98	-	0	0.01	0.01		PA
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TS	0.98	-	0	0.01	0.01		PA
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA

References

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Application of Struvite or Dried Urine		Applciation of Struvite or Dried Urine
	Values	Data Source
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	application_struvite_driedurine	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	struvite, transportedstruvite, dried_urine, transporteddried_urine	Spuhler, D. et al. (2021)
OUTPUT PRODUCT	NA	Spuhler, D. et al. (2021)
RELATIONS	Input: OR Output: NA	Spuhler, D. et al. (2021)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0.5, neighbourhood = 1, city = 1)	McConville, J. et al. (2020)
management_level	(household = 0.5, shared = 1, public = 1)	McConville, J. et al. (2020)
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	Same values allotted as treatment technology struvite precipitation (Akanksha Jain)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity needed. (Senecal-Smith, J. 2021)	
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	"As fertiliser is applied only one or twice in a growing season, storage of the dry urine is a given, and thus storage as a treatment is an ideal option." (Dry Urine | SLU Compendium) "Can be stored in a compact form and is easy to handle, transport and apply, especially in a granulated form." (Struvite | SLU Compendium) Struvite and dried urine can be stored easily and only require irregular use as fertiliser.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes needed. (Senecal-Smith, J. 2021)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed. (Senecal-Smith, J. 2021)	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed. (Senecal-Smith, J. 2021)	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be stored in a compact form and is easy to handle, transport and apply, especially in a granulated form." (Struvite | SLU Compendium) "Stable, so can be stockpiled/stored.", "Dry urine is a powder that can be applied using a mechanical spreader, but it can also be pelletised and applied with conventional farming equipment." (Dry Urine | SLU Compendium) Application as dry fertiliser does not require any additional technical or special parts.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. The absence, or poor growth of crops (limiting uptake of manure nutrients and water), winter weather, and winter soil conditions generally exacerbate off-site losses of manure-derived pollutants." (Liu et al. (2018)) The application of struvite is still possible in cold temperatures but the soil will not be able to absorb all of the nutritients and they would be washed away to surface waters or to the groundwater.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	All technologies associated with "Application of a certain product" are awarded performance values in accordance with each other. Generally, these products are aimed to be safe for use, however, they do carry a "low risk of pathogen transmission" (Compendium). In the event of flooding, surrounding areas of where these products are applied therefore bear some risk. Also, the social acceptance of these products can be low and people would not prefer flood waters to spread these products everywhere. Hence, their performance is reduced by 10% or 20% depending on the relative risk of pollution between different products (e.g., stabilized sludge riskier than stored urine). (Akanksha Jain). Struvite is considered to be quite a safe product therefore allotted a performance of 90%.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	Not affected by soil type.	yes

groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	Not affected by groundwater table, however, product should be sterile before application. (Senecal-Smith, J. 2021)	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Struvite formation may be coupled with precipitation of other constituents present in urine and wastewater, such as pathogens and heavy metals. However, the concentrations of these constituents, especially those of heavy metals, are generally below the permissible limits in the precipitated product, particularly if the struvite is precipitated directly from source-separated urine. If the struvite is precipitated from other, more contaminated sources (e.g., blackwater or reject water), heavy metal contamination may become an issue" (SLU). When applying struvite close to drinking water sources, one should have a good understanding of potential heavy metal contamination.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No construction needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	Very basic knowledge needed to know how much struvite to apply as fertilizer.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	No specific skills needed.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	The concept of applying struvite as fertiliser does not have a lifetime and can therefore be used at anytime. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be stored in a compact form and is easy to handle, transport and apply, especially in a granulated form. Slow-release fertiliser that provides plants with nutrients without the risk of burning the roots." (R7. Struvite - SLU Compendium) "Dry urine is a powder that can be applied using a mechanical spreader, but it can also be pelletised and applied with conventional farming equipment." (Dry Urine | SLU Compendium) The application of struvite and dried urine does not require any technical or special parts.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	1	-	0	0	0		(Senecal-Smith, J. 2021)
med (R)	1	-	0	0	0		-
k	2	-	-	-	-		PA
TN	0.9	-	0.1	0	0		(Senecal-Smith, J. 2021)
med (R)	0.9	-	0.1	0	0		-
k	2	-	-	-	-		PA
H2O	0.05	-	0.95	0	0		(Senecal-Smith, J. 2021)
med (R)	0.05	-	0.95	0	0		-
k	5	-	-	-	-		PA
TS	0.98	-	0.02	0	0		(Senecal-Smith, J. 2021)
med (R)	0.98	-	0.02	0	0		-
k	1	-	-	-	-		PA

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Application of Dried Faeces		Application of Dried Faeces				
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	application_of_dried_faeces	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	dried_faeces, transporteddried_faeces	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)				
capex_req_level	3	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	Dried faeces usually are applicated before planting crops. So there is a lot of work in a short time but then no regular operation or maintenance is required. Application is similar to the application of compost.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	Since there is no need for technical or special material or tools for the application there is no need for technical or special spare parts. Application is similar to the application of compost: "Materials required for Application of Pit Humus and Compost are locally available in most situations and include wheelbarrows, shovels, spades, rakes, and personal protective equipment (PPE). For cultivating land where compost or pit humus has been applied other gardening tools such as hoes, watering cans, seeds, etc. are required." (Emersan -> D.3 Application of Pit Humus and Compost)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. The absence, or poor growth of crops (limiting uptake of manure nutrients and water), winter weather, and winter soil conditions generally exacerbate off-site losses of manure-derived pollutants." (Liu et al. (2018)) The application of dried faeces is still possible on cold temperatures but the soil will not be able to absorb the nutritients and they would be washed away to surface waters or to the groundwater.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	All technologies associated with "Application of a certain product" are awarded performance values in accordance with each other. Generally, these products are aimed to be safe for use, however, they do carry a "low risk of pathogen transmission" (Compendium). In the event of flooding, surrounding areas of where these products are applied therefore bear some risk. Also, the social acceptance of these products can be low and people would not prefer flood waters to spread these products everywhere. Hence, their performance is reduced by 10% or 20% depending on the relative risk of pollution between different products (e.g., stabilized sludge riskier than stored urine). (Akanksha Jain). Dried faeces is considered to be quite a safe product therefore allotted a performance of 90%.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	The application is not based on soil absorption. No difference between different soil types. Dried faeces can be brought on the field on every type of soil.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	Not affected by groundwater table. However, it should be assured, that the dried faeces are sterile and safe for application.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"It is generally accepted that faeces should be stored between 6 to 24 months, although pathogens may still exist after this time (refer to WHO guidelines for specific guidance)." (Compendium) Because there is a remaining risk of contamination you should make safe that it is sterile before you applicate compost made of human excrements close to a drinking water source.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No construction needed.	yes

design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Faeces that are dried and kept at between 2 and 20 °C should be stored for 1.5 to 2 years before being used at the household or regional level. At higher temperatures (i.e., >20 °C average), storage over 1 year is recommended to inactivate Ascaris eggs (a type of parasitic worm). A shorter storage time of 6 months is required if the faeces have a pH above 9 (i.e., adding ash or lime increases the pH). WHO guidelines concerning the use of excreta in agriculture should be consulted beforehand." (Compendium) "If water or urine is mixed with the drying faeces, however, odours and organisms may become problematic because bacteria easily survive and multiply in wet faeces. Warm, moist environments are conducive to anaerobic processes, which can generate offensive odours. Dehydrated faeces should not be applied to crops less than one month before they are harvested. This waiting period is especially important for crops that are consumed raw." (Compendium) Some important considerations have to be done. Therefore high design skills are recommended. Requires consideration of health aspects!	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"When removing dehydrated faeces from dehydration vaults, care must be taken to prevent the powder from blowing and being inhaled. Workers should wear appropriate protective clothing. Faeces should be kept as dry as possible. If by accident, water or urine enters and mixes with drying faeces, more ash, lime or dry soil should be added to help absorb the moisture. Prevention is the best way to keep faeces dry." (Compendium) It is possible to applicate dried faeces with low OM skills. However, at least moderate OM skills might be necessary to keep the operation safe.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"The degree of pathogen inactivation will depend on the temperature, the pH (ash or lime addition raises the pH and inactivates pathogens) and the storage time. It is generally recommended that faeces should be stored and dehydrated for between 6 to 24 months, although pathogens can remain viable even after this time." (Dried Faeces | SLU Compendium) The concept of applying dried faeces does not have a lifetime and can therefore be used at anytime. The storage and drying of faeces itself takes place in technologies in the functional groups FG S or FG T. Therefore that a too short storage time might add pathogens into the soil and the technology might therefore not be the best short-term solution, is not considered here. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"The Application of Dried Faeces requires wheelbarrows, shovels, spades, rakes, and personal protective equipment (PPE). For cultivating the land where dried faeces have been applied other gardening tools may be required. Dried faeces can be stored and transported in used containers or bags." (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.98	-	0	0.01	0.01	* higher losses with surface application than incorporation into soil	Dunigan and Dick (1980)
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TN	0.94	-	0.04	0.01	0.01	* higher losses with surface application	Dunigan and Dick (1980)
med (R)	0.94	-	0.04	0.01	0.01		-
k	100	-	-	-	-		PA
H2O	0.98	-	0	0.01	0.01		EJ
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TS	0.69	-	0	0.3	0.01	Effects are comparable to processed sludge application	Lima et al. (2009)
med (R)	0.69	-	0	0.30	0.01		-
k	5	-	-	-	-		PA

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Application of Compost and Biochar						
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	application_of_compost_biochar	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	compost, transportedcompost, pithumus, transportedpithumus, biochar, transportedbiochar, ash, transportedash	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 0.5)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)				
capex_req_level	3	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	"The material must be allowed to adequately mature before being removed from the system. Then, it can be used without further treatment." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Materials required for Application of Pit Humus and Compost are locally available in most situations and include wheelbarrows, shovels, spades, rakes, and personal protective equipment (PPE). For cultivating land where compost or pit humus has been applied other gardening tools such as hoes, watering cans, seeds, etc. are required." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. The absence, or poor growth of crops (limiting uptake of manure nutrients and water), winter weather, and winter soil conditions generally exacerbate off-site losses of manure-derived pollutants." (Liu et al. (2018)) The application of compost is still possible on cold temperatures but the soil will not be able to absorb the nutritients and they would be washed away to surface waters or to the groundwater.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.9, no flooding = 1)	All technologies associated with "Application of a certain product" are awarded performance values in accordance with each other. Generally, these products are aimed to be safe for use, however, they do carry a "low risk of pathogen transmission" (Compendium). In the event of flooding, surrounding areas of where these products are applied therefore bear some risk. Also, the social acceptance of these products can be low and people would not prefer flood waters to spread these products everywhere. Hence, their performance is reduced by 10% or 20% depending on the relative risk of pollution between different products (e.g., stabilized sludge riskier than stored urine). (Akanksha Jain). Compost is considered to be quite a safe product therefore allotted a performance of 90%.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	The application of compost is not based on soil absorption. No difference between different soil types. Compost can be brought on the field on every type of soil.	yes

groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"The process of thermophilic composting generates heat (50 to 80 °C) which kills the majority of pathogens present." (Compendium) "Pit humus must be allowed to adequately mature before being removed from the system. It can then be used without further treatment." (Emersan) "A small risk of pathogen transmission exists, but, if in doubt, any material removed from the pit or vault can be further composted in a regular compost heap before being used or mixed with additional soil and put into a 'tree pit', i.e., a nutrient-filled pit used for planting a tree." (Compendium) Because there is a remaining risk of contamination you should make safe that it is sterile before you applicate compost made of human excrements in an area with a high groundwater level.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"The process of thermophilic composting generates heat (50 to 80 °C) which kills the majority of pathogens present." (Compendium) "A small risk of pathogen transmission exists, but, if in doubt, any material removed from the pit or vault can be further composted in a regular compost heap before being used or mixed with additional soil and put into a 'tree pit', i.e., a nutrient-filled pit used for planting a tree." (Compendium) Because there is a remaining risk of contamination you should make safe that it is sterile before you applicate compost made of human excrements close to a drinking water source.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No construction needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Compost and pit humus should not be applied to crops less than one month before they are harvested." (Compendium) Requires consideration of health aspects!	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	No OM skills required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 0.5)	The concept of applying compost does not have a lifetime and can therefore be used at anytime. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Materials required for Application of Pit Humus and Compost are locally available in most situations and include wheelbarrows, shovels, spades, rakes, and personal protective equipment (PPE). For cultivating land where compost or pit humus has been applied other gardening tools such as hoes, watering cans, seeds, etc. are required." (Emersan) To set up the application of compost and biochar no technical or special parts are required.	yes

Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")						
	Recovered	**Range**	**Airloss**	**Soilloss**	**Waterloss**	**Comments**	**Reference**
TP	0.98	-	0	0.01	0.01		PA
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TN	0.94	-	0.04	0.01	0.01		PA based on He et al. (2003)
med (R)	0.94	-	0.04	0.01	0.01		-
k	100	-	-	-	-		PA
H2O	0.98	-	0	0.01	0.01		PA
med (R)	0.98	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TS	0.69	-	0	0.3	0.01	PA based on: Effects are comparable to processed sludge application	Lima et al. (2009)
med (R)	0.69	-	0	0.30	0.01		-
k	5	-	-	-	-		PA

Additional Information	(Data from: He et al. (2003))						
	Biosolids	**Compost**	**Airloss Biosolids incorporated**	**Airloss Biosolids surface**	**Airloss Compost incorporated**	**Airloss Compost surface**	Spuhler et al. (2021)
Total N	49'000	18'800	0.00	0.01	0.00	0.00	
NH_{4-N}	2'726	55	0.04	0.23	0%	18%	
% Ammonia of TN	0.06	0.00					

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

Loetscher, T., & Keller, J. (2002). A decision support system for selecting sanitation systems in developing countries. *Socio-Economic Planning Sciences* , *36* (4), 267–290. https://doi.org/10.1016/S0038-0121(02)00007-1

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Spuhler, D., & Roller, L. (2020). *Sanitation technology library: Details and data sources for appropriateness profiles and transfer coefficients* . Eawag - Swiss Federal Institute of Aquatic Science and Technology.

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Liu, J., et al. (2018). "A review of regulations and guidelines related to winter manure application." Ambio 47(6): 657-670.

Lima, D. L. D., et al. (2009). "Effects of organic and inorganic amendments on soil organic matter properties." Geoderma 150(1-2): 38–45.

Application of Stabilized Sludge		
	Values	Data Source
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	application_of_sludge	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	processed_sludge, transportedprocessed_sludge, stabilized_sludge, transportedstabilized_sludge, pithumus, transportedpithumus, pellets, transportedpellets, briquettes, transportedbriquettes	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	4	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Solids are spread on the ground surface using conventional manure spreaders, tank trucks or specially designed vehicles." (Compendium) "Spreading equipment must be maintained to ensure continued use. The amount and rate of sludge application should be monitored to prevent overloading and, thus, the potential for nutrient pollution." (Compendium) Regular maintenance and monitoring is required.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.5, special = 0.3)	"Solids are spread on the ground surface using conventional manure spreaders, tank trucks or specially designed vehicles." (Compendium) "Spreading equipment must be maintained to ensure continued use. [...]." (Compendium) "May require special spreading equipment" (Compendium) Maintenance and reparation of the spreading equipment can occure. This will require techical spare parts and for the specially designed vehicles even specially manufactured spare parts.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. The absence, or poor growth of crops (limiting uptake of manure nutrients and water), winter weather, and winter soil conditions generally exacerbate off-site losses of manure-derived pollutants." (Liu et al. (2018)) The application of stabilized sludge is still possible on cold temperatures but the soil will not be able to absorb all of the nutritients and they would be washed away to surface waters or to the groundwater.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.8, no flooding = 1)	All technologies associated with “Application of a certain product” are awarded performance values in accordance with each other. Generally, these products are aimed to be safe for use, however, they do carry a “low risk of pathogen transmission” (Compendium). In the event of flooding, surrounding areas of where these products are applied therefore bear some risk. Also, the social acceptance of these products can be low and people would not prefer flood waters to spread these products everywhere. Hence, their performance is reduced by 10% or 20% depending on the relative risk of pollution between different products (e.g., stabilized sludge riskier than stored urine). (Akanksha Jain). Sludge is can still carry a lot of pathogens and is not considered to be as safe as other products and is therefore allotted a performance of 80%.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA

soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	The application is not based on soil absorption. No difference between different soil types. Stabilized sludge can be brought on the field on every type of soil.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"Depending on the source of the sludge and on the treatment method, it can be treated to a level where it is generally safe and no longer generates significant odour or vector problems. Following appropriate safety and application regulations is important. WHO guidelines on excreta use in agriculture should be consulted for detailed information." (Compendium) "May pose public health risks, depending on its quality and application" (Compendium) It's very important to d treat the sludge correctly and to prove its quality. But even though it seems like a small risk remains. That's why it's not recommendend to applicate it in areas with a high groundwater level. If you do so you should do further treatment do be safe that the sludge is free of pathogens.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Depending on the source of the sludge and on the treatment method, it can be treated to a level where it is generally safe and no longer generates significant odour or vector problems. Following appropriate safety and application regulations is important. WHO guidelines on excreta use in agriculture should be consulted for detailed information." (Compendium) "May pose public health risks, depending on its quality and application" (Compendium) It's very important to d treat the sludge correctly and to prove its quality. But even though it seems like a small risk remains. That's why it's not recommendend to applicate it close to drinking water sources.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	No construction needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Application rates and usage of sludge should take into account the presence of pathogens and contaminants, and the quantity of nutrients available so that it is used at a sustainable and agronomic rate." (Compendium) It's important to prove the quality of the sludge on a high level to prevent contamination with pathogens. Further are high design skills required to bring out the appropriate amount of sludge. If not enough is applicated the crop would suffer and if too much is applicated nutritients are washed away to surface waters or to the groundwater. Requires consideration of health aspects!	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"Solids are spread on the ground surface using conventional manure spreaders, tank trucks or specially designed vehicles." (Compendium) "Spreading equipment must be maintained to ensure continued use." (Compendium) The mainenance of the spreading equipment should be possible with moderate OM skills.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	The concept does not have a lifetime and can therefore be used at anytime. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA

construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.2, technical = 0.5, special = 0.3)	"Solids are spread on the ground surface using conventional manure spreaders, tank trucks or specially designed vehicles." (Compendium) "Spreading equipment must be maintained to ensure continued use. [...]." (Compendium) "May require special spreading equipment" (Compendium) Spreading equipment is required, which can consist of vehicles with additional installed technical parts or even specially designed and manufactured vehicles.	yes	
Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")						
	Recovered	**Range**	**Airloss**	**Soilloss**	**Waterloss**	**Comments**	**Reference**
TP	0.96	-	0	0.01	0.03	* fresh manure	Smith et al. (1998)
	0.96	-	0	0.01	0.03	_	-
k	25	-	-	-	-		PA
TN	0.9	-	0.1	0	0	* 11- 60% of applied NH4-N lost by NH3	Ryan und Keeney (1975)
	0.88	-	0.07	0.01	0.03		PA based on Smith et al. (1998)
	0.89	-	0.09	0.01	0.02		-
k	25	-	-	-	-		PA
H2O	0.01	-	0	0.01	0.01		PA
	0.01	-	0	0.01	0.01		-
k	100	-	-	-	-		PA
TS	0.69	-	0	0.3	0.01	Organic Matter content in Processed sludge is 40-70%; PA: upper range used to account for inorganic beneficial compounds	Torri et al. (2014)
	0.69	-	0	0.30	0.01		-
k	5	-	-	-	-		PA
Additional Information	(Data from: Ryan und Keeney (1975))						**Spuhler et al. (2021)**
	Processed sludge				**Medians**	**TC_lost_min**	**TC_lost_max**
Total N	54’329	40’143	35’449	34’457	37’796	0.03	0.17
NH4 - N	31’879	11’735	9’394	8’069	10’565	0.11	0.6
% Ammonia of TN	0.59	0.29	0.27	0.23	0.28		

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

Loetscher, T., & Keller, J. (2002). A decision support system for selecting sanitation systems in developing countries. *Socio-Economic Planning Sciences* , *36* (4), 267–290. https://doi.org/10.1016/S0038-0121(02)00007-1

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Smith, K. A., et al. (1998). "Organic manure phosphorus accumulation, mobility and management." Soil Use and Management 14(s4): 154-159.

Fill and Cover		Fill and Cover				
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	fill_and_cover	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	stored_faeces, transportedstored_faeces, dried_faeces, transporteddried_faeces, pithumus, transportedpithumus, stabilized_sludge, transportedstabilized_sludge	Tilley, E. et al. (2014)				
OUTPUT PRODUCT	NA	Tilley, E. et al. (2014)				
RELATIONS	Input: OR Output: NA	Tilley, E. et al. (2014)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 0)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 0.5, public = 0)	Tilley, E. et al. (2014)				
capex_req_level	3	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 1, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	"There is little maintenance associated with a closed pit other than taking care of the tree or plant. Trees planted in abandoned pits should be regularly watered. A small fence of sticks and sacks should be constructed around the sapling to protect it from animals." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	No spare parts needed.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, v	Feasible for all temperatures.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"Covering a pit or planting a tree does not eliminate the risk of groundwater contamination" (Compendium) The application is possible in areas with regular flooding. However, since groundwater contamination is possible it is not recommended to applicate this technology in area with regular flooding. Arborloo configuration exists, performance values allotted are similar to FG S Arborloo technology.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	The application is not based on soil absorption. No difference between different soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 4, b = 4, c = 999, d = 999)	"Covering a pit or planting a tree does not eliminate the risk of groundwater contamination" (Compendium) "A shallow pit, about 1 m deep, is needed for an Arborloo." (Compendium) A groundwater table is not compatible [...] where there is a risk of leakage if this table is situated less than 3 meters away from the point of infiltration (SCREENING CRITERIA -> GROUNDWATER.DEPTH) 1m + 3m = 4m	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"When a Single Pit or a Single VIP is full and cannot be emptied, "fill and cover", i.e., filling the remainder of the pit and covering it is an option, [...]." (Compendium) "New pit must be dug; the old pit cannot be re-used" (Compendium) Same excavation needed as for the construction of a single pit or a single VIP.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"Covering a pit or planting a tree does not eliminate the risk of groundwater contamination" (Compendium) The application is possible in areas with regular flooding. However, since groundwater contamination is possible it is not recommended to applicate this technology close to a drinking water source.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	"New pit must be dug; the old pit cannot be re-used" (Compendium) "Planting a tree in the abandoned pit is a good way to reforest an area, provide a sustainable source of fresh fruit and prevent people from falling into old pit sites. Other plants such as tomatoes and pumpkins can also be planted on top of the pit if trees are not available. Depending on the local conditions, however, the content of a covered pit or Arborloo could contaminate groundwater resources until it is entirely decomposed." (Compendium) If the construction includes planting a tree at least moderate construction skills might be required. However, to plant other plants like vegetables low construction skills are sufficient.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"When a Single Pit or a Single VIP is full and cannot be emptied, “fill and cover”, i.e., filling the remainder of the pit and covering it is an option, [...]." (Compendium) "New pit must be dug; the old pit cannot be re-used" (Compendium) Same design skills required as for the construction of a Single Pit or a single VIP. "Therefore, when selecting the pit location, users should already take the space and site conditions required for a new tree into account (e.g., distance to houses). A shallow pit, about 1 m deep, is needed for an Arborloo. It should not be lined as any lining would prevent the tree or plant from properly growing. A tree should not be planted, however, directly in the raw excreta. It should be planted in the soil on top of the pit, allowing its roots to penetrate the pit contents as it grows. It may be best to wait for the rainy	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Technique simple to apply for all users" (Compendium) "There is little maintenance associated with a closed pit other than taking care of the tree or plant. Trees planted in abandoned pits should be regularly watered. A small fence of sticks and sacks should be constructed around the sapling to protect it from animals." (Compendium) Low OM skills required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"New pit must be dug; the old pit cannot be re-used" (Emersan) A single point can only be used once (short-term). However, the concept does not have a lifetime and can therefore be used anytime as long as space is available. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"The Arborloo is a shallow pit on which a tree can be planted after it is full, while the superstructure, ring beam and slab are moved to a new pit. Before the Arborloo is used, a layer of leaves is put on the bottom of the empty pit. A cup of soil, ash or a mixture of the two should be dumped into the pit to cover excreta after each defecation. If they are available, leaves can also occasionally be added to improve the porosity and air content of the pile." (Emersan) The Arborloo requires a superstructure, ring beam and slab. It is assumed that these can be constructed from simple locally available materials. (Kukka Ilmanen, Eawag 2021)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0	1	0		PA
med (R)	0	-	0	1	0	-	-
k	100	-	-	-	-		PA

