FUNCTIONALITY ANALYSIS OF ECOSAN LATRINES IN RURAL AREAS OF BANGLADESH BASED ON ENVIRONMENT AND HEALTH ASPECTS

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September 2012

Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects

A thesis submitted by

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In partial fulfilment of the requirement for the degree of Master of Science in

Environmental Engineering

Department of Civil Engineering

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

September 2012

The thesis titled **Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects,** submitted by **Mohammad Ali**, Roll No. 100504506**,** Session **October 2005** has been accepted as satisfactory in partial fulfilment of the requirement for the degree of **Master of Science in Environmental Engineering** on 26th September 2012

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Mohammad Ali

Dedication

Dedicated to my heavenly mother Momtaz Begum,

father Rustum Ali Akand and two sister

ABSTRACT

Government of Bangladesh and other development organization are promoting the cheapest and easiest solution for sanitation, which is pit latrine and one of the main intentions is to increase sanitation coverage. As a country of flooding and high ground water table, pit latrines form a great threat for environment. It could be the best as the starting point to shift from open defecation but while considering long-term sustainability, improved technologies are essential depending on hydro-geological situation. To attain environmental and technological sustainability, concerns of developing appropriate context specific technologies and alignment of GOB's, around forty research institutions, INGO and NGO piloted more than 1293 EcoSan toilets of various models have been constructed to achieve the solution of above problem at a limited scale.

This study aimed to evaluate the suitability and potentiality of scaling up of Ecosan toilet in Bangladesh through focusing on the following aspects: (1) Socio-cultural and institutional (2) Financial and economic (3) Technology and operation (4) Environmental and health. The study carried out literature review, field observation, questionnaires interview from ecosan-user and non user, data collection, discussion with sanitation experts and finally data analysis. To evaluate the functioning performance of ecosan toilet in nine different geo-hydrological areas through a checklist was used to incorporate the ideas.

According to ecosan-user more than 88% and non ecosan user more than 78% of the respondents said, "using sanitised human excreta as fertilizer is a good idea". The same group believe that respectively 32% and 66% people of their area don't like eco-san toilet due to religious barrier and similarly 37% and 31% people of their area believe that eco-san is not acceptable with their culture respectively. In the case of non ecoSan user 98% know about the potentiality of urine and faeces as fertilizer and 33% having a practice of using in the field. Among them only 21% don't feel comfort of using these kind of organic fertilizer. In reality 32% female and 7% male doing the empting faeces vault job and whenever they get time both male and female (59%) of the respondents do the work regularly. There is a focus on environmental sanitation in National Sanitation Strategy (GoB, 2005) and Department of Public Health Engineering and Local Government endorsed this sanitation system and trying to replicate all over country by

providing fund to local government and incorporation in government project but country don't have yet any guideline for utilizing human urine and faeces.

Within every 6 months 42%, 12 month 31% and more than 24 month 20% have to desludging to keep the latrine functional. To avoid the desludging costly work 6% household construct new latrine. Both user and non-user 97 percent agreed that eco-san toilet should be available in all household. Considering the affordability 55% user want the same option at 4000-5000BDT and 50% nonuser claim the same at the amount of 4000BDT. 16% user respondent informed that their neighbor not interested to construct ecosan toilet. More than 50% of both user and non user respondent want to buy faeces organic fertilizer with BDT 5/kg and for the case of urine fertilizer 5BDT/litre. The 'Pay Back period' for investment in an ecosan toilet comes to 5.09 years, i.e. the investor in the ecosan toilet gets back all his investments (BDT 11,000) within a period of just over five years but without cost sharing it will take 10.5 years. The calculated FIRR is 8.11%. The investment is worth since the present average interest rate for a commercial bank home construction loan is 7.50%. This means that the family who construct an ecosan toilet from a bank loan will be able to pay the loan if the family sells urine and soil conditioner at market value.

According to both type of respondent (76%) skilled mason is locally available and around (56%) agreed that except the pan (in case of fibre glass made pan) all construction materials also locally available. Considering both management and function issue out of nine study area Chapai N.gonj (2380,1900) and Sreepur (1950, 1800) have combatively best and worst situation where as ideal situation (2000,2600). But considering the duration of using toilet Comilla Sadar has achieved the best position among all study area.

In different sample the moisture content of composted faeces was found high and some specimens were found to be wet. The composted excreta of Eco-Toilets had pathogenic burden of with parasite specially that of Ascaris *lumbricoides* and *Trichuris trichiura.* Bacteriological examination revealed no pathogenic organism. Parasitological examination revealed at least one type of parasite in each of the specimens. Cyst of *Entamoeba* was found in all specimens with varying number. All the *Entamoeba* found in the specimens were not pathogenic. Ova of *Ascaris* were found in almost all

specimens but *Trichuris* was found in one case. Though many of the ova were not found to be viable based on physical characteristics, but still some of them even in the dried specimen seemed to be capable of infection. It was common in both the cases of Practical Action Bangladesh and JADE that properly sun dried faeces after one month of preservation in airtight containers no parasite or few distorted parasite found. 73% respondent believes that EcoSan toilet help to reduce the diarrheal diseases and 90% people have to spend less than 100BDT/month for it but before using ecosan toilet 30% have to spend more than 400BDT/month.

Different laboratory result says that the contents of heavy metals and other contaminants such as pesticide residues are generally low or very low in excreta and it is found that the presence is below or within WHO and Bangladesh standard. Mean N (0.38%), P (0.04%), and K (0.1%) found in nine urine samples and in case of faeces mean N (0.35%), P (0.48%), K (2.75%) and Organic Matter (3.20%) is found which are important elements for soil nutrient and increase the water holding capacity of soil. There is very less scope of water pollution during disaster and subsurface and underground water layer. Post latrine handling without safety gear is a common practice of the user and this keeps them under health risk. In Bangladesh context (climate, food practice, toilet types, etc), it is not yet determined the way of sanitizing properly before use of human excreta to the farm land.

ACKNOWLEDGEMENT

The success of this thesis can be attributed to the Professor Dr. Md. Mafizur Rahman, my thesis supervisor for his extensive support and guidance since beginning of the thesis to the checking of corrections in final report. I am greatly indebted to my supervisor for his continuous inspiration to take this journey of learning.

The completion of this thesis was possible through the help, encouragement, and assistance of a number of people along with my supervisor. My colleagues of Oxfam GB Bangladesh Program provided me support and encouragement. In particular, I am grateful to Mr. Humayun Kabir Talukder, Public Health Engineer Coordinator, Mr. Golam Morshed, Public Helath Promoter Coordinator and Mr. Kaiser Rejve, Humanitarian Programme Manager for encouraging me in continuing my thesis while holding a full-time job.

I am very much grateful to Japan Association of Drainage and Environment BD (JADE BD), Society for People's Actions in Change and Equity (SPACE), Bangladesh Associastion for Social Advancement (BASA), Bangladesh Academy for Rural Development (BARD), Practical Action Bangladesh and Dhaka Ahasania Mission (DAM) organization particularly helped me for data collection and making interview of relevant officials.

I deeply appreciate the sacrifice made by my family members for my study. My mother, father and sisters all endured my negligence and absence with patience. I am thankful to their support and encouragement.

Above all, I am thankful to Almighty Allah, who provided me the opportunity and strength to carry out this work.

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LIST OF ACRONYMS

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

CHAPTER – 1
INTRODUCTION

1.1 General

Sanitation coverage, to say officially in Bangladesh, is better than many other developing countries in the world. In South 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.

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).

1.2 Statement of Problem

To overcome to the problem of conventional sanitation ecological sanitation was first introduced 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 EcoSan toilets 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 Ecosan toilet 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 spreading the ecological sanitation activities throughout the country (Chowdhury, 2007).

The Government of Bangladesh also motivated about EcoSan toilet and took initiatives on scaling up ecological sanitation throughout Bangladesh. GOB has undertaken initiatives for installing at least one EcoSan toilet in each union (4750 unions) as a demonstration in 2008 and allocated resources accordingly (Practical Action Bangladesh, 2010).

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

Therefore, it is very important to analyze functionally and sustainability of piloted ecosan toilets in different areas of Bangladesh and identify its health and environmental risk for it replication.

1.3 Objective of the Study

This thesis is carried out having the following objectives:

i) To assess technological viability of EcoSan latrine option in rural perspective
ii) To identify challenges experienced for scaling up of EcoSan latrine option in rural areas

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

i) Functionality of installed ecosan toilet in nine different areas.
ii) Sustainability of ecosan toilet for rural areas of Bangladesh.
iii) Understanding impacts of health and environmental aspect.
iv) Identify the challenges for scaling up and its way ahead.

1.4 Scope and limitation of the study

The study has mainly concentrated on 4 different major aspect covering area 1) sociocultural and institutional, 2) financial and economic, 3) technology and operation aspect and 4) environmental and health and also functionality analysis of ecosan toilet of nine survey area toilet. The study is based on the primary information extracted from questioner survey and key informants' interviews and secondary information has been used in case of different environment and health related laboratory data for analysis. Secondary information of surveys, published and unpublished governmental and international agency reports, studies of consultants also used to fulfill the study. There are several heterogeneous factors such as not all toilets are constructed in the same time, the motivation given by the implementing organization and after construction monitoring, long time monitoring and financial support for maintenance factors has a great influence to identify the real variation and gap.

1.5 Organization of the thesis work

The study has been presented in five distinct chapters. Chapter – 1 gives a general introduction of the problem, objective and outcome of the study along with scope and limitation of the study. Chapter – 2 describes the relevant theories of four different major aspects. It also depicts the information considering factor for the major four aspects. The methodologies of the study are outlined in Chapter-3. The schematic framework of the study in relation to data source, data collection, data collection methods are presented in the same Chapter – 3. The data from field and other secondary source on four different major aspects analyzed and experience and views of different organization for scaling up are analyzed and presented in Chapter – 4. The brief summary of overall findings is tabulated in this same chapter. The specific conclusion and recommendations are stipulated in Chapter – 5.

CHAPTER-2
LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature on sanitation coverage in Bangladesh, limitation of convention sanitation system and ecological sanitation toilet system with special emphasis on four different aspects like socio-cultural and institutional aspect, financial and economic aspect, technology and operation aspect and environmental and health aspect. An extensive literature survey of the documents on relevant researches and studies both in Bangladesh and oversees, has been performed and some of them are abstracted in this chapter. A review of literatures reveals that, only a limited number of studies have been accomplished on Bangladesh and no studies have so far been accomplished to quantify the Ecosan toilet feasibility. Some ideas from this review have been incorporated in the current study.

2.1.1 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 1.1.

Table 1.1: Sanitation Coverage in Bangladesh (JMP, 2010).

	Year	(% population)			
		Improved	Shared	Unimproved	Open defecation
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.

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 1.2: 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

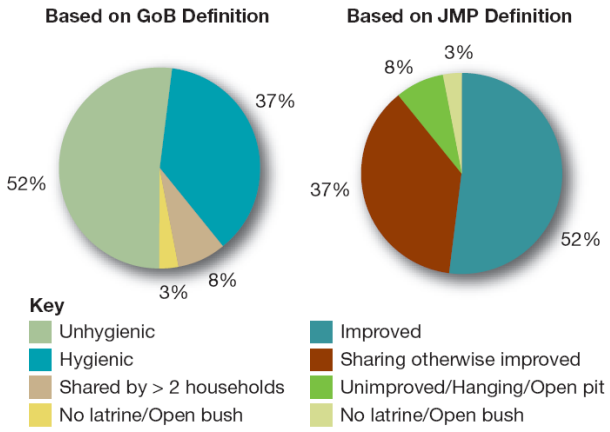


Fig 1.1: percentage of rural household latrine coverage in of declared unions (n = 3,000) (WSP, 2011)

2.1.2 Forms of sanitation used in rural 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 (Uddin 2011). Forms of sanitation of Bangladesh are presented below:

Table 1.3: Different forms of sanitation option 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

2.1.3 Challenges of sanitation coverage sustainability in Bangladesh

The major challenges that are still faced by Bangladesh are as follows.

2.1.3.a. Sanitation in disaster situation

This is particularly a challenge both in rural and urban areas during and after floods, cyclone and tidal surges. The sanitation facilities are either overflowed, inundated or are washed away resulting in a complete unhygienic situation. This has become a regular annual event. The costal belt is extremely vulnerable to such disaster. The post SIDR situation in 2007 has witnessed a complete devastation of the coastal people in respect of shelter, drinking water sources and sanitation facilities.

2.1.3.b. Appropriate sanitation technology for different hydro-geological areas

The high water table and flood prone areas, water scarce Barind area and hill districts, low land and haor areas are suffering from unavailability and appropriate technologies for those varying hydro-geologic conditions. The issue becomes very crucial particularly for urban slums built on water bodies.

2.1.3.c. Impact of climate change on sanitation

Identified as one of the most vulnerable countries of the world, Bangladesh is set to face serious challenges in terms of adverse effects of climate change. Like all other infrastructural development, sanitation infrastructure is also subject to more frequent and intense disasters predicted to be due to climate change and variability. Design changes of existing technologies or new robust technologies are not yet in place to face the challenges of climate change.

2.1.3.d. Financing for sanitation infrastructure

Financing for the sanitation infrastructure in both urban and rural areas in Bangladesh poses a great challenge. It is estimated that annual requirement for urban and rural sanitation infrastructure stands at US$ 197 million and US$ 19 million respectively while the current annual investment is only US$ 7 million for urban and US$ 9 million for rural. With this statistics it becomes clear that against the present level of investment of US$ 16 million per annum, there is a need for further annual investment of US$ 200 million, which appears to be a daunting task for Bangladesh right at this moment. If we add the investment requirement for water the figure would be US$ 307 million (GOB, 2005).

2.1.3.e. Sustainability of traditional sanitation

To uphold success of sanitation achievements in Bangladesh, the issues related to sustainability need to be reviewed critically and strategies to be taken.

The definition of sustainability often creates a debate. 'Sustainability' could be defined in many different ways. One of the simple ways could be to patch up sustainability issues in three folds– a) social, b) technological and c) institutional sustainability.

Hygiene promotion interventions over the period contributed to enhance knowledge level of people at all levels. But despite significant efforts made by different development partners, overall achievements made are not satisfactory. It is a felt need to empower community through access to information on hygiene issues as well as required facilities for enhancing their practice level. Dissemination of simplified hygiene messages through multiple channels is a pre-requisite condition to adopt hygienic behaviors and sustain the same. This could be further substantiated by developing community resource persons or volunteers for continuing hygiene promotion at community level. Likewise school teachers and student brigades could

also play stronger and extended roles. Inclusion remains a challenge to address sanitation needs of particular groups include adolescent girls, garment workers, floating people.

Promotion of low-cost latrines remained a challenge from the very beginning. It could be the best as the starting point to shift from open defecation but while considering long-term sustainability, improved technologies are essential depending on hydro-geological situation. Many organizations already developed a series of suitable technological options for different hydro-geological conditions offering a wide range of costs. These offer users to choose the most suitable option considering their ability to pay. However, appropriate technologies in certain difficult areas like hill/ char/ haor areas are still not available. To attain technological sustainability, concerns of developing appropriate context specific technologies and alignment of GoB's and other research institutions intentions towards that are needed.

Institutional sustainability links to achieve total sanitation. Whenever sanitation is perceived with totality concept, it is essential to ensure sanitation facilities are available at educational institutions, other institutes, public places, bus stops, ferry ghats, railways, riverine transports etc. This requires development and institutionalizing the process so that everybody feels their responsibilities to construct, use and maintain the sanitation facility in common places. However, the issues of proper use and maintenance of sanitation facilities at institutions and public places remain neglected and leads to non-functionality of the system. Recent initiatives by different development partners are appreciable to lease out such sanitation facilities by appropriate authorities or alternatively developing private sector operators to take over the management responsibility. Mandates of local government institutions regarding water and sanitation needs to be reviewed and substantiated by adequate support to play their roles. In addition, client-provider relationship needs to be strengthened for water and sanitation service providers at all levels. Encouragement of private sector participation for water and sanitation services and linking them with LGIs may lead to institutional sustainability. Addressing sanitation needs in slums through a holistic approach, urban slum policy could be another area to intervene for attaining institutional sustainability.

Most sanitation systems have been designed with these aspects in mind, but in practice they are failing far too often because some of the criteria are not met. In fact, there is probably no system which is absolutely sustainable. The concept of sustainability is

more of a direction rather than a stage to reach. Nevertheless, it is crucial, that sanitation systems are evaluated carefully with regard to all dimensions of sustainability. Since there is no one-for-all sanitation solution which fulfils the sustainability criteria in different circumstances to the same extent, this system evaluation will depend on the local framework and has to take into consideration existing environmental, technical, socio-cultural and economic conditions.

2.1.4 Focus on environmental sanitation in Bangladesh

Recent health statistics showed that Acute Respiratory Infection (*ARI*) is the leading cause of child mortality and morbidity in Bangladesh. It is now high time to put focus on the other aspects of environmental sanitation as defined in national sanitation strategy (GoB, 2005) as the county is approaching towards installation and use of hygienic latrines by all. According to the national sanitation strategy the term "100% sanitation" will mean to include all of the following:

i) No open defecation
ii) Hygienic latrines available to all,
iii) Use of hygienic latrines by all,
iv) Proper maintenance of latrines for continual use, and
v) Improved hygienic practice

100% sanitation should also mean total sanitary condition for healthy living. Therefore, in addition to above, the term must also include,

i) proper management of solid waste, and
ii) proper disposal of household wastewater and storm water.

Now the latrine coverage has increased significantly, the government needs to give more emphasis on total environmental sanitation.

2.1.5 Necessity of alternative sanitation options

Most of rural area of Bangladesh is short of water and subject to critical environmental degradation and polluting groundwater for using traditional low cost option, pit latrine and septic tank option. Even if the sanitation crisis can be communicated to and understood by more people, the need to find eco-friendly alternatives to conventional technologies for developing countries like Bangladesh remain. Therefore, considering the present context and sanitation situation of the country, there is a dire need of holistic

approach to call for hygienic, sustainable and eco-friendly alternatives, and hence the option of ecological sanitation toilets.

2.2.1 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 sounds sanitation. The basic of this approach 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.

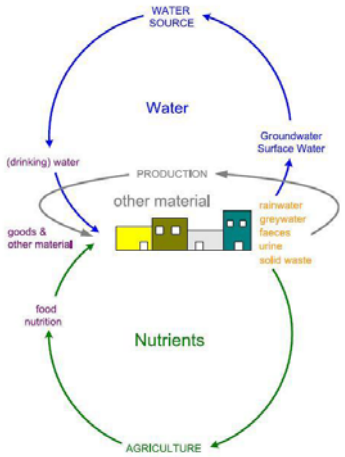


Fig. 1.2: Circular Flow in an Ecosan System (Langergraber, 2005).

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.

2.2.2 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.

2.3 Socio-cultural and institutional aspects of sanitation

The criteria in this category evaluate the socio-cultural acceptance and appropriateness of the system, convenience, system perceptions, gender issues and impacts on human dignity, the contribution to food security and stable and efficient institutional settings.
In Bangladesh context, Ecological sanitation is very challenging from the point of socio culture point of view. The majority of villagers preferred water based latrines and refuse contact with faeces. Some mental barriers can also be overcome by the high standard of comfort reached as showed by an ecological sanitation project.

2.3.1 Socio-cultural aspects of sanitation

It is difficult to separate the social and cultural aspects from each other when intertwined and together impact the health behaviour of a certain population. The social factors are socially constructed, such as norms and interpersonal interactions and cultural factors are the beliefs and values of a population. Socio-cultural aspects include norms and status as well as beliefs, ideals and values. Importance and difference of socio-cultural aspects and their place in water, sanitation and hygiene behaviours are closely related. Culture and the different ways in which it can be defined, many of which are including customs, knowledge and beliefs as well as moral. This also takes in the social part as these are seen as features of a group or a society and includes their social behaviour. This way it is difficult to separate the culture from the social and they can be seen as joined, socio-cultural aspects.

The social aspects of psychology, religion, and gender are examined to identify cultural criteria that influence the acceptance of compost toilets. Attitudes toward handling excreta vary worldwide, but there is no direct cause-effect relationship between attitude and behaviour. Likewise, the Muslim, Hindu and Judeo-Christian heritages vary in their doctrines regarding the handling of human excreta, which suggests that waterless toilets would be inappropriate where religion mandates water-based purification. In addition, gender-specific concerns associated with multi-family toilets and public conveniences are noted. The science of treating human excrement deals primarily with technology and degradation processes. It is not surprising, therefore, that the open literature is dominated by topics in the physical and natural sciences. What is surprising: the subject is not directly approached in the social sciences, e.g. cultural anthropology, human geography and behavioural psychology. This is unusual when one considers that the success of a treatment system depends on all the system components working together: device, process, nature, and society. The understanding of social issues is paramount if one intends to introduce an alternative sanitation system. Although treating excreta is a universal aspect of human existence, akin to food consumption, the topic has not been rigorously investigated by social scientists. The following report identifies three cultural influences that affect the acceptance (or rejection) of an alternative sanitation system: psychology, religion and gender.

Psychological Issues The psychological aspects of treating human excrement are not well known. Although there is a universal consensus that body wastes are sordid, our elimination behaviour and our feelings about it are all learned from our experiences, and evolve and change over time (Kira, 1995). As a result, there is no absolute right or wrong behaviour or attitude, except within a cultural context. In Western cultures, for example, the scale of excrement treatment stimulates different public reactions. Mention a pit privy or compost toilet, and the giggle-factor often creeps into the expression. Mention a central sewage system or the health-related statistics and the general response is far from humorous. With the exception of toilet training, the core of psychological literature is limited primarily to attitudes about human waste. Technically speaking, “attitude” includes three elements of behaviour: cognition, perception and a tendency to act. Prof. Templer California School of Professional Psychology notes that “the subject is an important aspect to human existence and is as taboo as sex was in the time of Freud and Kinsey” (Adams Templer 1998).

In concept, the bridge between attitude and behaviour appears obvious. In reality, the relationship is complex and somewhat unpredictable. For example, McCarthy and Shrum (1994) found that personal values about recycling solid wastes did not have a direct relationship with recycling behaviour. Values did, however, influence attitudes; and attitudes about the inconveniences of recycling influenced recycling behaviour. Although these findings are consistent with previous work on values and health food purchases, the McCarthy and Shrum (1994) study did not include excrement in their attitude-behaviour study. If one applies these psychological considerations to the subject of alternative waste treatment, one can understand the general scepticism towards compost toilets. To begin with, potential users are often unfamiliar with alternative disposal systems. Probably the most unfamiliar aspect of these sanitation options is that treatment requires some handling, at the household level, of the products. The cultural acceptability of handling human waste varies throughout the world. Although some cultures do not mind handling human excreta, and others find it abhorrent, most cultures are somewhere in between these two extremes. But these attitudes are not fixed. Experts in ecological sanitation note that when people see for themselves how a well-managed system works, most of their reservations about handling human waste disappear (Winblad 1998). A second cultural issue is whether waterless toilets will be accepted in cultures where washing after defecation is mandated by tradition and religion.

2.3.2 Religious issues of sanitation

Attitudes toward human waste are somewhat akin to attitudes toward diet. The mental dispositions towards both physical necessities are the result of cultural norms. And one of the dominant universal influences of social behaviour is religion. Religious doctrine both restricts diet (e.g. Islam prohibits pork) and promotes diet (e.g. Catholicism encourages fish on Friday). Although the influence of religion on waste behaviour appears less obvious, it does exist.

Concepts of clean and dirty, pure and polluting are well developed in the major world religions. Although most religious doctrines lack modern medical explanations of disease, they have a ritual and spiritual significance. Running water, for instance, may be acceptable for drinking because it is exposed to sunlight; considered to be “alive” and therefore “pure”, while water in wells (which does have these attributes) is deemed suitable only for washing (Franceys et al. 1992). Thus, when people are told that a new

treatment method will make their environment “cleaner”, it is often their own spiritual interpretation of “cleaner” that will be used.

The world’s largest major religion is Islam. Moslem doctrine prescribes strict procedures to limit contact with faecal material. Only the left hand can be used for cleansing after elimination; the right is used for eating. Moreover, the use of water for cleansing is specified. That is, a Muslim is obligated to use water to cleanse parts of the body through which impurities pass (Hooi and Hamzah, 1995).

Aside from these major religions, there are countless others that influence waste treatment behaviour. In some cultures, religion is not a separate element of society, rather an integral focal point. It is, therefore, difficult to determine if a particular behaviour is the result of religious doctrine or merely a learned behaviour. For example, the burying of feces is widely practiced to ward off evil spirits; separate facilities are sometimes provided for particular social groups; and contact with fecal matter is often unacceptable to certain individuals in society (Franceys et al. 1992).

Considering some developing countries are theocratic, the influence of religion should not be overlooked. Religious doctrine can become state law over night. With the rise of fundamentalism, voluntary behaviour often becomes compulsory. Enforceable personal behaviour is quite evident in Islamic theocracies, particularly with regards to women. The influence of theocracy on the design of both public and private toilets could be a reality if, for example, religious doctrine was interpreted to prohibit women from the workplace, restrict public toilets to men only, or mandate that men and women use separate toilets -- even in privacy of home.

