Wastewater Impact Assessment Tool V1. Science and Methods

Content

1. Global Indicators

The global indicators are intended to report on the status of water security issues at the global level. These indicators are classified in 4 different groups, the first one is the population indicator, which is used to observe how the population is distributed in the world. The next group is water quantity, in which there are all the indicators related to water quantity (available water, ratios of availability and demand, risk of flooding or drought ...). The third major group is water quality, in this group we find indicators that report the quality of water. Finally, the reputational risk indicator reports on the risk that a company has in establishing itself in a country of damaging its reputation.

Population		
		Population
Water Quality		
	Water availability	
		Water supply
		Flow accumulation
		Stream flow
		Seasonal variability
		Interannual variability
	Water demand	
		Water demand
	Water scarcity ratios	
		Water stress
		Water depletion
		Aridity index
	Groundwater	
		Groundwater table decline
	Flood risk	
		Riverine flood risk
		Coastal flood risk
	Drought risk	
		Drought risk
Water quality		
		Coastal Eutrophication Potential
		Surface Water Pharmaceutical Pollution

	Coastal Pharmaceutical Pollution
	Unimproved/ No drinking water
	Unimproved/ No sanitation
Reputational risk	
	Peak RepRisk Country ESG Risk Index

1.1 Population

The population indicator indicates the number of inhabitants in each region. The objective of this indicator is to inform about the number of people that can be affected by an industry in a region if it has a negative impact on the quality or quantity of water.

Name	Population
Sub-group	Population
Spatial resolution	60 X 60 arc minute cells
Temporal resolution	5 years
Temporal range	2000 - 2020
Source	CEISIN
Description	Data set whit the current world population and a 2030 BAU future scenario projection. (*Documentation » Gridded Population of the World (GPW), v4 | SEDAC*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2Water Quantity

Quantity indicators report on issues related to water quantity. There are 4 different subgroups related to water quantity. The first one Water availability informs about what is the quantity of water we find at a point, calculated in different ways and with different sources of information, in this subgroup are also the indicators that show the variability of quantity. The second subgroup is water demand, which informs about the demand of water for different uses. The third group links the availability and demand indicators to create ratios of availability/demand that indicate the water scarcity levels. The groundwater group indicates the status of the aquifers. Finally, the flood and drought indicators indicate the risk in each zone of being impacted by a flood or drought period and which population is going to be affected by it.

1.2.1 Water availability

Name	Water supply
Sub-group	Water availability
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 -2014
Source	Aqueduct
Description	Water supply is the amount of water available in one point, it takes in count the up-stream consumptive use and the flow accumulated upstream. It does not take in count groundwater resources. The units used are mm/year, each mm is one litre of water in one square meter of surface, to calculate the available water in an area it is necessary to multiply the value of mm/year by the number of square meters that have the area (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Flow accumulation
Sub-group	Water availability
Spatial resolution	3,75 X 3,75 arc minute cells
Temporal resolution	Annual
Temporal range	2019
Source	Global Fate
Description	Flow accumulation indicates the amount of water accumulated at each point as the sum of all points upstream. It counts the run-off values from High-resolution fields of global runoff combining observed river discharge and simulated water balances. (Acuña et al., 2020)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Stream flow
Sub-group	Water availability
Spatial resolution	30 X 30 arc minute cells
Temporal resolution	Annual
Temporal range	2000 - 2016

Source	WaterGap2.2d
Description	Stream flow is the volume of water flowing in one point, it considers the extraction of water for irrigation, livestock, domestic uses, manufacturing process and thermal power. The source of these indicator is the WaterGapv2.2.d, global hydrological model that quantifies human use of groundwater and surface water as well as water flows and water storage and thus water resources on all land areas of the Earth. Stream flow has a spatial resolution of 0,5o X 0,5o grid cells (55km X 55km at the Equator) (Müller Schmied et al., 2021). To calculate the stream flow, we use the 2000 - 2016 monthly data to calculate the mean value. To create the 2030 BAU future scenario values we did a lineal progression with the data from the WaterGap.
Used for	Calculus metrics that are related to the amount of water available.

Name	Seasonal variability
Sub-group	Water availability
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Source	Aqueduct
Description	Seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations of available supply within a year. (Hofste et al., n.d.)
Equation	$seasonal\ variability = \frac{SD_{[jan\ldots dec]}Q_m}{mean_{[jan\ldots dec]}Q_m}$ $SD: Standard\ deviation$ $Q_m: Average\ available\ water\ per\ month$
Risk categories	• <0,33 Low • 0,33 – 0,66 Low – medium • 0,66 – 1,00 Midium – High • 1,00 – 1,33 High • >1,33 Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Interannual variability

Sub-group	Water availability
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Source	Aqueduct
Description	Interannual variability measures the average between year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations in available supply from year to year. Interannual, or between year, variability is defined as the coefficient of variation (CV) of available water for each sub-basin. The CV is the standard deviation (SD) of the available water, divided by the mean. (Hofste et al., n.d.)
Equation	$interannual\ variability = \frac{SD_{[1960 \ldots 2014]} Q_m}{mean_{[1960 \ldots 2014]} Q_m}$ $SD: Standard\ deviation$ $Q_m: Average\ available\ water\ per\ month$
Risk categories	• <0,25 Low • 0,25 – 0,50 Low – Medium • 0,50 – 0,75 Medium – high • 0,75 – 1,00 High • >1,00 Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.2 Water demand

The water demand indicator provides information on the water demand at each point.

Name	Water demand
Sub-group	Water demand
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Source	Aqueduct
Description	Water demand measures the amount of water that is withdrawn at each point for domestic, agricultural, or industrial use.
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.3 Water scarcity ratios

This subgroup of indicators relates water demand or consumption to the amount of water available. Some of these are more focused on human actions and others are more focused on water consumption by vegetation.

Name	Water stress
Sub-group	Water scarcity ratios
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Source	Aqueduct
Description	Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and nonconsumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users. (Hofste et al., n.d.)
Equation	$WS = \frac{Gross\ Water\ Withdrawal}{Available\ Water\ - Net\ water\ Withdrawal}$
Risk categories	• <10% Low • 10 – 20% Low – medium • 20 – 40% Medium – high • 40 – 80% High • >80% Extremely high Sub-basins classified as “arid and low water use” (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Water depletion
Sub-group	Water scarcity ratios
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Source	Aqueduct

Description	Baseline water depletion measures the ratio of total water consumption to available renewable water supplies. Total water consumption includes domestic, industrial, irrigation, and livestock consumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate larger impact on the local water supply and decreased water availability for downstream users.
Equation	$WD = \frac{Net\ Water\ Withdrawal}{Available\ Water\ - Net\ water\ Withdrawal}$
Risk categories	• <5% Low • 5 – 25% Low – medium • 25 – 50% Medium – high • 50 – 75% High • >75% Extremely high Sub-basins classified as “arid and low water use” (Brauman et al., 2016)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Aridity index
Sub-group	Water scarcity ratios
Spatial resolution	30 X 30 arc seconds cells
Temporal resolution	Annual
Temporal range	1970 - 2000
Source	(Zomer et al., 2008)
Description	The second version of the Global Aridity Index (Zomer et al., 2008)is a global climate data for the 1970-2000 period, related to evapotranspiration processes and rainfall deficit for potential vegetative growth, based on the implementation of a Penman-Montieth Reference Evapotranspiration (ET0) equation. It provides information about the potential availability of water in regions with low water demand, thus they are used to better account for deserts and other arid areas in the risk assessment. Aridity is usually expressed as a generalized function of precipitation, temperature and potential evapo-transpiration. An Aridity Index can be used to quantify precipitation availability over atmospheric water demand.(*WWF Water Risk Filter Methodology Documentation*, 2021)
Risk categories	• >0,65 Humid • 0,5 – 0,65 Dry sub-humid • 0,2 – 0,5 Semi-arid • 0,03 – 0,20 Arid • <0,03 Hyper-arid

	(Middleton & Thomas, 1992)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.4 Groundwater

In this group of indicators there is only one indicator, Groundwater table decline, which serves to see what the trend of the amount of water in the groundwater aquifers is, and whether it is decreasing or increasing.