TN	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
H2O	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
TS	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

Loetscher, T., & Keller, J. (2002). A decision support system for selecting sanitation systems in developing countries. *Socio-Economic Planning Sciences , 36* (4), 267–290. https://doi.org/10.1016/S0038-0121(02)00007-1

Spuhler, D., de Morais Lima, P., Fritzsche, J., Ilmanen, K., Jain, A., van Sloten, M., & Willimann, C. (2021). SaniChoice Project Team. Department Sanitation, Water and Solid Waste for Development Countries (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland.

Spuhler, D., & Roller, L. (2020). *Sanitation technology library: Details and data sources for appropriateness profiles and transfer coefficients* . Eawag - Swiss Federal Institute of Aquatic Science and Technology.

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P., & Zurbrügg, C. (2014). *Compendium of Sanitation Systems and Technologies—2nd revised edition* . Swiss Federal Institute of Aquatic Science and Technology (EAWAG).

Biogas Combustion		Biogas Combustion
	Values	Data Source
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	biogas_combustion	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	biogas, transportedbiogas	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	4	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no ele	"When produced in household-level biogas reactors, it is most suitable for cooking." (Compendium) Biogas can be burned for thermal use, no electricity supply needed. Instead it produces a type of energy.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continous = 0)	"Biogas is usually fully saturated with water vapour, which leads to condensation. To prevent blocking and corrosion, the accumulated water has to be periodically emptied from the installed water traps. The gas pipelines, fittings and appliances must be regularly monitored by trained personnel. When using biogas for an engine, it is necessary to first reduce the hydrogen sulphide because it forms corrosive acids when combined with condensing water." (Compendium) "When produced in household-level biogas reactors, it is most suitable for cooking." (Compendium) When it is used only for cooking on household level only irregular OM should be necessary.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	Assumed that gas pipelines are required.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No need for concrete	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.5, special = 0.2)	"When produced in household-level biogas reactors, it is most suitable for cooking." (Compendium) "When using biogas for an engine, it is necessary to first reduce the hydrogen sulphide because it forms corrosive acids when combined with condensing water." (Compendium) "Appliances required depend on how the biogas will be used. Many appliances have to be designed specifically for use with biogas and these are not always widely available. However, conventional gas burning stoves can be easily modified for use with biogas by widening the jets and burner holes and reducing the primary air intake." (Emersan) Technical or even special spare parts might be needed for a biogas engine. It can be used only for cooking on household level and there technical parts for normal stoves are required. However, for some specially designed appliances, special spare parts might be required	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1,	Since the combustion of biogas is an exothermic process it is possible at any temperature. The difference in efficiency between different temperatures is negligible.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	For the technology "use of biogas for combustion", the criterion "flooding" is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	Combustion of biogas is not based on soil absorption. No difference between different soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	Combustion of biogas is not based on soil absorption. The groundwater depth has no influence on the performance.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	Combustion of biogas is not based on soil absorption. Exponation to drinking water has no influence on the performance.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Assuming that the biogas plant is well-constructed, operated and maintained (e.g., water is drained), the risk of leaks, explosions or any other threats to human health is negligible." (Compendium) Since there is a fatal risk of explosion if the application is not constructed properly high construction skills are recommended.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Compared to other gases, biogas needs less air for combustion. Therefore, conventional gas appliances need to be modified when they are used for biogas combustion (e.g., larger gas jets and burner holes). The distance through which the gas must travel should be minimized since losses and leakages may occur. Drip valves should be installed for the drainage of condensed water, which accumulates at the lowest points of the gas pipe." (Compendium) "Assuming that the biogas plant is well-constructed, operated and maintained (e.g., water is drained), the risk of leaks, explosions or any other threats to human health is negligible." (Compendium) Since there are different things to take in account and there is a fatal risk of explosion if the application is not designed properly high design skills required.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Biogas is usually fully saturated with water vapour, which leads to condensation. To prevent blocking and corrosion, the accumulated water has to be periodically emptied from the installed water traps. The gas pipelines, fittings and appliances must be regularly monitored by trained personnel. When using biogas for an engine, it is necessary to first reduce the hydrogen sulphide because it forms corrosive acids when combined with condensing water." (Compendium) "When produced in household-level biogas reactors, it is most suitable for cooking." (Compendium) "Assuming that the biogas plant is well-constructed, operated and maintained (e.g., water is drained), the risk of leaks, explosions or any other threats to human health is negligible." (Compendium) Since there is a fatal risk of explosion if the application is not maintained properly high maintenance skills are recommended even though the operation of the application of biogas as cooking heat requires only low skills.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	The lifetime of using biogas depends on the lifetime of the specific appliance. Therefore it is possible to use biogas in the short- and long-term. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.5, special = 0.2)	"Appliances required depend on how the biogas will be used. Many appliances have to be designed specifically for use with biogas and these are not always widely available. However, conventional gas burning stoves can be easily modified for use with biogas by widening the jets and burner holes and reducing the primary air intake." (Emersan) "Drip valves should be installed for the drainage of condensed water, which accumulates at the lowest points of the gas pipe.", "Piping is required and generally available in local markets. Gas cooking stoves are cheap and widely available. With proper instructions and simple tools the modifications can be done by a local handyperson." (Emersan) Biogas can be used in different types of appliances (household cooking stove, in an engine etc.). Most of these appliances can be found locally, though some further technical parts (e.g. drip valves) might be required. Some specially designed appliances might need to be specially manufactured.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	1	0	0		PA
med (R)	0	-	1	0	0		-
k	25	-	-	-	-		PA
TN	0	-	1	0	0		PA
med (R)	0	-	1	0	0		-
k	5	-	-	-	-		PA
H2O	0	-	1	0	0		PA
med (R)	0	-	1	0	0		-
k	100	-	-	-	-		PA
TS	0.95	-	0.05	0	0		PA
med (R)	0.95	-	0.05	0	0		-
k	25	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

Loetscher, T., & Keller, J. (2002). A decision support system for selecting sanitation systems in developing countries. *Socio-Economic Planning Sciences* , *36* (4), 267–290. https://doi.org/10.1016/S0038-0121(02)00007-1

Spuhler, D., de Morais Lima, P., Fritzsche, J., Ilmanen, K., Jain, A., van Sloten, M., & Willimann, C. (2021). SaniChoice Project Team. Department Sanitation, Water and Solid Waste for Development Countries (Sandec), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland.

Spuhler, D., & Roller, L. (2020). *Sanitation technology library: Details and data sources for appropriateness profiles and transfer coefficients* . Eawag - Swiss Federal Institute of Aquatic Science and Technology.

Mcconville, J., et al. (2020). "Guide to Sanitation Resource-Recovery Products & Technologies : a supplement to the Compendium of Sanitation Systems and Technologies."

Tilley, E., Ulrich, L., Lüthi, C., Reymond, P., & Zurbrügg, C. (2014). *Compendium of Sanitation Systems and Technologies—2nd revised edition* . Swiss Federal Institute of Aquatic Science and Technology (EAWAG).

Briquettes as Fuel		
	Values	Data Source
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	briquettes_as_fuel	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	briquettes, transportedbriquettes	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	From Sanivation Website: The plant intakes fecal sludge from exhauster trucks and outputs biomass fuels to replace firewood in industrial boilers. Application of briquettes happens in industrial boilers and therefore happens on a high level.
management_level	(household = 0, shared = 0.5, public = 1)	From Sanivation Website: The plant intakes fecal sludge from exhauster trucks and outputs biomass fuels to replace firewood in industrial boilers. Application of briquettes happens in industrial boilers and should therefore be managed on a high level.
capex_req_level	4	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	2	Sanivation successfully piloted this approach and is currently expanding. We assume medium maturity. See here: https://www.cdc.gov/globalhealth/stories/transforming_waste_to_fuel.html#:~:text=Sanivation%20uses%20innovative%2C%20low-cost,source%20for%20cooking%20or%20heating.&text=The%20briquettes%20burn%20more%20cleanly,and%20risk%20of%20respiratory%20disease.%20(CDC%20-%3E%20Sanivation
development_phase	(acute = 0, stabilisation = 1, development/recovery = 1)	Same values allotted as that of "Application of sludge" and treatment technology "Briquetting" (Akanksha Jain based on Gensch, R. et al. (2018)).

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continous = 0)	"Sanivation uses innovative, low-cost solar treatment technologies to transform fecal waste into briquettes that can be sold and used as a smell-free fuel source for cooking or heating." (CDC -> Sanivation) No additional O&M to other cooking/heating resources.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.4, special = 0.2)	"Sanivation uses innovative, low-cost solar treatment technologies to transform fecal waste into briquettes that can be sold and used as a smell-free fuel source for cooking or heating." (CDC -> Sanivation) For the application at a small scale there is no need for any special application, at a large scale there might be need for a special oven or similar.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1, v	Since the application of briquettes as fuel is an exothermic process it is possible at any temperature.	
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding=1, no flooding=1)	For the technology "using briquettes as fuel", the criterion "flooding" is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	The application is not based on soil absorption. No difference between different soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	The application is not based on soil absorption and contains no health risks. No difference between different groundwater depths.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	No excavation needed.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	The application is not based on soil absorption and contains no health risks. No difference between different drinking water exponation.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	It is asumed that there is no need for any construction in private use. For a application at a large scale moderate or even high construction skills might be required.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 1, skilled = 1, professional = 1)	On a small scale there is no need for any design skills, on a large scale moderate or high design skills might be required.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	On a small scale there is no need for any OM skills, on a large scale moderate OM skills might be required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	The concept of using briquettes as fuel does not have a lifetime and can therefore be used at anytime. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.4, special = 0.2)	"Sanivation uses innovative, low-cost solar treatment technologies to transform fecal waste into briquettes that can be sold and used as a smell-free fuel source for cooking or heating." (CDC -> Sanivation) For the application at a small scale there is no need for any special application, at a large scale there might be need for a special oven or similar.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0.05	0.95	0	some airloss is assumed	PA
med (R)	0	-	0.05	0.95	0	-	-
k	25	-	-	-	-		PA
TN	0	-	0.5	0.5	0	50% of airloss, rest goes to residue	PA
med (R)	0	-	0.50	0.50	0		-
k	5	-	-	-	-		PA
H2O	0	-	1	0	0	water is all lost to air	PA
med (R)	0	-	1.00	0	0		-
k	100	-	-	-	-		PA
TS	0.5	-	0	0.5	0	50% can be reused, all the rest is lost - based on the assumption that all the ash + some of the rest of TS contribute to the calorific value	PA
med (R)	0.50	-	0	0.50	0		-
k	25	-	-	-	-		PA

