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Comparative Analysis of Two Eco-Friendly Sanitation Options Biofil-Worm-Based Toilet (Emerging Technology) and UDDT/Ecosan: Case Bangladesh

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Abstract: ***To achieve 100 percent Open Defecation Free (ODF) status as well as to increase the sanitation coverage, pit latrine has been getting prime focus of sanitation actors both from government and non-government sectors throughout the country in Bangladesh. Although there are efforts and plans to reach the upper levels of sanition ladder, however, pit latrine has the advantage of being cheapest and easiest solution for sanitation. As a country of flooding and high ground water table, pit latrines form a great threat for environment. There is no doubt that, it could be the best as the starting point to shift from open defecation, nevertheless, while considering long-term sustainability, improved technologies are essential depending on hydro-geological situation. To attain environmental and technological sustainability, concerns of developing appropriate context specific technologies, to overcome to the problem of conventional sanitation, in 2004ecosan/UDDT toilet was first introduced and, after ten years in 2014,Biofiltoilet was introduced as another sustainable sanitation solutions for Bangladesh. These two sanitation options have been tested in different parts of Bangladesh and in alignment of GOB's, around forty research institutions, INGO and NGO installed more than 3000 toilets each option of various models has been constructed to achieve the solution of above problem at a limited scale. This study aimed to compare and evaluate the suitability and potentiality of scaling up of Ecosan/UDDT and Biofil toilet in Bangladesh through focusing on the following aspects: (1) Socio-cultural and institutional (2) Financial and economic (3) Technology and operation (4) Environmental and health. The study carried out literature review, field observation, questionnaires interview from user of 100 toilets to evaluate the functionality and performance of ecosan/UDDT and Biofil toilet which constructed in different parts of Bangladesh. Also, interview (KII) was conducted with seven sanitation experts and providers. According to JADE only 60% (2016)and based on the survey more than 40% installed ecosan/UDDT are functional. Similarly, according to Biofil company90% are toilets are functional and based on the survey more than 80% installed Biofil are functional which include toilet in camp context. Biofil user acceptance and satisfaction is higher than ecosan/UDDT and the influencing factors are no change in regular practice, no odour and desludging frequency is less. Skilled mason for Ecosan/UDDT construction is not available locally and on the other hand, only Biofil company has their own skilled mason group. Considering the cost effectiveness of both options HH (5.3 USD/user) and communal (1.5 USD/user) model of Biofil are more effective than Ecosan/UDDT, as its requires regular monitoring and O&M cost and desludging frequency and cost is higher than Biofil. Only 10% and 2% ecosan/UDDT user using compost and urine in the agricultural field respectively, but still cultural and religious issues are the main barrier to use the compost and urine of ecosan/UDDT as fertilizer. In case of Biofil, vermicompost is yet to use as fertilizer. According to lab test in both the cases, the nutrition value is high as potential organic fertilizer. Ecosan/UDDT user can't depend on the compost or urine as the volume is very much less than requirements and it can't complement the chemical fertilizer and there is no market demand for it. Needs properly sun dry faeces and use of safety gear during handling ismissing in practice level which increases health risk. For both the cases, different laboratory result says that the contents of heavy metals and other contaminants are generally low or very low in excreta and it is found that the presence is below or within WHO and Bangladesh Agricultural standard. Mean N, P, K and Organic Matter found in good percentage in different samples which are important elements for soil nutrient and increase the water holding capacity of soil. Presence of organic matter in vermicompost is higher than the compost from ecosan/UDDT. For both the cases the significant amount of microbial contamination were observed in some tube well water.76 percentages of EcoSan toilet surrounding water bodies are in range of no or without risk. Besides during flood there is little chance of contamination of surface water as well and it is applicable for Biofilferrocement tank model. It is proven that presence of E – coli is very much less than conventional pit latrine.***

1. Background

In recent years, Bangladesh has achieved commendable success in increasing basic sanitation coverage throughout the country. According to the Joint Monitoring Program (JMP) of the World Health Organization (WHO) and the UNICEF, Bangladesh's sanitation coverage (improved and shared) rose from 50 percent in 1990 to 89 percent in 2015; open defecation has gone down from 34 percent in 1990 to 1 percent in 2015 (WHO-Unicef, 2015); sanitation coverage by "improved" facilities now stands at 61 percent. While these figures represent a remarkable success story, these also indicate significant scope for improvement, especially with regard to "improved" sanitation coverage.

Almost total sanitation interventions in Bangladesh have been based on on-site sanitation systems (e.g. pit latrines and septic tanks), without much attention to the management of fecal sludge that accumulates in pits and septic tanks. Lack of proper management of wastewater and fecal sludge is causing severe environmental pollution and health problems, which is endangering the sustainability of on-site sanitation

services. Therefore, progress toward total sanitation coverage must be aligned to delivering access to quality services. This is particularly true in the urban slums and low-income communities of Bangladesh where environmental and physical constraints place significant barriers on the development of quality sanitation solutions.

There appears to be limited choice regarding types of on-site sanitation facilities, particularly in slums and low-income communities. In crowded communities, sufficient space is not available for re-setting of pit latrines when the pits fill up. In the absence of organized Fecal Sludge Management (FSM) services, pit contents are often drained to storm drainage, low-lying areas or pit emptying is carried out in unhygienic manner, posing significant risks to environment and public health. It is well recognized that technology and business driven solutions have a major role to play in helping to deliver better sanitation for the poor in Bangladesh.

In 2004, to overcome to the problem of conventional sanitation, ecological sanitation was first introduced in Bangladesh. Japan Association of Drainage and Environment (JADE) started a project "Technical Cooperative Activity of Improve Sanitation at Rural Area in Bangladesh, focusing on Dissemination and Awareness Raising" with the collaboration of Bangladesh Academy for Rural Development (BARD). The Government of Bangladesh also motivated about EcoSan toilet and took initiatives on scaling up ecological sanitation throughout Bangladesh. GOB has undertaken initiatives for installing at least one EcoSan toilet in each union (4750 unions) as a demonstration in 2008 and allocated resources accordingly (Practical Action Bangladesh, 2010). Besides the GOB, several non-governmental organizations have been taking initiative to promote EcoSan toilet in different regions of Bangladesh. The main organizations who are promoting EcoSan toilet in Bangladesh are: SPACE, BASA and Practical Action (Roy, 2009). All these organizations are promoting mostly EcoSan toilet as it gives maximum benefit from excreta. SPACE implemented 402 household and 15 school EcoSan toilets (Biplob, 2011). 106 eco-toilets were constructed in seven districts by Practical Action in association with BASA and SPACE under SHEWAB project (Practical Action Bangladesh, 2011). About 3000 EcoSan toilet are now available in Bangladesh (Roy, 2009).

In 2014, Biofil toilet was introduced in Bangladesh through a pilot project with the financial support of Bill & Melinda Gates Foundation (BMGF) and implemented jointly by ICCO Cooperation, DSK and iDE, where ICCO was the project lead. During the period of 2014-15, Biofil was independently validated by International Training Network

of Bangladesh University of Engineering Technology (ITN-BUET) and found feasible, which can be better alternative of traditional pit latrines. In 2015, DPHE tested the Biofil toilet in four different geographical contexts of Bangladesh and found it considerably successful. Afterward, beyond the pilot project, Biofilcom Bangladesh started promoting this technology through business approach and, until December 2018, more than 5000 units of Biofil toilets installed in different districts (Dhaka, Khulna, Gaibandha, Chittagong, Cox's Bazar, Sunamgonj) of Bangladesh through international and local NGOs i.e. Oxfam-GB, ACF, Water & Life, Water Operator Partnership, MSF, BRAC, CCDB, AOSED, and DSK.

1.1 Objective of the Study

This study is carried out having the following objectives:

a) To assess technological comparison of UDDT/Ecosan and Biofil toilet
b) To identify functionality and effectiveness of UDDT/Ecosan and Biofil toilet

It was intended that following outcomes would be achieved after the study

a) Functionality of installed ecosan/UDDT and Biofil toilet.
b) Sustainability of ecosan/UDDT and Biofil toilet for Bangladesh.
c) Understanding impacts of health and environmental aspect of ecosan/UDDT and Biofil toilet.
d) Identify the challenges for scaling up and its way ahead ecosan/UDDT and Biofil toilet.

1.2 Methodology

The study has mainly concentrated on functionality and effectiveness of two types of toilets i.e. household and communal/institutional which has been using more than two years and also for emergency context. Asses both the technology based on technical functional group and sustainability where the four different major aspect covering area under the dimensions of sanitation covering 1) sociocultural and institutional, 2) financial and economic, 3) technology and operation aspect and 4) environmental and health aspects.

A survey was conducted on 50 household type and two communal ecosan/UDDT toilets and 50 household type and two communal/institutional Biofil toilet which are most common latrine types installed in different part of Bangladesh, which has been using more than two years and the survey was done through questioner survey for user community, latrine physical checking checklist and key informants' interviews (KII) was conducted with seven sector professionals of different implementing organizations, and government department DPHE. Secondary information has been collected from published and unpublished governmental, international agency, studies of consultants also used to fulfil the study.

2. Introduction

Safe sanitation is essential for health, from preventing infection to improving and maintaining mental and social well-being. The lack of safe sanitation contributes to diarrhoea, a major public health concern and a leading cause of disease and death among children under five years in low- and middle- income countries; poor sanitation also contributes to several neglected tropical diseases, as well as broader adverse outcomes such as undernutrition. Lack of access to suitable sanitation facilities is also a major cause of risks and anxiety, especially for women and girls. For all these reasons, sanitation that prevents disease and ensures privacy and dignity has been recognized as a basic human right.

Sanitation is defined as access to and use of facilities and services for the safe disposal of human urine and faeces. A safe sanitation system is a system designed and used to separate human excreta from human contact at all steps of the sanitation service chain from toilet capture and containment through emptying, transport, treatment (in-situ or offsite) and final disposal or end use. Safe sanitation systems must meet these requirements in a manner consistent with human rights, while also addressing co-disposal of greywater, associated hygiene practices and essential services required for the functioning of technologies.

There are numerous definitions of sanitation. In this document, the word sanitation alone is taken to mean the safe management of human excreta. It therefore includes both the hardware (e. g. latrines and sewers) and the software (regulation, hygiene promotion) needed to reduce faecal-oral disease transmission. It also encompasses the reuse and ultimate disposal of human excreta. (DFID 1998, pp. 4)

The term "environmental sanitation" is used to cover the wider concept of controlling all the factors in the physical environment, which may have deleterious impacts on human health and well-being. In developing countries, it normally includes drainage, solid waste management and vector control, in addition to the activities covered by the definition of sanitation. (DFID 1998, Ch.1, pp. 4). In case of sanitation systems the first thing is: Why do we need any sanitation facilities such as latrines, flush toilets, septic tanks etc? What conditions must be fulfilled by a sanitation system?

A sanitation system must:

- Protect and promote health – it should keep disease-carrying waste and insects away from people, both at the site of the toilet, in nearby homes and in the neighbouring environment.
- Protect the environment – avoid air, soil, water pollution, return nutrients/ resources to the soil, and conserve water and energy.
- Be simple – the system must be operational with locally available resources (human and material). Where technical skills are limited, simple technologies should be favoured.
- Be affordable – total costs (including capital, operational, maintenance costs) must be within the users' ability to pay.
- Be culturally acceptable – it should be adapted to local customs, beliefs and desires.

- Work for everyone – it should address the health needs of children, adults, men, and women.

2.1 Environmental sanitation

During a meeting in Bellagio, Italy, from 1−4 February 2000, an expert group brought together by the Environmental Sanitation Working Group of the Water Supply and Sanitation Collaborative Council agreed that current waste management policies and practices are abusive to human well-being, economically unaffordable and environmentally unsustainable. They therefore called for a radical overhaul of conventional policies and practices world-wide, and of the assumptions on which they are based, in order to accelerate progress towards the objective of universal access to safe environmental sanitation, within a framework of water and environmental security and respect for the economic value of wastes. As a part of it both Ecosan and Biofil has been promoted in Bangladesh.

2.2 Technical Aspect

Biofil- worm-based toilet (Emerging Technology)
The Worm-Based Toilet is an emerging technology that has been used successfully in rural, peri-urban and camp settings. It consists of a pour flush pan connected to avermifilter (filter containing worms). The effluent infiltrates into the soil and the vermicompost (worm waste) is emptied approximately every 5 years.

By using composting worms the solids are considerably reduced. The system thus needs emptying less frequently than traditional pits systems. The vermicompost is generated at the top of the system and is a dry humus-like material, which, compared with untreated excreta, is relatively easy and safe to empty.

Design Considerations
The surface area of the household tank for the vermifilter varies from 0.7 m2 to 1 m2 dependingon the number of users. The depth of the tank is approximately1 m. The bottom of the tank is exposed to thesoil. The tank contains 40 cm of drainage material (gravelor stones), 10 cm of organic bedding material (coconut husks) and the worms. The lid to thistank needs to fit extremely well, but should not be sealed.

This is then connected to the pour flush system. Materials: Worm-Based Toilets can be constructed fromlocally available materials. The superstructure should contain a roof and a door for privacy. A pour flush pan isalso required. The offset tank can be made from various materials including concrete rings, masonry and brickwork.

The most important material is the worms. The type of worms required are composting worms. Four species of worms have been successfully used to date, namely Eiseniafetida, Eudriluseugeniae, Perionyxexcavatus and Eiseniaandrei. They can be found locally, bought from vermicomposting or vermiculture businesses, or imported.

Applicability
Worm-Based Toilets are a viable solution if long-term household sanitation is required and emptying is an issue. They are particularly appropriate in contexts where water is available and used for flushing, and in camp communities that have a strategy of implementing household systems. As the toilets can be built half above and half below the ground they can be used in areas with relatively high water tables (approx. 1 m). As the effluent enters the soil, a certain infiltration capacity is required. Securing a worm supply can be an issue for some countries. In Bangladesh now it is locally available.

Operation and Maintenance
General operation and maintenance(O & M) measures include regular cleaning of toilets, advice on proper use, minor repairs, regular checking of the well-being of the worms and the monitoring of the filling of the tank. These toilets require emptying approximately every 5 years. Ideally the toilets are emptied by the household after they have been un-used for one week, allowing the fresh faeces to be converted into vermicompost.

The vermicompost should be removed from the edges of the tank with a small spade, then the vermicompost from the middle should be spread across the surface to create a bedding later. The harvested vermicompost can be buried on-site. When sensitising the users, it should be highlighted that only water, faeces, urine and possibly toilet paper should go into these toilets. The toilets should only be cleaned with water and a brush, and should be flushed after every use including urination. As desludging is not like the pit latrine, its requires reset the organic bedding material coconut husks and adding the worms. If emptying by the households is not an option (due to acceptability issues or other reasons) other options involving local service providers need to be identified.

Health and Safety
If used and managed well, Worm-Based Toilets can be considered a safe excreta containment technology. They need to be equipped with Hand washing Facilities and proper hand washing with soap after toilet use needs to be addressed as part of the hygiene promotion activities. Recent research/studies suggest that the effluent from worm-based systems can be considered safer than the effluent from septic tanks and that the vermicompost generated can be considered safer than faecal sludge. However, more research is required to confirm this.

Costs
Worm-Based Toilets can be built using locally available materials. The worms can be costly, but in larger-scale projects worm cultivation can be incorporated. The cost is comparable to that of a well-constructed pitlatrine. O & M costs should be included over the lifetime of the toilet. Over time this technology becomes increasingly financially viable compared with other pit latrine systems.

Social Considerations
The potential handing over to beneficiaries and the roles and responsibilities for O & M need to be agreed upon from the design phase and closely linked to respective hygiene

promotion activities to ensure appropriate use, operation and maintenance of the facilities. The community needs to be sensitised to the worms and toilets. This can be done by highlighting advantages of the system, i.e. little space required, convenient water-based system, no odour, less emptying, rather than discussing the use of the worms. There has been little adverse reaction to the use of worms.

Strengths and Weaknesses

No odour Design is adaptable to locally available materials Low emptying frequency (> 5 years of use) Easier and more pleasant to empty Requires water for flushing (min 200 ml) and composting worms. Unclear if menstrual hygiene products can be digested by the worms Bleach or other chemicals cannot be used to clean the toilet.

2.3 Urine-Diverting Dry Toilet (UDDT)/Eco-San

A urine-diverting dry toilet (UDDT) is a toilet that operates without water and has a divider so that the user, with little effort, can divert the urine away from the faeces. The UDDT is built such that urine is collected and drained from the front area of the toilet, while faeces fall through a large chute (hole) in the back. Depending on the Collection and Storage/Treatment technology that follows, drying material such as lime, ash or earth should be added into the same hole after defecating.

Design Considerations

It is important that the two sections of the toilet are well separated to ensure that a) faeces do not fall into and clog the urine collection area in the front, and that b) urine does not splash down into the dry area of the toilet. There are also 3-hole separating toilets that allow anal cleansing water to go into a third, dedicated basin separate from the urine drain and faeces collection. Both a pedestal and a squat slab can be used to separate urine from faeces depending on user preference. Urine tends to rust most metals; therefore, metals should be avoided in the construction and piping of the UDDT. To limit scaling, all connections (pipes) to storage tanks should be kept as short as possible; whenever they exist, pipes should be installed with at least a 1%slope, and sharp angles (90°) should be avoided. A pipe diameter of 50 mm is sufficient for steep slopes and where maintenance is easy. Larger diameter pipes (> 75mm) should be used elsewhere, especially for minimum slopes, and where access is difficult. To prevent odours from coming back up the pipe, an odour seal should be installed at the urine drain.

Appropriateness

The UDDT is simple to design and build, using such materials as concrete and wire meshor plastic. The UDDT design can be altered to suit the needs of specific populations (i.e., smaller for children, people who prefer to squat, etc.).

Health Aspects/Acceptance

The UDDT is not intuitive or immediately obvious to some users. At first, users may be hesitant about using it, and mistakes made (e.g., faeces in the urine bowl) may deter others from accepting this type of toilet as well. Demonstration projects and training are essential to achieve good acceptance with users. For better acceptance of the system and to avoid urine in the faeces collection bowl, the toilet can be combined with a Urinal, allowing men to stand and urinate.

Operation & Maintenance

A UDDT is slightly more difficult to keep clean compared to other toilets because of both the lack of water and the need to separate the solid faeces and liquid urine. No design will work for everyone and, therefore, some users may have difficulty separating both streams perfectly, which may result in extra cleaning and maintenance. Faeces can be accidentally deposited in the urine section, causing blockages and cleaning problems.