Name	Groundwater table decline
Sub-group	Groundwater
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	1960 - 2014
Source	Aqueduct
Description	Groundwater table decline measures the average decline of the groundwater table as the average change for the period of study (1990–2014). The result is expressed in centimetres per year (cm/yr). Higher values indicate higher levels of unsustainable groundwater withdrawals. (Hofste et al., n.d.)
Risk categories	• <0cm/y Low • 0 – 2cm/y Low-medium • 2 – 4 cm/y Medium-high • 4 – 8 cm/y High • >8 cm/y Extremely high
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.5 Flood risk

Flood indicators serve to show the number of people who may be affected by flooding, not only taking into account the frequency of flooding but also exposure and vulnerability.

Name	Riverine flood risk
Sub-group	Flood risk
Spatial resolution	30 X 30 arc minute cells
Temporal resolution	Annual
Temporal range	2010
Source	Aqueduct

Description	Riverine flood risk measures the percentage of population expected to be affected by riverine flooding in an average year, accounting for existing flood-protection standards. Flood risk is assessed using hazard (inundation caused by river overflow), exposure (population in flood zone), and vulnerability. The existing level of flood protection is also incorporated into the risk calculation. It is important to note that this indicator represents flood risk not in terms of maximum possible impact but rather as average annual impact. The impacts from infrequent, extreme flood years are averaged with more common, less newsworthy flood years to produce the "expected annual affected population." Higher values indicate that a greater proportion of the population is expected to be impacted by riverine floods on average. (Hofste et al., n.d.)
Risk categories	• 0 to 1 in 1.000 Low • 1 in 1.000 to 2 in 1.000 Low – medium • 2 in 1.000 to 6 in 1.000 Medium – high • 6 in 1.000 to 1 in 100 High • More than 1 in 100 Extremely high
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Coastal flood risk
Sub-group	Flood risk
Spatial resolution	30 X 30 arc minute cells
Temporal resolution	Annual
Temporal range	2010
Source	Aqueduct
Description	Coastal flood risk measures the percentage of the population expected to be affected by coastal flooding in an average year, accounting for existing flood protection standards. Flood risk is assessed using hazard (inundation caused by storm surge), exposure (population in flood zone), and vulnerability. The existing level of flood protection is also incorporated into the risk calculation. It is important to note that this indicator represents flood risk not in terms of maximum possible impact but rather as average annual impact. The impacts from infrequent, extreme flood years are averaged with more common, less newsworthy flood years to produce the "expected annual affected population." Higher values indicate that a greater proportion of the population is expected to be impacted by coastal floods on average. (Hofste et al., n.d.)
Risk categories	• 0 to 9 in 1.000.000 Low • 9 in 1.000.000 to 7 in 100.000 Low – medium • 7 in 100.000 to 3 in 10.000 Medium – high • 3 in 10.000 to 2 in 1000 High • More than 2 in 1000 Extremely high

Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.2.6 Drought risk

Drought risk indicators show the number of people who may be affected by a period of drought, not only considering the frequency of droughts but also the exposure and vulnerability of the population affected.

Name	Drought risk
Sub-group	Drought risk
Spatial resolution	5 X 5 arc minute cells
Temporal resolution	Annual
Temporal range	2000 - 2014
Source	Aqueduct
Description	Drought risk measures where droughts are likely to occur, the population and assets exposed, and the vulnerability of the population and assets to adverse effects. Higher values indicate higher risk of drought. (Hofste et al., n.d.)
Risk categories	• 0,0 – 0,2 Low • 0,2 – 0, 4 Low – medium • 0,4 – 0,6 Medium • 0,6 – 0,8 Medium - high • 0,8 – 1,0 High (Carrão et al., 2016)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.3 Water quality

Water quality indicators indicate the state of the water and whether it is heavily polluted or not, as well as what percentage of people have access to treated water and the percentage of people using pit latrines without a slab or platform or directly disposing human waste in fields.

Name	Coastal Eutrophication Potential
Sub-group	Water quality
Spatial resolution	30 X 30 arc second cells
Temporal resolution	Annual
Temporal range	2000
Source	Aqueduct

Description	Coastal eutrophication potential (CEP) measures the potential for riverine loadings of nitrogen (N), phosphorus (P), and silica (Si) to stimulate harmful algal blooms in coastal waters. The CEP indicator is a useful metric to map where anthropogenic activities produce enough point-source and nonpoint-source pollution to potentially degrade the environment. When N and P are discharged in excess over Si with respect to diatoms, a major type of algae, undesirable algal species often develop. The stimulation of algae leading to large blooms may in turn result in eutrophication and hypoxia (excessive biological growth and decomposition that reduces oxygen available to other organisms). It is therefore possible to assess the potential for coastal eutrophication from a river's N, P, and Si loading. Higher values indicate higher levels of excess nutrients with respect to silica, creating more favourable conditions for harmful algal growth and eutrophication in coastal waters downstream.(Hofste et al., n.d.)
Risk categories	• < -5 Low • -5 – 0 Low – medium • 0 – 1 Medium – high • 1 – 5 High • > 5 Extremely high (*The Open Ocean Status and Trends SUMMARY FOR POLICY MAKERS International Hydrological Programme*, 2016)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Surface Water Pharmaceutical Pollution
Sub-group	Water quality
Spatial resolution	3,75 X 3,75 arc minute cells
Temporal resolution	Annual
Temporal range	2011 - 2013
Source	Global Fate
Description	Surface Water Pharmaceutical Pollution Indicates the concentration of the Diclofenac on the rivers from domestic uses, it takes in count the population consumption, the in-stream attenuation, excretion, and the removal at sanitation facilities. (Acuña et al., 2020)
Risk categories	• 0 Null • > 0 – 10 Low - medium • 10 – 30 Medium - high • 30 – 100 High • > 100 Extremely high (Acuña et al., 2020)

Name	Coastal Pharmaceutical Pollution

Sub-group	Water quality
Spatial resolution	3,75 X 3,75 arc minute cells
Temporal resolution	Annual
Temporal range	2011 - 2013
Source	Global Fate
Description	Coastal Pharmaceutical Pollution Indicates the amount of Diclofenac exported by the rivers to the ocean.(Acuña et al., 2020)
Risk categories	• < 10 Null • 10 – 50 Low - medium • 50 – 1.000 Medium - high • 1.000 – 100.000 High • > 100.000 Extremely high (Acuña et al., 2020)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Unimproved/ no drinking water
Sub-group	Water quality
Spatial resolution	Country (rural/urban)
Temporal resolution	Annual
Temporal range	2015
Source	WHO & UNICEF
Description	Unimproved/no drinking water reflects the percentage of the population collecting drinking water from an unprotected dug well or spring, or directly from a river, dam, lake, pond, stream, canal, or irrigation canal (WHO & UNICEF, 2017). Specifically, the indicator aligns with the unimproved and surface water categories of the Joint Monitoring Programme (JMP)—the lowest tiers of drinking water services. Higher values indicate areas where people have less access to safe drinking water supplies. (Hofste et al., n.d.)
Risk categories	• <2,5% Low • 2,5 – 5,0% Low – medium • 5,0% - 10,0% Medium – high • 10,0 – 20,0% High • >20,0% Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

Name	Unimproved/ no sanitation
Sub-group	Water quality
Spatial resolution	Country (rural/urban)
Temporal resolution	Annual
Temporal range	2015
Source	WHO & UNICEF
Description	Unimproved/no sanitation reflects the percentage of the population using pit latrines without a slab or platform, hanging/bucket latrines, or directly disposing human waste in fields, forests, bushes, open bodies of water, beaches, other open spaces, or with solid waste.(WHO & UNICEF, 2017) Specifically, the indicator aligns with JMP's unimproved and open defecation categories— the lowest tier of sanitation services. Higher values indicate areas where people have less access to improved sanitation services. (Hofste et al., n.d.)
Risk categories	• <2,5% Low • 2,5 – 5,0% Low – medium • 5,0% - 10,0% Medium – high • 10,0 – 20,0% High • >20,0% Extremely high (*Aqueduct_Global_Maps_2.1-Constructing_Decicion-Relevant_Global_Water_Risk_Indicators_final_0*, n.d.)
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

