# EWB Challenge: Assessment 3a: Team EWB Report
# Hygienic Solutions Sludge Management and Disposal

Lawrence Chai – Erin Chapman – Wed 8-10am

Design Team – 54

Joshua Keen – N10342061

Joseph Haddad – N10535268

Brittany Mendezona – N10234683

Andrea Cross - N10464972

Giles Cheers - N10486674

Tim Clark – N10494103

Word Count: 4850

Queensland University of Technology

# Executive Summary

The task at hand is to develop a design solution for a selected design project, which has been selected from the provided brief for Suco Holarua – (A village situated in Timor Leste). The selected design project is "Design Project 2.5" which deals with hygienic management and disposal of sludge. This project requires a solution which improves their current sludge management techniques providing a more hygienic means of disposal. Their current situation comprises of a large young population living under the national poverty line. With unideal environmental conditions due to rain and a rough mountainous terrain, it affects their environmental integrity and ability to properly and hygienically manage sludge.

Different design alternatives and approaches were investigated and evaluated to see which design best meets the task at hand. The four options considered were a Septic Tank system, Composting Toilets, Stylisation Ponds and Alterna. These designs were formed under developed criteria which encompass the Triple Bottom Line –(Social, Economic and Environment) and the Technical perspectives. These criteria provided the basis for design evaluation as it allowed the strengths and constraints of each design to be evaluated, and then assessed in an evaluative table with a score to see which design best approaches hygienic sludge management.

The final design chosen from the concepts was the Alterna design. This best fit the evaluation matrix and overall evaluation. The methodology of how this system will work is discussed. Detailing how the design cycle will work. Sludge will initially fall in the hole under the toilet block, to be turned into compost via the addition of leaves and ash which are composting agents. Furthermore, a manufacturing plan and cost analysis is reviewed showing that both economically and technically this system is well suited for the constraints these put on a solution. The main assumption considered with this design is that minimal costs should be needed in future as this system becomes more commonly implemented.

Outcomes of the design on the community are important as they are the ones potentially benefitting from this solution. With every solution there are benefits and limitations on its performance within its environment, in this case the community of Suco Holarua. These are discussed with recommendations to see how the solutions implementation can be further improved to better tackle proper hygienic sludge management.

Looking into EWB relationships the potential implementation of this design beyond just Suco Holarua open the scope of this design. EWB's other projects in Cambodia to help also improve their current systems. It opens doors to refurbishing the planet, people whilst assisting economically through profit generation.

# Table of Contents

## List of Figures



## List of Tables

# 1.0 Introduction

The client of this report is Engineers Without Borders (EWB), a non-profit, member-based community organisation which operates worldwide with a focus on developing skills, knowledge and appropriate engineering solutions to help disadvantaged and developing countries communities. Over the past 14 years, through partnerships and collaborations, they have created various engineering solutions to benefit disadvantaged communities in India, remote Australia, Vietnam, Asia and more (EWB 2019). This year EWB partnered with WaterAid to help the Suco Holurea communities in the Manufahi district of Timor-Leste. Their aim to improve roads, water and energy access and sanitation has seen significant improvement already. The recent growth in sanitation and hygiene and community engagement saw Suco Holurea declared open defecation free (WaterAid 2018).

The following report contains a design solution to be implemented in Suco Holarua, Timor-Leste for the 2019 Engineers Without Borders (EWB) challenge. The company Hygienic Solutions has chosen to focus on Design Project 2.5 - Hygienic sludge management and disposal (EWB challenge 2019). The report will cover the problem the company faces and the implementation location as well as presenting three design options that could be implemented. The report will evaluate the options against a criterion and present a final design solution for hygienic sludge management and disposal and the benefits this solution will have on the community.

## 1.1 Background Information

Timor-Leste is located slightly south of the equator and is home to one of the few remaining dry rainforests. These rain forests are highly susceptible to public impact due to the prominent slash and burn agricultural tactics of Timor-Leste. The burning of large areas of forest to provide areas of ash fertilized land harms the ecology and biodiversity of the land leading to degradation and declining stability of the regions (ACIAR 2018). Timor-Leste has short coastal plains which run inland to the Caldac mountain range. The range runs the length of Timor-Leste which causes a lot of the land scape to mountainous and rugged (see Figure 1) (Britannica 2019). Suco Holurea is located on the southern face of the mountain range, whose elevation and environment cause heavy rainfall during the wet season which has been estimated to last for around 70% of the year. The heavy rain and steep terrain cause a range of hazards. These include landslide, flash flood and the loss of crops and livestock, as well as posing significant threats to residents. Suco Holurea is located in the Manufahi district which boarders with the southern coast (see Figure 2). Suco Holurea as a residence of 7000

people spread throughout 13 communities, some only accessible by foot. This restricts the size of infrastructure that can be built at the location due to weather and terrain, causing solutions to be relative.

*Figure 1.1.1: Landscape of Timor-Leste*


*Figure 1.1.2: Map of Timor-Leste Districts (Australian National University 2019)*

A 2018 survey of the demographics of Timor-Leste recorded the current population to be 1.3 million with 0-14 years old making up 40%. Currently 37% of the population lives below the national poverty line of $1.25 USD (AU$1.81) per day (World Population Review 2019). Around 99% of the population are of Timorese decent with Tetum being the widest spoken language along with 32 indigenous languages. English and Indonesian are considered working languages. Roman Catholic is the largest practiced religion at over 97%. The survey also showed that 60% of rural areas had access to drinking water while little as 30% had access to sanitation facilities (indexmundai 2018). Of the 43 members that make up the Suco governance structure 14 are women (EWB 2019). Large inequalities also occur in labour where women are denied access to jobs. Large pay gaps and sexual violence displays the prominent gender inequality throughout Timor-Leste.