All of the surfaces should be cleaned regularly to prevent odours and to minimize the formation of stains. Water should not be poured in the toilet for cleaning. Instead, a damp cloth may be used to wipe down the seat and the inner bowls. Some toilets are easily removable and can be cleaned more thoroughly. It is important that the faeces remain separate and dry. When the toilet is cleaned with water, care should be taken to ensure that the faeces are not mixed with water. Because urine is collected separately, calcium- and magnesium-based minerals and salts can precipitate and build up in pipes and on surfaces where urine is constantly present. Washing the bowl with a mild acid (e.g., vinegar) and/or hot water can prevent thebuild-up of mineral deposits and scaling. Stronger (>24% acetic) acid or a caustic soda solution (2 parts water to 1 part soda) can be used for removing blockages. However, in some cases manual removal may be required.An odour seal also requires occasional maintenance. It is critical to regularly check its functioning.

Strengths and Weaknesses

+ Does not require a constant source of water
+ No real problems with flies or odours if used and maintained correctly
+ Can be built and repaired with locally available materials
+ Low capital and operating costs
+ Suitable for all types of users (sitters, squatters, washers, wipers)
- Prefabricated models not available everywhere
- Requires training and acceptance to be used correctly
- Is prone to misuse and clogging with faeces
- The excreta pile is visible
- Men usually require a separate Urinal for optimum collection of urine

2.4 Comparison of technologies based on Functional Groups

A sanitation system should consider all the products generated and all the Functional Groups these products are subjected to prior to being suitably disposed of domestic products mainly run through four different Functional Groups, which form together a system. Note: depending on the system, not every Functional Group is required.

User interface describes the type of toilet, pedestal, pan or urinal the user comes in contact with. User interfacealso determines the final composition of the product, as it is the place where water is introduced in the system. Thus, the

choice of user interface is often dependent on the availability of water.

Collection and storage/treatment describes the ways of collecting and storing products generated at the user interface; storage often also performs some level of treatment.

Conveyance describes the way in which products are moved from one process to another. Although products may need to be moved in various ways to reach the required process, the longest and most important gap lies betweenon-site storage and (semi-) centralised treatment. For the sake of simplicity, conveyance is thus limited to movingproducts at this point.

Use and/or disposal refers to the ways in which products are ultimately returned to the soil, either as harmless substances or useful resources. Furthermore, products can also be re-introduced into the system as new products. A typical example is the use of partially treated grey water used for toilet flushing.

Technologies are the specific infrastructural configurations, methods or services designed specifically to contain, transform or transport products to another process, point of use or disposal. (Tilley 2008)

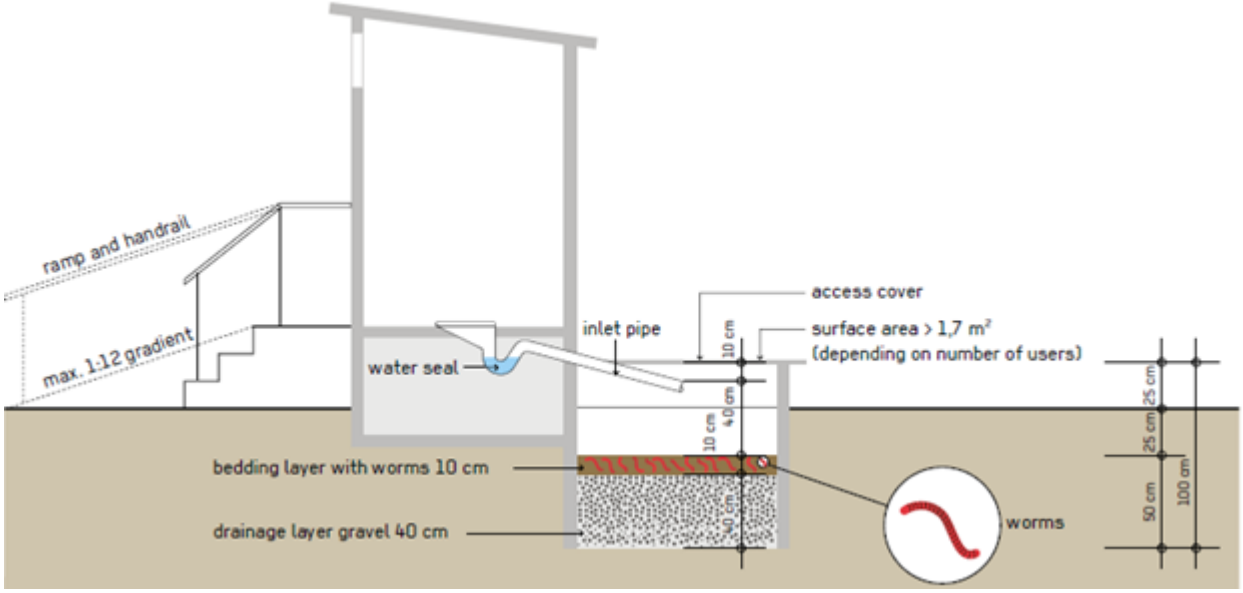


Figure: Schematic design of Biofil toilet

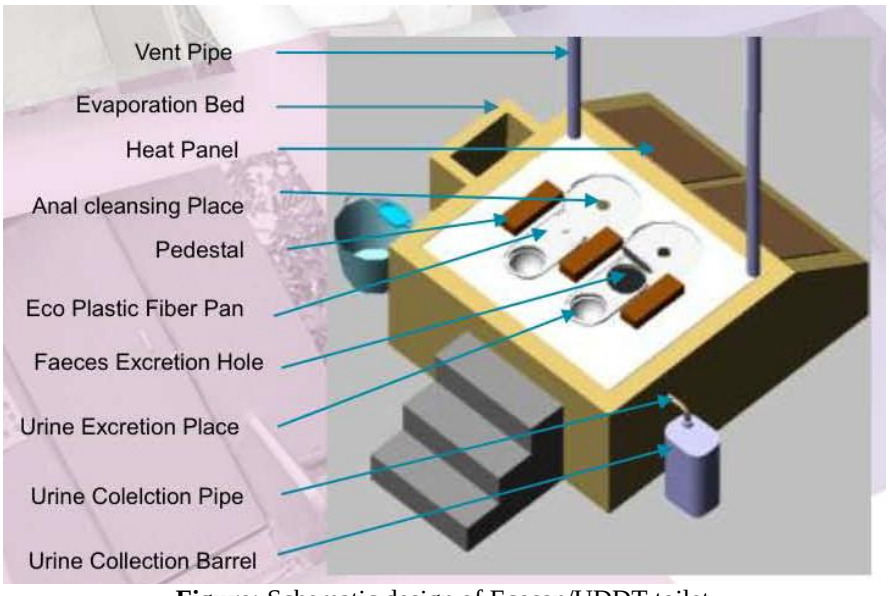


Figure: Schematic design of Ecosan/UDDT toilet

Table: Comparison of UDDT/Ecosan and Bio-fil toilet based on functional Group

	UDDT/Eco-San Toilet	Bio-fil Toilet
User interface		
Description	A urine diverting dry toilet (UDDT) is atoilet operating without water and separating the liquid (urine) from the solid (faeces) fraction. In a Ecosan/UDDT toilet, urine is collected and	The Biofil digester is set in a chamber/tank made of ferro-cement or brick (or any suitable local material), which could be laid above or below ground level depending on flood/groundwater level of the location. In the digester of a

	drained from the front area of the toilet, while faeces fall through a large chute (hole) in the back of the toilet (Figure 1). It is important for the two sections of the toilet to be well separated so that a) urine does not splash down into the 'dry' area of the toilet and b) faeces do not fall into and clog the urine collection area in the front. As shown in Figure 1 and depending on user preference, either a pedestal or a squat slab can be built/used to separate urine from faeces. (Tilley 2008)	Biofil toilet, the fecal solids are converted into vermicompost, which builds up slowly and is safe to handle (Figure 1 Biofil). In the digester, the fecal matter is retained on the top of the filter and is digested by the tiger worms, while the liquid (used for cleansing and regular O&M) drains through the filter media; this liquid effluent from the digester then flows into a soakage pit for infiltration of liquid into the subsurface. The soakage pit could be fitted with a filter/treatment system (optional) for further polishing of the effluent. Thus, Biofil toilets are designed to utilize the subsurface infiltration capacity of soil, which is common for virtually all on-site sanitation technologies. The toilet is fitted with a vent pipe. Superstructure of Biofil toilet can be built on top of the digester or it can be offset where space is available.
Suitability	The dry toilet is quite simple to designand build and can be altered to suit theneeds of specific populations (i. e. small children, people who prefer to squat etc.).	Design of Biofil toilet is flexible to be accommodated in almost everywhere i.e. slum areas, refugee camps, rural settings. The technology has been using as HH toilet, mobile toilet, community toilet and, a few of those has the option for person with disabilities. Both squating pan and high commode can be used.
Health Aspects/ Acceptance	The Ecosan/UDDT is not intuitive or immediately obvious to all users. Users may at first be hesitant to use it, and mistakes (e. g. faeces in the urine bowl) may also deter others from accepting this type of toilet. Education and demonstration projects are essential in achieving good acceptance among users.	Once introduced, Biofil toilet accepted everywhere. Potential users have confusion regarding earth worms, however, when they get explanation that those are the same worm for making vermicompost or catching fish, then they accept it openly. The most common liking users mentioned about Biofil is that the toilet does not have any bad smell.
Maintenance	A Ecosan/UDDT is slightly more difficult to keep clean than other toilets due to its lack of water and need to separate the solid from the liquid fraction. Since it forms part of a dry system, water should not be poured down the toilet, although the seat and the inner bowls should be wiped with a damp cloth. Metals should be avoided, as they tend to rust in the presence of urine.	There is no complex maintenance procedure. However, strong chemicals and over use of water not allowed. Recommended to clean the pan with brush and water everyday. If necessary, soap water can be used to clean the pan.
Costs	Ecosan/UDDTs come in a variety of shapes and sizes. A concrete and chicken wirepedestal could be made for as little as$ 5−10. Plastic squatting pans can sometimes be bought for as little as $ 2−3. More elaborate injection moulded fibreglass or stainless steel squat slabs can be much pricier.	Cost varies according to the model. A simple Biofil toilet for four members HHs with four rings, one slab, SATO pan, bamboo pillars, bamboo fence and, semi-transparent FRP (fibre reinforced plastic) roof can cost as low as USD 150. When, brick built tank and superstructure with RCC roof may cost up to USD 800.
Advantages	+ No flushing or no need for water flushing + Since faeces are dry and urine is separated, smells are minimal, though a lid should be used + Can be built on site with locally available materials + Very inexpensive	+ Manage the fecal solid on-site. No sewerage line required + No bad smell + Easy to use. No extra instruction to follow. + Maintenance is easy. + Less water (max. 300 ml) needed after every defecation + Tank emptying frequency is less + Can be build on-site with locally available materials + Can be prefabricated and installed anywhere within a short time
Disadvantages/ Concerns	− Its use may be difficult for some people (heavy, old and young) − Faeces can be accidentally deposited in the urine section and lead to clogging and cleaning problems − Urine pipes/fittings can become blocked with time	- Worms can be expensive - Size of the toilet tank is specific to number of regular user. - Strong chemicals are prohibited to clean the toilet pan. - Using too much water is not allowed.
Collection and storage / treatment		
Description	Dehydration vaults are used to collect,store and dry (dehydrate) faeces. Faeces will only dehydrate when the vaults are watertight to prevent external moisture from entering and when urine and anal cleansing water are diverted away from the vaults. When urine is separated from faeces, the faeces dry quickly. In the absence of moisture, organisms cannot grow and as such, smells are minimized and pathogens are destroyed. Vaults used for drying faeces in the absence of urine have various	Biofil toilet tank (digester) has a filter of made of porous slab, which retain the fecal solid in the centre of the tank and urine as well as water used for anal cleansing goes to the subsurface through the filter media. Earthworm provided inside the tank eat the fecal solids and generate vermicompost, which accumulated by the side of the walls of the tank.

	local names. One of the most common names for this technology is the Vietnamese Double Vaults.	
Health Aspects/ Acceptance	Dehydration Vaults can be a clean, comfortable, and easy-to-use technology. When users are well educated and understand how the technology works they may be more willing to accept it as a viable sanitation solution. When the vaults are kept dry, there should be no problems with flies or odours. Faeces from the double vaults should be very dry and relatively safe to handle provided they were continuously covered with material and not allowed to get wet. There is a low health risk for those whom have to empty or change the urine container. Faeces that have been dried for over one year also pose a low health risk.	By cleaning he toilet pan and top slab everyday with water and brush, Biofil toilet can remain as odour free and there will no flies as well. User do not need to follow any special measures to use this than a traditional pit/septic tank latrine, which they are generally habituated to.
Maintenance	To prevent flies, minimize odours and encourage drying, a small amount of ash, soil, or lime should be used to cover faeces after each use. Care should be taken to ensure that no water or urine gets into the Dehydration Vault. If this happens, extra soil, ash, lime, or sawdust can beadded to help absorb the liquid.Because the faeces are not actually degraded (just dried), dry cleansing materials must not be added to the Dehydration Vaults as they will not decompose. Occasionally, the mounded faeces beneath the toilet hole should be pushed to the sides of the pit for an even drying. Where water is used for cleansing, anappropriate User Interface should be installed to divert and collect it separately.	Maintenance is simple for Biofil toilet tank. No strong chemical should be used for cleaning the toilet pan. Instead, top slab and pan should be cleaned everyday by water and brush. If needed detergent or soap water can be used. Besides, using too much water for cleansing after defecation should be also avoided. Such practices will allow earth worms inside the tank to convert fecal solids into compost.
Cost	Depending on the cost of materials and labour, dehydration vaults can be quite affordable to more expensive. The size and waterproofness of the vault will determine a large part of the cost.	No separate cost needed. Tank of the Biofil toilet accumulates the fecal solids and compost.
Advantages	+ No need for water + Since faeces are relatively dry and the urine is separated, smells are minimised, though a lid should be used + Can be built on site with locally available materials	+ Manage the fecal solids on-site + No bad smell at all, even after opening the cover of the tank + Water can be used, which is essential in Bangladesh considering the behavioural aspects of users + Emptying/desludging frequency is much less compare to other toilet technologies + All materials are locally available to construct + Easy to use. No special instruction to follow.
Disadvantages/ Concerns	– Its use may be difficult for some people (heavy, old and young) – Faeces can be accidentally deposited in the urine section, causing blockages and cleaning problems – Additional urinals should be provided for men	- Strong chemicals are strictly prohibited to clean the toilet - Too much water for flashing should be avoided
Use and/or disposal		
Description	The different waste products can either be disposed of (without benefit) or reused for their nutrient content. In either case, it is important not to endanger public health or pollute the natural environment. Priority should always be given to the beneficial reuse of waste products. Organic waste recycling aims at reducing pathogen content and reclaiming valuable substances for possible reuse. Valuable nutrients include carbon (C), nitrogen (N), phosphorus (P), and other trace elements. Three main organic waste reuse methods are available.	Compost of the Boifil toilet tank can be used as fertilizer in the garden. Generally, compost accumulated by the side of the toilet tank, which can be collected by a spade by opening the monitoring slab or top slab. However, as the fresh fecal solid remain in the middle of the tank and, if part of those also come along with the compost during collecting, then it is better to cover the collected compost in the soil. Water used for handwashing after defecation can be reused for flushing.
Suitability		Properly collected compost is safe to use in the garden. Besides, as the quantity of compost is quite less, minimum space required to cover under the soil, if required.
Health Aspects/ Acceptance	Health hazards associated with excreta reuse are of two kinds: the occupational hazard to those who handle the excreta, and the risk that contaminated products from reuse may subsequently infect humans or animals through consumption or handling (Feachem et al 1983).	No serious health risk involved. Simple musk and gloves are adequate to collect and dispose the compost from the tank.

Maintenance		According to the experience so far, compost generated in Biofil toilet tank does not require any special maintenance procedure. It can be simply sundry for 5 to 7 days and then directly used in the garden.
Advantages	+Great potential for income generation + Potential to improve health and self-reliance of communities + Improves availability of drinking water + Drip irrigation is especially suited in arid and drought-prone areas + Reduced need of fertilisers	+ Reduce the risk of fecal solids disposed from the toilet tank to the nature + Reduce the risk of ground water contamination + Reduce the cost of emptying + No need to be connected with sewerage line
Disadvantages/ Concerns	− Effluent must be well settled to avoid clogging, as system is prone to Blockages − Application rate must be adapted to the type of soil, crop, climate etc., otherwise it could be damaging − Design and installation may require technical know-how	Further study required to be more certain about the use of compost in the garden

3. Comparison of technologies based on sustainability criteria

The list of criteria used within this report is presented in Table X. These kinds of comparison are to be made in actual situations, the sustainability assessment criteria should be identified through a participatory approach with all relevant stakeholders, and properly weighted as described above.

For illustrative purposes we chose to expand those criteria somewhat for the context of thisreport. The use of the same criteria for all examples will facilitate the illustration that somewhat similar sanitation systems might perform differently depending on context, and also highlight that different criteria might be weighed differently depending on the context.

The sanitation systems alternatives are scored in comparison to the 0 alternative with either + +, +, 0, –, – –. The + sign always indicates higher performance compared to the 0 alternative and the – sign always indicates lower performance compared to the 0 alternative.

Criteria that are difficult to analyse in matrix form, such as legal issues and institutional aspects, were discussed in the text for each illustrative example.

In order to understand the EcoSan and Biofiltoilet position consider all the sustainable criteria for Bangladesh context an expertise overview has been taken for based on their assumption on current situation, possible standard and finally compare with it the finding of study.

Table XX: Expert analysis using sustainability criteria developed by the Sustainable Sanitation Alliance (SuSanA)

		UDDT/Ecosan	Biofil	Standard for Bangladesh Code based on expert opinion
(1) Health:				
	Risk of exposure to pathogens	– –	– –	+
	Risk of exposure to hazardous substances	–	–	+
	Hygiene	0	++	+
	Nutrition	+	+	+
	Improvement of livelihood	+	+	++
	Downstream effects.	– –	– –	+
(2) Environment and natural resources:				
	Required energy	0	0	0
	Required water	+	+	+
	Other natural resources for construction	+	0	0
	Other natural resources for operation	+	+	+
	Other natural resources for maintenance	0	0	0
	Potential emissions from use	0	0	+
	Degree of recycling practiced and the effects of these	+ +	+ +	+
	Degree of reuse practiced and the effects of these	+	+	+
(3) Technology and operation:				
	Functionality	0	++	+
	Ease regarding construction	–	–	+
	EaseOperation and monitoring	+	++	+
	Suitability to achieve an efficient substance flow management	+	+	+
	Robustness of the system	+	+	+
	Vulnerability towards disasters	–	–	+
	Flexibility and adaptability of the system	+	++	+
(4) Financial and economic issues:				
	Investment costs	+	+	-
	Operation costs	+	0	0

	Maintenance costs	+	+	0
	Economic benefits in "productive" sanitation systems	+	0	+
	Capacity of households and communities to pay for sanitation	– –	– –	+
(5) Socio-cultural and institutional aspects:				
	Socio-cultural acceptance	0	++	0
	Appropriateness of the system	+	++	++
	Convenience	+	++	+
	Gender issues	+	+	+
	Impacts on human dignity	+ +	++	++
	Contribution to subsistence economies	+ +	+	+
	Food security	+	+	+
	Legal and institutional aspects	+	+	+

Expert analysis on performance indicators using sustainability criteria are mostly similar. In case of ecosan/UDDT has better performance in the area of Contribution to subsistence economies and Food security. In case of Biofil has better performance in the area of hygienic, functionality, operation and maintenance and Socio-cultural acceptance.