2.3.3 Gender issues of sanitation

Women and men usually have very different roles in water and sanitation activities; these differences are particularly pronounced in rural areas. Women are most often the users, providers, and managers of water in rural households and are the guardians of household hygiene. If a water system breaks down, women, not men, will most likely be the ones most affected, for they may have to travel further for water or use other means to meet the household’s water and sanitation needs. Women have a strong incentive to acquire and maintain improved, conveniently located water facilities, since they often spend more time collecting water. Hence, women and girls tend to benefit most when water quality and quantity improves. They tend to take shorter trips carrying heavy

containers, they may have more time for income-generating activities and they are able to spend more time in school.(World Bank, 2002).

Given their long-established, active role, women usually are very knowledgeable about current water sources, their quality and reliability, and any restrictions to their use. They will also be key players in implementing improved hygiene behaviours. Men are usually more concerned with water for irrigation or for livestock. While women are often more direct users of water, especially in the household, men traditionally may have a greater role than women in public decision-making. Because of these different roles and incentives, it is important to fully involve both women and men in demand-driven water and sanitation programs, where communities decide what type of systems they want and are willing to help finance.

In most societies, women have primary responsibility for management of household water supply, sanitation and health. Water is necessary not only for drinking, but also for food production and preparation, care of domestic animals, personal hygiene, care of the sick, cleaning, washing and waste disposal. (UN water 2006)

If one considers demographics alone, worldwide the majority of toilet users are women. Gender issues are primarily a concern when toilet facilities are multi-family or public. Ecosan has had an interesting effect on the gender roles associated with latrine construction. During the assessment study, it was found that in households with Ecosan toilets (dry Ecosan or wet Ecosan, ie urine diversion toilets), the task of emptying the urine container and the vault (also called faecal bin) seems to be that of males, but when it comes to conventional pit-san toilets, the task was usually carried out by women. Thus, Ecosan related task has not contradicted societal norms about the division of duties, while new ideas regarding benefits of recycling nutrients can introduce new values. In addition, the production of fertiliser through the use of Ecosan toilet has influenced both genders in the importance of latrines and their proper maintenance to benefit from the compost produced. However, some concerns were shown by some communities about disposing of menstrual blood in the Ecosan toilet, and such a practice also poses a challenge for the reuse of urine as fertiliser. The experience, based on the findings of the Ecosan assessment study conducted by JADE and BARD, showed that the use of Ecosan is accepted not only by the adult members of the family, but also by the children (as they were made aware by the family) and in schools through a value based water and sanitation education programme. The men shared opposite interests to

the women, who were more interested in the hygiene aspects of latrine use than the fertiliser. However, the end result is the same, a reduction in children's faeces around the compound and settlements' surroundings. Apart from the children, women too, who otherwise practiced open defecation, now used this toilet with greater confidence, privacy and security at any time (particularly at night) as they used to during open defecation.

2.3.4 Financial and economic aspect of sanitation

There are many examples of ecosan pilots and small-scale projects in Bangladesh. Consequently, but ecosan toilets are only used by a relatively small number of the rural population. Even in project area well known for ecosan, the coverage is by no means universal, and not all households are necessarily actively involved in reuse.

There is a whole range of technologies and management arrangements that can be adopted to promote the reuse of excreta. But based on the case study analysis, none are seen to provide an obvious model for up-scaling without considerable external support. The lower the capital costs, the higher are the benefits of reuse in ecosan option, in terms of Net Present Value (NPV). The operational expenditures have an impact on the overall financial and economic performance, but the impact is limited, compared to the influence of capital costs. The results show that operational and maintenance costs determine the financial performance (in terms of NPV) from a household perspective in situations where latrines are heavily subsidized. However, when subsidies are removed and overall project costs are taken into account, the picture changes remarkably, as the capital costs become the most critical factor which influences the financial performance of each option.

By reusing excreta, households with ecosan toilets can generate monetary benefits and increased crop production can have a positive impact on them financially. Evidently, poorer households seek to gain more in proportion to their household income. Although not only specific to ecosan, latrines may not be affordable for the poor without subsidies to reduce the extent of household investment. However, it needs to be recognized that all of the analyzed options may not be affordable for the poor without subsidies, and it is therefore important to consider the development of cheaper latrines that are ratified and promoted by government agencies. (WSP 2009)

The results from the model analyses demonstrate that various factors influence the crop yield, and this is a key determinant in the economic viability of ecosan. These factors

include the availability of land, the type of soil, and climatic conditions. The results indicate that in the right environment, ecosan can provide a positive net benefit and therefore the ecosan toilet is an attractive technological option that requires further consideration in sanitation programming. In particular, Ecosan provide an appropriate sanitation technology in situations where the practicalities and operational costs of servicing conventional onsite sanitation mean that desludging considered being viable.

The key factors influencing the viability of ecosan that operational and maintenance costs determine in urban environment are the amount of land the financial performance (in terms of NPV) from an available, and the agricultural conditions.

The yield is also a function of the agricultural conditions. Good agriculture conditions promote increased yields and it is in these conditions that excreta reuse is seen to be most beneficial. It is also arguable that in situations where the agricultural conditions are poor, it is advisable to reuse excreta. Whether it is considered to be economically attractive will ultimately depend on the household's income.

Although not included in the study, it has to be recognized that there are potentially other factors that contribute to the attractiveness of ecosan from a household perspective (notably reduced odours). On the other hand, there are other behavioural constraints related to use of ecosan toilet and the handling of faeces that may reduce the interest at the household level to utilize these technologies. Further research is required to assess which factors predominate under which situations. The results indicate that the benefits from crop production can offset the higher capital and operational costs, but the benefits may not be sufficient to cover additional costs required for implementing ecosan. There are many factors at hand, and the study highlights the complexity of the systems involved. The answer to this depends on physical, environmental and social factors.

Also points towards the need to reuse excreta as close to the point of generation as possible, whilst keeping the costs of installation down. Where this is not viable, a communal excreta reuse system becomes economically attractive, provided the project management and capacity building costs associated with the promotion of ecosan can be lowered. (WSP 2009)

2.3.5 Technology and operation aspect of sanitation

Incorporates the functionality and the ease with which the entire system including the collection, transport, treatment and reuse and/or final disposal can be constructed, operated and monitored by the user. Furthermore, the robustness of the system, its

vulnerability towards power cuts, water shortages, floods, etc. and the flexibility and adaptability of its technical elements to the existing infrastructure and to demographic and socio-economic developments are important aspects to be evaluated.

2.3.5.1 Technical aspects of EcoSan toilets

Pit toilets are most used in toilet in rural area of Bangladesh which can contribute to the spread of disease. Pit toilets can leach contents into groundwater, spreading pathogens from faeces and excess nutrients from urine into water bodies. Excess nutrients in water bodies can lead to excess algae growth which can deprive fish of oxygen and make water unsafe for human drinking or bathing. Pathogens from faeces can lead to disease for those bathing in, washing with and drinking contaminated water. For children and vulnerable individuals, diarrhoea and waterborne illnesses can lead to dehydration and death. (BGS 2001)

As an alternative to these harmful cycles, EcoSan's primary goals include:

i) Prevention of disease
ii) Protection of the environment
iii) Recovery of nutrients (Huuhtanen, S., Laukkanen, A., 2009)

EcoSan stores faeces in a composting chamber where ash, lime or other additives are used to raise the pH of the waste and thereby break down pathogens. After about six months of storage without the addition of fresh faeces, the resulting material should be dry, rich, soil-like compost containing relatively few pathogens and may be used as a soil conditioner for agriculture. If EcoSan is installed and used properly, it assists in the prevention of disease. Protection of the environment, the next goal of EcoSan, is accomplished on several levels. First, the use of urine as fertiliser rather than releasing it directly into the aquatic environments prevents problems such as eutrophication. Secondly, the environment benefits from the conservation of fresh water by not using water for flushing. Thirdly, the reduced need for chemical fertilisers when a family uses urine on their fields is beneficial to the environment. The minerals used to make fertiliser are typically mined and processed via environmentally destructive practices using large amounts of energy, water, explosives and harmful chemicals. (Niwagaba, C., 2007) Once produced, these fertilisers leak from fields into ground and surface water, especially when applied in excess, and cause the same problems with excess nutrients as urine does in water. Finally, EcoSan users suspect that urine acts as a natural pesticide. By avoiding chemical pesticides, EcoSan plays a role in protecting

entire food chains from the multiple ill effects of these chemicals. The last important goal of EcoSan is the recovery of nutrients. Rather than the conventional linear path, where resources are continually used up and nutrients are disposed of into water bodies, EcoSan creates a renewable cycle of nutrients going from soil to plants to humans and back to soil again. Ecological sanitation takes the nutrients present in human excreta and recycles them back into agriculture. This does not, however, mean applying raw faeces to crops. A key part of the EcoSan system is the destruction of most or all disease causing pathogens before re-use of excreta as compost or liquid fertiliser. Results from scientific studies of pathogen destruction in EcoSan systems have provided us with guidelines for the treatment of urine and faeces before re-use as fertiliser.

Ecological Sanitation refers to the entire process of excreta containment, re-use and crop production. However, the physical component of EcoSan with which humans interact most frequently is the toilet. An EcoSan toilet must be carefully designed to accommodate the social and cultural norms for toilet design. It must make the user feel comfortable while still functioning to prevent disease, protect the environment and recover nutrients. There are multiple types of EcoSan toilets used in Bangladesh and still others used in other countries. The types can vary by design: type of pan or bowl, size/type of excreta chambers and component materials. These variations may depend on which materials are available, how much a family is willing to spend on the toilet, whether the family wants to use water for flushing or how often the family can fill and empty the faeces chambers. EcoSan toilets only make sense if a family is able to use or sell the faeces compost and urine fertiliser produced, if there are sufficient additives available for use in the toilet, if there is enough space inside or outside the house for construction and if the given location is warm enough to allow for sufficient drying of the faeces. (Gtz 2004)

2.3.5.2 Types of EcoSan toilets

In general, two types of EcoSan toilets have been introduced in Bangladesh : urine-diverting dry toilets and urine-diverting wet toilets. Almost all of the EcoSan toilets constructed so far are dry toilets double vault model, with some modifications. Basic components of these toilets are two separate watertight vaults with ventilation pipes for storage of faeces, a urine collection vessel and a system for diverting anal cleansing water. The vaults, which are separated by a brick wall, are constructed above ground level with brick masonry to avoid contact with ground water. There are several design

developed and constructed by different organization in different place of Bangladesh. So far all the developed eleven models design and technical description are in Appendix- B. The basic features of the dry toilets are presented below:

Vaults: In most cases, the volume of each of the vaults is 0.35 cubic metres and the height of the vault is normally two feet. The inner walls of the chambers are plastered with cement sand mortar.

Vault door: The vault door needs to be big enough to allow easy removal of the contents from the vault but it should not allow moisture to seep in. Several different options have been tried out for the vault door. In most toilets, a flush door of a size not less than 6"x 6" has been provided in one side of each of the vaults to facilitate the removal of dry content. The holes are closed with either a metal sheet, concrete slab or transparent PVC sheet.

Urine diversion system: A polythene pipe of 50 mm diameter is provided to divert the urine from the urine container or jerry can to the urine collection vessel made of brick masonry, plastic tank or Jerry can. The size of the urine collection plastic container varies from 20 to 40 litres because they are inexpensive and there is less chance or leakage.

Anal cleansing: In the Dry EcoSan toilet, there is a separate hole for anal cleansing. The wastewater from anal cleansing is conveyed through a concealed pipe into a soak pit/ evaporation bed. Occasionally, the soak pit is also a small wetland with plants such as reeds planted on it.

Super structure: The outer size of the toilets is generally 5’x4’2" and all the brick walls are 4" thick. The EcoSan toilets constructed within Bangladesh have some variation in design, construction materials and use. Some major designs are mentioned below.

2.3.5.2.a Double vault ecosan toilets

The double vault ecosan is a widely-used design of the EcoSan toilet. It is a modified version of a Vietnamese double-vault dry toilet and was used in the first EcoSan pilot project in Bangladesh. The Ecosan has two separate watertight chambers for faeces storage with a ventilation pipe attached. There is one urine collection vessel, made of brick masonry, a plastic tank or a Jerry can. Newer versions often use a plastic tank (to prevent leakage) surrounded by bricks for support. The size of the urine tank varies

between 50 and 100 litres or plastic container varies from 20 to 40 litres, depending on the frequency of urine use as fertiliser. The faeces chamber walls are made of brick and plastered with cement and sand mortar in order to be water-tight. They have a masonry wall separating them. They are constructed above ground level to avoid seepage of faecal matter into the ground water even though the mortar should not allow it. Each chamber should have an internal volume of around 0.35 cubic metres with a height of only 0.6 metres (2 feet). An additional small chamber is made for the percolation of wash water. The outer walls of the toilet, placed above the chambers, are generally around 10 centimetres thick and made of bricks. The walls should enclose an area of 1.5 x 1.25 metres to allow enough space for the squatting pan and water bucket. To facilitate compost removal from the faeces chambers, square openings of 6" x 6 " (or greater) are provided for each of the chambers. The openings are covered with a metal sheet, concrete slab, fibreglass, glass or transparent PVC sheet. Newer toilets use sliding-door style covers made of glass. Near the urine storage tank there is a small soak pit for collecting anal cleansing water. This water is evaporated and disinfected by soil and by sitting in the sun.

2.3.5.2.b Two-vault solar model

A few two-vault solar EcoSan toilets have been installed in most of the piloted area. The basic components are the same as the Ecosans except the faeces chamber access holes are kept at an inclined angle (rather than vertical) and chamber covers are made of sheet metal, painted black. When these black metal sheets are orientated towards sunlight, they heat up and cause the chamber temperature to rise as well. The black metal sheet covers are larger than covers used for Ecosan because greater sunlight-exposed areas increase heating effects. With higher temperatures the faeces may dry faster, causing pathogens to die more quickly. Few of these models have been installed but they are comparable in price to Ecosan and are slightly more effective in drying faeces.

2.3.5.2.c Single vault movable container type

The single vault movable container toilet is a dry toilet designed for indoor use. A plastic container mounted on a metal frame is placed directly below the squatting pan. This container stores faeces until it is full and then is replaced by a second container. The urine collection system is similar to that of a Ecosan toilet and urine is diverted into

a plastic tank. Anal cleansing water empties into another tank which must be poured into a soak pit periodically. This model is ideal for households with limited space available for building construction. Currently there are five indoor EcoSan toilets of the single-vault moveable container type located in Practical Action Bangladesh project area.

2.3.5.2.d Urine diversion pour-flush toilets

The urine diversion pour-flush model, also known as Wet EcoSan, is essentially a modification of the double pit pour-flush toilet with an added mechanism for urine diversion. A special urine-separating pan must be used, as with other EcoSan models, and urine is collected in a poured into the faeces chamber but urine is still collected separately. The pan for the Wet EcoSan is slightly different from the Dry EcoSan model as the pan is designed to collect water as well. Currently, two types of pans, one made from cement and another made from fibreglass which was made project based by different organization. This type of EcoSan is especially useful in areas where plenty of water is easily available and handling of faeces is socially undesirable. Currently there are 20 Wet EcoSan toilets in the Shirajgon constructed by MMS organization. In these toilets, urine is diverted into 20 to 30 litre plastic containers through a small rubber pipe while the faeces and the wastewater is carried by a 110 millimetre diameter polyethylene pipe to a distribution chamber and two concrete lined pits, which are four and a half feet deep.

2.3.6 Various components of EcoSan toilets

Over the last five years, various design changes have been made in the EcoSan toilets built in Bangladesh - based on experience and feedback from users. These changes have been components of EcoSan toilets and analyse their performance.

Squatting pan

In Bangladesh, squatting pans are often preferred to low level pan commode-style toilets. Therefore, all except one toilet has used various types of squatting pans. To effectively separate urine and faeces, prevent cross-contamination, allow faeces to fall into one of the two tanks and still have an easy-to use shape, a squatting pan must be carefully designed. Various models of squatting pan have been tested, including a combined pan with two holes for faeces and one hole for urine and a model with two

separate pans, one over each faeces chamber. The benefits and drawbacks of each type of pan are shown below.

Combined pan

The combined pan has a urine hole in the middle and two larger holes on either end for faeces. Each faeces hole is located over one of the two faeces chambers, and each has a cover to prevent vector access and eliminate odours. The hole over the full chamber ought to be covered with a special sign or symbol to allow the chamber to sit for six months without the addition of fresh faeces. This type of pan may be moulded out of cement or from plastic glass fibre. Plastic glass fibre combined pans are widely used. This pan design has some important advantages. It saves space compared to a two-pan design. The width of the toilet floor need only be wide enough for one pan, although there must be additional room to allow for squatting in either direction over the two faeces holes. The design saves money by only requiring one pan, rather than two, and one urine diversion pipe. In most of rural Bangladesh, families and local communities as a whole do not have many spare funds: keeping costs low is crucial.

Unfortunately, this type of pan also causes a number of problems for users. Several users complained that it is easy for urine to enter the full vault since faeces hole covers are not completely sealed and splashing occurs. Also, the urine pipe often becomes disconnected from the pan and allows urine into one of the faeces tanks. (This can be fixed by using a threaded pipe connection into the pan and perhaps tightening the connection using Teflon tape). Any leakage of urine or water into the faeces tank will create excess moisture and prevent faeces desiccation so it is important to fix any pipe connection problems. Unless faeces are dry, large numbers of pathogens will remain in the excreta and later contaminate crops. One final issue arose with each faeces hole being located near the edge of the faeces chamber rather than in the centre of the chamber. As a result, excrement started to pile up along one side of the vault and it was difficult for users to push the pile over and spread it out. Two pan system and the other type of pan, used more often in recent versions of EcoSan, is a toilet with two separate pans. Each pan has two holes, one for faeces and one for urine, and most pans have designated non-slip areas for foot placement. The faeces drop directly into the middle of the faeces chamber and urine is conveyed to the collection vessel via a small pipe. These pans are typically made of cement and polished with white cement. Lids to cover

faeces holes are also made of cement. With this type of pan, if the faeces hole of the pan not in use is covered, the pot used for ash may be placed on it.

This system of pans is well-liked by users, and there were few problems encountered with the design. By placing the ash pot over the pan which is not in use, confusion over which pan to use is eliminated. This is a particular concern for guests or new users who aren't used to seeing two pans side-by-side. People like the appearance of these pans in general. The one major problem area was the connection between the urine pipe and pan, as with the combined pan. Many toilets surveyed were found to leak at this point. Pan for Wet EcoSan Two types of pans have been developed in Bangladesh for Wet EcoSan toilets – one made of cement and another made of fibre glass. Both the pans have two holes - one for faeces and one for urine. The area between the holes is sloped towards the faeces hole as the water is collected together with the faeces.

Pan cover

The faeces' hole cover is a surprisingly important component of EcoSan toilets. If the lid is consistently placed over the hole, lifted only for use, and replaced afterwards, the likelihood of flies breeding inside the vault diminishes. Lids at the village sites were made of cement, metal, PVC, or plastic. The lids made of PVC, plastic and metal were lightweight and did not always cover the faeces hole adequately. They were more easily knocked off of the hole, and were sometimes accidentally misplaced by users. Lids of cement were comparatively heavy and did not tend to move or get lost. Therefore, users preferred cement lids and perceived them as more practical.

Faeces collection chambers

The internal size of faeces collection chambers is more or less uniform for all EcoSan toilets observed in the field. The standard size (0.35 cubic metres) was adequate for most families. All toilets ought to have above ground faeces collection chambers. If space allows, it may be better in the future to make tanks larger so that faeces may be allowed more than six months to fully dry and allow pathogens to die. In cases where families are large and the normal tank size would fill in fewer than six months, larger chambers should be considered by the family and builder.

Urine-pipes and urine-collection-tank

Urine pipes posed a problem in many of the EcoSan toilets observed. As noted earlier, the joint between the pipe and the pan is often loose and may cause leakage. This is particularly bad in the PVC pans where the urine pipe does not have a proper connection mechanism and the pipe itself is often very short. Without adequate length, any movement in the pipe or pressure put on it may cause it to become disconnected from the pan. This is an easy problem to fix although a longer PVC pipe will be slightly more expensive than a shorter one. The size of urine pipes was sometimes a problem in certain toilets. Some were using 15 mm diameter HDP pipes which were easily clogged by salt precipitation from the urine. Therefore, urine pipes should not be less than 50 mms in diameter in order to prevent clogging. In most cases, the urine pipe is placed so that urine flows freely into the tank unassisted. The end of the pipe must be submerged in urine inside the tank to prevent the air from reacting with urine and producing ammonia. Nitrogen is urine's most abundant nutrient and if ammonia is formed, part of the nitrogen will be lost when the ammonia escapes as a volatile gas. If the pipe outlet is placed near the bottom of the tank, at least halfway to the bottom, the problem of nitrogen loss should be minimal.

The size of the urine tank is another problematic point. Many toilets have tanks which are too small and don't allow urine to sit for a long enough time before being used. Although urine contains significantly fewer pathogens than faeces, it is still recommended that urine sit for at least one week before it is used as an edible crop fertiliser. Therefore, the urine tank should be at least 20 litres in capacity. The urine tank must always have an airtight cover to ensure that air doesn't react with the urine and cause nitrogen loss via ammonia volatilisation. However, in many toilets, tanks are frequently kept open and precious nitrogen is lost.

Ventilation pipes

A ventilation pipe is another crucial component of the EcoSan toilet. Proper ventilation is necessary for the dehydration of faeces and for minimisation of odours inside the toilet. Not have a ventilation pipe or had a ventilation pipe that was too short, clogged or had no cover on the top end is a common case. While these problems seem simple, they may cause the entire EcoSan system to fail and result in users losing faith in the technology as a whole. During construction, it is important that the ventilation pipe be

tall enough to push odours outside. Pipes which are low to the ground leave EcoSan toilet interiors with a foul smell. Pipes ought to remain unclogged if they have a cover on top, although, if a clog occurs somehow, it needs to fix immediately. A cover over the ventilation pipe is essential to prevent rainwater from entering the faeces chamber. Once wet, the six-month period becomes inadequate for sufficient pathogen die-off.

Lighting

In Bangladesh households, toilets are not normally designed for comfort and accessibility. They often lack adequate lighting and ventilation. During EcoSan site visits, it was discovered that EcoSan toilets are treated no differently - most of the toilets have inadequate light and ventilation. Only small holes are made in the walls of toilets to allow light inside. The holes are usually not covered with fly screens although it is important to keep flies from breeding inside the toilet. The majority of toilets also do not have an electric lighting system attached for nighttimes use. Whenever there is a lack of light, it becomes easy to misuse the EcoSan toilet. If the toilet room is dark, a user might spill anal cleansing water into the urine or faeces hole without noticing. They might not be able to see where to put ash, and might spill it or forget to use it entirely.

Access doors/heat panel in vaults

Faeces chamber access doors must be properly designed so that vaults are easy to open every six months but stay tightly closed the rest of the year. The doors must allow faeces to be removed easily from the vaults twice per year. In most of the EcoSan toilets studied, access doors are made of metal, concrete, wooden planks, transparent PVC sheet and other materials. Hole sizes were not uniform: some were not large enough to allow easy access to the vault contents while others provided plenty of area for emptying. Of all the materials used for access doors, metal sheet seemed to be the most problematic. These metal lids had corroded in a few toilets due to moisture from within the chamber and from the outside air. Rain can also lead to corrosion. Once the metal is corroded, doors may not shut properly and flies or odours in toilets can become a problem. Also, it is hard to open the corroded doors for chamber emptying. Users with concrete slab access doors seemed more satisfied but were not without complaints - water leakage from the slab joints were seen in many units. The transparent PVC sheet seemed to work well and has an aesthetically pleasing appearance when first installed. Unfortunately, however, many PVC sheet doors were placed in bright sunlight and

began buckling over time. Once the doors are hot enough, they bend slightly and openings are formed for flies and rodents to enter the faeces chambers. Perhaps if lids were made of thicker PVC sheet they could more easily resist melting. Some newer EcoSan toilets were made with fiberglass or glass sliding access doors and seemed to have fewer problems than the other materials. Fiberglass is quite expensive as a material but glass is cheaper and more widely available. If concrete slab doors are preferred, it would be possible to design them so that the side of the slab is jointed with cement mortar after each time the vault is emptied.

2.3.7 Toilet superstructure

Door shutter

Toilets are places of privacy; the toilet user must feel safe, comfortable and unwatched. Generally in EcoSan toilets plastic and CI sheet used as door. Although these allow for some privacy, they cannot be locked and lead to potential embarrassment for the user. To ensure acceptability of EcoSan technology, it is better to use a solid door made of wood or metal.

Height of toilet

EcoSan toilets, like any toilet, should allow any user to stand inside without hitting his/her head. While this is not typically a problem in the EcoSan toilets visited, a few toilets had a very low ceiling height. This can make using the toilet difficult and uncomfortable, so it is best for designers to create an interior height of around two metres.

Roof

EcoSan toilets are, at their essence, dry toilets: the faeces vault, urine tank and inner toilet area should be completely watertight. Any leakage in the roof may lead to dampness in the vaults and generally create an unpleasant or smelly environment within the toilet room.