Due to the country's poor sanitation and waste management the environment has been seriously impacted with large amounts of waste being discarded. The heavy rainfall often means the waste ends up in water ways and oceans, affecting the integrity of the environment and habitats (EWB 2019). The country also has poor road infrastructure although this has been increasing over the years. The Ministry of Finance and World Bank review found in 2011 only 20% of roads were traversable in 2wd (TheDiplomat 2019). This is relevant to the design idea as the transport of the waste would be a challenge.

### Current Sludge Management

Timor-Leste currently has very little implementation in sludge management or waste management in general. Tibar land fill site is the only one remaining dumping site for the capital Dili, however open dumping has been applied. The government has no system of transport for solid waste and any management is run by private companies or contractors (uncrd 2018). Timor-Leste's new government have affirmed commitment to improve access to clean water and sanitation and is a top priority. The statistics have improved but 43% of the population don't have proper wastewater sanitation and 26% are without access to clean water (WaterAid 2018).

Globally 2.4 billion people do not have access to adequate sanitation facilities and half have to practice open defecation. This causes high risk to bugs, parasites and diseases as faeces contain thousands of bacteria. 9.2% of child death is diarrhoea related in low income countries (On Health 2017). The current common practice for sludge management in developing countries is digging latrine pits to be filled and covered, drying beds or being used for burning.

## 1.2 Task Identification

Suco Holarua saw a huge improvement recently when it was declared open defecation free in 2018 by WaterAid (WaterAid 2018). The problem however is the Timor-Leste government does not have an active system of collection and transport for solid waste outside of its capital Dili, which are run by private companies. The issue addressed is the disposal of the village's sludge waste. To create a safer and more hygienic way to dispose of sludge to further increase the safety, sanitation and hygiene of Suco Holarua. This is a pressing issue due to the enormity of issues that arise due to poor hygiene and sanitation.

## 1.3 Project Scope

The focus of the designs for the sludge management in Suco Holurea will be to deal with the waste with little transport. As there is no rural collection plan and the road quality and infrastructure is still poor, dealing with the sludge close to its origin would be ideal. Considerations for the solutions will be simple technology due to the low economy of the region. Time period to process and separate the material is not a large problem. This is due to the cost of modern sludge management systems, so the most practical and economical solution would be to let the layers filter naturally. The initial implementation of the design will be on a smaller scale which will be able to increase with the economy.

# 2.0 Design Options

## 2.1 Design Considerations

When developing designs 'triple bottom line' – (TBL) which covers social, environmental and economic aspects. Alongside technical aspects of the design were considered. These factors are crucial for developing an effective sludge solution for Timor-Leste. As ensuring TBL and Technical criteria are set in place and met will provide the best solution catered for the region. The community features a very socially tight bond, putting pressure on the design abiding the specific needs of the local community. Its environment is mostly comprised of natural rugged mountainous terrain. Potential designs should aim to not disrupt and harm the environment. From an Economic perspective the cost of a solution should be kept low whilst technically advanced mechanisms or solutions that require extensive professional maintenance should be avoided. Therefore, the simpler the design the better.

Below is a table of all our considerations in the TBL and Technical factors of the design.

***Table 2.1.1 TBL and Technical factors considered.***

| **Design Considerations** | |
|---|---|
| **Economic – (Cost & Materials)** | Locally Produced Materials which are Inexpensive |
| | Materials suitable to withstand a tropical environment |
| | Environmentally Safe Materials |
| **Environmental – (Sustainability)** | Duration of life-cycle |
| | Reduction of Ecological Contamination i.e. water supply |
| | Biproduct produced from faecal sludge composting which benefits agriculture |
| **Social – (Community Engagement, Ethics and Impact)** | Design which can be easily integrated within the community |
| | Direct human contact with faecal sludge is minimalised |
| | The design can be independently used solely by the community |
| **Technical – (Construction & Practicality)** | A design which is ergonomic |
| | A design which does not need constant professional instruction |
| | A design which can be easily built by the community |
| | Cleaning and Maintenance is minimalised |

## 2.2 Alternative Approaches

In this section application of the constraints in the table above to create and research different design approaches to hygienic sludge management. The table provided a strong outline and form of criteria matrix allowing the designs to all be strong approaches to faecal sanitation.

