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Assessment of UDDTs as a Flood Resilient and Affordable Sanitation Technology, and their Potential to Contribute to the Fertilizer Demand

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Master of Science Thesis

by

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Abstract

Compared to many other developing countries, the official sanitation condition in Bangladesh is relatively good. The Government of Bangladesh (GOB) has declared to achieve 100% sanitation coverage over the country by 2013. As the main intention is to increase sanitation coverage, GOB is promoting the cheapest and easiest solution for sanitation, which is the pit latrine. As a country of flooding and high ground water table, pit latrines form a great threat for environment. The seepage causes ground water pollution causing people to suffer when using ground water for drinking purposes. Additionally, every year floods destroy many sanitation facilities and force people to resort to open defecation.

In the literature, UDDT is advised to be the most suitable option in flood-prone areas. There is also some evidence of implementing UDDT in flood-prone areas. However, upscaling UDDTs may lead to acceptance of users and to too high costs.

This study aimed to evaluate the suitability of UDDTs in flood-prone areas of Bangladesh. Furthermore, affordability of UDDT is also analyzed in this study. In addition, projection was made on potential contribution of human excreta to fertilizer demand for one case study area.

This research carried out through literature review, field observation, questionnaires interview, data collection, discussion with sanitation experts and finally data analysis. Two flood-prone areas, Manikgonj and Munshigonj, were visited to evaluate the condition of UDDTs and questionnaires interviews were carried out to find out the performance during flood period. Experiences on sanitation for flood-prone areas were collected from SPACE, Practical Action, Oxfam GB and Concern Universal.

Analysis of experiences on sanitation in flood-prone areas shows that raised latrine above the highest flood level is the most suitable sanitation technology for flood-prone areas. Form field survey, average height of UDDT is found 0.69 m which is higher than average highest flood level of 0.31 m. Also sanitation expert from BARD, SPACE, Practical Action, Oxfam GB and Concern Universal agreed on the suitability of UDDTs for flood-prone areas of Bangladesh.

A design of UDDT is developed in this study with the desire to minimize the cost and to make UDDT technology simple. Basis of the design is the design concept of pit latrine. With the design, the cost was reduced by 50% of BARD designed UDDT. Still, the price is over the amount that people are currently contributing to a UDDT in different projects. This limit could be reached if the emptying cost of latrine were considered. If the fertilizer value of human excreta is taken into account, UDDT may even become profitable. This study also found that 78% of the total fertilizer demand could be compensated through human excreta from the case study area.

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List of Abbreviations

BARD	Bangladesh Agricultural Rural Development
BARC	Bangladesh Agricultural Research Council
BDT	Bangladesh Taka
CVDP	Comprehensive Village Development Project
DPHE	Department of Public Health and Engineering
DAE	Department of Agricultural Extension
DORP	Development Organization of the Rural Poor
GOB	Government of Bangladesh
JADE	Japan Association of Drainage and Environment
MOA	Ministry of Agriculture
MP	Muriate of Potash
SPACE	Society for People's Actions in Change and Equity
SHEWA-B	The Sanitation, Hygiene, Education and Water Supply in Bangladesh
SuSanA	Sustainable Sanitation Alliance
TSP	Triple Super Phosphate
UDT	Urine Diversion Toilet
UDDT	Urine Diversion Dehydration Toilet
UNICEF	United Nations International Children's Emergency Fund
WatSan	Water and Sanitation

1 INTRODUCTION

1.1 Background

Official sanitation coverage in Bangladesh is relatively better than many other developing countries in the world. In Southern Asia, only 34% population has access to improve sanitation (MDG, 2010). But in Bangladesh 55% of the urban and 52% of the rural people have access to improved sanitation facilities. This improvement is mostly based on pit latrine which is becoming the main problem on sanitation for Bangladesh. Still, with the current rate of sanitation improvement, Bangladesh will miss the MDG target by 10.5% of the total population.

Some 42% of urban people and 70% of rural people are using pit latrine (JMP, 2010). Reasons behind the popularity of pit latrine are: locally available material, high affordability and easy to install. Government of Bangladesh has also been promoting pit latrine to achieve high sanitation coverage. Yet, Bangladesh is a land of high ground water table and most rural people use ground water as drinking water source. As a result, people are still suffering a lot of with good sanitation coverage. It was estimated that the people of Bangladesh spend no less than taka 5000 million annually to cover physician's fee, medicine and travel cost to clinic treating the major water borne diseases. Children under five years suffer from diarrhea 3-5 times every year (GOB, 2005).

In Bangladesh, sanitation facilities are vulnerable due to annual flooding events which destroy watsan facilities. Pit latrines, though being the most popular form of sanitation in Bangladesh, are most vulnerable to flooding. During flood periods the pit latrines overflow, excreta come out with flood water and cause serious health hazard and degradation of environment. Moreover, people lose sanitation facilities during flood period and have no other option but to use open defecation. Also flood water contain large amount of silt that filled the latrine during flood. As a result people lose their sanitation facilities permanently.

Raised latrine is recommended as the most suitable technology for sanitation in flood-prone areas (DPHE, 2002, Kazi, 2003, Mamun, 2010, Morshed, 2010). Specifically, UDDTs are recommended for flood-prone area as UDDTs is itself a raised sanitation technology (E. Muchiri, 2009). There are also some evidences of promoting UDDT in flood-prone areas. UNICEF successfully constructed 575 UDDT in a flood-prone areas of Mozambique (Madeleine Fogde, 2011). Terre des hommes implemented 100 UDDT in Barguna district of Bangladesh which is one of the most flood-prone area of Bangladesh (Mazeau, 2009). Under SuSanA, a working group analyzed 17 case studies worldwide, where more resilient and in many aspects more sustainable sanitation solution have been used in emergency. The study group suggested UDDT as a suitable technology for flood prone areas (Åse Johannessen, 2010).

However, UDDT is expensive technology. But UDDT do not require any emptying cost which can't be avoided in pit latrine. By considering emptying cost, the UDDT could be reached to affordable. Also, UDDT gives the benefit from excreta use by keeping urine and feces separate, which may help to evaluate UDDT affordable or even profitable.

At the same time, as an agricultural country Bangladesh has a very good opportunity of using human excreta as a fertilizer. Agriculture provides livelihood to more than two-thirds of the rural population of Bangladesh (Rasul and Thapa, 2004). Chemical fertilizer is the main feed for agriculture. Use of chemical fertilizer increased six-fold between 1970 and 1990 (Osmani, 1990). Increased demand led to increase the price of chemical fertilizer. In this circumstance, it is required to introduce the use of human excreta as fertilizer in Bangladesh.

1.2 Problem identification

This study identifies three problems regarding sanitation in Bangladesh.

- Floods are major problem for sanitation in flood-prone areas of Bangladesh which makes sanitation system unsustainable.
- Ground water pollution form seepage of unlined pit latrine.
- Human excreta, which could be a good source of fertilizer, are polluting the environment by discharging untreated.

1.3 Research objective

The specific objectives of the study are:

- Assessment of UDDTs as flood-resilient sanitation technology.
- Assessment of UDDTs as affordable sanitation technology.
- To estimate potential contribution of human excreta to the fertilizer demand.

1.4 Research Questions

In order to meet the objectives, this study aims at answering the following questions:

- Are the current practiced UDDTs applicable in flood-prone areas of Bangladesh?
- Are the UDDTs affordable for the people of Bangladesh?
- What is the probable contribution of human excreta to the current fertilizer demand?

1.5 Scope of the thesis

The main focuses of this research is to analyze UDDTs as a flood resilient and affordable sanitation technology. Evaluation process is carried out through field visit and experience sharing form different organizations. As it was not possible to evaluate the condition of UDDT during flood time, performance of UDDT during flood period was evaluated through questionnaire survey.

During cost optimization of UDDTs, main attention was given to the feces chamber which is the main concern of UDDTs. Superstructure is not a big concern of cost optimization.

Projection on potential contribution of human excreta to fertilizer demand is another focuses of this study. Fertilizer demand of case study area is calculated based on Nitrogen, Phosphorus and Potassium, as these nutrients could be compensated by human excreta. Other nutrients that are also necessary for plant production were not considered in this study.

The outputs of this study are presented in the results chapter. The methodology used for obtaining the results is presented in methodology chapter. In the discussion chapter, the findings are analyzed to obtain required output. Limitations that were considered during study were also described in the discussion chapter. Literature that reviewed during study period is presented in the literature review chapter.

This report will be a guideline for the people who are working with sanitation in flood-prone areas. Details cost estimation was done for UDDT in this study which will help for further cost optimization of UDDT. This report also guides to make UDDT technology simple.

2 LITERATURE REVIEW

2.1 World sanitation status

Sanitation has received international attention with the announcement of MDGs. In September 2000, the United Nations General Assembly endorsed eight Millennium Development Goals, of which reduction in child mortality and ensuring environmental sustainability are directly linked with sanitation (UN, 2000). After that in September 2002, the World Summit on Sustainable Development (WSSD) voiced a stronger concern for promoting sanitation as adequate sanitation is necessary to protect human health and environment. It is estimated that the burden of infectious diarrheas would be reduced by some 17 percent annually, if improved water supply and basic sanitation were extended to the unserved and by some 70 percent annually, if universal piped, well-regulated water supply and full sanitation were achieved (UN, 2003). In this respect, it was agreed to go after a specific sanitation target: halving the figure 2.4 billion people who do not have access to basic Sanitation facilities by 2015 (UN, 2002).

Challenge on improving on sanitation is becoming more and more challenging with time. With the current progress in sanitation, the world will miss the Millennium Development Goal (MDG) on sanitation. In 2008, an estimated 2.6 billion people around the world lacked access to an improved sanitation facility (Robert Bos, 2010, UN-Water, 2008). Only 1.3 billion people gained access to improved sanitation between 1990 and 2008. At the current trend, an estimated 2.7 billion people will be without basic sanitation by 2015, which means that target will be missed by 1 billion (Robert Bos, 2010).

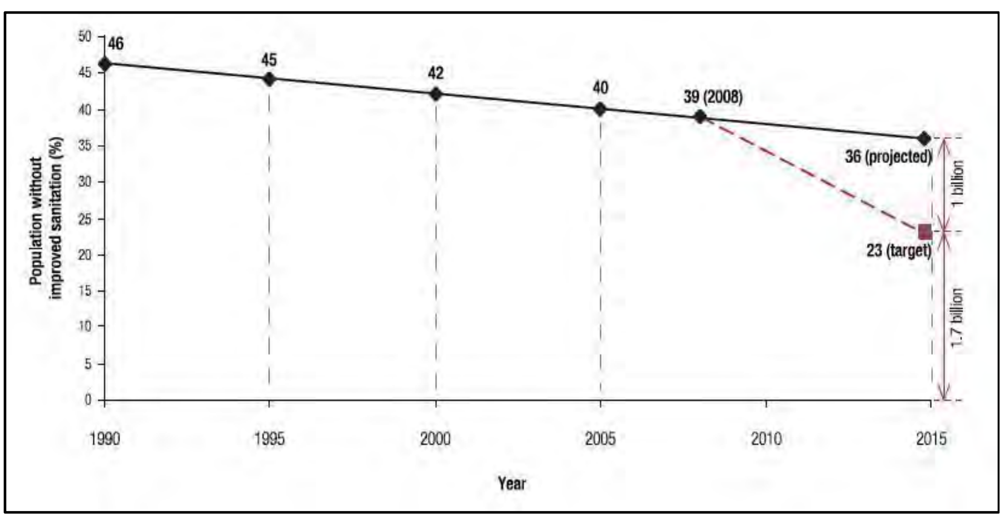


Figure 2-1: Trend on decrease of unimproved sanitation users (Robert Bos, 2010).

Sanitation improvements are bypassing the poor. Seven out of ten people without improved sanitation live in rural areas (Robert Bos, 2010). The Poorest people suffer the most form lack of access sanitation. Over the period 1990-2008, sanitation coverage for the whole of the developing regions increased by only 5 per cent in urban areas and by 43 per cent in rural areas (MDG, 2010). Still the gap between the sanitation coverage between rural and urban areas is huge.

2.2 Sanitation status in Bangladesh

The sanitation coverage of Bangladesh is in fact better than of many other developing countries. According to JMP report 2010, urban and rural sanitation coverage is 80% and 76% respectively in the year 2008. But only 55% people in urban area and 52% people in rural area have access to improved sanitation facilities. With the current trend of progress on sanitation, Bangladesh will miss the MDG target on sanitation by 10.5%.

The Government of Bangladesh (GOB) is committed to achieve the MDG target on sanitation. Sanitation was not a matter of priority before 2003. In the first south Asian Conference on Sanitation (SACOSAN) in October 2003, GOB announced its target of 'Sanitation for All by 2010', keeping its commitments to the MDG targets.

In Bangladesh, previous top-down, supply-driven approaches to sanitation had not been successful. Government has changed its framework and takes new initiatives to move forward. In an expression of its commitment to sanitation provision, the Government of Bangladesh has committed 20% of its national Annual Development Program Block allocations to fund local administrations in improving sanitation to the poorest (UNDP, 2006). Government also declared cash rewards on sanitation. TK 200,000 for open defecation free Unions and TK 500,000 for open defecation free Upozilas (Roy, 2009). Despite of such initiatives, Bangladesh cannot achieve its ambitious plans to achieve nationwide coverage of sanitation by 2010 and shifted the deadline from 2010 to 2013 in National Sanitation Conference 2011 on 6th January, 2011.

Despite a reasonably better coverage of sanitation facilities, fecal-oral transmission remains as one of the main causes of water borne diseases in Bangladesh. Diarrhoea is the most common suffering from improper sanitation and children are the most sufferers. Every children under five years suffer from diarrhea 3-5 times every year and every year 110000 children under five years die because of diarrhea (GOB, 2005). It was estimated that people of Bangladesh spend no less than taka 5000 million annually to cover physician's fee, medicine and travel cost to clinic in treating the major water borne diseases. The cost would be much higher if the loss of income, time spent for patient care, and effect on child development are factored in. The poor are the hardest hit by the sanitation related diseases. Loss of income and productivity due to disease may push a poor family further into poverty and debt, thereby perpetuating the cycle of poverty.

2.2.1 Sanitation Coverage in Bangladesh

Sanitation coverage improves rapidly in rural area rather than in urban area. People with improved sanitation facilities increased from 28% to 52% in rural area but in urban area it decreases slightly from 57% to 55% (JMP, 2010). Great improvement is achieved in decreasing open defecation practices in rural areas. In 1990, 40% of rural population was practicing open defecation and in 2008 it decreased to 8%. Detailed on sanitation coverage is presented in table 2-1.

Table 2-1 : Sanitation Coverage in Bangladesh(JMP, 2010).

	Year	Urban (% population)			
		Improved	**Shared**	**Unimproved**	**Open defecation**
URBAN	2008	55	25	17	3
	2005	56	26	14	4
	2000	56	26	13	5
	1995	56	26	12	6
	1990	57	26	10	7
RURAL	2008	52	24	16	8
	2005	48	22	16	14
	2000	40	18	18	24
	1995	33	15	18	34
	1990	28	13	19	40

Bangladesh has a large variation on sanitation coverage between urban and rural areas. The poorest are the most sufferers for sanitation. 43% of the poorest people are using un-improved sanitation facilities and still 22% are practicing open defecation (Robert Bos, 2010). These lead them suffering from many diseases and push a poor family further into poverty and debt, thereby perpetuating the cycle of poverty.

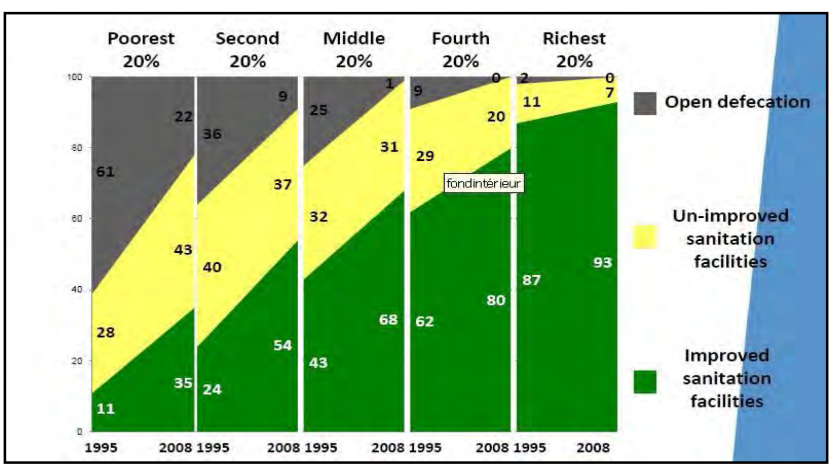


Figure 2-2: Sanitation practices by wealth quintile,1995/2008 (Robert Bos, 2010).

A national baseline survey was conducted in 2003 to assess the reason for not having sanitation facilities in Bangladesh. According to that survey, 73% person people do not use sanitation facilities due to lack of money.

Table 2-2: Reasons for not having a latrine in Bangladesh (GOB, 2005).

Area/Region	Number of households with no latrines	Lack of Money (%)	Lack of Awareness (%)	Lack of Space (%)	Preference for open defecation (%)
National	89,82,551	73	25	11	4
Rural	85,95,626	73	25	10	4
Urban	3,86,925	80	21	18	3

2.2.2 Forms of Sanitation Used in Bangladesh

Bangladesh has one wastewater treatment plant in the capital with 8.5% coverage of the total population (GOB, 2003, JMP, 2010). The plant is overloaded and is bypassing most of the influent in the river. Septic tank is another common practice in urban areas. If the septic tank is not connected to sewer system, generally a soak pit is used to release the effluent to the ground, otherwise effluent just released to the nearest water source. Major portion of population are using unlined pit latrines, which continuously pollutes the ground water. As ground water is the major source of drinking water, people are suffering from water borne disease in spite of high sanitation coverage. Forms of sanitation of Bangladesh are presented below:

Table 2-3 : Forms of Sanitation in Bangladesh(JMP, 2010).

Types of Sanitation	**% Urban**	**% Rural**
Flush - to Piped sewer system	8.5	0.2
Flush - to Septic Tank	29.8	9.0
Flush - to Pit Latrine	7.6	5.5
Flush - do not know where	0.6	0.0
Flush - somewhere else	12.9	0.6
Pit latrine with slab	14.1	22.0
Pit Latrine without slab	19.5	42.3
Hanging toilet/latrine	5.1	11.1
Bucket Latrine	0.1	0.1
No facility, bush, field	1.7	9.1

2.3 Floods in Bangladesh

The life and livelihood of people of Bangladesh have been revolving around river waters over the ages. Floods are natural phenomena that occur annually in Bangladesh. Bangladesh has around 310 rivers. The Ganges, the Brahmaputra and the Meghna are the three mighty rivers. Total catchment area of these three great rivers is about 1.72 million square kilometer. Only about 7.5 percent lies within Bangladesh (Monirul Qader Mirza, 2002). Therefore, Bangladesh forced to drain out huge cross-border monsoon runoff together with its own runoff. The volume of generated runoff exceeds the capacity of the rivers most of the time and this makes Bangladesh one the most flood vulnerable countries in the world.

Rural people are the most sufferers from flooding. 73% of the total population of Bangladesh lives in rural area. On average, 20% area of the country inundates annually and during an extreme flood event this can reach as high as about 70% (Paul, 1997).

Bangladesh experiences mainly four types of floods (Kazi, 2003). These are flash flood, tidal flood, rainwater flood and monsoon flood. First, flash flood is characterized by sharp rise and fall in water levels causing high flows from nearby hills or mountains. They occur suddenly and are of relatively short duration. The flash flood overtops river banks and water readily enters the flood plain. Flash floods are very unpredictable. Second, tidal flood occurs in the coastal belt of Bangladesh, often with storm surges generated by tropical cyclones. The land is flooded at high-tide twice daily by saline water near the sea and by sweet water in the inland. Third, rainwater flood occurs due to high intensity rainfall over Bangladesh. Due to inadequate drainage capacity, such rainstorm of 3 to 10 days duration sometime cause localized floods inundating latrines which are one of the reasons of environmental degradation. Duration of such floods depends on the water levels in the main rivers. Last, monsoon season floods are large and normally last from July to October. This is the normal river flood arising from over spilling of rivers especially the major rivers which usually rise slowly. Major floods occur when the peak-flow of the Ganges coincides with that of the Brahmaputra. The monsoon season floods are a combination of river inflow, seasonal rainfall and backwater effect from the rivers.

2.3.1 Why flood is problem for sanitation?

In Bangladesh, one of the many reasons of poverty and vulnerability is the annual events of flooding, which submerges land, damages crops, property, and watsan facilities, disrupt economic activities and causes diseases and loss life. It is one of the major problems for Bangladesh that makes the sanitation system unsustainable. During flood, pit latrine or other type of conventional latrine flooded, excreta come out with flood water and cause serious health hazard. This also causes serious degradation of environment. During flood, people loose sanitation facilities and forced to do open defecation. This causes additional health hazard. Also ground water table remains high after flood. So it is very difficult to take out water from pit latrine. Flood water also contain large amount of silt that filled the latrine during flood. As a result people lose their sanitation facilities permanently and move to open defecation after flood.

Bangladesh has experienced a devastating cyclone named SIDR in 2007 just after severe flood. According to the official report of DPHE as of 21 January 2008, a total of 55,279 latrines were partially or fully damaged in the SIDR affected areas. The estimated total loss in these districts was about 1.3 million US dollars. Spread of fecal pollution is also a major concern during flood. It was found that the unacceptable level of contamination of total coliforms, fecal coliforms and fecal streptococci ranged from 23.8% to 95.2%, 28.6% to 95.2% and 33.3% to 90.0% respectively after the 2004 flood in Dhaka (Sirajul Islam, et al., 2007).

A study was carried out in 6 Upozila of Bangladesh in May 2008 which was almost seven and six months after the last flood and cyclone SIDR (Mamun, 2008). The objective of this study was to find out damages on watsan facilities during flood. It was found that sanitation coverage fell drastically. About 90% of the latrines were either completely destroyed or partially damaged. According to the respondents and the key informants, losses due to the destruction of latrines and other physical structures were enormous and it imposed a huge financial burden for the community having no or inadequate money to rebuild the damages latrines and other structures. Open defecation practices increase tremendously after flood. Finding related with open defecation practices during and after flood is presented in figure 2-3.

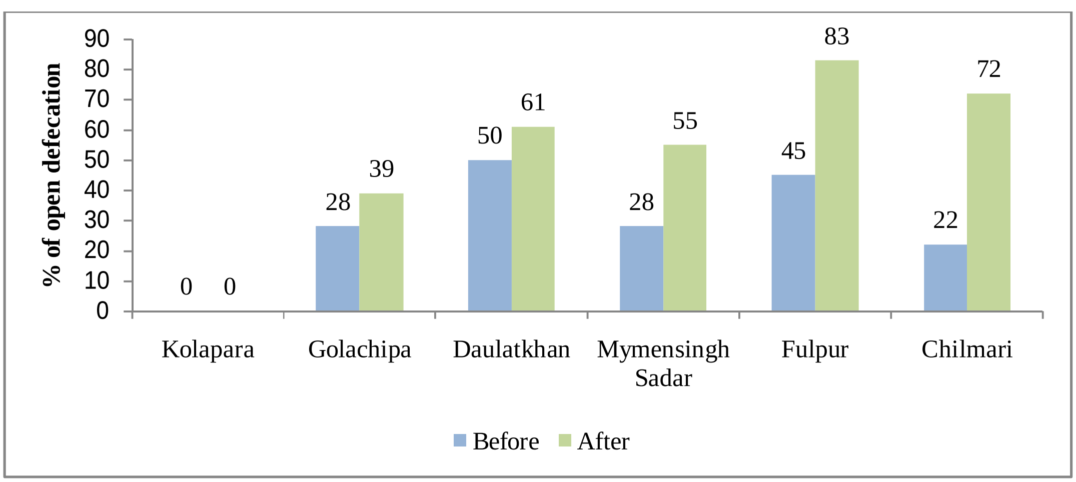


Figure 2-3: Open defecation status before and after flood in 2007 (Mamun, 2008).

There was a substantial increase in the number of patients due to water borne diseases during disaster. The children, women and elderly people were affected much more than the other groups. It was also found that at least one of their family members got sick due to water-borne diseases during and after flood. Among other water-borne diseases, there were dysentery, jaundice, cholera and typhoid. The potential reason of the high prevalence of diarrhea is poor watsan situation during and after the disaster in the affected areas. Findings on survey on occurrence of water borne diseases after flood 2007 is presented in table 2-4.

Table 2-4: Occurrences of water-borne diseases after flood in 2007(Mamun, 2008).

Type of Diseases	**Kalapara (%)**	**Golachipa (%)**	**Daulatkhan (%)**	**Chilmari (%)**	**Mymensingh (%)**	**Fulpur (%)**
Note: Information regarding any family member getting sick due to water borne diseases after 2007 flood.						
Yes	64.7	55.6	33.3	72.2	66.7	83.3
No	35.3	44.4	66.7	27.8	33.3	16.7
Types of diseases						
Dysentery	9.1	10.0	16.7	38.5	8.3	20.0
Diarrhoea	81.8	60.0	83.3	69.2	100.0	73.0
Jaundice		30.0				6.7
Blood Dysentery	18.2			7.7		20.0
Cholera				7.7		
Typhoid					16.7	40.0
Others		10.0		15.4		13.3

2.3.2 Sanitation technology for flood prone areas

To investigate sanitation strategies and technologies for high-water table and flood-prone areas of Bangladesh, a study was conducted by ITN-Bangladesh, a centre for water supply and waste management. Multiple data collection technique was used in the study including a socioeconomic and technical survey at field level. The field survey was conducted in three different areas namely, Dhaka, Patuakhali and Sylhet. These three areas represent four different types of floods that occur in Bangladesh every year such as normal river flood, rain water flood, tidal flood and flush flood. Based on the analysis and the outcome of the socioeconomic and technical survey, recommendations are made on both sanitation strategies and technologies (Kazi, 2003).