Comparison of technologies based on environmental and health aspect

The main goal of environment friendly toilet is to return the valuable nutrients from urine and faeces back to the environment and avoid the pollution often caused by conventional sewerage management. The waste in toilet is sanitized as the pathogens die off and the resultant safe soil conditioner (from faeces) and fertilizer (from urine) is then recycled and used to assist crop production (Sidhu, JPS. et al. 2008). Reusing human excreta demands reassurance that the composted excreta is free of pathogenic burden, as excreta may contain bacteria, protozoa and helminthes.

The environmental impact of different sanitation systems can be measured in terms of the use of natural resources, discharges to water bodies, air emissions and impacts on soils. Most relevant in relation to the use of excreta are the potential environmental impacts on soil and water bodies (WHO 2006).

Impacts on soil

The benefits of recycling biosolids onto agricultural land include providing essential nutrients for crop needs and organic matter for improving soil tilth, water-holding capacity, soil aeration, and an energy source for earthworms and beneficial microorganisms (Evanylo, G.K., 1999). Relevant substances to consider in terms of environmental impacts on soil me salt so heavy metals, organic compounds and nutrients. Presence of metal in both cases compost sample are within the WHO and Ministry of Agriculture limits. Lab test result in APPENDIX H

Table 4: Heavy metal presence in Ecosan and Biofil sample

	KP-1	KP-2	SP-1	NP-2	Biofil	WHO limit	Ministry of Agriculture: limits (maximum)
Zinc (ppm)	90.91	111.93	85.69	148.74	524.60	65000	Zn = 0.01%
Copper (ppm)	43.52	29.82	58.36	31.05	105.85	6667	Cu = 0.05%
Lead (ppm)	0	2.6	2.48	4.17	21.89	122	Pb = 30 ppm
Cadmium (ppm)	0.092	0.104	0.074	0.196	1.60	62	Cd = 5 ppm
Nickel (ppm)	12.15	12.04	11.95	10.68	26.10	450	Ni = 30 ppm
Chromium (ppm)	11.05	13	12.59	9.62	11.56		Cr = 50 ppm

Nutrients back to environment

Urine from UDDT/Ecosan

Urine contains large quantities of nitrogen (mostly as urea), as well as significant quantities of dissolved phosphates and potassium, the main macronutrients required by plants, with urine having plant macronutrient percentages (i.e. NPK) of approximately 11-1-2 by one study or 15-1-2 by another report, illustrating that exact composition varies with diet (Jönsson and Vinnerås 2004). When diluted with water (at a 1:5 ratio for container-grown annual crops with fresh growing medium each season, or a 1:8 ratio for more general use), it can be applied directly to soil as a fertilizer. The fertilization effect of urine has been found to be comparable to that of commercial fertilizers with an equivalent NPK rating.

Compost from UDDT/Ecosan

Human faeces consist mainly of undigested organic matter such as fibres made up of carbon. Although faeces contain fewer nutrients than urine, the humus produced from faeces actually contains higher concentrations of phosphorus and potassium. After pathogen destruction through dehydration and/or decomposition the resulting inoffensive material may be applied to the soil to increase the amount of available nutrients, to increase the organic matter content and to improve the water-holding capacity.

Vermicompost from Biofil

Vermicompost (vermi-compost, vermiculture) is the product of the composting process using various species of worms, usually red wigglers, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicast. Vermicast (also called worm castings, worm humus, worm manure, or worm feces) is the end-product of the breakdown of organic matter by earthworms. These castings have been shown to contain reduced levels of contaminants and a higher saturation of nutrients than the organic materials before vermicomposting. Vermicompost contains water-soluble nutrients and is an excellent, nutrient-rich organic fertilizer and soil conditioner. It is used in farming and small scale sustainable, organic farming. Vermicomposting can also be applied for

treatment of intro. A variation of the process is vermifiltration (or vermidigestion) which is used to remove organic matter, pathogens and oxygen demand from wastewater or directly from black water of flush toilets.

Table 4: Presence of O, N, P, K presence in faeces

Item		*Ecosan Mean*	*Biofil Mean*
P^H		8.95	6.00
Organic Matter	%	3.20	15.63
Nitrogen (N)	%	0.35	1.20
Phosphorus (P)	%	0.48	1.12
Potash (K)	%	2.75	0.36

Compost from ecosan/UDDT and Biofil are suitable for use in agricultural land as a fertilizer and soil conditioner. Organic matter in vermicompost is higher than the compose from ecosan/UDDT.

Scope of ground water pollution

Since the EcoSan are placed aboveground level, the chance of groundwater contamination is less for low water table areas. According to Sphere standard the distance between depth of water table and the bottom of the pit level should be at least 5 feet (1.5 meter). So considering this standard EcoSan toilet reduces the risk of groundwater contamination due to its elevated heights of the rings. In this regard Ecoan toilet is suitable for low water table area (8 feet or less during wet season).

In Oxfam project areas significant amount of microbial contamination were observed in some tube well water. People were used to traditional pit latrine which was one of the causes of such contamination. Since the project areas are mostly Char area and the water table in these areas are high especially during rainy season (APPENDIX – D), according to Sphere Standard it is difficult to maintain approximate 5 ft (1.5 meter) in between the distance of water table depth and the depth of pit bottom level. EcoSan latrines have two concrete and brick-lined vaults that store and stabilize the faeces during use, completely eliminating the possibility of seepage and contamination of groundwater sources. So, EcoSan is a suitable technology for high water table areas where groundwater could be protected from microbial contamination. According to the table: 4.11, 76 percentages of EcoSan toilet surrounding water bodies are in range of no or without risk. Besides during flood there is little chance of contamination of surface water as well.

Table 4.11: Ground water pollution risk analysis

Grade	No. Coli form count	Risk	Ecosan/UDDT		Biofil	
			Frequency	Percentage	Frequency	Percentage
A	0	No risk, WHO guideline value, no action required	34	34	2	2
B	01 – 10	Low risk, need action and follow-up	42	42		
C	11 - <50	Intermediate risk, highly polluted, immediate action needed	22	22		
D	>50	High risk, gross/highly polluted and not acceptable, suspend the source	3	3		

JADE took another initiative to assess risk of presence of parasite of the surrounding condition of the rural leaving environment like around the pit latrine and around EcoSan toilet by doing some sub surface water. Table 4.12 it is proven that presence of E – coli is very much less than conventional pit latrine. In both dry and wet season the sub surface level water table has been measured in Oxfam field the result is in APPENDIX – D.

Table 4.12: Comparison of microbiological contamination in different sites

Sample no.	Sample Type	Result CFU/g	Parasite sum
1	Around EcoSan toilet	1,200	6
2		14,800	5
3		820	4
4		1,130	5
5	Around pit latrine	6,840	8
6		910	5
7		24,080	6
8		970	3
9	Around Biofil toilet		
10			
11			

Health Impact

Table 4.17: Comparison of Ecosan and Biofil without and with dried specimens

		Total bacterial count cfu/gm	Total coliform cfu/gm	Faecal coliform cfu/gm	Salmonella/shigella spp. cfu/gm	Vibor spp. cfu/gm
Without dried up specimens	Biofil	7.5×10^5	5.0×10^3	7.0×10^2	Not detected	Not detected
	Ecosan		43×10^3		Absent	Absent
Sun dried up specimens	Biofil	$9.0X10^2$	Not detected	Not detected	Not detected	Not detected
	Ecosan				Absent	Absent

Table 4: Biofil without and with ash specimens

Sample Code	Total bacterial count cfu/gm	Total coliform cfu/gm	Faecal coliform cfu/gm
T-1 with ash	$9.0X10^2$	Not detected	Not detected
T-1 without ash	$1.1X10^3$	Not detected	Not detected
T-2 with ash	$5.0X10^2$	Not detected	Not detected
T-1 without ash	$5.8X10^2$	Not detected	Not detected

The Role of UDDT/Ecosan and Biofil Toilet Systems in Emergencies

In an emergency situation, the choice of dry or ecological toilet systems, such as urine diversion toilets, composting toilets, or warm based toilets is very often driven by factors other than the re-use of its by-products. Such toilets first of all do not require any water to function safely and treatment

is much easier if no infrastructure for treatement is available (e.g. drying and composting). Unlike pit latrines, they can be used for longer time, making them a much more attractive option in terms of longevity. Moreover, the dry system such as ecosan toilets are very often better suited to rocky ground or areas with high water tables, making them more resistant to cyclic flooding for instance.

Moreover urine diverting toilets reduce odour and flies and if refugee camps are established long-term, urine can for instance be reused for gardening (see also reuse of urine. However, ecological toilets require more careful operation and maintenance, and handling of excreta poses higher health risks. A case study has shown that ecological technologies e.g. UDDTs can be successfully implemented in the long-term phase of an emergency response (MWASE 2006). The two most important criteria for ecological toilet applicability have been identified as the awareness and expertise in ecological toilets within the aid agencies, and the availability of standardised, lightweight toilet units that are quick to assemble and easy to transport (VON MUENCH et al. 2006).

Experience of UDDTs in during and post emergency context

Bangladesh has made a significant contribution to supply improved sanitation facilities in rural areas in recent years. As it is the most known option, pit latrines were the most favourable technology. Yet, as Bangladesh is a country of flooding and high groundwater table, pit latrines not only flush out and cause pollution; they also become inaccessible during floods, and remain filled with silt after the floods. Every year floods destroy many sanitation facilities and force people to resort to open defecation, despite the capital-intensive investment. Urine Diversion Dehydration Toilets (UDDTs)were evaluated on their suitability in flood-prone areas and their affordability in the context of Bangladesh. A survey conducted in two flood-prone areas of Bangladesh showed that with an average height of 0.69 m the UDDTs are higher than the average highest flood level of 0.31 m. To decrease cost and construction complexity, a local design was developed based on the current pit latrine, at 50% of the costs of the current UDDTs. Although the resulting cost is still not within reach for most Bangladeshi, the affordability could be increased by taking into account avoided emptying costs as well as the added value of human excreta as a fertilizer. In other flood-prone areas UDDTs have been installed successfully. In response to cyclone Sidr, the International non-governmental organization (NGO) Terre des Hommes (TdH) implemented a post-rehabilitation project on sanitation in the Barguna district: 100 UDDTs were constructed in the Sidr affected area (Mazeau 2009). The United Nations Children's Fund (UNICEF) constructed 575 UDDTs in a flood-prone area in the Guara-Guara region of Mozambique, which is at or below sea level. The beneficiaries there selected UDDTs with faeces vaults above ground as the most suitable technology for their region (Fogde et al. 2011).

After six weeks a survey was conducted in a study and findings are following:

- After two months, 75% of the UDDT are under regular use.
- The use is not homogeneous amongst the households' members. Some families are still using their previous sanitation facility in parallel with UDDT.
- Beneficiaries who adopted the UDDTs recognized the comfort and the safety of the UDDT. They also use the UDDT because it is the only toilet non flooded during storm events.

Specific requirements for operating and maintaining urine diversion dehydration toilets, contradict some traditional and religious practices in rural Bangladesh:

- Traditionally emptying of latrines is most of the time done by hired sweepers. Taboos on sanitation may jeopardize the handling of dried excreta required to maintained the UDDT. Beneficiaries explain that they do not know exactly what they will do when the chamber is full.
- Some informants cited concerns about the orientation of the squatting pan and the location of the toilets. For them it is not in accordance with their religion and tradition. However, people understand the principle of urine diversion dehydration and don't demonstrate any resistance to it.
- A woman is not using the UDDT because the toilet is not located behind the house as some tradition required it.
- The weight of traditional practices and the difficulties of changing the practices of the rural population are underlined in addition to other issues.

Drawing a hierarchy amongst different aspects such as religion, gender, level of education and social structure remains context specific. The analysis of findings demonstrates that socio-cultural aspects such as gender or social structure can be a barrier for dry toilets project. Implementers need to mitigate these aspects through adapted communication programmes.

Experience of Biofil in refugee camp context

After four years of field trials in Bangladesh, Oxfam has adopted the ingenious Biofil Toilet for the Rohingya refugee response. These innovative toilets use a particular species of earthworm to compost waste. According to Compendium of Sanitation Technologies in Emergencies the Worm-Based Toilet is an emerging technology that has been used successfully in rural, peri-urban and camp settings. It consists of a pour flush pan connected to a vermifilter (filter containing worms). The effluent infiltrates into the soil and the vermicompost (worm waste) is emptied approximately every 5 years.

Around one million Rohingya people have sought safety in Bangladesh refugee camps in the last year. Bangladesh is one of the world's most densely populated places, marked by extreme poverty, so the arrival of this new population places immense pressure on the country's already fragile water and sanitation infrastructure. Management of waste, water and sanitation is therefore critical in these sprawling refugee camps, where the risk of cholera and other waterborne disease is ever-present.

Oxfam put in place more than 1,000 new BioFil toilets in Cox's Bazar, dramatically reducing the volume of sewerage requiring treatment in the camps. The new toilets offer a range of benefits – they make use of local construction

materials, generate compost, reduce odour and, reduce desludging frequency.

Biofil has been successfully using in the camps of Rohiynga people in Cox's Bazar, Bangladesh, who had forcefully displaced from Myanmar. Since October 2017, more than 4000 units of Biofil of different models installed in different camps through international and local NGOs (including Oxfam). Approximately 90% of installed Biofil has been found functional in December 2018. From user perspectives, Biofil has the advantage and liked most because of having no bad smell. It was also observed that, Biofil is easy to installed and can be constructed in big number within a short period of time, which is essential in emergency situation. Although Biofil suppose not to be desludged in ideal situation, however, because of big number of user in the camps, many units had to be desludged. Nevertheless, compare to other toilet technologies of the camps, frequency of desludging of Biofil is about four times less and, volume of fecal solids mixed with compost is one fourth than that of other toilet systems. Over the period of time, different models of Biofil developed to accommodate the need of people in the camps and, it has been observed that Boifil tank made with 48" dia rings or with twin pits system is more sustainable than other models. There are instance of Biofil in the camps, which are yet to be desludged even after 12 months of use. Besides, it is possible to convert traditional pit latrine in to Biofil with minimum cost, and it has been already started in camps. Furthermore, Biofilcom, the agency promoting the Biofil toilet in Bangladesh through business approach, has developed a model with fibre glass (total toilet), which can be transported in a packet and installed within 30 minutes. Such option is very much suitable for any emergency.

4. Experience and views of different organization

To get response from different experienced organizations' views and opinions and as well as identify the prospects and strategies for promotion of EcoSan and Biofil toilet in Bangladesh, is one of the important parts of this study. In this regard, representatives of Bangladesh Academy for Rural Development (BARD), Practical Action Bangladesh, Bangladesh Association for Social Advancement (BASA), Society for People's Actions in Change and Equity (SPACE), Oxfam, Japan Association of Drainage and Environment (JADE), ACF, UNHCR, and DPHE were consulted. Through an interview process strength, weakness, opportunity and threat (SWOT) analysis of UDDT/EcoSan and Biofil has been done to determine the current status of UDDT/EcoSan and Biofil promotion in Bangladesh and explore future options for scaling up the application of UDDT/EcoSan and Biofil in Bangladesh.

Strengths for ecosan and Biofil toilet promotion

The main strength of the UDDT/EcoSan and Biofil toilets and the system for its promotion in Bangladesh are listed below. Future programmes to further promote UDDT/EcoSan and Biofil in Bangladesh need to build on these strengths.

UDDT/Ecosan	Biofil
• Social taboo and religious barrier to use EoSan manure and agricultural product addressed • Concerned stakeholders including GO, NGO, UN body and others development partners acknowledged the technology. • National level policy makers recognized this technology. • NGOs are coming forward to expand this technology over the country. • Research on design modification and application of urine and feces as manure is going on. • Department of Public Health Engineering (DPHE), the sole agency of Bangladesh government for water supply and sanitation has accepted it as one of the improved sanitation technologies. • Sub Assistant Engineers of DPHE has been trained about EcoSan toilet. • Technical features and benefits of this technology documented and disseminated by different media for easy access of mass people.	• Biofil toilet technology was validated by International Training Network of Bangladesh University of Engineering Technology (ITN-BUET) through 16 months long monitoring during the year 2014-15 and, found feasible. • Department of Public Health Engineering (DPHE) validated the technology in four different geographical contexts (cost, hill, river island, and haor) of Bangladesh and found it considerably successful. • The technology has been promoting by a private agency through business approach, which ensure the sustainability and further development/strengthening of it. • In the long run, Biofil is much cheaper compare to other toilet technologies • Biofil toilet can be made by using rings and slabs available in the market widely.

Weaknesses for UDDT/Ecosan and Biofil toilet promotion

The main weaknesses of the UDDT/EcoSan and Biofil toilets and its promotion in Bangladesh are as follows:

UDDT/Ecosan	Biofil
• High construction cost is the main weakness for household level promotion. • As a technology, it is not yet fully user friendly due to movement for anal washing and spreading of ash in the feces hole after each toilet use. • In some areas ash is not easily available and in some seasons ash is not easily store. • Insufficient storing capacity, transportation and manual application of urine as fertilizer is treated as troublesome and hatred job. • Due to design concern well-off families are not interested to have it. • Stranger and guest needs to be instructed before use.	• Size of the tank of Biofil toilet is specific to the number of users. Toilet to remain close for 2-3 days if too much over use takes place. • Primary investment cost is higher than that of pit latrine

Along with above points there are some more issue has been identified by the interviews which are given below

Issues	UDDT/Ecosan	Biofil
Social and cultural acceptance of toilets	Low	High
Orientation to the outsiders on the use of toilet	High	Low
Odour	Medium	Low
Space constraints	Medium	Medium
Level of awareness and knowledge on the importance and management	High	Low
The level of satisfaction from the user	Medium	High
Consideration of environmental soundness	High	High
Initial investment	Medium	Medium
Changes in people's perception and behaviour	High	Low

Opportunities for UDDT/ecosan and Biofil toilet promotion

The current scenario in Bangladesh creates several opportunities for further promotion of UDDT/EcoSan and Biofil, which are listed below. These opportunities must be capitalised to scale up the application of UDDT/EcoSan and Biofil in Bangladesh.