2.4 Environmental and health aspect of sanitation

Environmental aspect involves the required energy, water and other natural resources for construction, operation and maintenance of the system, as well as the potential emissions to the environment resulting from use. It also includes the degree of recycling

and reuse practiced and the effects of these (e.g. reusing wastewater; returning nutrients and organic material to agriculture), and the protecting of other non-renewable resources, for example through the production of renewable energies (e.g. biogas).

Health aspect includes the risk of exposure to pathogens and hazardous substances that could affect public health at all points of the sanitation system from the toilet via the collection and treatment system to the point of reuse or disposal and downstream populations. This topic also covers aspects such as hygiene, nutrition and improvement of livelihood achieved by the application of a certain sanitation system, as well as downstream effects.

2.4.1 Environmental aspect of sanitation

Excreta are an important source of nutrients for many farmers. The direct use of excreta on arable land tends to minimize the environmental impact in both the local and global context. Reuse of excreta on arable land secures valuable fertilizers for crop production and limits the negative impact on water bodies. The environmental impact of different sanitation systems can be measured in terms of the conservation and use of natural resources, discharges to water bodies, air emissions and the impacts on soils. In this type of assessment, source separation and household-centred use systems frequently score more favourably than conventional systems.

Application of excreta to agricultural land will reduce the direct impacts on water bodies. As for any type of fertilizer, however, the nutrients may percolate into the groundwater if applied in excess or flushed into the surface water after excessive rainfall. This impact will always be less than that of the direct use of water bodies as the primary recipient of excreta. Surface water bodies are affected by agricultural drainage and runoff. Impacts depend on the type of water body (rivers, agricultural channels, lakes or dams) and their use, as well as the hydraulic retention time and the function it performs within the ecosystem.

Phosphorus is an essential element for plant growth, and external phosphorus from mined phosphate is usually supplied in agriculture in order to increase plant productivity. World supplies of accessible mined phosphate are diminishing. Approximately 25% of the mined phosphorus ends up in aquatic environments or is buried in landfills or other sinks. This discharge into aquatic environments is damaging, as it causes eutrophication of water bodies.

Urine alone contains more than 50% of the phosphorus excreted by humans. Thus, the diversion and use of urine in agriculture can aid crop production and reduce the costs of and need for advanced wastewater treatment processes to remove phosphorus from the treated effluents.

The use of excreta in agriculture has the potential for both positive and negative environmental impacts. It is important to minimize the environmental impact associated with the direct use of excreta in agriculture in both the 1ocal and global context. For large-scale implementation, environmental impact assessment is a useful tool for the analysis. A procedure for measuring the environmental impacts of different sanitation approaches involves the analysis of material flows or a life cycle analysis for the production of different crops, which may also lead to a better understanding of the environmental impacts of different agricultural practices.

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

2.4.1.1 Impacts on soil

Relevant substances to consider in terms of environmental impacts on soil metal salts, heavy metals and presence of organic compounds.

2.4.1.2 Presences of metals

The content of heavy metals in excreta is generally low or very low, compared with other sources with potential impacts on soil, and depends on the amounts present in consumed food products. The contents of urine reflect metabolism, and the levels of heavy metals in urine are very low (Jnsson et a1., 1999; Vinneräs, 2002; Palmquist, 2004). Concentrations of heavy metals are relatively higher in faeces than in urine, but the concentrations are lower than in chemical fertilizers (e.g. cadmium) and farmyard manure (e.g. chromium and lead). The main proportion of the micronutrients and other heavy metals passes through the intestine unaffected (Fraŭsto da Silva & Williams, 1997). Of all the liquid household effluents, grey water may have the highest heavy metal content.

2.4.1.3 Presence of organic compounds

The major proportion of the nutrients in the wastewater originated from the urine. Of the amounts consumed in food, about 80-90% of the nitrogen, 50-80% of the phosphorus and 80-90% of the potassium are found in this fraction (Berger, 1960; Schroeder & Nason, 1971; Lentner et al., 1981; Guyton, 1992; Frausto da Silva & Williams, 1997). Faeces are by weight the smallest of the biodegradable waste fractions. Between 30 and 40 kilograms, wet weight, of faeces is produced per person and year. This corresponds to 10- 15 kilograms of dry matter (Paper I; Lentner et al. 1981). The volume produced per person depends upon the composition of the food consumed. Meal and other foods low in fiber produce smaller volumes than food high in fibre (Guyton, 1992). On average, one stool per person and day is produced, but it varies from one week up to five per day (Lentner et al., 1981; Pharmacia, 2000). Urine and faecal fertilizers are mixed into the topsoil, where there is a high level of biological activity. Usually the substances are retained there for months. The dominant removal mechanism for these substances is adsorption. Removal efficiencies are greater in soils containing higher contents of silt, clay and organic matter.

However, fertilizers containing organic materials will help to buffer the negative effects of the salts in the soil profile. There are four ways in which salinity effects soil productivity:

1) It changes the osmotic pressure at the root zone.

2) It provokes specific ion (sodium, boron or chloride) toxicity.

3) It may interfere with plant uptake of essential nutrients (e.g. potassium and nitrate) due to antagonism with sodium, chloride and sulphates.

4) It may destroy the soil structure by causing soil dispersion and clogging of pore spaces. This results in an increased lateral drainage, but may also affect the oxygenation. Both low-salinity waters and high sodium concentrations in the water in relation to calcium and magnesium concentrations in the soil exacerbate the effects.

2.4.1.4 Impacts on water bodies

Application of excreta to agricultural land will reduce the direct impacts on water bodies. However, as for any type of fertilizer, the nutrients may percolate to groundwater if applied in excess or be flushed into surface water after excessive rainfall. This impact will always be less compared with that of the direct use of water bodies as the primary recipient. The impact of reuse of human excreta in agriculture on

groundwater quality depends on factors such as agricultural application rate, the type of irrigation water the soil type, aquifer vulnerability, the agricultural practices and the type of crops, as well as the recharge and groundwater use (Foster et al., 2004).

In order to avoid negative effects of using excreta as agricultural fertilizers, the following should be considered (Foster et. a1. 2004):

i) improve agricultural practices;
ii) establish criteria to operate wells used to supply water for human consumption in the surroundings (establish safe distances to the agricultural site, depth of extraction and appropriate construction);
iii) routinely monitor groundwater.

Surface water bodies are affected by agricultural drainage and impacts depend on the type of water body (rivers, agricultural channels, lakes or dams) and their use, as well as the hydraulic retention time and their function within the ecosystem.

A high organic load will, independently of the source, affect the dissolved oxygen levels, thus impacting aquatic organisms. Additionally, the nitrogen or phosphorus washed into water bodies will lead to eutrophication and subsequent oxygen depletion and will facilitate the growth of toxin-producing algae (Chorus & Bartram, 1999).

Organic chemicals originating from excreta and grey water will only minimally impact surface water bodies due to their adsorption to soil particles after application. The soil will act as a filter before the respective pollutants reach groundwater and surface waters.

Nitrogen can contaminate groundwater and surface water bodies by infiltration and agricultural runoff . The amount of nitrogen leached depends on crop demand, hydraulic load due to rain and agricultural water, soil permeability and nitrogen content in soils. Agricultural runoff containing phosphorus can cause eutrophication in surface water bodies (reservoirs and lakes). High concentrations of biodegradable organic matter in agricultural runoff water can lead to the consumption of dissolved oxygen in lakes and rivers.

Phosphorus is an essential element for plant growth, and mined phosphates are a common input into agricultural production in order to increase crop productivity. Soil phosphorus content varies with parent material, texture and management factors, such as rate of application, type of phosphorus applied and soil cultivation (Sharpley, 1995). It is usually present in soils in relatively important quantities. World supplies of accessible mined phosphate are diminishing. It is predicted that phosphate-carrying rock/mineral reserves will run out in 60-130 years. The mining of phosphate causes

environmental damage because it is often removed close to the surface in large open mines, leaving behind scarred land. Moreover, phosphate-carrying rocks/minerals also contain varying amounts of non-desired elements, such as cadmium. Approximately 25o/a of the mined phosphorus ends up in aquatic environments or buried in landfills or other sinks (Tiessen, 1995). The discharge into aquatic environments causes eutrophication of water bodies, leading to more environmental damage. to reduce the phenomenon of eutrophication, wastewater treatment plants require additional phosphorus removal treatment capacity, which adds to the costs and complexity of the treatment process.

Urine alone contains more than 50% of the phosphorus excreted by humans, Thus, the diversion of urine and its use in agriculture can aid crop production and reduce the need for costly, advanced wastewater treatment processes to remove phosphorus from the effluents (EcoSanRes2005).

2.4.2 Health aspect of sanitation

A primary benefit of sanitation is improved human health, achieved by breaking the transmission of pathogens to humans by the containment of faeces. This is essential to reducing the incidence of common illnesses such as diarrhoea, the cause of some 2.5 million deaths a year. Sanitation involves human behaviour. Discussions around the health aspects of sanitation must therefore centre on the user, to ensure that sustained hygienic behaviours, enabled by sustained sanitation systems, ultimately improve human health. Debates around the value and appropriateness of "ecological" forms of sanitation and latrines typically focus on the benefits to be gained from recycling excreta; capturing the nutrient value of human excreta, while reducing environmental pollution. The impact of an ecological sanitation system on human health – starting with the user – is less well debated. The result is a general misunderstanding and conflicting views about the implications of ecological forms of sanitation on the health of users and the wider community (WELL 2006).

Human excreta contain large number of pathogenic microorganisms, that directly or diluted in the wastewater constitute a threat to human health. Diarrhoeal and parasitic diseases are major contributors to the Global Burden of Disease (GBD), where environmental transmission through contaminated water, food crops or through direct contact to faecal contaminated sources are major contributors. From a hygienic

perspective, use of excreta may reduce the risks of pathogen exposure, if treatment and other barriers against exposure are accounted for. In contrast, the risks may be enhanced, due to improper practices in the handling chain of excreta, and due to both improper treatment and use of wastewater, as well as diffuse exposure. Occurrence of disease-causing organisms in human excreta is the result of infection in individuals. Such infections do not necessarily manifest with clinical symptoms, but will lead to an excretion of the pathogens in question. For organisms infecting the gastrointestinal track, this excretion is mainly through faeces. The prevalence of infections mirrors the hygienic situation in a society. Infections are always an exception and not a general situation for an individual. Infections of individuals may, in rare cases, be chronic, for bacterial and viral diseases. The individuals are then called "carriers". Parasitic worms (helminths) may establish themselves for long periods in the human body and have a high prevalence rate in societies with unsanitary conditions. An individual will normally excrete large amounts of microorganisms in faecal material. The numbers are in the range of 1011-1013/g.

2.4.2.1 Pathogens in faeces and its nature

Enteric infections can be transmitted by pathogenic species of bacteria, viruses, parasitic protozoa and helminths. From a risk perspective, the exposure to untreated faeces is always considered unsafe, due to the potential presence of pathogens. There are many different types of organisms causing enteric, parasitic or other types of infections which may occur, and their prevalence in a given society is often unknown. In surveillance systems, bacteria have traditionally been considered the leading group of organisms causing gastrointestinal illness. This is partly the case in developing countries, where outbreaks of cholera, typhoid and shigellosis are of major concern and seem to become more frequent in urban and peri-urban areas (S. Brian, WHO, *pers. comm.*, 2003). Enteric viruses are also of general importance and are now further considered to cause the majority of gastrointestinal infections in industrialized regions (Svensson, 2000).

More than 120 different types of viruses may be excreted in faeces, with the most common from the enteroviruses, rotavirus, enteric adenoviruses and human caliciviruses (noroviruses) groups (Tauxe & Cohen, 1995). Hepatitis A is also recognized as a pathogenic virus of major concern when applying wastes to land and is considered a

risk for water- and food-borne outbreaks, especially where the sanitary standards are low. The importance of Hepatitis E is emerging.

Among bacteria, at least *Salmonella*, *Campylobacter* and enterohaemorrhagic *E. coli* (EHEC) are generally of importance, in both industrialized and developing countries, when evaluating microbial risks from various fertilizer products including faeces, sewage sludge and animal manure. They are also important as zoonotic agents (transmission between humans and animals, as well as their faeces/manure). In areas with insufficient sanitation, typhoid fever (*Salmonella typhi*) and cholera (*Vibrio cholera*) constitute major risks in relation to improper sanitation and contamination of water. *Shigella* is also a common cause of diarrhoea in developing countries, especially in settings where hygiene and sanitation is poor.

The parasitic protozoa, *Cryptosporidium parvum* and *Giardia lamblia/intestinalis* have been studied intensively during the last decade, partly due to their high environmental resistance and low infectious doses, and for *Cryptosporidium* its association with several large waterborne outbreaks and for *Giardia* its high prevalence as enteric pathogen. *Entamoeba histolytica* is also recognized as an infection of concern in developing countries. The general importance of others such as *Cyclospora* and *Isospora* is currently debated.

In developing countries, helminth infections are of greater concern. The eggs (ova) of especially *Ascaris* and *Taenia* are very persistent in the environment, and therefore regarded as an indicator of hygienic quality (WHO, 1989). Hookworm disease is widespread in moist tropics and subtropics, and affects nearly one billion people worldwide. In developing nations, these infections exaggerate malnutrition and indirectly cause the death of many children by increasing their susceptibility to other infections that could normally be tolerated. The uninfective eggs from *Ascaris* and hookworms that are excreted in the faeces require a latency period and favourable conditions in soil or deposited faeces to hatch into larvae and become infectious (CDC, 2003).

Schistosoma haematobium has earlier been mentioned in relation to excretion with urine. Other types of *Schistosoma*, e.g. *S. japonicum* and *S. mansoni* are excreted in faeces. *S. japonicum* is mainly prevalent in the Far East and *S. mansoni* in Africa and in

parts of South and Central America, mainly Brazil (WHO, 2003). More than 200 million people are currently infected with schistosomiasis. The use of faeces, as for urine, should not have an impact unless fresh and untreated faecal material is applied close to freshwater sources where the snail is present.

In the literature, excreta-related diseases have been divided into groups depending on their features regarding transmission, survival etc. (WHO, 1989; Feachem, *et al.*, 1983). Along with this information, major control measures are given. Notable is that these general measures often include a combination of improved housing, health education, supply of water, provision of toilets and treatment of excreta before use or discharge. Diversity of the type of toilets provided, interventions including the whole water and sanitation system are therefore important to improve the health situation.

Table 2.1: Examples of hazards and exposure routes associated with the use of wastewater, excreta and grey water in agriculture and aquaculture

Hazard	Exposure route	Comments
Excreta-related pathogens Bacteria (*Escherichia coli*, *Vibriocholerae*, *Salmonella* spp., *Shigella* spp.)	Contact Consumption	Bacteria die off more rapidly on crops than some other pathogens (e.g. helminths) but may still present a health risk. Disease outbreaks of cholera, typhoid and dysentery have been associated with the use of wastewater, excreta or greywater for irrigation of Vegetables. As these pathogens can survive in the environment sufficiently long to pose health risks, produce disinfection/washing and cooking are important health protection measures.
Helminths - Soil-transmitted helminths (*Ascaris*, *Ancylostoma*, *Necator*, *Hymenolepis*, *Strongyloides*, *Toxocara*, *Trichuris*, *Taenia* spp.)	Contact Consumption	Major risk in agriculture, especially where untreated wastewater and excreta are used and sanitation standards are low. Eggs can survive in the environment for a long time. Hookworm infections (*Ancylostoma duodenale*, *Necator americanus*) are common in some areas where farmers do not wear adequate shoes or boots.
- Trematodes (*Clonorchis*, *Opisthorchis*, *Fasciola*, *Schistosoma* spp.)	Contact Consumption	Major risk in aquaculture where trematode parasites are present. Distribution is limited to certain geographic areas. Foodborne trematodes are transmitted through

		food consumption (especially the consumption of raw, unprocessed fish); schistosomiasis is spread through skin contact with contaminated fresh water.
Protozoa (*Giardia*, *Cyclospora*, *Cryptosporidium*, *Entamoeba* spp.)	Contact Consumption	Have been found on wastewater-irrigated vegetables at the point of harvest and in the market. Protozoa can survive in the environment long enough to pose health risks.
Viruses (hepatitis A and E viruses, adenovirus, rotavirus, norovirus)	Contact Consumption	Viruses are present in high numbers in wastewater and excreta, and some types can survive in the environment long enough to pose health risks. Contamination of crops has led to disease outbreaks.
Vector-borne pathogens (*Plasmodium* spp., dengue virus, *Wuchereria bancrofti*, Japanese encephalitis virus)	Vector contact	Risk for any water resource development activities in relevant geographic areas where vector-borne diseases are present. Most insect vectors breed in clean water, with the exception of vectors of lymphatic filariasis, which breed in organically polluted water.
Skin irritants	Contact	The causes of skin irritation such as contact dermatitis (eczema) are likely due to a mixture of microbial and chemical hazards.
Chemicals Antibiotics (chloramphenicol)	Consumption	Potential risk to consumers of aquacultural products where these substances are used in fish production.
Cyanobacterial toxins (microcystin-LR)	Contact Consumption	Potential risk to consumers of aquacultural products — especially blue-green algae nutritional supplements (*Spirulina*).
Heavy metals (arsenic, cadmium, lead, mercury)	Consumption	May accumulate in plants — both aquatic and terrestrial.
Phthalates and phenols	Consumption of water coming from aquifers recharged through wastewater irrigation	These compounds have been found in aquifers used for human drinking-water supplies that have been inadvertently recharged through wastewater irrigation. Some of these chemicals may have endocrine disrupting properties.
Halogenated hydrocarbons (dioxins, furans, PCBs)	Consumption	Not absorbed by plants, but may contaminate surfaces if plants are not peeled or washed before consumption. Potential for bioaccumulation in

		larger carnivorous fish raised in waste-fed aquacultural facilities.
Pesticides and their residues (e.g. aldrin, DDT)	Contact Consumption	Risk mostly related to pesticide application practices.

Sources: WHO (1995, 1999); BGS-CNA (1998); Chorus & Bartram (1999); Blumenthal et al. (2000a, 2000b); Gilroy et al. (2000); van der Hoek et al. (2005).

Table 2.2: Pathogen reductions achievable by various health protection measures

Control measure	Pathogen reduction (log units)	Notes
Excreta storage without fresh additions	6	The required pathogen reduction to be achieved by excreta treatment refers to stated storage times without addition of fresh untreated excreta. Pathogen reductions for different treatment options are presented in chapter 5 of Volume 4.
Greywater treatment	1–>4	Values relate to the relevant treatment options. Generally, the highest exposure reduction is related to subsurface irrigation.
Localized (drip) irrigation with urine (high-growing crops)	2–4	Crops where the harvested parts have not been in contact with the soil
Materials directly worked into the soil	1	Should be done at the time when faeces or urine is applied as a fertilizer
Pathogen die-off (withholding time one month)	4–>6	A die-off of 0.5–2 log units per day is cited for wastewater irrigation. Reduction values cited are conservative to account for a slower die-off of a fraction of the remaining organisms.
Produce washing with water	1	Washing salad crops, vegetables and fruit with clean water
Produce disinfection	2	Washing salad crops, vegetables and fruit with a weak disinfectant solution and rinsing with clean water
Produce peeling	2	Fruits, root crops
Produce cooking	6-7	Immersion in boiling or close-to-boiling water until the food is cooked ensures pathogen destruction

Sources: Beuchat (1998); Petterson & Ashbolt (2003); NRMMC & EPHCA (2005).

The ideal conditions to kill pathogens are reported as:

i) low moisture content (<25%);
ii) high pH (>10); and
iii) high temperature (>36°C).

Ecological latrines use the following techniques to encourage pathogen reduction:

i) Providing sufficient storage time with suitably sized pits or vaults.
ii) reducing the moisture content by:
    a) separating urine from faeces. Although this reduces the moisture content, it can still vary with the use of the latrine for bathing, 'wateriness' of stools, etc;
    b) heating faeces with a solar drying plate, to evaporate moisture from the faeces; or
    c) adding dry material such as ash, soil or lime to absorb moisture from the faeces.
iii) increasing the pH by adding dry wood ash or lime.
iv) increasing the temperature by:
    a) heating the faeces using a solar drying plate; or
    b) adding wood shavings or living material (such as leaves), to help the composting process to be as aerobic as possible.
v) encouraging predation by the addition of soil containing a variety of micro-organisms capable of killing or consuming the pathogens. It is important to note that the "ideal conditions" needed for pathogen reduction require good user management, and there will be variation in conditions within even a small project.

Implications of such findings are that:

i) minimum storage times should be one year; and
ii) until there is evidence that pathogens are consistently destroyed, ecological latrine users should be encouraged to bury the solids removed from the pit/vault.

The safety of ecological sanitation is not dependent solely on the ability of an ecological latrine to reduce the pathogen level to a safe standard, but also the risk posed by post-latrine handling of the excreta and the hygienic behaviour of the household and wider community.

Post-latrine handling independent of the latrine type, stored excreta from all ecological latrines (with the exception of the Arborloo) are intended to be taken from the pit and applied to land. How this process is carried out has a significant impact on the risks associated with using human waste as a fertilizer. The removal and application process involves three areas of risk:

i) those responsible for emptying the pit and applying excreta to the land become infected through direct contact;
ii) children and adults walk, work or play in the area where excreta is deposited or applied to land, and poor hygiene practices lead to contamination and infection; and
iii) contamination of crops, which is particularly important for crops that may not be cooked before eating, such as tomatoes or lettuce.

The risk of contamination to members of the community depends on how the removed excreta are applied to the land, as well as the amount of time people from the community spend on that land. When excreta are deposited near people's homes, or on land where people often congregate, the risk of contamination is increased.

A high risk of contamination occurs if the contents are spread by hand to the land and used as a top dressing. Exposed helminth eggs and pathogens will be a health risk to anybody walking on the land, although this risk will diminish with time as pathogen die-off is accelerated through the effects of sunlight and desiccation.

If excreta or excreta-derived products are applied to the field before planting crops:

i) farm and sanitation workers should be adequately protected during the process;
ii) the excreta should be placed in trenches and covered with at least 25cm of soil; and
iii) root crops should not be planted directly over the trenches.

The degree of risk is also related to the growing time of the crop and survival time of the contaminating pathogen, either in the soil or on the crop. Only when pathogen survival times are shorter than crop growing cycles, is the potential risk posed to both crop handlers and consumers reduced. The high persistence and low infective dose for Ascaris (see Table 2.3) makes this pathogen the greatest cause for concern.

Table2.3 : Survival rates of certain excreted pathogens in soil and on crops, at 20-30˚C

Common infections	**Survival time in soil (days)**	**Survival time on crops (days)**
Virus: Enteroviruses	<100 but usually <20	<60 but usually < 15
Bacteria: Faecal coliforms	<70 but usually < 20	<30 but usually < 15
Helminths: Ascaris lumbricoides	Many months	<60 but usually < 30

Summing up the safety factors

The safety of ecological, or in fact, any form of sanitation, can be summarized as (Box 1):

Good pathogen reduction in latrine	+	Good post-latrine handling	+	Good hygienic behaviour	=	Safe (ecological) sanitation

Source: WELL 2006

2.4.2.2 Health protection measures

To achieve the health-based targets, the implementation of various health protection measures may be required. The regulatory framework should ensure that the correct measures are implemented in the correct settings. Although in some cases one measure may be sufficient to achieve the health-based target (e.g. extensive treatment of wastewater), in practice it will usually be preferable to employ a combination of measures. For example, wastewater treatment plus a withholding period to allow pathogen die-off prior to harvest plus good food hygiene plus cooking of food may be sufficient to reduce health risks adequately. The combination of different health protection measures adds additional barriers for preventing exposures to the hazards and thus will reduce the potential health risks. The available health protection measures will vary according to the sociocultural, economic and environmental circumstances found in each situation. In practice, however, health protection measures can be taken to reduce potential health risks even in low-resource settings. In these situations, it may be necessary, however, to prioritize the health protection measures put into place so that exposure to the health hazards that pose the greatest risk (e.g. helminths in agriculture or foodborne trematodes in aquaculture) are dealt with first.

2.4.2.3 Treatments to sanitizing excreta

2.4.2.3.1Factors that influence pathogen die-off

After excretion, the concentration of enteric pathogens usually declines with time by death or loss of infectivity of a proportion of the organisms. Protozoa and viruses are unable to grow in the environment outside the host, thus their numbers will always decrease, whereas bacteria may multiply under favourable environmental conditions. Helminths may need a latency period after excretion before being infective. The ability of a microorganism to survive in the environment is defined as its persistence to withstand the prevailing conditions. Often in investigations it is expressed as the total inactivation with time of the microorganism in question under specified environmental conditions. However, for the health risk predictions of the impact of different transmission routes from human excreta, the inactivation curves or T90-values (time for a 90% inactivation of organisms) are needed.

Time and prevailing conditions are the overall features affecting survival of microorganisms in the environment. Several physicochemical and biological factors have an impact, but this impact differs between microorganisms. For overall risk estimates, the selection of the most resistant organisms is a conservative approach also accounting for other, more sensitive species. The environmental- and organism-related factors all interact, yielding varying survival characteristics at any particular location. Factors that are especially important for the reduction of enteric microorganisms are listed in bellow. These factors can also be used separately or in combination with time as treatment methods to produce safe fertilizers from excreta.