Technically correct solution to the problem of latrine flooding is to construct raised latrine (Kazi, 2003, Morshed, 2010). There are many ways to raise the latrine depending on local conditions. However, some other technological provisions are made to protect the groundwater as well as surface water from contamination. Earth stabilized raised pit latrines, step latrine and mound latrine is found suitable for flood-prone areas. The raised pit latrine also increases the volume of the pit for accumulation of excreta. As the filtrate may seep out at the base of the mound rather than infiltrate the ground, earth mound is not suitable on clay soils (Kazi, 2003).

Earth stabilized raised pit latrine - This type of latrine can be used in areas experienced with any four types of flood that occur in Bangladesh every year. The latrine gets extended life with the increasing of pit volume as it is raised. This latrine requires more space area to stabilize soil around the raised portion of the pit lining. Both porous and non-porous lining can be used above the ground level for raising the pit. Details of the earth stabilized raised pit latrine is shown in Figure 2-5.

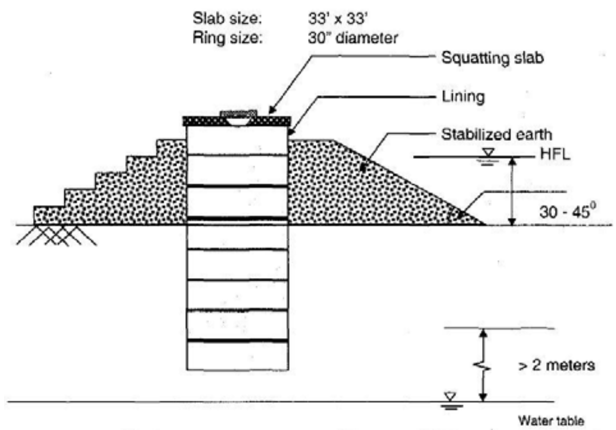


Figure 2-4: Earth stabilized Raised Pit Latrine (Kazi, 2003).

Earth should be stabilized around the extended lining with a slope of 30-40 degree that also provides easy access to the latrine. Stabilized soil around the lining should be permeable to be used as infiltration area. To prevent filtrate seeping out of the sides, the soil should be well compacted and thick enough. A permeable base of stabilized soil is also required to avoid seeping out rather than infiltrate into the ground.

Step Latrine - The principle of step latrine is also raised the latrine up to highest flood level to avoid floodwater intrusion into the pit. In this technology sewage is not permitted to leak through pit that's why non-porous lining is used. The extended portion of the pit is made water-sealed by plastering both sides. Water-sealed section of the lining should also be extended 1 - 1.5 ft. immediately below the ground level to avoid sewage seeping out on ground.

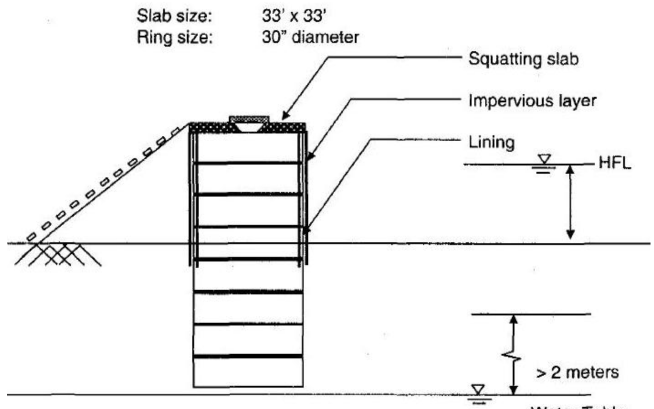


Figure 2-5: Step Latrine (Kazi, 2003).

Steps will be required to gain access to this latrine. This type of latrine requires relatively smaller horizontal space than earth stabilized latrine. The lining above ground level must be strong and durable to support the infrastructure. Step latrine is necessary where space is limited.

Mound Latrine - This technology is suitable where space is limited and watertight linings are not available. A mound of soil surrounds the extended portion of the pit and side slope should be stable. The mound should be thick enough to prevent filtrate seeping out of the sides. Part of the section of the lining can be made of permeable soil to be used as leaching area. Mound latrine is not recommended on clay soils to avoid seeping out at the base of the mound rather than infiltrate the ground. Additional earthen steps needed to gain access to this latrine.

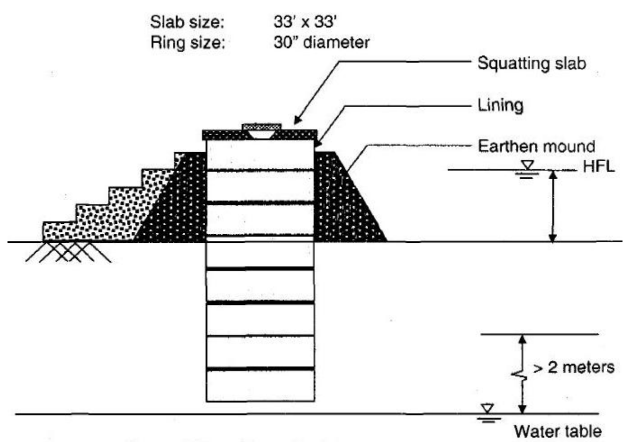


Figure 2-6: Mound Latrine (Kazi, 2003).

2.3.3 Case Studies on Sanitation in flood-prone areas

Different organizations are working with sanitation for flood prone areas in Bangladesh. Some case studies form Oxfam GB, Dhaka Ahsania Mission, SPACE and Practical Action is presented here.

Oxfam GB, a non-governmental organization, has undertaken four pilot projects to help Bangladesh to achieve 100 per cent sanitation coverage and promoting socially and culturally acceptable technologies that are appropriate for flood prone areas. Nine types of latrine technology were field tested together and all the latrine were raised up above the highest flood level. The technologies are Ecosan latrine, Urine diversion latrine, combined pit latrine, Earthen raised single pit latrine, Single pit latrine with cement and sand coated plinth, Cluster latrine, Drum latrine, Clay pot latrine and Floating latrine. Each type of latrine shows a number of advantages and disadvantages which depend on the support of the community and the nature of flooding. All Ecosan and Urine diversion latrines are functioning well. Though the technology is new to the users, the community people accepted the technology. But people want modified low cost technology with local material. Earthen raised single pit latrine and Pit latrine with cement and sand coated latrine are the most accepted latrine as these latrines is like a regular latrine. Another reason for the acceptability of this toilet is low cost (Morshed, 2010).

In order to identify disaster friendly technological options in water and sanitation, Dhaka Ahsania Mission, a non-governmental organization, organized a workshop on Disaster Friendly Water and Sanitation Technologies. Participants from Bangladesh Rural Advancement Committee (BRAC), Bangladesh University of Engineering and Technology (BUET), Concern Universal, Disaster Forum, Department of Public Health Engineering (DPHE), NGO Forum, SPACE, UNICEF and many others organization share experiential learning about existing practices and technologies in flood and cyclone affected areas. Participants suggested considering the maximum flood level as the plinth level for constructing any watsan facility. Earth Stabilized Raised pit step latrine, UDDT and offset latrine are identified as a disaster friendly sanitation technology (Shafiqul Islam, August 2009).

SPACE, a non-governmental organization, is working with UDDT toilet since 2005 (Pramanik, 2009). SPACE implemented 25 UDDT in Munshiganj district, 60 UDDTs in Manikgonj district, and 22 toilets in Gaibandha district. These three districts are highly flood-prone areas of Bangladesh.

A research on ecological sanitation was conducted by Practical Action, a non-governmental organization, in context of congested urban slums, haor areas, high water table areas and water crisis regions of Bangladesh. Eleven designs have been developed, considering the geo-hydrological features of the difficult areas and other socio-physical aspects. Participatory Technological Development (PTD) approach was followed to develop the designs. A total of 106 eco-toilets of seven designs have been constructed through the community participation at 16 clusters in seven districts. After six months of toilet construction, a feedback survey conducted through questionnaires and FGD among users and local stakeholders. It was found that people have accepted this technology and they are already habituated with the eco-toilet. Among the eleven designs, 7 designs were implemented at field under this project (Action, 2011). Detail design of those toilets is presented in Appendix - 4. Cost of implemented design under SHEWA-B project is presented in table 2-5.

Table 2-5: Construction cost of different type of UDDT ((Action, 2011))

Sl. No.	Type of UDDTS	Construction Cost (BDT)
1	Fixed Chamber System Using Plastic Fiber Pan	15,125
2	Movable Plastic Drum System Using Plastic Fiber Pan (Single Vault)	16,950
3	Movable Plastic Drum System Using High Commode (Single Vault)	17,650
4	Fixed Chamber System Using Modified Traditional Eco Pan	14,025
5	Fixed Chamber System Using Traditional Eco Pan	14,330
6	Movable Plastic Drum System Using Traditional Eco Pan	16,855
7	Elevated Movable Plastic Drum System with RCC Column	23,600

2.4 Agriculture in Bangladesh

Agriculture is the dominant sector in the Bangladesh economy and is contributing 36 percent of national GDP (Rasul and Thapa, 2004). It is still the largest sector of employment providing jobs to 22.8 million compared with 6.9 million in industry and 17.7 million in the services sector in 2006 (Bank, 2008). Agriculture provides livelihoods to more than two-thirds of the rural population in Bangladesh (Rasul and Thapa, 2004). People of Bangladesh has one of the lowest land per person ratios in the world, in1995 this was only 0.09 ha (Ali, 1995). As land is scarce in Bangladesh, emphasis has been given for increasing food production by intensifying the use of land, chemical fertilizers, pesticides and water.

Bangladesh has made significant progress towards achieving its goal of food grain self-sufficiency. This achievement has been mostly due to introducing modern rice varieties which is now cultivated in almost half of the rice area, which in turn increased the use of chemical fertilizers, pesticides and water. Subsidies are given to the farmers for chemical fertilizers, pesticides and equipment for irrigation which enable farmers to adopt these technologies for increasing crop yields (Hossain, 1988). The other important reason of achieving food grain self sufficiency is dramatic increase of double or triple-cropped land proportion. On other side, traditional cropping practices, like mixed cropping, crop rotation, and intercropping have decreased tremendously (Hossain and Kashem, 1997). .

2.4.1 Fertilizer use in Bangladesh

Inorganic fertilizers have been introduced into Bangladesh during early 1950's as a supplemental source of plant nutrients. But their use started increasing steadily only form mid 1960's along with the introduction and expansion of modern varieties accompanied by the development of irrigation facilities (BARC, 2005). Due to High yield varieties of rice and triple cropping pattern, soil lost its capacity to supply nutrient. Traditionally, farmers used to apply farmyard manure and mulch crop residues to the land to enhance soil fertility. This tradition has been abandoned gradually because of reduced livestock herd size and increased use of dung and crop residues as fuel. As a result, most soils in Bangladesh have less than 2% of organic matter content, some soils even having less than 1% (BARC, 2005). To meet the increased fertilizer demand, people became more dependent on chemical fertilizer. Fertilizer nutrient use rate increased in Bangladesh more rapidly than its neighboring country.

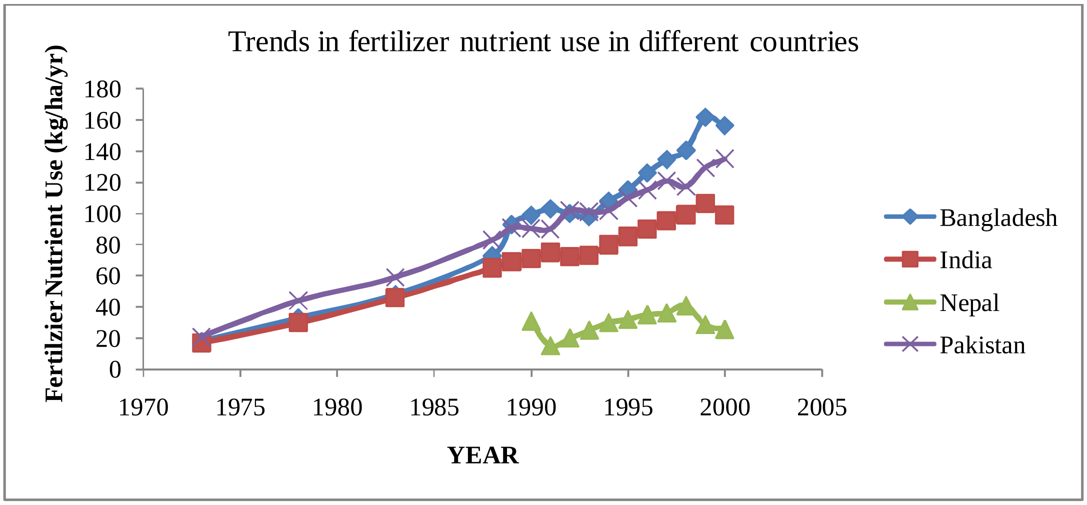


Figure 2-7: Trends in Fertilizer Nutrient Use in Bangladesh (MOA, 2007).

At present, many different kinds of chemical fertilizer are used in Bangladesh. Nitrogen (N) and Phosphorus (P) are the two most critical nutrient elements for agriculture and horticulture production all over the world. Need of Phosphorus is approximately one tenth of that of Nitrogen. The third essential nutrient is Potassium (K) (Heinonen-Tanski and van Wijk-Sijbesma, 2005). These three nutrients could be compensated by human excreta. Seven different kinds of fertilizer commonly used in Bangladesh that contain N, P, K. These are Urea, Triple Super Phosphate (TSP), Single Super Phosphate (SSP), Di-ammonium Phosphate, Muriate of Potash (MP) and Potassium Sulphate. Nutrient content of these fertilizers are given below (BARC, 2005):

Table 2-6: Nutrient content of different fertilizer (BARC, 2005)

Fertilizer Name	**Formula**	**Nutrient composition (%)**		
		N	**P**	**K**
Urea	$CO(NH_2)_2$	46	-	-
Ammonium Sulphate	$(NH_4)_2SO_4$	21	-	-
Triple Super Phosphate (TSP)	$Ca(H_2PO_4)_2$	-	20	-
Single Super Phosphate (SSP)	$Ca(H_2PO_4)_2 + CaSO_4$	-	8	-
Di-ammonium Phosphate	$(NH_4)_2HPO_4$	18	20	-
Muriate of Potash (MP)	KCL	-	-	50
Potassium Sulphate	K_2SO_4	-	-	42

Use of chemical fertilizer is increased six-fold between 1970 and 1990 (Osmani, 1990, Rahman and Thapa, 1999). At present, chemical fertilizer is the main factor in the growth of domestic food production.

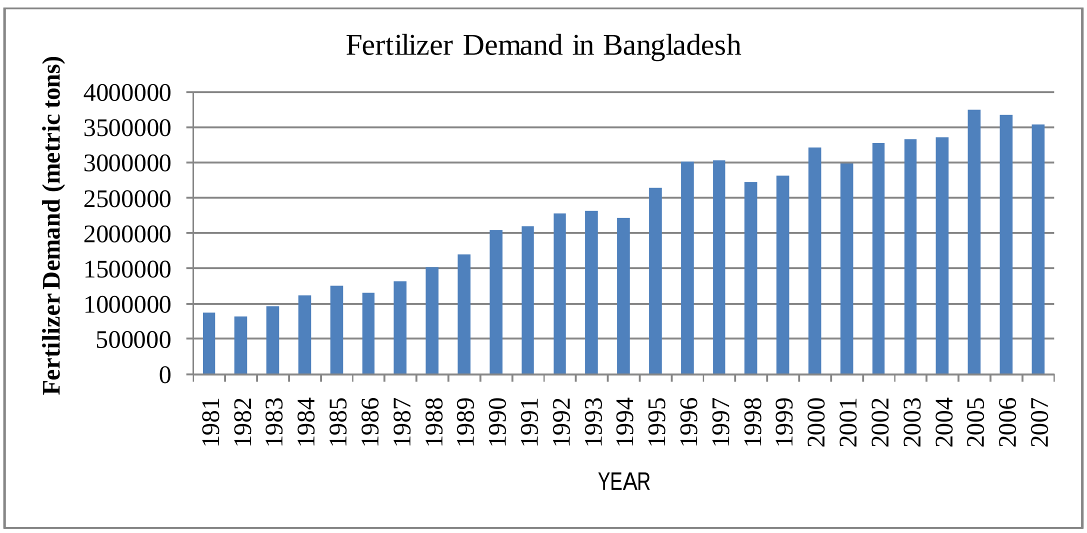


Figure 2-8: Fertilizer demand of Bangladesh (MOA, 2007).

Most of the fertilizers that are used in Bangladesh are imported. The lifetime of global economical phosphorus reserves estimated between 60 to 130 years (Steen, 1998). Production of nitrogen based fertilizer depends heavily on oil and gas, which are non-renewable (Greenwood and Earnshaw, 1998). It is estimated that these resources will reach their global peaks in about 10 years for gas and approximately 20 years for oil

(Bentley, 2002). In 2007, Bangladesh imported about 10% consumption of urea, about 75% of the consumption of TSP and 100% of its potassic fertilizer (in the form of manure of potash). Price of imported fertilizer is increasing more rapidly than those produced in the country.

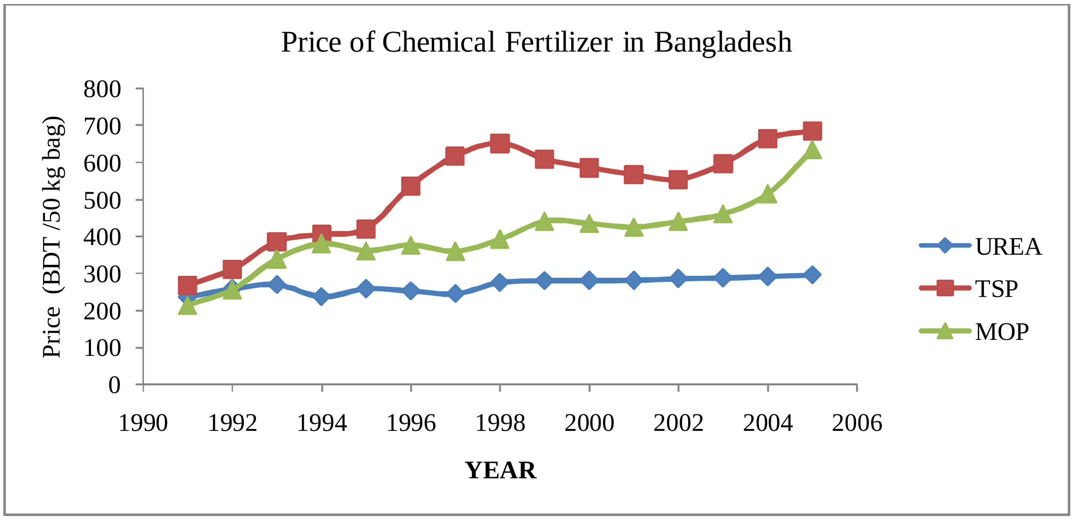


Figure 2-9: Fertilizer price status in Bangladesh (MOA, 2007).

2.4.2 Needs for recycling nutrients from human excreta

The sustainability of conventional agricultural practices is Bangladesh is under threat. The effects of conventional practices are: the continuous degradation of land and water resources, the declining yields due to indiscriminate use of agro-chemicals (Rasul and Thapa, 2003). The increasing use of chemical fertilizers, insecticides and pesticides has contributed to the contamination of water bodies and the spread of diseases, which has adversely affect the aquatic life, livestock and people's health (Altaf Hossain and Salam, 1994, Asaduzzaman, 1996).

Soil erosion is regular phenomenon in all year in Bangladesh. It happens due to flood in wet seasons and due to strong wind in dry seasons. Chemical fertilizer, while boosting plant growth, cannot replace topsoil. Topsoil contains humus formed from decayed plant and animal matter and is rich in carbon compounds and micro-organisms necessary for plant growth, which are not found in chemical fertilizers. The addition of humus is therefore necessary to maintain and renew the topsoil. In Bangladesh farmers are now a day's experiencing reduced productivity on their lands due to loss of topsoil's (Chowdhury, 2007).

Present state of increased and imbalanced use of chemical fertilizer and pesticides, declining soil fertility, decreasing yields has became a serious challenge for Bangladesh

(Rasul and Thapa, 2003). Though, conventional agriculture has enabled farmers to fulfill their immediate needs at the cost of environmental degradation, thereby threatening the sustainability of agriculture itself as well as the health of people consuming its products (Rasul and Thapa, 2003). Therefore, need for sustainable agriculture is increasing in response to concerns about the adverse environmental and economic impacts of conventional agriculture (Hansen, 1996).

Human excreta have the potential to supply all three essential nutrients to the soil. If fertilization of urine is done carefully directly into the soil at the correct time and the amount used is moderate, urine nitrogen has the same agricultural value as nitrogen of commercial mineral fertilizers (Richert Stintzing, et al., 2002). The intake of phosphorus from urine is better that from mineral fertilizers (Kirchmann and Pettersson, 1994). In order to maintain sustainable availability of nutrients for food production, the nutrients in excreta should be recycled in Bangladesh.

2.5 Ecological Sanitation

Ecological Sanitation or Ecosan is a closed loop system which closes the gap between sanitation and agriculture. It can be characterized as, "sanitize-and-recycle". It is a holistic concept towards ecologically and economically sound sanitation. The basic of this approaches is to recycle nutrient from excreta with as less expenditure on material and energy as possible to contribute to a sustainable development (Langergraber, 2005). Ecosan is not a specific technology. Urine diversion may be used in ecological sanitation (ecosan) concepts, but not all ecosan projects use urine diversion (von Münch, 2009).

Conventional sanitation practices can be classified into two broad categories, "flush-and-discharge" or "drop-and-store". If the excreta are not managed properly, both these two process has significant negative impact on environment. First, flush-and-discharge approaches require proper treatment for an acceptable level of nutrient and pathogen destruction which is very expensive and difficult to control. In developing countries, still over 90% of sewage is discharged untreated, polluting rivers, lakes and coastal areas (Langergraber, 2005). Second, drop-and-store technologies can prevent pollution in some places. But this option causes serious health hazard where flooding occurs and water table is high. Ecological sanitation system is introduced to overcome the problems with conventional sanitation.

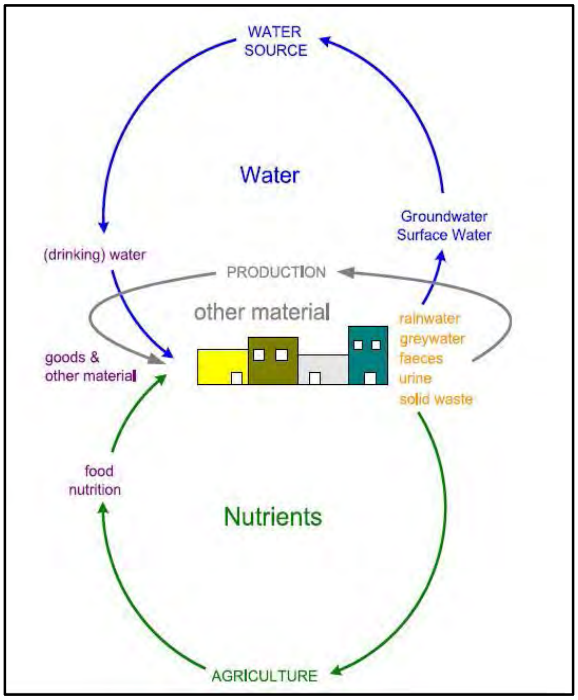


Figure 2-10: Circular Flow in an Ecosan System (Langergraber, 2005).

Ecosan approaches considered human excreta as a resource. It is based on three fundamental aspects: rendering human excreta safe, preventing pollution rather than attempting to control it after pollution, and using the safe products of sanitized human excreta for agricultural purposes. Human excreta are processed until they are completely free of disease organisms. The nutrients contained in the excreta are then recycled by using them in agriculture.

2.5.1 Ecosan Technologies

There are two basic concepts of Ecosan technologies; composting and dehydrating. Selection of technology is depends on climate, social-cultural demand, technical capability, agriculture etc.

Composting Toilets

In a composting toilet human feces, or feces plus urine, are deposited in a processing chamber along with organic household. Sometimes garden refuse and bulking agents like straw, peat moss, wood shavings are also added in the processing chamber. Waste can also be collected in containers. Composting is a complex natural biological process. If properly designed 70-90% volume reduced in toilet. In this process organic substances are mineralized and turned into humus (Winblad, et al., 2004).

Dehydration Toilet

The concept of this toilet is to evaporate or dry out the excreta instead of optimizing the conditions for composting. For efficient operation, water or urine should not be added to the dehydration system and dry material like ash, sawdust should add to enhance the dehydration process. Because of the addition of dry material, there is little reduction in volume. There is also minimal decomposition of organic material because of the low moisture content. The end product of dehydration is not compost but rather a kind of mulch which is rich in nutrients, carbon and fibrous material. Dehydration is a way of destroying pathogenic organisms. It does this by depriving them of the moisture they need to survive (Winblad, Simpson-Hébert and Calvert, 2004).