### 2.2.1 Design Option 1 – Septic Tank

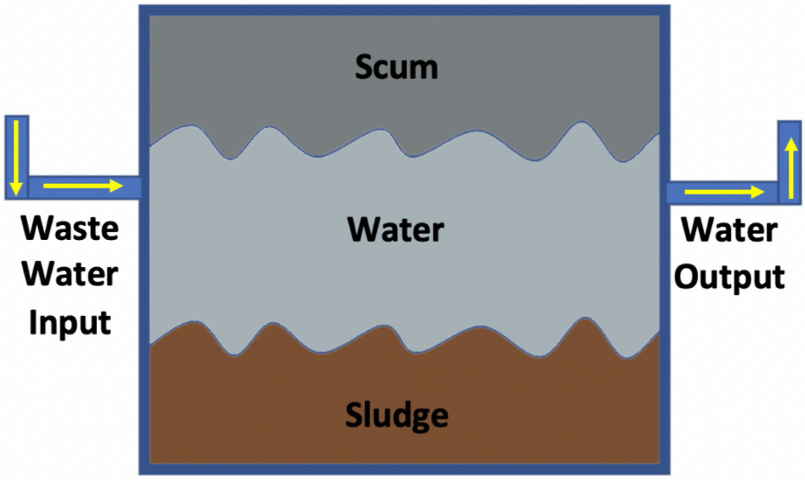


*Figure 2.2.1.1 Design Option 1 Diagram*

| Evaluation Table | |
|---|---|
| **Strengths** | **Constraints** |
| Creates Jobs for the community. | Expensive to install, requires lots of materials, skilled labour and energy. |
| Easy to use as it is automatically fed by the toilets. | Some of the materials are not easily locally sourced. |
| Minimal energy is required to operate it. | Skill maintenance workers are required to keep it operational and clean. |
| Allows water to be reused. | Needs lots of underground space. |
| No environmental harm. | May require a drainage field. |

***Table 2.2.1.1 Evaluation Table Design Option 1***

**Functionality:**

The septic tank is an underground concrete/steel tank that can be placed in a garden or under a toilet block. Functioning as an automatically fed sludge reservoir. This water comes in one end from toilets/toilet blocks as waste water and comes out the other as treated wastewater which can then go to a draining field or can be reused in the toilets as flushing water.

The tanks allow inputted sludge to separate from the particles in it. Heavier sludge sinks down to the bottom and the lighter scum float up to the top allowing the water to float in the middle. This water is then able to be pumped out of the tank to a drainage field or to be reused in the toilets. This system requires tank maintenance where workers are needed to go inside and clean the interior from the sludge and scum to allow more wastewater to be processed.

(HealthyWA, 2019) (Septic Systems Australia, 2019) (Ozzi Kleen, 2019)

### 2.2.2 Design Option 2 – Composting Toilet

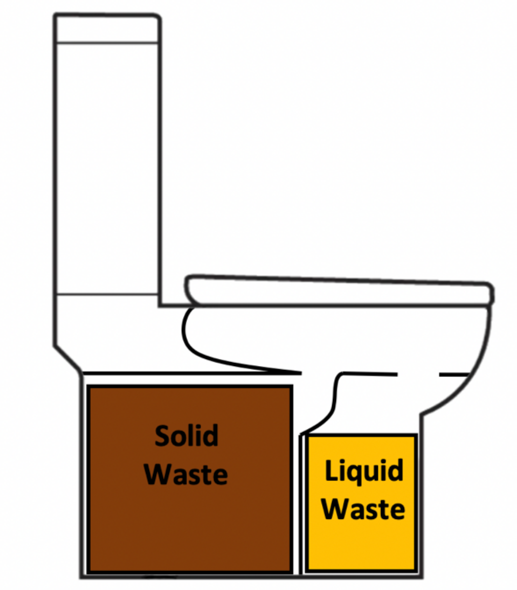


*Figure 2.2.2.1 Design Option 2 Diagram*

| Evaluation Table | |
|---|---|
| **Strengths** | **Constraints** |
| Little to no water usage. | Requires dumping every 4-6 weeks. More so for liquid waste. |
| Urine is the only liquid waste. | Removing the compost is not everyone's cup of tea. |
| Most designs do not require electricity. | If not installed properly can produce odours. |
| Easy to operate. | Requires non-traditional toiletry practices. (men need to sit to urinate and only one type of waste at a time can be flushed.) |
| Can produce fertilizer which is beneficial to the non-edible environment. | Some toilet designs are expensive. |

***Table 2.2.2.1 Evaluation Table Design Option 2***

**Functionality:**

The Composting Toilet is a form of toilet which operates similarly and aims to replicate a traditional toilet experience without the need for a liquid flush. The solid waste falls down a Chute only for solid waste, whilst liquids go down another. The only liquids the toilet outputs are the liquid human waste. The solid waste can then be turned into composted nutrient rich soil for non-edible plants.

It works by firstly separating the liquid waste and the solid waste. There are two chutes in the toilet, one that redirects the each to their respective collection container. With the solids, they are mixed with a moist composting material like saw dust to create a moist environment. This state is key to effective composting as it allows for aerobic digestion to take place. The solid collection container features a handle which is required to be spun after each use to allow for the new solids to be mixed in with the composting material and any older solids. Once the containers are full the waste inside can be disposed of.

(Ecoflo, 2019) (Nature Loo, 2015) (Clivus Multrum, 2019)