2.4.2.3.1.a Temperature

Most microorganisms survive well at low temperatures (<5°C) and rapidly die off at high temperatures (>40-50°C). This is the case in water, soil, sewage and on crops. To ensure inactivation in e.g. composting processes, temperatures around 55-65°C are needed to kill all types of pathogens (except bacterial spores) within hours (Haug, 1993).

2.4.2.3.1.b pH

Many microorganisms are adapted to a neutral pH (7). Highly acidic oralkaline conditions will have an inactivating effect. Addition of lime to excreta in dry latrines

and to sewage sludge can increase pH and will inactivate microorganisms. The speed of inactivation depends on the pH value, e.g. it is much more rapid at pH 12 than at pH 9.

2.4.2.3.1.c Ammonia

In natural environments, ammonia (NH_3) chemically hydrolysed or produced by bacteria can be deleterious to other organisms. Added ammonia-generating chemical will also facilitate the inactivation of pathogens in e.g. excreta or sewage sludge (Ghigletti *et al.*, 1997; Vinnerås *et al.*, 2003*a*).

2.4.2.3.1.d Moisture

Moisture is related to the organism survival in soil and in faeces. A moist soil favours the survival of microorganisms and a drying process will decrease the number of pathogens, e.g. in latrines.

2.4.2.3.1.e Solar radiation/ UV-light

UV-irradiation will reduce the number of pathogens. It is used as a process for the treatment of both drinking water and wastewater. In the field, the survival time will be shorter on the soil and crop surface where sunlight can affect the organisms.

2.4.2.3.1.f Presence of other microorganisms

The survival of microorganisms is generally longer in material that has been sterilized than in an environmental sample containing other organisms. Organisms may affect each other by predation, release of antagonistic substances or competition.

2.5.2.3.1.g Nutrients

If nutrients are available and other conditions are favourable, bacteria may grow in the environment. Enteric bacteria adapted to the gastrointestinal tract are not always capable of competing with indigenous organisms for the scarce nutrients, limiting their ability to reproduce and survive in the environment.

2.4.2.3.1.h Other factors

Microbial activity is dependent on oxygen availability. In soil, the particle size and permeability will impact the microbial survival. In soil as well as in sewage and water

environments, various organic and inorganic chemical compounds may affect the survival of microorganisms.

2.4.2.4 Treatment for faeces

2.4.2.4.*i* Storage

The number of pathogens in faecal material during storage will be reduced with time due to natural die off, without further treatment. The type of microorganism and storage conditions governs the time for reduction or elimination. The ambient temperature, pH and moisture etc. will affect the inactivation as well as biological competition. Since the conditions during storage vary, so do the die-off rates, which may make it harder to predict appropriate storage times.

In 1983, Feachem *et al.* compiled extensive data based on literature studies on pathogen/ indicator reductions in different materials, including nightsoil and faeces. The data are presented as "less than values" as shown in Table 2.4, and do not consider the initial concentrations, but focus on total inactivation. From additional literature studies, Arnbjerg-Nielsen *et al.* (2004, in press) estimated the decimal reduction times for various pathogens (T90-values given for 20°C in Table 2.4). The prevailing studies of pathogen inactivation in human faeces are however few, and other materials such as animal manure and sewage sludge were also taken into consideration to estimate inactivation rates. Based on these T90 values the times needed for a decimal inactivation were similar to the ones presented as full inactivation by Feachem *et al.* (1983). If the initial concentrations are higher and a 1st order die-off kinetic applied, the time for a total die-off would be significantly longer. The 1st order kinetic is however, not necessarily applicable during extended storage. It should further be pointed out that the later calculations just consider storage and no additional treatment. Inactivation of pathogens in soil is additionally important for the risk related to use of excreta, even though treatment of the material should aim to substantially reduce the pathogens before it is applied to land. Comparative decimal inactivation values are given in Table 2.4, again with longer survival times reported in more recent literature than those estimated by Feachem *et al.* (1983). On crops, however, the inactivation rate is often considered to be more rapid with T90 values in the range of a few days (Asano *et al.*, 1992; Petterson *et al.*, 1999). At least one year of storage is needed at ambient temperature, without additional treatment, the guideline value stated for helminths by WHO (1989). Strauss

and Blumenthal (1990) suggested that one year was sufficient under tropical conditions (28-30°C), whereas at lower temperatures (17-20°C) 18 months would be needed.

In a South African study, *Salmonella* was found in stored faeces after one year (Austin, 2001). Wood ash was sprinkled over the faeces, giving a pH of 8.6-9.4, thus this study is a combination of storage and alkaline treatment (Table 2.4). *Salmonella* could have grown in the material. Weekly turnings of the faecal heap rather than having it in a plastic container gave high reduction of pathogens and the faecal indicators, and resulted in low moisture (Austin, 2001). Aeration may increase the inactivation and a partial composting may have taken place (temperature not reported). This manual turning will however expose the person handling the material to unsanitized faeces.

In a Danish study, the subsequent risks related to the use of faeces that had been stored for 0-12 months without additional treatment, were calculated (Arnbjerg-Nielsen *et al.*, in press; Schönning *et al.*, manuscript). *Ascaris* posed the highest risk with a 100% risk of becoming infected upon exposure for vulnerable persons after accidental ingestion of the material, if one person in the household had been infected during the collection period. The protozoa *Giardia* and *Cryptosporidium,* and rotavirus, that are of greater concern in the Danish setting, resulted in risks of 10-90% after accidental ingestion during handling or using unstored faeces in the garden. After storage for 6 months the risk was extrapolated to be 10% whereas after 12 months it was typically around 1:1 000. The risk for hepatitis A or bacterial infections was generally lower. The storage was assumed to occur at temperatures around 20°C and data reported for this temperature range were used to calculate the reduction of pathogens to bellow table

Table 2.4: Estimated survival times and decimal reduction values of pathogens during storage of faeces and in soil, given in days if not stated otherwise No additional treatment is applied. (norm. = normally)

Microorganism	**Faeces and sludgea20-**	**Faeces T90b~20°C**	**Soila20-30°C**	**Soil T90b~20°C**	**Soilc Absolute maxd/ normal**
Bacteria					1 year/ 2 months
Faecal coliforms	<90 norm. <50	15-35 (*E. coli*)	<70 norm. <20	15-70 (*E. coli*)	
Salmonella	<60 norm. <30	10-50	<70 norm. <20	15-35	
Viruses	<100 norm. <20	Rotavirus: 20-100 Hepatitis A: 20-	<100 norm. <20	Rotavirus: 5-30 Hepatitis A:	1 year/ 3 months

Microorganism	Faeces and sludgea20-30°C	Faeces T90b~20°C	Soila20-30°C	Soil T90b~20°C	Soilc Absolute maxd/ normal max
Protozoa (*Entamoeba*)	<30 norm. <15 e	*Giardia*: 5-50 *Cryptosporidium*: 20-120	<20 norm. <10 e	*Giardia*: 5-20 *Cryptosporidium*:30-400	1 /2 months
Helminths (egg)	Several months	50-200 (*Ascaris*)	Several months	15-100 (*Ascaris*)	7 years/2 years

Source: (Feachem et al., 1983a; Arnbjerg-Nielsen et al., in pressb; Kowal, 1985c, in EPA, 1999).

Absolute maximum for survival is possible during unusual circumstances such as at constantly low temperature or in well-protected conditions.

Data are missing for *Giardia* and *Cryptosporidium*; their cysts and oocysts might survive longer than the time given here for protozoa.

In a study in Mexico (Franzén & Skott, 1999), the faecal material had a moisture level of 10%, a pH of around 8 and a temperature of 20-24°C. At this low moisture content the reduction of the conservative viral indicator, the bacteriophage (*Salmonella typhimurium* 28B) was 1.5 log10 after six weeks of storage. The analyses were performed in a latrine to which the phages had been added and without subsequent faecal addition.

Low moisture content was concluded to have a beneficiary effect in a study in Vietnam, with the fastest inactivation of bacteriophages in latrines with the lowest moisture content (Carlander & Westrell, 1999). These latrines also had a pH around 9 and higher temperatures than in the above study (see also *Alkaline treatments*). A total inactivation of *Ascaris* was recorded within six months. The inactivation was not statistically related to any single factor in the latrines, but a combination of high temperature and high pH was suggested to account for the main reduction are shown in following table.

In El Salvador, an extensive study of the faecal material collected in urine-diverting toilets has been conducted. Material to increase pH is added by the users to the faecal material but recording of some pH-values around 6 implies that, in some toilets, treatment by storage alone is occurring (Moe & Izurieta, 2003). Survival analysis suggested that faecal coliforms would survive >1,000 days and *Ascaris* around 600 days in latrines with a pH of less than 9.

Storage is especially beneficial in dry hot climates resulting in desiccation of the material and low moisture contents aiding pathogen inactivation. If all the faecal material is dry right through, the pathogen decrease is facilitated. Esrey *et al.* (1998) suggested that there is rapid pathogen destruction at moisture levels below 25%, and that this level should be aimed for in ecological sanitation toilets that are based on dehydration (i.e. storage). Low moisture content is also beneficial in order to reduce smell and fly breeding (Esrey *et al.*, 1998; Carlander & Westrell, 1999). Regrowth of bacterial pathogens may however occur after application of moisture (water) or if the material is mixed with a moist soil as indicated by results reported by Austin (2001). Desiccation is not a composting process and when moisture is added the easily metabolized organic compounds will facilitate bacterial growth, including e.g. *E. coli* and *Salmonella*, if small amounts of these are occurring or introduced into the material.

Protozoan cysts are sensitive to desiccation, and this also affects their survival on plant surfaces (Snowdon *et al.,* 1989; Yates & Gerba, 1998). Normal moisture levels do not inactivate *Ascaris* eggs, with values below 5% needed (Feachem *et al.,* 1983). Information for the corresponding effective time is currently lacking.

2.4.2.4.*ii* Heat treatment

Heat is one of the most effective ways of killing pathogens and is the parameter used to achieve inactivation in some of the most applied processes for e.g. sewage sludge treatment. In Figure 2.1 (from Feachem *et al*., 1983) the inactivation of pathogens is plotted as a function of temperature and time. This, with a margin, create a defined "safety zone". If the corresponding temperature-time relationship is achieved in all of the exposed material, it may be considered microbiologically safe for handling and use. For example, if a temperature >55°C has been reached for one to a few days, an efficient inactivation has occurred. The relationships between time and temperature for various pathogens have been widely accepted even though "new" pathogens have been identified and literature giving slight variations on the results has been published.

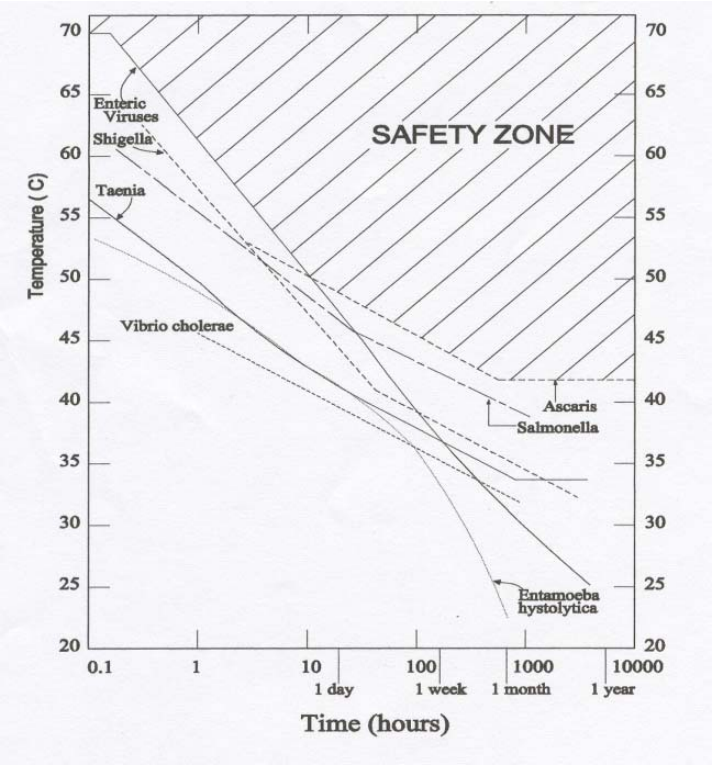


Figure 2.1: safety zone diagram (Feachem et al., 1983)

2.5 Functionality analysis of sanitation option

Good toilets are based on good design and availability as much as they are on good management and maintenance. (Greed, 2003, Gershernson and Penner, 2009). The third pillar is social factors like: education of users, training of cleaners and attendants and cultural change in societal attitude towards the topic of (public) toilets. (Klaesener Metzner, 2010). Operation and maintenance of these systems remains a major challenge for any kind of sanitation option in rural areas. Furthermore, while construction costs may be fairly straight forward, operation and maintenance costs and benefits are difficult to estimate.

2.6 Sustainability criteria of sanitation option

The sustainability of sanitation systems is, as already mentioned, a complex matter to assess due to its dependency on the actual context. Criteria for sustainability need to be developed in close cooperation with all relevant stakeholders and take into consideration institutional matters, such as the existing legal framework and institutional capacity, preferences among future users, environmental conditions in the

actual area and so on. What may be judged as sustainable in one context might not be the same for another setting.

Thus, it is impossible to identify a complete list of factors that will affect the sustainability of a sanitation system without knowing the specific context.

With regard to the upcoming IYS 2008, the Sustainable Sanitation Alliance (SuSanA), has developed a set of criteria for the overall sustainability assessment of a sanitation system. These criteria may serve as a basis for further improving the definition of improved sanitation being presently used by the JMP. The main objective of a sanitation system is to protect and promote human health by providing a clean environment and breaking the cycle of disease. In order to be sustainable, a sanitation system has to be not only economically viable, socially acceptable and technically and institutionally appropriate, but it should also protect the environment and the natural resources. When improving an existing and/or designing a new sanitation system, sustainability criteria related to the following aspects given in the following table should be considered. Most sanitation systems have been designed with these aspects in mind, but in practice they are failing far too often because some of the criteria are not met. In fact, there is probably no system which is absolutely sustainable. The concept of sustainability is more of a journey rather than a stage to reach. Nevertheless, it is crucial, that sanitation systems are evaluated carefully with regard to all dimensions of sustainability. Since there is no one-forall sanitation solution which fulfils the sustainability criteria under different circumstances to the same extent, this system evaluation will depend on the local framework and has to take into consideration existing environmental, technical, socio-cultural and economic conditions.

The gtz EcoSan project is actively involved in the development of sustainability criteria in different projects and working groups such as the Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA) and the EU project NETSSAF. The developed sustainability criteria include amongst others criteria on the impact to the environment, social, cultural and gender aspects and economical and financial issues. It was seen as important that e.g. the impact to the environment was considered as discharge values to the environment and not as elimination rates.

Taking into consideration the entire range of sustainability criteria, it is important to observe some basic principles when planning and implementing a sanitation system. These were already developed some years ago by a group of experts and were endorsed by the members of the Water Supply and Sanitation Collaborative Council as the

"Bellagio Principles for Sustainable Sanitation" during its 5th Global Forum in November 2000.

(1) Health:	
	risk of exposure to pathogens
	risk of exposure to hazardous substances
	hygiene
	nutrition
	Improvement of livelihood
	downstream effects.
(2) Environment and natural resources:	
	required energy
	water
	other natural resources for construction
	other natural resources for operation
	other natural resources for maintenance
	potential emissions from use
	degree of recycling practiced and the effects of these
	degree of reuse practiced and the effects of these
(3) Technology and operation:	
	functionality
	ease regarding construction,
	operation and monitoring
	suitability to achieve an efficient substance flow management
	robustness of the system
	vulnerability towards disasters
	flexibility and adaptability of the system
(4) Financial and economic issues:	
	investment costs
	operation costs
	maintenance costs
	economic benefits in "productive" sanitation systems
	capacity of households and communities to pay for sanitation
(5) Socio-cultural and institutional aspects:	
	socio-cultural acceptance
	appropriateness of the system
	convenience
	gender issues
	impacts on human dignity
	contribution to subsistence economies
	food security
	legal and institutional aspects

CHAPTER-3
METHODOLOGY

3.1 Introduction

A systematic and logical study needs a methodology, in which various stages or steps of collecting data or pieces of information are explained and the analytical techniques are defined. This chapter describes the methods and study design, i.e., planning of activities for data collection, analysis and process of reporting. All the aspects related to the study area, working procedure, survey and data collection process are also discussed in this chapter.

3.2 Conceptualizing the Study

A brief overall concept of the study in terms of what is intended to this study has been developed by the following ways:

i) Concept about the study is developed from the previous relevant studies.

ii) Sanitation sector professional, ecosan toilet piloting and promoting organization also helped to formulate the concept.

iii) Several articles from journals, thesis report, conference document, books and also web document influence to conduct the study and conceptualize the ideas.

3.3 Selection of Study Area

The study area was selected on the basis of different geo-hydrological, physical, natural disaster and cultural context of Bangladesh where the eco-san toilet installed by different organization as pilot basis. Summary of the geological and physiographic characteristics of the different study sites is given in Table 3.1 and location of sites are shown in Figure 3.1.

Table 3.1: Geological and physiographic characteristics of the different study sites

Sl. No.	Upazilas	Location	Hydrology	Geological group-formation (exposed)	Physiographic	Disaster
1	Biswamvarpur	north-eastern part of Bangladesh	Mainly deeply flooded land	Alluvium, stream deposits, delta plain deposits, flood plain deposits	Haor Basin	Flash flood
2	Jamalpur Sadar	north-eastern part of Bangladesh	Mainly deeply flooded land	Alluvium, stream deposits, delta plain deposits, flood plain deposits	Jamuna floodplain and Madhupur tract	
3	Alikadam	South-Eastern part of Bangladesh	Hilly land (non - flooded)	Miocene, Surma Group	High hill ranges	
4	Chapai Nabab gonj	Northern part of Bangladesh	Mainly seasonally wet/shallowly flooded land in basins	Pleistocene Terraces (Madhupur Clay)	Barind tract	Drought

Contd. Table 3.1

Sl. No.	Upazilas	Location	Hydrology	Geological group-formation (exposed)	Physiographic	Disaster
5	Sharsha	South-western part of Bangladesh	Mainly seasonally wet/shallowly flooded land in basins	Alluvium, stream deposits, delta plain deposits, flood plain deposits	Ganges river floodplain	Cyclone and tidal surge
6	Keshobpur	South-western part of Bangladesh	Mainly seasonally wet/shallowly flooded land in basins	Alluvium, stream deposits, delta plain deposits, flood plain deposits	Ganges river floodplain	Cyclone and tidal surge
7	Comilla Sadar	Central south-east part of Bangladesh	Mainly seasonally wet or shallow flooded land	Alluvium, stream deposits, delta plain deposits, flood plain deposits	Tippera surface and old Meghna estuarine floodplain	
8	Shyamnagar	South-western part of Bangladesh	Saline land, part saline in dry season	Alluvium, stream deposits, delta plain deposits, flood plain deposits	Ganges tidal and river floodplain	Cyclone and tidal surge
9	Sreepur	Central north-east part of Bangladesh	Mainly level highland, part well drained, part seasonally wet or shallowly flooded	Pleistocene Terraces (Madhupur Clay)	Madhupur tract	

Total no. of ecosan toilet surveyed is 87 the detail of the study area is given in Table 3.2.

Table 3.2: Details of study area

Sl. No	District (s)	Upazilas	Union	Ward	Village	Toilet surveyed
1	Sunamgonj	Biswamvarpur	Salukabad	5	Gorer gao	5
			Dhonpur	1	Islampur	5
2	Jamalpur	Jamalpur Sadar	Banshchara	2	Mohonpur	2
			Ghoradhap	7	Ghopolpur	5
3	Bandarban	Alikadam		7	Babupara	2
				5	Shonaichari	2
				2	Mongchapara	2
				1	Amtalipara	4
4	Chapai Nababgonj	Sadar	Gobratola	9	Asharak	5
		Gomostapur	Rohonpur	5	Bongpur	5
5	Jessore	Sharsha	Baganchara	8	Tengra	5
				9	Samta	5
		Keshabpur	Sagardari	1	Bashbari	5
				1	Raghurampur	5
7	Comilla	Comilla Sadar	Kalirhat	3	Hatigara	10
8	Satkhira	Shyamnagar	Kashimari	5	Kashimari	5
			Atulia	9	Chotochupot	5
9	Gazipur	Sreepur	Maona	2	Chakpara	10

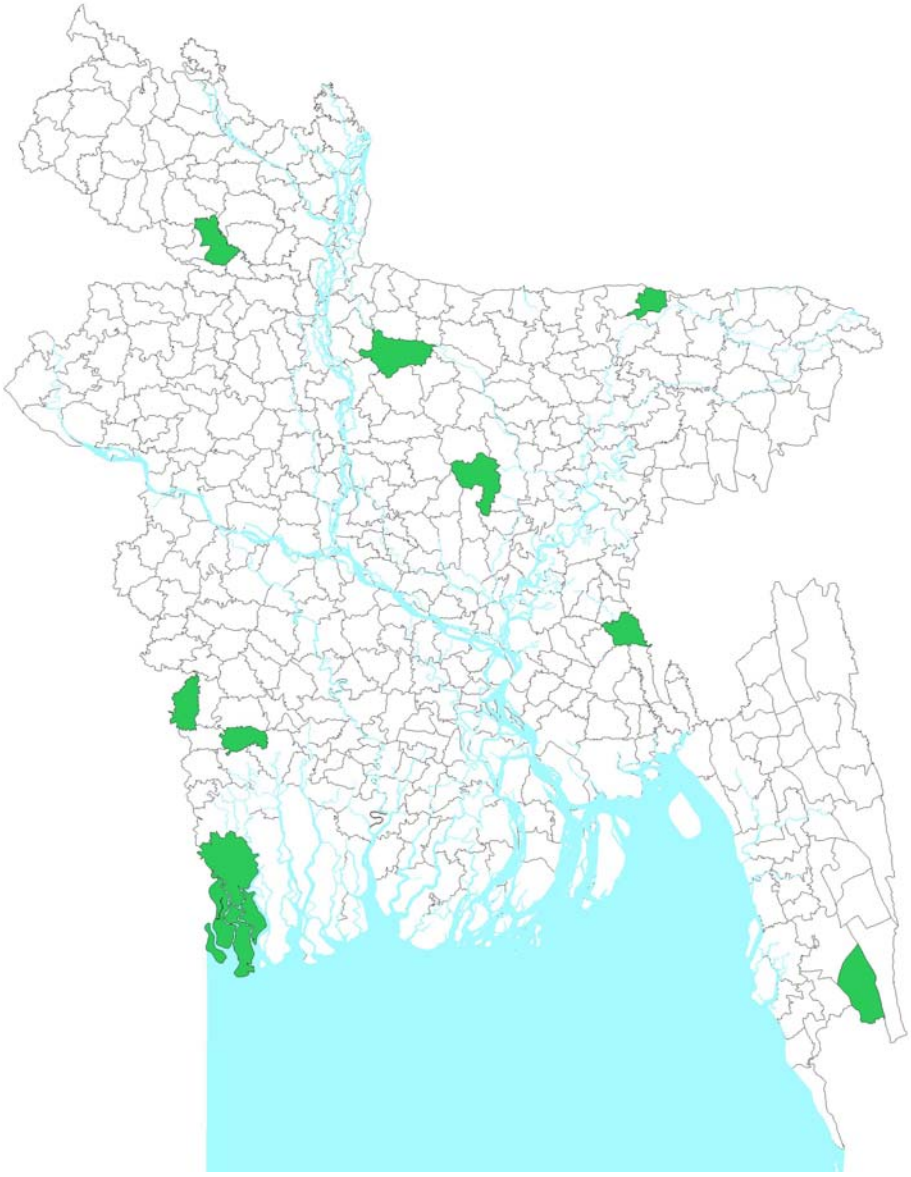


Fig. 3.1: Map of study areas

3.4 Framework of study

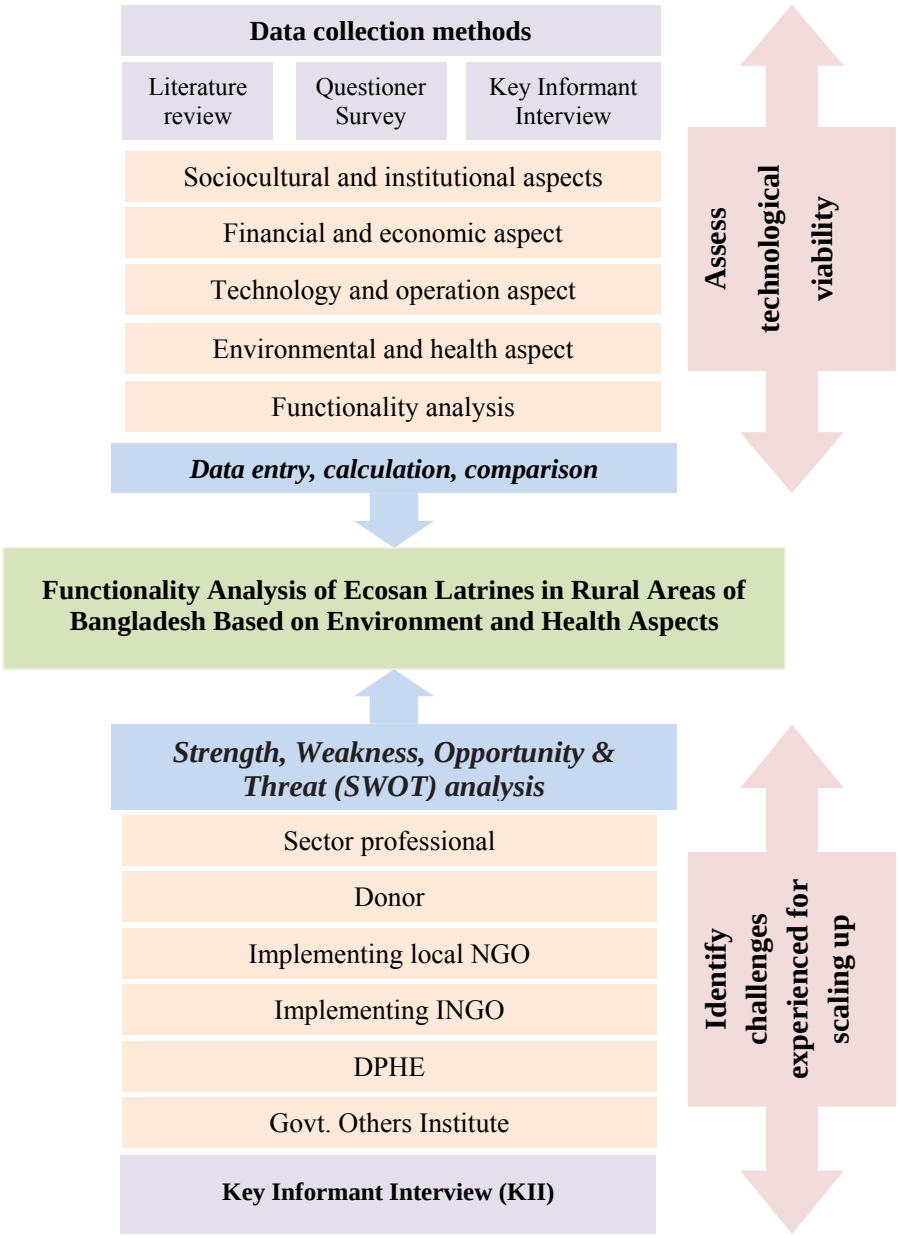


Fig 3.2 Schematic framework of thesis work

3.5 Survey and interview:

Based on practical experience and literature study, two types of questionnaires, checklists and Key Informant Interview (KII) was developed for field study:

a) Questionnaire for EcoSan users (Appendix A)

b) Questionnaires for neighbors (non EcoSan user) (Appendix A)

c) Checklist to be used during the observation of EcoSan toilets (Appendix A)

d) KII for local representative of public, DPHE, implementer and sector professional. (Appendix A)

The questionnaires have been tested in field among six households to assess the practicality of the questions and type of expected responses. The results of field tests discussed with experts. Keeping the objectives and goals in mind, the questionnaires was then revised to make it more practical and user friendly. The survey was conducted for 87 households in nine study areas that have been using an EcoSan toilet for at least one year. It was also decided to survey the neighbors of EcoSan user (non ecosan user) and the number will be same 87.