Urine Diversion Dehydration Toilet

To maximize the utilization of human excreta, it is better to keep urine and feces separate. In a urine diversion toilet, urine is collected separately from feces and from water. That's why urine diversion toilet has two collection systems: one for urine and one for feces. Sometime a third collection system is required for anal wash water. If the toilet is designed to collect both urine and feces separately without mixing with water then it is called Urine Diversion Dehydration Toilet (UDDT) (Dr. Elisabeth von Münch, December, 2009).

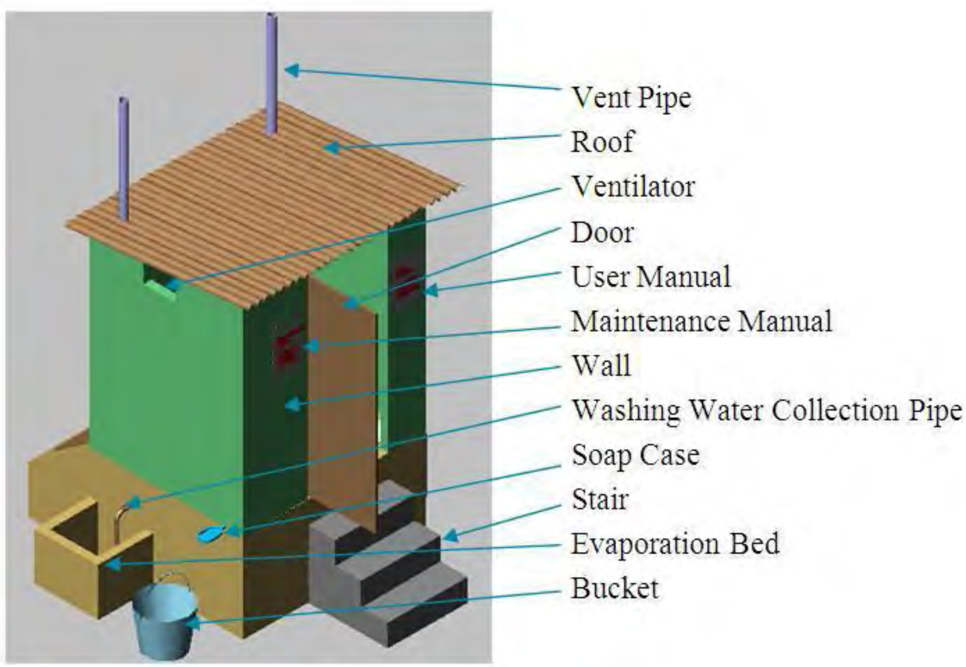


Figure 2-11: Outside view of UDDT (SPACE Bangladesh)

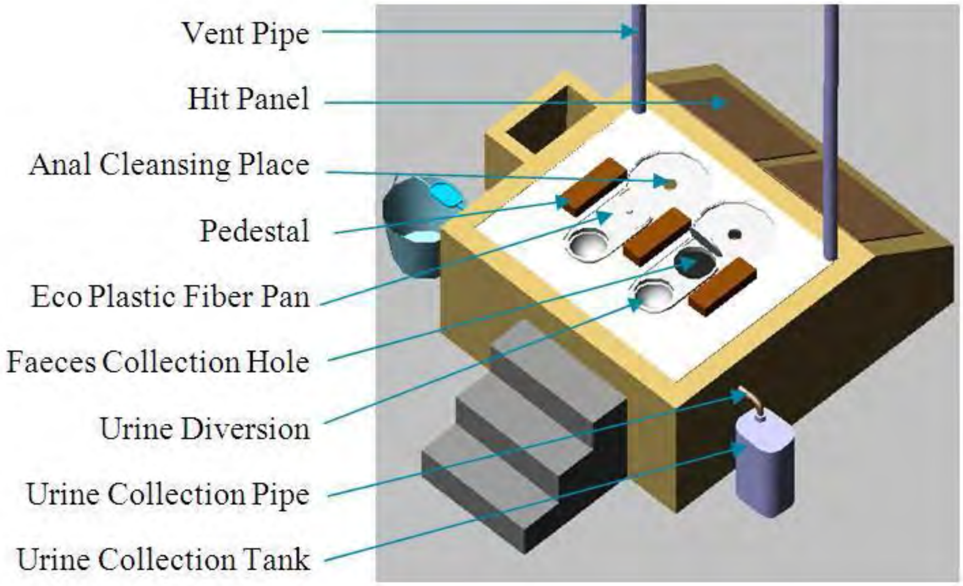


Figure 2-12: Inside view of UDDT (SPACE Bangladesh)

Benefits of UDDT

Water savings: As the feces collected directly to the chamber, UDDTs require no flash water whereas conventional urinals require 4L per flush, flush toilet require 8-12 L per flush. Thus UDDTs is most suitable sanitation technology in water crisis areas.

Maximizing nutrient reuse benefit: Urine contain 88% nitrogen, 67% phosphorus and 73% potassium of total daily excretion by human (Karak and Bhattacharyya, 2011). If urine can be collected separately then maximum benefit can be achieved by applying urine. On other hand, composted feces are also a good fertilizer and a good source of organic matter.

Less odor: If the urine and feces are not mixed, the odor becomes much less than when urine and feces are mixed together. Therefore, UDDTs can be installed inside home also without any problem.

Protecting ground water pollution: UDDTs collect urine and feces above ground. Also feces chamber of UDDTs needs to be water tight. As a result ground water does not have any contact with human excreta. Therefore UDDTs can achieve groundwater protection.

Design of UDD toilet

The main concept of UDD toilet is the separation of urine from feces. Urine is collected in container through pipe and feces directly go to feces chamber. There are two distinct type of UDDT. One is single chamber UDDT and another is double chamber UDDT. Double vault UDDTs are designed to operate in batches to facilitate the composting of feces. And in single chamber UDD only one collection cum storage compartment for containment of feces (ESF, 2009).

Sunny place is preferred for UDDT as it enhances the dehydration process for feces. The toilets should be build in relatively high place to protect it from rain and flood water from entering into feces vault (Chowdhury, 2008). It is essential to make a provision for adequate storm water drainage around the chamber. For this purposes, ground should slope away for front side to back side of toilet. If not possible, it is required to make a shallow ditch around the vault to the divert the storm water away from the structure (Austin, 2006).

Feces Vault

The entire chamber shall be constructed above ground. To disinfect the feces, a minimum storage period of twelve months is recommended (Austin, 2006, MOH, 2007). Recommended volume of feces vault is 70 liters (0.07 m^3) per person per year (Austin, 2006, GTZ, 2006). The opening of each feces vault should be 0.5m x 0.5 m to facilitate the emptying of the chamber (ESF, 2009). The diameter of hole in the pan or slab for defecation should be minimum 0.15m (GTZ, 2006).

Urine storage tank

Diameter of urine collection pipes should preferably be not less than 50 mm diameter and slopes should be at least 2% (1:50) (Austin, 2006). Otherwise Phosphate may precipitates in the pipe and cause clogging. In order to maximize the fertilizer value of urine, the container should also be sealed to protect losses of Nitrogen in the form of Ammonia (GTZ, 2006, von Münch, 2009). Poly-propylene pipes and PVC pipes are recommended for collection of urine. It is essential that the end of urine-pipes should be placed at the bottom of the tank and not at the top to prevent smell and Ammonia losses (Stefan Deegener, August 2009).

Sample calculation for one Feces Vault of UDD toilet for 6 persons

Volume of one feces vault = 0.07*6 = 0.42 m^3
Volume of one ring of 3'diameter and 1'height = 7.06 ft^3 = 0.2m^3
(Details of ring is given in Appendix - 3)
Three rings are required for one feces chamber.

2.5.2 Use of human excreta as fertilizer

All over the world, human excreta have been using to fertilize fields and fishponds and to enhance the soil organic fraction both in urban and rural areas. Use of the wastewater in agriculture became an established practice in arid and seasonally arid zones. Farmers of China have a long record of collecting mixed excreta and applying it onto their farms. Japan adopted this tradition in the 12th century, and farmers bought urine and feces from town dwellers. 50% of excreta in Japan is collected and returned to agricultural field in 2008 (Drangert, 1998).

Wastewater is used as a source of irrigation water as well as a source of plant nutrients, allowing farmers to reduce or even eliminate the purchase of chemical fertilizer. In Lima, Peru, farmers are illegally accessing and breaking up buried trunk sewers from which raw wastewater is diverted to vegetable garden. Agricultural reuse of wastewater is practiced throughout South America and in Mexico and is also widespread in North Africa, Southern Europe, Western Asia in South Asia and in the United States. It has been estimated that 10% of the world's wastewater is used for irrigation in the year 2000 (Strauss, 2000).

Human feces contain 70% to 85% of water and the rest is mainly organic material. Urine contains 93% to 96% of water and dry solids of some 50 to 70 g per person per day. The urea easily dissolves in water and becomes accessible to plants. The nutrient content of human excreta collected in a year is approximately equal to what has been eaten during the year. If a person eats some 250 kg of cereals, his excreta contain the amount of various nutrients required for the corresponding cereal or biomass production. Details of three important nutrients in human (Swedish) excreta and the amounts of nutrients required for cereal production is presented in table 2-7.

Table 2-7: The fertilizer equivalent of human excreta (Drangert, 1998).

Important Nutrients	Urine 500 l/yr	Feces 50 l/year	Total	Nutrient needed for 250 kg cereals
Nitrogen (N)	4 kg	0.5 kg	4.5 kg	5.6 kg
Phosphorus (P)	0.4 kg	0.2 kg	0.6 kg	0.7 kg
Potassium (K)	0.9 kg	0.3 kg	1.2 kg	1.2 kg

The nutrients in urine have the same fertilizing effects as those of artificial mineral fertilizer, if the same amount of Nitrogen, Phosphorus and Potassium is applied. Use of urine in agriculture as fertilizer has the potential to reduce demand for artificial mineral fertilizer (ESF, 2009). Research was carried out all over the world to test the fertilizer effect of urine. Urine was used as a fertilizer for growing barley in Sweden during 1997 to 1999. It was found that the Nitrogen effect of urine corresponded to about 90 percent of that of equal amounts of Ammonium Nitrate mineral fertilizers, which is estimated to correspond to about 100 percent of equal amounts of ammonium fertilizer, after accounting for the Nitrogen lost in the form of ammonia from the urine. Experiment was conducted on cabbage, spinach, maize and tomato by using urine as fertilizer in South Africa. Diluted urine responded as a good source of nutrients, especially Nitrogen, for cabbage and spinach. Maize gives same output form urea and urine. It was also found that above 200 kg Nitrogen/ha do not show any significant increase in yield (Anna Richert and Dagerskog, 2010).

To investigate the nutrient efficiency of urine in comparison with mineral fertilizer and compost, a research project was carried out in Ghana during 2004 and 2005. It was found that the fertilization with Phosphorus and Potassium enriched urine increases the yield of sorghum about 3.5 times. Results prove the efficiency of urine as fertilizer. Another experiment with urine was done in Mexico to greenhouse grown lettuce. Urine was compared with compost, a urine-compost mixture, and no fertilizer at all. Except for the unfertilized control, application rate was 150 kg of total Nitrogen per hectare in all treatments. In the experiment, urine gave the best yield of lettuce (Anna Richert and Dagerskog, 2010).

The produced nutrients, specifically food, on farms are discharged as waste. This loss of nutrients on farms is compensated for by mineral fertilizer of fossil origin (Langergraber, 2005). The losses in two ways, long term and short term. Short term lose the price of chemical fertilizer which is increasing continuously. Long term losses are decreasing of cropping yields, soil fertility and organic matter content in the soil. The sustainability of conventional agriculture is under threat which should be replaced by ecological agriculture.

Excreta Generation Rate

The amount of feces and urine excreted daily by individuals varies on how much a person drinks and sweats, and also on other factors such as diet, physical activity and climate (Lentner, 1981). Even in comparatively homogeneous groups there may be a wide variation in the amounts of excrete produced (Franceys, et al., 1992). The only way to obtain an accurate determination of the amount at a particular location is direct measurement. WHO suggests that if local information is not available, the figures in table 2-8 can be used as reasonable average.

Table 2-8: Urine and Feces generation rate (Franceys, Pickford and Reed, 1992).

Diet Types	Feces (wet mass)	Urine
	kg/cap.day^{-1}	l/cap.day^{-1}
High-protein diet in a temperate climate	0.12	1.2
Vegetarian diet in a tropical climate	0.40	1.0

Some specific studies were done on the generation rate of urine and feces in different country and region of world.

Table 2-9: Quantity of wet feces excreted by adults (Geurts, 2005).

Place	Quantity (per person)	
	gm/day	Kg/year
China (men)	209	76
India	255	93
India	311	113
Peru (rural Indians)	325	118
Uganda (villagers)	470	171
Malaysia (rural)	477	174
Kenya	520	190

Table 2-10: Quantity of urine exerted by adults from different sources.

Place and source	Quantity (per person)	
	l/day	l/year
Europe and north America (Del Porto and Steinfeld, 1999).	1.2	438
Sweden (Jönsson, 2004)	1.5	548
China (Jönsson, 2004)	1.5	548
Southern Thailand (Schouw, et al., 2002)	0.6-1.2	329
(Tilley, et al., 2008)	1.5	548

Nutrient Content of Human Excreta

Consumed plant nutrients leave the human body fully with excreta, when the body is fully grown. While the body is still growing, some nutrients are taken up and integrated into the body’s tissues (Jönsson, 2004). Once the skeleton and muscles reach their full size, no more plant nutrients are retained and accumulated in the body. Nutrients (N, P, and K) exerted by human body through urine and feces in different countries are given in table 2-11.

Table 2-11: estimation of excretion in different countries (Jönsson, 2004).

Country	Nitrogen kg/cap.yr	Phosphorus kg/cap.yr	Potassium kg/cap.yr
China, total	4.0	0.6	1.8
Urine	3.5	0.4	1.3
Feces	0.5	0.2	0.5
Haiti, total	2.1	0.3	1.2
Urine	1.9	0.2	0.9
Feces	0.3	0.1	0.3
India, total	2.7	0.4	1.5
Urine	2.3	0.3	1.1
Feces	0.3	0.1	0.4
South Africa, total	3.4	0.5	1.6
Urine	3.0	0.3	1.2
Feces	0.4	0.2	0.4
Uganda, total	2.5	0.4	1.4
Urine	2.2	0.3	1.0
Feces	0.3	0.1	0.4

2.5.3 Ecological sanitation in Bangladesh

Ecological sanitation was first initiated in Bangladesh in 2004. 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) in 2004. Under this project, 40 Urine Diversion Dehydration Toilets (UDDT) have been constructed in Comilla and Munshiganj district. Later on BARD construct another 99 Eco-toilet in six villages of Comilla during 2007-2009 in collaboration with JADE and JIC. To disseminate the knowledge on Ecological Sanitation, a national seminar was held on 21 August 2006. Sixty government, non-government and donor level participants attended in the national seminar. Project site of UDDT was also visited by professional from different government and non-government organizations during a two days national workshop at BARD in February 2007. Participants suggested to spread the ecological sanitation activities throughout the country (Chowdhury, 2006).

The Government of Bangladesh also motivated about UDDT and took initiatives on scaling up ecological sanitation throughout Bangladesh. GOB has undertaken initiatives for installing at least one UDDT in each union (4750 unions) as a demonstration in 2008 and allocated resources accordingly (Action, 2011).

Besides the GOB several non-governmental organizations have been taking initiative to promote UDDT in different regions of Bangladesh. The main organizations who are promoting UDDT in Bangladesh are: SPACE, BASA and Practical Action (Roy, 2009). All these organizations are promoting mostly UDDTs as it gives maximum benefit from excreta. SPACE implemented 402 household and 15 school UDDTs (Pramanik, 2009). 106 eco-toilets were constructed in seven districts by Practical Action in association with BASA and SPACE under SHEWAB project (Action, 2011). About 3000 UDDT toilets are now available in Bangladesh (Roy, 2009).

Experiences of using human excreta as fertilizer in Bangladesh

Using human excreta in the field is not a common practice in Bangladesh. Traditionally cow dung, farmyard manure, poultry manure and compost are used as fertilizer in Bangladesh. But people do not think about using human excreta as fertilizer. It is a very common attitude of the people of Bangladesh towards the human excreta that human feces are a very bad thing which cannot be touched by hands (Chowdhury, 2007), whereas people touch cow dung without hesitation and use it in field. Motivation is the main tool to enable people for using excreta as fertilizer. If people are presented with functioning systems in practice and benefit from using excreta in field, it is easy to motivate them towards UDD toilet. Comilla district in Bangladesh is a good example of that.

BARD and SPACE conducted a questionnaire survey among the users and non-users of UDDT in Comilla and Srinagar district in order to find out the response on using human excreta. Figure 14 shows people's willingness to use human excreta that come out through survey. Almost all the users show positive intention against using human excreta in both districts. However, non-users show different willingness in two projects.

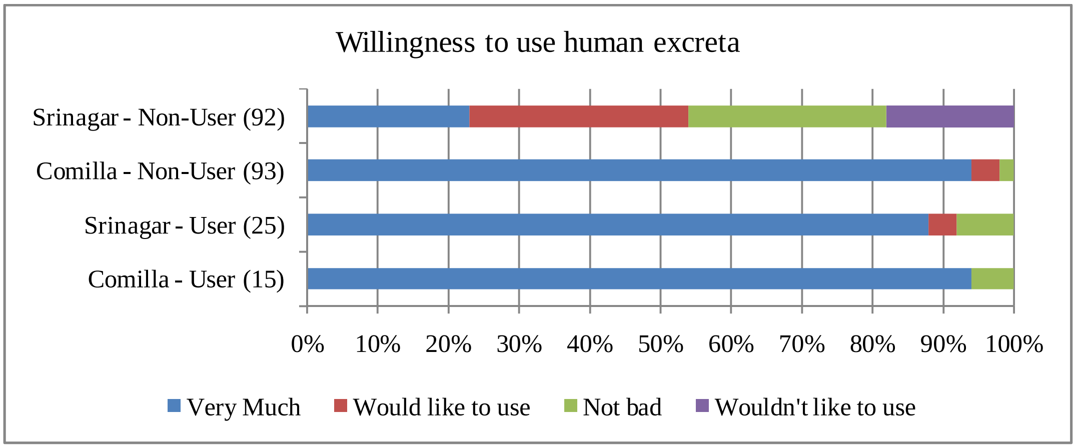


Figure 2-13: Willingness to use human excreta (Chowdhury, 2007).

To assess fertilizer value of human excreta, SPACE conducted experiments in two demonstration plots. Spinach and stalk vegetables were cultivated by the concerned toilet owners. One demonstration plot was used for testing urines and the other plot is used for testing dry feces. Each plot was further divided into four parts. Manures were applied followed by demonstration guidelines which are presented in table 2-12. Spinach was cultivated in demonstration plot-1 and stalk was cultivated in demonstration plot 2.

Table 2-12: Fertilizer dozes in demonstration plots (SPACE Bangladesh).

	FECES			**URINE**		
	Fertilizer	**Unit**	**Quantity**	**Fertilizer**	**Unit**	**Quantity**
Plot-1	Cow dung	g/plot	3000	No Fertilizer	-	-
Plot-2	Feces	g/plot	6000	Only Urine	Liter/plot	6
Plot-3	Cow dung	g/plot	3000	Urine	Liter/plot	6
	Urea	g/plot	333	TSP	g/plot	167
	MP	g/plot	333	MP	g/plot	167
Plot-4	Feces	g/plot	6000	Urea	g/plot	167
	Urea	g/plot	333	TSP	g/plot	167
	MP	g/plot	333	MP	g/plot	167

Highest production of spinach was found form fertilizer combination of feces, urea and MP. The second highest production was found from plot where only feces were applied as fertilizer. From demonstration-2, highest production of stalk was found from the combination of urine, TSP and MP. Second highest production came from applying only urine which was 2.9 kg.

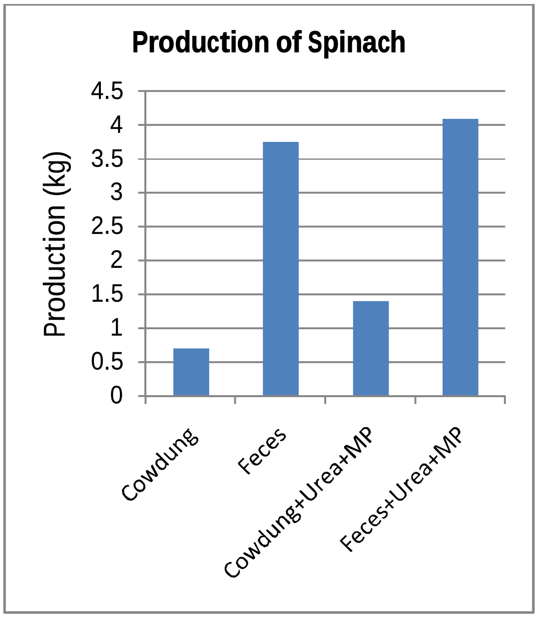


Figure 2-14: Production of Spinach (SPACE)

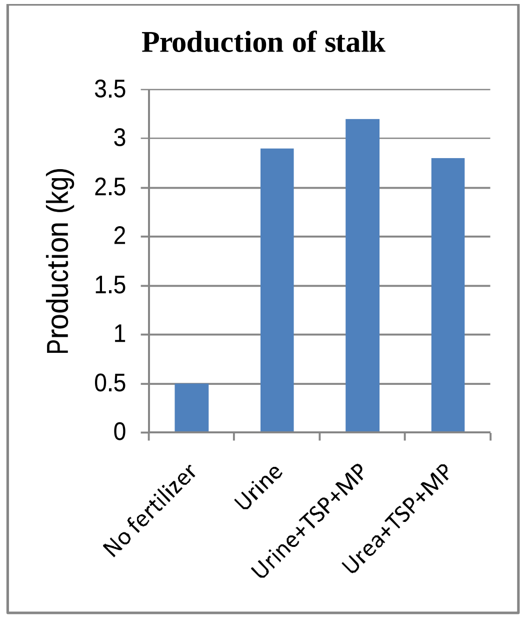


Figure 2-15: Production of stalk (SPACE)

In both cases, human excreta perform better than chemical fertilizers. Production of spinach with only urine is 93% of highest production and stalk with only feces is 90% of highest production. Also survey shows that general acceptance of UDDT users with the use of human excreta in agriculture in Bangladesh is high.

3 METHODOLOGY

The methodology used for this research comprises of desk study, data collection, field observation, and discussion.

3.1 Desk study

Desk study involved studying various articles and reports related to sanitation in Bangladesh, existing forms of sanitation, problems with current sanitation practices. Literature related with ecological sanitation technologies and case studies on ecological sanitation were reviewed to find out the prospects of ecological sanitation in Bangladesh. Focus was given to the experience of different organizations who already implemented ecological sanitation in Bangladesh. Special attention was given to sanitation technology in flood-prone areas. Literature was also reviewed to find out the problems related with sanitation in flood-prone areas and different sanitation options presently practiced in Bangladesh.

3.2 Data collection

Data collection was carried out to discover the most suitable technology among the implemented technology in different flood-prone areas. Data was collected from different government and non-government organizations that are working with sanitation in flood prone areas or working with ecological sanitation.

Basic required information were: the design of sanitation technology for flood prone areas, design of currently practiced ecosan technology, bill of quantity of ecosan technology, case studies on ecological sanitation in Bangladesh, and information about the case study area to determine contribution of excreta to fertilizer demand (details of case study area is presented in paragraph 3.5). These data were collected from different organizations of Bangladesh. The organizations are: DPHE, BARD, SPACE, ITN, Practical Action Bangladesh, Oxfam GB Bangladesh, Concern Universal and DAE. List of contact persons of these organizations are presented in Appendix-1.

Two questionnaires were developed (presented in appendix-1) to collect data from the field. One was targeted to finding out the cost of existing toilet. The survey was carried out in Comilla district. Targeted people were those who built their own toilet and are maintaining it. The other questionnaire was developed to find out the performance of UDD toilets during flood period. Targeted people were those who have UDDT and are living in flood prone area. Household surveys were carried out in Manikgonj and Gaibandah district.

3.3 Field observations

Field observations were done to evaluate the condition of existing UDD toilet in flood-prone area. Two flood-prone areas, Manikgonj and Gaibandah, were visited to evaluate the condition of existing UDD toilet. Conditions were evaluated by observing five parameters: 1) condition of superstructure, 2) condition of feces vault and cover, 3) condition of urine collection system, 4) entrance condition of toilet and 5) cleanliness of toilet. The conditions are marked in five categories: very good, good, normal, bad and very bad. Consideration for these categories is presented in paragraph 4.2.

3.4 Discussion

Discussion was made with sanitation experts working on ecological sanitation in Bangladesh (list of discussants is presented in Appendix-1), users of UDD toilets, non-users of UDD toilets, and masons of UDDT.

Sanitation experts discussed sanitation technologies for flood prone areas, prospects of ecological sanitation in Bangladesh and need of low cost UDDT technology. Discussion was held with a mason to establish the bill of quantity of currently practiced UDD toilets and to design a new type of UDDT for Bangladesh at reduced cost.