### 2.2.3 Design Option 3 – Stabilisation Pond

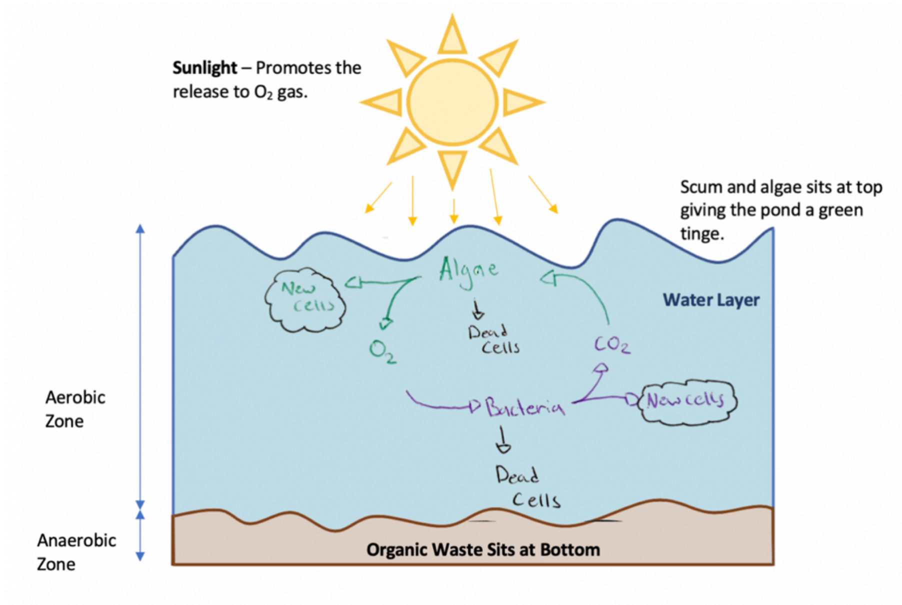


*Figure 2.2.3.1 Design Option 3 Diagram*

| Evaluation Table | |
|---|---|
| **Strengths** | **Constraints** |
| Cost effective. | Toilets need to be near a pond or it could get expensive man making one. |
| Easy Operation | Requires a sizeable area. |
| Caters for sludge waste both liquid and solid. | Odours can lead to issues. |
| No need for manual handling. | Knowledgeable workers are required for maintenance of the pond. |
| No environmental harm. | Can attract unwanted mosquitos. |

***Table 2.2.3.1 Evaluation Table Design Option 3***

**<u>Functionality:</u>**

Stabilisation ponds are essentially shallow 1.5m ponds which allow for the organic waste (sludge). To be placed into it and naturally oxidise it.

Organic waste is placed into the shallow pond creating a septic tank like environment. The shallow sludge sinks down to the bottom whilst all the scum floats up top leaving the water in the middle. This allows the formation of two zones called the Upper Aerobic and Lower Anaerobic Zones. In the Upper Aerobic Zone, bacterial facultative activity occurs where $O_2$ cells are release allowing for the formation of the new clean cells. Whilst in the Lower Anaerobic Zone the solids settle to the bottom and release of $CO_2$ cells occur for the formation of new clean cells. This allows for both the water and solids to naturally be processed and clean as all the cells in the water are now new and clean.

(SSWM, 2018) (The Water & Carbon Group, 2019) (Global Water Pathogen Project. 2019)

### 2.2.4 Design Option 4 – Alterna

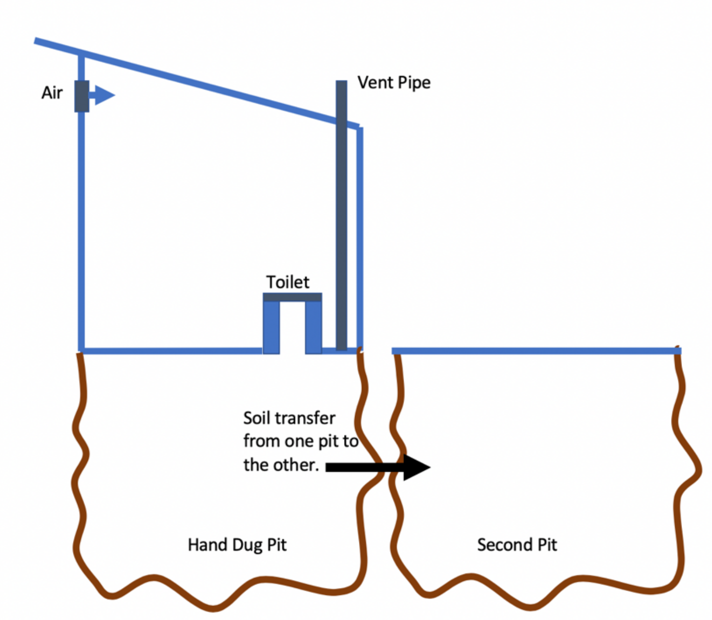


*Figure 2.2.4.1 Design Option 4 Diagram*

| Evaluation Table | |
|---|---|
| **Strengths** | **Constraints** |
| Cost Effective. | Requires two pits which can take up space. |
| Easy to Build. | Maintenance of the pits is needed. |
| Can be used like a normal toilet. | Low life cycle. |
| Minimal to no water usage. | Community needs technical assistance with building it. |
| Creates Rich and safe to handle compost. | Requires occasional human contact with faecal sludge. |

***Table 2.2.4.1 Evaluation Table Design Option 4***

**Functionality:**

The Alterna system is just like a normal toilet block in which can be used communally. However, it features a hole underneath for waterless flushing and composting of faecal Sludge.

Initially, a pit/hole is dug in the ground where the toilet block is planned to be constructed and placed. As shown in the diagram above, a normal toilet is used surrounded by a toilet block which lets in air to ventilate both the toilet and the hole. This ventilation is for the faecal sludge that will fall in the hole to stay aerated and allow for composting in the hole. Upon filling the pit, the toilet block is removed exposing the hole so that it can be dug out and placed into a second dug hole which will have leaves and ash to cover it. These act as composting material and allow for the composting process to complete and from nutrient rich soil.

(Morgan Peter, 2009) (Morgan Peter, 1999)

## 2.6 Design Evaluation

The design evaluation section via looking at the strengths and constraints of each design done above in the table for each design. Shall be further put into a decision-making matrix that encompasses the TBL and technical criteria set. Allowing for a strong evaluation as to which design really excels upon the others.

### 2.6.1 Decision Making Matrix

Using the design requirements criterion, each design solution will be assessed.