To assess technological viability of EcoSan latrine option in rural perspective

To identify locally acceptable technology, it is necessary to make it clear the requirements for technology, which include respondent to local characteristics and needs in each local community. It is critical that implementation observes appropriate steps so that the solutions are sustainable based on simple technologies which can be carried out by the communities and maintained and operated over the long term. There are several key factors which determine whether technology is appropriate for the specific situation. Technological viability will be assessed through major our aspect like social, economical, technological, and environmental and health issue. Besides constituting an effective disease barrier, smart sanitation solutions prevent environmental pollution and optimise the use of resource in terms of nutrients, water, and energy. Sanitation must meet the needs of the user, must be simple to use, to maintain and repair, be possible to replicate and be affordable. Questionnaire survey for EcoSan users, non EcoSan user (neighbors of Ecosan user) and functionality checklist which will be covered all the parameter of three aspects. Environmental and health aspect will be covered by the secondary data source. Pilot basis different type of ecosan model designed by different organization and an inventory of developed ecosan toilet models in Bangladesh is given in Appendix - B.

All the parameters under the four aspects are mentioned below:

Socio-cultural and institutional aspects

Availability, appropriateness of the system by and for the community: its convenience, perceptions of the system, gender issues, and impact on human dignity, willingness to

pay, acceptance to people, reliability, religious barrier, cultural barrier, use of urine and compost faeces, local people interest to buy product using urine and compost faeces, local need and demand.

Financial and economic aspect

Affordability, cost effectiveness, installation cost (capital), operation cost, maintenance cost, technological life cycle cost, cost of by product (urine and compost as fertilizer), potential economic benefits.

Technology and operation aspect

These aspects reflect the functionality through checking major components of ecosan latrine (stair, door, floor of the toilet, sitting pedestal, faeces hole, lid of faeces hole, urination place, urine drain pipe, connection between urine drain pipe and container, urine container, anal washing place, anal washing drain pipe, evaporation bed, roof, gas pipe, faeces vault, heat panel and surrounding mortar of heat panel). The ease with which the system can be constructed, operated, and monitored using the available human resources (e.g. the local community, availability of skill mason) and availability of construction materials.

Environmental and health aspect

This includes risk of exposure to pathogens and hazardous substances that originate from the sanitation system (from the toilet through the collection and treatment system to the point of reuse or disposal). Major parameter are generation or disposal of bi-product, safe handling of urine and excreta, susceptibility of bacteriological contamination, potentiality of use of urine and excreta.

Functionality analysis

Checklist survey was carried out in order get the status of eighty seven toilets in nine different areas of Bangladesh. This checklist includes all the major components of the latrines and the operation and maintenance issues as parameter of technical aspect which is mentioned above. To understand functionality of latrine the function model (Azad-uz-zaman, et. al.,2011) will be used and findings will be compared for different areas;

Function model: $S_{Fj}=\sum W_i * F_{ij}$;

here, S_{Fj}: j-area's name, W_i:item i's weight,

F_{ij}: item i's goodness (%),

i= 1,2,….18, j=1,2,…7

Management-model,

$$S_{Mj}=\sum W_i * M_{ij}$$

Here, S_{Mj}: j-area's score, W_i: item i's weight,

M_{ij}: item i's goodness (%),

i=1, 2…12, j=1, 2….9

To identify challenges experienced for scaling up of ecosan in rural areas

Key Informant Interview (KII) was used as an important method for collection of information based on their field experiences of institution/organization and sector professional. The objective of the organizations/institutions interviews is to gain feedback on their experiences, views, prospects and strategies for its promotion EcoSan toilet in Bangladesh. Bangladesh Academy for Rural Development (BARD), Practical Action Bangladesh, Bangladesh Association for Social Advancement (BASA), Commitment Consultants, Society for People's Actions in Change and Equity (SPACE), Oxfam GB Bangladesh, Japan Association of Drainage and Environment (JADE), Japan International Cooperation Agency (JICA), UNICEF and DPHE are the ten listed organizations/institutions relevant personnel and as a watsan taskforce member union parisad member (public representative) was also interviewed to achieve the objectives of the thesis.

Questionnaire Survey

Based on practical experience and litreature study, three types of questionnaires and checklists were developed for field study:

i) Questionnaire for EcoSan users (Appendix A)
ii) Questionnaires for the neighbours of EcoSan users (Appendix A)
iii) Checklist to be used during the observation of EcoSan toilets (Appendix A)

The questionnaires were tested among six households to assess the practicality of the questions and type of expected responses. The results of field tests were discussed with

experts and team members. Keeping the objectives and goals in mind, the questionnaires were then revised to make them more practical and user friendly. It was decided that the survey would be conducted for all households that have been using an EcoSan toilet for at least one month.

To conduct the household survey, 18 surveyors from nine different project sites were selected. Before the commencement of survey work, training was conducted to orientate the surveyor. During the orientation, the intention of each question was explained and discussed in detail and a general standard for survey of various parameters was set. Some skills necessary for the conduction of a survey were also discussed. To gain confidence, some practical work in conducting surveys was also done during the orientation training. The questionnaire survey was done for each household using the EcoSan toilets and one neighbour non ecosan user were selected for interview about their perception of it. Total eighteen surveyor survey nine different areas for four days to cover econsan user, non ecosan user, public representative and DPHE personal.

Field observation

The surveyor also made household visits to targeted number of houses in the study area. During these visits, the surveyor interviewed the house owner about their use of toilets and observed the EcoSan toilets using checklist. The use of EcoSan toilets by children and their attitude towards these toilets was also studied during the house visit. The use of dry faeces and urine in agriculture were also studied during the visit. In addition, some of the farms, where urine and faeces were used, were also visited.

Interviews with key informants

People who are involved in the promotion of EcoSan toilets, public representative , DPHE engineers and sector professional were interviewed to gain their input on the use of EcoSan and strategies for its promotion.

Also visited almost all of the organizations involved in promoting EcoSan toilets, such as national NGOs, international NGOs, donor organizations, Unicef and Department of Public Health Engineering (DPHE), to gain feedback on their experiences. (Appendix A)

Table 3.3 List of Interviewees

Name of Interviewees	Designation	Organization
Tofayel Ahmed	Deputy Country Representative	JADE Bangladesh
Rafiul Islam	Sr. Monitoring Officer	Practical Action Bangladesh
A.K.M. Rafiqul Islam	Coordinator(Dev. Projects)	Bangladesh Association for Social Advancement (BASA)
Abdullah Al Mamun	Joint Director	Bangladesh Academy for Rural Development (BARD)
Azahar Ali Pramanik	Executive Director	Society for People's Actions in Change and Equity (SPACE)
Golam Morshed	Public Health Promoter	Oxfam GB Bangladesh
Qumrun Nahar	WES Specialist	UNICEF
Alauddin Ahmed	National Consultant	WHO
S.M Zulkernine	Training and Technology Specialist	ITN, BUET
Md. Anowar Hossain	PD, National Sanitation Project	Department of Public Health Engineering (DPHE)

In interview, some of the questions were predetermined, while others are open. Questions were asked according to a flexible checklist or guide but not from a formal questionnaire. There are four types of interviews: individual household and key informant. Interviews can provide in-depth, inside information if trustful relationship is established with informants (Ahmed, 2004).

3.6 Analysis of data

After completing all of the above activities, the obtained data was tabulated and analyzed to prepare the final report. The draft report was discussed with key stakeholders and finalized based on the comments received. The quantitative aspect involved coding and analyzing of data using Microsoft Excel software from which analyses is done to come up with some of the results present in the final report.

CHAPTER – 4
ANALYSES AND RESULT

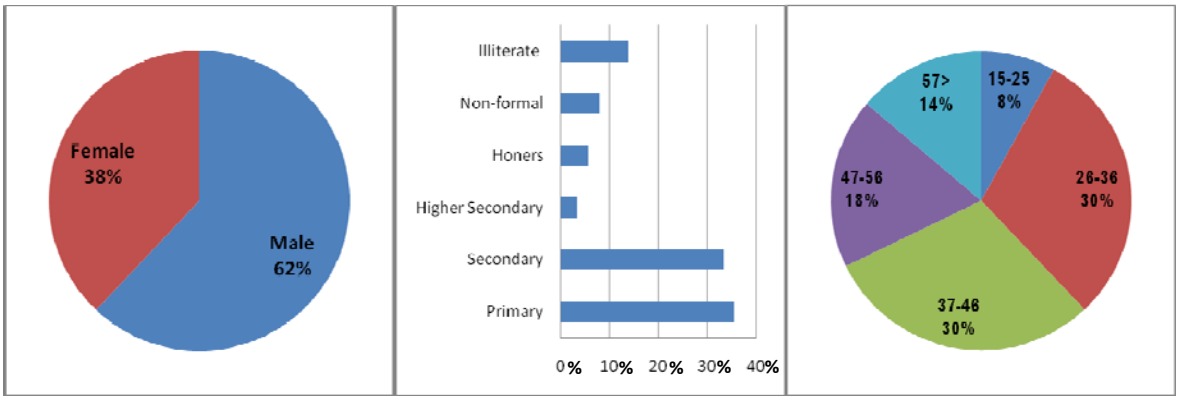
4.0 Introduction

The survey was conducted for 87 household EcoSan toilet users and 87 household neighbours who do not use the EcoSan toilets in nine different study areas of Bangladesh. Altogether, neighbours were selected from 100% of the households with EcoSan toilets. Nine different geographical locations where different organization construct eco toilet as pilot bases and the households were selected randomly.

4.1 Respondents' Profile

4.1.1.a EcoSan User

The total 87 EcoSan user of the study household among which about 62% male and 38% are female. Among these 60% age limit is 26-46 and 35% completed primary education, 40% completed secondary and higher education and only 15% are illiterate. Figure 4.1 shows the sex, education and age group of EcoSan user respondent.

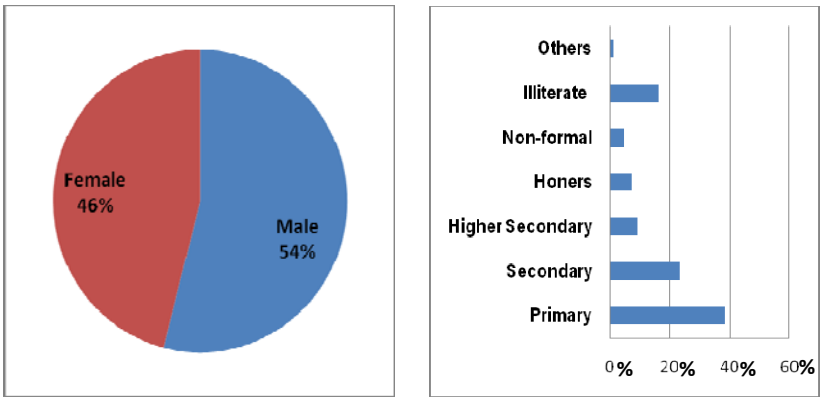


(a) **(b)** **(c)**

Figure 4.1: EcoSan user respondent information (a) Sex of user respondent (b) Education of user respondent (c) Age group of user respondent

4.1.1.b Non EcoSan User

The total 87 non EcoSan user of the study household among which about 54% male and 46% are female. Among them 38% completed primary education, 40% completed secondary and higher education and only 15% are illiterate. Figure 4.2 shows the non EcoSan user neighbor respondent sex and education information.



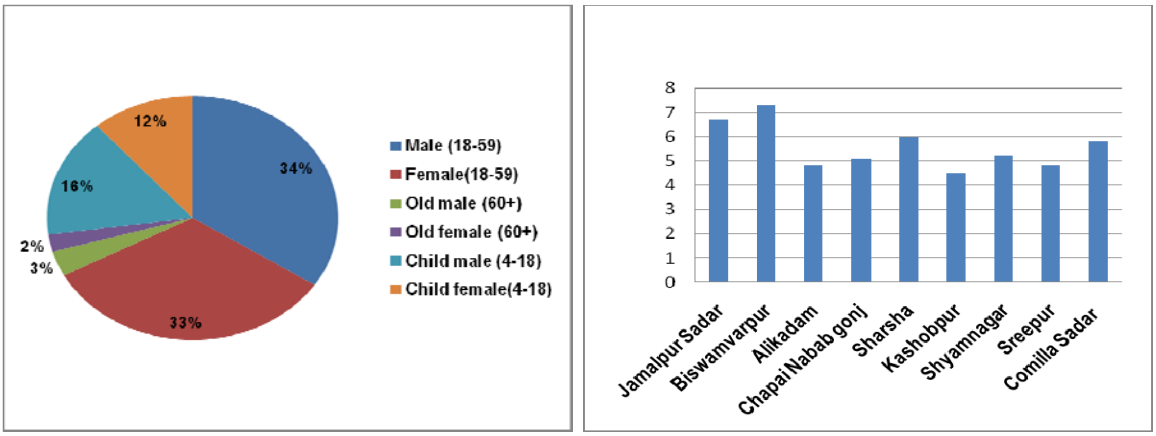
(a) **(b)**

Figure 4.2: Non EcoSan user neighbor respondent information (a) Sex of non user respondent (b) Education of non user respondent

4.1.2 Household socio-demographic profile

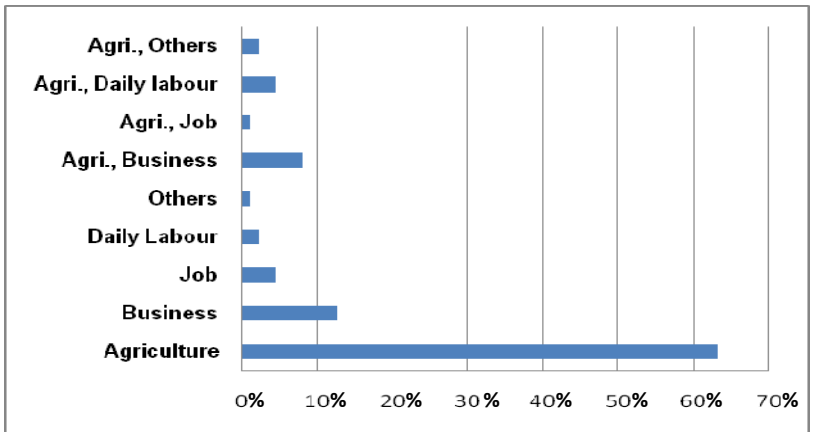
EcoSan toilet users

Of the 87 households surveyed within the selected nine study area, 482 people, including 131children the age between four to eighteen, are using the toilets. The average family size is approximately 5.57 persons. The smallest average family size, found in Kashobpur is 4.5 persons, while the highest, found in Biswamvarpur is 7.8 persons. Of all user households, 62% of them work in the agricultural sector and 10% partly engaged with agriculture. Daily labour occupies another 4%, with services making up 5% and business - 13%. Figure shows the household socio-demographic profile information like HH members, HH family size, HH head occupation, HH land ownership information of EcoSan user.



(a) **(b)**

Figure 4.3: Household socio-demographic profile of EcoSan usre (a) User HH members information (b) User HH family size information



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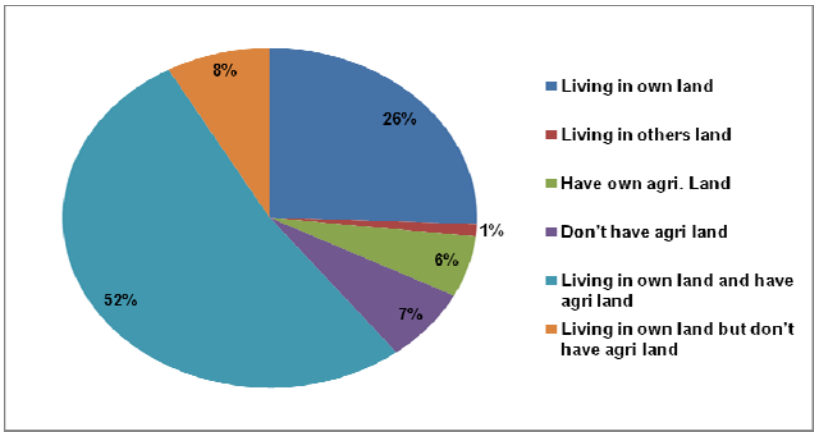


(d)

Figure 4.3: Household socio-demographic profile of EcoSan usre (c) User HH head occupation information (d) User HH land ownership information

Figure 4.3shows the household socio-demographic profile of EcoSan usre. Though most respondents HH practice agriculture as their primary occupation, the majority own only a small area of cultivable land. About 35% of user households do not own any agricultural land. Therefore, almost all of the EcoSan users surveyed can be categorised as small farmers. Figure 4.4 shows the occupation of non EcoSan toilet users.

Non EcoSan toilet users

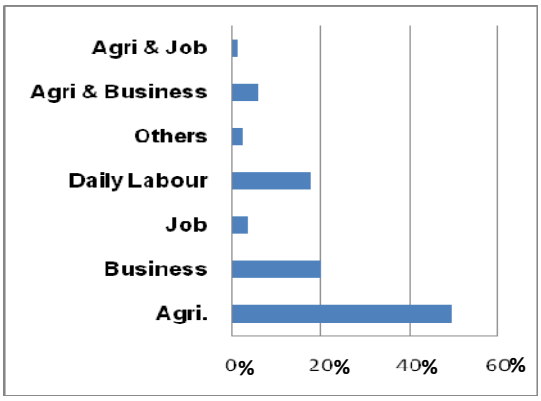


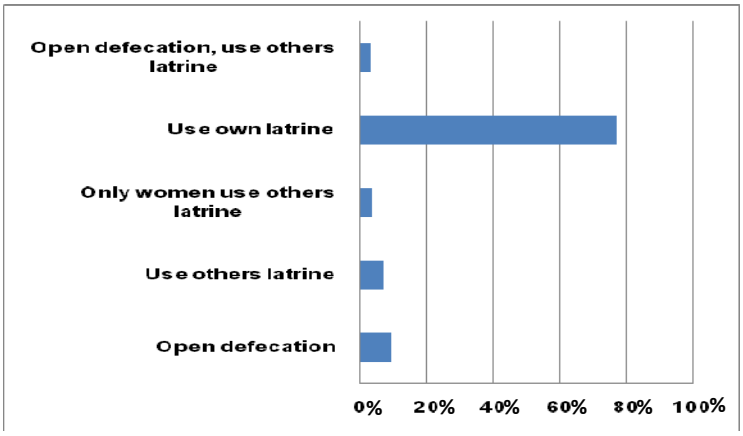
Figure 4.4: Occupation of non EcoSan toilet users

The socio-economic background of the neighbours was fairly similar to the EcoSan owners. Figure 4.4shows the occupation of non EcoSan toilet users. The main occupations of the families surveyed were agriculture (45%) as primary occupation and another 8% were somehow engaged with agriculture. Among them 18% were involved with daily labour and rest others 25% involved in service and business.

4.1.3 Access to toilets other than EcoSan

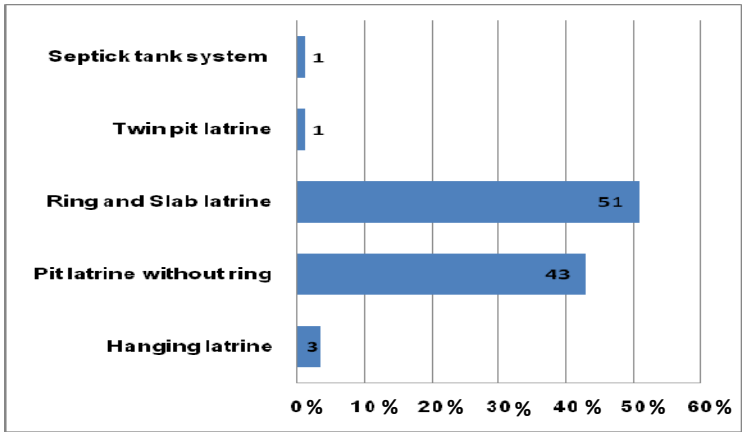
4.1.3.a Pervious practices and views of EcoSan user

Of the 87 households, 78% had access to their own latrine among which 50% used ring and slab latrine option and 40% used pit latrine without latrine. To construct that kind of latrine 52% and 35% spend maximum 1000BDT and 2000BDT respectively. Figure 4.5shows that pervious practices, type of latrine used and advantages and disadvantage of that type latrine and views of EcoSan user.