3.5 Case study area

Raicho village under Comilla district was selected as case study area to find out the contribution of human excreta as fertilizer to the current fertilizer demand. Key information required for this study is population of different age, Land use pattern and the type of fertilizer used in the case study area. Population information and land use pattern of Raicho village were collected form Village Information Book of Comprehensive Village Development (CVDP) Project. CVDP project was conducted by Development and Co-operatives Division of the Ministry of LGRD & Co-operatives and 1575 village were selected to develop village information book under this project. Information about fertilizer dozes for different crops in different season is collected from District office of Department of Agricultural Extension in Comilla.

Location: Raicho is a small village. It is under Kalibazar Union in Comilla District, and is located 15 km outside of the district center (see figure 3-1)

Figure 3-1: Location of Raicho village (Google Map)

Population: There are 267 families living in Raicho village, with a total population of 1464 (BARD, 2008). This makes the population density is 1483 person/km^2. An average person per household is 5.5. Details of population according to age are presented in figure 3.2.

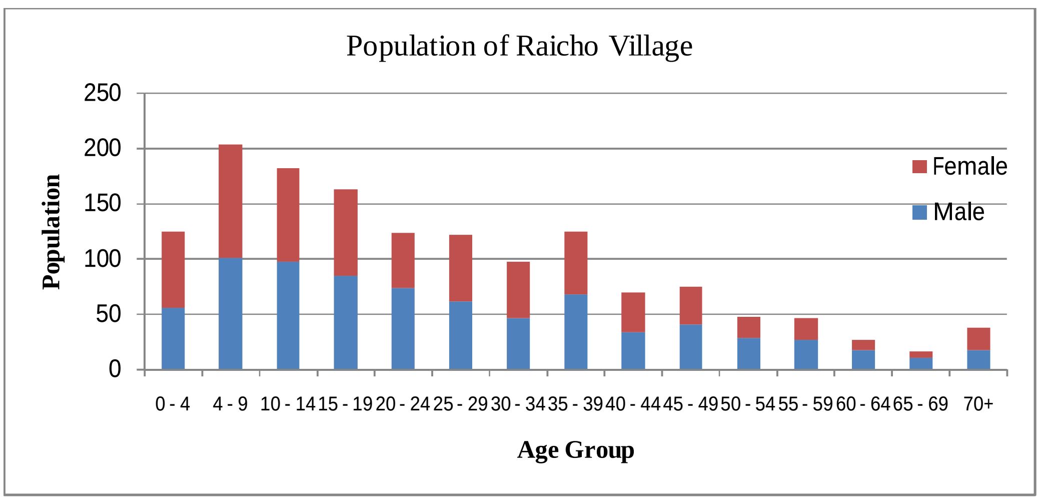


Figure 3-2: Population of Raicho Village (BARD, 2008).

Sanitation status: Sanitation coverage of Raicho village is excellent. No open defecation practices at this moment in Raicho village. 10 households are using septic tank, 39 households have UDD toilet and the rest are using pit latrines (BARD, 2008).

Land Use Pattern

Total area of the village is 244 acres. Among that 195 acres (80%) are cultivable land, 31 acres (13%) are residential area and the rest area is occupied by road and pond. Some land is single cropped, some is double cropped and some is triple cropped. Land use pattern is presented in figure 3.3.

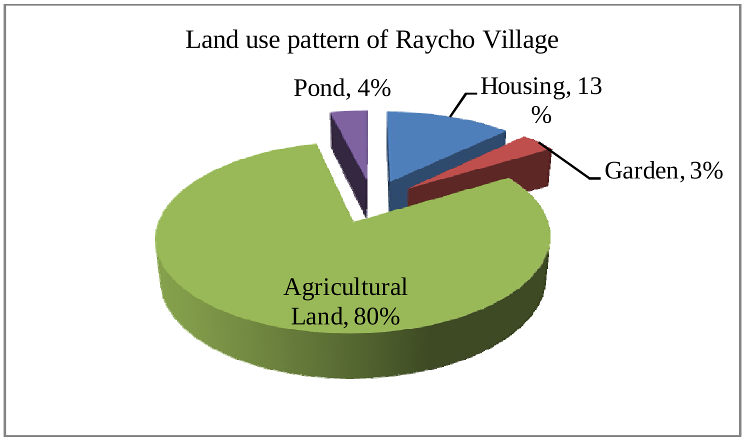


Figure 3-3: Land use pattern of Raicho Village (BARD, 2008).

Agriculture and Cropping Pattern: Agriculture is the main way of living of the people of Raicho village. Among 267 families, 68 families cultivate their own land, 5 families cultivate own and rented land and 72 families cultivate only rented land. Total 145 families directly depend on agriculture. The farmers of Raicho village mainly grow rice. They usually grow three different kinds of paddies: Aus, Amn and Boro. Farmers usually grow vegetables in high lands where irrigation is not easy. The distribution of land under different crops is presented in Table 3-1.

Table 3-1: Land use pattern of Raicho village (BARD, 2008).

Seasons	**Type of crop**	**Land under cultivation**		**Production Kg/Acre**
		Acre	**% of Total Land**	
15 Oct. to 15 Mar.	Boro	80.8	52.54	1856
	Potato	3.3	2.15	2768
15 Mar. to 15 July	Aus	73.8	47.96	1176
15 July to 15 Oct.	Amn	84.1	54.68	1180

3.6 Framework of Methodologies

Table 3-2: Framework of Methodologies

	1. Assessment of UDDTs as a flood resilient sanitation technology.	2. Assessment on affordability of UDDT for Bangladesh.	3. Potential contribution of human excreta to fertilizer demand.
Desk Study	▪ Literature review on sanitation for flood-prone areas.	▪ Literature review on UDDT technology. ▪ Develop bill of quantity of currently practiced UDDT ▪ Design of low cost UDDT ▪ Develop bill of quantity of low cost UDDT.	▪ Determination of fertilizer demand of case study area ▪ Determination of human excreta generation from case study area.
Data Collection	▪ Collection of case studies on UDDT in flood-prone areas from different organizations. ▪ Data collection through questionnaires-2. ▪ Data collection through field observations.	▪ Data collection through questionnaires-1 to find out cost of existing sanitation facilities. ▪ Find out the beneficiary contribution on UDDT in different projects.	▪ Fertilizer dozes for different crops in different seasons of case study area. ▪ Population of different age of case study area. ▪ Cropping pattern and land use pattern of case study area.
Discussion	▪ Discussion with sanitation experts on flood resilient sanitation technology. ▪ Discussion with UDDT users in flood prone areas about the performance of UDDT during flood time.	▪ With local mason to develop bill of quantity of existing and designed UDDT. ▪ With sanitation experts on the feasibility of proposed low cost UDDT technology.	▪ Discussion with farmer of case study area on fertilizer dozes for different crops.
Outcomes	▪ Appropriate sanitation technologies for flood-prone areas. ▪ Suitability of UDDT for flood-prone areas.	▪ Low cost and simple UDDT technology.	▪ Probable contribution of human excreta to fertilizer demand.

4 RESULTS

This chapter presents outcomes of activities with different methodologies for achieving specific research objective. First, findings on the performance of UDDT during flood period and existing conditions of UDDTs are demonstrated in paragraph 4.2. In addition, summery of experiences of different organizations with flood prone sanitation technology was also presented in paragraph 4.1. Paragraph 4.3 contains cost estimations of existing UDDT, affordability of people for sanitation and a recommendation of simple UDDT technology. Finally, in paragraph 4.4, a projection was made on the possible contribution of human excreta to the fertilizer demand of a selected case study area.

4.1 Experiences on sanitation in flood-prone areas form different organizations.

Discussions were made with sanitation experts form SPACE, Practical Action, Concern Universal and Oxfam GB. These organizations are working with sanitation in flood-prone areas of Bangladesh. Case studies on sanitation in flood-prone areas from these organizations are presented in paragraph 2.3.3. Experiences of these organizations are presented in table 4-1.

Table 4-1: Experiences on sanitation in flood-prone areas from different organizations.

Organization Name	Experiences
Oxfam GB	According to the experts from Oxfam GB, raised latrine is the most suitable technology for flood-prone areas of Bangladesh. UDDTs are also suitable in this regard, but people want modified low cost technology of UDDT with local material.
SPACE	SPACE has a very good experience of implementing UDDT in flood-prone areas. Experts from SPACE recommended UDDT as the best technology for flood-prone areas.
Concern Universal	Experts from this organization recommend considering flood before implementing any watsan facilities in flood-prone areas. According to them, highest flood level should consider as plinth level during construction of any watsan facility.
Practical Action	Practical action conducted a research on UDDT. According to the experts of Practical Action, UDDT is the most suitable option for disaster prone areas in Bangladesh. According to their considerations, the disaster prone areas are: urban slums, haor areas, high water table areas and water crisis region.

4.2 Evaluation of UDDT as a flood resilient sanitation technology

UDDTs in Munshiganj and Gaibandha district were visited to find out their performance during flood period and to evaluate their existing condition. Performance of UDDTs during flood period was evaluated by household survey. Key information was accessibility of UDDTs during flood period, height of highest flood level and height of toilet. Survey results are presented in table 4-2.

Table 4-2: Findings from survey on UDDT in flood prone areas.

Sl. No.	Name of Area	Average age of toilet	Average highest flood height		Average height of toilet		Accessibility during flood	Remarks
		years	ft	m	ft	m		
1	Madubpur, Manikgonj	2.0	1.3	0.4	1.6	0.49	yes	Highest flood in 1998
2	Goailbari, Gaibandha	0.5	1	0.3	2.5	0.76	yes	Highest flood in 1988
3	Kumidpur, Gaibandha	0.6	0.75	0.23	2.7	0.82	yes	Highest flood in 1988

Condition of UDDT toilet was assessed by observing five indicators. These are: condition of superstructure, condition of feces vault and cover, conditions of urine collection system, entrance condition, and cleanliness condition. Superstructure, feces vault and cover, urine collection system and entrance condition are marked as very good, if the components looks clean. If there is no damage on those components of toilet then marked as good and with little damage marked as average. The components are noted as poor, if there is any big damage but purpose can be served and very poor if toilet is not possible to use the toilet.

Table 4-3: Conditions of UDDT in flood-prone areas.

Indicators	Very good		Good		Average		Poor		Very Poor	
	HH#	%	HH#	%	HH#	%	HH#	%	HH#	%
Superstructure	2	10%	18	90%	-	-	-	-	-	-
Feces vault and cover	1	5%	18	90%	-	-	1	5%	-	-
Urine collection system	1	5%	18	90%	-	-	1	5%	-	-
Entrance condition	-	-	18	90%	2	10%	-	-	-	-
Cleanliness condition	1	5%	9	45%	8	40%	2	10%	-	-
Note: Very good - if looks clean, Good - no damage, Average - little damage, Poor - big damage but purpose can be served, Very poor - not possible to use.										

4.3 Affordability of UDDT technology

Affordability of people for UDDT was determined from the cost of existing sanitation facilities and from the beneficiary contribution to the existing UDDT. Survey was conducted on 37 household, among them 23 households are users of UDDT and they have shared the cost of UDDT. The rest, 14 households have pit latrine and they pay for the toilet.

Non-users of UDDT are interviewed in Comilla district. All the interviewed people are using pit latrine but with different kinds of superstructure. Superstructures of 29% toilets are made of brick, 42% toilets are made of corrugated iron sheet, and 29% toilets are made by bamboo fence. Cost of different types of latrines is presented in table 4-5.

Table 4-4: Cost of existing sanitation facilities.

Sl. No.	Toilet type	Income Range (yearly)	Average Income (yearly)	Construction cost	% of income
1	Brick structure	48000-144000	82500	6500	8%
2	C.I.Sheet Structure	60000-96000	72000	3830	5%
3	Bamboo fence and tin on top	36000-96000	60360	2038	3%
Average			71620	4,123 (≈4,000)	6%

Owners of UDDT were interviewed with questionnaire-2 in Comilla, Manikgonj and Gaibandah district. UDDT owners of Comilla, Manikgonj and Gaibandah district shares 3000 BDT, 2000 BDT and 2000 BDT respectively. Data was also collected from different organizations to find out the beneficiary contribution in different projects. Detailed cost sharing in different projects is presented in Table 4-4.

Table 4-5: Cost sharing for UDDT by the beneficiary.

Sl. No.	Location	Implemented by	Financed By	Shared Cost (BDT)
1	Comilla	BARD	JADE	3000
2	Munsigonj	SPACE	JADE	3900
3	Gaibandha	SPACE	UKAID and UNICEF	2000
4	Manikgonj	SPACE	Australian High Commission	2000
5	Gazipur	SPACE	Australian High Commission	3000
6	Jessore	SPACE	Australian High Commission	3500
7	Jessore	SPACE	JADE	5500
Average				3271(≈3000)

To check the affordability of UDDT, bill of quantity of current practiced UDDT was prepared. Cost was estimated separately for different components to allow for reduction cost in each component. Bill of Quantity of UDDT was made with the design collected from BARD, as this is the first published design of UDD toilet in Bangladesh (Chowdhury, 2008). GOB has adopted this design and is working on spreading this design all over the country. Detailed cost estimation was made on the basis of this design (Appendix - 2). Table 4-5 shows the cost of different component of the BARD design.

Table 4-6: Cost of different component of BARD designed UDDT (currently practiced).

Sl. No.	COMPONENTS	COST(BDT)
1	Foundation	1593
2	Feces Chamber	3266
3	R C C slab	4582
4	Side wall for toilet	4239
5	Roof and door	3200
6	Stair	983
7	Evaporation bet & urine container	525
Total Cost		18,388 (≈18500)

Knowledge from different sources was combined to reduce the overall cost of UDDT. Input was obtained from:

- Current pit latrine practice: buy, carry and install.
- The objective to make UDDT simple
- Expert's ideas obtained through interviewing local mason.

With the basic principle of pit latrine, a design of UDDT is developed. With the new design, three components will require to make the feces chamber. These are: foundation slab, ring and cover slab with pan. Detailed of the design is presented in Appendix-3.

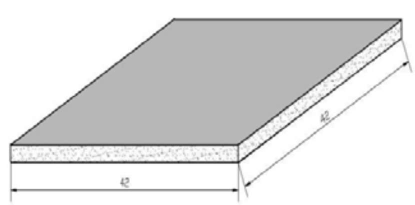


Figure 4-1: Foundation slab (dimensions are in inch)

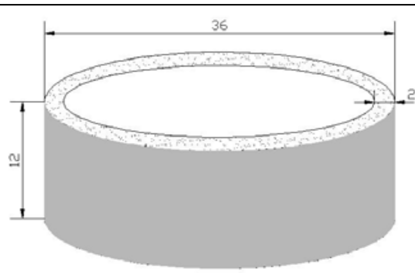


Figure 4-3: Ring (dimensions are in inch)

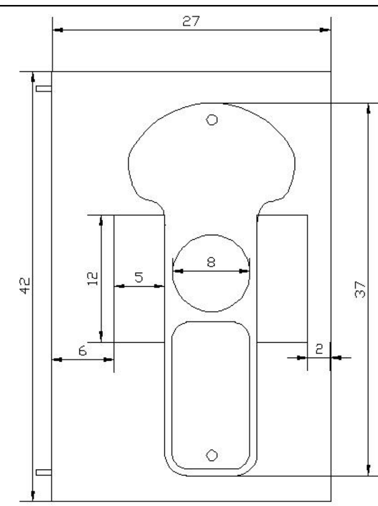
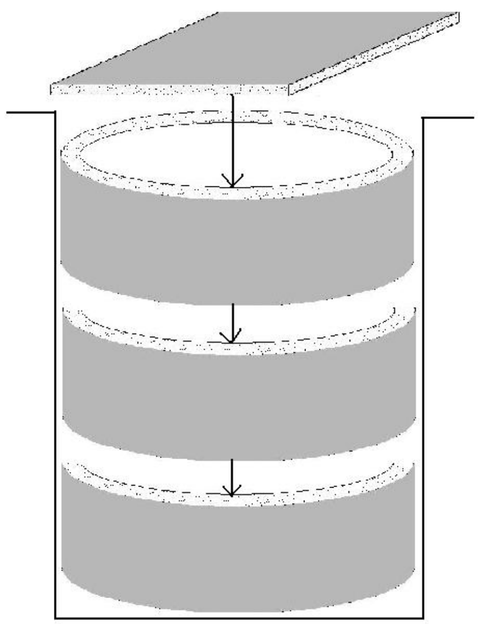
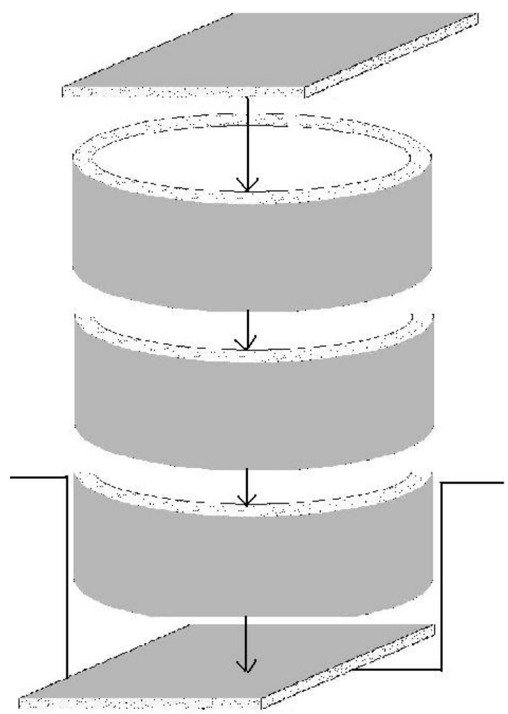


Figure 4-2: Slab with pan (dimensions are in inch)

The technology of pit latrine and proposed UDDT is presented in Table 4-7.

Table 4-7: Technology comparison between pit latrine and proposed UDDT.

PIT LATRINE	**PROPOSED UDDT**
Steps of pit latrine construction: ▪ Buy 5 to 7 ring (according to the no. of family members) and 1 slab. ▪ Dig hole in the ground according to the ring size ▪ Place the ring in the hole and put slab on it.	The basic differences in construction between the pit latrine and proposed UDDTs are: ▪ One ring should be placed underground and two rings should be placed above ground. ▪ Additionally, it is required to place one foundation slab at bottom. ▪ The most important step for proposed UDDT is to make the feces chamber water tight. For this purpose details guidelines presented in appendix-3 should be followed. ▪ And of course, UDDT require two chambers for alternate use.
 Figure 4-4: Pit latrine technology.	 Figure 4-5: Proposed UDDT technology.

Bill of quantity was made for the proposed UDDT technology (detail bill of quantity is presented in Appendix - 3). Cost comparison between different components of proposed UDDT and BARD designed UDDT are presented in table 4-8.

Table 4-8: Cost comparison between different components of BARD designed and proposed UDDT.

Sl. No.	Component	Current practices UDDT (BDT)	Low cost UDDT (BDT)	% Reduction
1	Foundation	1593	519	67%
2	Feces Vault	3266	1435	56%
3	R.C.C. Slab	4582	2591	43%
4	Side wall, door and roof	7439	3430	54%
5	Stair	983	983	0%
6	Evaporation bed	525	514	2%
TOTAL		18,388	9,473(≈9,500)	48.48% (**≈50%**)

4.4 Analysis of fertilizer demand and nutrient production of case study area

Specific fertilizer dozes are recommended for Raicho village by the agriculture extension office, Comilla that is presented in table 4-8. These recommendations are based on Fertilizer Recommendation Guide-2005 by Bangladesh Agricultural Research Council (BARC). Data was collected from Agricultural Extension Office of Comilla district.

Table 4-9: Fertilizer dozes for different crops in different seasons for case study area

Seasons	**Crops**	**Yield Goal recommended by BARC**	**Fertilizer dozes**					
			Urea	N	TSP	P	MP	K
		Kg/acre	kg/acre	kg/acre	kg/acre	kg/acre	kg/acre	kg/acre
Rabi	Boro	2424	90.9	41.814	19.695	3.939	30.3	15.15
	Potato	76	39	17.94	6.48	1.296	32.38	16.19
Kharif-1	T Aus	1636	25.755	11.847	12.12	2.424	15.15	7.575
Kharif-2	T.Amn	1697	51.51	23.694	7.575	1.515	13.635	6.8175

Fertilizer demand of case study area was calculated from these recommendations. Detailed on cropping and land use pattern is presented in paragraph 3.5. Data was collected from village information book of Raicho village, developed under CVDP project. Fertilizer demand was calculated separately for each season.

Table 4-10: Total fertilizer demand of case study area.

Seasons	Type of Crop	Cultivated land (acre)	Fertilizer Type	Fertilizer Doze	Nutrient Content	Total Demand		
						N	P	K
				kg/ acre	kg/ acre	kg	kg	kg
Season - 1	Paddy (Boro-HYV)	80.8	Urea (N-46%)	90.90	41.81	3379	318	1224
			TSP (P-20%)	19.70	3.94			
			MP (k-50%)	30.30	15.15			
	Vegetable	1.1	Urea (N-46%)	39.00	39.00	43	1	18
			TSP (P-20%)	6.48	1.30			
			MP (k-50%)	32.38	16.19			
Season - 2	Paddy (Aus-MV)	73.8	Urea (N-46%)	25.76	11.85	874	179	559
			TSP (P-20%)	12.12	2.42			
			MP (k-50%)	15.15	7.58			
	Vegetable	1.1	Urea (N-46%)	39.00	39.00	43	1	18
			TSP (P-20%)	6.48	1.30			
			MP (k-50%)	32.38	16.19			
Season - 3	Paddy (Amn-MV)	84.1	Urea (N-46%)	51.51	23.69	1993	127	573
			TSP (P-20%)	7.58	1.52			
			MP (k-50%)	13.64	6.82			
	Vegetable	1.1	Urea (N-46%)	39.00	39.00	43	1	18
			TSP (P-20%)	6.48	1.30			
			MP (k-50%)	32.38	16.19			
					TOTAL	**6374**	**629**	**2410**

Like fertilizer demand, production of nutrient was also calculated separately for different seasons. Detailed of population of case study is given in paragraph 3.5. Children between 0 to 4 years as well as 31 people who are working abroad are excluded from total population. For the rest generation rate was considered same.

Table 4-11: Total nutrient content in human excreta in case study area

Seasons	Total Population	Probable Fertilizer Production From Urine Kg per capita per year			Probable Fertilizer Production From Feces Kg per capita per year			Total Production Kg		
		N	P	K	N	P	K	N	P	K
Season-1	1308	3.67	0.04	1.97	0.40	0.28	0.61	2182	175	1384
Season-2	1308	3.67	0.04	1.97	0.40	0.28	0.61	1756	141	1114
Season-3	1308	3.67	0.04	1.97	0.40	0.28	0.61	1384	111	877

Comparison between fertilizer demand and production is presented in table 4-11.

Table 4-12: Potential contribution of human excreta to fertilizer demand

Seasons	Total Fertilizer Demand (kg)			Total Nutrient generation from excreta (kg)			% Contribution by human excreta			Additional Fertilizers required (kg)		
	N	P	K	N	P	K	N	P	K	N	P	K
Season - 1	3421	320	1242	2182	175	1384	64%	55%	111%	1232	144	0
Season - 2	917	180	577	1756	141	1114	191%	78%	193%	0	40	0
Season - 3	2036	129	591	1384	111	877	68%	86%	148%	651	18	0

According to the calculation, 100% need of Potassium could be met through using human excreta. Additional 1883 kg Nitrogen and 202 kg Phosphorus fertilizer is required to apply in field.

5 DISCUSSION

5.1 Sanitation technology for flood-prone area

Natural disaster has its own characteristics, which can't completely be controlled by any means. However, disaster preparedness can essentially prevent and reduce the risks of natural disasters. To reduce the damage on sanitation facilities during flood, many organizations are working with sanitation in flood-prone area of Bangladesh to search for the most suitable sanitation technologies. Some experiences from Oxfam GB, Practical Action, Dhaka Ahsania Mission, and SPACE are analyzed in this study to find out appropriate sanitation technology for flood prone areas. According to their experiences, raised latrine above highest flood level is appropriate solution for sanitation in flood prone area. Sanitation experts from these organizations also agreed on UDDT as a flood resilient sanitation technology.

Field survey and observations evaluated UDDT as a suitable technology for flood-prone areas. During field survey, average height of toilet is found 0.69 m above ground which is higher than average highest flood level of 0.31 m. UDDT is itself a raised technology as it is generally builds above ground level. People always try to build their house above highest flood level. As UDDT do not have bad smell, it is preferred to build this toilet near house. In some cases it was found that height of UDDT is more than height of house. Also, feces chamber of UDDT is water tight. So that ground water can't enter in it. During and after flood, ground water table became high. In this circumstance unlined latrine is difficult to use. But UDDT is very comfortable during flood time. Field survey shows that 100% users have a good experience of using UDDT during and after flood.

5.2 Affordability of UDD toilet

UDDTs are disseminating slowly in Bangladesh. The reasons are difficult technology of UDDTs and high construction cost. The entire UDDT that exists at present in Bangladesh were constructed by different organizations. Organizations trained some mason to build their toilet as mason needs special training to build UDD toilet. As a result, the technology is known to few peoples only. In 2008, GOB has undertaken initiatives for installing at least one UDDT in each union as a demonstration. Only about 20% unions could install UDDT. Most of the unions could not install due to insufficient technical knowledge (Action, 2011). Also, construction cost of UDDT is high. During questionnaire survey on 14 non-users of UDDT, it is found that 92%

households have interest to have UDDT. Among them 92% could not install due to high construction cost.