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Co-Combustion		Co-combustion				
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	co_combustion	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	transportedstored_faeces, transporteddried_faeces, transportedsludge, transportedprocessed_sludge, transportedstabilized_sludge, transportedpithumus	Gensch, R. et al. (2018)				
OUTPUT PRODUCT	NA	Gensch, R. et al. (2018)				
RELATIONS	Input: OR Output: NA	Gensch, R. et al. (2018)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0, city = 1)	Gensch, R. et al. (2018)				
management_level	(household = 0, shared = 0, public = 1)	Gensch, R. et al. (2018)				
capex_req_level	6	Spuhler, D. et al. (2021)				
opex_req_level	4	Spuhler, D. et al. (2021)				
technical_maturity	3	Gensch, R. et al. (2018)				
development_phase	(acute = 0, stabilisation = 0, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	"As part of the process energy is generated, which can be used for heating or the production of electricity." (Emersan) Since the technology itself can be used for the production of electricity, no electricity supply is needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 0.3, continous = 0.7)	"Regular monitoring of the plant or reactor is needed." (Emersan) "Operation and maintenance (O & M) costs are also high, as specialised personnel must operate the plant." (Emersan) Continous operation of the incineration plant is assumed.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed except for ventilation, which can be constructed from local material (e.g. mental)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.5, difficultly available = 0.75, concrete = 1)	"The main requirement for incineration is an incineration furnace. [...] Pyrolysis and gasification reactors can be constructed with locally available materials on a small scale." (Emersan) To construct an incineration furnace, pyrolysis or a gasification reactor, it is assumed that they can be built from concrete or other material (metal, brick, etc.). We assume that the other material would perform less well, e.g. in regard to lifetime and local experience working with such alternative materials. (Kukka Ilmanen, Eawag 2021)	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.1, technical = 0.4, special = 0.5)	"The main requirement for incineration is an incineration furnace. An incineration furnace requires many different special parts and materials, particularly for the treatment of the exhaust gases, which can be dangerous for public and environmental health. The required special parts are often not locally available. With an existing solid waste incineration plant, Co-Combustion of Sludge can be done immediately. Pyrolysis and gasification reactors can be constructed with locally available materials on a small scale." (Emersan) "In modern incinerators, advanced pollution control systems (electrostatic precipitators, acid gas scrubbers, etc.) are designed to minimise pollution and to ensure compliance with environmental standards." (SLU Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1,	Since the co-combustion of sludge is an exothermic process it is possible at any temperature. The difference in efficiency between different temperatures is negligible.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	For the technology "incineration or co-combustion of sludge", the criterion "flooding" is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	Co-Combustion of Sludge is not based on soil absorption. No difference between different soil types.	
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	Co-Combustion of sludge is not based on soil absorption. The groundwater depth has no influence on the performance.	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"The main requirement for incineration is an incineration furnace. An incineration furnace requires many different special parts and materials, particularly for the treatment of the exhaust gases, which can be dangerous for public and environmental health. The required special parts are often not locally available. With an existing solid waste incineration plant, Co-Combustion of Sludge can be done immediately. Pyrolysis and gasification reactors can be constructed with locally available materials (e.g. oil drum, locally produced burner) on a small scale." (Emersan) To build an incineration furnace excavation might be needed. To run pyrolysis or a gasification reactor excavation should not be needed.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA

surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	Co-Combustion of sludge is not based on soil absorption. Exponation to drinking water has no influence on the performance.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The main requirement for incineration is an incineration furnace. An incineration furnace requires many different special parts and materials, particularly for the treatment of the exhaust gases, which can be dangerous for public and environmental health. The required special parts are often not locally available. With an existing solid waste incineration plant, Co-Combustion of Sludge can be done immediately. Pyrolysis and gasification reactors can be constructed with locally available materials (e.g. oil drum, locally produced burner) on a small scale." (Emersan) For the construction of the incineration furnace with lots of special parts and not locally available material high construction skills are recommended. However, if only moderate or low construction skills are available the application of pyrolysis or a gasification reactor could still be feasible.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"Before incineration, sludge needs to be dewatered e.g. in Unplanted or Planted Drying Beds. The energy can be used for example, to power cement kilns. [...] Methods for incineration include mass burn incineration, fluidised-bed incineration and co-incineration with municipal solid waste or in cement factories. An emerging technology in heat application treatment is pyrolysis or gasification of faecal sludge. Pyrolysis or gasification happens through heating in an oxygen-depleted environment, thus preventing combustion. Gasification occurs at temperatures above 800 °C, pyrolysis between 350 and 800 °C." (Emersan) Lots of different things to take in account. High design skills required.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Highly skilled workers are needed to operate and maintain an incinerator and a pyrolysis or gasification reactor. Since high temperatures are reached, only trained staff should operate and maintain the reactor and be in the vicinity." (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"the lifetime of typical incinerators (20-30 years)" (National Research Council (US) 2000) It is assumed that sludge incinerators have similar lifetimes to a normal incinerator. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.1, technical = 0.4, special = 0.5)	"The main requirement for incineration is an incineration furnace. An incineration furnace requires many different special parts and materials, particularly for the treatment of the exhaust gases, which can be dangerous for public and environmental health. The required special parts are often not locally available. With an existing solid waste incineration plant, Co-Combustion of Sludge can be done immediately. Pyrolysis and gasification reactors can be constructed with locally available materials on a small scale." (Emersan) "In modern incinerators, advanced pollution control systems (electrostatic precipitators, acid gas scrubbers, etc.) are designed to minimise pollution and to ensure compliance with environmental standards." (SLU Compendium)	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
TN	0	-	1	0	0		PA
med (R)	0	-	1	0	0		-
k	100	-	-	-	-		PA
H2O	0	-	1	0	0		PA
med (R)	0	-	1	0	0		-
k	100	-	-	-	-		PA
TS	0	-	1	0	0		PA
med (R)	0	-	1	0	0		-
k	100	-	-	-	-		PA

Additional Information

If the sludge is burned, most substances get volatized. Phosphorus cannot volatize and is therefore found in the remaining slag, which is assumed to be deposited and therefore eventually occur as soil loss. Spuhler et al. (2021)

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Soak Pit		Soak Pit
	Values	**Data Source**
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	soak_pit	-
DATA COMPILER	Julian Fritzsche	-
INPUT PRODUCT	effluent, secondary_effluent, greywater, urine, stored_urine, stabilized_urine	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 0)	Tilley, E. et al. (2014)
capex_req_level	5	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0.5, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No electricity is required for a soak pit	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 1, regular = 0, continuous = 0)	"A well-sized soak pit should last between 3 and 5 years without maintenance. To extend the life of a soak pit, care should be taken to ensure that the effluent has been clarified and/ or filtered to prevent the excessive build-up of solids. Particles and biomass will eventually clog the pit and it will need to be cleaned or moved. When the performance of the soak pit deteriorates, the material inside the soak pit can be excavated and refilled." (Compendium) Almost no operation and maintenance should be required	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1	No pipes are required for this technology	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps are required for this technology	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"It can be left empty and lined with a porous material to provide support and prevent collapse, or left unlined and filled with coarse rocks and gravel. The rocks and gravel will prevent the walls from collapsing, but will still provide adequate space for the wastewater. In both cases, a layer of sand and fine gravel should be spread across the bottom to help disperse the flow. To allow for future access, a removable (preferably concrete) lid should be used to seal the pit until it needs to be maintained." (Compendium) Concrete is not necessary but preferably used as a lid. However, the lid material does not affect the performance of the technology.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium) "Particles and biomass will eventually clog the pit and it will need to be cleaned or moved. When the performance of the soak pit deteriorates, the material inside the soak pit can be excavated and refilled." (Emersan) The filling and lining material might need to be replaced, but it consists of porous material, sand gravel, coars rocks, that should be locally available.	yes
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
0	0	FALSE		0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"They can be used in almost every temperature, although there may be problems with pooling effluent in areas where the ground freeze." (Kumar (2017))	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	"They are not appropriate for areas prone to flooding or that have high groundwater tables."(Compendium) This technology is generally not suited for flood prone areas as its functioning is hampered severely under inundation conditions. However, they are still awarded a low performance of 10% as there exists a possibility to construct these technologies in elevated or non-flooded plot areas of a flood prone region. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA

soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0, silt = 0.25, sand = 1, gravel = 0	"As wastewater (greywater or blackwater after primary treatment) percolates through the soil from the soak pit, small particles are filtered out by the soil matrix and organics are digested by microorganisms. Thus, soak pits are best suited for soil with good absorptive properties; clay, hard packed or rocky soil is not appropriate." (Compendium) Does primarily rely on soil absorption.	yes	
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 4.5, b = 7, c = 999, d = 999)	"s The soak pit should be between 1.5 and 4 m deep, but as a rule of thumb, never less than 2 m above the groundwater table." (Compendium) The vertical distance also depends on the permeability of the soil, we use 3 meters as a minimum distance to the groundwater as suggested by Monvois et al. (2012).	yes	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Excavation is necessary.	yes	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"It should be located at a safe distance from a drinking water source (ideally more than 30 m)" (Compendium)	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	" The main design criterion is the volume of the pit, which should be in proportion to the number of people using the soakaway and based on local water consumption levels to ensure efficient infiltration. The construction of a soakaway does not require high-level skills.", "Low-level skills (can be constructed by a local craftsman)" (Monvois et al. (2012))	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The main design criterion is the volume of the pit, which should be in proportion to the number of people using the soakaway and based on local water consumption levels to ensure efficient infiltration" (Monvois et al. (2012)) The design is rather simple, however, the prevailing geological circumstances must be considered. Requires at least basic expertise for design.	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"A well-sized soak pit should last between 3 and 5 years without maintenance. To extend the life of a soak pit, care should be taken to ensure that the effluent has been clarified and/ or filtered to prevent the excessive build-up of solids. Particles and biomass will eventually clog the pit and it will need to be cleaned or moved. When the performance of the soak pit deteriorates, the material inside the soak pit can be excavated and refilled." (Compendium) Operation and maintenance should be required very rarely and only include declogging, excavating, refilling or similar. The only crucial factor is determining which actions should be taken. The actions itself are very basic.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 0.5)	"A well-sized soak pit should last between 3 and 5 years without maintenance. To extend the life of a soak pit, care should be taken to ensure that the effluent has been clarified and/or filtered to prevent the excessive build-up of solids." (Emersan) The lifetime is meant for 3-5 years though with good maintenance it can be extended.	yes	
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"Can be built and repaired with locally available materials" (Compendium) "The filling and lining material [...] consists of porous material, sand gravel, coarse rocks, that should be locally available." (Emersan)	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
TN	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
H2O	0	-	0	1	0		PA

med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
TS	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA

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Leach Field						
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	leach_field	-				
DATA COMPILER	Julian Fritzsche	-				
INPUT PRODUCT	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, greywater, transportedgreywater urine, transportedurine, stored_urine, transportedstored_urine	Tilley, E. et al. (2014)				
OUTPUT PRODUCT	NA	Tilley, E. et al. (2014)				
RELATIONS	Input: OR Output: NA	Tilley, E. et al. (2014)				
COMMENTS						
Pre-Filter Criteria	Values	Data Source				
applicability_level	(household = 1, neighbourhood = 0.5, city = 0)	Tilley, E. et al. (2014)				
management_level	(household = 1, shared = 1, public = 0.5)	Tilley, E. et al. (2014)				
capex_req_level	6	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.5, no el	"A dosing or pressurized distribution system may be installed to ensure that the whole length of the leach field is utilized and that aerobic conditions are allowed to recover between dosings." (Emersan) Usually no electricity is required, however, a dosing or pressurized distribution system may be used. Technology can work without electricity, however, in some cases a larger-scale dosing or pressurized system may be introducted and electricity is required.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.9, regular = 0.1, continuous = 0)	"A leach field will become clogged over time, although this may take 20 or more years, if a well-maintained and well-functioning primary treatment technology is in place. Effectively, a leach field should require minimal maintenance; however, if the system stops working efficiently, the pipes should be cleaned and/or removed and replaced. To maintain the leach field, there should be no plants or trees on it." (Compendium) Regular maintenance should not be necessary except for weeding the leach field etc.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	"...a perforated distribution pipe is laid on top." (Compendium) Pipes are necessary for distribution pipes and also to build the recommended sewer connection for future connections/emptying.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficultly available = 0.75, pumps = 1)	"A dosing or pressurized distribution system may be installed to ensure that the whole length of the leach field is utilized and that aerobic conditions are allowed to recover between dosings." (Compendium) Even though no pumps are usually required, a pressurized dosing system (which is essentially a pumping system) might be installed and therefore has a higher score if pumps are available.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	Usually no concrete is used (Compendium)	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.5, special = 0.2)	"Not all parts and materials may be locally available" (Compendium) Pipes and other technical spare parts will be necessary. Special geotextile fabric might need to be replaced.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"They can be used in almost every temperature, although there may be problems with pooling effluent in areas where the ground freezes." (Compendium)	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	"Infiltration trenches should not be located in an area prone to flooding as they are liable to overflow, rendering them temporarily unusable." (Monvois et al. (2012)) This technology is generally not suited for flood prone areas as its functioning is hampered severely under inundation conditions. However, they are still awarded a low performance of 10% as there exists a possibility to construct these technologies in elevated or non-flooded plot areas of a flood prone region. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA

soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0, silt = 0.25, sand = 1, gravel = 0	Requires a soil type that allows effluent to infiltrate (Monvois et al. (2012)). Similar to the soak pit a leach field also requires soil with good absorptive properties (Compendium). Does primarily rely on soil absorption.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 3.45, b = 5, c = 999, d = 999)	"Each trench is 0.3 to 1.5 m deep and 0.3 to 1 m wide. " (Compendium) The trenches are laid at least 15cm beneath the ground (Compendium). We assume a maximum depth of 50cm of the trenches. The minimum permissible groundwater depth with a vertical safety distance of 3 meters therefore is 3.45 (0.3 + 0.15 + 3) (best case). The optimum is reached at 5m (1.5 + 0.5 + 3) (worst case). There's no upper limit.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	"Each trench is 0.3 to 1.5 m deep and 0.3 to 1 m wide." (Compendium) Shallow and wide excavation required.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"To prevent contamination, a leach field should be located at least 30 m away from any drinking water source." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"The main design criteria are the volumes of water discharged, the available surface area and the infiltration capacity of the soil. The design and construction of infiltration trenches require highlevel skills." (Monvois et al. (2012)) The construction requires high level skills, but the design is more important and difficult.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The main design criteria are the volumes of water discharged, the available surface area and the infiltration capacity of the soil. The design and construction of infiltration trenches require highlevel skills." (Monvois et al. (2012)) To ensure proper infiltration and no pollution to the groundwater, high level skills are required. Especially if a great amount of effluent is discharged.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Low-level skills (no on-going maintenance) to high-level skills (if there is clogging)" (Monvois et al. 2012) If there is clogging, high level skills are required, however, it is assumed that skilled labour is partly sufficient.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Has a long lifespan (depending on conditions)" (Emersan)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.3, technical = 0.5, special = 0.2)	"Not all parts and materials may be locally available" (Compendium) Pipes and other technical parts will be necessary. Special geotextile fabric might be required.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
TN	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
H2O	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
TS	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA

References

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Monvois, J., et al. (2012). How to select appropriate technical solutions for sanitation, Concerted Municipal Strategies (CMS), a program coordinated by the Municipal Development Partnership (MDP) and programme Solidarité Eau (pS-Eau). n°4.

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Irrigation		Irrigation
	Values	**Data Source**
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	irrigation	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, stormwater, transportedstormwater	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		

Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	McConville, J. et al. (2020)
development_phase	(acute = 0.5, stabilisation = 1, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.5, no el	"Commercial-scale irrigation systems for industrial production are expensive, requiring pumps and an operator. Small-scale drip irrigation systems can be constructed out of locally available low-tech materials and are inexpensive. Ready-made kits are also widely available. A filtration unit before the drip irrigation system is highly recommended to reduce the risk of clogging." (SLU Compendium) Electricity is not necessary, since pumps can be replaced by gravitation. However, electricity for pumps might be required on a large sale or if the irrigation is not possible only with gravitation.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Drip irrigation systems must be periodically flushed to avoid biofilm growth and clogging from all types of solids. Pipes should be checked for leaks as they are prone to damage from rodents and humans. Drip irrigation is more costly than conventional irrigation, but offers improved yields and decreased water/operating costs.." (Compendium) At a small scale irrigation might also be possible manual with a watering can. That needs less maintenance since there you do not need any special material or construction but it is very labour intensive. Both cases lead to a need for regular OM.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	"There are two kinds of irrigation technologies appropriate for treated wastewater: 1) Drip irrigation above or below ground, where the water is slowly dripped on or near the root area; and 2) Surface water irrigation where water is routed overland in a series of dug channels or furrows. [...]Generally, drip irrigation is the most appropriate irrigation method; it is especially good for arid and drought prone areas. Surface irrigation is prone to large losses from evaporation but requires little or no infrastructure and may be appropriate in some situations. [..]Drip irrigation is the only type of irrigation that should be used with edible crops" (Emersan) At a small scale irrigation might also be possible manual with a watering can. And the technology configuration with surface water irrigation can be conducted without pipes. However it performs a lot worse than drip irrigation.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 0.5, difficultly available = 0.75, pumps = 1)	"Commercial-scale irrigation systems for industrial production are expensive, requiring pumps and an operator. Small-scale drip irrigation systems can be constructed out of locally available low-tech materials and are inexpensive. Ready-made kits are also widely available. A filtration unit before the drip irrigation system is highly recommended to reduce the risk of clogging." (SLU Compendium) Alternative configuration of technology without pumps is possible, since gravitation can be used. But it usually performs worse depending on the local slopes.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	"Commercial-scale irrigation systems for industrial production are expensive, requiring pumps and an operator. Small-scale drip irrigation systems can be constructed out of locally available low-tech materials and are inexpensive. Ready-made kits are also widely available. A filtration unit before the drip irrigation system is highly recommended to reduce the risk of clogging." (SLU Compendium) "A drip irrigation system can be constructed using locally available materials such as a storage tank, and a hose or drip tape." (Compendium) "Not all parts and materials may be locally available" (Emersan)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	"There is no doubt that land application of manure to frozen or cold and wet ground has potential to exacerbate nutrient loss in runoff. The absence, or poor growth of crops (limiting uptake of manure nutrients and water), winter weather, and winter soil conditions generally exacerbate off-site losses of manure-derived pollutants." (Liu et al. (2018)) Irrigation can still be possible in cold temperatures but the soil will not be able to absorb all of the nutritients and they would be washed away to surface waters or to the groundwater. Further a construction with pipes can take serious damage when the irrigation water freezes.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.8, no flooding = 1)	"Appropriate treatment (i.e., adequate pathogen reduction) should precede any irrigation scheme to limit health risks to those who come in contact with the water. Furthermore, it may still be contaminated with the different chemicals that are discharged into the system depending on the degree of treatment the effluent has undergone." (Compendium) A risk for a contamination either with pathogens or with chemicals remains and because irrigation is based on soil absorption. Irrigation can be considered as "Application of reclaimed water" All technologies associated with "Application of a certain product" are awarded performance values in accordance with each other. Generally, these products are aimed to be safe for use, however, they do carry a "low risk of pathogen transmission" (Compendium). In the event of flooding, surrounding areas of where these products are applied therefore bear some risk. Also, the social acceptance of these products can be low and people would not prefer flood waters to spread these products everywhere. Hence, their performance is reduced by 10% or 20% depending on the relative risk of pollution between different products (e.g., stabilized sludge riskier than stored urine). (Akanksha Jain). Effluent water used for irrigation must be properly treated before use in fields, however the risk of pathogen transmission during flooding events will be quite serious if this effluent quality is not up to the standard. It therefore bears more risk than other products and is accordingle allotted a performance of 80%.	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand	(clay = 1, silt = 1, sand = 1, gravel = 1, r	Even though irrigation is based on soil absorbtion the performance of the technology must not depend on the soil type. If drip irrigation is used there is almost no risk of seepage of the irrigated effluent.	yes

groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 3, b = 3, c = 999, d = 999)	"Appropriate treatment (i.e., adequate pathogen reduction) should precede any irrigation scheme to limit health risks to those who come in contact with the water. Furthermore, it may still be contaminated with the different chemicals that are discharged into the system depending on the degree of treatment the effluent has undergone." (Compendium) Since the risk for a contamination either with pathogens or with chemicals remains irrigation should not be done in areas with a high groundwater table.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	"There are two kinds of irrigation technologies appropriate for treated wastewater: 1) Drip irrigation above or below ground, where the water is slowly dripped on or near the root area; and 2) Surface water irrigation where water is routed overland in a series of dug channels or furrows." (Compendium) At a small scale irrigation might also be possible manual with a watering can. There are variations possible without need for excavation.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"Appropriate treatment (i.e., adequate pathogen reduction) should precede any irrigation scheme to limit health risks to those who come in contact with the water. Furthermore, it may still be contaminated with the different chemicals that are discharged into the system depending on the degree of treatment the effluent has undergone." (Compendium) Since the risk for a contamination either with pathogens or with chemicals remains irrigation should not be done close to a drinking water source.	
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0.5, skilled = 1, professional = 1)	"May require expert design and installation" (Compendium) High construction skills are recommended, moderate construction skills could be sufficient but also cause problems such as clogging more often due to inpropper construction. However, at a small scale irrigation might also be possible manual with a watering can. That leads to need for lower construction skills since there you do not need any special construction. The performance might be lower at a small scale.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"May require expert design and installation" (Compendium) "Raw sewage or untreated blackwater should not be used, and even well-treated water should be used with caution. Long-term use of poorly or improperly treated water may cause long-term damage to the soil structure and its ability to hold water." (Compendium) "The application rate must be appropriate for the soil, crop and climate, or it could be damaging. To increase the nutrient value, urine can be dosed into irrigation water; this is called "fertigation". The dilution ratio has to be adapted to the special needs and resistance of the crop." (Compendium) "Appropriate treatment (i.e., adequate pathogen reduction) should precede any irrigation scheme to limit health risks to those who come in contact with the water. Furthermore, it may still be contaminated with the different chemicals that are discharged into the system depending on the degree of treatment the effluent has undergone. When effluent is used for irrigation, households and industries connected to the system should be made aware of the products that are and are not appropriate to discharge into the system. Drip irrigation is the only type of irrigation that should be used with edible crops, and even then, care should be taken to prevent workers and harvested crops from coming in contact with the treated effluent. The WHO guidelines on wastewater use in agriculture should be consulted for detailed information and specific guidance." Lots of things to be taken in account. High design skills are required.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Drip irrigation systems must be periodically flushed to avoid biofilm growth and clogging from all types of solids. Pipes should be checked for leaks as they are prone to damage from rodents and humans. Drip irrigation is more costly than conventional irrigation, but offers improved yields and decreased water/operating costs." (Compendium) At a small scale irrigation might also be possible manual with a watering can. That leads to need for lower maintenance skills since there you do not need any special material or construction to maintain. The performance might be lower at a small scale.	yes
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE		0	NA	NA
0	0	FALSE		0	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	Typical irrigation systems are drip irrigation and surface irrigation systems. "Normal life expectancy of a [subsurface drip irrigation] system is considered to be 12 to 15 years. Some systems have been reported to last 20 years with good maintenance, and could last longer provided good quality water is used." (Reich, D. et al. (2014)) No data could be found for the lifetime of surface irrigation systems, but is assumed to have a similar lifetime or at least more than 5 years.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.6, technical = 0.4, special = 0)	"Not all parts and materials may be locally available" (Compendium) "Commercial-scale irrigation systems for industrial production are expensive, requiring pumps and an operator. Small-scale drip irrigation systems can be constructed out of locally available low-tech materials and are inexpensive. Ready-made kits are also widely available. A filtration unit before the drip irrigation system is highly recommended to reduce the risk of clogging." (SLU Compendium) "A drip irrigation system can be constructed using locally available materials such as a storage tank, and a hose or drip tape. Ready-made kits are also widely available." (Emersan)	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0.9	-	0	0.1	0	* retainment depends on soil type	Odindo et al. (2016)
med (R)	0.9	-	0	0.1	0		-
k	100	-	-	-	-		PA
TN	0.87	-	0.03	0.1	0	* retainment depends on soil type	Odindo et al. (2016)
med (R)	0.87	-	0.03	0.1	0		-
k	100	-	-	-	-		PA
H2O	0.9	-	0	0.1	0	* retainment depends on soil type	Odindo et al. (2016)
med (R)	0.9	-	0	0.1	0		-
k	100	-	-	-	-		PA
TS	0.9	-	0	0.1	0	* retainment depends on soil type	Odindo et al. (2016)
med (R)	0.9	-	0	0.1	0		-
k	100	-	-	-	-		PA