(a)

Figure 4.5 : Pervious practices, type of latrine used and advantages and disadvantage of that type latrine and views of EcoSan user (a) User HH defecation practice



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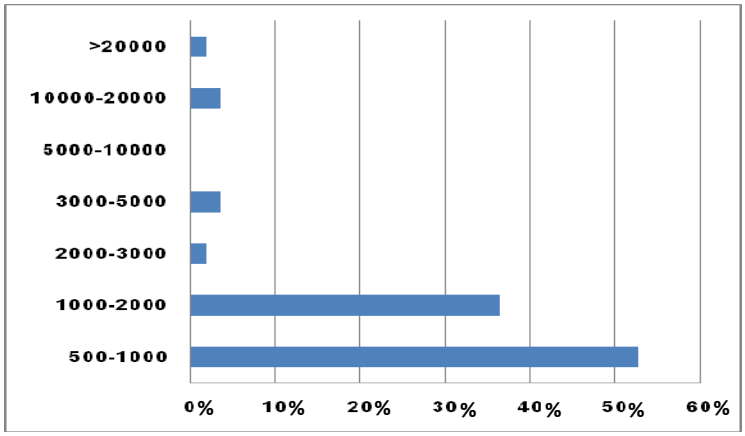

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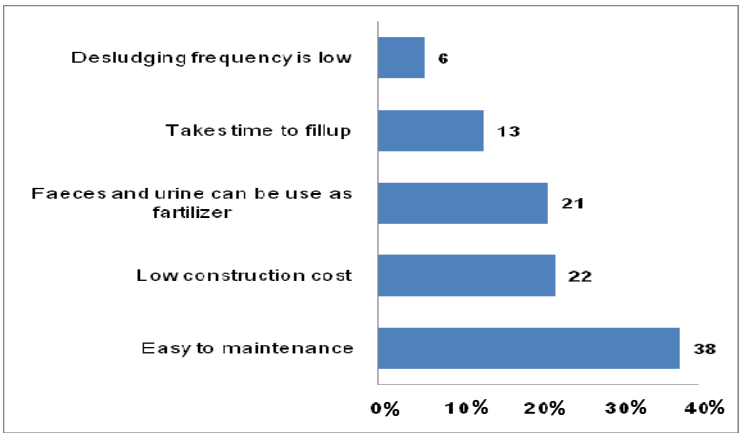
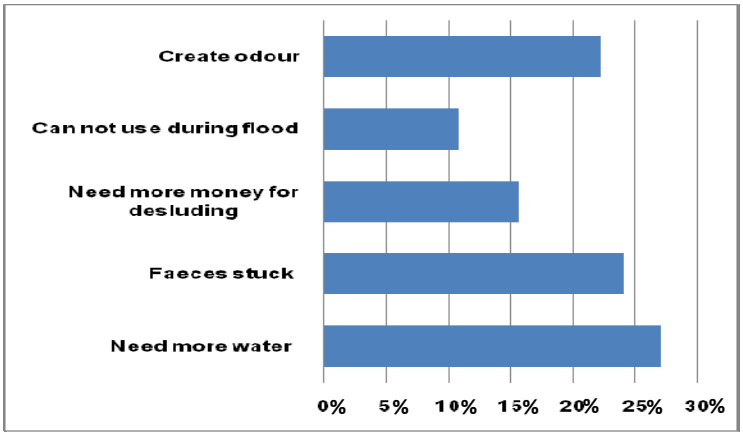


(d)

Figure 4.5 : Pervious practices, type of latrine used and advantages and disadvantage of that type latrine and views of EcoSan user (b) User HH latrine type information (c) User HH latrine cost information (d) Benefit of previous option



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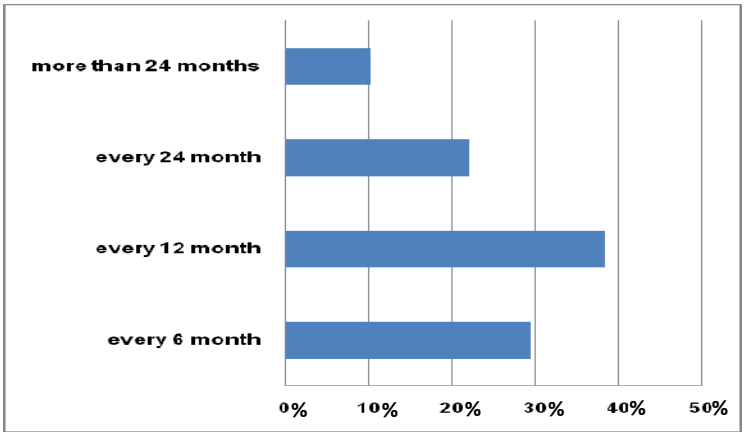

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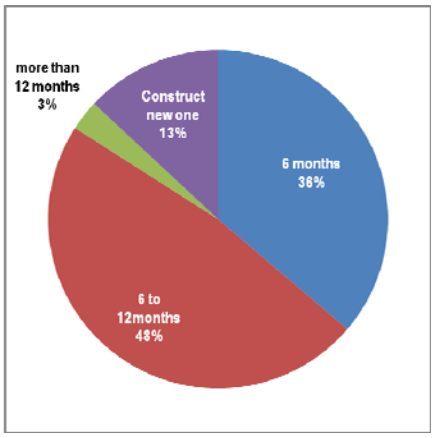

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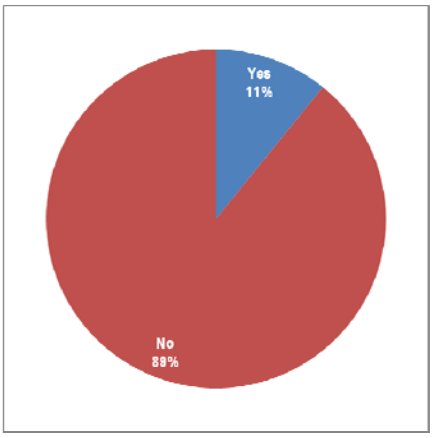


(h)

Figure 4.5 : Pervious practices, type of latrine used and advantages and disadvantage of that type latrine and views of EcoSan user (e) Disadvantage of previous option (f) Disadvantage of previous option (g) Previous latrine desludging frequency (h) Have other latrine than EcoSan

Considering main advantage of the previously used latrine was that it was easy to maintenance (38%), construction cost is low (22%) and on the other hand need more

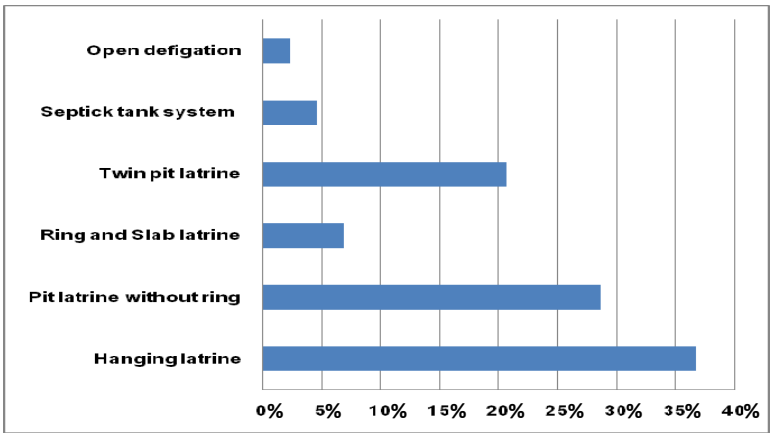
water to keep the latrine clean (23%), create bad odour (22%), faeces stuck at water seal (24%) and need good amount of money for desludging (16%). Previously used latrine durability was low like in every 6 months, 12 month, 24 month and more than 24 month user have to construct new latrine at 28%, 38%, 22% and 10% respectively. Within every 6month 36%, 12 month 48%, more than 12 month 3% have to desludging to keep the latrine functional. To avoid the desludging costly work 13% household construct new latrine. About 11% of the surveyed household have other latrine addition to their EcoSan toilet which is used by guest and some family member like children, pregnant women and older member.

4.1.3.b Present practices and views of non EcoSan user

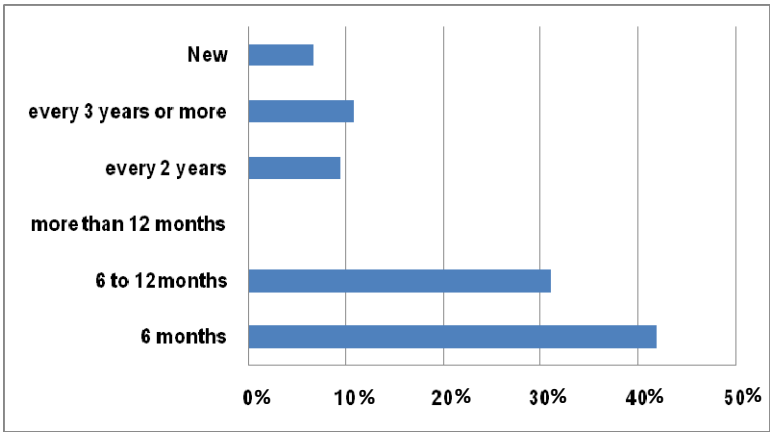
Of the 87 households, 113 (38%) had access to some kind of toilet (hanging latrine), (28%) had access to pit latrine without using ring, (21%) had access to comparatively sustainable twin pit latrine. Simple pourflush pit latrine using ring –slab and septic tank own by respectively 8 and 5%.

Low construction cost is main (more than 50%) advantage is reported by the respondent and on the other hand need much water in every time to use and clean (30%), bad odour (22%), faeces remain in the water seal (20%), not useable during disaster (15%) and remaining 12% mentioned about the high desludging cost. Bad odour is always one of main disadvantage which was reported by 70%, sometime by 15% and rest 15% option don't have odour problem. To keep the latrine clean and for every time use need more water or to bring water twice difficulty was mentioned by 93%.

Within every 6month 42%, 12 month 31%, more than 24 month 20% have to desludging to keep the latrine functional. To avoid the desludging costly work 6% household construct new latrine. Below figure 4.6 shows that present practices and views of non EcoSan user which includes latrine type, latrine desludging frequency, presence of bad odor, water requirements for maintenance, advantages and disadvantages of latrine. Figure 4.6 shows that present practices, type of latrine using and advantages and disadvantages of the toilet and views of non EcoSan user.



(a)



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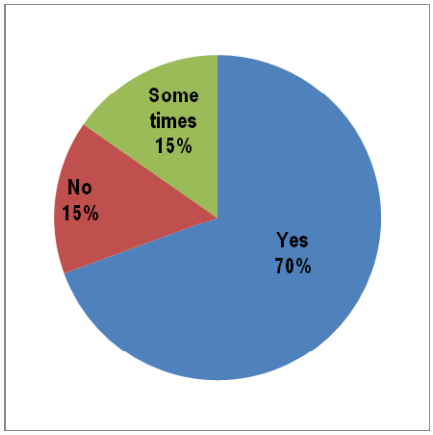

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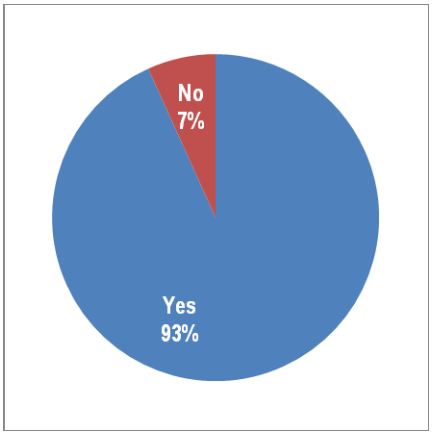
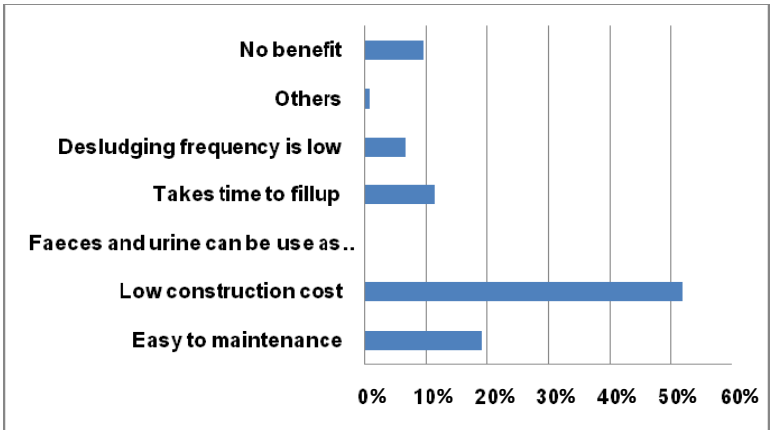


(d)

Figure 4.6: Present practices, type of latrine using and advantages and disadvantages of the toilet and views of non EcoSan user (a) Non user HH latrine type information (b) Non user HH latrine desludging frequency (c) Presence of bad odor (d) Water requirements for maintenance



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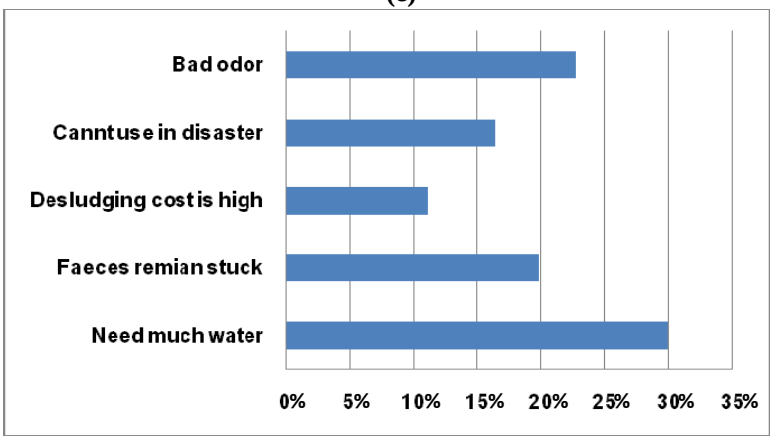


(f)

Figure 4.6: Present practices, type of latrine using and advantages and disadvantages of the toilet and views of non EcoSan user (e) Non user HH latrine advantages (f) Non user HH latrine disadvantages

It is common practice of the pit latrine user is that they discharge the black water in nearby water bodies when it started filled up. The latrine connected to septic tanks, but most of these tanks are not properly designed and are merely a pit lined with masonry. Very few people have constructed watertight septic tanks where the anaerobic biological process can take place. Once the pits are filled, the content is removed manually or by using a suction device. The content is usually discharged again into nearby water bodies without any kind of treatment.

4.2 Socio-cultural and Institutional aspects

4.2.1 Socio-Cultural Aspects

4.2.1.1 Introduction

Choice and behaviours related to sanitation are usually deeply rooted in a cultural understanding; sanitation and related topics are often taboos. These fundamental aspects are different again when planning an ecological sanitation system, since the approach tries to close the loop, and products which are regarded as waste are reused again. During planning an EcoSan system, three cultural considerations must be addressed: First, psychological deterrents associated with the handling human waste tend to be universal. Second, gender issues need to be considered- from both universal and local perspectives. Third, religious can be a significant influence (WaterAid 2008).

Cultural beliefs vary so widely in different parts of the world that it is not possible to assume that any of the practices that have evolved in relation to excreta use can be really transferred elsewhere: a thorough assessment of the local socio-cultural context is always necessary.

A fundamental difference can be found between faecophilic and faecophobic societies. While the former have few if any taboo against handling and talking about human faeces (e.g. typical Asian countries) the latter is a term associated with taboos against handing and taking about human faeces (e.g. typical Asian countries).

An in-depth understanding of the social fabric concerning people's views towards EcoSan will enlighten authorities about motivational factors behind people's acceptance or rejection.

The traditional mindset of people does not need to be a barrier to ecological sanitation. If the necessary care is taken and cultural concerns and fears are considered, it is possible to implement loop-based ecological sanitation systems also in faecophobic societies. Once the benefits of sustainable solutions is understood by the people, and if there is a mutual confidence and security that the treated and recycled excreta are something useful and safe, barriers can often be overcome. This holds true especially if there are further benefits resulting from ecological sanitation, such as an improved health and

social status (especially for women), higher yields in agriculture or improved social status (e.g., due to the installation of a toilet in the household).

In order to successfully plan and implement an ecological sanitation system, it is crucial to consider these aspects.

4.2.1.2 Community motivation for using an EcoSan toilet

Most users mentioned several factors that had motivated them to install and use an EcoSan toilet. Almost 32% of respondents said the availability of fertiliser provided by EcoSan was the primary motivational factor, while 12% listed their need to have a toilet as the main factor. Thirty-three% of users said they were motivated by EcoSan's ability to protect the environment. Another 19% were attracted to the technology because of subsidies available. Approximately 3% of users were influenced to build these toilets by neighbours who encouraged them. Figure 4.7shows the reason of constructing EcoSan toilet.

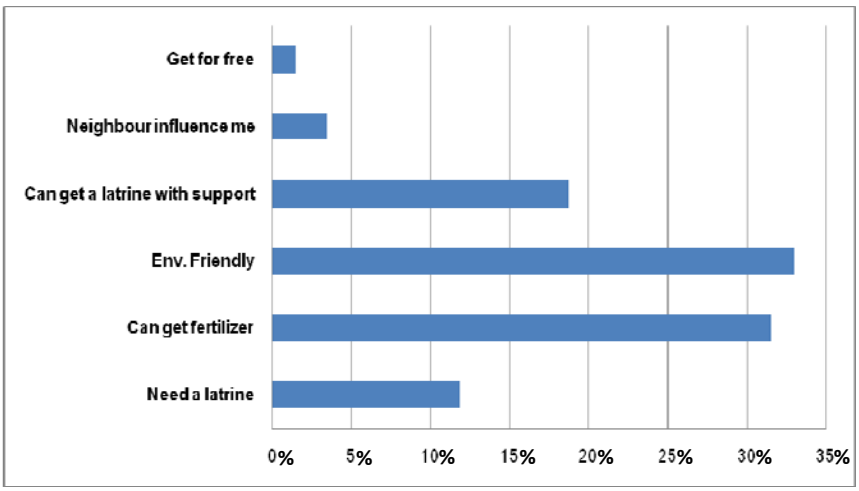


Figure 4.7: Reason of constructing EcoSan toilet

4.2.1.3 Community Perceptions about the System

4.2.1.3.1 User attitude towards EcoSan

In general, all of the users were happy with their EcoSan toilets. They are using it and are also recommending others to do so. According to respondent the main advantages of EcoSan toilets as mentioned by the users are as follows:

i) EcoSan toilets give good fertiliser, which is a blessing for poor farmers.

ii) The toilet makes defecation very easy. It was very hard to go out during the night and on rainy days.

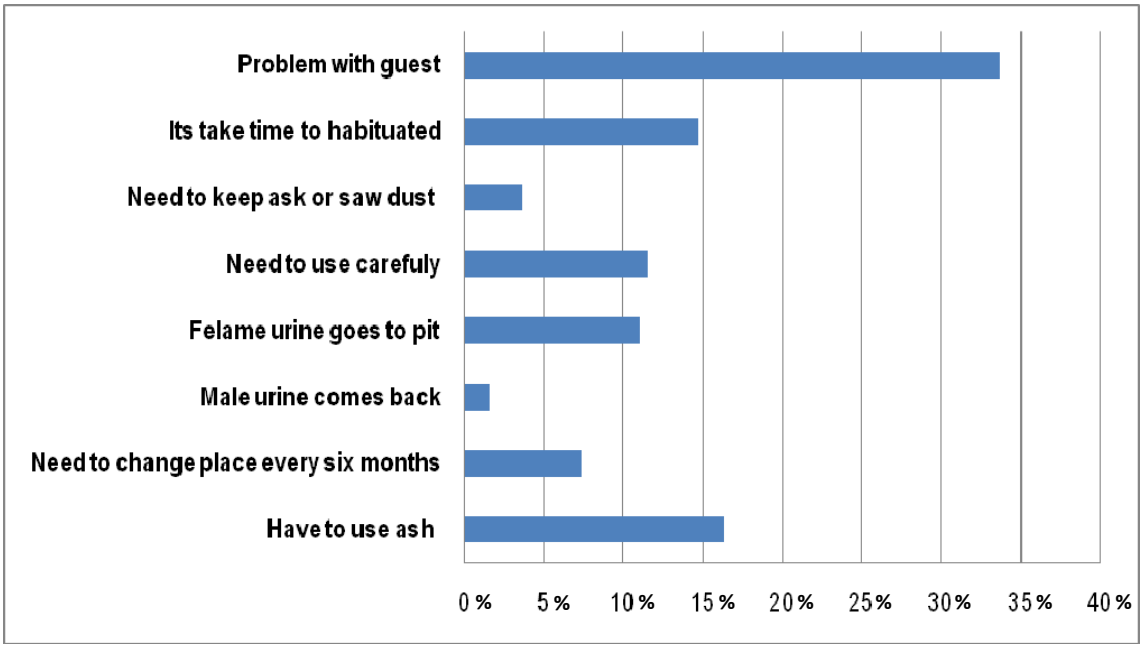
iii) The urine not only works as a fertiliser but also works as a pesticide.
iv) Prolonged use of urine and faeces in the field will increase production.
v) Can be used during flood
vi) No need desludging cost
vii) Need less maintenance than conventional latrine
viii) Need less water to keep clean than conventional latrine
ix) Can be used for longer period.

4.2.1.3.2 Disadvantages of EcoSan toilets

The main disadvantages of EcoSan toilets as mentioned by the users, based on respondent experiences, are as follows:

i) The toilet is costly and poor people cannot afford it without financial subsidies.
ii) Difficult to use for aged, pregnant women and small kid.
iii) Need more space
iv) Need ash or saw dust available all times
v) Carrying the liquid urine is difficult and it smells bad when it is applied.
vi) Eating the vegetables grown with urine feels a little strange.
vii) Removing the content of the vault will be difficult job.

All family members, including the children, are using the toilets for both urination and defecation. However, some small children occasionally don't use the toilet. As per the responses of users and observations in the field, the use of toilets is found to be satisfactory and most of the toilets are clean and well maintained. The users do not have any complaints about the EcoSan toilets and they are generally satisfied. Overall, it can be concluded that the EcoSan users are satisfied and the technology is very appropriate for the rural context. Figure 4.8 shows that disadvantages and current using problem of EcoSan toilet.



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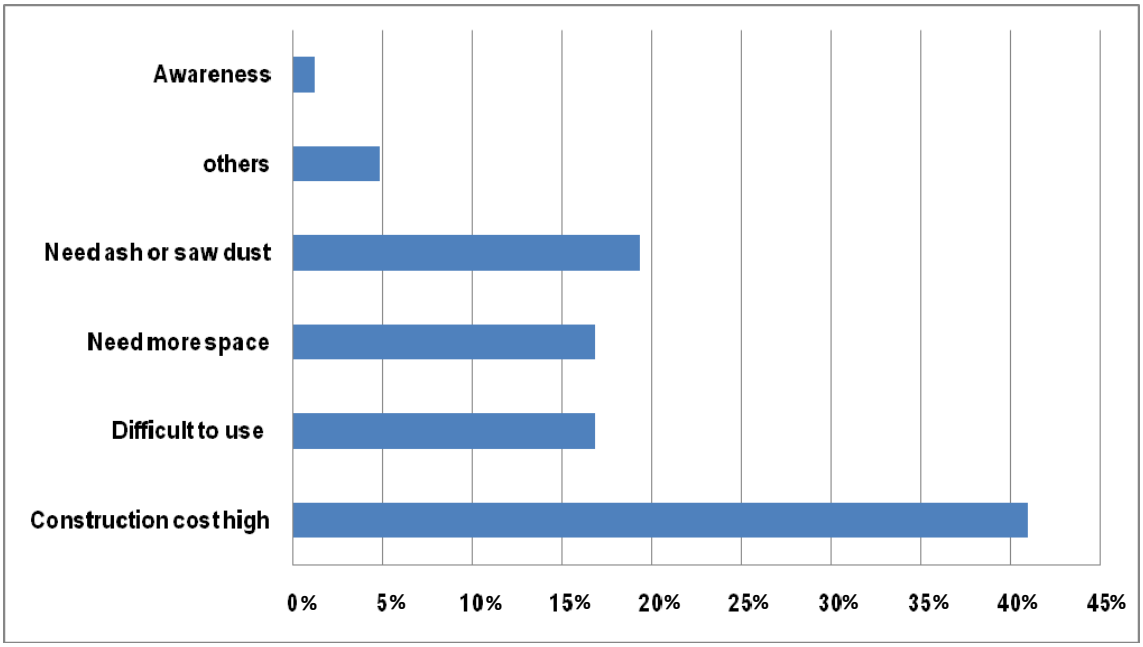
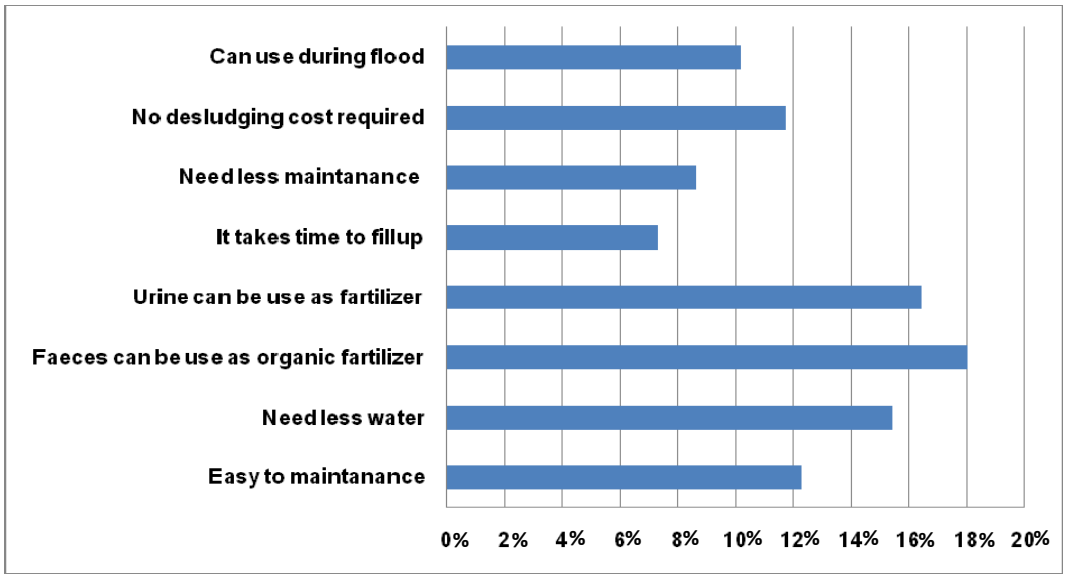


(b)

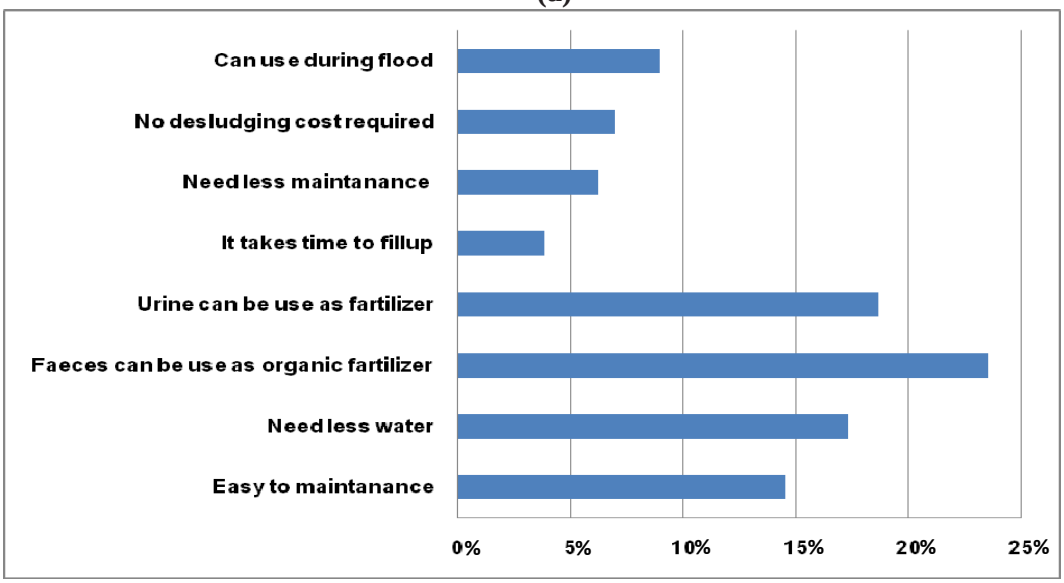
Figure 4.8 : Problem in using and disadvantage of EcoSan toilet (a) Current using problem with EcoSan toilet (b) Disadvantagesof EcoSan toilet

4.2.1.3.3 Perceived advantages of EcoSan toilets

Most of the users (about 50%) given priority to that the fertiliser value of excreta and recycling of nutrients and water saving are the major advantages of the EcoSan toilets. About 35% priority given in three issues like can be used during flood; no de-sludging cost is needed and easy to maintenance. Rest 15% to two issues of need less maintenance and takes time to fill-up. Which represent that respondents motivated by the advantages of this technology. Figure 4.9 shows that benefits of EcoSan toilet and other latrine.