UDDT/Ecosan	Biofil
• Life span of EcoSan toilet is 15-20 years. • It is disaster (flood or cyclone) resilient as its structure is durable and watertight chamber can be constructed on the upper ground of homestead. • Flashing is not necessary to wash away the feces, so it requires limited water. • Improve living environment by confining diseases causing organisms. • Reducing diseases frequency, a family can save about 2000 BDT medical cost per year. At national context this amount will be about 64.34 billion BDT /year (estimated). • A farmer household can reduce fertilizer cost about 700 BDT per year by using dried feces and urine as manure. At national context this amount will be 12.5 billion/year (estimated).	• International agencies Oxfam-GB and ACF have installed the Biofil toilet in big numbers in camps of Rohingya people. Such initiative indicates the possibility of Biofil in many other countries of similar environment, where these agencies are involved. • In Ghana, Biofil has been mostly sold among middle income community living in multi storied building apartments. Such opportunity is also there in Bangladesh and neighbouring countries, however, some examples to be created through research. • Traditionally, people of Bangladesh are habituated to use water for cleansing after defecation. However, they carry little amount of water during defecation, which is completely suitable for Biofil toilet. • According to environmental law of Bangladesh, discharging fecal solids from the tank of toilet to the open space/drain or water bodies is illegal. However, people has very limited options as there is no sewerage line (other than maximum 10% HH of Dhaka City Corporation), and treatment plants are fur away or inadequate. Biofil as an emerging toilet technology, provides the better option to users to maintain the environmental law of the country. • All the materials required for constructing Biofil are available locally. • Using Biofil toilet as easy as traditional pit latrine. No special measures to be followed. • As the technology separate the liquid and solids effectively, it has high potential to be introduced in passenger trains and passenger ships of the country.

Threats for UDDT/ecosan and Biofil toilet promotion

The potential threats that may hamper further growth of UDDT/ EcoSan toilets in Bangladesh are as follows:

UDDT/Ecosan	Biofil
There is no threat to promote UDDT. Otherwise, apparently there is no operational threat also. But due to knowledge and practice gap some operational threat may appear: • It will create bad smell that attract flies to spread diseases - If ash is not spread properly and the lid of defecation hole is not covered well - If water pours in the feces volt during anal washing. - If heat panels are not set properly then rainwater go inside the feceasvault. • Secondary treatment of feces is needed to make it free from health threats by sun drying that require careful management. If anyone avoids prescribed management then there is chance of occurring health threat. • As volume of urine is more, thus urine is advised to use frequently. If someone do not follow it then urine overflows, bad smells creates and surrounding environment turned into hub of pathogenic pollution.	• Lack of implementation of environmental law, which allows people to connect their toilets with storm drainage system (in the urban area) and/or to the open water bodies e.g. canal, river, low land areas (in the rural and semi-urban areas. • Although apparently there is no/less subsidy available now for making toilet by the low income community, however, practically, huge subsidy is still available through the national and international development agencies in different ways. Such options are big challenge for any toilet technology to be sustainable. • Ignorance of national and international NGOs regarding necessity of different options to ensure FSM in a particular region. • Low quality materials prepared by traditional sanitation entrepreneurs.

The way ahead for UDDT/EcoSan and Biofil promotion

Overall, the introduction and promotion of UDDT/EcoSan and Biofil toilets in Bangladesh has been successful and the positive response of users, as well other key stakeholders, clearly indicates that there is a need to further promote this innovative technology. The SWOT analysis indicates that the existing UDDT/EcoSan toilets and the system to promote them have plenty of strengths as well as opportunities. In this context, the road ahead for UDDT/EcoSan toilet should be designed to build on the strengths and to take advantage of the opportunities, while overcoming the few weaknesses and avoiding the threats. One-size-fits-all approach is not appropriate in the case of UDDT/EcoSan toilet promotion. Different cultural, geographic and demographic situations produce different reactions to UDDT/EcoSan technologies. The promotion of UDDT/EcoSan may, therefore, have more success when presented as an option in a range of technologies rather than through a doctrine position that states: "this is the only way". Listed below are key recommendations for promotion and

scaling up the application of UDDT/EcoSan and Biofil toilets in Bangladesh.

UDDT/Ecosan	Biofil
• Institutionalise a system for promoting UDDT/EcoSan • Incorporate Agricultural sector to further promote UDDT/EcoSan • Demonstrate UDDT/EcoSanall over Bangladesh • Integrate UDDT/EcoSanin existing projects and programmes • Reduce the cost of UDDT/EcoSan • Promote organic fertiliser • Raise awareness on UDDT/EcoSan • Build capacity of the communities • Conduct research and monitoring • Build effective networks for learning and coordination	• Testing among the middle income community • Involving existing sanitation entrepreneurs throughout the country • Establishing semi automatic workshop • Organize promotional events and disseminate IEC materials • Role of subsidies • Flexible in terms of choice of toilet type

5. Comparison of technologies based on performance

According to the JADE and other sources around 3,000 HH ecosan/UDDT has been installed in different part of Bangladesh by different agencies. Similarly, around 2800 HH/sharing and 60 communal Biofil toilets have been installed, however 98% has been installed in camp context. In this study mostly installed two options has been considered for detail analysis and Biofil sharing type not considered in this part for analysis.

Table 3: Performance of different options

Sanitation Option	Number / % of installed	Number / % functional	Installation cost (BDT)	User Number	Regular O&M cost (BDT)	Desludging frequency (months)	Desludging Cost (per year)	Durability (Year)
Biofil- HH model	80	95%	48000	8	900	36 – 48	1500	15
UDDT/Ecosan - HH model	3000 or 99 %	60%	27000	5	2880	6 – 12	6000	12
Biofil - Communal model	60	95%	105000	80	900	36 – 48	3750	15
UDDT/Ecosan - Communal model	20 or Less than 1 %	10%	120000	100	2100	6 – 12	22500	12

Comparison of technologies based on cost and benefits

Cost Efficiency Analysis

Cost effectiveness and suitability are the key factor for better design and effective sanitation program. Considering all the factors like installation cost, management cost, monitoring & hygiene promotion cost, regular O&M cost, desluding cost, durability and number of user cover by the option.

6. Conclusion and Recommendation

Ecosan/UDDT and Biofil toilet was introduced to solve the problem with the conventional sanitation system for rural, urban and emergency settings. To identify local acceptabiliy of these technologjies, it is necessary to make it clear the requirements for technology, which include response to local characteristics and needs in each local community. It is critical that implementation observes appropriate steps so that the solutions are sustainable based on simple technologies which can be carried out by the communities and maintained and operated over the long term. There are several key factors which determine whether technology is appropriate for the specific situation. Technological viability can be accessed through major aspects like social, economical, technological, and environmental and health issue.

Considering the four different Functional Aspects 1) user interface, 2) collection and storage/treatment, 3) conveyance and 4) use and/or disposal mostly slimier on-site sanitation system, except there is additional filtration system which called Biofil digester. Because of pour flush system and no additional requirement for maintenance make the option more acceptable to user.

Expert analysis on performance indicators using sustainability criteria 1) Health, 2)Environment and natural resources, 3) Technology and operation, 4) Financial and economic issues and 5) Social-cultural and institutional aspects developed by the Sustainable Sanitation Alliance (SuSanA) are mostly similar. In case of ecosan/UDDT has better performance in the area of Contribution to subsistence economies and Food security. In case of Biofil, it has better performance in the area of hygienic, functionality, operation and maintenance and Socio-cultural acceptance.

No significant impact on soil because of the presence of heavy metal in the compost are within the limit of WHO and Agriculture which means safe to use any agricultural land. Vermicompost from Biofilis rich in all content then compost from ecosan/UDDT. Similar result found for the presence of Organic matter, N, P and K in both type of compost. But the utilization of it is very low like only 10% and 2% ecosan/UDDT user using compost and urine in the agricultural field respectively, but still cultural and religious are one of the main barrier influence in using as fertilizer. In case of Biofilvermicompost is yet to use as fertilizer.

Considering the ground water contamination for both the cases there is no significant amount of microbial contamination were observed in some tube well water. Besides during flood there is little chance of contamination of surface water as well and alsoit is proven that presence of E – coli is very much less than conventional pit latrine.

Both the technology is found disaster (flood) resilient and this is one of the main reason user prefer ecosan/UDDT option. In the camp context Biofil found more acceptable by the user and provider. On the other hand, the experience of ecosan/UDDT installed after the super cyclone was not accepted by user because of socio-cultural aspects.

According to the strength of both technologies is that Department of Public Health Engineering (DPHE) validated the technology in four different geographical contexts (cost, hill, river island, and haor) of Bangladesh and also different organizing trying to promote these options.

Primary investment cost for both technology is high. Also, availability of skilled mason for ecosan/UDDT toilet construction and Biofil company is sole supplier are the weakness in promoting the options. Beside that continuous monitoring and support requirements and socio-cultural barrier became obstacle for its success in the long run especially for ecosan/UDDT.

The opportunity for these two technologies is disaster (flood or cyclone) resilient as its structure is durable and watertight chamber can be constructed on the upper ground of homestead. But Biofil can be one of good option for camp and in emergency context as using Biofil toilet as easy as traditional pit latrine and no special measures to be followed. Secondary treatment of feces is needed to make it free from health threats by sun drying that require careful management as there is chance of occurring health threat. Alsono/less subsidy available now for making toilet by the low income community to introduce second generation environment friendly toilet are the main threat for promoting these two technology.

According to the survey more than 40% installed ecosan/UDDT and 80% installed Biofilare functional. Considering the cost effectiveness of both options HH (5.3 USD/user) and communal (1.5 USD/user) model of Biofil are more effective than Ecosan/UDDT, as its requires regular monitoring and O&M cost and desludging frequency and cost is higher than Biofil.

The SWOT analysis through an interview process clearly determines the current status of Ecosan/UDDT promotion in Bangladesh will be more challenging than Biofil. There is still need of in depth research design and use of compost for both the cases. It is expected that if there any funding or investment in this sector by local financer or entrepreneur or bank it will be encouraged the communities to promote and scale up both the technologies.

Appendix – A: Questionnaire for latrine users communities

Questionnaire survey for "Comparative Analysis of two eco-friendly sanitation options Worm-Based Toilet (Emerging Technology) and UDDT: case Bangladesh"

	Date		
	Upazila		
	Union		
	Word		
	Village		
A	Family information		
1	Name of the respondent		
2	Cell phone No.		
3	Age of the respondent		
4	Sex of the respondent	Male	Female
	Education		
	Major income source of the family		
B	Information about previous latrine		
1	Where did your family members use latrine or defecation before having this latrine?	a. open defecation	
		b. used other's latrine	
		c. only women used latrine	
		d. used own latrine	
2	What type of latrine did you use earlier	a. hanging latrine	
		b. ring less pit latrine	
		c. ring-slab latrine	
		d. twin pit latrine	
		e. septic tank latrine	
3	How much you had to spend for installation of previous latrine?		
4	What were the advantages of previous latrine?	Maintenance is easy	
		Installation cost is low	
		Fecal matters are used as fertilizer	
		Take long time to fill up	
		Cleaning requirement is not frequent like other latrine	
		Others	
5	What are the disadvantages of previous latrine?	Wastes of water	
		Bloked by faeces/fecal matters	
		Evacuation cost high	
		Useless during flood	
		Odour	

		Others		
7	What are the frequency of previous pit cleaning/ desludging? And expenditure?			
C	Socio-ethical aspects			
1	Has the society not positive attitude towards your latrine?	Yes	No	Somebody
2	Did the community know about advantage of your latrine and they visit it?	Yes	No	Somebody
3	Did the community show their interest to see your latrine and to install it?	Yes	No	Somebody
4	Religiously is your latrine accepted by the community?	Yes	No	Somebody
D	Information about the uses & maintenances of ecosan toilet			
1	What is the frequency of cleaning of existing ecosan toilet			
3	Who cleans the latrine now??	Men		
		Women		
		Both men and women as and when required		
		Any body of the family		
4	What material is used to clean the latrine now	Ash		
		Water		
		harpic/ Latrine cleaning chemical or power		
		Detergent powder		
		Others		
5	Do you think the cleaning cost of this latrine is low?	Yes	No	
6	Do you think the cleaning is not labour intensive?	Yes labour intensive	No	Moderate
E	Technological			
1	How many years have you been using this ecosan toilet?	.....year .....month		
2	Why you have installed this type of latrine?	It was needed		
		We get manure		
		Environment friendly		
		Less expensive		
		Neighbors encouraged		
		Free of cost		
3	What are the advantages of toilet	Maintenance is easy		
		Least wastes of water		
		Faeces are used as manure		
		Urine used as manure		
		Take long time to fill up		
		Cleaning not required frequently		
		No cost is involved to vacate the latrine		
		It is usable during monsoon		
		Others		
4	Did you face any problem during initially use the latrine?	Yes		
		No		
		Not so significant		
5	Do you facing any problem to use the toilet now?	Ash is always required		
		To use alternative part in six month interval		
		Spread out the men's urine		
		Women's urine used to enter into the faeces chamber		
		Use carefully		
		Ensured supply of ash and saw dust		
		Takes time to habituate		
		Problem for guests		
6	What initiative is taken to solve the problem?			
7	Do you feel that odour, fly, mosquito are problem?	Frequent		
		Less than previous		
		Better		
		There is no problem regarding this		
11	Which persons do not use the toilet?	Old aged		
		Kids		
		Handicapped		
		Others		
13	Do the women feel safe to use the toilet?	Yes		No
14	Do the women feel comfort to use the toilet?	Yes		No
15	What kinds of problem did you face during using the toilet?			
16	Which problems were very frequent?			
17	Do you always suffer from the odour of latrine?	Yes	No	Occasionally
18	What do you think about the reason of odour?			
19	Do you face any problem during using the pan?	Yes		No
20	If any, what types of problem?			

22	If any problem, to whom it is concern?				
26	What are reasons of feeling discomfort?	The kids are afraid from large size of scot-hole			
		Old aged members do not prefer closed latrine			
		Old mens prefer open latrine			
		Others.....			
29	Have you any recommendation to improve the structure of the latrine				
30	Whichone is usually used, ash or saw, after defecation?	1. Ash	2. Saw dust		
31	From where do you collect the ash/sawdust?	Own source			
		From neighbor, if not available			
		From outside			
		Purchased, if necessary			
32	What about the market price of ash and sawdust?	Price of ash @..... Tk/kg			
		Price of sawdust @.....Tk/kg			
35	What is your opinion regarding the longevity of this latrine	.....year			
F	Information related to fecal matters used as manures				
1	Do you use the fecal matters and urine as fertilizer?	Yes	No	Sometimes	
6	Faeces or urine, which one, do you feel comfort to use?	Faeces	Urine	Both	
7	How many times did you extract manure from latrine?	Never			
		Once			
		Twice			
		Four or more times			
8	How long it requires filling up one chamber of toilet?	3 months			
		6 month			
		8 months			
		1 year			
	How long you have to wait when filling up the latrine pit for useable again?				
13	What is your opinion regarding the responsibility towards extracting manures from the latrine	Men's responsibility			
		Women's responsibility			
		Both's responsibility			
		Both			
14	Presently who does extract the manure?	Men			
		Women			
		Both men & women			
		Any body can perform			
		It requires 1-2 hours			
15	Do you think the cleaning of this latrine is not so labour intensive?	Yes, labour intensive			
		No hard			
		Moderately hard			
31	Do you use urine and faeces as fertilizer?				
	How much money you can save if you use urine and faeces as fertilizer?				
47	Considering the advantages about longevity and sustainable structure of latrine, what is your evaluation regarding the expenditure of installing a latrine?	Less	Higher	Reasonable	
G	Health related information				
1	How much you had to spend per month for diarrhea, before using this latrine?	……Tk			
2	How much you had to spend for diarrhea, after using this latrine?	……..Tk			
3	How many family members were affected by diarrhea before using this latrine?	.....person			
4	How many family members were affected by diarrhea during last two months?	.....person			
5	Do you think this type of latrine helped to reduce the diarrheainfectation in your family?	1. Yes	2. No	3. Seems to be	
6	What types of diseases have been affected your family members last one year?	Name of the diseases	Winter	Summer	Monsoon
		Diorhhea			
		Cholera			
		Loose motion			
		Dysentry			
		Jaundice/Hepatitis-A			
		Skin diseases			
		Stomachache			
		Others			
7	When do you family members wash their hands with soap and or ash?	After defecation			
		Before meal			
		After cleaning the babiesfaeces			
		Before feeding the babies			
		Before serving foods			
		Before cooking			
8	From where do you collect drinking water?	Tube-well			
		River/pond			
		Falls/haor/baor/wetlands			

9	What is the distance between drinking water source and un hygiene latrine?	Within 10 feet		
		Within 20 feet		
		Within 30 feet		
		More than 30 feet		
10	From where do you collect cooking water?	Tubewell		
		River/pond/wetland		
		Falls/haor/baor/wetlands		
11	If there any hanging latrine close to your water sources	1. Yes	2. No	
12	Do you drink boiled water or use chemical for purification ?	1. Yes	2. No	
15	Did you ever feel sick after applying the manure in the farm?	1. Yes	2. No	3. Not
H	Environment related			
1	Do you think your toilet is environment friendly?	1. Yes	2. No	3. May be
2	How it is Yes or No, please explain			
3	Does the fecal matter inside the chamber usually pollute the surroundings?	1. Yes	2. No	
4	Do you think during monsoon/disaster (flood, cyclone, tornedo) this latrine is being usable?	1. Yes	2. No	
5	Do you think the latrine will last long due to its good structure	1. Yes	2. No	
6	How frequent the flood seen during last 10 years?	1. Yes	2. No	
7	How many times your house has been submerged due to flood?	1. Yes	2. No	
8	Did the water enter into thefaeces-chamber of latrine during flood?	1. Yes	2. No	
9	Did the faeces-chamber pollute the environment during monsoon/flood?	1. Yes	2. No	
I	Institutional information			
1	Did you receive any training before installing the latrine?	1. Yes	2. No	
2	What were topics of the training	How to use latrine		
		Maintenance		
		How to utilize fecal matters as manure		
		Others		
3	Has the assisting organization yet been monitoring?	1. Yes	2. No	
4	Has the assisting organization yet been helping to repair the latrine?	1. Yes	2. No	
5	Has the assisting organization yet been helping to desludgethe latrine?	1. Yes	2. No	
J	Installation and uses of ecosan toilet			
1	Do you think this toilet is option for the community?	1. Yes	2. No	
2	If yes or know, what is the reason?			
3	What is the installataion cost of this toilet?			
4	How much did you spend/sharedfor installation this toilet?			
6	Are the skilled massion workers available in your locality?	1. Yes	2. No	
7	Are the larine-goods easily available in the market?	1. Yes	2. No	3. Except pan
8	Without any subsidy, what is your expectation about the affordable price of this latrine for the local community?			
9	Is it possible to install ecosan toilet in every household of the village without any assistance from government and or other organizations?	1. Yes	2. No	
13	What are constraints behind not popularizing this toilet?	Costly		
		Difficult to use		
		Land intensive		
		Need saw dust and ash		
		Others		
14	Do you have any comments on this toilet?			