Affordability of people for UDDTs was measured by analyzing the cost of existing sanitation facilities and the cost sharing of UDDT owner. At present, practice of UDDT is to share 10%-30% of total cost by the beneficiary. On an average, people contribute 3000 BDT for having UDDT. And average cost of existing sanitation facilities is 4000 BDT. Based on the two figures, it was expected to develop UDDT technology within 3000 to 4000 BDT.

Proposed design reduces the cost by 50% of the BARD designed UDDT. Still the price is beyond the targeted amount. Main obstacles on reduction the cost of UDDT are: cost of pan, cost of stair and cost of superstructure. Cost of two pans is 2000 BDT which is 21% of total cost. Stair is another major part of UDD toilet. As the height of UDDTs is high, it is required to have good access facilities for UDDT especially for flood-prone areas. In addition, as UDDT build near house, superstructure should be good enough for privacy purpose.

With the current practiced design of UDDT, it is very difficult for single household to construct a UDDT. First, the household needs to manage a trained mason on UDDT, which is difficult in most of the region of Bangladesh. Second, 15 to 17 days are required to construct a UDDT with curing time. But mason needs to work 8 to 9 days. The rest days are curing time. It is not feasible for household to pay mason in the rest day. On other hand it is difficult to hire mason with a condition to work for some specific days with interval. Third, quality should be ensured during construction time.

Apparently it is not possible to provide UDDT within the affordable limit of people. But if the life period and emptying cost is taken into consideration then UDDT will be affordable for people. During field survey it was found that average emptying cost is 340 BDT. If life time of UDDT is considered 20 years ((Action, 2011)), then total cost of current sanitation facilities will be 11000 BDT, which is higher than the cost of proposed UDDT technology. Also, UDDT will give benefit from using human excreta as fertilizer. It was also found that fertilizer value of human excreta form a family of 5 adults is 625 BDT/year (fertilizer prices are presented in figure - 2.9). Detailed calculation is presented in table 5-2.

Table 5-1: Fertilizer value of human excreta from a family of five members

No of Adult	Total Nutrient Production (Kg)			Equivalent Fertilizer (Kg)			Rate (BDT) (price of year 2004-2005)			Total
	N	P	K	Urea	TSP	MOP	Urea	TSP	MOP	BDT
5	20	0.3	13	44	1.6	26	6	14	13	625

5.3 Contribution of human excreta to fertilizer demand

Raicho village under Comilla district was selected as case study area to find out the contribution of human excreta as fertilizer to the current fertilizer demand of the village. Raicho village was selected as case study area because UDDT was first initiated in Bangladesh in this village. At present Raicho village has 39 UDD toilets and people of this village are now habituated of using human excreta as fertilizer.

Some limitations were taken into consideration during calculation of nutrient content from human excreta. First, no study was found on excreta generation rate for Bangladesh. In this study widely used urine generation rate 500 liter per person per year and feces generation rate 50 kg person per year was taken as standard for Bangladesh. Detailed on excreta generation rate is presented in paragraph 2.5.2. Second, there are some losses of nitrogen from urine through ammonia which was not considered during calculation. Also, there is no published data about nutrient content of human excreta for Bangladesh. Under SHEWAB project, nutrient content in human excreta was analyzed by Soil, Water and Environment Department, University of Dhaka, Bangladesh. Findings were presented in a national level experience sharing workshop of SHEWAB project at Dhaka. Table 5-1 contains the nutrient content of human excreta found under SHEWA-B project.

Table 5-2: Nutrient content in human excreta of people of Bangladesh

URINE			FECES		
Nitrogen kg/year	Phosphorus kg/year	Potassium kg/year	Nitrogen kg/year	Phosphorus kg/year	Potassium kg/year
3.67	0.04	1.97	0.40	0.28	0.61

Data analysis from table 4-12 shows that no need to provide any extra Potassium, if all the people use their excreta properly to the field. Additional Nitrogen required for season-1 is 1232 kg and for season-3 is 651 kg, which is 29% of total demand of Nitrogen. Total Phosphorus required in three seasons is 202 kg which is 32% of total demand. Total fertilizer demand for case study area is 9413 kg/year. Additional fertilizer required 2045 kg/year. That is human excreta can contribute 78% of total fertilizer demand of case study area.

6 CONCLUSIONS AND RECOMMENDATIONS

First objective of this study is to assess the suitability of UDDT for flood-prone areas of Bangladesh. And this study evaluated UDDT as a flood resilient sanitation technology. It was also found that raised latrine is most suitable sanitation option for flood-prone areas of Bangladesh. For the sustainability of sanitation facilities, floods should be considered first during proposing sanitation solution for flood-prone areas. This study recommends building all the sanitation facility above highest flood level in flood prone areas.

Another objective on UDDT is to assess its affordability. As the currently practiced UDDT is not affordable for the people, a simple technology of UDDT is designed to reduce the cost. Still, the cost of proposed UDDT is beyond the affordable limit of people of Bangladesh. By considering the emptying cost, the proposed UDDT will reach to the affordable limit. Also the proposed technology of UDDT coincides with the pit latrine technology, which is the most popular form of sanitation for Bangladesh. It is expected that proposed UDDT will increase the dissemination rate of UDDT in Bangladesh.

Analysis of this study shows that 78% of fertilizer demand can be compensated form using human excreta as fertilizer in the case study area. This message is encouraging to give focus on ecological agricultural system in Bangladesh. Only thing is needed to wipe out the evading sense against human excreta. Traditionally Cow dung, Farmyard manure, Poultry manure and Compost are used as fertilizer in Bangladesh. Addition of human excreta in the fertilizer list will make revolution for agriculture as well as for sanitation. Field survey and experiences of different organizations show that almost all UDDT users are using urine and feces as fertilizer, which shows a very good prospect of ecological sanitation in Bangladesh.

This study recommends implementing a pilot project with proposed design of UDDT to evaluate the performance. The objective of this research is to develop a simple UDDT technology that goes with current practices: buy, carry and install. By implementing a pilot project, it will be easy to evaluate whether the study can reach its goal or not.

To maximize the fertilizer benefit from human excreta, proper management of urine is necessary. At this moment there is no arrangement for storing urine. People use urine immediately after the container is full, no matter whether it is required to use or not. It is required to search proper storage techniques in context of Bangladesh.

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APPENDICES

Appendix- 1 : **Questionnaires for household survey, List of Discussant**

Appendix- 2 : **Cost Estimation of Currently practiced UDDT**

Appendix- 3 : **Construction manual of low cost UDDT**

Appendix- 4 : **Different options of UDDT**

Appendix - 1

Questionnaires for Household Survey to determine Affordability

Date: ... ... Time: ... ... Location: ... ...

1. Name of Respondent: ... ...
2. Sex: Male / Female   Age: ... ...
3. How many family members do you have? ... ...
4. What is your profession? ... ...
5. What is your average income?

   Daily: ... ... or Weekly: ... ... or Monthly: ... . Yearly: ... ...
6. What kind of Toilet do you have?

   A. Pit latrine B. VIP latrine C. Eco toilet Others ... ...

Construction cost of Toilet

7. What is the construction cost for Sub structure? ... ...
8. What kind of superstructure do you have? Superstructure made by

   A. Brick B. Tin C. Bamboo Fence D. Others ... ...
9. What is the construction cost of your superstructure? ... ...
10. What is the yearly operation and maintenance cost? ... ...
11. How do you empty your toilet and how often? ... ...
12. What is the emptying cost of your toilet? ... ...
13. How long are you using this toilet? ... ...
14. Are you satisfied of using your toilet?

    A. Yes B. No **IF No**
15. What is your objection with this toilet? Specify ... ...

16. What kind of toilet do you want to have? A. Eco toilet B. Pit latrine C. Specify ... ...

17. Main obstacle of having preferred toilet?

A. Money B. Technology C. Unwillingness D. Others ... ...

Questionnaires for Household Survey to Evaluate the Applicability of UDDTs in Flood-Prone Area

Date: ... ... Location: ... ...

1. Name of Respondent: ... ... Sex: Male / Female
2. How long are you using this toilet? ... ... Years
3. How many floods you have passed with this toilet? ... ... Nos.
4. What is the average height of regular flooding? ... ... Feet
5. What is the height of toilet? ... ... Feet
6. Is it possible to use this toilet during flood? A. Yes B. No
7. What are the problems of using this toilet during flood?

   A. Bad Smell B. Difficult to access C. Water enter into feces vault D. Difficult to Collect Urine E. Others ... ...
8. Does the toilet need any maintenance work after flood? A. Yes B. No
9. If yes what kind and cost? Specify ... ...
10. What is status of excreta use?

    A. Both Urine and Feces B. Only Urine C. Only Feces D. Nothing
11. What is the contribution of you in building this toilet?

    A. NGO build this toilet

    B. House hold contribute % of total cost. The amount is ... ... Taka.

    C. House hold contribute the full cost. The amount is ... ... taka.
12. What is your average income? Daily: ... ... or Monthly: ... ... or Yearly: ... ...

Table 1.1: Observations of UDD Toilet.

Sl. No.	Observation parameter	Very Good	Good	Normal	Bad	Very Bad
1	Condition of Superstructure					
2	Condition of Feces Vault and cover					
3	Condition of Urine collection system					
4	Entrance condition of toilet					
5	Cleanliness of toilet					

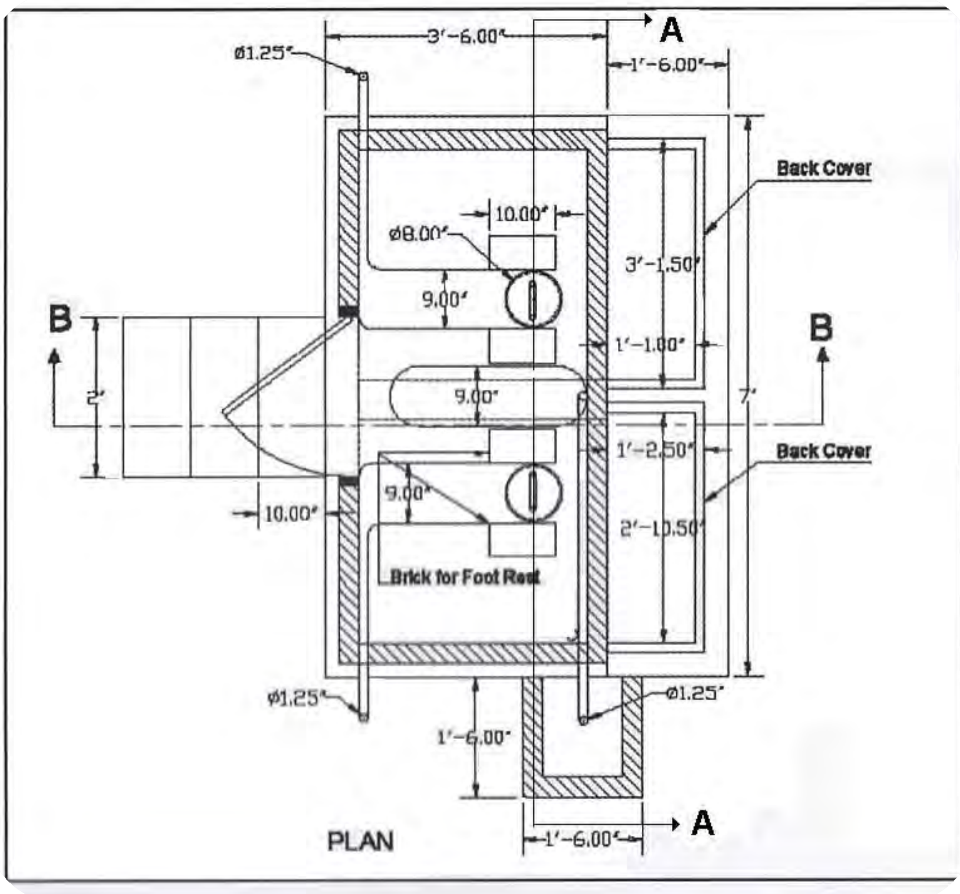
Table 1.2: List of discussant during field visit in Bangladesh

Sl. No.	Discussant Name	Organizations	Position	E-mail address
Contact persons from Government Organizations				
1	Dr. Masudul Hoq Chowdhury	BARD	Director	chowdhury62@yahoo.com
2	S.M Zulkernine	ITN-BUET	Training and Technology Specialist	smzulker@yahoo.com
Contact persons from Non-Government Organizations(NGO)				
3	Md. Azahar Ali pramanik	SPACE	Executive Director	space.equity@gmail.com
4	Sanjan Kumar Barua	Practical Action	Senior Technical Officer	sanjan.dhk@live.com
5	Abdullah Al Mamun	Practical Action	Project Manager	mamun@practicalaction.org.bd
6	Zahidul Mamun	Concern Universal	Head - Health Unit	zahidul.mamun@concern-universal.org
7	Golam Morshed	Oxfam GB	Public Health Promoter	GMorshed@Oxfam.org.uk
8	Zobair Hasan	DORP		dorpco@dhaka.net
8	Zobair Hasan	DORP		health@dorpbd.org

Appendix-2

Cost Estimation of Currently practiced Urine Diversion Dehydration Toilet (UDDT) designed by BARD

Figure 2.1: Architectural plan and Section of BARD designed UDD toilet



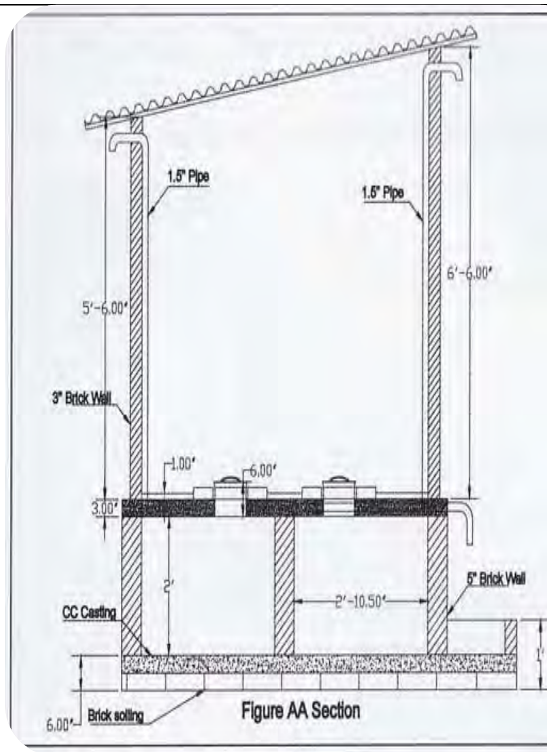


Figure AA Section

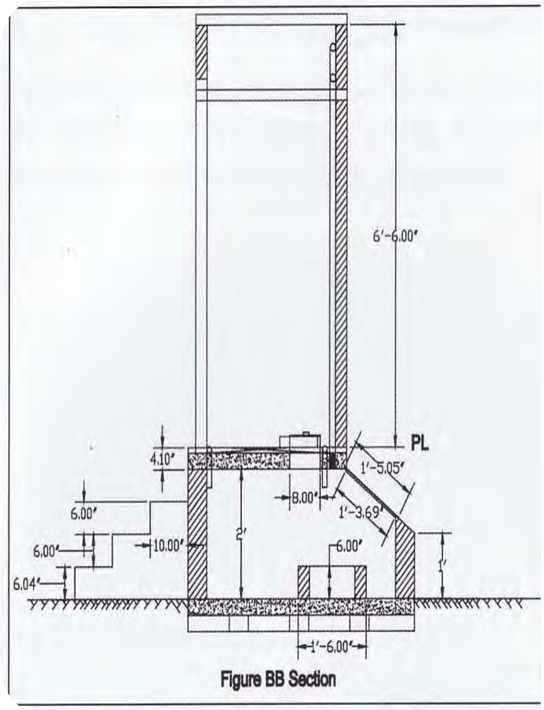


Figure BB Section

Cost estimation for Foundation

Table 2.1: Detailed estimation for Foundation

Sl No	Details			Unit Price (BDT)	Total Cost (BDT)
1	Bricks	102	Nos	6	612
2	Cement	37	3kg	400/50 kg	299
3	Sand	2.6	$Feet^3$	15	39
4	Khoa	5.3	$Feet^3$	70	368
5	Mason	0.5	days	350	175
6	Mason helper	0.5	days	200	100
				Total	1593

Cost estimation for Feces Vault

Table 2.2: Detailed estimation for Feces Vault

Sl No	Details			Unit Price (BDT)	Total Cost(BDT)
1	Bricks	227	nos	6	1362
2	Cement	37.6	kg	400/50 kg	301
3	Sand	3.5	$Feet^3$	15	53
4	Cover (0.97m x 0.457m)	2	nos	500	1000
5	Mason	1	day	350	350
6	Mason helper	1	day	200	200
				Total	3266

Cost estimation for Frame work for R C C slab and Casting of R C C slab

Table 2.**3:** Detailed estimation for Casting for R. C. C. work

Sl No	Details			Unit Price (BDT)	Total Cost (BDT)
1	Shuttering material				300
2	PVC pipe (Dia - 8", Height - 6")	2	nos	60	120
3	Fiber pan	2	nos	1000	2000
4	Khoa	3.5	$Feet^3$	70	245
5	Cement	37.6	kg	400/50 kg	301
6	Sand	1.7	$Feet^3$	15	26
7	Rod (φ 2) 2.134 m 8 Nos	7	kg	70	490
	1.067 m 15 Nos				
8	Mason	2	days	350	700
9	Mason helper	2	days	200	400
				Total	4582

Cost estimation for side wall for toilet

Table 2.4: Details estimation for side wall for Toilet

Sl No	Details			Unit Price (BDT)	Total Cost (BDT)
1	Bricks	417	nos	6	2502
2	Cement	67.725	kg	400/50 kg	542
3	Sand	6.3558	$Feet^3$	15	95
4	Mason	2	days	350	700
5	Mason helper	2	days	200	400
				Total	4239

Cost estimation for Roof and door

Table 2.5: Details estimation for Roof

Sl No	Details			Unit Price (BDT)	Total Cost (BDT)
1	Tin (2.73m x 0.76m)	3	nos	300	900
2	fittings				200
3	Frame for roof and door	2	nos	500	1000
3	Carpenter	2	days	350	700
4	Carpenter helper	2	days	200	400
				Total	3200

Cost estimation for Stair

Table 2.6: Details estimation for stair

Sl No	Details			Unit Price (BDT)	Total Cost(BDT)
1	Bricks	58	nos	6	348
2	Cement	9.03	kg	400/50 kg	72
3	Sand	0.88	$Feet^3$	15	13
4	Mason	1	days	350	350
5	Mason helper	1	days	200	200
				Total	983

Cost estimation for evaporation bed for anal cleaning water and urine container

Table 2.7: Details cost estimation for Evaporation bed

Sl No	Details			Unit Price (BDT)	Total Cost (BDT)
1	Bricks	14	nos	6	84
2	Sand	0.35	$Feet^3$	15	5
3	khoa	0.71	$Feet^3$	50	35
4	30 liter container	2	nos	200	400
				Total	525

Total cost of UDD toilet

Table 2.8: Total cost of UDD toilet

Sl. No.	COMPONENT	Construction cost
1	Foundation	1593
2	Feces Chamber	3266
3	R C C slab	4582
4	Side wall for toilet	4239
5	Roof and door	3200
6	Stair	983
7	Evaporation bet & urine container	525
	Total Cost	18388

Detail calculations

Calculation for foundation:

Area of excavation = 2.134m x 1.524 m = 3.25 m^2
Area of one Brick = .254 m x .127 m = .032 m^2
No of Brick required =102 Nos
Volume of cement concrete mixing on top = 2.134 m (7') x 1.524 m (5') x .0762 m (6") = 0.248 m^3
Cement: Sand: Khoa = 1:3:6
Cement = 0.248 m^3 (1/10) = .0248 m^3
Sand = 0.248 m^3 (3/10) = .0744 m^3
Khoa = 0.248 m^3 (6/10) = .01448 m^3

Calculation for Side and Middle wall for Feces Vault:

Area of wall = (2.134m x 1.524 m) x 2 x .3048m (lower portion of wall) + (2. 134m + 1.067m x 2+.1524m
x 2) x .3048m (Upper portion of wall)
= 2.23 m^2 + 1.39 m^2
= 3.62 m^2
Side area of one Brick= 0.254m x 0.063m = 0.016 m^2
No of Brick required =227 Nos
Plaster work =0.00054m^3 x 227 = .1226 m^3
Cement: Sand =0.025 m^3: 0.1 m^3

Frame work for R C C slab and Casting of R C C slab:

Volume of Cement Concrete Mixing = (2.134 m (7') * 1.067m (3.5') * .076m (3")) = $0.173m^3$

Cement: Sand: Khoa = 1: 2: 4

Cement = 0.025 m^3

Sand = 0.049 m^3

Khoa = 0.099 m^3

Side wall for toilet:

Area of wall = (2.134m (length) + 1.067m (width) *2.134m (height) * 2- 0.762m * 2.134 (door space)) = 8. 09 m^2

Side surface area of one Brick = 0.254m x 0.076m = 0.0194 m^2

No of Brick required =417 Nos

Plastering material = 417x $0.00054m^3$ = 0.225 m^3

Cement: Sand = 0.045 m^3 : 0.18 m^3

Calculation for Stair:

	Height	Width	Length	Volume
1st part	0.4572	0.254	0.61	0.0708386
2nd part	0.3048	0.254	0.61	0.0472257
3rd part	0.1524	0.254	0.61	0.0236129
			Total	**0.1416771**

Volume of one Brick = 0.254m x 0.127m x 0.076m = 0.0024516 m^3

No of Brick required =58 Nos

Plastering material = 58 x $0.00054m^3$ = 0.0313 m^3

Cement: Sand = 0.006 m^3 : 0.25 m^3

Appendix - 3

Construction manual of proposed Urine Diversion Dehydration Toilet

List of contents

List of Tables

List of Figures

1. Architectural plan and Section of proposed low cost UDD toilet

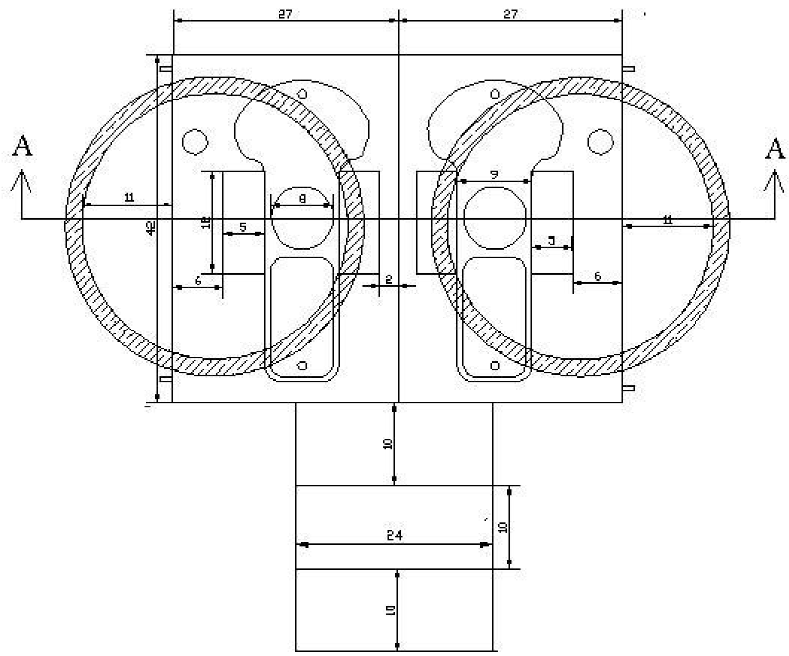


Figure - 3.1: Plan of UDD toilet (all dimensions are in inch)

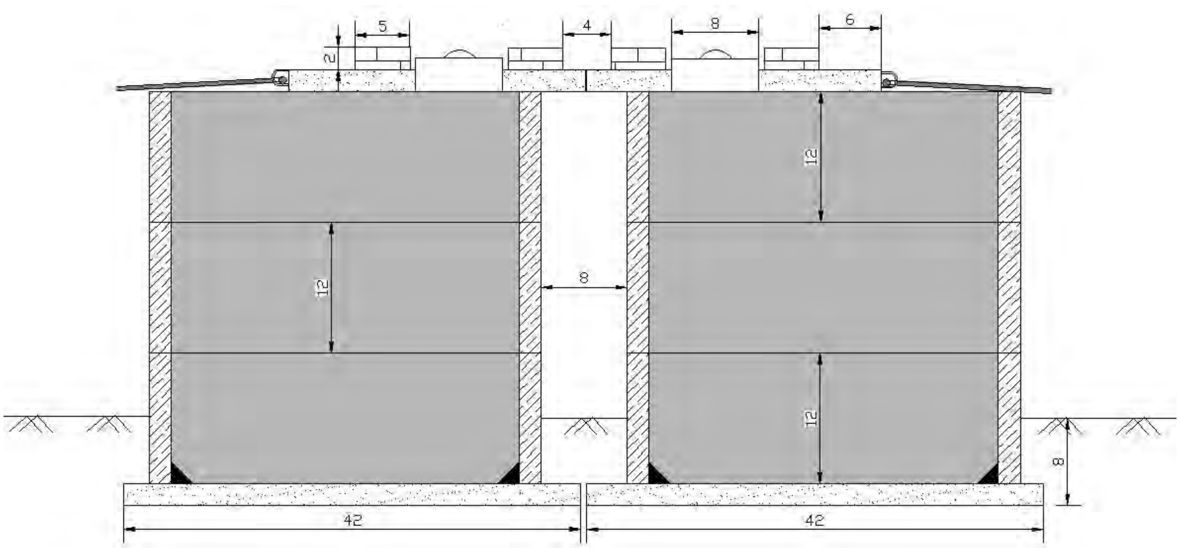


Figure 3.2: Cross Section A-A t (all dimensions are in inch)

2. Different component of UDD toilet

Slab for foundation

Two precast slab of size 3.5'x3.5' are required for foundation. Thickness of slab is 2". Cement, Sand and Khoa ratio should be 1:3:6.