(a)



(b)

Figure 4.9: Benefits of EcoSan toilet and other latrine (a) Advantages perceived by EcoSan user (b) Advantages perceived by non EcoSan user

Non EcoSan user also has similar kind of response. About 80% priorities given to that the fertiliser value of excreta and recycling of nutrients, water saving and easy to maintenance are the major advantages of the EcoSan toilets. Around 17% priority given in three issues like can be used during flood, no need desludging cost and need less maintenance. Rest 3% takes time to fill-up. That represents, non user respondents are well aware of the advantages of this technology and motivation for constructing EcoSan toilet is high.

4.2.1.3.4 Neighbours attitude towards EcoSan toilets

Most of the neighbours are well aware of the EcoSan toilets. Out of the 87 households surveyed, 98 responded that they knew about the toilets in detail and only two present household had not heard about the EcoSan toilet and they are well aware of the advantages and disadvantages of the toilet. Figure 4.4 shows that non user neighbor's perception towards EcoSan toilet.

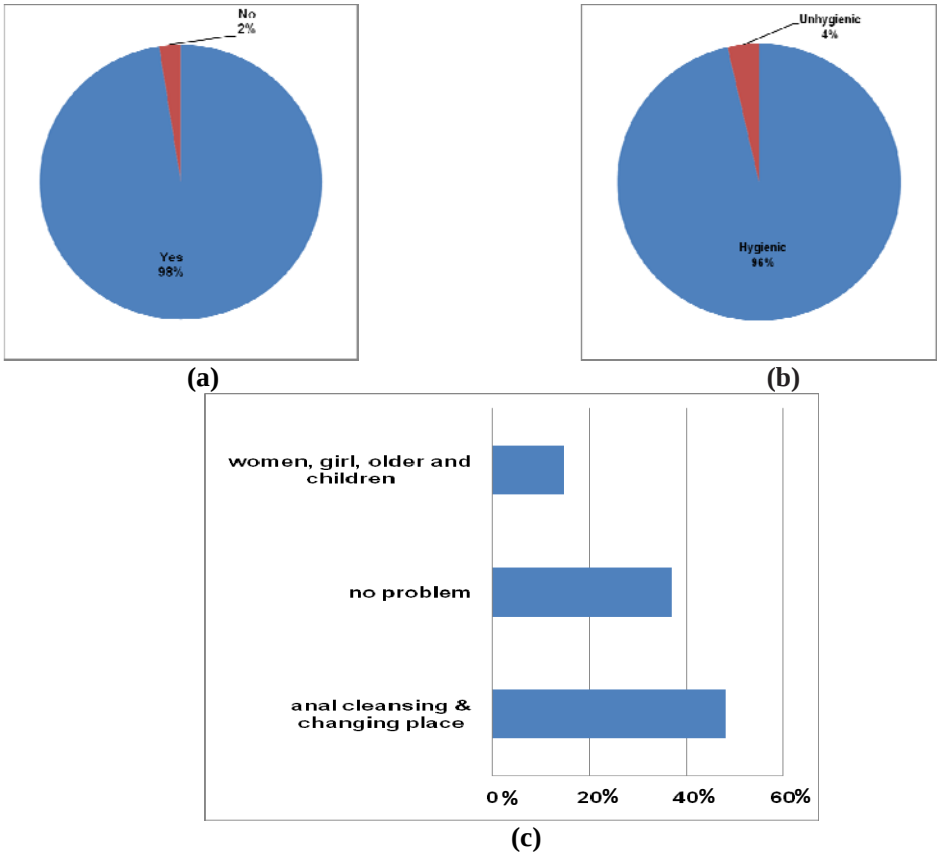
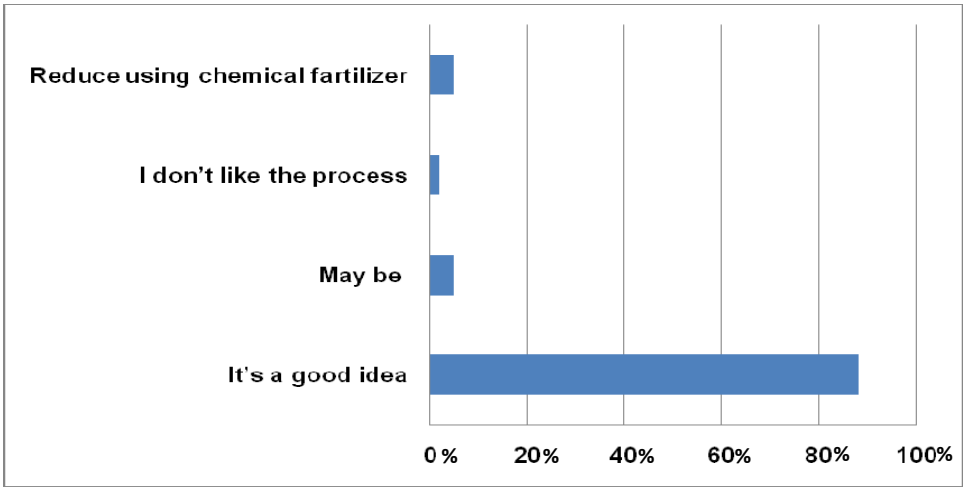


Figure 4.10: Non user neighbors' perception towards EcoSan toilet (a) Non user knows about neighbor EcoSan toilet (b) Perception about hygienic condition of EcoSan toilet (c) Perception about problem with EcoSan toilet

According to community perception, 96% EcoSan toilet is hygienic and about 97% of them recommended the toilet should be constructed in all household and only three disagree with that. That represents the positive attitude towards EcoSan toilets by the respondents. About 48% of neighbours surveyed said anal cleansing or changing place for anal cleansing is the major problem and 15% said the using problem of women, children and older. These results clearly indicate that the people who are not using the EcoSan toilets are also positive towards the technology.

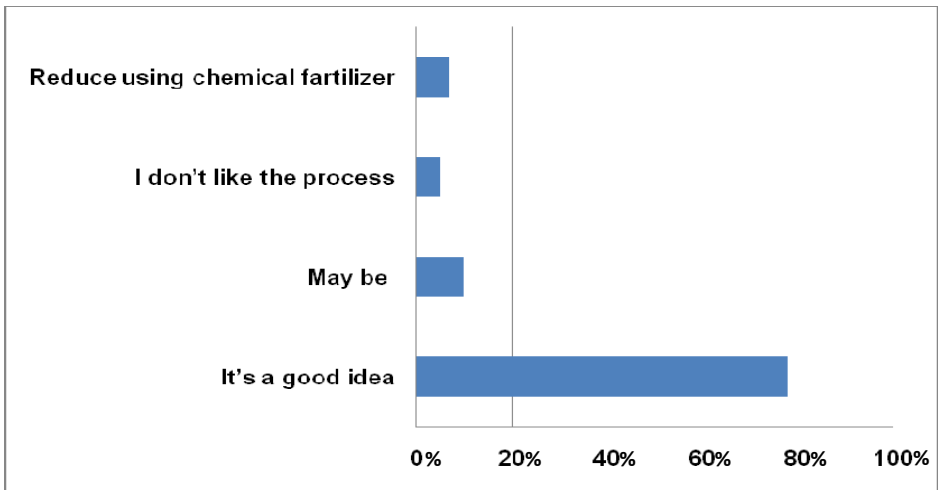
4.2.1.3.5 Community attitude towards nutrient recycling

According to EcoSan user more than 88% of the respondents said that using sanitised human excreta as fertiliser is a good idea. However, 5% have doubts about it, 2% doesn't prefer the system and 5% think that it will reduce the demand of chemical fertilizer. Figure 4.11 shows that user and non user attitude towards nutrient recycling.



(a)

Figure 4. 11: User and non user attitude towards nutrient recycling (a) EcoSan user attitude towards nutrient recycling



(b)

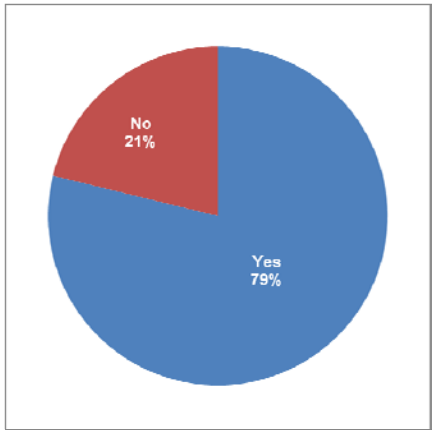
Figure 4. 11: User and non user attitude towards nutrient recycling (b) Non EcoSan user attitude towards nutrient recycling

On the other side according to non EcoSan user more than 78% of the respondents said that using sanitized human excreta as fertiliser is a good idea. However, 10% have doubts about it, 5% of the respondents said re-use of sanitized human excreta is not a good practice and is not suitable for modern society. They feel the consumers of the food may not accept the product, or the process of applying the excreta will be difficult and disgusting. 7% of the respondents think that the use of sanitized human excreta will reduce the use of chemical fertiliser to a great extent. In the remarks they mentioned that it can only replace chemical fertiliser by a small portion and according to the respondents do not believe in replacing chemical fertiliser with human excreta.

4.2.1.3.5.1 Use of urine and faeces

One of the most successful and as well as challenging aspects of EcoSan toilets is using urine and faeces application. Almost all the user respondent believe that both urine and faeces are good fertilizer and before using EcoSan toilet 13% use these kind of organic fertilizer and 4% in some cases use the same. All of the EcoSan toilets have 20 to 30 litre capacity urine collection plastic jerry can and all of the houses have experience of using urine in the fields. Currently 36% using only urine, 27% only faeces, 22% using both and 15% are not using anything. Some (62%) of the toilet owners said that the urine there are facing difficulty of using urine like smell bad and preservation. While 23% users using faeces and 18% using both when applying in the field. Figure 4.6 shows that knowledge and practice of EcoSan toilet user and non user of using urine and faeces as fertilizer.

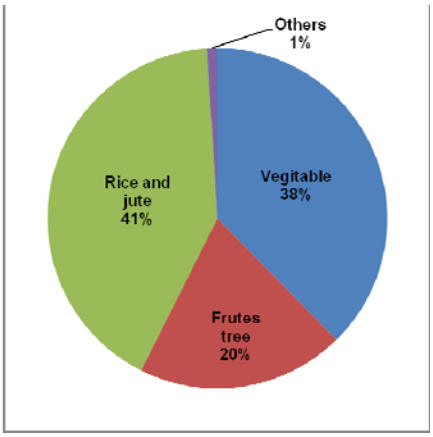
Figure 4.12 : Knowledge and practice of EcoSan toilet user and non user of using urine and faeces as fertilizer (a) EcoSan user knows urine and faeces is kind of fertilizer (b) EcoSan user pervious practice of using urine and faeces as fertilizer (c) EcoSan user current practice of urine and faeces as fertilizer (d) EcoSan user feel difficult to use urine and faeces as fertilizer (e) EcoSan non user knows urine and faeces is kind of fertilizer (f) EcoSan non user practice of using urine and faeces as fertilizer

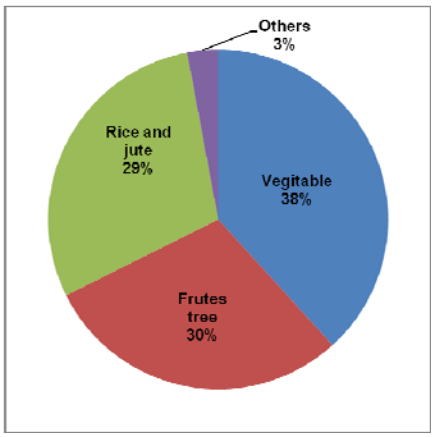


(g)

Figure 4.12 : Knowledge and practice of EcoSan toilet user and non user of using urine and faeces as fertilizer (g) EcoSan non user feel difficult to use urine and faeces as fertilizer

In the case of non EcoSan user 98% know about the potentiality of urine and faeces as fertilizer and 33% having a practice of using in the field. Among them only 21% don't feel comfort of using these kind of organic fertilizer. Figure 4.13 shows that practice of EcoSan toilet user of using urine and faeces usage as fertilizer.





(a) **(b)**

Figure 4.13: Practice of EcoSan toilet user of using urine and faeces usage as fertilizer
(a) Practic of using faeces as fertilizer (b) Practic of using urine as fertilizer

They have applied urine to and faeces in different crops, vegetable and fruit trees. The practice of using faeces compost found that about 41% in rice and jute, 20% in fruit trees, 38% in vegetables and rest 1% in others. Similarly, the practice of using urine found less (28%) in rice and jute, more (20%) in fruit trees, same 38% in vegetables and rest 3% in others.

4.2.1.4 Willingness to build or pay for EcoSan toilets

In figure 4.14 shows that community interest and demand to construct EcoSan toilet according to the user and non user.

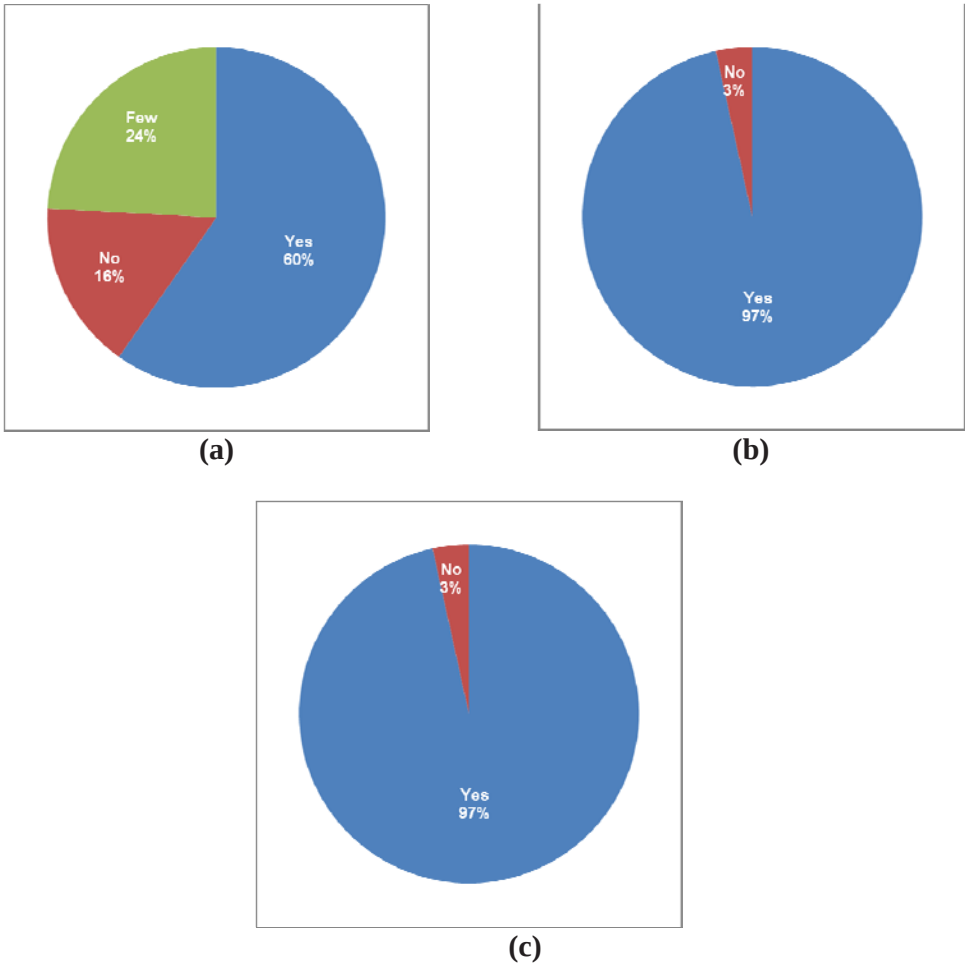
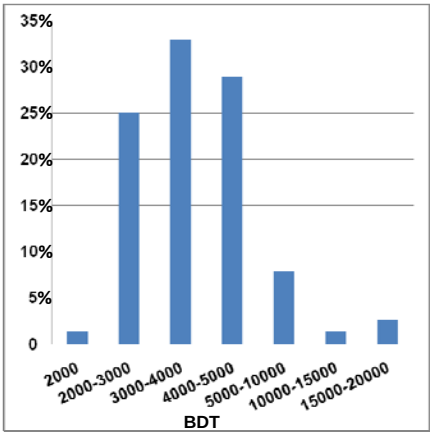
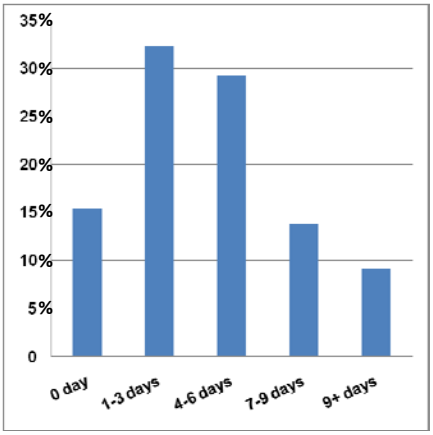


Figure 4.14: Interest and demand to construct EcoSan toilet in the community. (a) Non user neighbor interested to construct EcoSan toilet; (b) User want EcoSan toilet in all HH; (c) Non user want EcoSan toilet in all HH

The user respondent mentioned asked how households showed an interest in EcoSan toilets. According to the user respondent about the non EcoSan user neighbour that 60% are interested, 24% said not all are interested and rest 16% are not interested to construct EcoSan at their house. Both user and non-user 97% agreed in the same point that is EcoSan toilet should be available in all household and only 3% disagree with this. According to the figure 4.15 it shows that construction cost considering sharing, labour sharing and subsidy and non user proposed price.



(a)



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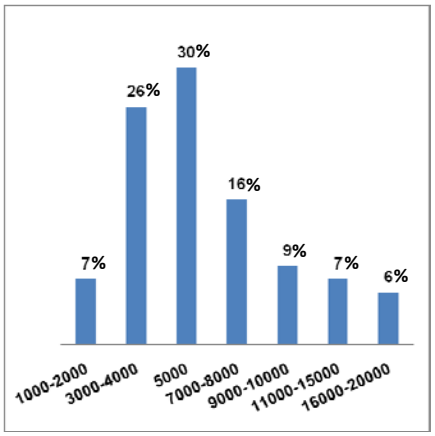

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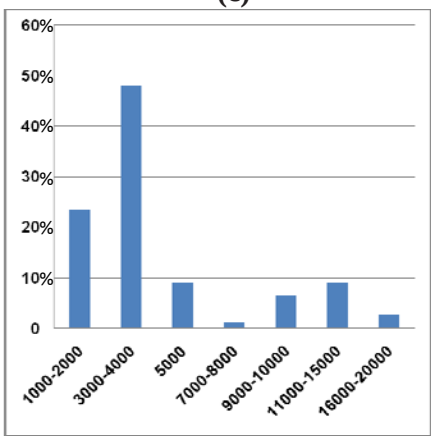


(d)

Figure 4.15 : Construction cost considering sharing and subsidy and non user proposed cost (a) Construction cost share by user (b) User contribute labour (c) Want to spend without subsidy by user (d) Want to spend without subsidy by non user

All the survey toilet is constructed under different project and user have to share certain amount of the construction. In some cases user also provide labour during construction. Mostly 15 – 40% construction cost is shared by the user. It was found that around 60% user

gave 3 – 5 days labour during the construction period as non-skilled labour and which is equivalent to 450 – 750 BDT. About 50% of the households were ready to invest between BDT. 3000 - 4000 for an EcoSan toilet. Second major portion 22% are ready to invest between BDT. 1000 - 2000 for toilet construction, while 10% are ready to invest BDT. 5000 and rest 18% want to invest BDT. 7000 – 16000. There are some not willing to invest anything at all and one reason is they have sustainable latrine option like sceptic tank. This reflect two things of expressed their willingness to install EcoSan toilets in their houses. This indicates that the EcoSan toilets have a good image in the community.

4.2.1.5 Religious barrier to Ecosan toilet

Religious beliefs affects remarkably to formation of sanitation culture since many religious habits and rituals have a connection to sanitation. Definitions of good and bad, polluted and clean can be found in many religious. This affects to utilized latrine types and attitudes towards latrines, latrine waste handling and use of the waste (Warner, 2005). Islam is the main religion in Bangladesh. Islam determines specific rules on how to handle with excreta. Only left hand can be used for anal washing purposes after defection (right is used for eating purpose) and water is used for anal cleansing and hand washing. Therefore in Islamic country like Bangladesh use of EcoSan will be a big challenge for the religious reason.

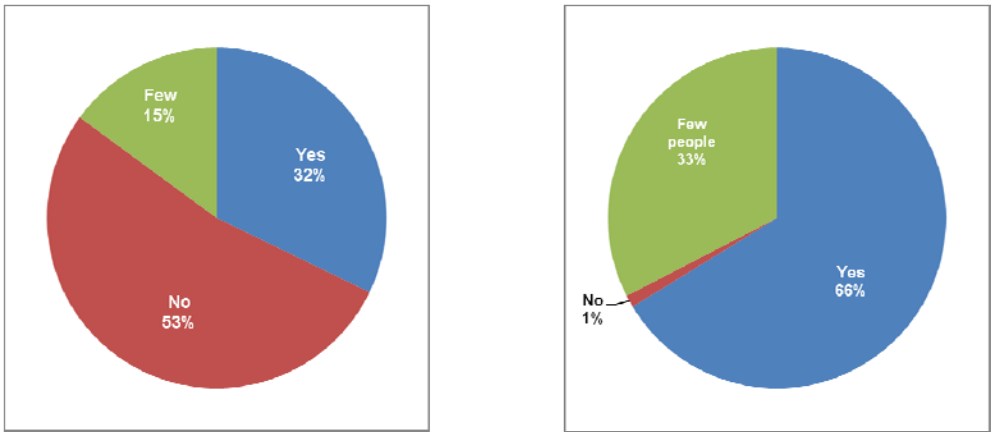


Figure 4.16: Religious barrier in the society to EcoSan toilet according to EcoSan toilet user and non user (a) Religious barrier in the society according EcoSan user (b) Religious barrier in the society according EcoSan non user

In some Islamic countries like Yemen dry latrine are used and in this case washing can be carried out in washing places in contact with latrines (Warner-2005). Figure 4.16 shows that religious barrier in the society to EcoSan toilet according to EcoSan toilet user and non user.

According to EcoSan user only 32% and non EcoSan users believe that 66% people of their area don't like EcoSan toilet due to religious barrier and similarly 15% and 33% people have the doubt accordingly.