***Table 2.6.2.1 Decision Making Matrix***

| | Septic Tank | Composting Toilet | Double Ventilated Improved Pit | Fossa Alterna |
|---|---|---|---|---|
| **Cost and Materials** | | | | |
| *Locally Produced Materials which are Inexpensive* | 1 | 2 | 3 | 4 |
| *Materials suitable to withstand a tropical environment* | 3 | 2 | 3 | 4 |
| *Environmentally Safe Materials* | 4 | 3 | 3 | 3 |
| **Environmental Sustainability** | | | | |
| *Duration of life-cycle* | 4 | 3 | 1 | 4 |
| *Reduction of Ecological Contamination i.e. water supply* | 4 | 3 | 2 | 3 |
| *Biproduct produced from faecal sludge composting which benefits agriculture* | 2 | 4 | 3 | 4 |
| **Community Engagement, Ethics and Impact** | | | | |
| *Design which can be easily integrated within the community* | 1 | 2 | 3 | 3 |
| *Direct human contact with faecal sludge is minimalised* | 2 | 2 | 2 | 2 |
| *The design can be independently used solely by the community* | 1 | 2 | 2 | 3 |
| **Construction and Practicality** | | | | |
| *A design which is ergonomic* | 3 | 2 | 2 | 3 |
| *A design which does not need constant professional instruction* | 1 | 2 | 2 | 4 |
| *A design which can be easily built by the community* | 1 | 1 | 2 | 4 |
| *Cleaning and Maintenance is minimalised* | 1 | 2 | 2 | 3 |
| **Total** | 28 | 30 | 30 | 35 |

***Table 2.6.2.1 Matrix Grading Criteria***

| | |
|---|---|
| 1 | Does not Satisfy Design Criterion Requirements |
| 2 | Partially Satisfies Design Criterion Requirements |
| 3 | Satisfies Design Criterion Requirements |
| 4 | Exceeds Design Criterion Requirements |

### 2.6.3 Justification of Selected Option

Using the created criterion displayed in the *Table 2.6.2.1,* it is evident that the Fossa Alterna design strategy is the best solution for hygienic sludge management and disposal in Suco Holarua. The Fossa Alterna design strategy received a consistently high range of scores over the decision-making matrix, each successfully meeting, if not exceeding the design criterion requirements. The only requirement which was not fully met was regarding minimalizing direct human contact with faecal sludge. Although this requirement was not fully met, the reflective benefits, as a result of human contact with the sludge, outweigh the negatives. The times in which persons will have to come into contact with excrement is during the soil filling and bi-product shovelling phases, as outlined in section *2.2.4.*

# 3.0 Final Design

## 3.1 Design Methodology

### 3.1.1 Design Summary

Suco Holarua was recently declared as open defecation free (ODF), meaning that the entire village has access to basic toilet facilities (Engineers Without Borders Australia 2019). Since the community has taken active steps in becoming more equipped for the hygienic management of faecal sludge, the population of Suco Holarua are now able to explore potential positive uses for this biproduct. Hence, the Fossa Alterna design strategy is a step forward for the Suco, as it both implements and progresses the populace's current hygienic status, whilst providing a solution for positive uses of faecal sludge without adding to the current environmental crisis in Timor-Leste.

The Fossa Alterna design is effectively a processing unit. Defined as a short cycle alternating, waterless double pit, it is designed to make a faecal biproduct that can be used as a nutrient rich soil conditioner (Sustainable Sanitation and Water Management Toolbox 2019). Requiring a constant input of soil, ash and leaves which are filled with organisms like worms, fungi and bacteria, these organic materials accelerate the degradation process of the Fossa Alterna (SSWM 2019). Thus, turning unhygienic excreta into a nutrient rich, safe to handle compost. The reason for using ash in the pit is to reduce odours, regulate the amount of flies and helps to make the pit slightly more alkaline (Morgan 2009).

As this design is a double pit, one pit degrades whilst the other is used for filling. Depending on its size, it should ideally take one year for each pit to fill and for the cycle to repeat (SSWM 2019). Throughout the composting process, the material will become a dry, earth like mixture, which is then removed manually for its application on local agriculture. In comparison to the Double Ventilated Improved Pit, analysed in section *2.2.4*, the Fossa Alterna degrades faster than the former due to added carbonaceous bulking material, hence, the double dry pit strategy works at a better efficiency (Tilley et al. 2014).

Through using a composting process for managing faecal sludge in the rural area of Suco Holarua, this effectively minimises the risk for disease outbreaks and ecological contamination. Additionally, the Fossa Alterna design provides a positive use for this biproduct, allowing nutritious compost to enhance the village's main source of income, agriculture.

### 3.1.2 Cycle Process

*Figure 3.1.2.1* explains the cycle process of the Fossa Alterna design in its most simplistic manor. A more detailed description of this devices cycle is explained in the following subheadings.

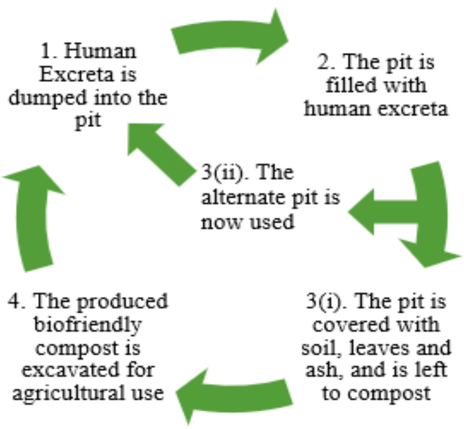


*Figure 3.1.2.1: Cycle Process of Fossa Alterna*

*3.1.2.2 Human Excreta is Dumped into the Pit*
Human faeces are excreted through a squat hole into the pit. Once finished, a top layer of soil, ash and leaves are added to fully cover the excrement.