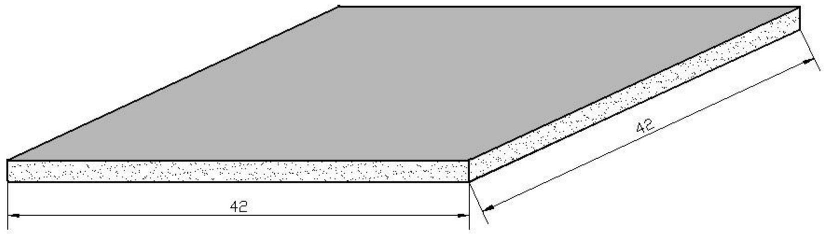


Figure 3.3: Slab for Foundation

Ring

Diameter, height and thickness of ring are 3', 1', 2" respectively. Cement, Sand and Khoa ratio should be 1:2:4.

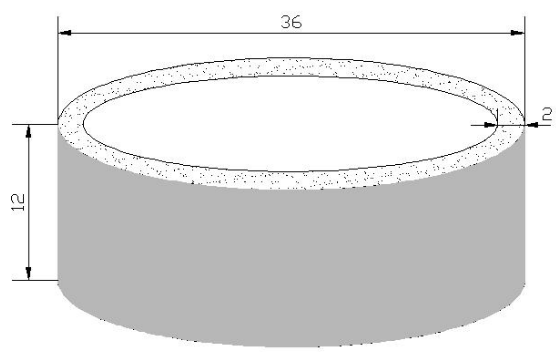


Figure 3.4: Ring

Pipes

To keep the toilet free from bad smell, vent pipe can be used to transfer bad smell from feces vault to outside. Poly Venyle Chloride (PVC) pipe of 3 inch diameter works good for ventilation. Cowl and screen should place on top of it. PVC pipe of 1.5 inch diameter can be used to collect urine and anal cleaning water. Flexible pipe is required to make connection between the pan and collection pipe.

Slab with pan for feces chamber

Slab is the most important part of UDD toilet, for which mason needs training. The pan should fix in slab during casting. Size of slab is 27" x 42". Cement, Sand and Khoa ratio should be 1:2:4.

Figure 3.5: Pan of Plastic Fiber (Source: Practical Action)

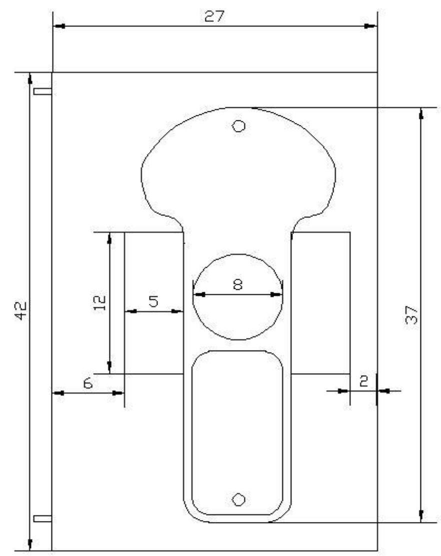


Figure 3.6: Slab with Pan

Roof and side wall Material

Roof material needs to be durable. Tin is preferred as roof material as it last long. Tin is also preferred as side wall material. As people build the UDDT near to home, it is required to ensure proper privacy.

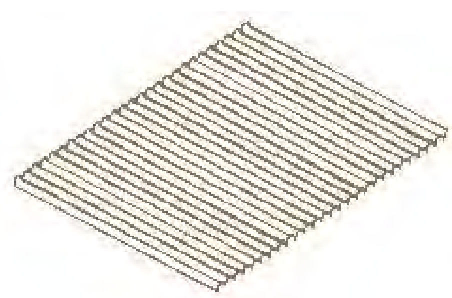


Figure 3.7: CI sheet

3. Different steps of construction for proposed UDDT

Selection of place for UDD toilet

Traditionally people of Bangladesh build their toilet away from home due to bad smell. As there is less or no bad smell from UDD toilet, it can build near home. Generally place with proper sunlight is preferred for UDD toilet, as it enhance the compost process of feces. Access to feces chamber need to consider during site selection.

Foundation

To construct UDD toilet 7'x3.5' area needs to be excavated with a depth of 8". The bottom of the excavation needs to be made plain and should compact properly. After compaction two precast slab of 3.5'x3.5'x2" size should place side by side.

Feces Chamber

On top of each foundation slab, three precast ring should be placed one after another for one feces chamber. Distance between two chambers will be 8". Before placing each ring, a layer of cement and sand mixing of ratio 1:4 should be placed to ensure proper bonding. To protect leakage in the bottom, the joint between the foundation slab and ring should be sealed with cement and sand mixing according to design.

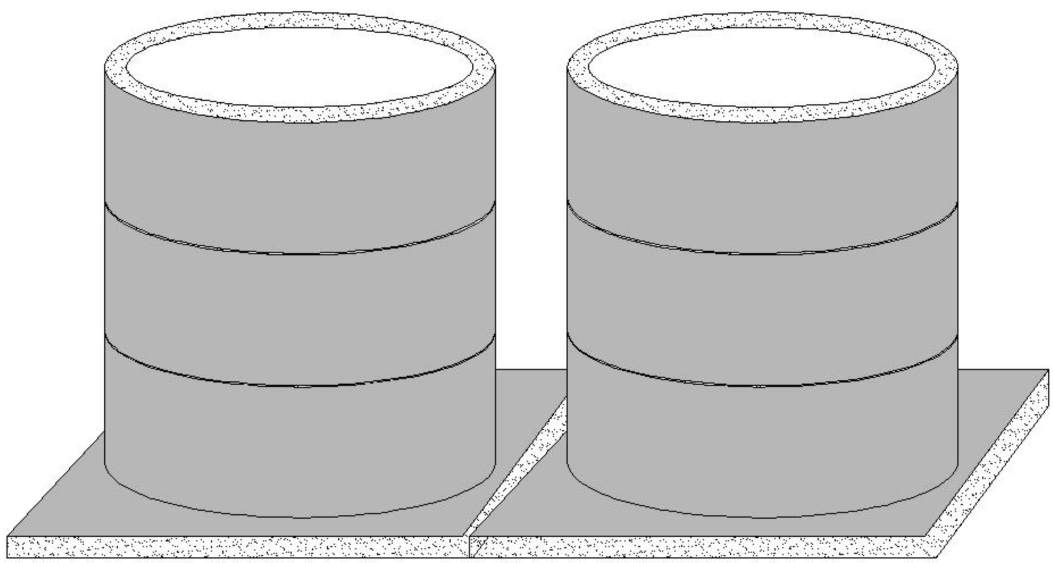


Figure 3.8: Feces chamber

Placing of slab on Ring

Slab should be placed on each feces chamber in such a way that collection hole of urine and anal cleaning water should be out of ring. Distance between slab and inner side of ring should be 11 inch. Before placing the slab on ring, a layer of mortar should placed on ring for proper bonding. There should not be any gap between two slabs.

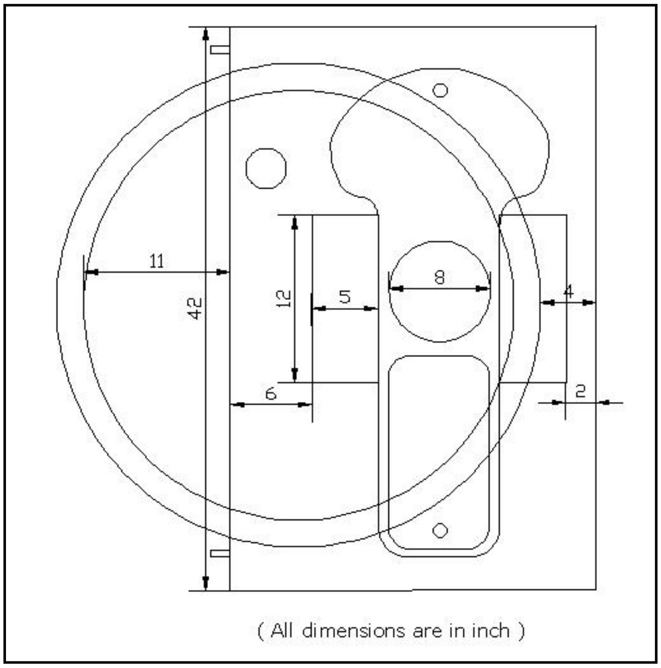


Figure 3.9: Position of slab on feces chamber

4. Bill of Quantity of low cost UDD toilet

Construction cost of Foundation Slab

Table 3.1: Construction cost of Foundation Slab

Sl No	Details	Quantity	Unit	Unit Price (BDT)	Total Cost (BDT)
2	Cement	9	Kg	8	72
3	Sand	0.63	ft^3	15	9.45
4	Khoa	1.26	ft^3	70	88.2
5	Wire				70
6	Mason	0.1	day	200	20
				Total	260

Construction cost of Ring

Table 3.2: Construction cost of Ring

Sl No	Details	Quantity	Unit	Unit Price (BDT)	Total Cost (BDT)
1	Cement	7	Kg	8	56
2	Sand	0.32	ft^3	15	4.8
3	Khoa	0.64	ft^3	60	38.4
4	Mason	0.5	day	200	100
5	Wire				40
				Total	239

Construction cost of Slab

Table 3.3: construction cost of slab without pan

Sl No	Details	Quantity	Unit	Unit Price (BDT)	Total Cost (BDT)
1	Fiber pan	1	nos	1000	1000
2	Cement	8	Kg	8	64
3	Sand	0.38	ft^3	15	5.7
4	Khoa	0.76	ft^3	60	45.6
5	Mason	0.5	day	200	100
6	Wire				80
				Total	1295

Construction cost of Superstructure

Table 3.4: construction cost of Superstructure

Sl No	**Details**	**Quantity**	**Unit**	**Unit Price (BDT)**	**Total Cost (BDT)**
1	Bamboo	6	nos	50	300
2	CI Sheet	6	nos	180	1080
3	Wood	2	cft	500	1000
4	pvc pipe				400
5	nut, bolt, clamp, nail, screw				350
7	Labour	1	day	300	300
				Total	3430

Construction cost of Stair

Table 3.5: Construction cost for Stair

Sl No	Details	Quantity	Unit	Unit Price (BDT)	Total Cost (BDT)
1	Bricks	58	nos	6	348
2	Cement	9 kg	kg	8	72
3	Sand	0.88	Ft^3	15	13.2
4	Mason	1	days	350	350
5	Mason helper	1	days	200	200
				Total	983

Construction cost of Evaporation Bed

Table 3.6: Construction cost for Evaporation bed

Sl No	Details	Quantity	Unit	Unit Price (BDT)	Total Cost (BDT)
1	Brick	10	Nos	6	60
2	Sand	0.35	Ft^3	15	5.25
3	khoa	0.7	Ft^3	70	49
4	30 liter container	2	Nos	200	400
				Total	514

Total construction cost of low cost UDD toilet

Table 3.7: Total cost of low cost UDDT

Sl. No.	Description of Item	Unit	Quantity	Rate (BDT)	Amount (BDT)
1	Foundation	nos	2	260	519
2	Feces Chamber	nos	6	239	1435
3	RCC slab	nos	2	1295	2591
4	Side wall, roof and door				3430
5	Stair				983
6	Evaporation bed and urine container				514
				Total	9,473

5. Detail calculation for low cost UDD toilet

Calculation for Foundation Slab

Volume of Slab = 3.5x3.5x.17= 2.1 ft^3
Cement: Sand: Khoa = 1:3:6
Cement = 2.1 ft^3 (1/10) = 0.21 ft^3 = 0.0059 m^3 = 9 kg
Sand = 2.1 ft^3 (3/10) = 0.63 ft^3
Khoa = 2.1 ft^3 (6/10) = 1.26 ft^3

Calculation for Ring

Volume of one ring = (3.1428 /4)($3^2 - 2.75^2$)*1 = 1.13 ft^3
Cement: Sand: Khoa = 1:2:4
Cement = 1.13 ft^3 (1/7) = 0.16 ft^3 = 0.0045 m^3 = 7 kg
Sand = 1.13 ft^3 (2/7) = 0.32 ft^3
Khoa = 1.13 ft^3 (4/7) = 0.64 ft^3

Calculation for slab

Size of one slab = 3.5'x2.25'

Volume of one slab = (3.5'x2.25'x0.17') = 1.34 ft3

Cement: Sand: Khoa = 1:2:4

Cement = 1.34 ft3 (1/7) = 0.19 ft3 = 0.0054 m3 = 8 kg

Sand = 4.38 ft3 (2/7) = 0.38 ft3

Khoa = 4.38 ft3 (4/7) = 0.76 ft3

Calculation for Frame:

Total length of angle bar = (10x4)(Front side)+9x2 (back side)+ (3.5x6+5x8)(two side)+(6.5x2+2.5x2)(door) = 137 ft = 41.76 m

Calculation for tin for Door and roof

Dimension of tin = 9'x2.5'

Area of Roof = 3.5'x 4.5'

Tin required or roof = 1 nos

Area of Door = 2.5'x 6.5'

Tin required for door = 1 nos

Total tin required = 2

Appendix - 4

Different options of UDDT

SHEWA-B project undertook an action research on Ecological Alternatives in Sanitation in Difficult Areas of Bangladesh. Urban slums, haor areas, high water table areas and water crisis regions are considered as difficult areas of Bangladesh. Eleven designs have been developed, considering the geo-hydrological features of the difficult areas. Freedom was given to the beneficiaries to select their own toilet. Among the 11 designs, 7 designs were selected by the beneficiaries. These are:

Option-1: Fixed Chamber System Using Plastic Fiber Pan

Option- 2: Movable Plastic Drum System Using Plastic Fiber Pan (Single Vault)

Option- 3: Movable Plastic Drum System Using High Commode (Single Vault)

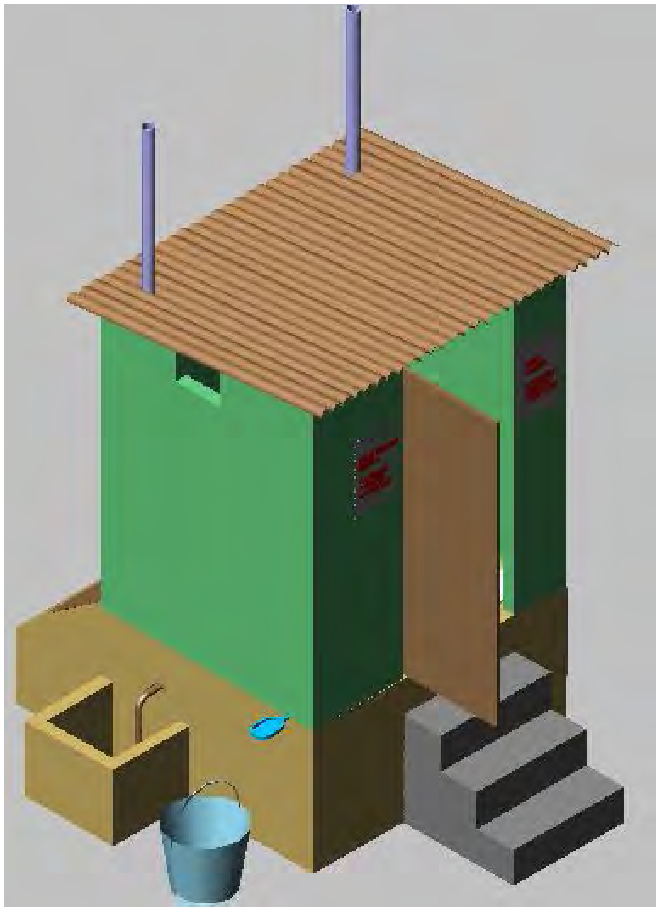
Option- 4: Fixed Chamber System Using Modified Traditional Eco Pan

Option- 5: Fixed Chamber System Using Traditional Eco Pan

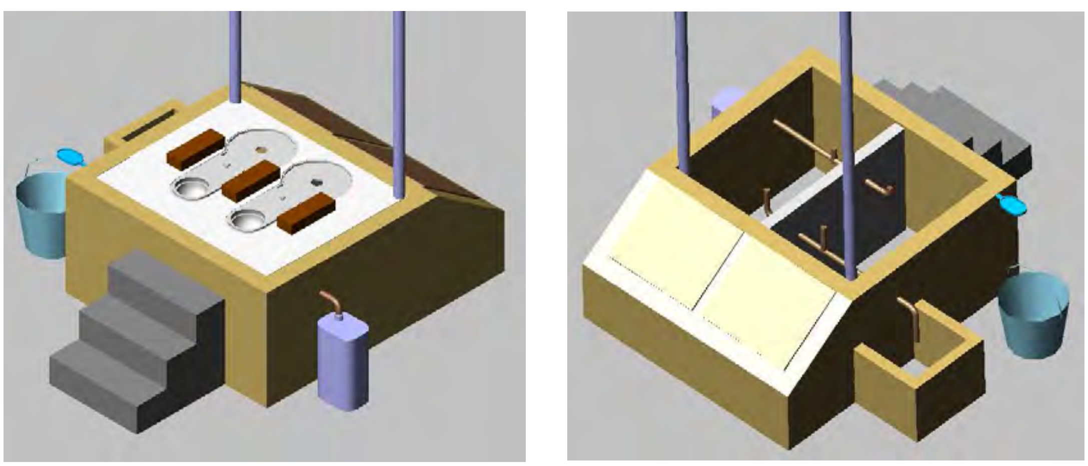
Option- 6: Movable Plastic Drum System Using Traditional Eco Pan

Option- 7: Elevated Movable Plastic Drum System with RCC Column

Option-1: Fixed Chamber System Using Plastic Fiber Pan



Out Side View



Internal Components

Option-1: Fixed Chamber System Using Plastic Fiber Pan

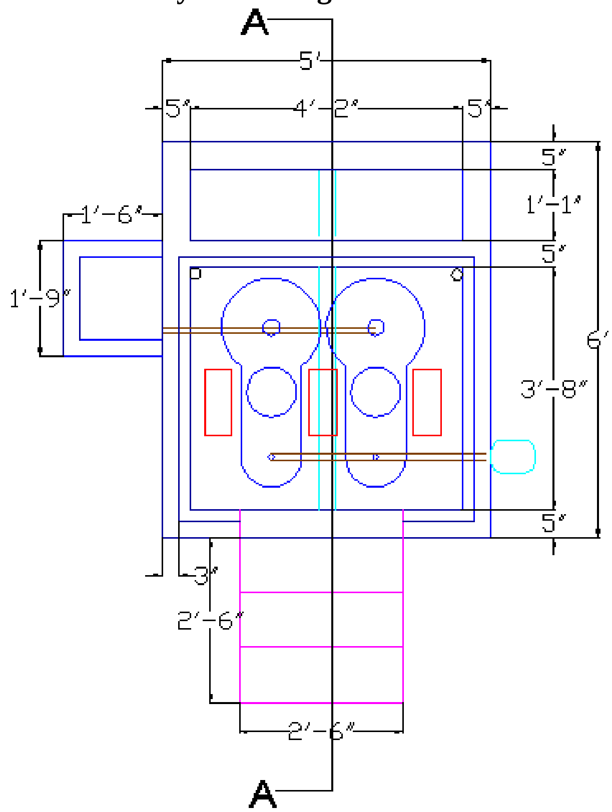


FIGURE: PLAN

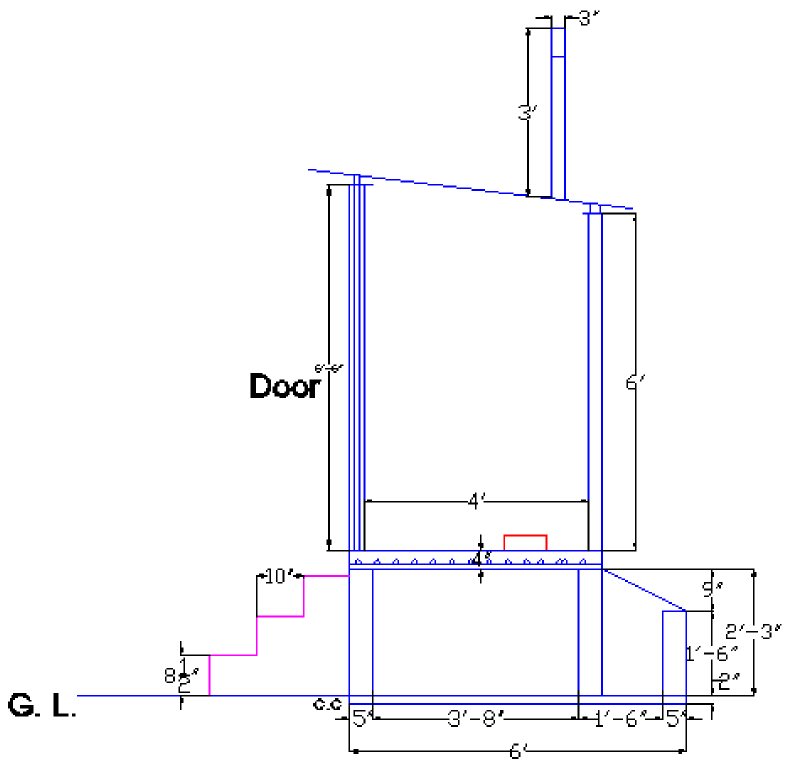
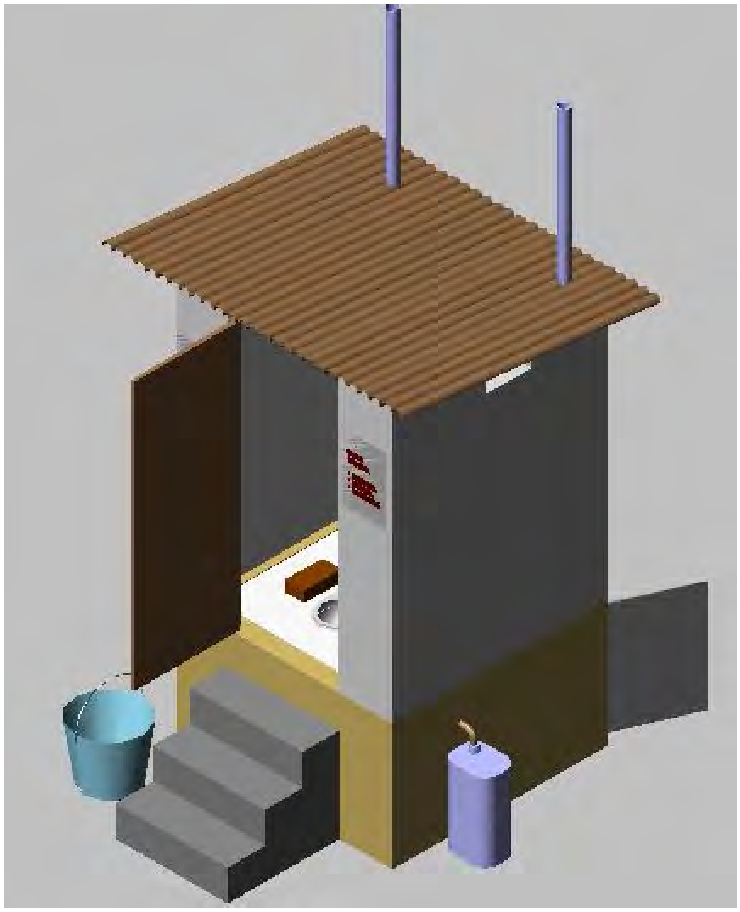