1.4 Reputational risk

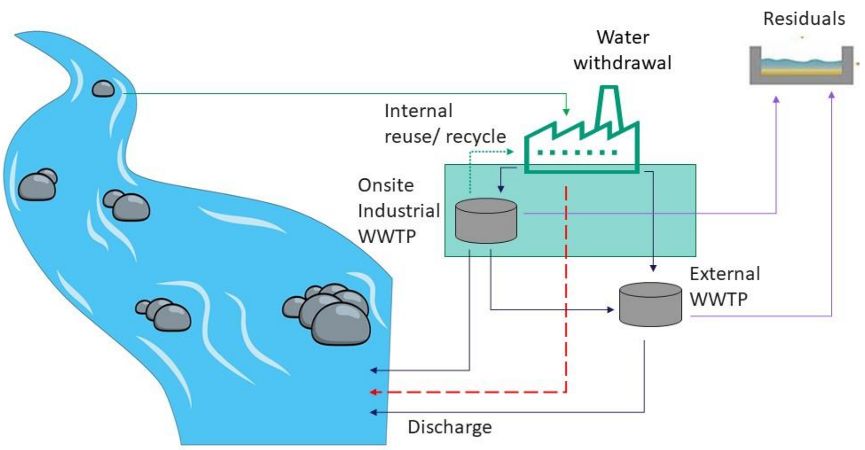
Reputational risk indicators represent stakeholders' and local communities' perceptions on whether companies conduct business sustainably or responsibly with respect to water.

Name	Peak RepRisk Country ESG Risk Index
Sub-group	Reputational risk
Spatial resolution	Country
Temporal resolution	Annual
Temporal range	2016 - 2018
Source	RepRisk
Description	The Peak RepRisk country ESG risk index quantifies business conduct risk exposure related to environmental, social, and governance (ESG) issues in the corresponding country. The index provides insights into potential financial, reputational, and compliance risks, such as human rights violations and environmental destruction. The peak value equals the highest level of the index in each country over the last two

	years. The higher the value, the higher the risk exposure.(Hofste et al., n.d.) For more information on how this index is calculated, you can consult the methodology on the RepRisk website. (*RepRisk | RepRisk Methodology Overview*, n.d.)
Risk categories	• <25% Low • 25 – 50% Low – medium • 50 – 60% Medium – high • 60 – 75% High • >75% Extremely high
Used for	Providing information about the global indicator is merely informative; no metric uses this indicator to calculate impact.

2. Impact assessment

The calculation of the impact of the industry is done from a series of calculations or metrics quantifying the impact by considering different factors, some of which are more focused on water quality and the impact on the ecosystem and others are more focused on the amount of water or the emission of greenhouse gases.



2. 1 Pollution impact

The following metrics calculate the impact of pollutants on the river. there are 3 main groups of metrics, those related to industrial effluent, those related to the impact on the ecosystem and those dealing with the efficiency of water treatment. The list of pollutants measured to calculus the impact are COD, Total Nitrogen, Total phosphor, and some of the Priority Pollutants (PP), the PP can threaten human health or ecosystems. The list of the 33 priority substances was composed by the European Commission with a panel of experts in the field of chemistry and maritime pollution, delegates of the member states and European firms and the European Environment Agency. The table above show which PP those the ecosystem impact metrics consider. (*Priority Substances - Water - Environment - European Commission*, n.d.)

PP Name
1,2-Dichloroethane
Cadmium
Hexachloro-benzene
Mercury
Lead
Nickel
C10-13 Chloroalkanes
Hexachloro-butadiene
Nonylpheno
Tetrachloro-ethylene
Trichloro-ethylene

2.1.1 Effluent toxicity level

Name	Toxic units in the effluent
Description	Toxic units in the effluent aims to calculus haw toxic is industry effluent for the ecosystem. To calculate the ecotoxicity potential, we have used the PP concentrations values from which in 24h cause the deaths or lack of movement of 50% of *Daphnia magna* individuals. These values (EC50) have been extracted from different studies compiled into two different databases, the ECOTOX Knowledgebase from the United States Environmental Protection Agency (*ECOTOX | Home*, n.d.) and from the NORMAN Ecotoxicology Database. (*NORMAN Ecotoxicology Database*, n.d.) This metric has no impact categories because it calculates with respect to the industry effluent and not with respect to the water body.
Equation	

	$EC_{toxPP} = \frac{PP_{effl}}{W_{effl}} \cdot \frac{1}{EC50_{PP}}$ Where: EC_{toxPP}: ecotoxicity potential of one PP PP_{effl}: load of the PP in the effluent W_{effl}: amount of water discharged to the water body $EC50_{PP}$: Values of EC50 from the databases

Table of EC50 values

PP name	Scientific name	Duration (h)	Endpoint	Effect	Concentration (µg/L)	Source Freitag et a
1,2-Dichloroethane	*Daphnia magna*	24	EC50	immobile	150000	(Freitag et al., 1994)
Cadmium	*Daphnia magna*	24	EC50	mortality	9,5	(Kim et al., 2017)
Hexachloro-benzene	*Daphnia magna*	24	EC50	Immobile	30	(Calamari D et al., 1983)
Mercury	*Daphnia magna*	24	EC50	mortality	1,4	(Kim et al., 2017)
Lead	*Daphnia magna*	24	EC50	mortality	440	(Kim et al., 2017)
Nickel	*Daphnia magna*	24	EC50	immobile	1000	(Haley & Kurnas, 1993)
C10-13 Chloroalkanes	*Daphnia magna*	24	EC50	mortality	65000	(Freitag et al., 1994)
Hexachloro-butadiene	*Daphnia magna*	24	EC50	immobile	500	(Knie et al., 1983)
Nonylphenol	*Daphnia magna*	24	EC50	immobile	150	(Brennan et al., 2006)
Tetrachloro-ethylene	*Daphnia magna*	24	EC50	immobile	3200	(Bringmann & Kuehn, 1982)
Trichloroethylene	*Daphnia magna*	24	EC50	Immobile	76000	(Bazin et al., 1987)

Name	Average concentration of the pollutants in the effluent (whit respect to EQS)
Description	The Environmental Quality Standards (EQS) are the limits approved by the EU's Water Framework Directive. The directive sets environmental quality standards for priority pollutants (PP) and eight other pollutants. These

	substances include the metals cadmium, lead, mercury and nickel, and their compounds; benzene; polyaromatic hydrocarbons (PAH); and several pesticides. Several of these priority substances are classed as hazardous. Each PP has a maximum allowable concentration (MAC) for inland surface waters. The metric of impact is a ratio between the EQS concentration limits and the industry effluent concentration, higher values indicate a higher impact.(*Priority Substances - Water - Environment - European Commission*, n.d.) This metric has no impact categories because it calculates with respect to the industry effluent and not with respect to the water body.
Equation	$EEQSI_{PP} = \frac{PP_{effl}}{W_{effl}} \cdot \frac{1}{EQS_{PP}}$ Where: $EEQSI_{PP}$: Concentration of a given PP in the effluent compared to its maxmum allowable concentration in the EU's Water Framework directive PP_{effl}: load of the PP in the effluent W_{effl}: amount of water discharged to the water body EQS_{PP}: Maximum allowable concentration of a PP in the EU's Water Framework directive

Table of EQS values

PP Name	EQS [mg/l]
1,2-Dichloroethane	0,01
Cadmium	0,001
Hexachloro-benzene	0,0005
Mercury	0,00007
Lead	0,0072
Nickel	0,02
C10-13 Chloroalkanes	0,0014
Hexachloro-butadiene	0,0006

Nonylpheno	0,002
Tetrachloro-ethylene	0,01
Trichloro-ethylene	0,01

(*Priority Substances - Water - Environment - European Commission*, n.d.)