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Fish Pond		**Fish Pond**				
	Values	**Data Source**				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	fish_pond	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, greywater, transportedgreywater, stormwater, transportedstormwater	Tilley, E. et al. (2014)				
OUTPUT PRODUCT	NA	Tilley, E. et al. (2014)				
RELATIONS	Input: OR Output: NA	Tilley, E. et al. (2014)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	7	Spuhler, D. et al. (2021)				
opex_req_level	7	Spuhler, D. et al. (2021)				
technical_maturity	3	McConville, J. et al. (2020)				
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no ele	"No electrical energy is required" (T5. WSP - Emersan) Fish ponds can be ventilated to support aerobic conditions. However it is possible to build it without any electricity supply and since the technology configuration with aerobic fish ponds is based on T5. WSP, which does not require any electrical energy, it is assumed that electricity does not affect the technology performance. Other configurations of the fish pond require even less aeration.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"The fish need to be harvested when they reach an appropriate age/size. Sometimes after harvesting, the pond should be drained so that (a) it can be desludged and (b) it can be left to dry in the sun for 1 to 2 weeks to destroy any pathogens living on the bottom or sides of the pond." (Compendium) "The water used to dilute the waste should not be too warm, and the ammonium levels should be kept low or negligible because of its toxicity to fish." (Compendium) Temperature and ammonium level should be monitored regularly.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	Ponds require inlet and outlet pipes (Emersan)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Can be built and maintained with locally available materials" (Emersan) No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.9, technical = 0.1, special = 0)	"Can be built and maintained with locally available materials" (Emersan) If not built at an industrial scale or/and with pump ventilation, simple spare parts are sufficient to operate and maintain the fish pond.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0.5, temperate = 1	"This technology is appropriate for warm or tropical climates with no freezing temperatures, [...]." (Compendium)	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	Regular flooding could be fatal for this technology. Fish could leave the pond and escape or be dead after a flood. "There may be concern about contamination of the fish, especially when they are harvested, cleaned and prepared. If they are cooked well, they should be safe, but it is advisable to move the fish to a clear-water pond for several weeks before they are harvested for consumption." (Compendium) Further contamination of the surrounding area is a risk due to wastewater leaving the pond. However, to prevent the fish from escaping and wastewaster leaving the pond precautions can be made. Therefore additional design and construction is required. The functioning of this technology can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, r	The application is not based on soil absorption. No difference between different soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"There may be concern about contamination of the fish, especially when they are harvested, cleaned and prepared. If they are cooked well, they should be safe, but it is advisable to move the fish to a clear-water pond for several weeks before they are harvested for consumption." (Compendium) The technology is not based on soil absorption. But there is a remaining risk of contaminating the groundwater. However it is possible to build it at a high groundwater table, but then it is very important to build it propperly and to prevent any leakage of the pond to the ground.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Shallow and wide excavation is assumed to be required.	yes

surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"There may be concern about contamination of the fish, especially when they are harvested, cleaned and prepared. If they are cooked well, they should be safe, but it is advisable to move the fish to a clear-water pond for several weeks before they are harvested for consumption." (Compendium) The technology is not based on soil absorption. But there is a remaining risk of contaminating the drinking water. However it is possible to build it close to a drinking water source, but then it is very important to build it propperly and to prevent any leakage of the pond to the ground.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"May require expert design and installation" (Compendium) It is assumed that a simple design variation without any pumps that is built only with locally available material can be contructed with low construction skills. However, moderate construction skills are recommended.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"May require expert design and installation" (Compendium) "The design should be based on the quantity of nutrients to be removed, the nutrients required by the fish and the water requirements needed to ensure healthy living conditions (e.g., low ammonium levels, required water temperature, etc.). When introducing nutrients in the form of effluent or sludge, it is important to limit the additions so that aerobic conditions are maintained. BOD should not exceed 1 g/m2/d and oxygen should be at least 4 mg/L. Only fish tolerant of low dissolved oxygen levels should be chosen. They should not be carnivores and they should be tolerant to diseases and adverse environmental conditions. Different varieties of carp, milkfish and tilapia have been successfully used, but the specific choice will depend on local preference and suitability." (Compendium) "The water used to dilute the waste should not be too warm, and the ammonium levels should be kept low or negligible because of its toxicity to fish." (Compendium) Lots of things to be taken in account. High design skills are required.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 1, professional = 1)	"The fish need to be harvested when they reach an appropriate age/size. Sometimes after harvesting, the pond should be drained so that (a) it can be desludged and (b) it can be left to dry in the sun for 1 to 2 weeks to destroy any pathogens living on the bottom or sides of the pond." (Compendium) "The water used to dilute the waste should not be too warm, and the ammonium levels should be kept low or negligible because of its toxicity to fish." (Compendium) Monitoring of the the temperature and the ammonium level requires at least moderate, better high, OM skills.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Advantages of ponds and lagoons include they are economical, capable of handling high flows, adaptable to changing organic loads, decreased sludge handling, long design life, serve as wildlife habitat." (PSATS, Di Vittorio) Fish ponds are assumed to be similar to treatment ponds	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.9, technical = 0.1, special = 0)	"Can be built and maintained with locally available materials" (Emersan) If built at an industrial scale or/and with pump ventilation, some technical parts are required in the fish pond.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
TN	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
H2O	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
TS	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Floating Plant Pond

	Values	Data Source
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	floating_plant_pond	-
DATA COMPILER	Matthias van Sloten	-
INPUT PRODUCT	effluent, transportedeffluent, secondary_effluent, transportedsecondary_effluent, greywater, transportedgreywater, stormwater, transportedstormwater	Tilley, E. et al. (2014)
OUTPUT PRODUCT	NA	Tilley, E. et al. (2014)
RELATIONS	Input: OR Output: NA	Tilley, E. et al. (2014)
COMMENTS		

Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 0, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 0, shared = 0.5, public = 1)	Tilley, E. et al. (2014)
capex_req_level	6	Spuhler, D. et al. (2021)
opex_req_level	5	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Similar technology concept (with regard to construction, design, O&M, etc.) to that of fish ponds, hence same values allotted. (Akanksha Jain based on Gensch, R. et al. (2018))

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 0.9, no el	"To provide extra oxygen to a floating plant technology, the water can be mechanically aerated but at the cost of increased power and machinery." (Compendium) Floating plant ponds can be ventilated and supplied with fresh water with pumps which could improve the performance of the technology slightly.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Floating plants require constant harvesting. The harvested biomass can be used for small artisanal businesses, or it can be composted. Mosquito problems can develop when the plants are not regularly harvested. Depending on the amount of solids that enter the pond, it must be periodically desludged. Trained staff is required to constantly operate and maintain it." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0.5, difficultly available = 0.75, pipes = 1)	Ponds require inlet and outlet pipes (Compendium)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	"Can be built and maintained with locally available materials" (Compendium) No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.9, technical = 0.1, special = 0)	"Can be built and maintained with locally available materials" (Compendium) "To provide extra oxygen to a floating plant technology, the water can be mechanically aerated but at the cost of increased power and machinery." (Compendium) If not built at an industrial scale or/and with additional technical components, simple spare parts are sufficient to operate and maintain the floating plant pond.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0, cold = 0.5, temperate = 1	"This technology is appropriate for warm or tropical climates with no freezing temperatures, [...]." (Compendium)	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.5, no flooding = 1)	"Some plants can become invasive species if released into natural environments" (Compendium) "Adequate signage and fencing should be used to prevent people and animals fro-m coming in contact with Floating Plant Pond the water. Workers should wear appropriate protective clothing [...]." (Compendium) Regular flooding could be fatal for this technology. Invasive plants and wastewater could leave the pond to the surrounding area. However, to prevent invasive plants and the wastewater from leaving the pond precautions can be made. Therefore additional design and construction is required. The functioning of this technology can be severely disrupted by flooding events. However, it is possible that they can be protected from flooding by building embankments or mounds of adequate height around them. Since a flood-preventive configuration of the technology is possible, it is allotted a performance of 50%. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, ro	The application is not based on soil absorption. No difference between different soil types.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 0, b = 0, c = 999, d = 999)	"Adequate signage and fencing should be used to prevent people and animals fro-m coming in contact with Floating Plant Pond the water. Workers should wear appropriate protective clothing [...]." (Compendium) The technology is not based on soil absorption. But there is a remaining risk of contaminating the groundwater. However it is possible to build it at a high groundwater table, but then it is very important to build it propperly and to prevent any leakage of the pond to the ground.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.5)	Shallow and wide excavation is assumed to be required.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA

drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 1, not close = 1)	"Adequate signage and fencing should be used to prevent people and animals fro-m coming in contact with Floating Plant Pond the water. Workers should wear appropriate protective clothing [...]." (Compendium) The technology is not based on soil absorption. But there is a remaining risk of contaminating the drinking water. However it is possible to build it close to a drinking water source, but then it is very important to build it propperly and to prevent any leakage of the pond to the ground.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	It is assumed that a simple design variation without any technical components that is built only with locally available material can be contructed with low construction skills. However, moderate construction skills are recommended.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"Locally appropriate plants can be selected depending on their availability and the characteristics of the wastewater. To provide extra oxygen to a floating plant technology, the water can be mechanically aerated but at the cost of increased power and machinery. Aerated ponds can withstand higher loads and can be built with smaller footprints. Non-aerated ponds should not be too deep otherwise there will be insufficient contact between the bacteria-harbouring roots and the wastewater." (Compendium) "Adequate signage and fencing should be used to prevent people and animals from coming in contact with the water. Workers should wear appropriate protective clothing. WHO guidelines on wastewater and excreta use in aquaculture should be consulted for detailed information and specific guidance." (Compendium) Lots of things to be taken in account. High design skills are required.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"Floating plants require constant harvesting. The harvested biomass can be used for small artisanal businesses, or it can be composted. Mosquito problems can develop when the plants are not regularly harvested. Depending on the amount of solids that enter the pond, it must be periodically desludged. Trained staff is required to constantly operate and maintain it." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Advantages of ponds and lagoons include they are economical, capable of handling high flows, adaptable to changing organic loads, decreased sludge handling, long design life, serve as wildlife habitat." (PSATS, Di Vittorio) Floating ponds are assumed to be similar to treatment ponds	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.9, technical = 0.1, special = 0)	"Can be built and maintained with locally available materials" (Compendium) "To provide extra oxygen to a floating plant technology, the water can be mechanically aerated but at the cost of increased power and machinery." (Compendium) If built at an industrial scale or/and with pump ventilation, some technical parts are required in the floating plant pond.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
TN	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
H2O	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
TS	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA

References

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Surface Water Disposal		Water Disposal
	Values	Data Source
FUNCTIONAL GROUP	D	-
UNIQUE IDENTIFIER (ID)	water_disposal	-
DATA COMPILER	SaniChoice Project Team	-
INPUT PRODUCT	secondary_effluent, transportedsecondary_effluent, stormwater, transportedstormwater	Spuhler, D. & Roller, L. (2020)
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)
COMMENTS		
Pre-Filter Criteria	**Values**	**Data Source**
applicability_level	(household = 1, neighbourhood = 1, city = 1)	Tilley, E. et al. (2014)
management_level	(household = 1, shared = 1, public = 1)	Tilley, E. et al. (2014)
capex_req_level	3	Spuhler, D. et al. (2021)
opex_req_level	3	Spuhler, D. et al. (2021)
technical_maturity	3	Tilley, E. et al. (2014)
development_phase	(acute = 0, stabilisation = 0.5, development/recovery = 1)	Gensch, R. et al. (2018)

Screening Criteria	Type and Function	Applicable for this Functional Group?	Categories [Unit]	Technology Values (Data)	Data Source / Assumptions	Internal Review Done?
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no ele	Technology is relying on stormwater drains or on pipes with similar functionality to stormwater drains. Water can be transported by gravity and pumps are not necessary	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0, regular = 1, continous = 0)	"Regular monitoring and sampling is important to ensure compliance with regulations and to ensure public health requirements. Depending on the recharge method, some mechanical maintenance may be required." (Compendium)	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	"Groundwater Recharge does not require materials. Preceding technologies to add the water to the receiving water body," (Emersan) Pipes are needed for conveyance but not for disposal itself. No additional pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	"Groundwater Recharge does not require materials. Preceding technologies to add the water to the receiving water body," (Emersan) Pipes are needed for conveyance but not for disposal itself. No additional pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No need for concrete.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.5, special = 0)	"Depending on the recharge method, some mechanical maintenance may be required." (Compendium) No information of any special material required. Availability of technical spare parts should be sufficient.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	If the ground is frozen, water disposal might not be possible anymore.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 1, no flooding = 1)	For the technology "water disposal", the criterion "flooding" is considered to irrelevant. It should function successfully (100% performance) in flood prone areas without any issues. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 1, gravel = 1, r	Technology is relying on stormwater drains or on pipes with similar functionality to stormwater drains. Therefore the technology uses lining material and does not rely on soil absorption.	yes
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 3, b = 3, c = 999, d = 999)	"Groundwater recharge is increasing in popularity as groundwater resources deplete and as saltwater intrusion becomes a greater threat to coastal communities. Although the soil is known to act as a filter for a variety of contaminants, groundwater recharge should not be viewed as a treatment method. Once an aquifer is ontaminated, it is next to impossible to reclaim it." (Compendium) The effluent/water should not reach the groundwater.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 1)	Excavation is needed for the construction of the conveyance but not for disposal itself. No additional excavation needed.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"There are numerous models for the remediation potential of contaminants and microorganisms, but predicting downstream or extracted water quality for a large suite of parameters is rarely feasible. Therefore, potable and non-potable water sources should be clearly identified, the most important parameters modelled and a risk assessment completed." (Compendium) "Groundwater recharge is increasing in popularity as groundwater resources deplete and as saltwater intrusion becomes a greater threat to coastal communities. Although the soil is known to act as a filter for a variety of contaminants, groundwater recharge should not be viewed as a treatment method. Once an aquifer is ontaminated, it is next to impossible to reclaim it." (Compendium) The effluent/water should not reach a drinking water source.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	Construction skills are needed for the construction of the conveyance but not specifically for disposal itself. No high-level construction skills needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0, professional = 1)	"It is necessary to ensure that the assimilation capacity of the receiving water body is not exceeded, i.e. that the receiving body can accept the quantity of nutrients without being overloaded. Parameters such as turbidity, temperature, suspended solids, BOD, nitrogen and phosphorus (among others) should be carefully controlled and monitored before releasing any water into a natural body. Local authorities should be consulted to determine the discharge limits for the relevant parameters as they can widely vary. For especially sensitive areas, a post-treatment technology (e.g., chlorination) may be required to meet microbiological limits. The quality of water extracted from a recharged aquifer is a function of the quality of the wastewater introduced, the method of recharge, the characteristics of the aquifer, the residence time, the amount of blending with other waters and the history of the system. Careful analysis of these factors should precede any recharge project." (Compendium) Very complex design and therefore high design skills required.	yes

om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0, skilled = 0, professional = 1)	"Regular monitoring and sampling is important to ensure compliance with regulations and to ensure public health requirements. Depending on the recharge method, some mechanical maintenance may be required." (Compendium) Since there is a complex design and due to the monitoring and sampling high OM skills are highly recommended.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	The concept of discharging effluent into waterbodies does not have a lifetime and can therefore be used for the short- or long-term. (Kukka Ilmanen, Eawag 2021)	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.7, technical = 0.3, special = 0)	"Depending on the recharge method, some mechanical maintenance may be required." (Compendium) No information of any special material required. Availability of technical parts should be sufficient.	yes

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments	Reference
TP	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
TN	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
H2O	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA
TS	0	-	0	0	1		PA
med (R)	0	-	0	0	1		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Surface Disposal and Storage		Surface Disposal and Storage				
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	surface_disposal_and_storage	-				
DATA COMPILER	SaniChoice Project Team	-				
INPUT PRODUCT	dried_faeces, transporteddried_faeces, processed_sludge, transportedprocessed_sludge, stabilized_sludge, transportedstabilized_sludge, pithumus, transportedpithumus, compost, transportedcompost	Spuhler, D. & Roller, L. (2020)				
OUTPUT PRODUCT	NA	Spuhler, D. & Roller, L. (2020)				
RELATIONS	Input: OR Output: NA	Spuhler, D. & Roller, L. (2020)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 0.5, neighbourhood = 0.5, city = 1)	Tilley, E. et al. (2014)				
management_level	(household = 0.5, shared = 1, public = 1)	Tilley, E. et al. (2014)				
capex_req_level	5	Spuhler, D. et al. (2021)				
opex_req_level	3	Spuhler, D. et al. (2021)				
technical_maturity	3	Tilley, E. et al. (2014)				
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 1	"Immediate Surface Disposal sites can later be upgraded to more advanced Sanitary Landfills by retrofitting leachate piping and lining materials for groundwater protection. An engineered Sanitary Landfill needs expert technical design." (Gensch, R. et al. (2018)) For 'development/recovery' 100% suitability instead of 50% were allotted. The reasoning was that a landfills are often used in development projects and can become more appropriate by upgrading them. (Kukka Ilmanen, Eawag 2021)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no ele	No electricity needed.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continous = 0)	"Little operation skills or maintenance required" (Compendium) No additional operation and maintenance required but to deposit materials (perhaps by hand).	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 1, difficultly available = 1, pipes = 1)	No pipes needed.	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No pumps needed.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 1, difficultly available = 1, concrete = 1)	No concrete needed.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.5, special = 0.1)	"For more advanced systems, leachate piping and liner materials are needed and possibly piping to collect the gas produced. For some landfill uses it is advised to cover the waste and therefore a waterproof cover is needed." (Emersan) "May require special spreading equipment" (Compendium) This special spreading equipment might require specially-manufactured spare parts. What kind of spare parts are needed is depending on what equipment is used. The larger the scale of the application the more technical equipment might be required.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 1, cold = 1, temperate = 1,	"Surface disposal and storage can be practiced in almost every climate [...]." (Compendium) Feasible for all temperatures.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	"Surface disposal and storage can be practiced in almost every climate and environment, although they may not be feasible where there is frequent flooding or where the groundwater table is high." (Compendium) This technology is generally not suited for flood prone areas as its functioning is hampered severely under inundation conditions. However, they are still awarded a low performance of 10% as there exists a possibility to construct these technologies in elevated or non-flooded plot areas of a flood prone region. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA
soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 1, silt = 1, sand = 0.5, gravel = 0.	"If a surface disposal and storage site is protected (e.g., by a fence) and located far from the public, there should be no risk of contact or nuisance. The contamination of groundwater resources by leachate should be prevented by adequate siting and design." (Compendium) Since a small risk of contaminating the groundwater remains the soil type has an influence on the performance. On sandy, gravelly or rocky ground the water seeps away faster and contamination ist easier possible. However it can be built safe but therefore more effort is needed.	yes

groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 3, b = 3, c = 999, d = 999)	"If a surface disposal and storage site is protected (e.g., by a fence) and located far from the public, there should be no risk of contact or nuisance. The contamination of groundwater resources by leachate should be prevented by adequate siting and design." (Compendium) "Surface disposal and storage can be practiced in almost every climate and environment, although they may not be feasible where there is frequent flooding or where the groundwater table is high." (Compendium) Since a small risk of contamination remains the application at areas with a high groundwater table is not recommended.	yes
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard = 0.75)	"The contamination of groundwater resources by leachate should be prevented by adequate siting and design." (Compendium) The construction for example of a drainage to prevent the leachate to reach groundwater could require some excavation. However also designs excluding excavation are possible.	yes
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0.5, not close = 1)	"If a surface disposal and storage site is protected (e.g., by a fence) and located far from the public, there should be no risk of contact or nuisance. The contamination of groundwater resources by leachate should be prevented by adequate siting and design." (Compendium) Since a small risk of contamination remains the application close to a drinking water source is not recommended. However it can be built safe but therefore more effort is needed.	
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	Construction skills are needed for the construction of the conveyance but not for disposal itself. No high-level construction skills needed.	yes
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	"The main difference between surface disposal and land application is the application rate. There is no limit to the quantity of sludge that can be applied to the surface since nutrient loads or agronomic rates are not a concern. Attention must be paid, however, to groundwater contamination and leaching. More advanced surface disposal systems may incorporate a liner and leachate collection system in order to prevent nutrients and ontaminants from infiltrating the groundwater. Sites for the temporary storage of a product should be covered to avoid rewetting by rainwater and the generation of leachate." (Compendium) For a simple design without any security measures low design skills could be sufficient. However, for a safer design that prevents the ground from being contaminated high deisgn skills are recommended.	yes
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 1, skilled = 1, professional = 1)	"Little operation skills or maintenance required" (Compendium) "Staff should ensure that only appropriate materials are disposed of at the site and must maintain control over the traffic and hours of operation. Workers should wear appropriate protective clothing." (Compendium)	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 1, long = 1)	"Surface Disposal and Sanitary Landfills can be suitable options for sludge disposal during an acute response phase, if there is land available away from human contact and waterbodies. Immediate Surface Disposal sites can later be upgraded to more advanced Sanitary Landfills by retrofitting leachate piping and lining materials for groundwater protection." (Emersan) Surface Disposal can be used in the short-term, but also in the long-term in upgraded facilities as long as sufficient space is available.	yes
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA

construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.4, technical = 0.5, special = 0.1)	"For more advanced systems, leachate piping and liner materials are needed and possibly piping to collect the gas produced. For some landfill uses it is advised to cover the waste and therefore a waterproof cover is needed." (Emersan) For larger scale applications more technical equipment (piping) might be required. "May require special spreading equipment" (Compendium) This special spreading equipment might need to be specially manufactured.	yes	