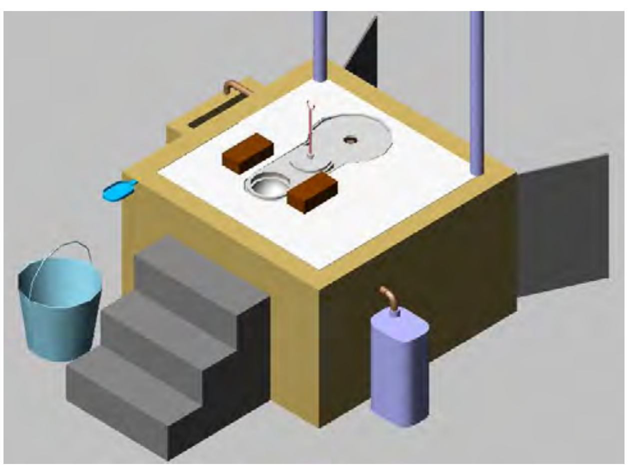
FIG: SECTION A-A

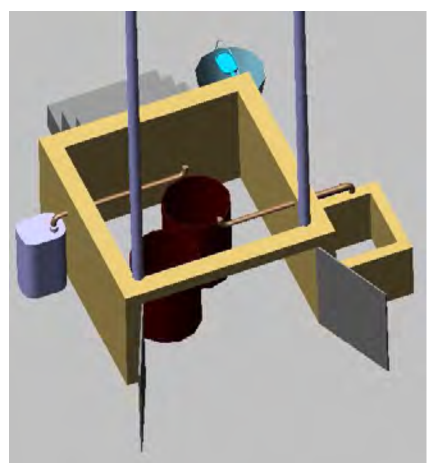
BOQ for Fixed Chamber System Using Plastic Fiber Pan					
Items	**Specification**	**Unit of Measure**	**Unit**	**Unit cost**	**Amount in TK.**
Brick	Second class	nos.	650	4.5	2,925
Cement	Composite	bags	5	350	1,750
Sand	FM=1.2	cft	50	20	1,000
Khoa (Brick Chips)	First class	cft	13	40	520
M.S. Rod	8 mm@ 6″ C/C	kg	9	50	450
G.I Sheet	2.5′x6′	nos.	2	350	700
C.I. Sheet for door	2.5′x6′	no.	1	350	350
Wood		cft	1	300	300
Paint & White Cement		kg	5	40	200
Paint (Red Oxide)		kg	0.5	240	120
Hardware items		-	-	-	300
Polythine	5' x 6'	nos.	1	50	50
Back cover		nos.	2	200	400
Sign Board+ User Manual	2′x2.5′	no.	1	380	380
				Sub total	**9,445**
Sanitary Items Cost					
Eco-Pan		nos.	2	700	1,400
Vent Pipe	3″	ft	15	20	300
Cowl	1.5″	nos.	2	15	30
Pipe(For anal clinging & urine diversion)	1″	ft	10	17	170
Elbow	1″	nos.	3	10	30
Tee	1″	no.	1	10	10
Flexible pipe	1″	meter	1	30	30
Urine Pot	Transparent	no.	1	160	160
Bucket	10 litre	no.	1	50	50
				Sub total	**2,180**
Labour Cost					
Mason charge		Contract	-	-	2,600
Roof & Door making		Contract	-	-	300
Paint labour charge		Contract	-	-	200
Shuttering charge		Contract	-	-	400
				Sub total	**3,500**
				Total Amount	**15,125.00**

Option- 2: Movable Plastic Drum System Using Plastic Fiber Pan (Single Vault)



Out Side View





Internal Components

Option- 2: Movable Plastic Drum System Using Plastic Fiber Pan (Single Vault)

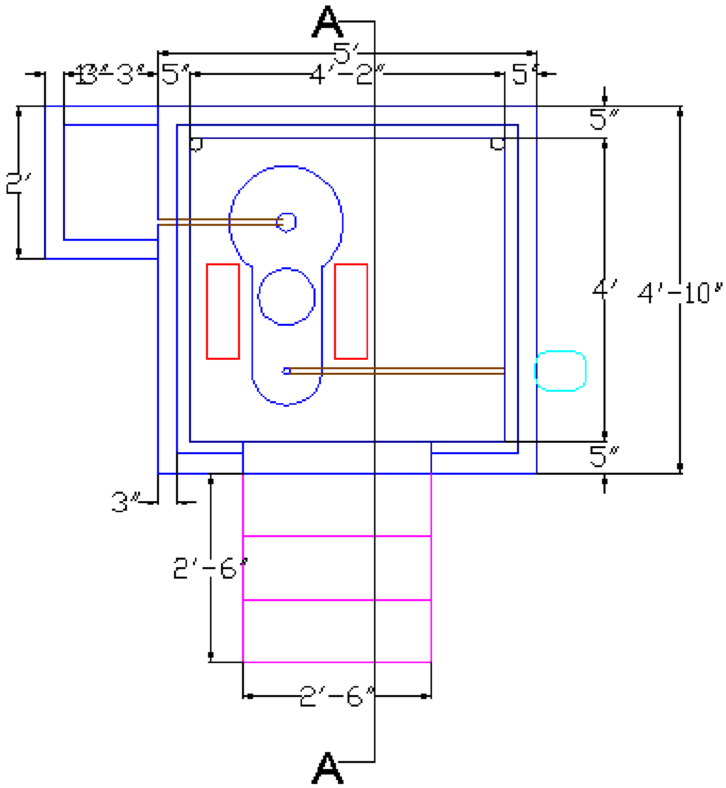


FIGURE: PLAN

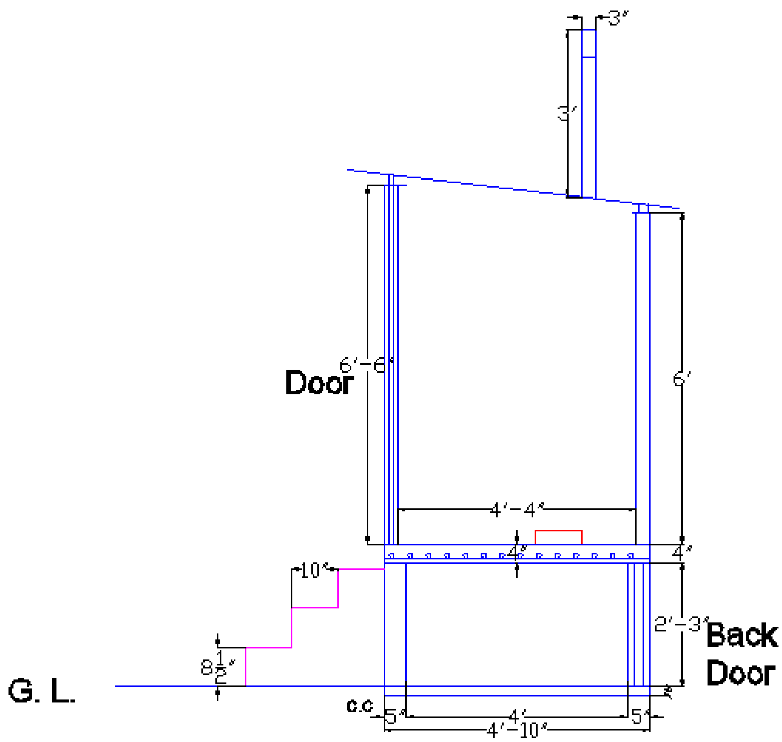


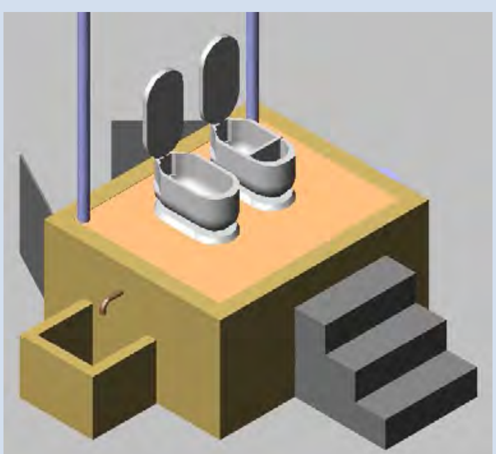
FIG: SECTION A-A

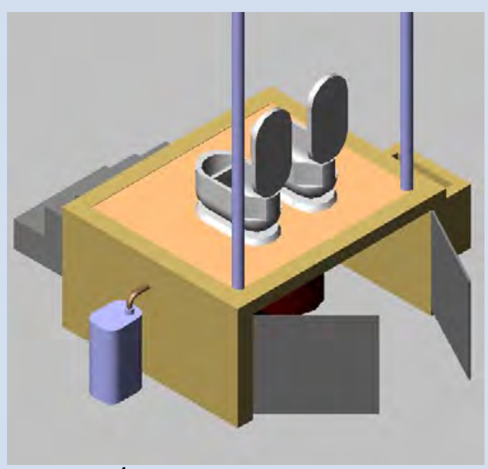
BOQ for Movable Plastic Drum System using Plastic Fiber Pan (Single Vault)

Items	Specification	Unit of Measure	Unit	Unit cost	Amount in TK.
Brick	Second class	nos.	620	4.5	2,790
Cement	Composite	bags	5	350	1,750
Sand	FM=1.2	cft	50	20	1,000
Khoa (Brick Chips)	First class	cft	13	40	520
M.S. Rod	8 mm@ 6″ C/C	kg	9	50	450
Back Door	4.2' x 2.25'	nos.	1	1400	1,400
G.I. Sheet	2.5´x6´	nos.	2	350	700
C.I. Sheet for door	2.5´x6´	no.	1	350	350
Wood		cft	1	300	300
Polythine	5' x6'	nos.	1	50	50
Plastic Drum		nos.	2	630	1,260
Paint & White Cement		kg	5	40	200
Paint (Red Oxide)		kg	0.5	240	120
Hardware items		-	-	-	300
Back cover		nos.	2	200	400
Sign Board+ User Manual	2´x2.5´	no.	1	380	380
				Sub total	**11,970**
Sanitary Items Cost					
Eco-Pan		nos.	1	700	700
Vent Pipe	3″	ft	15	20	300
Cowl	1.5″	nos.	2	15	30
Pipe(For anal clinging & urine diversion)	1″	ft	10	17	170
Elbow	1″	nos.	3	10	30
Tee	1″	no.	1	10	10
Flexible pipe	1″	meter	1	30	30
Urine Pot	Transparent	no.	1	160	160
Bucket	10 litre	no.	1	50	50
				Sub total	**1,480**
Labour Cost					
Mason charge		Contract	-	-	2,600
Roof & Door making		Contract	-	-	300
Paint labour charge		Contract	-	-	200
Shuttering charge		Contract	-	-	400
				Sub total	**3,500**
				Total Amount	**16,950.00**

Option- 3: Movable Plastic Drum System Using High Commode (Single Vault)

Out Side View





Internal Components

Option- 3:Movable Plastic Drum System Using High Commode (Single Vault)

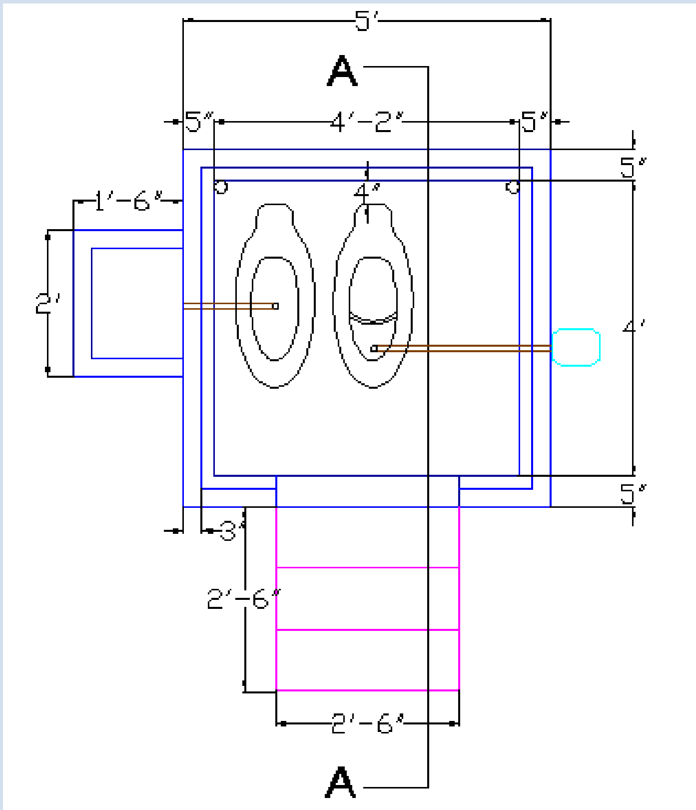


FIGURE: PLAN

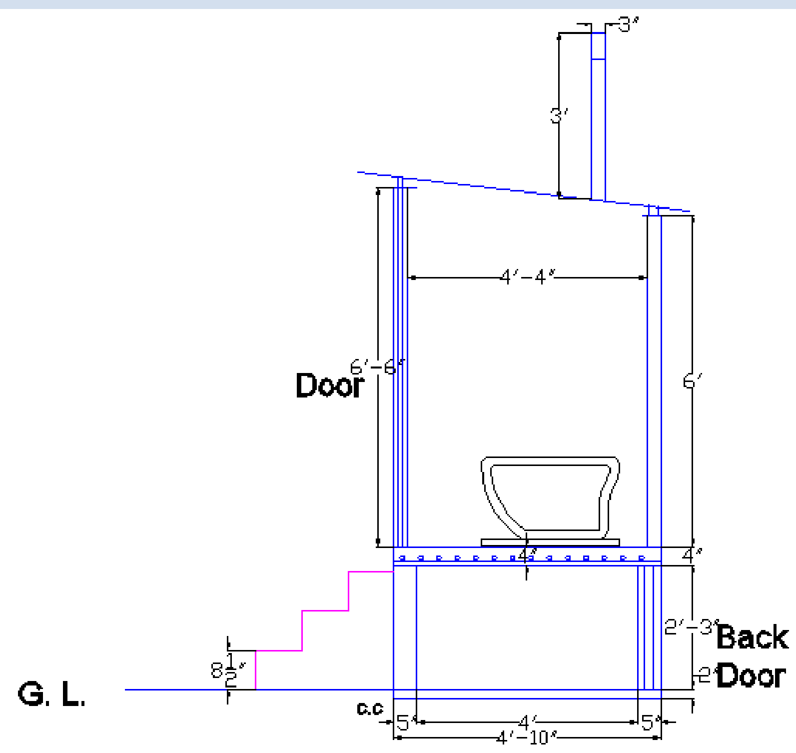
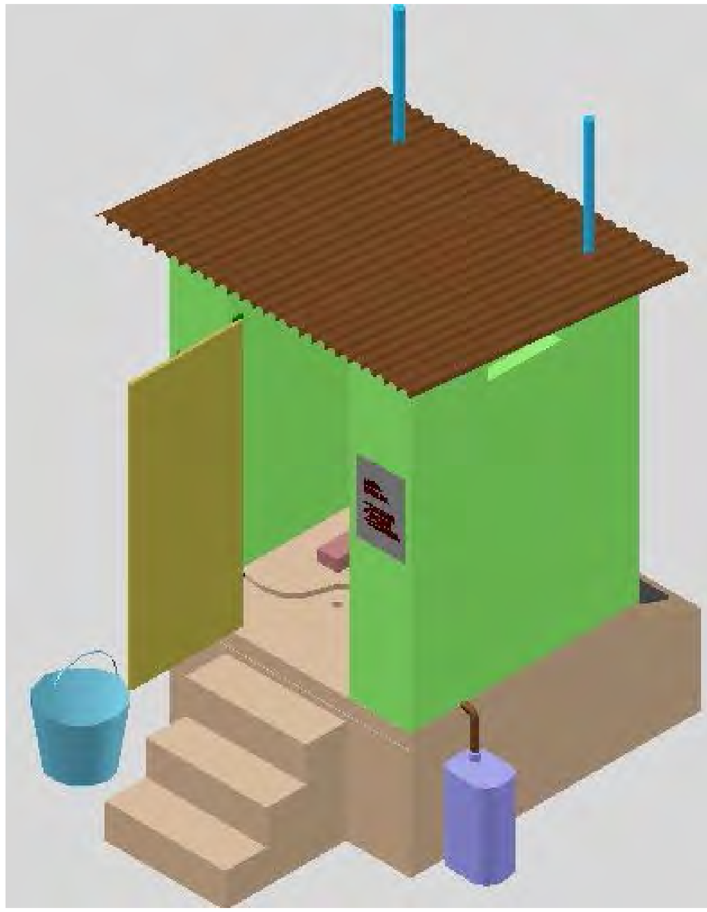


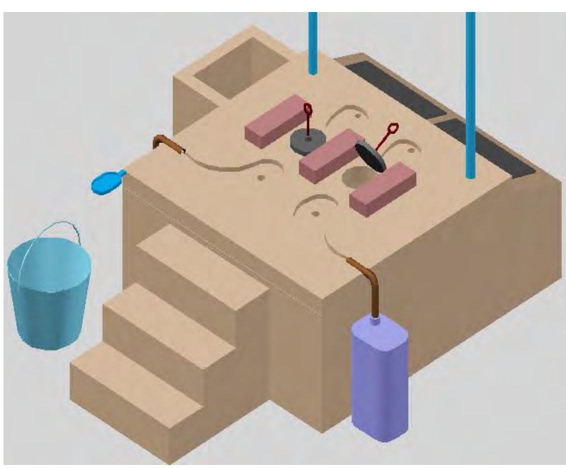
FIG: SECTION A-A

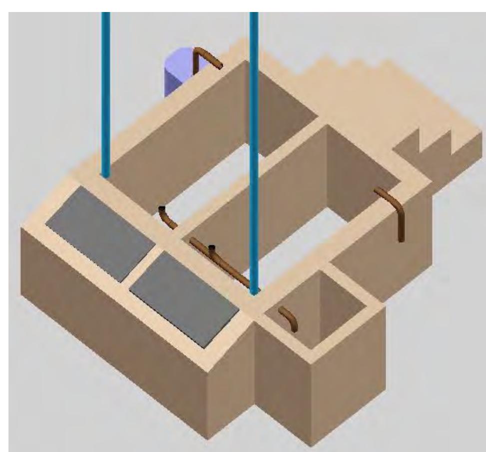
BOQ for Movable Plastic Drum System Using High Commode (Single Vault)					
Items	**Specification**	**Unit of Measure**	**Unit**	**Unit cost**	**Amount in TK.**
Brick	Second class	nos.	620	4.5	2,790
Cement	Composite	bags	5	350	1,750
Sand	FM=1.2	cft	50	20	1,000
Khoa (Brick Chips)	First class	cft	13	40	520
M.S. Rod	8 mm@ 6″ C/C	kg	9	50	450
Back Door	4.2' x 2.25'	nos.	1	1400	1,400
G.I. Sheet	2.5´x6´	nos.	2	350	700
C.I. Sheet for door	2.5´x6´	no.	1	350	350
Wood		cft	1	300	300
Polythine	5' x6'	nos.	1	50	50
Plastic Drum		nos.	2	630	1,260
Paint & White Cement		kg	5	40	200
Paint (Red Oxide)		kg	0.5	240	120
Hardware items		-	-	-	300
Back cover		nos.	2	200	400
Sign Board+ User Manual	2´x2.5´	no.	1	380	380
				Sub total	**11,970**
Sanitary Items Cost					
Eco-Commode		nos.	2	700	1,400
Vent Pipe	3″	ft	15	20	300
Cowl	1.5″	nos.	2	15	30
Pipe(For anal clinging & urine diversion)	1″	ft	10	17	170
Elbow	1″	nos.	3	10	30
Tee	1″	no.	1	10	10
Flexible pipe	1″	meter	1	30	30
Urine Pot	Transparent	no.	1	160	160
Bucket	10 litre	no.	1	50	50
				Sub total	**2,180**
Labour Cost					
Mason charge		Contract	-	-	2,600
Roof & Door making		Contract	-	-	300
Paint labour charge		Contract	-	-	200
Shuttering charge		Contract	-	-	400
				Sub total	**3,500**
				Total Amount	**17,650.00**

Option- 4: Fixed Chamber System Using Modified Traditional Eco Pan



Out Side View





Internal Components

Option- 4: Fixed Chamber System Using Modified Traditional Eco Pan

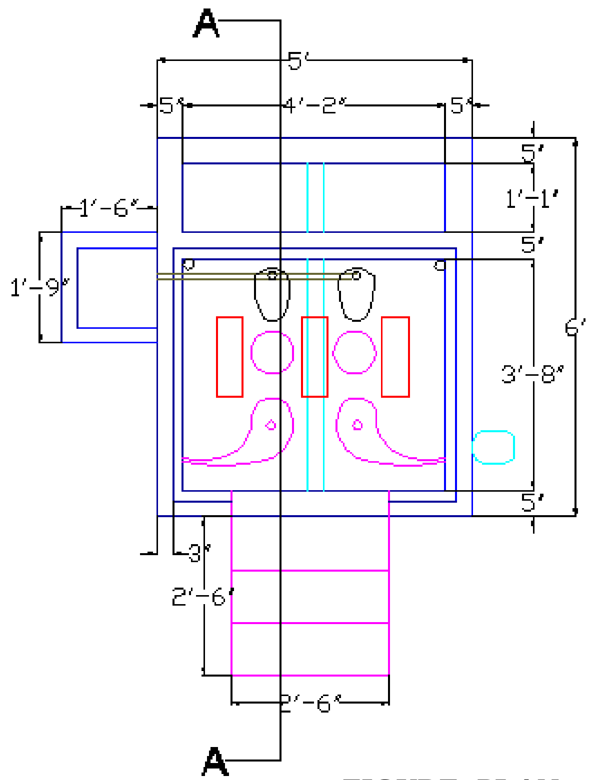


FIGURE: PLAN

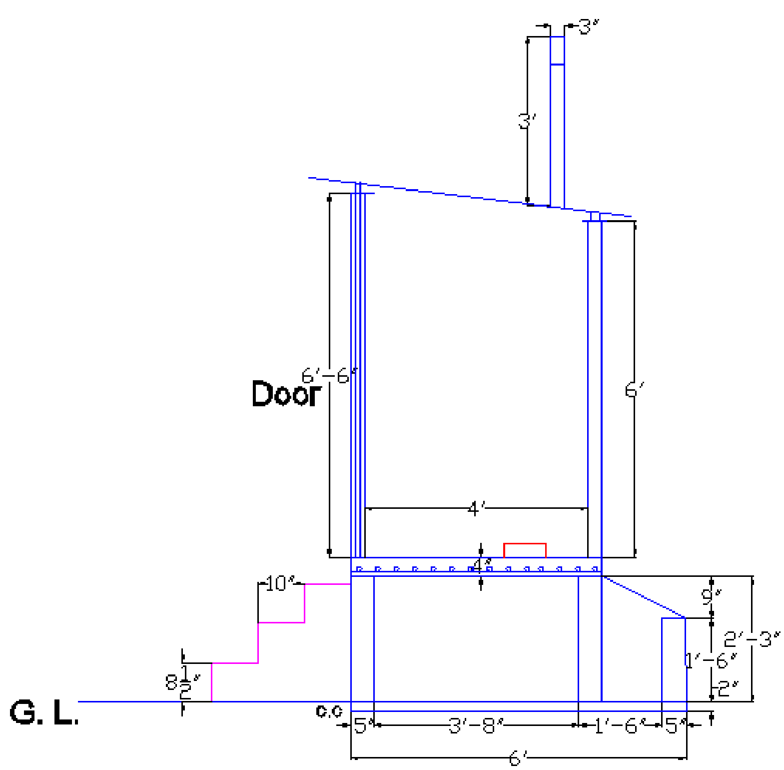
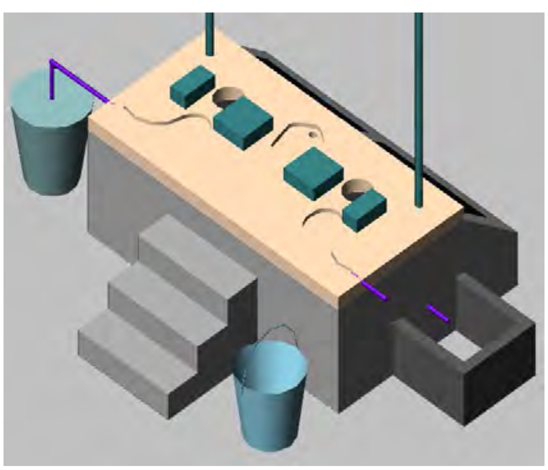


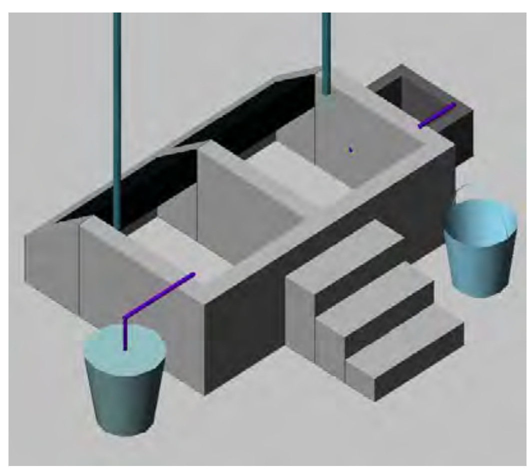
FIG: SECTION A-A

BOQ for Fixed Chamber System Using Modified Traditional Eco-Pan					
Items	**Specification**	**Unit of Measure**	**Unit**	**Unit cost**	**Amount in TK.**
Brick	Second class	nos.	650	4.5	2,925
Cement	Composite	bags	5	350	1,750
Sand	FM=1.2	cft	50	20	1,000
Khoa (Brick Chips)	First class	cft	13	40	520
M.S. Rod	8 mm@ 6″ C/C	kg	9	50	450
G.I Sheet	2.5′x6′	nos.	2	350	700
C.I. Sheet for door	2.5′x6′	no.	1	350	350
Wood		cft	1	300	300
Polythine	5' x6'	nos.	1	50	50
Paint & White Cement		kg	5	40	200
Paint (Red Oxide)		kg	0.5	240	120
Hardware items		-	-	-	300
Back cover		nos.	2	200	400
Sign Board+ User Manual	2′x2.5′	no.	1	380	380
				Sub total	**9,445**
Sanitary Items Cost					
Pipe for Making Pan	8″	ft	1	160	160
Pan Cover		nos.	2	70	140
Vent Pipe	3″	ft	15	20	300
Cowl	1.5″	nos.	2	15	30
Pipe(For anal clinging & urine diversion)	1″	ft	10	17	170
Elbow	1″	nos.	3	10	30
Tee	1″	no.	1	10	10
Flexible pipe	1″	meter	1	30	30
Urine Pot	Transparent	no.	1	160	160
Bucket	10 litre	no.	1	50	50
				Sub total	**1,080**
Labour Cost					
Mason charge		Contract	-	-	2,600
Roof & Door making		Contract	-	-	300
Paint Labour charge		Contract	-	-	200
Shuttering charge		Contract	-	-	400
				Sub total	**3,500**
				Total Amount	**14,025.00**