2.1.1 Pollution load to the environment

Name	Increase in the concentration of the pollutant in the receiving water body
Description	Increase in the concentration of the pollutant in the receiving water body is a calculous of the increment of the industry pollutants on the receiving water, it calculous what are the final concentration on the river will be supposing the receiving water has a concentration of 0. The delta load is calculated for COD, Total Nitrogen, Total phosphor, and the PP and it used to calculus the Increase in toxic units in the receiving water body after discharge and Increase of the average concentration of the pollutants in the receiving water body after discharge (whit respect to EQS). **This metric is not an impact metric per se but rather a necessary calculation to calculate the next two metrics.**
Equation	$Delta = \frac{PP_{effl}}{W_a + W_{effl} - W_w}$ Where: $Delta$: Increase in the concentration of pollutant in the receiving water body PP_{effl}: load of the PP in the effluent W_a: amount of water available on the river, which is extracted from the stream flow global indicator. W_{effl}: amount of water that the industry discharge on the river W_W: amount of water withdrawn from the river

Name	Increase in toxic units in the receiving water body after discharge
Description	Toxic units in the receiving water body indicates if the concentration after the effluent discharge on the water body exceed the EC50, supposing the receiving water has a concentration of 0. These metric does not calculus values for COD, TN, TP, just for PP.
Equation	

	$$Delta\_ecotox_{PP} = \frac{D_{PP}}{EC50_{PP}}$$ Where: $Delta\_ecotox_{PP}$: Increase in TU in the receiving water body caused by the PP $Delta\_ecotox_{PP}$: delta load of a PP $EC50_{PP}$: Value of EC50 from the databases for PP
Impact categories	• > 2 Very high impact • 1 – 2 High impact • 1 – 0,2 Medium impact • < 0,2 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Increase of the average concentration of the pollutants in the receiving water body after discharge (whit respect to EQS)
Description	Final concentration in the receiving water body with respect to EQS indicates if the concentration after the effluent discharge on the water body exceed the Environmental Quality Standards, supposing the receiving water has a concentration of 0. These metric does not calculus values for COD, TN, TP, just for PP.
Equation	$$DeltaEQS_{PP} = \frac{D_{PP}}{EQS_{PP}}$$ Where: $DeltaEQS_{PP}$: Increase of the concentration of a PP in the receiving water body (with respect to the maxmum allowable concentration in the EU's Water Framework directive) D_{PP}: delta load of a PP EQS_{PP}: Maximum allowable concentration of a PP in the EU's Water Framework directive
Impact categories	• > 2 Very high impact • 1 – 2 High impact • 1 – 0,2 Medium impact • < 0,2 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Eutrophication potential

Description	Eutrophication potential (EP) is defined as the potential to cause over-fertilization of water and soil, which can result in increased growth of biomass. It will always have positive values; higher values indicate higher impact. It converts the pollutants to PO4 equivalent to calculus the total Eutrophication potential.

Tables of PO4 equivalent

Pollutants	Kg pollutant	Kg PO4 eq
Ammonia	1	0,35
Ammonium, ion	1	0,33
COD, Chemical Oxygen Demand	1	0,022
Nitrate	1	0,1
Nitric acid	1	0,1
Nitrite	1	0,1
Nitrogen	1	0,42
Nitrogen oxides	1	0,13
Nitrogen, total	1	0,42
Phosphate	1	1
Phosphoric acid	1	0,97
Phosphorus	1	3,06
Phosphorus pentoxide	1	1,34
Phosphorus, total	1	3,06

(*CML-IA Characterisation Factors - Leiden University*, n.d.)

2.1.3 Treatment efficiency

Name	Average percentage of treatment efficiency (compared to WWTP influent)
Description	This metric indicates what is the percentage of pollutant load that the WWTP eliminates from the industry water.
Equation	$Eff_P = \frac{P_{infl} - P_{effl}}{P_{infl}} \cdot 100$ Where:

	Eff_P: percentage of treatment efficiency of p (compared to WWTP influent) P_{infl}: load of P in the influent P_{effl}: load of P in the effluent
Impact categories	• > 25 Very high impact • 25 – 50 High impact • 50 – 75 Medium impact • < 75 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Average percentage of treatment efficiency (compared to industry influent)
Description	This metric indicates whether there is an improvement in water quality due to its use by the industry. When the water that goes back to the river is cleaner than the one that the industry extracts from the rivers the value of the ITE is bigger than 100.
Equation	$Eff_P = \frac{P_{effl}}{P_{industry}} \cdot 100$ Where: Eff_P: percentage of treatment efficiency (compared to industry influent) of a pollutant P_{effl}: load of a pollutant in the effluent of the WWTP $P_{industry}$: load of a pollutant in the influent of the industry
Impact categories	• > 100 Impact • < 100 Positive impact The impact categories have been established by a panel of ICRA experts.

2.2 Freshwater impact

Name	Dilution factor
Description	The dilution factor (DF) can be defined as the ratio between receiving water body flow to total industrial wastewater effluent generated within a catchment. Higher values indicate less impact on the river.
Equation	$DF = \frac{W_a + W_{effl} - W_w}{W_{effl}}$

	Where: W_a: amount of water available on the river, which is extracted from the stream flow global indicator. W_{effl}: amount of water that the industry discharge on the river W_W: $a$mount of water withdrawn from the river
Impact categories	• >100 Low impact • 10 – 100 Medium impact • 1 – 10 High impact • <2 Very high impact (Rice & Westerho, 2017)

Name	Recycled water factor
Descriptio n	This metric indicates the percentage of the reused water used by the industry respect the water discharged by industry (to direct discharge, onsite industry WWTP effluent and to external WWTP effluent). Values that may have this metric range from 0 to 100, the larger its value the more efficient the water recycled is.
Equation	WRF= $\frac{W_r}{OWWTP_i+EWWTP_i+DD}X100$ *Where:* WRF: percentage of the reused water used by the industry respect the water that leaves the industry W_r: amount of water that the industry reuses/recycles from the WWTP. $OWWTP_i$: Onsite industrial WWTP influent $EWWTP_i$: External WWTP influent DD: Directly discharged water
Impact categories	• 0 – 2 Very high impact • 2 – 5 High impact • 5 – 20 Medium impact • + 20 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Treated water factor

Description	This metric indicates the ratio between the water remaining after the industry consumption and the water that is treated in the WWTP.
Equation	$$TWF = \frac{W_t}{OWWTP_i + EWWTP_i + DD} X100$$ *Where:* TWF: ratio between the water remaining after the industry consumption a the water that is treated W_t: amount of water used by the industry that is treated in a WWTP $OWWTP_i$: Onsite industrial WWTP influent $EWWTP_i$: External WWTP influent DD: Directly discharged water
Impact categories	• > 25 Very high impact • 25 – 50 High impact • 50 – 75 Medium impact • < 75 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Consumption available ratio (level of water stress)
Description	This metric is calculated from the relationship between the amount of water withdrawn by the industry and the amount of water available and multiplied by 100. It indicates the percentage of the available water withdrawn by the industry’s consumption. This metric may have values ranging from 0, to a value greater than 100, indicating that the demand for water is higher than the available.
Equation	$$LWS = \frac{W_w}{W_a} \cdot 100$$ Where: LWS: the relationship between the amount of water withdrawn by the ind and the amount of water available W_a: amount of water available on the river, which is extracted from the stream flow global indicator. W_W: amount of water withdrawn from the river
Impact categories	• 0 – 2 Very high impact • 2 – 5 High impact

	• 5 – 20 Medium impact • + 20 Low impact The impact categories have been established by a panel of ICRA experts.

Name	Specific water consumption
Description	Specific water consumption is a metric that indicates what is the amount of water from the water body needed to produce a tone of product manufactured in the industry. Higher values indicate higher water demand.
Equation	$SWC = \frac{T_{ppi}}{W_w}$ Where: SWC: Specific water consunmption T_{PPI}: Tons of product produced by the industry W_W: amount of water withdrawn from the river

2.3 Carbon impact

This metric indicates the GHG emissions from the industry. It counts the amount of CO2 equivalent that is produced during the water treatment, water discharge, the emissions from sludge management and the emissions from biogas. It will always have positive values; higher values indicate higher impact. The methodology to calculus the global warming potential is from the Energy Performance and Carbon Emissions Assessment and Monitoring Tool (ECAM). (*Sanitation Treatment*, n.d.)