Transfer Coefficients (copied from "Sanitation_Technologies_TC_database_20210622.xlsm")

	Recovered	Range	Airloss	Soilloss	Waterloss	Comments/Specifications	Reference
TP	0	-	0	0.97	0.03	Inspired by application of compost and application of Processed sludge	PA
med (R)	0	-	0	0.97	0.03	-	-
k	25	-	-	-	-		PA
TN	0	-	0.01	0.96	0.03	Some air loss, otherwise as above	PA
med (R)	0	-	0.01	0.96	0.03		-
k	25	-	-	-	-		PA
H2O	0	-	0.03	0.96	0.01	more airloss than soil loss, otherwise like P	PA
med (R)	0	-	0.03	0.96	0.01		-
k	100	-	-	-	-		PA
TS	0	-	0.03	0.96	0.01	Same as fof water	PA
med (R)	0	-	0.03	0.96	0.01		-
k	100	-	-	-	-		PA

References

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). *Compendium of Sanitation Technologies in Emergencies* . German WASH Network (GWN), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Global WASH Cluster (GWC) and Sustainable Sanitation Alliance (SuSanA).

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Borehole Latrine						
	Values	Data Source				
FUNCTIONAL GROUP	D	-				
UNIQUE IDENTIFIER (ID)	borehole_latrine	-				
DATA COMPILER	Matthias van Sloten	-				
INPUT PRODUCT	faeces, excreta, blackwater	Gensch, R. et al. (2018)				
OUTPUT PRODUCT	NA	Gensch, R. et al. (2018)				
RELATIONS	Input: OR Output: NA	Gensch, R. et al. (2018)				
COMMENTS						
Pre-Filter Criteria	**Values**	**Data Source**				
applicability_level	(household = 1, neighbourhood = 1, city = 0)	Gensch, R. et al. (2018)				
management_level	(household = 1, shared = 1, public = 0.5)	Gensch, R. et al. (2018)				
capex_req_level	6	Spuhler, D. et al. (2021)				
opex_req_level	6	Spuhler, D. et al. (2021)				
technical_maturity	3	Gensch, R. et al. (2018)				
development_phase	(acute = 1, stabilisation = 0.5, development/recovery = 0)	Gensch, R. et al. (2018)				
Screening Criteria	**Type and Function**	**Applicable for this Functional Group?**	**Categories [Unit]**	**Technology Values (Data)**	**Data Source / Assumptions**	**Internal Review Done?**
water_supply	Performance, Categorical	FALSE	house yard public none	NA	NA	NA
water_volume	Performance, Trapez	FALSE	[L/cap/day]	NA	NA	NA
electricity_supply	Performance, Categorical	TRUE	electricity intermittent no electricity	(electricity = 1, intermittent = 1, no elec	No need for electricity.	yes
fuel_supply	Performance, Categorical	FALSE	fuel no fuel	NA	NA	NA
frequency_of_om	PDF, Categorical	TRUE	irregular regular continuous	(irregular = 0.5, regular = 0.5, continous = 0)	"General operation and maintenance (O & M) measures include routine tasks such as checking the availability of water to ensure personal hygiene, of soap and dry cleansing material and monitoring the condition and fill level of the hole. Particular attention should be paid to the cleanliness of the top of the borehole. This is easily soiled and will quickly begin to smell and harbour flies if not regularly cleaned. As desludging is usually not an option the latrine should be decommissioned X.6 when filled up to the top 0.5 m of the hole." (Emersan) Maintenance is between regular and irregular.	yes
pipe_supply	Performance, Categorical	TRUE	no pipes difficultly available pipes	(no pipes = 0, difficultly available = 0.5, pipes = 1)	"For the borehole lining, a pipe should be used, with a minimum length of 0.5 m and corresponding to the borehole diameter.","diameter usually between 0.3 to 0.5m."(Emersan)	yes
pump_supply	Performance, Categorical	TRUE	no pumps difficultly available pumps	(no pumps = 1, difficultly available = 1, pumps = 1)	No need for pumps.	yes
concrete_supply	Performance, Categorical	TRUE	no concrete difficultly available concrete	(no concrete = 0.75, difficultly available = 0.75, concrete = 1)	"The user interface can be made out of wood, bamboo, concrete or prefabricated plastic. For the superstructure, materials should be used that are readily available and that can be applied rapidly (e.g. bamboo, grass matting, cloth, wood, plastic or metal sheeting)." (Emersan) Concrete not necessary, but can perform a bit better for long-term solutions compared to local materials with shorter lifetimes.	yes
spare_parts	PDF, Categorical	TRUE	simple technical special	(simple = 1, technical = 0, special = 0)	"To construct a Borehole Latrine a manual or mechanical auger or a drilling machine is the main requirement. The user interface can be made out of wood, bamboo, concrete or prefabricated plastic. For the superstructure, materials should be used that are readily available and that can be applied rapidly (e.g. bamboo, grass matting, cloth, wood, plastic or metal sheeting)." (Emersan) The drill is only required for the construction and is not needed as a spare part. The spare parts can be made from local material.	yes
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
0	0	FALSE	0	NA	NA	NA
temperature	Performance, Categorical	TRUE	very cold cold temperate warm hot	(very cold = 0.5, cold = 0.7, temperate =	A borehole latrine can be built in colder climates but there has to be taken in account that leachate respectively soil absorbtion performance can be lower if the bottom of the pit is frozen.	yes
flooding	Performance, Categorical	TRUE	flooding no flooding	(flooding = 0.1, no flooding = 1)	"As with all pit-based systems, groundwater contamination can be an issue and soil properties such as the permeability of the soil and groundwater level should be properly assessed X.3 to identify the minimum distance to the next water source and limit exposure to microbial contamination." (Emersan) A low performance of 10% is allotted to the category "flooding" given that there exists the possibility that borehole latrines could be built at elevated/ non-flooded plot areas of the flood-prone region. (Akanksha Jain)	yes
vehicular_acces	Performance, Categorical	FALSE	no access difficult full	NA	NA	NA
slope	Performance, Categorical	FALSE	flat not flat	NA	NA	NA

soil_type	Performance, Categorical	TRUE	clay silt sand gravel rock	(clay = 0.25, silt = 0.5, sand = 1, gravel =	"Special attention should be paid to [...] ground conditions and soil permeability. Poorly permeable soil will increase the rate at which the borehole fills." (Emersan) "The soil needs to be stable and free of rock, gravel and boulders." (Emersan) Soil percolation and filtration is desired resulting in lower desludging rates.	yes	
groundwater_depth	Performance, Trapez	TRUE	water depth [m]	(a = 8, b = 13, c = 999, d = 999)	"Depending on the soil type and drilling equipment the borehole should be between 5 to 10 m deep with a diameter of usually between 0.3 to 0.5m." (Emersan) "Groundwater contamination might be an issue" (Emersan)	yes	
excavation	Performance, Categorical	TRUE	easy hard	(easy = 1, hard =0.5)	"Depending on the soil type and drilling equipment the borehole should be between 5 to 10 m deep with a diameter of usually between 0.3 to 0.5m." (Emersan) Volume of excavation is not that big. In areas where excavation is hard the construction is still possible but therefore it gets more labour intensive.	yes	
surface_area_onsite	Performance, Trapez	FALSE	[m2/plot]	NA	NA	NA	
surface_area_offsite	Performance, Trapez	FALSE	m2/pers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
drinking_water_exposure	Performance, Categorical	TRUE	Close Not close	(close = 0, not close = 1)	"As with all pit-based systems, groundwater contamination can be an issue and soil properties such as the permeability of the soil and groundwater level should be properly assessed X.3 to identify the minimum distance to the next water source and limit exposure to microbial contamination." (Emersan)	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
construction_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 1, professional = 1)	"Quick to construct" (Emersan) Requires the operation of drilling equipment.	yes	
design_skills	Performance, Categorical	TRUE	Ladder: unskilled skilled professional	(unskilled = 0, skilled = 0.5, professional = 1)	Special attention should be paid to the expected groundwater level and the associated risks of groundwater pollution as well as the topography, ground conditions and soil permeability. Poorly permeable soil will increase the rate at which the borehole fills. Some design knowledge required to identify the location of the latrine.	yes	
om_skills	Performance, Categorical	TRUE	Ladder: Unskilled Skilled Professional	(unskilled = 0.5, skilled = 1, professional = 1)	"General operation and maintenance (O & M) measures include routine tasks such as checking the availability of water to ensure personal hygiene, of soap and dry cleansing material and monitoring the condition and fill level of the hole. Particular attention should be paid to the cleanliness of the top of the borehole. This is easily soiled and will quickly begin to smell and harbour flies if not regularly cleaned. As desludging is usually not an option the latrine should be decommissioned X.6 when filled up to the top 0.5 m of the hole." (Emersan) The only crucial thing is determining when to decommission the latrine.	yes	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
cleansing_method	Performance, Categorical	FALSE	Washers Soft wipers Hard wipers	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
0	0	FALSE	0	NA	NA	NA	
lifetime	Performance, Categorical	TRUE	short (< 1 year) medium (1-5 years) long (>5 years)	(short = 1, medium = 0.7, long = 0.5)	"Borehole Latrines are usually temporary solutions but depending on diameter, depths and number of users they can also be considered a longer-term solution with a potential life span of several years. " (Emersan)	yes	
speed_implement_toilet	PDF, Categorical	FALSE	rapid (< 3 days) moderate (3 days to 2 weeks) slow (> 2 weeks)	NA	NA	NA	
speed_implement_treatment	PDF, Categorical	FALSE	rapid (few days to a week) moderate (few weeks up to three months) slow (> 3 months)	NA	NA	NA	
scalability	Performance, Categorical	FALSE	easy difficult	NA	NA	NA	
construction_parts	PDF, Categorical	TRUE	simple technical special	(simple = 0.5, technical = 0.1, special = 0.4)	"To construct a Borehole Latrine a manual or mechanical auger or a drilling machine is the main requirement. The user interface can be made out of wood, bamboo, concrete or prefabricated plastic. For the superstructure, materials should be used that are readily available and that can be applied rapidly (e.g. bamboo, grass matting, cloth, wood, plastic or metal sheeting)." (Emersan) The drilling machine might need to be specially-manufactured, however most of the superstructure and user interface can be made from simple local material.	yes	

Transfer Coefficients	(copied from "Sanitation_Technologies_TC_database_20210622.xlsm")						
	Sludge	**Range**	**Airloss**	**Soilloss**	**Waterloss**	**Comments/Specifications**	**Reference**
TP	0	-	0	1	0		PA
med (R)	0	-	0	1	0	-	-

k	100	-	-	-	-		PA
TN	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
H2O	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA
TS	0	-	0	1	0		PA
med (R)	0	-	0	1	0		-
k	100	-	-	-	-		PA

Additional Information

All the inputs of the borehole latrine end up as losses, no products recovered. Spuhler et al. (2021)

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