Option- 5: Fixed Chamber System Using Traditional Eco Pan

Out Side View





Internal Components

Option- 5: Fixed Chamber System Using Traditional Eco Pan

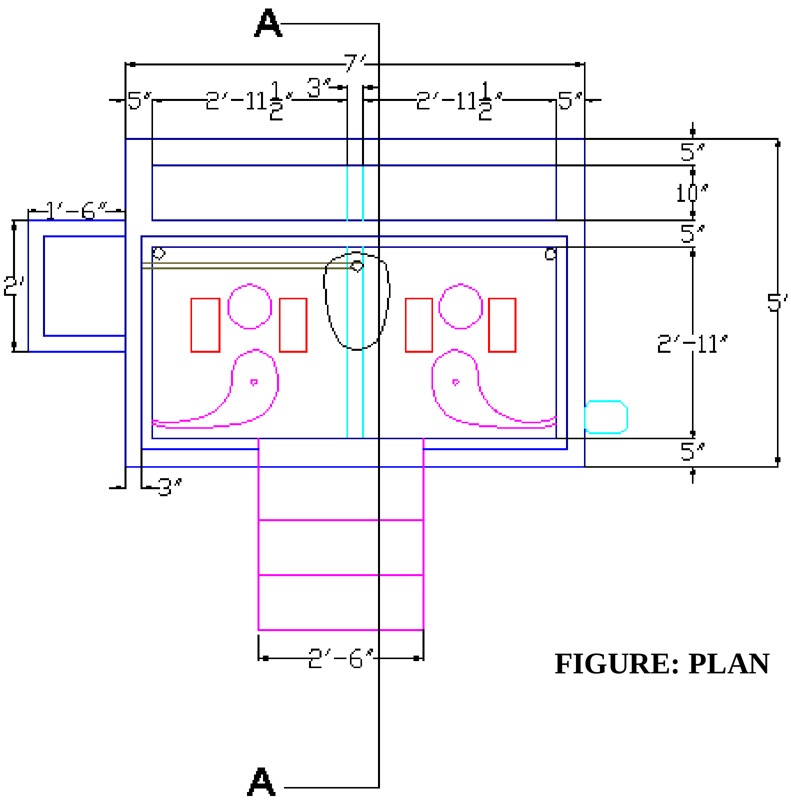


FIGURE: PLAN

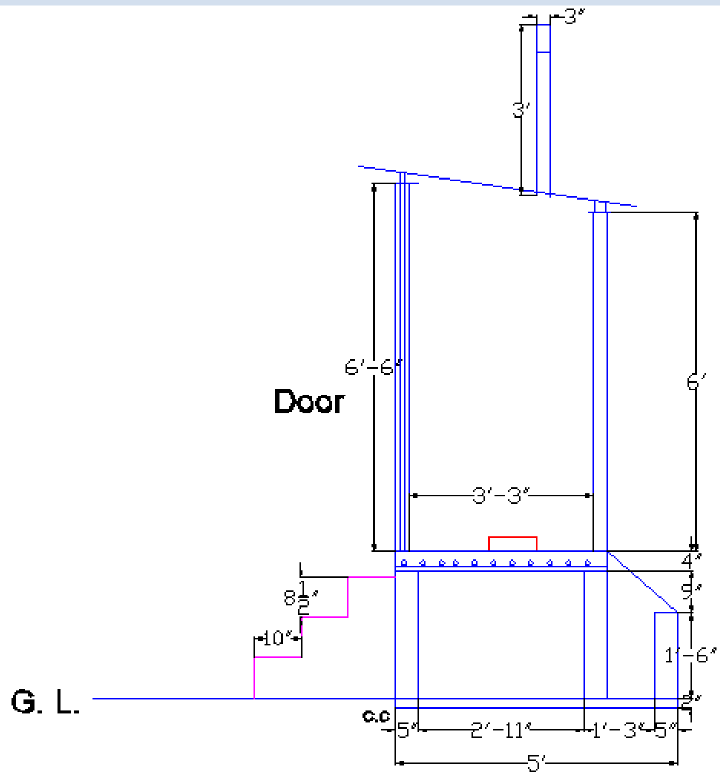
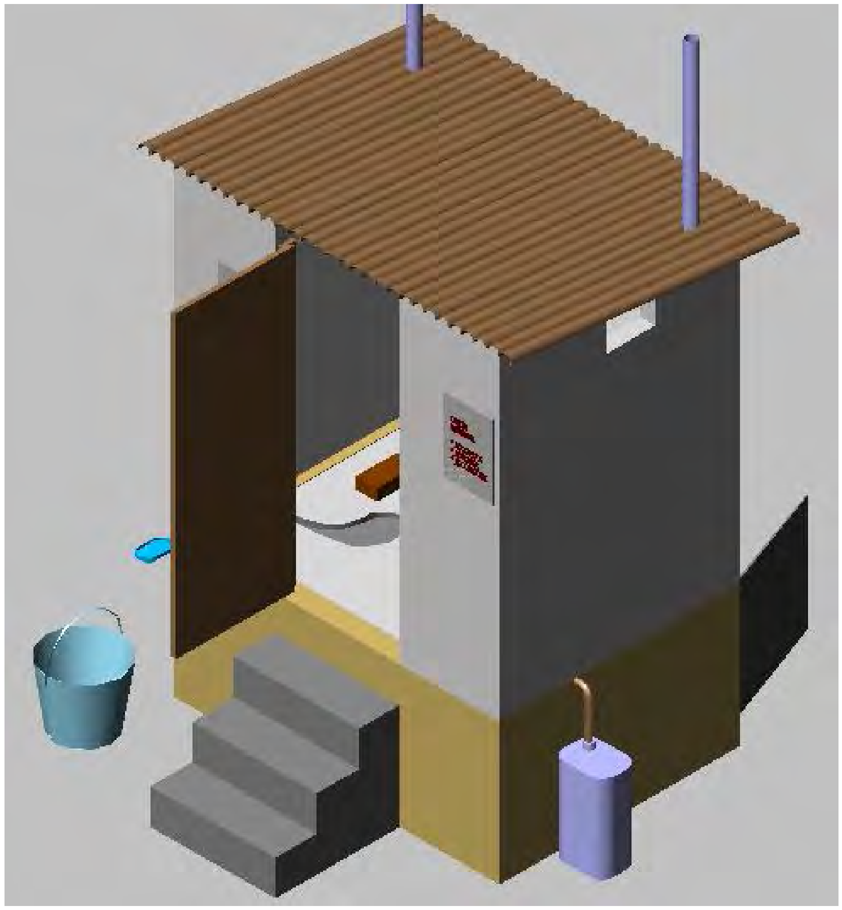


FIG: SECTION A-A

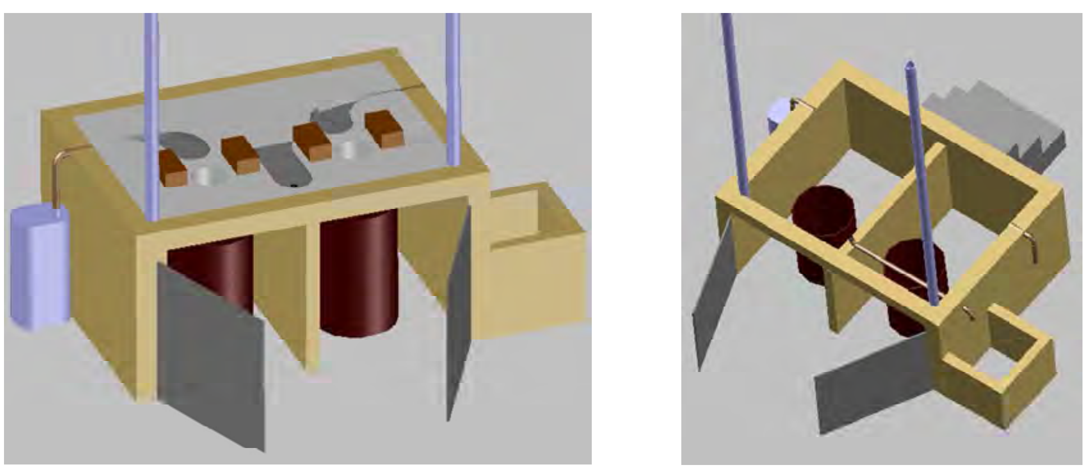
BOQ for Fixed Chamber System Using Traditional Eco Pan

Items	Specification	Unit of Measure	Unit	Unit cost	Amount in TK.
Brick	Second class	nos.	700	4.5	3,150
Cement	Composite	bags	5	350	1,750
Sand	FM=1.2	cft	50	20	1,000
Khoa (Brick Chips)	First class	cft	15	40	600
M.S. Rod	8 mm@ 6″ C/C	kg	9	50	450
G.I Sheet	2.5´x6´	nos.	2	350	700
C.I. Sheet for door	2.5´x6´	no.	1	350	350
Polythine	5' x6'	no.	1	50	50
Wood		cft	1	300	300
Paint & White Cement		kg	5	40	200
Paint (Red Oxide)		kg	0.5	240	120
Hardware items		-	-	-	300
Back cover		nos.	2	200	400
Sign Board+ User Manual	2´x2.5´	no.	1	380	380
				Sub total	**9,750**
Sanitary Items Cost					
Pipe for Making Pan	8″	ft	1	160	160
Pan Cover		nos.	2	70	140
Vent Pipe	3″	ft	15	20	300
Cowl	1.5″	nos.	2	15	30
Pipe(For anal clinging & urine diversion)	1″	ft	10	17	170
Elbow	1″	nos.	3	10	30
Tee	1″	no.	1	10	10
Flexible pipe	1″	meter	1	30	30
Urine Pot	Transparent	no.	1	160	160
Bucket	10 litre	no.	1	50	50
				Sub total	**1,080**
Labour Cost					
Mason charge		Contract	-	-	2,600
Roof & Door making		Contract	-	-	300
Paint labour charge		Contract	-	-	200
Shuttering charge		Contract	-	-	400
				Sub total	**3,500**
				Total Amount	**14,330.00**

Option- 6: Movable Plastic Drum System Using Traditional Eco Pan



Out Side View



Internal Components

Option- 6: Movable Plastic Drum System Using Traditional Eco Pan

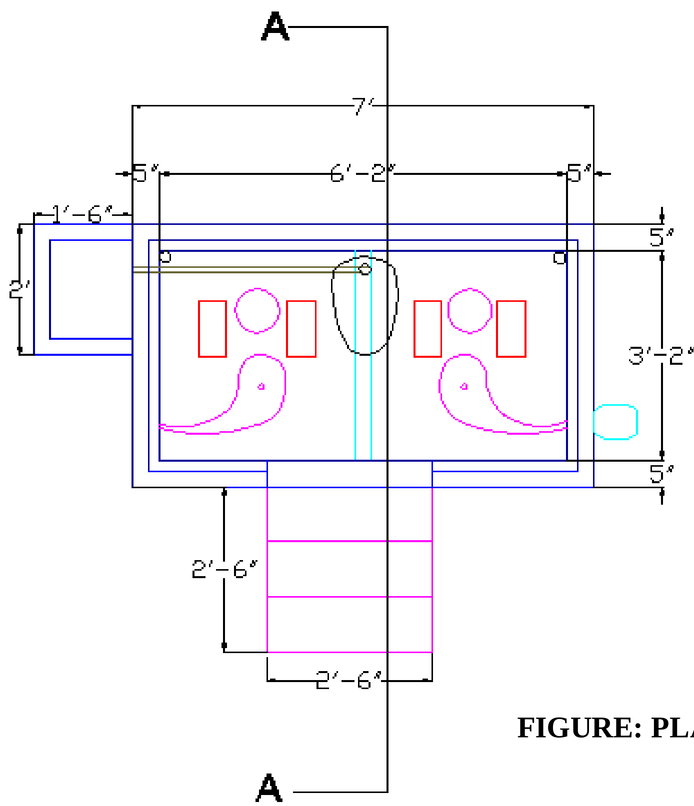


FIGURE: PLAN

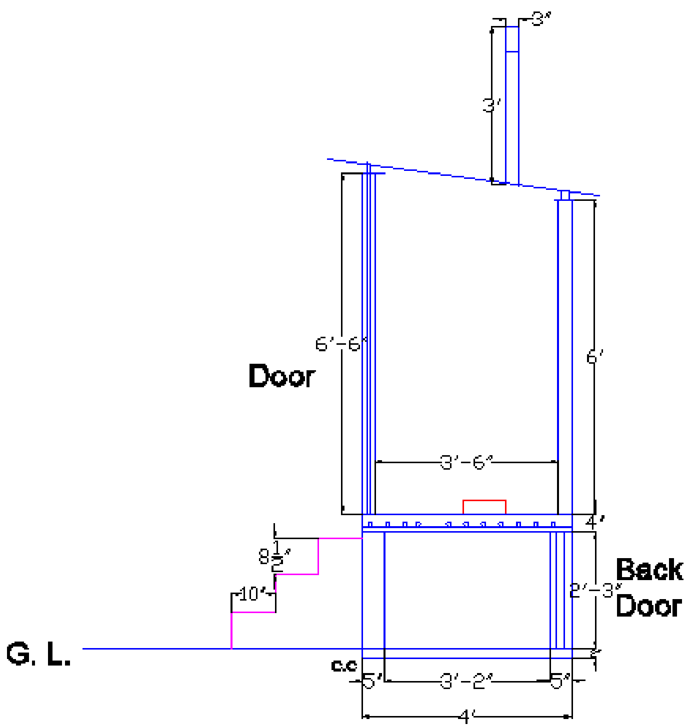
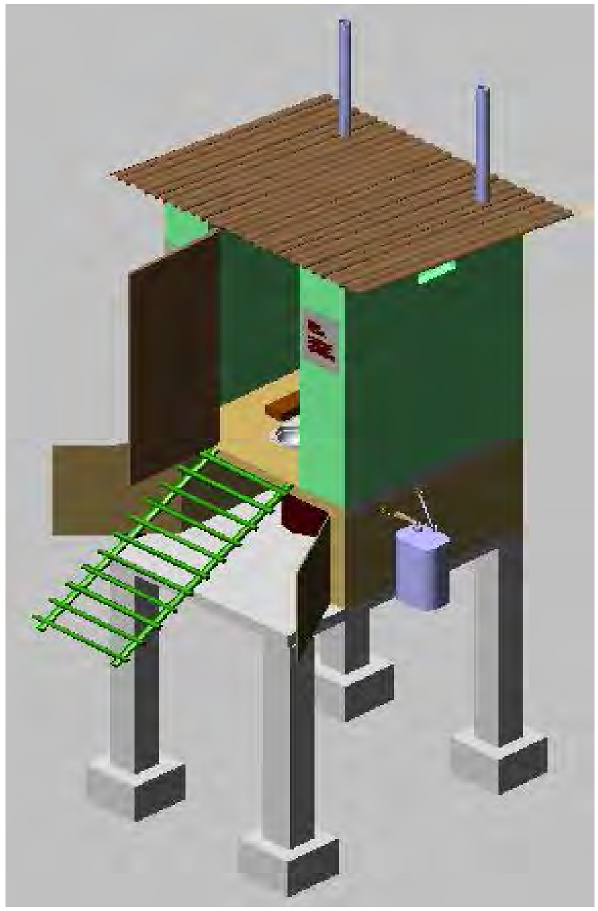


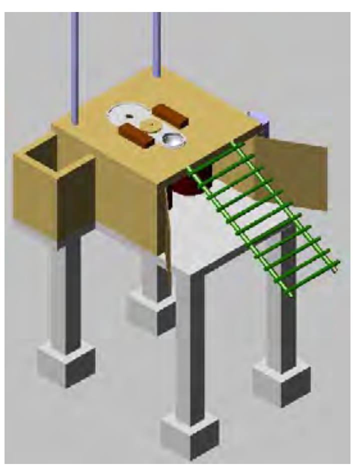
FIG: SECTION A-A

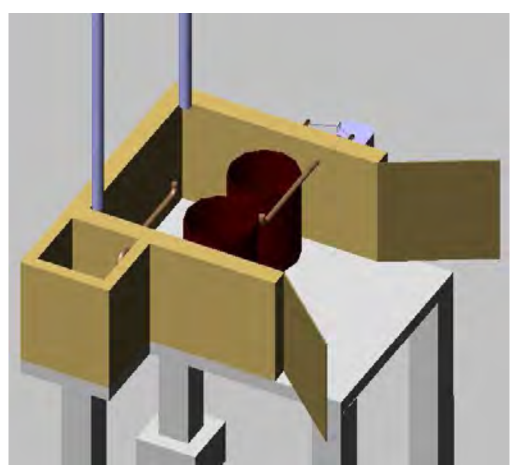
BOQ for Movable Plastic Drum System Using Traditional Eco-Pan					
Items	**Specification**	**Unit of Measure**	**Unit**	**Unit cost**	**Amount in TK.**
Brick	Second class	nos.	670	4.5	3,015
Cement	Composite	bags	5	350	1,750
Sand	FM=1.2	cft	50	20	1,000
Khoa (Brick Chips)	First class	cft	15	40	600
M.S. Rod	8 mm@ 6″ C/C	kg	9	50	450
G.I Sheet	2.5′x6′	nos.	2	350	700
C.I. Sheet for door	2.5′x6′	no.	1	350	350
Wood		cft	1	300	300
Back Door	4.2' x 2.25'		1	1400	1,400
Polythine	5' x6'	nos.	1	50	50
Plastic Drum		nos.	2	630	1,260
Paint & White Cement		kg	5	40	200
Paint (Red Oxide)		kg	0.5	240	120
Hardware items		-	-	-	300
Back cover		nos.	2	200	400
Sign Board+ User Manual	2′x2.5′	no.	1	380	380
				Sub total	**12,275**
Sanitary Items Cost					
Pipe for Making Pan	8″	ft	1	160	160
Pan Cover		nos.	2	70	140
Vent Pipe	3″	ft	15	20	300
Cowl	1.5″	nos.	2	15	30
Pipe(For anal clinging & urine diversion)	1″	ft	10	17	170
Elbow	1″	nos.	3	10	30
Tee	1″	no.	1	10	10
Flexible pipe	1″	meter	1	30	30
Urine Pot	Transparent	no.	1	160	160
Bucket	10 litre	no.	1	50	50
				Sub total	**1,080**
Labour Cost					
Mason charge		Contract	-	-	2,600
Roof & Door making		Contract	-	-	300
Paint labour charge		Contract	-	-	200
Shuttering charge		Contract	-	-	400
				Sub total	**3,500**
				Total Amount	**16,855.00**

Option- 7: Elevated Movable Plastic Drum System with RCC Column



Out Side View





Internal Components

Option- 7: Elevated Movable Plastic Drum System with RCC Column

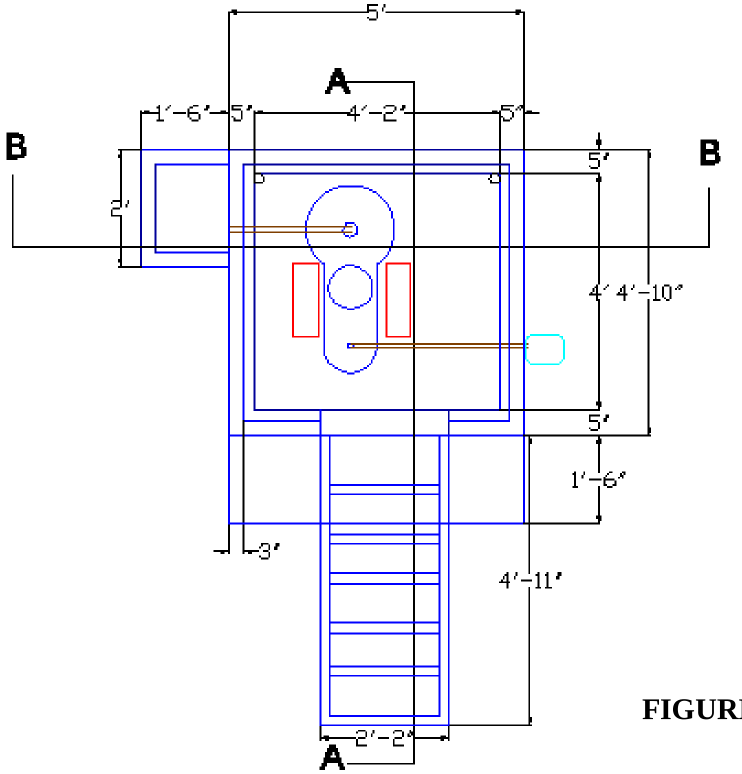


FIGURE: PLAN

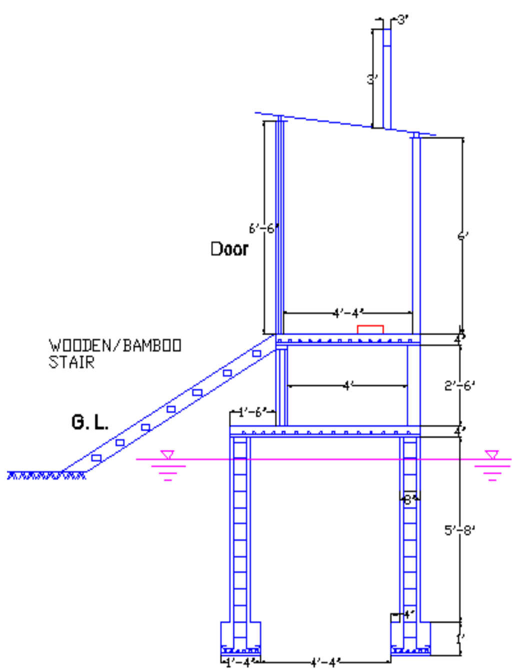


FIG: SECTION A-A

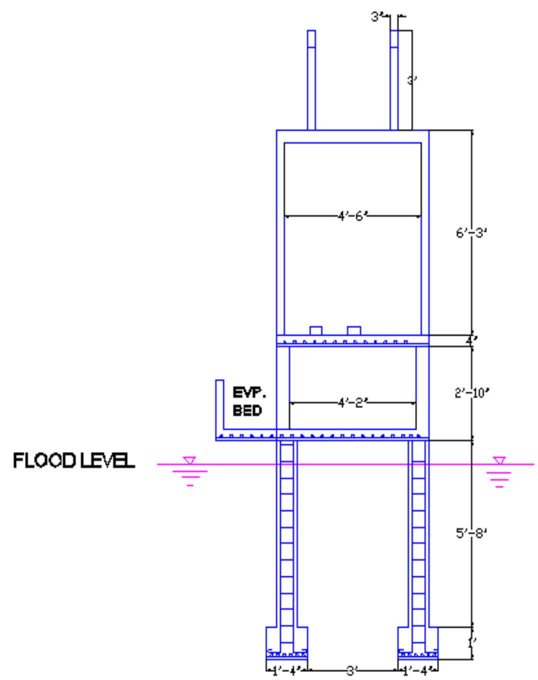


FIG: SECTION B-B

BOQ for Elevated Movable Plastic Drum System With RCC Column

Items	Specification	Unit of Measure	Unit	Unit cost	Amount in TK.
Brick	Second class	nos.	540	4.5	2,430
Cement	Composite	bags	9	350	3,150
Sand	FM=1.2	cft	100	20	2,000
Khoa (Brick Chips)	First class	cft	35	40	1,400
M.S. Rod	8 mm@ 6″ C/C	kg	45	50	2,250
Back Door	4.2' x 2.25'	nos.	1	1400	1,400
G.I. Sheet	2.5´x6´	nos.	2	350	700
Bamboo		nos.	4	120	480
C.I. Sheet for door	2.5´x6´	no.	1	350	350
Wood		cft	1	300	300
Plastic Drum		nos.	2	630	1,260
Paint & White Cement		kg	5	40	200
Paint (Red Oxide)		kg	0.5	240	120
Hardware items		-	-	-	300
Back cover		nos.	2	200	400
Sign Board+ User Manual	2´x2.5´	no.	1	380	380
				Sub total	**17,120**
Sanitary Items Cost					
Eco-Pan		nos.	1	700	700
Vent Pipe	3″	ft	15	20	300
Cowl	1.5″	nos.	2	15	30
Pipe(For anal clinging & urine diversion)	1″	ft	10	17	170
Elbow	1″	nos.	3	10	30
Tee	1″	no.	1	10	10
Flexible pipe	1″	meter	1	30	30
Urine Pot	Transparent	no.	1	160	160
Bucket	10 litre	no.	1	50	50
				Sub total	**1,480**
Labour Cost					
Mason charge		Contract	-	-	3,500
Roof & Door making		Contract	-	-	300
Paint labour charge		Contract	-	-	200
Shuttering charge		Contract	-	-	1000
				Sub total	**5,000**
				Total Amount	**23,600.00**