*3.1.2.3 The Pit is Filled with Human Excreta*
For a family of up to six they are expected to fill a 1.5m deep pit after approximately twelve months. General observations should be made on the pit every six months to ensure that the excrement/plant mixture is breaking down.

*3.1.2.4.1 The Pit is Covered with Soil, Leaves and Ash and is Left to Compost*
The pit which has recently been filled with the mixture is covered with another layer of topsoil and is left to compost over the following year.

*3.1.2.4.2 The Alternate Pit is now Used*
Once the pit in use is filled, the newly composted contents of the second pit is excavated and used for agricultural purposes. After this process has been completed, the superstructure which stands over the used pit is then moved over to the newly emptied pit.

*3.1.2.5 The Produced Biofriendly Compost is excavated for Agricultural use*
The newly excavated biofriendly compost which is ready for agricultural use is beneficial for plant growth and nutrition. Acting as a soil conditioner, the compost helps to accelerate plant growth and also acts as a sunscreen for the plant's roots, to protect it from the harmful tropical sun during the dry seasons (Morgan 2009).

## 3.2 Design Implementation

### 3.2.1 Manufacturing Plan

*3.2.1.1 Making the Ring Beam and Digging the Pits*
As Suco Holarua is situated in a tropical climate which experiences heavy rainfall, a ring beam method should be conducted to create a resilient design. Using reinforced bricks to outline the edges of the pit, as seen in *Figure 3.2.1.1.1,* this removes the likelihood of the pit walls from falling in due to extensive rainfall. The ring beams dimensions should be constructed in accordance to *Figure 3.2.1.1.2*. Each pit is recommended to be built within one metre of each other, illustrated in *Figure 3.2.1.1.1*.

*Figure 3.2.1.1.1: Fossa Alterna's brick ring beam design being implemented in Lilongwe, Malawi. The bricks act as a reinforcement for the walls of the pit, preventing wall collapses. Bricks also act as a foundation for the superstructure shell and toilet to sit on. The wall should be constructed out of locally sourced mortar and bricks. These materials should be slammed hard into place to ensure that these materials last for as long as possible (Morgan 2009).*

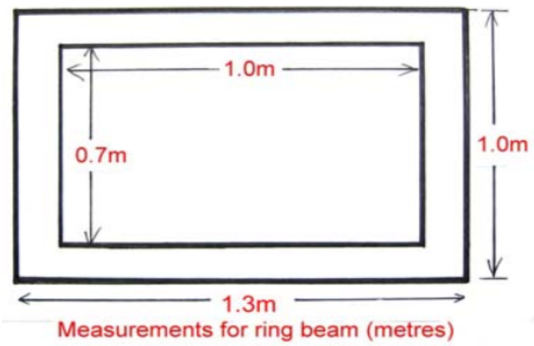


*Figure 3.2.1.1.2: Measurements of the brick ring beam construction. The bricks should run to the bottom of the pit in sandy, wet or fluid soils to reduce the risk of collapse. The pit should be of 1.5m depth and shouldn't be dug any lower than groundwater level. A concrete slab should be built in the bottom of the pit to ensure that there are no leakages of contaminated matter into the surrounding environment (Morgan 2009).*

#### *3.2.1.2 Constructing the Superstructure*

Based upon the materials available, the superstructure can be built out of wood, bamboo, steal, reed or grass (SSWM 2019). For the geographical nature of Suco Holarua, being a mountainous region, timber and grass should be used for the main construction of the superstructure, as depicted in *Figure 3.2.1.2.1*. As these materials are also sourced locally, they are inexpensive and simple to build with. Traditional grass weaving techniques used in Timor-Leste can be used on the walls of frame to ensure that the design is as water tight as possible. The roof of the superstructure can either be produced using an inexpensive thatched grass roof, or a more durable plastic or corrugated iron roof (Morgan 2009). Using lighter materials allows the superstructure to be more easily transferable between pits every twelve months.

*Figure 3.2.1.2.1: Superstructure constructed out of timber in Lilongwe, Malawi. The superstructure has been designed to sit on top of the constructed brick ring beam and is able to be transferable across both pits after twelve months (Morgan 1999).*

### 3.2.2 Total Costing of Fossa Alterna

To completely implement the Fossa Alterna design into Suco Holarua's community, there are a few costs to recognise. These include materials, labour, signage and posters and maintenance. Hence, an estimate budget can be made to further exemplify the benefits of this inexpensive design. Below *Table 3.2.2.1* and *Table 3.2.2.2,* highlights the approximate rollout budget required for this design to be functional:

***Table 3.2.2.1 Cost Analysis of Materials for Fossa Alterna (EWB Australia 2019)***

| Item | Quantity | Units | Costing (USD) | Sub-Total |
|---|---|---|---|---|
| Bricks | 1 | 38kg | 6.00 | 6.00 |
| Construction Sand | 1 | 15m$^3$ | 7.50 | 7.50 |
| Timber | 30 | 2m Beams | 0.05 | 1.50 |
| Iron Supports | 2 | 3m | 1.5 | 3.00 |
| Bucket | 1 | 1 | 2.75 | 2.75 |
| | | | **TOTAL** | 20.75 |

***Table 3.2.2.2 Total Cost Analysis for Fossa Alterna***

| Category | Units | Costing (USD) | Sub-Total (USD) |
|---|---|---|---|
| Labour (World Bank Group 2019) | 2 | 3.43 per day/per person | 6.86 |
| Education, Posters and Promotion | 1 | 2.50 | 2.50 |
| Materials | 1 | 20.75 | 20.75 |
| Maintenance | 1 | 4.00 | 4.00 |
| | | **TOTAL** | 34.11 |

The total implementation cost for the Fossa Alterna to be installed into the Suco Holarua community comes to USD$34.11 for each unit. USD is the current currency of Timor-Leste, so all figures are calculated as such.