Name	Indirect emissions from electricity consumption (IEFEC)
Equation	$\text{IEFEC} = convkwh \cdot nrgcons \cdot W_t$ Where: $convkwk$: Emission factor for grid electricity $nrgcons$: Electricity consumed from the grid for wastewater treatment per cubic meter treated W_t: Amount of water treated

Name	Emissions from fuel engines (EFFE)

Description	Direct CO2 emitted from on-site engines in wastewater stages based upon sum of CO2, CH4 and N2O emission from stationary combustion
Equation	$ECO_2 = \frac{V \cdot FD_{CO_2} \cdot NCV_{CO_2} \cdot EF_{CO_2}}{1000}$ $EN_2O = \frac{V \cdot FD_{N_2O} \cdot NCV_{N_2O} \cdot EF_{N_2O} \cdot EQ_{N_2O}}{1000}$ $ECH_4 = \frac{V \cdot FD_{CH_4} \cdot NCV_{CH_4} \cdot EF_{CH_4} \cdot EQ_{CH_4}}{1000}$ $\mathrm{EFFE} = ECO_2 + ECH_4 + EN_2O$ Where: V: Volume of fuel consumed EQ_{N_2O}: *Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$*)* EQ_{CH_4}: *Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)*

Table of equation values

Fuel type	EFCH4 (kg/TJ)	EFN2O (kg/TJ)	EFCO2 (kg/TJ)	FD (kg/L)	NCV (TJ/Gg)
Diesel	3	0,6	74100	0,84	43
Gasoline/Petrol	3	0,6	69300	0,74	44,3
Natural Gas	10	0,1	56100	0,75	48

(Wagner & Walsh, n.d.)

Name	Emissions from treatment (EFT)
Equation	$CH_4 = (bodinfl - bodslud) \cdot CH_4efactre \cdot CH_4eq$ $N_2O = (\mathrm{tninfl}) \cdot N_2Oefactre \cdot NtoN_2O \cdot N_2Oeq$ $EFT = CH_4 + N_2O$

	Where: $bodinfl$ *: influent COD load* $bodslud$*: COD removed as sludge* *CH4efactre: CH4 emission factor* CH_4eq*: conversion of CH4 emissions to CO2 equivalent emissions (34 kgCO2eq/kgCH4)* tninfl*: Total Nitrogen load in the influent* $N_2Oefactre$ *: N2O emission factor* $NtoN_2O$ *: N2O-N to N20 conversion factor (1.57 gN2O/gN2O-N)* N_2Oeq *: conversion of N2O to CO2 equivalent emissions (298 kgCO2eq/kgN2O)* (Deborah Bartram et al., 2019)

Name	Sludge composted
Description	Amount of CO2eq emissions due to sludge composted
Equation	$TVS = \frac{slucompTVS}{100} \qquad Ncont = \frac{slucompNcont}{100}$ $\boldsymbol{If\ emissions\ are\ treated, or\ piles\ covered}: CH_4 = 0$ $\boldsymbol{Else}$: $CH4 = sludgemass \cdot TVS \cdot TVStoOC \cdot \mathrm{upEF} \cdot \mathrm{OCto}CH_4 \cdot ctCH_4eq$ $\boldsymbol{If\ ratio\ CN} > \boldsymbol{30}: N_2O = 0$ $\boldsymbol{Else\ if}: \boldsymbol{solid\ content\ of\ compost} > \boldsymbol{55}: N_2O = 0$ $\boldsymbol{Else}$: $N_2O = sludgemass \cdot Ncont \cdot lowCNE\mathrm{F} \cdot \mathrm{ctNto}N_2O4428 \cdot ctN_2Oeq$ $CO_2SC = CH_4 + N_2O$ ***Where:*** $sludgemass$ *: Amount of sludge that is sent to composting (dry weight)* $slucompTVS$*: Total Volatile Solids (TVS) content of sludge composted (% of dry weight).* $TVStoOC$ *: Organic Carbon content in Volatile Solids (0,56 gOC/gVS)* upEF *: CH4 emission factor for uncovered pile (fraction of initial C in solids)*

	$\mathrm{OCto}CH_4$: *Organic C to CH4 conversion factor (=16/12* gCH_4/gOC*)* $ctCH_4eq$: *Conversion of CH4 emissions to CO2 equivalent emissions (34 kgCO2eq/kgCH4)* $slucompNcont$: *N content of sludge stored (% of dry weight)* $lowCNE\mathrm{F}$: *N2O emission factor for low C:N ratio* $\mathrm{ctNto}N_2O4428$: *N2O-N to N2O conversion factor (44/28 gN2O/gN2O-N)* ctN_2Oeq: *Conversion of N2O emissions to CO2 equivalent emissions (298 kgCO2eq/kgN2O)* CO_2SC: Amount of CO2eq emissions due to sludge composted
Source	Section 12.8 "Composting", Beam page 147 (page 169 in PDF)

Name	Sludge incineration
Description	Amount of CO2eq emissions due to sludge incineration
Equation	$CH_4 = (4{,}85e-5)\cdot sludgemass \cdot ctCH_{4eq}$ $\boldsymbol{If\ Tf < 1023}: Tf = 1023 \quad n = \frac{161{,}3 - 0{,}14 \cdot Tf}{100}$ $\boldsymbol{If\ n < 0}: n = 0$ $N_2O = sludgemass \cdot Ncont \cdot n \cdot ctN_2Oeq$ $\boldsymbol{If\ SNCR\ is\ used}$: $N_2O = 1{,}2 \cdot sludgemass \cdot Ncont \cdot n \cdot ctN_2Oeq$ $CO_2SI = CH_4 + N_2O$ Where: $sludgemass$: *Amount of sludge that is sent to incineration (dry weight)* $ctCH_{4eq}$: *Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* $Ncont$: *N content of sludge incinerated (% of dry weight)* *Tf: Average highest temperature of combustion achieved in a Fluidized Bed incinerator* ctN_2Oeq: *Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$*)* CO_2SI: Amount of CO2eq emissions due to sludge incineration
Source	Section 12.10 "Combustion (Incineration)", Beam, page 161

Name	Land application of sludge
Description	Amount of CO2eq emissions due to land application of sludge
Equation	$TVS = \frac{slucompTVS}{100}$ $\quad Ncont = \frac{slulaNcont}{100}$ $Ccontent = sludgemass \cdot TVS \cdot TVStoOC$ $Ncontent = sludgemass \cdot Ncont$ $ratioCN = \frac{Ccontent}{Ncontent}$ $\boldsymbol{If\ ratioCN > 30}: N_2O = 0$ $\boldsymbol{Else\ if\ biosolids\ are > 80}\%$: $N_2O = 0{,}5 \cdot sludgemass \cdot Ncont \cdot EF \cdot ctNtoN_2O4428 \cdot ctN_2Oeq$ $\boldsymbol{Else:}$ $N_2O = sludgemass \cdot Ncont \cdot EF \cdot ctNtoN_2O4428 \cdot ctN_2Oeq$ $CO_2LA = N_2O$ Where: $sludgemass$ *: Amount of sludge that is sent to land application (dry weight)* $TVStoOC$*: Organic Carbon content in Volatile Solids (0,56* gOC/gVS*)* $slulaNcont$*: N content of sludge sent to land application (% of dry weight)* *SlucompTVS: Total Volatile Solids (TVS) content of sludge composted (% of dry weight).* EF : Amount of Nitrogen converted to N2O $ctNtoN_2O4428$*: N2O-N to N2O conversion factor (=44/28* gN_2O/gN_2O-N*)* *ctN2Oeq: Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$) CO_2LA: Amount of CO2eq emissions due to land application of sludge
Source	Section 12.11 "Land application", Beam page 166

Name	Landfilling of sludge

Description	Fugitive methane emissions from biosolids decomposition in the landfill during the first 3 years after placement, and N2O emissions from landfilled biosolids
Equation	$TVS = \frac{slucompTVS}{100}$ $CH_4gas = \frac{slulfCH_4ingas}{100}$ $DOCf = \frac{slulfDOCf}{100}$ $dc3ry = \frac{slulfdecomp3yr}{100}$ $Ncont = \frac{slulfNcont}{100}$ $CH_4 = sludgemass \cdot TVS \cdot TVStoOC \cdot un \cdot OCtoCH_4 \cdot CH_4gas \cdot DOCf \cdot dc3yr \cdot MCF \cdot ctCH_4eq$ $N_2O = sludgemass \cdot Ncont \cdot lowCNEF \cdot NtoN_2O \cdot ctN_2Oeq$ $CO_2LFS = CH_4 + N_2O$ *Where:* $sludgemass$*: Amount of sludge that is sent to landfilling (dry weight)* $slucompTVS$*: Total Volatile Solids (TVS) content of sludge composted (% of dry weight)* $TVStoOC$*: Organic Carbon content in Volatile Solids (0,56*gOC/gVS*)* un*: Model uncertainty factor* $OCtoCH_4$*: Organic C to CH4 conversion factor (=16/12* gCH_4/gOC*)* $slulfCH_4ingas$*: CH4 in landfill gas* $slulfDOCf$*: Decomposable organic fraction of raw wastewater solids* $slulfdecomp3yr$*: Percentage decomposed in first 3 years of the decomposable organic fraction of raw wastewater solids.* MCF*: Methane correction for anaerobic managed landfills* $ctCH_4eq$*: Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* $slulfNcont$*: N content of sludge sent to landfilling (% of dry weight)* $lowCNEF$*: N2O emission factor for low C:N ratio* $NtoN_2O$*: N2O-N to N2O conversion factor (=44/28* $gN_2O/gN_2O\text{-}N$*)* ctN_2Oeq*: Conversion of N2O emissions to CO2 equivalent emissions (298* $kgCO_2eq/kgN_2O$*)* CO_2LFS*: Amount of* CO_2 *eq due to Landfilling of sludge*