Signature of the interviewer
Date:

Signature of respondent
Date:

APPENDIX – B: Check list to determine the proper functioning of latrine

Questionnaire survey for "Comparative Analysis of two eco-friendly sanitation options Worm-Based Toilet (Emerging Technology) and UDDT: case Bangladesh"

	Address: User Name: User Contact Number:				
1	Which option?	1) UDDT 2) Bio-fill			
2	What type of latrine	1) HH 2) Sharing 3) Communal 4) Institutional			
3	Super structure is made of which material?				
4	Closet water point (TW/Tap stand/ stream/pond)	A) Within 10 feet, B) Within 20 feet, C) Within 30 feet D) More than 30 feet			
5	Is the latrine constructed in no flooded/high land?	1	Yes	2	No
6	Is there enough ventilation?	1	Yes	2	No
7	Is there enough light inside?	1	Yes	2	No
8	Is the inside door locking system works properly?	1	Yes	2	No
9	Is there proper privacy? No one can see outside?	1	Yes	2	No

10	Is the proper access road and is fine with user?	1	Yes	2	No
11	Is the access road inundated during rain/monsoon?	1	Yes	2	No
12	Is there any lighting system for night use?	1	Yes	2	No
13	Is there any flies inside or outside?	1	Yes	2	No
14	Is there any hand washing place closest to latrine?	1	Yes	2	No
15	Is there any soap inside/outside the latrine for use after defecation?	1	Yes	2	No
16	Is there any dustbin placed inside the latrine?	1	Yes	2	No
17	Is there any odour generate from inside the latrine?	1	Yes	2	No
18	Is there any odour generate from outside the latrine?	1	Yes	2	No
19	Are the stairs OK?	1	Yes	2	No
20	Are the doors OK?	1	Yes	2	No
21	Is the inside floor of the latrine OK?	1	Yes	2	No
22	Is the Padastral/foot raise areOK?	1	Yes	2	No
23	Is the squatting pan, is OK?	1	Yes	2	No
24	Is the pit/septic tank for faeces outlet OK?	1	Yes	2	No
25	Is the faecesoverflowing the pit/septic tank OK?	1	Yes	2	No
26	Is there any proper soak pit?	1	Yes	2	No
27	Is wastewater water entering into the soak pit without any obstacle?	1	Yes	2	No
28	Is wastewater water overflowing the soak pit?	1	Yes	2	No
29	Is evaporation bed OK?	1	Yes	2	No
30	Is evaporation bed properly functioning?	1	Yes	2	No
31	Is heat panel OK?	1	Yes	2	No
32	Is there any leak in the heat panel?	1	Yes	2	No
33	Is the roof of the latrine OK?	1	Yes	2	No
34	Is the water leaking from the roof?	1	Yes	2	No
35	Is there proper drainage surrounding the latrine?	1	Yes	2	No
36	Is the gas pipe OK?	1	Yes	2	No
37	Is there any arrangement for water inside the latrine?	1	Yes	2	No
38	Is the surrounding environment clean?	1	Yes	2	No
	Signature of the interviewer: Date:				

APPENDIX – C: KII Questionnaire for sector professional

Questionnaire survey for "Comparative Analysis of two eco-friendly sanitation optionsWorm-Based Toilet (Emerging Technology) and UDDT: case Bangladesh"

	Name :			
	Designation and Organization :			
	Cell phone No.			
2	Have you ever use UDDT and Bio-fill toilet?	Yes	No	
			UDDT	Bio-fill
3	What are the advantages of ecosan toilet?	Maintenance is easy		
		Least wastes of water		
		Faecess are used as manure		
		Urine used as manure		
		Take long time to fill up		
		Cleaning not required frequently		
		No cost is involve to vacate the latrine		
		It is usable during monsoon		
		Others		
4	Is there difficulties have to face to use this toilet?	Yes	No	
5	Which type of problem has to face most?	Yes	No	
6	Do community people have interest to this toilet?	Yes	No	
12	Does the toilet is still useable?	Yes	No	
13	Does the user using faece and urine from the ecosan toilet as fertilizer?	Yes	No	
14	Does the user is a successful farmer?	Yes	No	
15	Do you think every household in your area should have this kind of toilet?	Yes	No	
17	What are the ways to scaling up the promotion of using this toilet?			
22	What are constraints behind not popularizing this toilet?	Costly		
		Difficult to use		
		Land intensive		
		Need saw dust and ash or worm		
		Others		
23	Do you think this kind of toilet is socially acceptable?	Yes	No	
24	Do you know that, due to religious barrier this latrine is not acceptable to all communities?	Yes	No	

	Do you think O&M is difficult?	Yes	No
	Do you think O&M cost is high?	Yes	No
	Do you think desluding is an issue for this option?	Yes	No
	According to user which options are user friendly?	Yes	No
25	Do you think to use urine and faeces as fertilizer is accepted by the farmer?	Yes	No
26	Do you think community people accepted to buy product from using use urine and faeces as fertilizer?	Yes	No
27	Do you think this latrine is the only environment friendly toilet?	Yes	No / Don't know
28	To popularizing this latrine which institution should take more initiative first?	Local government	DPHE
29	Do you have any comments on this toilet?		

Signature of the interviewer
Date:

Signature of respondent
Date:

Appendix – D: List of Biofil Toilet installed in different places

Sl	Area	Nos. of Installed Biofil Toilet	Type of Toilet	Model	Year	Duration	Desludging frequency	Status	Remarks
1	Aminbazar, Dhaka	15	Household Toilet		2014	5			
2	Kunderpar, Gaibandha	3	Household Toilet		2015	4			
3	Derai, Sunamgonj	3	Household Toilet		2015	4			
4	Cox's Bazar Sadar	3	Household Toilet		2015	4		Functional	
5	Kunderpar and Mollar Char, Gaibandha	2	School Toilet		2015	4			
6	Boro Bazar, Cox's Bazar	1	Public Toilet		2015	4		Functional	People not using for different management issue
7	Laimi para, Bandarban	3	Household Toilet		2016	3			
8	Kallayanpur, Dhaka	1	Household Toilet		2016	3			
9	Kutupalong, Ukhiya (ACF)	3	Household Toilet		2016	3			
10	Madarbuniya, Ukhiya (ACF)	135	Household Toilet		2016	3			
11	Bhashantek, Dhaka (W&L)	10	Household Toilet		2017	2		Functional	
12	Dhamalkot, Mirpur, Dhaka (Water Operator Partnership)	2	Household Toilet		2017	2			
13	Khulna Citi Corporation, Khulna	2	Household Toilet		2017	2			
14	Unchiprang, Teknaf, Cox's Bazar (Oxfam)	20	Household Toilet		2017	2			
15	Unchiprang, Teknaf, Cox's Bazar (AOSED)	35	Household Toilet		2017	2			
16	Balukhali, Ukhiya, Cox's Bazar (CCDB)	5	Household Toilet		2017	2			
17	Unchiprang, Teknaf, Cox's Bazar	1045	Household Toilet		2018	1			
18	Balukhali, Ukhiya, Cox's Bazar	80	Household Toilet		2018	1			
19	Mirpur, Dhaka (DSK)	1	Household Toilet		2018	1			
20	Moheshkhali, Cox's Bazar	150	Household Toilet		2018	1		Functional	10% pit is full and need to be desludging, this latrine are not in suitable location.
21	Nala, Kathmandu, Nepal	2	Household Toilet		2018	1			
22	Kutubdia, Cox's Bazar	80	Household Toilet		2018	1			
23	Rajapalong, Ukhiya, Cox's Bazar	50	Household Toilet		2018	1			
24	Kutupalong, Ukhiya	430	Household Toilet		2018	1			
25	Noyapara, Teknaf	250	Household Toilet		2018	1			
26	Balukhali, Ukhiya, Cox's Bazar	117	Community Toilet, 5 Cubicles		2018	1			
27	Different offices of ACF at camp	25	Office Toilet		2018	1			
28	Balukhali, Kutupalong, Lambashia of Ukhiya, Cox's Bazar	50	Community Toilet, 4 cubicles, Twin Pits		2018	1			
29	Balukhali, Kutupalong, Lambashia of Ukhiya, Cox's Bazar	20	Community Toilet, 2 cubicles,		2018	1			

			Twin Pits						
30	Chittagong City Corporation, Ctg.	4	Household Toilet		2018	1			
31	Cox's Bazar Sadar	6	Household Toilet		2019	0			
32	Jadimora, Teknaf	25	Convertion		2019	0			
	Total	**2578**							

Appendix – E: List of UDDT/Ecosantoilet installed in different places

Division	District	Number of EcoSan Toilet Installed	Divisional Total
Dhaka	Dhaka	3	241
	Gazipur	107	
	Manikganj	60	
	Munshiganj	25	
	Jamalpur	10	
	Narayanganj	5	
	Narshingdi	18	
	Faridpur	12	
	Tangail	1	
Chittagong	Bandarban	89	320
	Comilla	201	
	Chittagong	10	
	Rangamati	20	
Khulna	Jessore	185	246
	Satkhira	52	
	Meherpur	9	
Rajshahi	Chapainawabganj	48	152
	Naogaon	57	
	Sirajganj	47	
Barishal	Bhola	2	107
	Barguna	100	
	Noakhali	5	
Sylhet	Moulovibazar	12	52
	Sunamganj	40	
Rangpur	Rangpur	61	217
	Gaibandha	87	
	Kurigram	69	
Total		1335	1335

EcoSan Toilet Type		
Household	Community	Total
1290	45	1335

EcoSan Toilet Use Pattern		
Use	Not Use	Total
1265	70	1335

Appendix – F: Different types UDDT/Ecosan toilet model design and technical description

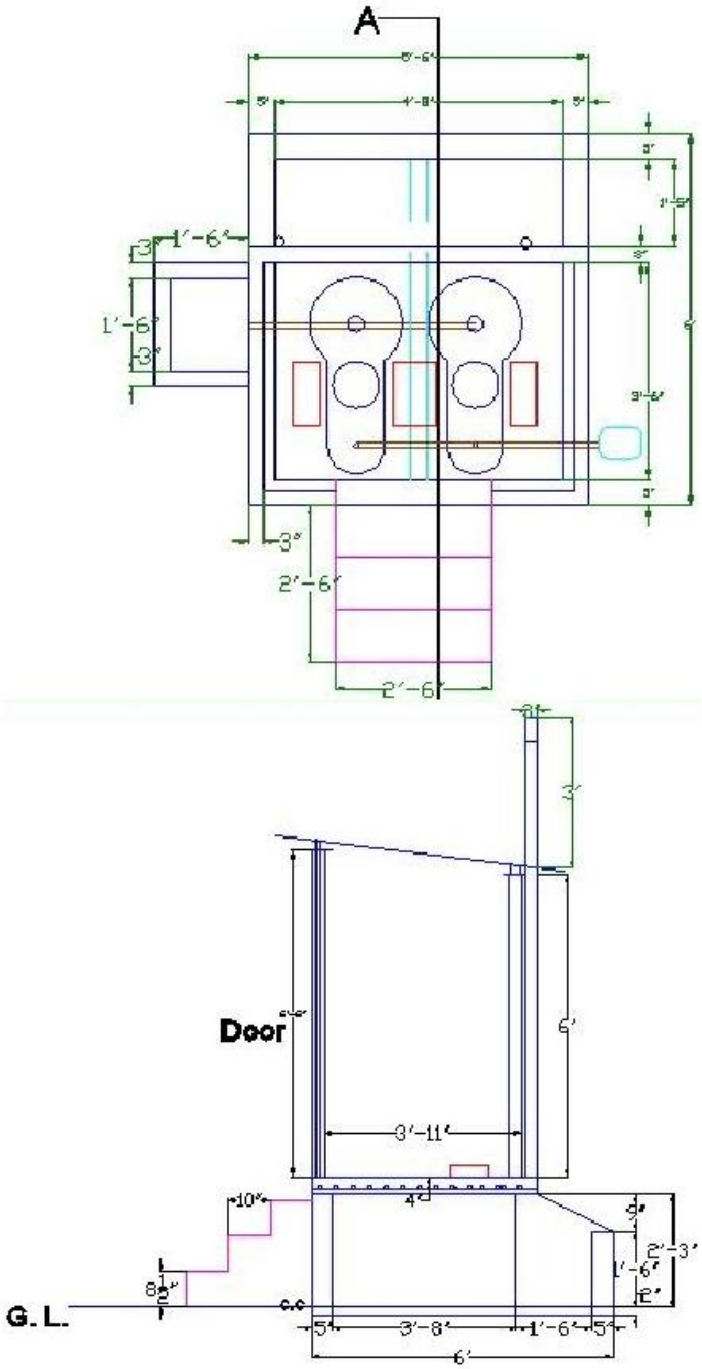
Option 1: Fixed Chamber System Using Plastic Fiber Pan

Characteristics

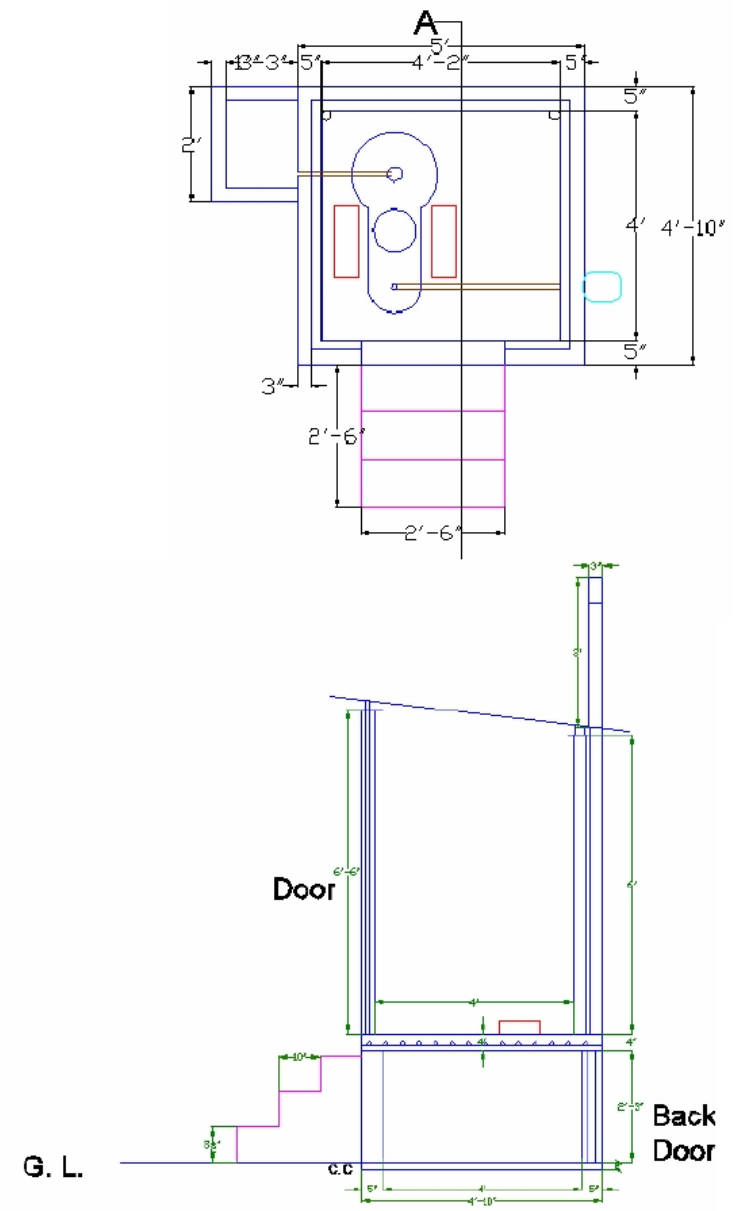
- Two plastic fiberecopans (alternate use in six month interval), Ecopan separates the faeces, urine, and anal cleansing water
- Two fixed chamber (brick made) for faeces storage.
- Dark black painted GI sheet is used as the heat panel on back of the chamber, Heat panel facilitate the drying of faeces and moisture reduction ensuring heat trapping from sunlight.
- Two vent pipes from two corners are used to remove the odor from the toilet. Require 33 square feet of area.
- Substructure should be made of brick.

Construction cost

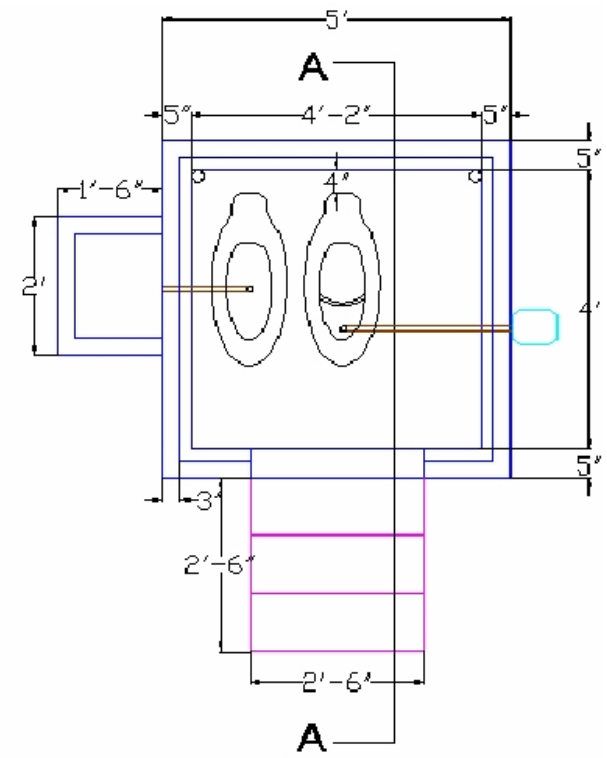
- BDT 12819.00 for brick structure (substructure cost BDT 8369.00) and
- Cost BDT 11219.00, if superstructure made by Bamboo.