## 3.3 Assumptions and Concepts Adopted

Following the implementation of the Fossa Alterna in Suco Holarua, there is the assumption that total costs will decrease over time. Seen in *Table 3.2.2.2*, the cost for education, posters and promotions will diminish over time to a negligible cost once the community becomes more acquainted with the purpose and process of the design. Furthermore, once all Fossa Alterna systems have been installed within the community, there will be no additional costs. The assumption has also been made that eventually, after the initial period of 12-24 months, the Fossa Alterna's investment scheme will come to fruition. Locals will benefit from accelerated crop harvest due to the produced biofriendly soil conditioner. The Fossa Alterna design will eventually pay for itself due to the increased crop yields. With endless use and only needing minor repairs over years of use, this design will provide an economic boost for the local community of Suco Holarua.

# 4.0 Overall Outcomes

## 4.1 Potential Benefits to the Community

The Fossa Alterna will provide many benefits to the community of Suco Holarua. From an economic standpoint, the Fossa Alterna can be constructed using locally produced materials which have a low capital cost and none or very low operating costs. These materials are also environmentally safe and are able to withstand Timor Leste's tropical environment. The Fossa Alterna is also environmentally sustainable. The double pits are used alternately which means the life-cycle is virtually unlimited, it provides a significant reduction in pathogens and generates nutrient-rich humus with good potential for use as a soil conditioner. From a social perspective, the Fossa Alterna can be easily integrated within Suco Holarua and it can be independently be used by any member of the community. Compared with non-ventilated pits, flies and odors are significantly reduced. With regards to the construction and practicality, the Fossa Alterna is ergonomic, does not need constant professional instruction, can easily be built by the community and has very minimal cleaning and maintenance. The Fossa Alterna also requires no transport which is one of the most important criteria for suitable sludge management as Suco Holarua has no rural collection plan and very poor road quality. (Eawag, Stauffer and Spuhler 2019)

## 4.2 Potential Limitations and Constraints to the Community

The Fossa Alterna may become an issue to community health where the groundwater table is too high and water enters the pits. Water in the pits encourages the development of vectors and pathogens and fills the pore spaces depriving aerobic bacteria of the oxygen that is required for degradation. (Eawag, Stauffer and Spuhler 2019) It is also important that water or any other liquid apart from urine is not put into the Fossa Alterna. This is where adequate community education on the safe and proper use of our system is of utmost importance.

## 4.3 Recommendations for Future Adaptations

To prevent water contamination in the pits, the Fossa Alterna can be raised or built slightly above the ground via a raised platform. This could be developed using locally sourced wood or even concrete slabs. These will provide a system of sealing the pit from any unwanted water that may enter.

# 5.0 Wider EWB Relationships

The Fossa Alterna shines in its adaptability beyond just the region of Suco Holorua. It's a system of waste management ready to be implemented into any number of existing at-risk regions. Like EWB's commendable efforts in Timor-Leste, they are also heavily involved in humanitarian work in Cambodia in conjunction with the Cambodian Rural Development Team. The work is focused around three themes: latrine use, hand-washing, and drinking clean water (CRDT 2019). The picture below shows a neighbourhood representation of houses containing any form of latrine use (green) and those without (yellow). While also noting the bordering proximity to the local river and water supply. Currently being polluted by existing systems of waste disposal. The people of the Kratie Province need to take steps with the Fossa Alterna to decrease the risks of personal contamination (people), while protecting their natural waterway (planet) for the previously discussed affordability of the Fossa Alterna (profit).

*Figure 5.1 Ksach Leav Community Map (CRDT, 2019)*

The EWB challenge is also involved with attempts to minimise the risk of landslide risks around the region of Suco Holorua. While not directly connected to methods of preparedness and risk response, the Fossa Alterna offers the opportunity for change on a larger scale. From the early 1990s to 2005 Timor-Leste lost 19.4% of its forest and woodland habitat to deforestation (Mongabay 2006). This deforestation is having adverse effects on the local environments and populations. Heavy deforestation on sloped areas like those near Suco Holorua exposes the soil to rain and drought. This drastically increases likely hood of Landslides during the rainy seasons which in Suco Holorua last for up to 70% of the year. By education the populations of at-risk areas of aspects of forestry conservation in conjunction with fertilization aspects of the Fossa Alterna. The people can begin breathing life into a dwindling and increasingly dangerous environment at no extra cost to themselves. A system that works perfectly with the framework of triple bottom line. Refurbishing the environment (Planet), increasing the safety of lives (people) at no extra cost (profit).

# 6.0 Conclusions

Through this informative and in-depth investigation, plausible improvements to the waste management sector of Suco Holarua, Timor-Leste have been suggested and explored. Not only could the successful implementation of a Fossa Alterna design drastically improve the waste management sector but it could also aid the sanitation and hygiene sectors which would therefore improve everyday life.