Source	Section 12.9 "Landfill disposal", page 153, Beam methodology document

Name	Sludge stockpiling
Description	Amount of CO2eq emissions due to sludge stockpiling
Equation	$$lifespan\_int = \lfloor lifespan \rfloor$$ $$lifespan\_dec = lifespan - lifespan\_dec$$ $$rate_{CH4}(i) = \begin{cases} sludgemass \cdot 0.2 \cdot 10^{-3} & \text{if } i < 1 \\ sludgemass \cdot 2 \cdot 10^{-3} & \text{if } 1 <= i < 3 \\ sludgemass \cdot 9.8 \cdot 10^{-3} & \text{if } 3 <= i < 20 \\ 0 & \text{if } i >= 20 \end{cases}$$ $$rate_{N2O}(i) = \begin{cases} sludgemass \cdot 60 \cdot 10^{-3} & \text{if } i < 1 \\ sludgemass \cdot 26.8 \cdot 10^{-3} & \text{if } 1 <= i < 3 \\ sludgemass \cdot 17.4 \cdot 10^{-3} & \text{if } 3 <= i < 20 \\ 0 & \text{if } i >= 20 \end{cases}$$ $$rate_{CO2}(i) = \begin{cases} sludgemass \cdot 30.1 \cdot 10^{-3} & \text{if } i < 1 \\ sludgemass \cdot 30.5 \cdot 10^{-3} & \text{if } 1 <= i < 3 \\ sludgemass \cdot 10.1 \cdot 10^{-3} & \text{if } 3 <= i < 20 \\ 0 & \text{if } i >= 20 \end{cases}$$ $$CH_4 = lifespan\_dec \cdot rate_{CH4}(lifespan\_int) + \sum_{i=0}^{lifespan\_int-1} rate_{CH4}(i)$$ $$N_2O = lifespan\_dec \cdot rate_{N2O}(lifespan\_int) + \sum_{i=0}^{lifespan\_int-1} rate_{N2O}(i)$$ $$CO_2 = lifespan\_dec \cdot rate_{CO2}(lifespan\_int) + \sum_{i=0}^{lifespan\_int-1} rate_{CO2}(i)$$ $$CO_2SP = CH_4 + N_2O + CO_2$$ Where: $sludgemass$: Amount of sludge that is stockpiled (dry weight) $lifespan$: Expected timespan than the biosolid stockpile (BSP) will be emitting GHGs CO_2SP: Amount of CO2eq emissions due to sludge composted
Source	Majumder, R., Livesley, S., Gregory, D., & Arndt, S. (2014, 05 15). Biosolids stockpiles are a significant point source for greenhouse gas emissions. Journal of Environmental Management, 143, pp. 34-43.

Name	Sludge storage

Description	Amount of CO2eq emissions related to sludge storage
Equation	$TVS = \frac{slustoTVS}{100} \quad FCH_4 = \frac{slustoFCH_4}{100} \quad CH_4EF = \frac{slustoEF}{100}$ $CH_4potential = sludgemass \cdot TVS \cdot TVStoOC \cdot OCtoCH_4 \cdot FCH_4$ $CH_4 = CH_4potencial \cdot CH_4EF \cdot ctCH_4eq$ $CO_2SS = CH_4$ Where: $sludgemass$: Amount of sludge that is stored prior to disposal $slustoEF$: Emission factor due to storage $slustoTVS$*:* Total Volatile Solids (TVS) content of sludge stored *(% of dry weight).* $slustoFCH_4$*:* CH4 potential factor $TVStoOC$*: Organic Carbon content in Volatile Solids (0,56*gOC/gVS*)* $OCtoCH_4$*: Organic C to CH4 conversion factor (=16/12* gCH_4/gOC*)* $ctCH_4eq$*: Conversion of CH4 emissions to CO2 equivalent emissions (34* $kgCO_2eq/kgCH_4$*)* *CO_2SS: Amount of CO_2 eq due to sludge storage*
Source	(*ECAM V3*, n.d.)

Name	Truck transport of sludge
Description	Indirect CO2 emitted from sludge transport off-site
Equation	$CO_2 = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFCO_2}{100}$ $N_2O = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFN_2Oveicles\,X \cdot ctN_2Oeq}{100}$ $CH_4 = \frac{vol \cdot fuelFD \cdot fuelNCV \cdot fuelEFCH_4Oveicles \cdot ctCH_4Oeq}{100}$ $CO_2TTS = CO_2 + N_2O + CH_4$ Where:

	V: Volume of fuel consumed *ctN_2Oeq: Conversion of N2O emissions to CO2 equivalent emissions* *$ctCH_4eq$: Conversion of CH4 emissions to CO2 equivalent emissions* *CO_2TTS: Amount of CO_2 eq due to truck transport of sludge.*
Source	IPCC 2006, Volume 2, Chapter 3: Mobile Combustion, Table 3.2.2 (page 21)

Table of equation values

Fuel type	EFCH4 (kg/TJ)		EFN2O (kg/TJ)		EFCO2 (kg/TJ)	FD (kg/L)	NCV (TJ/Gg)
	engines	vehicles	engines	vehicles			
Diesel	3	3.9	0.6	3.9	74100	0.84	43
Gasoline/Petrol	3	3.8	0.6	1.9	69300	0.74	44.3
Natural Gas	10	92	0.1	0.2	56100	0.75	48

Name	Total emissions from Sludge management
Description	GHG emissions from sludge management operations (storing, composting, incineration, land application, landfilling, stockpiling and truck transport).
Equation	$$CO_2SM = CO_2SC + CO_2SI + CO_2LA + CO_2LFS + CO_2SP + CO_2SS + CO_2TTS$$ *CO_2SM: Total emissions from Sludge management* *CO_2SC: Amount of CO_2eq emissions due to sludge composted* *CO_2SI: Amount of CO_2eq emissions due to sludge incineration* *CO_2LA: Amount of CO_2eq emissions due to land application of sludge* *CO_2LFS: Amount of CO_2eq due to Landfilling of sludge* *CO_2SP: Amount of CO_2eq emissions due to sludge composted* *CO_2SS: Amount of CO_2eq emissions related to sludge storage* *CO_2TTS: Amount of CO_2eq due to truck transport of sludge.*

Name	Water reuse transport (EFWRT)
Equation	$ECO_2 = \frac{V \cdot FD_{CO_2} \cdot NCV_{CO_2} \cdot EF_{CO_2}}{1000}$ $ECH_4 = \frac{V \cdot FD_{CH_4} \cdot NCV_{CH_4} \cdot EF_{CH_4} \cdot EQ_{CH_4}}{1000}$ $EN_2O = \frac{V \cdot FD_{N_2O} \cdot NCV_{N_2O} \cdot EF_{N_2O} \cdot EQ_{N_2O}}{1000}$ $E_{TOTAL} = ECO_2 + ECH_4 + EN_2O$ *V: Volume of fuel consumed* EQ_{N_2O}*: Conversion of N2O emissions to CO2 equivalent emissions* EQ_{CH_4}*: Conversion of CH4 emissions to CO2 equivalent emissions*

Table of equation values

Fuel type	EFCH4 (kg/TJ)	EFN2O (kg/TJ)	EFCO2 (kg/TJ)	FD (kg/L)	NCV (TJ/Gg)
Diesel	3,9	3,9	74100	0,84	43
Gasoline/Petrol	3,8	1,9	69300	0,74	44,3
Natural Gas	92	0,2	56100	0,75	48