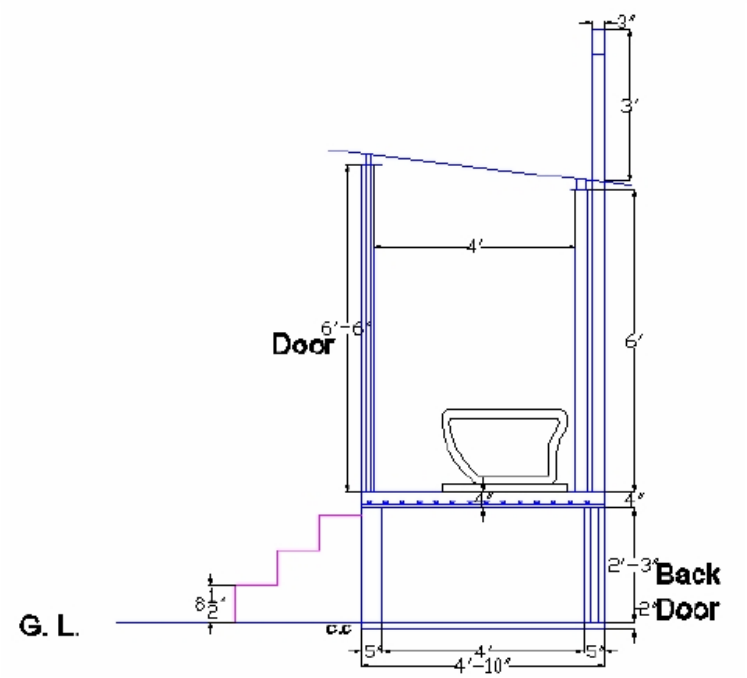


Option 2: Movable Drum System Using Plastic Fiber Pan (Single Pan)
Characteristics • One plastic fiberecopan is used (Ecopan will separate the faeces, urine and anal cleansing water) • Two plastic drums are used instead of fixed chamber (alternate use in six month interval) • Two vent pipes in two corners have been used to remove the odor from the toilet • No heat panel is used as faeces store in drum, • A back door is provided for taking in and out of the plastic drum Require 25 square feet of area. • Bamboo/Mud or other available materials can be us for Substructure of the toilet
Construction cost • BDT 12156.00 for brick structure (substructure cost BDT 7766.00) • Cost BDT 10616.00, if superstructure made by Bamboo

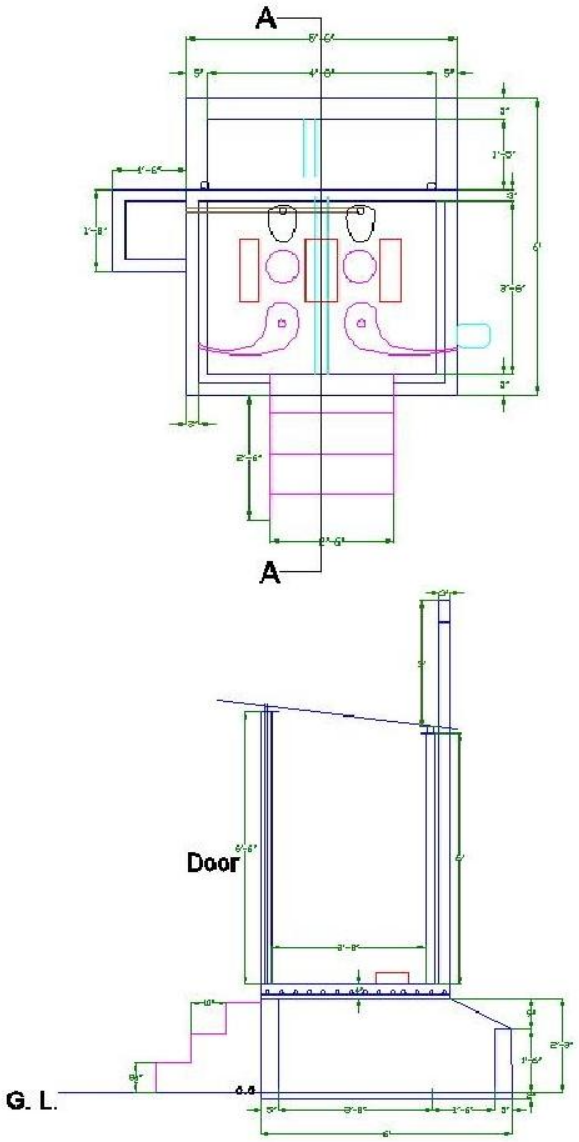


Option 3: Movable Drum System Using High Commode (Single Pan)
Characteristics • Two special type of high commode is used. One commode uses to divert the urine and collect faeces on drum, another for anal cleansing. • Two plastic drums are used instead of fixed chamber (alternate use in six month interval). • Two vent pipes from two corners are used to remove the odor from the toilet. • No heat panel will be used as faeces store in drum. • A back door is provided for taking in and out of the plastic drum instead of heat panel. • Area required to construct is 25 sq feet. • Bamboo/Mud or other available materials can be us for Substructure of the toilet.
Construction cost • Construction cost BDT 13146.00 for brick structure (substructure cost BDT 8696.00) • Cost BDT 11196.00, if superstructure made by Bamboo.

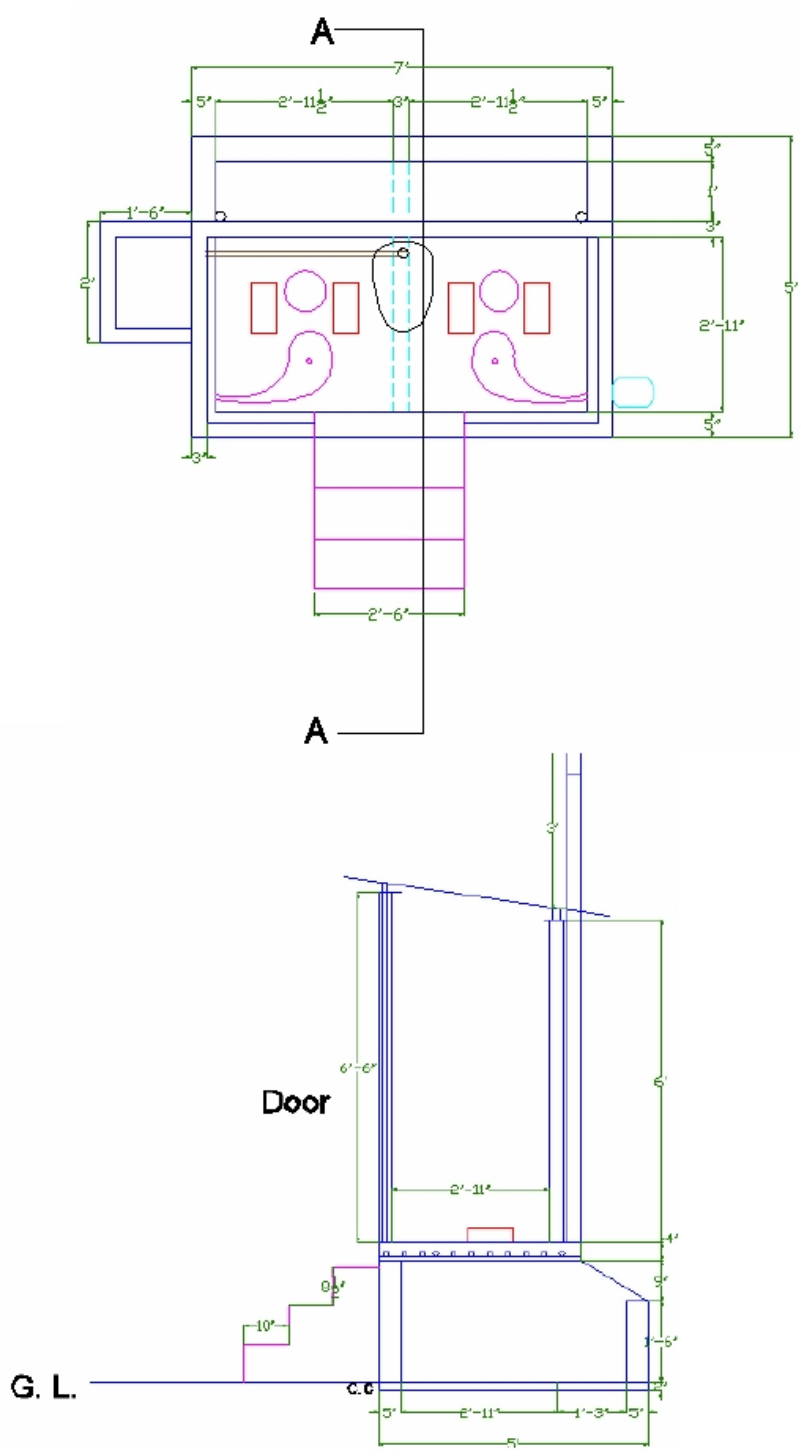




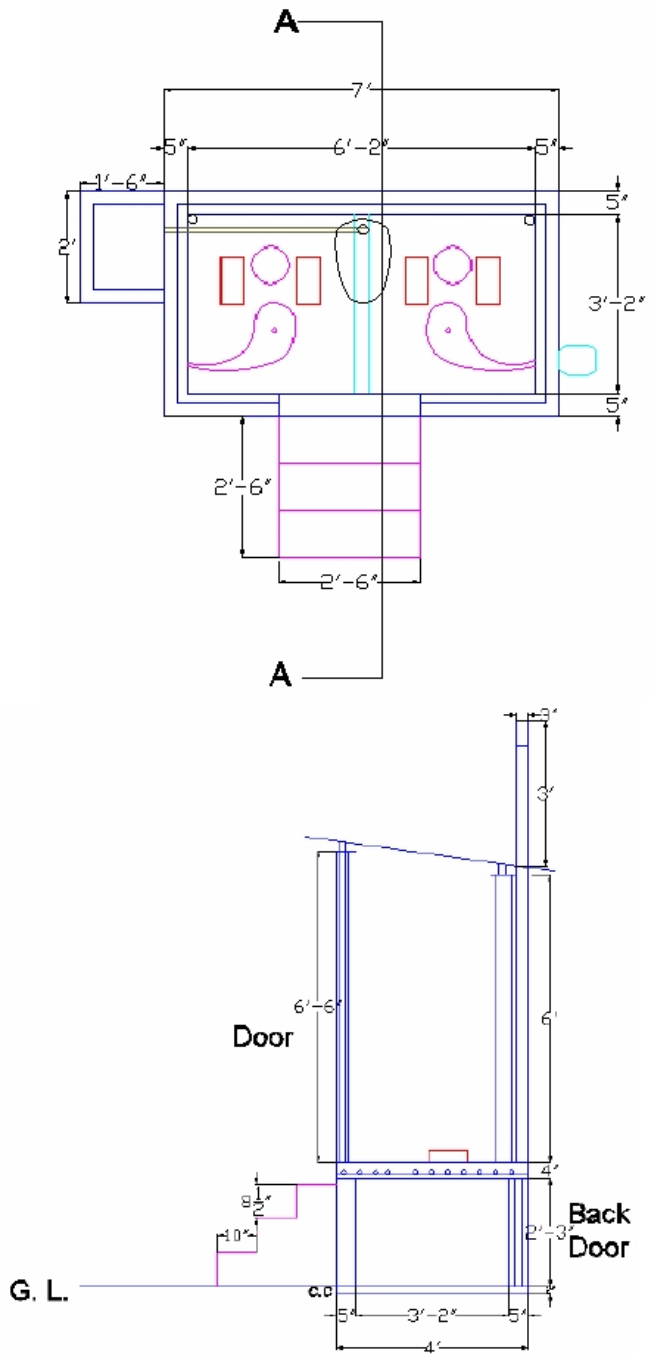
Option 4: Fixed Chamber System Using Modified Traditional Eco Pan
Characteristics • Option modified from traditional ecopan introduced by BARD. • Slab on PL (plinth level) constructed such a way which provides facilities for urinal separation and faces. • Anal cleansing facility is provided back instead of middle of the slab (it reduce the space requirement). • Two pans and two fixed chamber is used. • Two vent pipes in two corners are used removing the odor from the toilet. • Dark black painted GI sheet is used as the heat panel on back of the chamber. • Option requires 33 square feet of area. Substructure should be made on brick.
Construction cost • Construction cost BDT 11679.00 for brick structure (substructure cost BDT 7229.00) • Cost BDT 10079.00, if superstructure made by Bamboo.



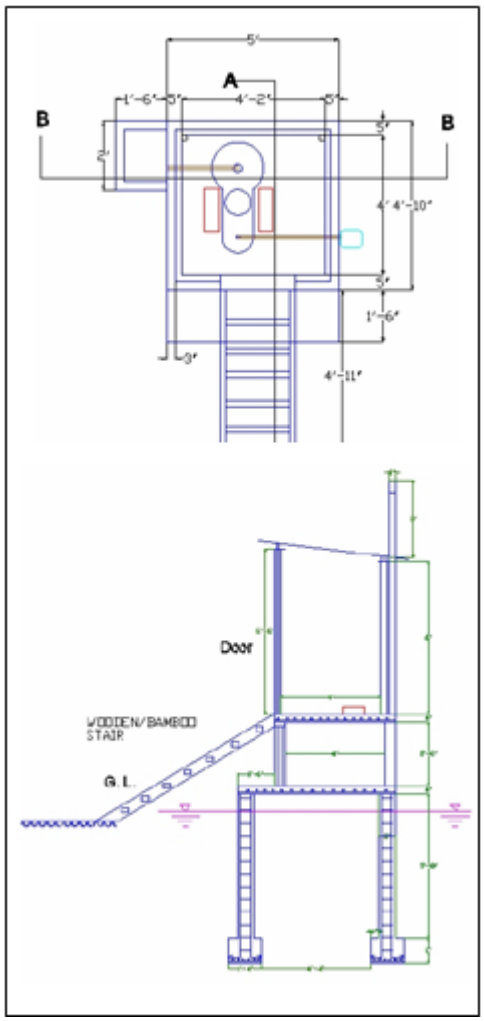
Option 5: Fixed Chamber System Using Traditional Eco-Pan
Characteristics • Traditional eco-toilet. • Slab on PL (plinth level) constructed such a way which provides facilities for urinal separation and faces. • Anal cleansing facility is provided middle of the slab two pans and two fixed chamber is used. • Two vent pipes in two corners are used removing the odor from the toilet. • Dark black painted GI sheet is used as the heat panel on back of the chamber. Option requires 35 square feet of area. Substructure should be made on brick.
Construction cost • Construction cost BDT 12279.00 for brick structure (substructure cost BDT 7789.00) • Cost BDT 10639.00, if superstructure made by Bamboo.



Option 6: Movable Plastic Drum System Using Traditional Eco-Pan
Characteristics • Option modified from traditional ecopan introduced by BARD. • Slab on PL (plinth level) constructed such a way which provides facilities for urinal separation and faces. • Anal cleansing facility is provided back instead of middle of the slab (it reduce the space requirement). • Two pans and two movable drums are used. • Two vent pipes in two corners are used removing the odor from the toilet. • A back door is provided for taking in and out of the plastic drum instead of heat panel. Option requires 25 square feet of area. • Bamboo/Mud or other available materials can be us for Substructure of the toilet.
Construction cost • Construction cost BDT 12436.00 for brick structure (substructure cost BDT 7946.00) and Cost BDT 10796.00, if superstructure made by Bamboo.



Option 7: Elevated Movable Plastic Drum System with RCC Column
Characteristics • Option specially designed for haor and flood prone area • The toilet has an elevated platform by R.C.C column and slab. One plastic fiberecopan and two movable plastic drum is used • One ladder is provided to reach the elevated platform from ground level. • No heat panel is used • A back door provided for taking in and out of the plastic drum instead of heat panel This option requires 25 square feet of area. Entire structure made by brick and concrete
Construction cost • Construction cost BDT 17500.00 for brick structure (substructure cost BDT 13110.00) • Cost BDT 15960.00, if superstructure made by Bamboo.



Option 8: Single Pit Urine Diversion Toilet
Characteristics • By definition, it can not be said eco toilet. • Option specially designed with minimum cost for the poor people. One urine diversion pan with water sealing component is used. • One special pan provides facilities for separation urine and faeces. No separate facilities for anal cleansing. • Faeces and anal cleansing water will go directly to the ring pit (05 nos). Vent is provided at the middle of the toilet. • Urine will go to the urine pot through separate pipeline. This option requires 12 square feet of area.
Construction cost • Cost BDT 5405.00 for bamboo made super-structure.

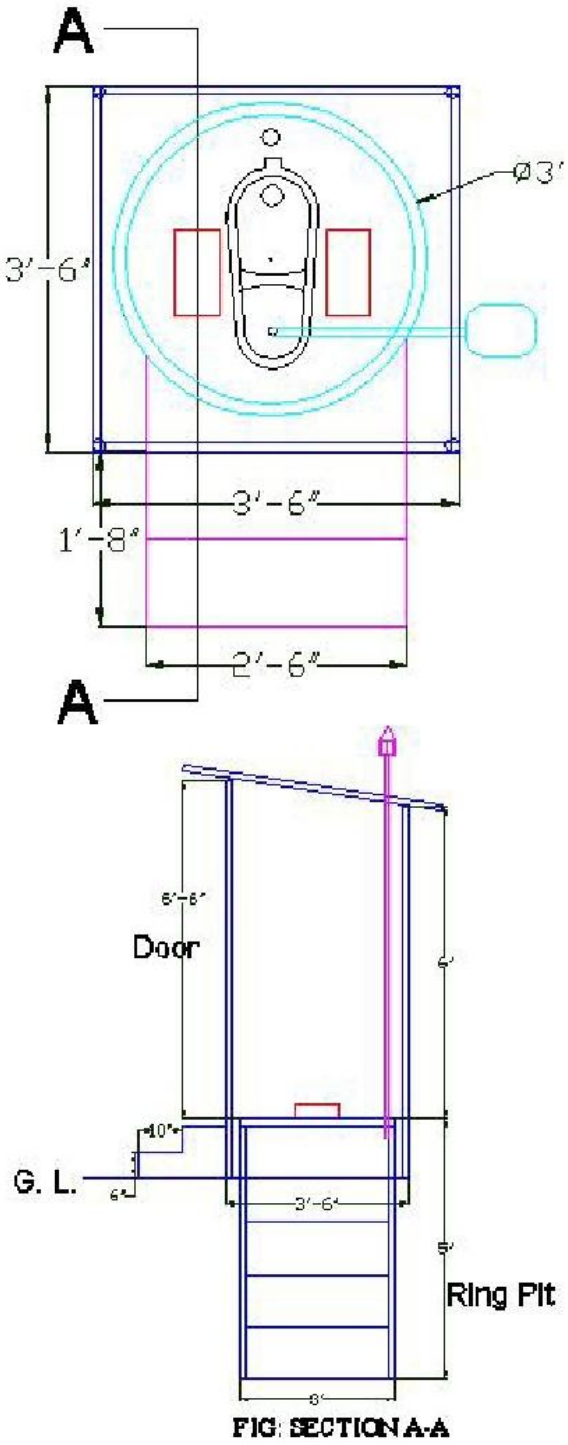
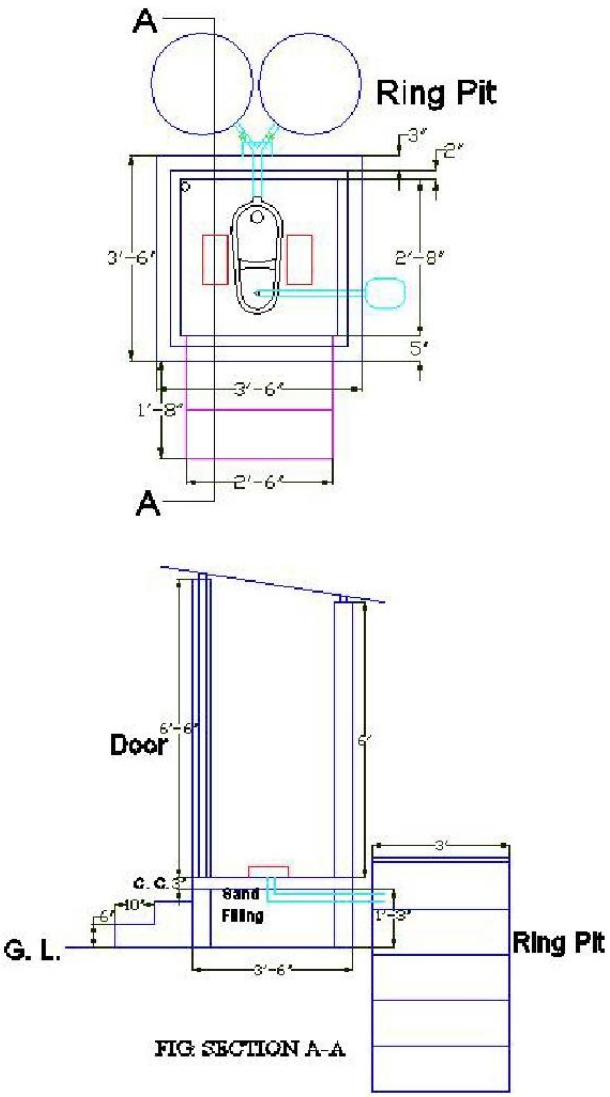
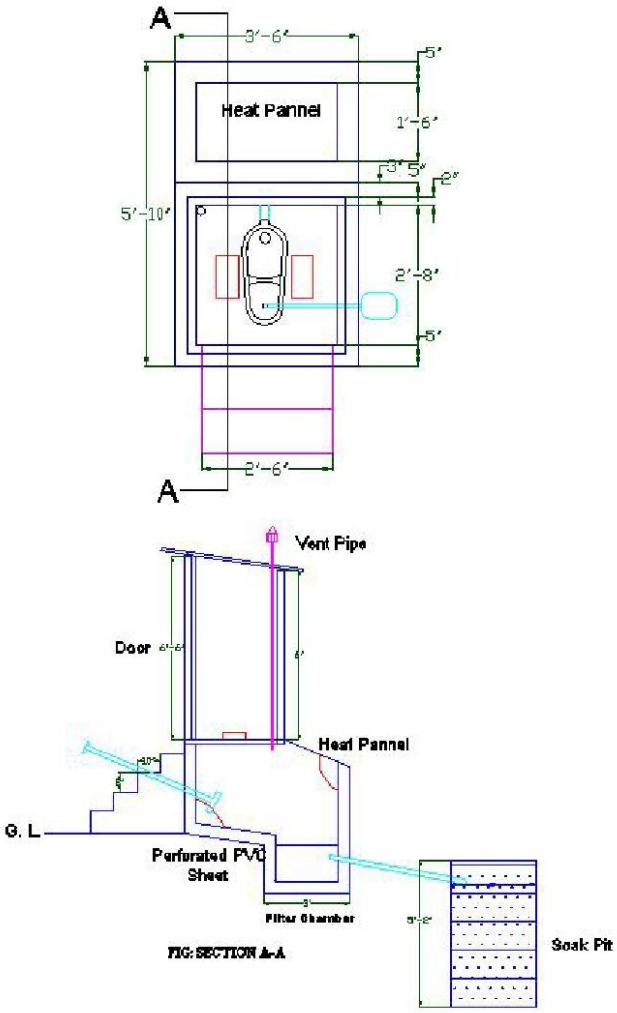