The practicality of this design is unparallel. It's easy construction, minimal management and inessential need of professional instruction makes it the most effective solution. Furthermore, the fact that the implementation of this design would decrease the deaths related to open defecation should be extremely compelling. Although some contact with the faecal sludge is required the contact is still minimal and the benefits of this process far outweigh the negatives. A Fossa Alterna strategy would be valuable to the environment as the waste that would previously be discarded into waterways would now not be and the bi-product of the process could have agricultural benefits. Moreover, one of the most important criteria for this design was to make it financially suitable. Not only does this solution require little funding but it is also only to be made from locally produced, inexpensive materials, strengthening the Timor-Leste economy making this design truly unparallel in benefits.

The management of waste is such a necessary process in every country. Hygienic Solutions truly believe that safe waste management is a human right. The people of Timor-Leste, like every country, deserve to not have to worry about their waste and how it will affect their health. This solution could truly change lives and help shift the focus from what should be such a small part of life to bigger issues. Timor-Leste can only truly progress as a country when the safety of its people is ensured. Effective waste management is an easy place to start. Ensuring safe waste management means ensuring a better future.

# 7.0 References

ACIAR. 2018. “Timor-Leste” Accessed May 20, 2019. https://www.aciar.gov.au/East-Asia/Timor-Leste

Clivus Multrum. 2019. “Waterless Composting Toilets” Accessed May 1, 2019. https://www.clivusmultrum.com.au/

Ecoflo. 2019. “Wastewater Management” Accessed May 1, 2019. https://ecoflo.com.au/cms/c

Encyclopaedia Britnnica. 2019. “East Timor” Accessed May 20, 2019. https://www.britannica.com/place/East-Timor.

Engineers Without Borders Australia. 2019. “Material and Equipment Price List.” Accessed May 2, 2019 https://www.ewb.org.au/explore/initiatives/ewbchallenge/ptl/ptl-resources/ptl-raw-data

Engineers Without Borders Australia. 2019. “Sanitation.” Accessed May 2, 2019. https://ewbchallenge.org/2-sanitation

Engineers Without Borders Australia. 2019. “2019 EWB Challenge Design Brief - WaterAid Timor-Leste.” Accessed May 2, 2019. Melbourne: Engineers Without Borders Australia.

EWB Challenge. 2019. “Cambodian Rural Development Team (CRDT)” Accessed May 20, 2019. https://ewbchallenge.org/design-area-2-sanitation-and-hygiene-0

EWB Challenge. 2019. “Climate Resiliance” Accessed May 20, 2019. https://ewbchallenge.org/5-climate-resilience

Global Water Pathogen Project. 2019. “Waste Stabilization Ponds.” Accessed May 2, 2019. https://www.waterpathogens.org/book/waste-stabilization-ponds

HealthyWA. 2019. “Understanding Septic Tanks” Accessed May 1, 2019. https://healthywa.wa.gov.au/Articles/U_Z/Understanding-Septic-Tank-Systems

Mongabay. 2019. “Timor Leste” Accessed May 20, 2019. https://rainforests.mongabay.com/deforestation/archive/Timor-Leste.htm

Morgan Peter. 1999. “The Fossa Alterna: A Method for Recycling Human Waste.” Accessed May 2, 2019. http://aquamor.tripod.com/Fossa1.htm

Morgan Peter. 2009. “The Fossa Alterna: How to Build and Manage the Latrine that makes Humus.” Accessed May 2, 2019. https://aquamor.info/uploads/3/4/2/5/34257237/manual_for_the_fossa_alterna.pdf

Nature Loo. 2015. “Welcome to Nature Loo Composting Toilets” Accessed May 1, 2019. https://www.nature-loo.com.au/main/

Ozzi Kleen. 2019. “Ozzi Kleen Septic Tank ST10 – ST10A Range” Accessed May 1, 2019. https://www.ozzikleen.com.au/residential/waste_water/septic-tanks

Septic Systems Australia. 2019. “Septic Tanks” Accessed May 1, 2019. https://www.septicsystemsaustralia.com.au/septic-tanks

SSWM. 2018. “Waste Stabilisation Ponds.” Accessed May 1, 2019. https://sswm.info/node/8199

Sustainable Sanitation and Waste Management Toolbox. 2019. “Fossa Alterna” Accessed May 2, 2019. https://sswm.info/humanitarian-crises/urban-settings/planning-process-tools/implementation-tools/fossa-alterna

The Water & Carbon Group. 2019. “Waste Stabilisation Ponds.” Accessed May 2, 2019. http://waterandcarbon.com.au/technology/waste-stabilisation-ponds/

Uncrd. 2018. “Waste Management in Timor-Leste” Accessed May 20, 2019. http://www.uncrd.or.jp/content/documents/RT2_06_Timor_Leste.pdf

WaterAid. 2018. “Holarua village in Timor-Leste declared open defecation free” Accessed May 20, 2019. https://www.wateraid.org/au/articles/holarua-village-in-timor-leste-declared-open-defecation-free

Water Aid. 2019. “Timor-Leste government make clean water and decent toilets a top priority” Accessed May 20, 2019. https://www.wateraid.org/au/articles/timor-leste-government-make-clean-water-and-decent-toilets-a-top-priority

World Bank Group. 2019. “Doing Business 2019: Economy Profile of Timor-Leste” Accessed May 2, 2019. Chicago: World Bank Group.

World Population Review. 2019. “Timor-Leste Population 2019” Accessed May 20, 2019. http://worldpopulationreview.com/countries/timor-leste-population/

# 8.0 Appendices