(Davies Waldron, 2006)

Name	Emissions from water discharged (EFWD)
Equation	$CH_4 = bodeffl\ x\ CH_4efacdis\ x\ CH_4eq$ $N_2O = tneffl\ x\ N_2Oefacdis\ x\ NtoN_2O\ x\ N_2Oeq$ $DW_e = CH_4 + N_2O$

	$bodeffl$: Effluent COD load *$CH_4efacdis$: CH4 emission factor* *CH_4eq: conversion of CH4 emissions to CO2 equivalent emissions (34 kgCO2eq/kgCH4)* *$tneffl$: Total Nitrogen load in the effluent* *$N_2Oefacdis$: N2O emission factor* *$NtoN_2O$: N2O-N to N20 conversion factor (1.57 gN2O/gN2O-N)* *N_2Oeq: conversion of N2O to CO2 equivalent emissions (298 kgCO2eq/kgN2O)*

Name	Biogas (anaerobic digestion of sludge)
Description	*GHG emissions from biogas*
Equation	$biogas_{flared} = \frac{P \cdot V}{R \cdot T} \cdot \frac{biogas_{flared}}{100} \cdot \frac{biog_{CH_4}}{100} \cdot \frac{44}{1000}$ $biogas_{valorised} = \frac{P \cdot V}{R \cdot T} \cdot \frac{biogas_{val}}{100} \cdot \frac{biog_{CH_4}}{100} \cdot \frac{44}{1000}$ $biogas_{leaked} = \frac{P \cdot V}{R \cdot T} \cdot \frac{biogas_{leaked}}{100} \cdot \frac{biog_{CH_4}}{100} \cdot \frac{16}{1000}$ $EFB = biogas_{flared} + biogas_{valorised} + biogas_{leaked}$ *Where:* *P: 1.013 X 10^5 Pa* *V: Volume of biogas produced in the WWTP* *R: 8,31446261815324 J/K.mol* *T: 273,15K* *$Biog_{flrared}$: Biogas flared (%volume)* *$Biog_{CH4}$: Percent of the methane content in the produced biogas* *$Biog_{val}$: Biogas valorised in the treatment plant to heat the digesters or the building and/or run a Co-generator to generate heat and electricity* *$Biog_{leaked}$: Biogas leaked to the atmosphere (%volume)*
Source	*IPCC 2006, Volume 5, Chapter 4 Biological treatment of solid waste, equation 4.1, page 5*

Total emissions

Name	Total emissions
Description	Total emissions of GHG. This metric has no impact categories because it is not possible to put a limit on the amount of GHG emitted, each company must set its impact categories.
Equation	$TE = IEFEC + EFFE + EFT + EFB + EFWRT + EFWD + EFSM$ Where: *IEFEC:* Indirect emissions from electricity consumption *EFFE:* Emissions from fuel engines *EFT:* Emissions from treatment *EFB:* Emissions from biogas *EFWRT:* Emissions from water reuse transport *EFWD:* Emissions from water discharged *EFSM:* Emissions from sludge management

3. Indicators for external reporting

there are different pages and methods to calculate the impact of industries, that is why WIAT also gives the values that these pages need to generate these reports. this section explains the different metrics needed and how they are calculated. The two pages are the GRI and CDP Water Security.

GRI (Global Reporting Initiative) is the independent, international organization that helps businesses and other organizations take responsibility for their impacts, by providing them with the global common language to communicate those impacts.

CDP's work with water security motivates companies to disclose and reduce their environmental impacts by using the power of investors and customers. The data CDP collects helps influential decision makers to reduce risk, capitalize on opportunities and drive action towards a more sustainable world. Highlights.

Name	Water withdrawal
Description	Sum of all water drawn from surface water, groundwater, seawater, or a third party for any use over the course of the reporting period. The units for the water withdrawal in GRI is m3/year.
Reporting	Reporting to GRI 303: Water and effluents 2018

Name	Effect of water withdrawal on the water body
Description	Percentage of water withdrawal related to water available.
Equation	$Efect\ of\ water\ withdrawal = \frac{W_w}{W_a} X\ 100$ *Ww: water withdrawal* *Wa: water available*
Reporting	Reporting to GRI 303: Water 2016

Name	Water recycled and reused
Description	Total volume of water recycled and reused as a percentage of the total water withdrawal.
Equation	$Water\ recycled\ and\ reused = \frac{W_{rr}}{W_w} X\ 100$ *Wrr: water recycled and reused* *Ww: water withdrawal*
Reporting	Reporting to GRI 306: Effluents and waste 2016

Name	Water discharge
Description	Total volume of planned and unplanned water discharges
Reporting	Reporting to GRI 306: Effluents and waste 2016

Name	Effect of water discharge on the water body
Description	Percentage of water discharged to receiving water body.
Equation	$Effect\ of\ water\ discharge = \frac{W_d}{W_a - W_W} X\ 100$

	Wd: water discharged *Wa: water available* *Ww: water withdrawal*
Reporting	Reporting to GRI 303: Water 2016

Name	Water withdrawal
Description	Amount of water withdrawal from the water body in megalitres/years. (*CDP Water Security 2021 Questionnaire*, n.d.)
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Water discharge
Description	Amount of water discharged to the water body in megalitres/years. (*CDP Water Security 2021 Questionnaire*, n.d.)
Reporting	Reporting to CDP Water Security 2021 Questionnaire

Name	Water reused
Description	Amount of water reused by the industry. (*CDP Water Security 2021 Questionnaire*, n.d.)
Reporting	Reporting to CDP Water Security 2021 Questionnaire

4. Industry inputs

4.1 Industry typology

Some of the values of the industry inputs can be estimated depending on the industry typology. During the advance inputs you can choose what is your industry type, according to the NACE level 2 typology of industries. (*EUROPA - Competition - List of NACE Codes*, n.d.)

CCAE	NACE_I	ISIC_I	DESCRIPTION
C10	C10	C10	Manufacture of food products
C11	C11	C11	Manufacture of beverages
C12	C12	C12	Manufacture of tobacco products

C13	C13	C13	Manufacture of textiles
C14	C14	C14	Manufacture of wearing apparel
C15	C15	C15	Manufacture of leather and related products
C16	C16	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	C17	C17	Manufacture of paper and paper products
C18	C18	C18	Printing and reproduction of recorded media
C19	C19	C19	Manufacture of coke and refined petroleum products
C20	C20	C20	Manufacture of chemicals and chemical products
C21	C21	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	C22	C22	Manufacture of rubber and plastic products
C23	C23	C23	Manufacture of other non-metallic mineral products
C24	C24	C24	Manufacture of basic metals
C25	C25	C25	Manufacture of fabricated metal products, except machinery and equipment
C26	C26	C26	Manufacture of computer, electronic and optical products
C27	C27	C27	Manufacture of electrical equipment
C28	C28	C28	Manufacture of machinery and equipment n.e.c.
C29	C29	C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	C30	C30	Manufacture of other transport equipment
C31	C31	C31	Manufacture of furniture
C32	C32	C32	Other manufacturing
C33	C33	C33	Repair and installation of machinery and equipment

4.2 Industry estimated pollution values

To facilitate user input, some of the contaminants can be estimated by taking into account the type of industry, so if the user does not know some data, it can be estimated based on previous inputs. Those contamination values according to industry are extracted from the report "les substances dangereuses pour les milieu aquatique dans les rejets industriels. (Barré et al., 2016)

	C10	C11	C13	C14	C15	C16	C17
1,2-Dichloroethane µg/L	-	-	-	-	-	-	100,00
Anthracene µg/L	-	-	-	-	-	-	-
Benzene µg/L		-	-	-	0,58	0,37	-
Cadmium µg/L	0,32	0,46	-	-	0,89	0,90	1,19
Chloroalkanes µg/L	-	-	-	-	3,35	-	-
Hexachloro-benzene µg/L	-	-	-	-	-	-	-
Hexachloro-butadiene µg/L	-	-	-	-	-	-	-
Mercury µg/L	95,00	0,13	-	-	0,20	0,16	0,17
Nickel µg/L	4395,00	15,11	-	-	24,96	8,27	7,55
Nonylpheno µg/L	0,73	1,22	654,55	-	555,00	1,67	441,50
Lead µg/L	1985,00	12,36	-	-	12,06	11,76	5,36
Tetrachloro-ethylene µg/L	-	-	-	-	156,16	-	100,00