FIG: SECTION A-A

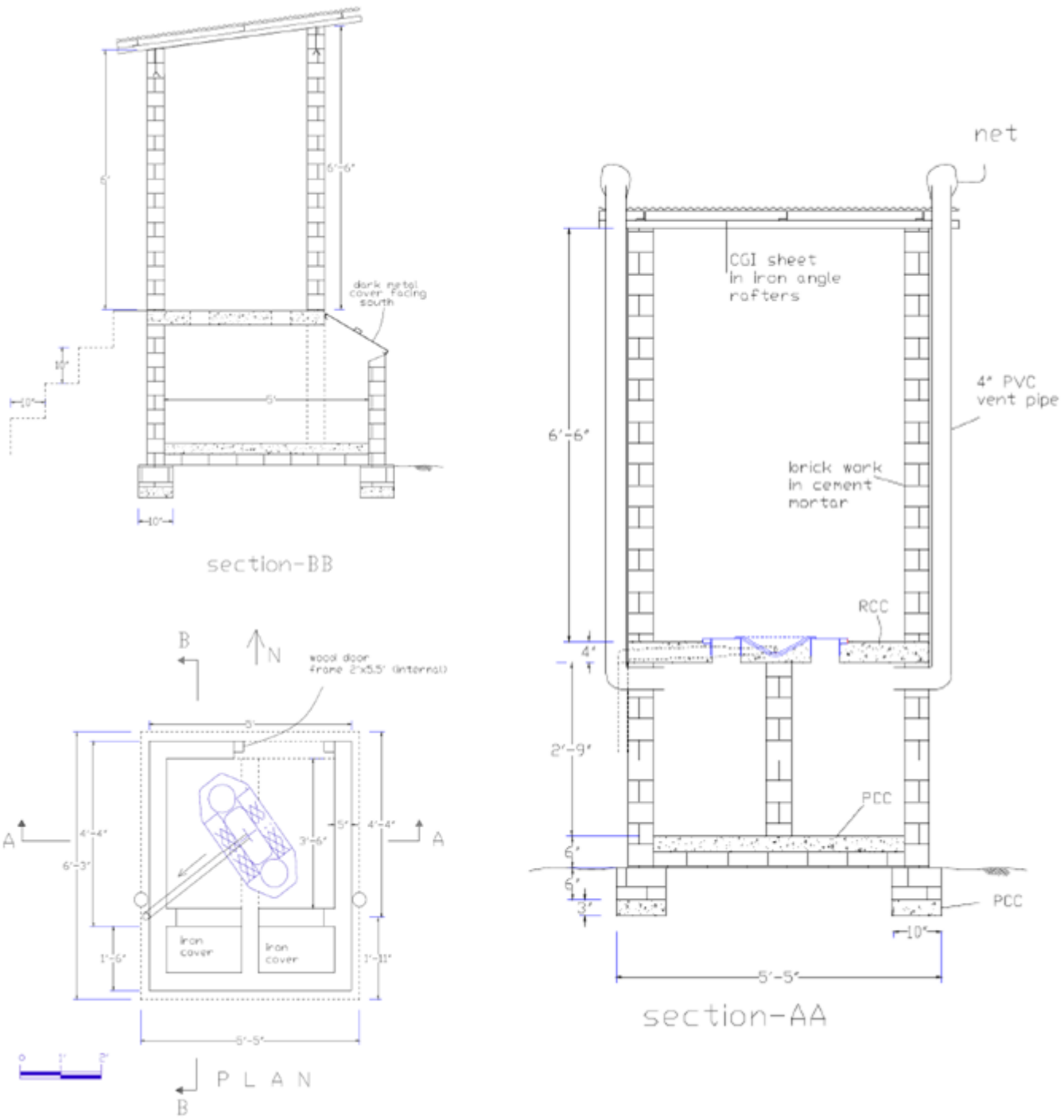
Option 9: Twin Pit Urine Diversion Toilet
Characteristics • Popularly known as twin pit but little modification that is one special pan provides facilities for separation urine and faeces with water sealing component. One urine diversion pan is used for this option. No separate facilities for anal cleansing. • Faeces and anal cleansing water will go directly to the ring pit (10 nos). Two ring pits is used alternately in six month interval after filling of one. The area required to construct this option is 25 sq feet.
Construction cost • Construction cost BDT 11200.00 for brick structure (substructure cost BDT 7600.00) • Cost BDT 9220.00, if superstructure made by Bamboo



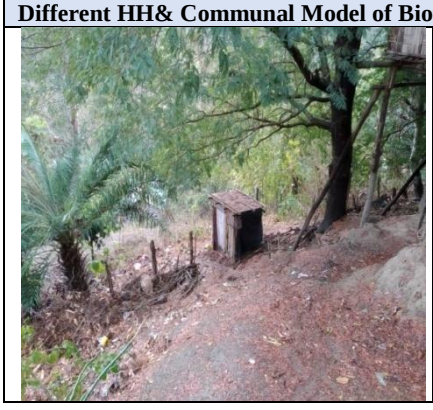
Option 10 : Waste Concern Model using Urine Diversion Pan
Characteristics • UNICEF designed implemented by waste concern. • Urine will go directly to the urine container by separate pipeline • Faeces and anal cleansing water goes to the sub-structure chamber. • Anal cleansing water goes to soak pit through a filter media • Faces will remain upon on the filter media Heat panel is used. • The area required to construct this option is 30 sq feet.
Construction cost



Option 11: UDDT, Terre des hommes Lausanne
Characteristics • Separation of excreta and urine/liquids • Containment of excreta in a vault where it can dehydrate • Infiltration of urine and anal wash water in the soil (urine is not collected and used as a fertiliser because there is no demand for it • Alternate use of the vault, approximately every twelve months.
Construction cost • 42456 BDT



Appendix – G:Different types Biofil toilet model design and technical description

Different HH& Communal Model of Biofil Toilet		
	**Direct drop in tank of rings and slab** Details: • 4 rings (30 inches dia) • 1 slab • 1 Sato pan • Biofil filter • Bamboo pillars • Bamboo walls • Transparent plastic roof on bamboo frame • 3" dia Vent pipe	Constriction Cost: BDT 15000 O&M Cost: BDT 20 (annually) Number of user: 05 Desludging frequency: Once in 5 years

	**Off set system in tank of rings and slab** Details: • 5 rings (30 inches dia) • 2 slabs • 1 Ceramic pan • Biofil filter • Bamboo pillars • Bamboo walls • Transparent plastic roof on bamboo frame • 3" dia Vent pipe	Constriction Cost: BDT 18000 O&M Cost: BDT 20 (annually) Number of user: 05 Desludging frequency: Once in 5 years
	**Single pit direct drop system** Details: • 5 rings (35 inches dia) • 1 slab with SATO pan • Biofil filter • Bamboo pillars • Laminated plain sheet walls on wooden frame • Transparent plastic roof on wooden frame • 4" dia Vent pipe	Constriction Cost: BDT 26000 O&M Cost: BDT 20 (annually) Number of user: 05 Desludging frequency: Once in 6 years
	**Single pit direct drop system** Details: • 5 rings (48 inches dia) • 1 slab with SATO pan • Biofil filter • Angle pillars • Laminated plain sheet walls on angle frame • Transparent plastic roof on angle frame • 4" dia Vent pipe	Constriction Cost: BDT 56000 O&M Cost: BDT 20 (annually) Number of user: 08 Desludging frequency: Once in 6 years
	**Onset system with ferrocement tank and soak pit** Details: • 3'X6'X2' size ferrocement tank • 1 Ceramic pan • Biofil filter • Angle pillars with red oxide coating • CI sheet walls on Angle frame • Transparent plastic roof on Angle frame • 4" dia Vent pipe • 1 soak pit with 3-4 rings and 1 slab	Constriction Cost: BDT 58000 O&M Cost: BDT 20 (annually) Number of user: 08 Desludging frequency: Once in 7 years
	**Onset system with ferrocement tank and soak pit** Details: • 3'X6'X2' size ferrocementtank • 1 Ceramic pan • Biofil filter • Wooden pillars with red oxide coating • CI sheet walls on wooden frame • Transparent plastic roof on wooden frame • 4" dia Vent pipe • 1 soak pit with 3-4 rings and 1 slab	Constriction Cost: BDT 48000 O&M Cost: BDT 20 (annually) Number of user: 08 Desludging frequency: Once in 7 years

	**Onset system with brick built tank and soak pit** Details: • 4'X7'X2.5' size tank • 1 Ceramic pan • Biofil filter • Brick walls • Concrete roof • Plastic door • 4" dia Vent pipe • 1 soak pit with 3-4 rings and 1 slab	Constriction Cost: BDT 75000 O&M Cost: BDT 20 (annually) Number of user: 08 Desludging frequency: Once in 8 years
	**Twin pit (Off set system) with two cubicles** Details: • Twin pits with 48" diarigns. 10 rings of 6" height in each pit. • Two top slabs with 4" dia vent pipe • 2 Ceramic pans with flipper of SATO pan • 2 Biofil filter • 3'-10" long, 3' wide and 6' height superstructures • Roof with FRP • 1 inspection pit	Constriction Cost: BDT 105000 O&M Cost: BDT 40 (annually) Number of user: 20/cubicles/day (in slum or refugee camp) Desludging frequency: Minimum one year
	**Twin pit (Off set system) with four cubicles** Details: • Twin pits with 48" diarigns. 10 rings of 6" height in each pit. • Two top slabs with 4" dia vent pipe • 4 Ceramic pans with flipper of SATO pan • 2 Biofil filter • 3'-10" long, 3' wide and 6' height superstructures • Roof with FRP • 1 inspection pit	Constriction Cost: BDT 160000 O&M Cost: BDT 80 (annually) Number of user: 80 (in slum/refugee camp) Desludging frequency: Minimum one year
	**Four cubicles Biofil Toilet with offset twin pits and ramp for person with disabilities** Details: • Twin pits with 48" diarigns. 10 rings of 6" height in each pit. • Two top slabs with 4" dia vent pipe • 4 Ceramic pans with flipper of SATO pan • 1 folding wooden chair for person with disabilities • 2 Biofil filter • 3'-10" long, 3' wide and 6' height superstructures • Roof with FRP • Ramp with SS ralling • 1 inspection pit	Constriction Cost: BDT 180000 O&M Cost: BDT 80 (annually) Number of user: 80 (in slum/refugee camp) Desludging frequency: Minimum one year
	**Five cubicles Bifol Toilet block with direct drop holding tank** Details: • Superstructure made of laminated plain sheet on wooden frame with bamboo pillars. • FRP roof on wooden freame • 4" dia vent pipe • Brick built holding tank • Biofil filter • RCC top slab • SATO pan • Earth around compacted and covered with	Constriction Cost: BDT 130000 O&M Cost: BDT 100 (annually) Number of user: 75 (in slum and refugee camp) Desludging frequency: Minimum one year

	geotex bags	
	**Mobile Biofil Toilet** Details: • Superstructure made of laminated plain sheet on angle. • FRP roof on angle • 4" dia vent pipe • Tank with drawer consists Biofil filter (made of stone chips) • Top slab made of fiber glass • Fiber glass pan with flipper of SATO pan • Stairs made of angle • 1 soak pit	Constriction Cost: BDT 80000 (available on daily rental basis) O&M Cost: BDT 20 (annually) Number of user: Unlimited (drawer of the tank can be replaced once one is full) Desludging frequency: Depends on the use. (minimum 50 users/day/toilet in a four day's event did not need to desludge)
	**Biofil 'Toilet in a Packet'** Details: • Total toilet is made of fiber glass including Biofil filter • Stair is made of angle • 4" dia vent pipe • One soak pit • Toilet is available in a packet of 80 kg. other than worms • Worms are available in a separate packet • Possible to install within 30 minutes by 3 persons	Constriction Cost: BDT 90000 O&M Cost: BDT 20 (annually) Number of user: 10 at HH level, 20 at slum/refugee camp Desludging frequency: Minimum 5 years at HH level and, minimum 1 year at slum/refugee context
Community/Institutional Option		
	**Communal Biofil Toilet Block for slum** Details: • Nine superstructures made of CGI sheets on wooden frame. • FRP roof on wooden frame • 4" dia vent pipe • Tank of ferrocement blocks with Biofil filter inside • SATO pan • Stairs • 9 soak pits	Constriction Cost: BDT 450000 O&M Cost: BDT 180/year Number of user: 90 Desludging frequency: Minimum 5 years
	**Communal BiofilToilet Block for school** Details: • Three superstructures made of CGI sheets on wooden frame. • FRP roof on wooden frame • 4" dia vent pipe • Tank of ferrocement blocks with Biofil filter inside • SATO pan • Ramp • 3 soak pits	Constriction Cost: BDT180000 O&M Cost: BDT 60/year Number of user: 500 Desludging frequency: Minimum 5 years

	**Communal latrine for market place** Details: • Block of three toilets and one urinal. Made of brick walls and RCC roof with plastic doors. • FRP roof on wooden frame • 4" dia vent pipe • Offset tank of brick wall and RCC covers with Biofil filter inside • Ceramic pans	Constriction Cost: BDT 410000 O&M Cost: BDT 100/year Number of user: 100/day Desludging frequency: Minimum 1 year
	**Converting existing pit/holding tank latrine in to Biofil Toilet** Details: • Remove the superstructure • Inserting Biofil filter in the middle of the existing tank • Replacing the existing superstructure	Constriction Cost: Depends on the existing structure. However, generally less than 50% of constructing a new toilet O&M Cost: Not more than BDT 100/year Number of user: Depends on the size of the structure Desludging frequency: Depends on the number of user (however, minimum 3 times less than previous option)

APPENDIX – H: Photograph of survey toilets

Biofil Toilet




Location: Cox's Bazar Sadar **Number of Toilet:**3 **Model: Type:** HH **Year of Installation:** 2015

Location: Boro Bazar, Cox's Bazar**Number of Toilet:**1 **Model: Type:** Public **Year of Installation:** 2015


Location: Madarbuniya, Ukhiya**Number of Toilet:**135 **Model: Type:** HH **Year of Installation:** 2016



Location: Number of Toilet: Model: Type: Shared Emergency **Year of Installation:** 2018

Location: Unchiprang, cox. Bazar**Number of Toilet: Model: Type:** HH**Year of Installation:** 2019

UDDT/Ecosan Toilet




Location: Number of Toilet: Model: Type: HH**Year of Installation:** 2018




Location: Narangonj, Dhaka**Number of Toilet:**3**Model: Type:** Pubic (slum)**Year of Installation:** 2016




Location: Narangonj, Dhaka**Number of Toilet:**3**Model: Type:** Pubic (slum)**Year of Installation:** 2016

Location: Narangonj, Dhaka**Number of Toilet:**3**Model: Type:** Pubic (slum)**Year of Installation:** 2016

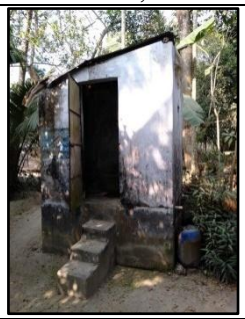

Location: Narangonj, Dhaka **Number of Toilet:**3**Model: Type:** Pubic (slum)**Year of Installation:** 2016




Location: Sharsha, Jossore **Number of Toilet:Model: Type:** HH **Year of Installation:** 2008




Location: Sharsha, Jossore**Number of Toilet:Model: Type:** HH **Year of Installation:** 2008




Location: Kashobpur, Jossore**Number of Toilet:Model: Type:** HH **Year of Installation:** 2008

Appendix – I : Lab test results

Ecosan Compost Test

icddr,b

Environmental Microbiology Laboratory

Lab. I.D # 11 Receipt No: 22587 Reporting Date: 13.01.2011

Particular of Sample : Human Compost

Location : SSUS Sonargaon, Gabandha

Date received : 04.01.2011

Examination requested: Identification of Parasite in Human Compost

REPORT

Name of parasites	Form found	Results (Count/gm)
Helminth		
1. *Ascaris* spp.	Egg	160
2. *Ancylostomes* spp.	Larva	0
3. *Necator* spp.	Larva	0
4. *Hymenolepis* spp.	Egg	40
Protozoa		
1. *Entamoeba* spp.	Cyst	720
2. *Giardia* spp.	Cyst	0
3. *Cryptosporidium* spp.	Cyst	0
4. *Cyclospora* spp.	Cyst	0