Trichloro-ethylene µg/L	75,00	0,10		-	0,61	0,18	100,00
BOD5 mg/L O2	336,26	231,09	410,10	40,00	-	33,33	366,27
TOC mg/L C	414,29	-	171,67	-	-	-	-
Phosphorus mg/L	26,11	20,45	32,59	10,00	-	10,00	27,53
Nitrogen mg/L N	12,95	-	-	-	-	-	-
Phosphate mg/L	-	-	-	-	-	-	-
Nitrate mg/l N	41,41	95,71	42,73	-	-	-	20,00

	C18	C19	C20	C21	C22
1,2-Dichloroethane µg/L	-	-	647,13	-	-
Anthracene µg/L	-	0,06	0,15	0,02	-
Benzene µg/L	0,37	2,43	47,44	-	-
Cadmium µg/L	0,60	0,33	0,58	0,73	-
Chloroalkanes µg/L	-	-	8,60	-	-
Hexachloro-benzene µg/L	-	2,00	0,01	-	-
Hexachloro-butadiene µg/L	-	-	4,94	-	-
Mercury µg/L	-	105,00	0,19	0,26	-
Nickel µg/L	6,60	8,87	92,76	4,58	-
Nonylpheno µg/L	3,33	-	56760,86	1,26	1000,00
Lead µg/L	3,32	1,22	14,40	3,48	-
Tetrachloro-ethylene µg/L	0,50	95,00	5,16	0,20	-
Trichloro-ethylene µg/L	0,27	-	0,67	0,19	-
BOD5 mg/L O2	750,00	300,00	598,81	559,87	603,10
TOC mg/L C	-	300,00	276,00	250,00	-
Phosphorus mg/L	40,19	30,00	39,81	35,97	35,00
Nitrogen mg/L N	90,00	-	-	-	-
Phosphate mg/L	30,00	90,00	68,00	90,00	10,00
Nitrate mg/l N	10,00	100,00	74,81	-	80,00

	C23	C24	C25	C26	C27	C28
1,2-Dichloroethane µg/L	-	-	-	-	-	-
Anthracene µg/L	0,01	0,02	-	-	-	0,01
Benzene µg/L	-	-	-	-	-	-
Cadmium µg/L	1,31	21,67	-	-	-	10015,00
Chloroalkanes µg/L	-	5,81	-	-	-	5105,00
Hexachloro-benzene µg/L	-	-	-	-	-	-
Hexachloro-butadiene µg/L	-	-	-	-	-	-
Mercury µg/L	33,48	0,18	-	-	-	85,00
Nickel µg/L	18,51	619,92	3854,17	-	2000,00	20,14
Nonylpheno µg/L	0,96	1,06	-	-	-	-
Lead µg/L	339,66	35,68	-	-	-	2212,80
Tetrachloro-ethylene µg/L	-	0,21	-	-	-	-
Trichloro-ethylene µg/L	-	0,34	-	-	-	-
BOD5 mg/L O2	59,04	586,54	641,41	33,33	86,67	328,75
TOC mg/L C	-	-	-	-	-	-

Phosphorus mg/L	11,28	10,00	40,87	10,00	25,71	32,86
Nitrogen mg/L N	18,44	-	70,00	-	-	-
Phosphate mg/L	-	-	-	-	20,00	20,00
Nitrate mg/l N	-	-	89,84	-	-	100,00

	C29	C30	C31	C32	C33
1,2-Dichloroethane µg/L	-	-	-	-	-
Anthracene µg/L	-	-	-	-	-
Benzene µg/L	-	-	-	-	-
Cadmium µg/L	-	-	-	-	-
Chloroalkanes µg/L	-	-	-	-	-
Hexachloro-benzene µg/L	-	-	-	-	-
Hexachloro-butadiene µg/L	-	-	-	-	-
Mercury µg/L	-	-	-	-	-
Nickel µg/L	-	-	-	-	-
Nonylpheno µg/L	-	-	-	-	-
Lead µg/L	-	-	-	-	-
Tetrachloro-ethylene µg/L	-	-	-	-	-
Trichloro-ethylene µg/L	-	-	-	-	-
BOD5 mg/L O2	563,16	-	35,00	35,00	40,00
TOC mg/L C	-	-	-	-	-
Phosphorus mg/L	39,25	-	10,00	38,75	10,00
Nitrogen mg/L N	-	-	-	-	-
Phosphate mg/L	30,00	-	-	-	-
Nitrate mg/l N	94,74	-	-	-	-

4.3 Wastewater treatment plants estimated pollutants removal values

For most of the PP the values of the removal percentage depending on the type of WWTP can be estimated to, following the below table results. The values are from a non-published, yet bibliography research done by ICRA.

	WWTP typology		
PP Name	Primary	Secondary	Tertiary
1,2-Dichloroethane	21,25	58,50	80,00
Cadmium	21,50	45,50	63,00
Hexachloro-benzene	-	-	57,25
Mercury	36,00	16,70	-
Lead	41,50	53,49	67,75
Nickel	17,00	50,10	39,00
C10-13 Chloroalkanes	10,00	40,00	-
Hexachloro-butadiene	5,00	80,00	-
Nonylpheno	43,00	79,00	95,00
Tetrachloro-ethylene	23,50	80,00	94,00

Trichloro-ethylene	10,00	75,33	94,00

4.4 Other estimated values

The rest of the WIAT estimated values have the following values or formulas and sources.

Estimation	Values, explanation, or equation	Used to calculate	Source
Emission factor for grid electricity	The values estimated for emissions factor for grid electricity comes from the European Investment Bank the values of the emission factor depend in which country the industry is located.	Indirect emissions from electricity consumption	(*EIB Project Carbon Footprint Methodologies Methodologies for the Assessment of Project GHG Emissions and Emission Variations*, 2020)
% Biogas produced that is flared	The value of % of biogas produced that is flared is usually 98.	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)
Biogas leaked to the atmosphere (% volume)	Biogas leaked to the atmosphere (% volume) is usually 2.	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)
Biogas valorised as heat and/or electricity	$Bval = 100 - Bf - Bs - Bleak$ Bval: biogas valorised as heat or electricity Bs: biogas sold Bf: biogas that is flared Bleak: biogas leaked to the atmosphere	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)
Biogas sold (% volume)	$Bs = 100 - Bf - Bval - Bleak$ Bs: biogas sold Bf: biogas that is flared	Biogas (anaerobic digestion of sludge)	(*ECAM V3*, n.d.)

	Bval: biogas valorised as heat or electricity Bleak: biogas leaked to the atmosphere		
N_2O emission factor for low C:N ratio	1,5%	Sludge composted Landfilling of sludge	(Brown et al., 2008)
CH_4 emission factor for uncovered pile (factor of initial C in solids)	2,5%	Sludge composted	(Brown et al., 2008)
CO2eq equation rate	0,25	Emissions from fuel engines Emissions from treatment Sludge composted Sludge incineration Land application of sludge Landfilling of sludge Sludge stockpiling Amount of CO2 eq emissions related to sludge storage Emissions from water discharged	(*The Biosolids Emissions Assessment Model (BEAM): A Method for Determining Greenhouse Gas Emissions from Canadian Biosolids Management Practices Final Report*, 2009)
Average highest temperature of combustion achieved in a	1023	Sludge incineration	(*The Biosolids Emissions Assessment Model (BEAM): A Method for Determining Greenhouse Gas*

Fluidized Bed incinerator			*Emissions from Canadian Biosolids Management Practices Final Report*, 2009)
Uncertainty factor	0,9	Landfilling of sludge	(*CDM: Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities*, n.d.)
CH_4 in landfill gas	50%	Landfilling of sludge	(*CLEAN DEVELOPMENT MECHANISM 2008 IN BRIEF*, n.d.)
Decomposable organic fraction of raw wastewater solids	80%	Landfilling of sludge	(Bani Shahabadi et al., 2009)
Percentage decomposed in first 3 years	69,9%	Landfilling of sludge	(*CDM: Approved Baseline and Monitoring Methodologies for Large Scale CDM Project Activities*, n.d.)

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