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Md. Sirajul Islam
Environmental Microbiologist and Head
Environmental Microbiology Lab
LSD, ICDDR,B, GPO Box-128
Dhaka-1000, Bangladesh

Dept. of Soil, Water & Environment
University of Dhaka
Dhaka 1000
Bangladesh

Tel : 9661920-73/7470, Fax : (880-2) 8615583; www.univdhaka.edu

Date:20.02.11

Report on Compost

Table 1: Results of the supplied compost analysis

sample No.	Moisture (%)	pH	EC dS/m	O.C. (%)	Total N (%)	Total p (%)	Total K (%)	Total Mn (%)	As	Pb	Cd	Cr	Ni
										ppm			
1	10.26	8.35	19.6	3.13	0.37	0.240	0.643	0.065	BDL	2.51	0.46	21.90	20.64

Prof. Dr. S.M. Ullah
Chairman

icddr,b

Environmental Microbiology Laboratory

Lab. I.D # 11 Receipt No: 22587 Reporting Date: 13.01.2011

Particular of Sample : Human Compost

Location : SSUS Sonargaon, Gabandha

Date received : 04.01.2011

Examination requested: Bacteriological test

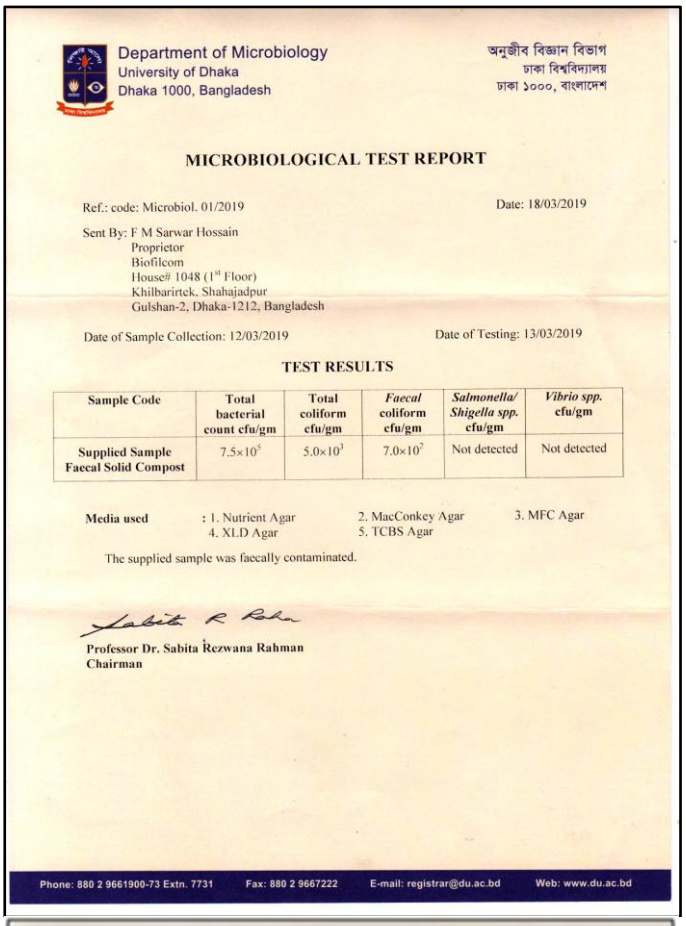
REPORT

Name of test	Unit	Results
1. Total coliforms	MPN /g	43
2. *Vibrio cholerae*	Present or absent / 10g	Absent
3. *Salmonella & Shigella* spp.	Present or absent / 10g	Absent
4. *Clostridium perfringens*	Present or absent / g	Absent

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Md. Sirajul Islam
Environmental Microbiologist and Head
Environmental Microbiology Lab
LSD, ICDDR,B, GPO Box-128
Dhaka-1000, Bangladesh

Biofil Compost Test



Department of Microbiology
University of Dhaka
Dhaka 1000, Bangladesh

অনুজীব বিজ্ঞান বিভাগ
ঢাকা বিশ্ববিদ্যালয়
ঢাকা ১০০০, বাংলাদেশ

MICROBIOLOGICAL TEST REPORT

Ref.: code: Microbiol. 01/2019 Date: 18/03/2019

Sent By: F M Sarwar Hossain
Proprietor
Biofilcom
House# 1048 (1st Floor)
Khilbarirtek, Shahajadpur
Gulshan-2, Dhaka-1212, Bangladesh

Date of Sample Collection: 12/03/2019 Date of Testing: 13/03/2019

TEST RESULTS

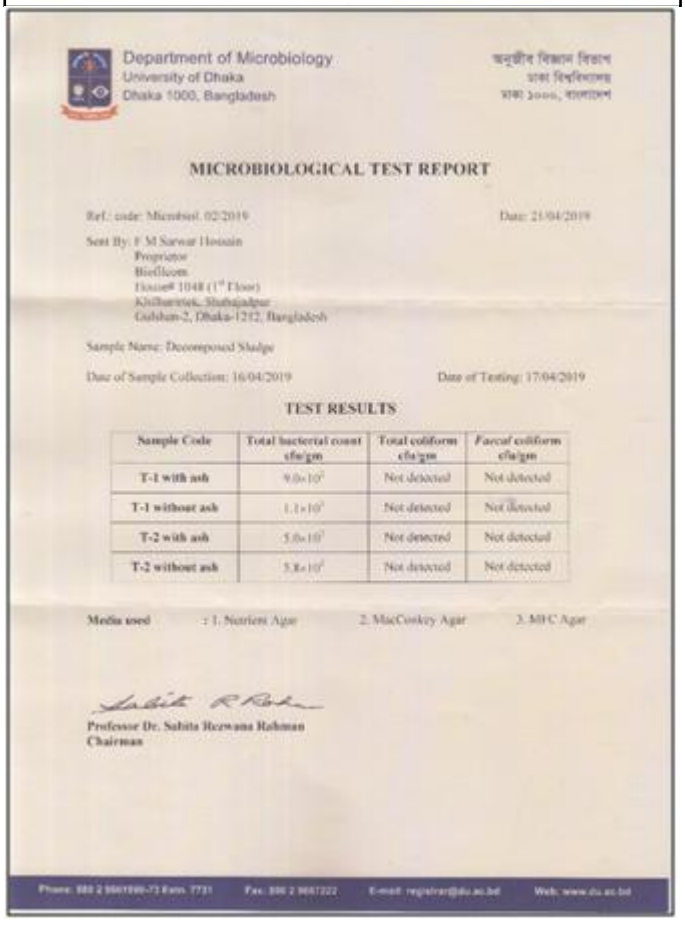
Sample Code	Total bacterial count cfu/gm	Total coliform cfu/gm	*Faecal* coliform cfu/gm	*Salmonella/ Shigella spp.* cfu/gm	*Vibrio spp.* cfu/gm
Supplied Sample Faecal Solid Compost	7.5×10^5	5.0×10^3	7.0×10^2	Not detected	Not detected

Media used : 1. Nutrient Agar 2. MacConkey Agar 3. MFC Agar
4. XLD Agar 5. TCBS Agar

The supplied sample was faecally contaminated.

Professor Dr. Sabita Rezwana Rahman
Chairman

Phone: 880 2 9661900-73 Extn. 7731 Fax: 880 2 9667222 E-mail: registrar@du.ac.bd Web: www.du.ac.bd



Department of Microbiology
University of Dhaka
Dhaka 1000, Bangladesh

MICROBIOLOGICAL TEST REPORT

Ref.: code: Microbiol. 02/2019 Date: 21/04/2019

Sent By: F M Sarwar Hossain
Proprietor
Biofilcom
House# 1048 (1st Floor)
Khilbarirtek, Shahajadpur
Gulshan-2, Dhaka-1212, Bangladesh

Sample Name: Decomposed Sludge

Date of Sample Collection: 16/04/2019 Date of Testing: 17/04/2019

TEST RESULTS

Sample Code	Total bacterial count cfu/gm	Total coliform cfu/gm	*Faecal* coliform cfu/gm
T-1 with ash	9.0×10^5	Not detected	Not detected
T-1 without ash	1.1×10^6	Not detected	Not detected
T-2 with ash	5.0×10^5	Not detected	Not detected
T-2 without ash	3.8×10^5	Not detected	Not detected

Media used : 1. Nutrient Agar 2. MacConkey Agar 3. MFC Agar

Professor Dr. Sabita Rezwana Rahman
Chairman

মৃত্তিকা, পানি ও পরিবেশ বিভাগ
ঢাকা বিশ্ববিদ্যালয়
ঢাকা ১০০০

Department of Soil, Water and Environment
University of Dhaka
Dhaka 1000
Bangladesh

Date: 28. 03. 2019

Report of Analysis

Sample supplied by

BIOFILCOM
House # 1048 (1st Floor)
Khilbarirtek, Shahajadpur
Gulshan-2, Dhaka-1212, Bangladesh

Sample Title: Organic Fertilizer (Fecal Sludge)

Analytical Results:

Sl. No.	Physical Parameters	Value
1.	Physical condition	Non- granular Solid Organic Material
2.	Colour	Dark grey to black
3.	Odour	Absence of foul odour
4.	Moisture (%)	68.89
	Chemical Parameters (air dry basis)	
5.	pH	6.00
6.	Organic Carbon (%)	15.63
7.	Total Nitrogen (%)	1.20
8.	C : N	13.02 : 1
9.	Total Phosphorus (%)	1.12
10.	Total Potassium (%)	0.36
11.	Total Copper (Cu) (ppm)	105.85
12.	Total Zinc (Zn) (ppm)	524.60
13.	Total Lead (Pb) (ppm)	21.89
14.	Total Cadmium (Cd) ppm)	1.60
15.	Total Chromium (Cr) (ppm)	11.56
16.	Total Nickel (Ni) (ppm)	26.10
17.	Inert material (%)	< 1.0

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APPENDIX – J :Biofil survey in emergency camp situation

Area	Camp Nos./Name	Block	Type of Toilet	Installation Date	Recommended Nos of User	Nos. of Regular User	Nos of additional users in any particular day	Empty Space Available in the tank (inches)	Last desludging date	Name of User/s (Interviewee)	Toilet Installed by	Comments of Users about the toilet	If the tank filled up quickly, then, what are the reasons	Is there any bad smell in the toilet	What are the reasons of bad smell	If nearby toilets are full, then, whether users of those use this toilet	If yes, then how long (days)	How many	Any other info	Remarks
Balukhali	10	H 12	4 cubicles holding tank	August, 2018	60	260	70	12	Yet to be desludged	Shahid Alam, Anwar	ACF	Good; no bad smell; made of steel; will sustain long	NA	No	NA	No	NA	NA	Pan was dirty	
Balukhali	10	H 13	4 cubicles holding tank	July, 2018	60	100	20	18	Yet to be desludged	Monir Ahmed	ACF	Good; no bad smell; made of iron	NA	No	NA	Yes	10	200	Pan was dirty	
Balukhali	10	H 10	4 cubicles holding tank	July, 2018	60	220	No	12	Yet to be desludged	Md. Ilias	ACF	Good; no bad smell; made of iron	NA	No	NA	No	NA	NA	Pan was dirty	Every month 30 people of Tablig Jamat use the toilet for 7 days
Balukhali	10	H 22	4 cubicles holding tank	July, 2018	60	200	30	6	Yet to be desludged	Abdul Motaleb	ACF	Good; no bad smell; made of steel	NA	No	NA	No	NA	NA	Pan was dirty	Mazhi: Khairul Amin; he wants two more toilets
Balukhali	10	F 12	4 cubicles holding tank	July, 2018	60	80	No	12	Yet to be desludged	Abdul Gani	ACF	Good; made of steel; no bad smell; looks beautiful	NA	No	NA	Yes	10	30	Pan was dirty	Mazhi: Hazibullah
Balukhali	10	H 22	4 cubicles twin pits	12/12/2018	60	150	No	34	Yet to be desludged	Khairul Amin	ACF	Good; made of steel; no bad smell	NA	No	NA	Yes	3	30	Pan was dirty	Mazhi: Kairul Amin; 3 cubicles traditiona toilet beside is full, however, yet to be desludged.
Balukhali	10	H 12	4 cubicles twin pits	12/12/2018	60	125	No	34	Yet to be desludged	Jamal Hossain	ACF	Good; feeces are not seen, no bad smell	NA	No	NA	No	NA	NA	-	Majhi: Rahmatullah
Balukhali	10	H 25	4 cubicles twin pits	12/12/2018	60	200	No	33	Yet to be desludged	Jalal Ahmed	ACF	Good; made of steel; no bad smell	NA	No	NA	No	NA	NA	-	Majhi: Enayet
Balukhali	10	H 23	4 cubicles twin pits	12/12/2018	60	125	No	34	Yet to be desludged	Md. Kalam	ACF	Good; no bad smell; strong superstucture	NA	No	NA	No	NA	NA	Walls are loose	Majhi: Bosir
Balukhali	10	H 22	4 cubicles twin pits	12/12/2018	60	100	No	34	Yet to be desludged	Jahid; Nurul Amin	ACF	Good; made of steel; no bad smell	NA	No	NA	No	NA	NA	Pan was dirty	Majhi: Khairul
Balukhali	10	H 22	Pit with 48" dia rings	Feb, 2018	20	20	No	6	Yet to be desludged	Khairul	Oxfam	Good; no bad smell; no need to desludge for long time; superstructure is strong	NA	No	NA	Yes	5	45	Pan was dirty	Majhi: Khairul
Balukhali	10	H 22	Pit with 48" dia rings	Feb, 2018	20	25	No	6	Yet to be desludged	Kashem	Oxfam	Very good; no bad smell; made of steel	NA	No	NA	No	NA	NA	Pan was dirty	Majhi: Khairul
Balukhali	10	H 31	Pit with 48" dia rings	Jan, 2018	20	20	No	21	Yet to be desludged	Rashida Begum	Oxfam	Good; no bad smell; do not fillup quickly; strong superstructure	NA	No	NA	Yes	10	100	Pan was dirty	Majhi: Taher
Balukhali	10	H 31	Pit with 48" dia rings	Jan, 2018	20	10	No	22	Yet to be desludged	Matamim	Oxfam	Good; no bad smell; strong superstructure	NA	No	NA	No	NA	NA	Pan was dirty	Majhi: Taher
Balukhali	10	H 30	Pit with 48" dia rings	Jan, 2018	20	50	No	23	01/02/2019	Mahibullah	Oxfam	Good; no bad smell; strong superstructure	NA	No	NA	No	NA	NA	-	Majhi: Shamim
Balukhali	10	H 27	5 cubicles holding tank	Dec, 2017	75	720	No	22	26/12/2018	Arefa Begum	ACF	Good; No bad smell	Too many users	No	NA	Yes	7	84	Used like public toilet; pan was dirty	
Balukhali	10	H 44	5 cubicles holding tank	July, 2018	75	250	No	18	Yet to be desludged	Laila	ACF	Good; no bad smell; strong superstructure	NA	No	NA	No	NA	NA	Pan was dirty	Majhi: Anwar
Balukhali	10	G 6	5 cubicles holding tank	Jan, 2018	75	250	No	2	Aug, 2018	Yasmin	ACF	Good; no bad smell	Too many users	No	NA	No	NA	NA	Pan was dirty	Majhi: Samir
Balukhali	10	G 5	5 cubicles holding tank	July, 2018	75	250	No	18	Yet to be desludged	Nur Islam	ACF	Good; no bad smell; Engle superstructure; will not break easily	NA	No	NA	No	NA	NA	Pan was dirty	Majhi: Zakir Ahmed
Balukhali	10	H 46	5 cubicles holding tank	Dec, 2017	75	250	No	16	Oct, 2018	Rahmatullah	ACF	Good; no bad smell	NA	No	NA	No	NA	NA	-	Majhi: Rafiq
Balukhali	10	H 30	Single unit with 35" dia rings	Dec, 2017	15	35	No	23	Jan, 2018	Nur Sabur	Oxfam	Good, no bad smell	NA	No	NA	No	NA	NA	Fisrt time desludged on Jan 30 2018	Majhi: Shamim
Kutupalong	Madhuchora	F 10	Single unit with 35" dia rings	Dec, 2017	15	32	No	23	10 Jan, 19	Nur Hossain	Oxfam	Good, no bad smell	NA	No	NA	No	NA	NA	At the beginning 150 users for 10 months	Toilet nos. 16; GPS ID: kut-lat 0593
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	30	No	23	10 Jan, 19	Mohammad Ali	Oxfam	No bad smell	NA	No	NA	No	NA	NA	At the beginning 100 users for 8 months	Toilet nos. 18; GPS ID: kut-bu-2652
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	32	No	23	10 Jan, 19	Md. Hossain	Oxfam	No bad smell	NA	No	NA	No	NA	NA	At the beginning 160 users for 10 months	Toilet Nos. 23; GPS ID: kut-lat-4712
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	20	No	23	10 Jan, 19	Md. Rahim	Oxfam	No bad smell	NA	No	NA	No	NA	NA	Athe beginning 100 Users for 10 months	Toilet Nos. 24; GPS ID: kut-lat-4710; People from nearby mosqe also increased the load as users
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	20	No	23	10 Jan, 19	Nurul Haque	Oxfam	No bad smell	NA	No	NA	No	NA	NA	At the beginning 30 usrs for 10 months	Toilet Nos. 20; GPS ID: kut-lat-4711; about 7" space was available during 1st emptying of tank
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	40	No	6	Yet to be desludged	Dildar Mia	Oxfam	No bad smell	NA	No	NA	No	NA	NA	At the beginning 115 users for 10 months	Toilet Nos. 43; GPS ID: kut-lat-4774
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	30	No	12	Yet to be desludged	Junayed	Oxfam	Good	NA	No	NA	No	NA	NA	At the beginning 120 usrs for 8 months	Toilet Nos. 44; GPS ID: kut-lat-4773
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	12	No	30	Yet to be desludged	Md. Nur	Oxfam	Good	NA	No	NA	No	NA	NA	At the beginning 100 usrers for 6 months	Toilet Nos. 47; GPS ID: kut-lat-4775
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	12	No	18	Yet to be desludged	Farid Mia	Oxfam	Good	NA	No	NA	No	NA	NA	At the beginning 112 usrs for 9 months	Toilet Nos. 48; GPS ID: kut-lat-4776
Kutupalong	Madhuchora		Single unit with 35" dia rings	Dec, 2017	15	40	No	30	Yet to be desludged	Syed Nur	Oxfam	Operating well	NA	No	NA	No	NA	NA	At the beginning 120 usrs for 6 months	Toilet Nos. 36; GPS ID: kut-lat-3554

APPENDIX – K : List of Key Informant Interviews

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