4.2.1.6 Cultural barriers to EcoSan toilet

Initial concerns that EcoSan would be culturally unacceptable are eroding over time. But there is some culture of using dry faeces for winter vegetable in some area. These products are eaten without reservation, although people are reluctant to talk about this practice in public gatherings. The consumption of agricultural products grown on abandoned pit latrines strongly suggests that potential cultural concerns regarding food grown with human excrement are not grounded in the reality of community practice in all study area. The study areas have diverse religious communities. Islam is most widely practised and others are followed closely by Christianity, Hinduism and Buddhism. Figure 4.17 shows that Cultural barriers to EcoSan toilet according to the user and non usre.

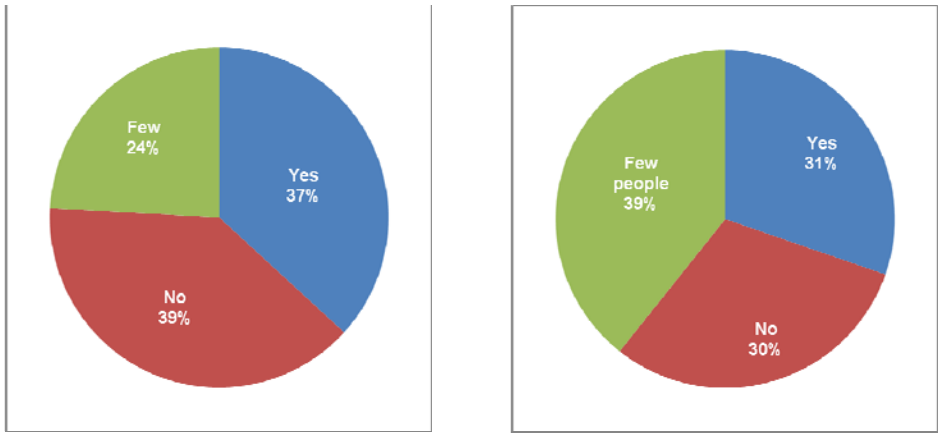


Figure 4.17: Cultural barriers to EcoSan toilet (a) Cultural barriers in the society according to EcoSan user (b) Cultural barriers in the society according to non EcoSan user

According to EcoSan user and non user 37% and 31% people of their area believe that EcoSan is not acceptable with their culture respectively. Similarly 24% and 39% people are not so rigid with their cultural practice to accept the EcoSan system.

Figure 4.18 shows that previous practice of EcoSan user of using urine and faeces as fertilizer.

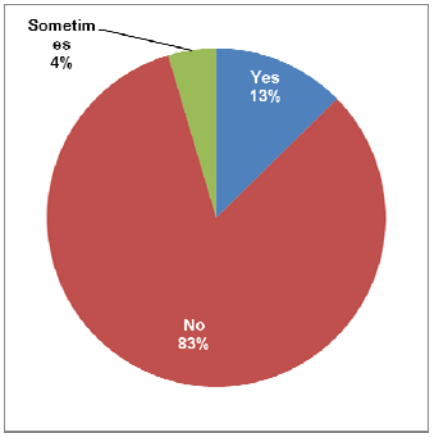
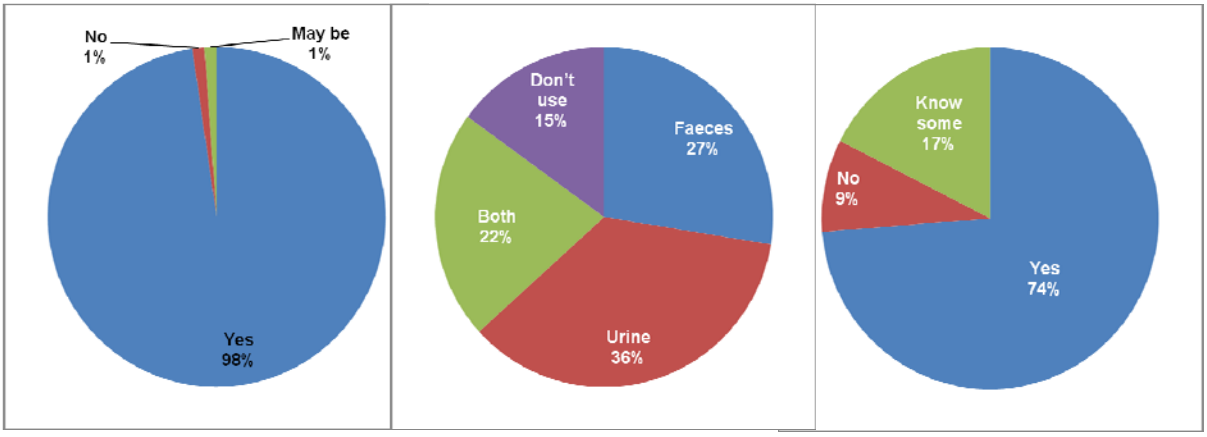


Figure 4.18: Previous practice of using urine and faeces as fertilizer

Excreta-based fertilizers are still a sensitive issue for some cases despite the relatively high acceptance of the EcoSan concept and a willingness to consume food grown using urine or composted human excreta, a certain sensitivity of some farmers towards the products. Around 17% people more or less use urine and faeces as fertilizer according to the EcoSan user comments and rest 83% people never have that kind of practice previously.

4.2.1.7 Practice of using of urine and compost faeces

Figure 4.19 shows knowledge and practice of using urine and faeces as fertilizer. According to the figure 4.13 most significant evidence for the potential for EcoSan acceptance among the study respondents is that 99% of the respondents believe that the EcoSan system would be beneficial, 91% of the respondent knows the method of using urine and faeces and 85% of the user using urine and faeces as fertilizer.



(a) **(b)** **(c)**

Figure 4.19: Knowledge and practice of using urine and faeces as fertilizer (a) Knows urin and faeces is kind of fartilizer (b) Current practice of urine and faeces as fartilizer (c) Knows about method of using urine and faeces as fartilizer

The main reason for this can be found in the potential ability to produce fertilizer themselves.

4.2.1.8 Local people interest to buy product using urine and compost faeces

Further evidence of this reservation towards the human excreta-based products can be drawn from the finding that even though farmers are willing to consume food grown with human excreta-based fertilizer. There is a good demand of the product in the market and according to the respondent around 70% people like to purchase. Only 6% customer are not willing buy when they heard about the using human excreta based fertilizer or compost has been used in growing their products. Figure 4.20 shows local people interest to buy product using urine and dry faeces.

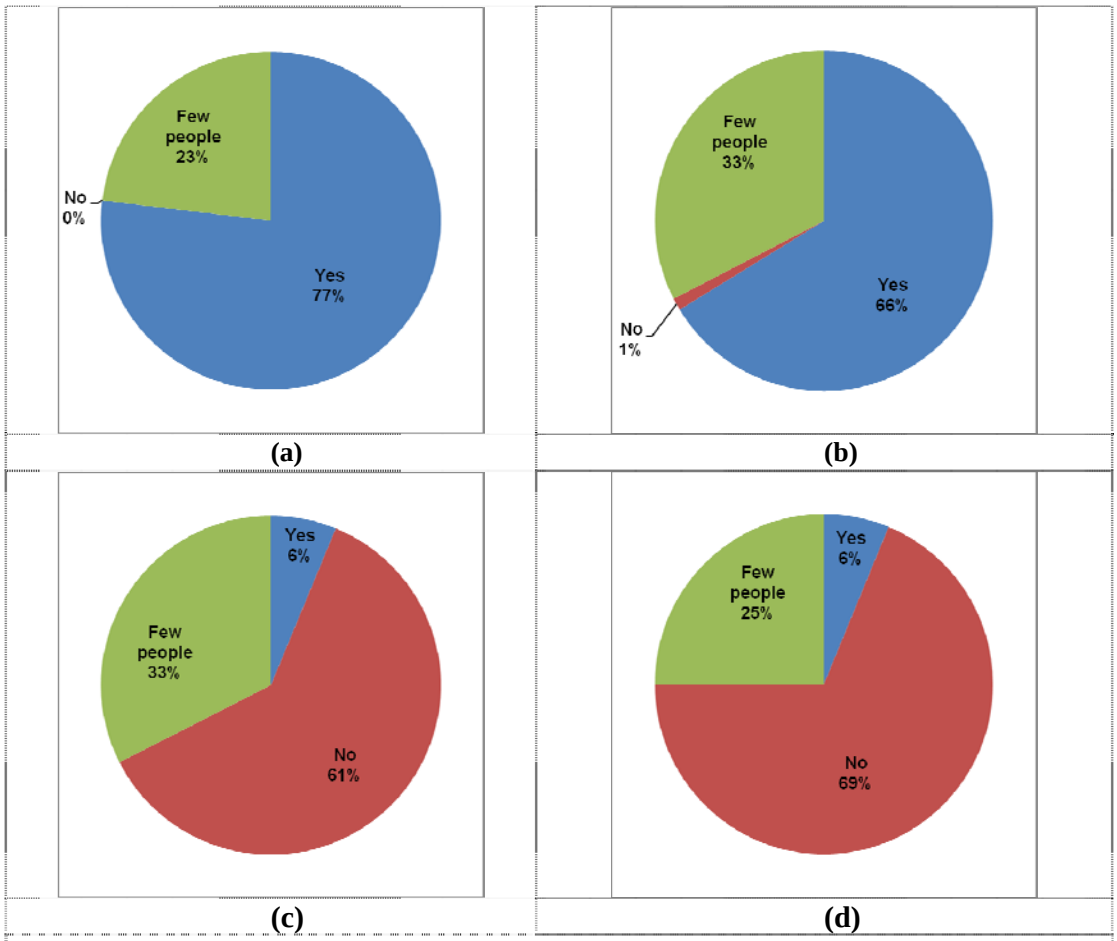


Figure 4.20: Local people interest to buy product using urine and dry faeces
(a) Demand on urine and faeces product according to EcoSan user
(b) Demand on urine and faeces product according to EcoSan nonuser
(c) Dislike urine and faeces product according to EcoSan user (d) Dislike urine and faeces product according to non EcoSan user

4.2.1.9 Local need and demand of ecosan toilet

Sanitation has been a big problem in all over Bangladesh, as the area has a high groundwater table, gets flooded during monsoons every year and faces a low perceived need for sanitation and along with user can grow vegetable and crops with organic EcoSan fertilizer and without pesticides. The owners are very happy with their EcoSan systems themselves and there is high demand of EcoSan toilet in all the study areas. However, they admit that guests sometimes have problems to use the differently-designed toilets. Figure 4.21 shows that local need and demand of EcoSan toilet.

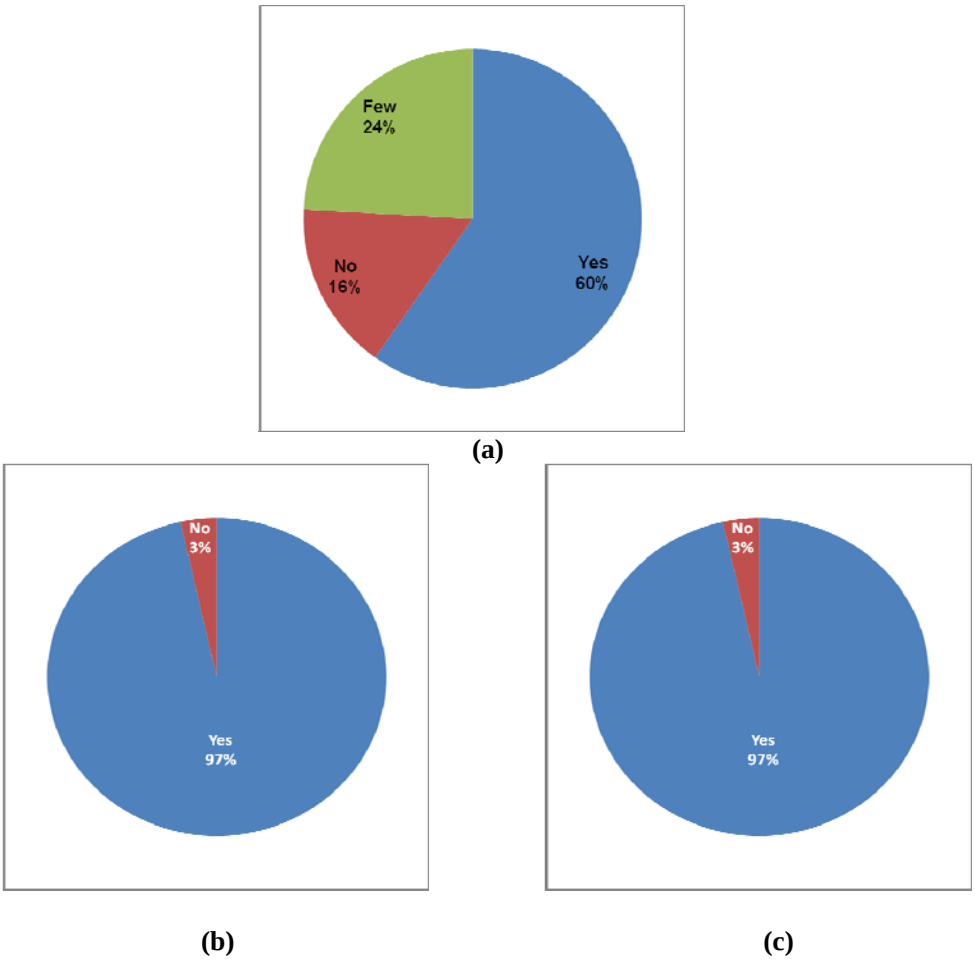


Figure 4.21: Local need and demand of EcoSan toilet (a) Neighbor interested to construct according to user (b) Usre want EcoSan toilet in all HH (c) Non user want EcoSan toilet in all HH

Neighbor interested to construct according to user 16% user respondent people of their community are not interested to construct EcoSan toilet at their home. But 97% both respondent in case of user and non user are believe that EcoSan toilet should be available in all household of their community.

4.2.1.10 Local people interest to buy urine and faeces compost fertilizer

More than half of the respondents expect that the EcoSan system would increase their income or reduce their costs, due to self production of fertilizer or increased availability locally of organic fertilizer at lower prices. The high cost and limited availability of chemical and organic (from animal waste) fertilizers, means current fertilizer in Bangladesh demand is not entirely met, and any additional supply of fertilizer is regarded as beneficial and responsive to demand. Figure 4.22 shows that local people interest to buy urine and faeces compost fertilizer in terms of proposed price.

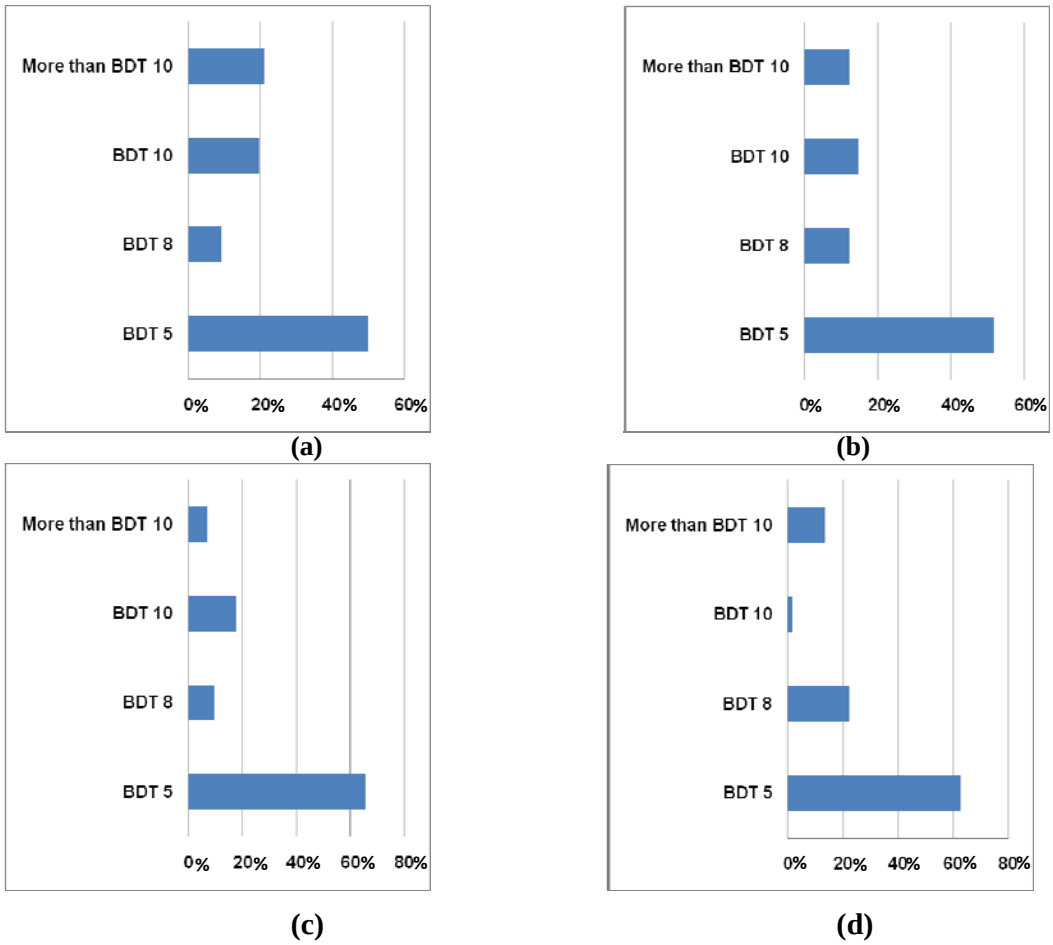


Figure 4.22: Local people interest to buy urine and faeces compost fertilizer
(a) According to EcoSan user proposed price of faeces fertilizer
(b) According to non EcoSan user proposed price of faeces fertilizer
(c) According to EcoSan user proposed price of urine fertilizer
(d) According to non EcoSan user proposed price of urine fertilizer

50% of both type of respondent want to buy faeces organic fertilizer with BDT 5 and for the case of urine fertilizer 50% user want to pay 5BDT and in case of nonuser 60% wants to pay the same.

4.2.1.11 Gender issues and impact on human dignity

4.2.1.11.a Gender aspects of ecosan toilet

In sanitation both physical and gender differences between men and women are of importance. (When we refer to gender differences, it mean the social and cultural differences between the sexes.) Physical characteristics make a difference in the sanitary habits of men and women. While a man can stand during urination, a woman has to squat or sit. This can lead to different demands when it comes to sanitation. Because of the physical differences, women are, in general, more concerned with the hygienic conditions of the toilet. Women are also more vulnerable to the unhygienic conditions during their monthly periods, during and after pregnancy.

The gender topic is more variable and complex. Gender and sanitation issues differ between countries, culture, religion or socio-economic class. In some countries, privacy and protection of girls and women while using sanitation facilities might be the greatest concern; in other countries, the unequal distribution of work related to sanitation (disposing of human waste, collecting water for hand washing) might be an issue. (Westerhof, B. Sanitation and Gender: A Gender approach for effectiveness and equality, IRC, Delft, 2005). Gender is important to consider, not only when we think in terms of the user, but equally in the case of the construction, implementation, development, financing and maintenance of sanitation systems. To meet the needs, both men and women should be involved in the processes mentioned above, otherwise a lack of motivation of either one of the sexes can make a project or technology will fail.

However, since discrimination of women and girls – who are mostly the key actors in water and sanitation issues on a household level, prevails, it may be important to make for their equal rights first. Another important issue is access to sanitation –women usually suffer more if they do not have access to sanitation. Their special needs (concerning safety and design of sanitary facilities) have to be taken into account.

However, the gender perspectives on sanitation and/or on ecological sanitation have not been well establishes so far. This holds true for both men and women. While in most areas in developing countries do the construction of latrines, women are usually responsible for keeping them clean and useable.

"In all societies men and women play different roles, have different needs, and face different constraints. Gender roles differ from the biological roles of men and women, although they may overlap in nearly all societies. Gender roles are socially constructed. They demarcate responsibilities between men and women, social and economic activities, access to resources, and decision making authority. Biological roles are fixed, but gender roles can and do change with social, economic, and technological change. Social factors underlie and support gender-based disparities." (Fong, Wakeman and Bhushan 1996).

The household is the basic unit of sanitation planning, but even within the household, there are deep differences between children, women and men in terms of behaviour, preferences, power, access to resources, time spent at home, information, and skills (Khyber 1994).

Addressing gender issues in sanitation means to have a closer look at social relationships to see the different roles of community members and the complicated structure between women and men, girls and boys with regard to decision making, choice and manner of use of technology, hygiene, food security, financial security, crop production and health issues. Participation does not mean merely inviting the men from all types of households to come to a meeting and vote on toilet designs, it requires deliberate and skilled facilitation to elicit this same information from women, servants, and the social or ethnic classes who are given the "dirty work" in any particular society. The people charged with the dirty work have critical knowledge about the workings of the system, but they are frequently ignored as key stakeholders.

4.2.1.11.b Gender roles in EcoSan latrines

EcoSan has had an interesting effect on the gender roles associated with latrine construction. During the assessment study, it was found that in households with EcoSan toilets (dry EcoSan or wet EcoSan, i.e. urine diversion toilets), the task of emptying the urine container and the vault (also called fecal bin) seems to be that of males, but when it comes to conventional pit-san toilets, the task was usually carried out by women. Thus, EcoSan related task has not contradicted societal norms about the division of duties, while new ideas regarding benefits of recycling nutrients can introduce new values. In addition, the production of fertilizer through the use of EcoSan toilet has influenced both genders in the importance of latrines and their proper maintenance to benefit from the compost produced. However, some

concerns were shown by some communities about disposing of menstrual blood in the EcoSan toilet, and such a practice also poses a challenge for the reuse of urine as fertiliser.

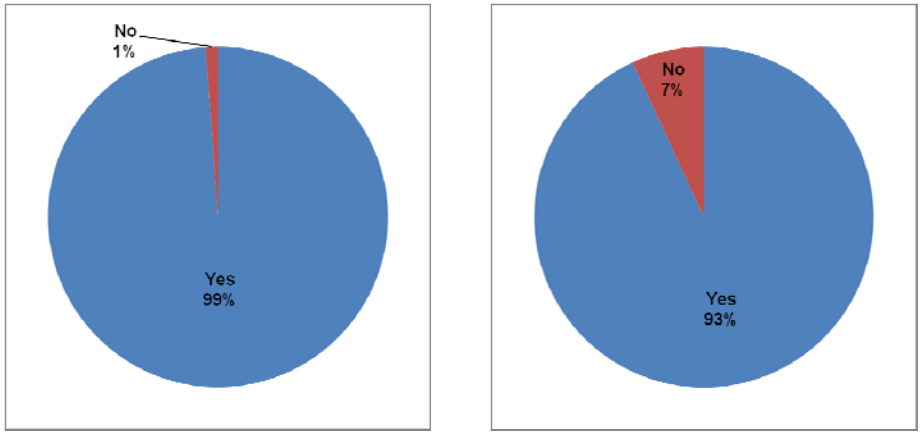
The men shared opposite interests to the women, who were more interested in the hygiene aspects of latrine use than the fertilizer. However, the end result is the same, a reduction in children's feces around the compound and settlements' surroundings. Apart from the children, women too, who otherwise practiced open defecation, now used this toilet with greater confidence, privacy and security at any time (particularly at night) as they used to during open defecation.

4.2.1.11.c Convenience factors and dignity issues of ecosan toilet

Convenient use and operation have proven to be of crucial importance for users of sanitation facilities, including the level of comfort, privacy and security. The cost to construct and maintain installations is another important consideration. Many users who have changed to urine-diverting systems from pit or VIP latrines appreciate the level of comfort that, by their perception, is comparable with that of water toilets. When permanently installed in the house, they are more convenient for use day and night and provide security for women and girls who would otherwise be exposed to the risk of sexual harassment when visiting external toilet facilities. Permanente in-house structures receive a great deal of attention and have therefore become status symbols in some areas. They can also be adapted to accommodate different anal cleansing practices (Drangert, 2004a). The handling of excreta is closely linked to issues of human dignity. In some societies, those working with excreta may be perceived as “unclean” and the work is often a task reserved for those living on the margins of society in the weakest of social positions.

4.2.1.11.d Privacy and convenience of ecosan toilet

The privacy and convenience of the EcoSan Toilet installations are often seen as protecting and promoting human dignity, by providing safe, private toilet facilities. Care should be taken in the design to ensure not only that they meet the need of the majority of the adult population but also that sanitation facilities are assessable and usable for small children, the elderly and the disabled, and that their dignity is protected. In-house facilities can help to ensure that these goals are achieved. Figure 4.23 shows that user feeling about safe, security and comfort ability while using EcoSan toilet.



(a) **(b)**

Figure 4.23: User feeling about safe, security and comfort ability while using EcoSan toilet. (a) User feel safe and scuried to use (b) User feel comfort to use

99% respondent felt that women and girls feel safe and secured in using EcoSan toilet any time of the days and 93% respondent also mentioned that women and girls of their house feel comfort or not face much difficultly of using EcoSan toilet.

4.2.1.11.e Management roles of ecosan toilet

For proper use and functioning of EcoSan toilets, there is need for a management at household.

The management should consider all important components, which include:

i) Routine issues – collection and application of ash, cleaning of the toilet,

ii) Putting out of use the filled-up faecal vault; and opening the vault to put in use,

iii) Emptying of the urine containers; as well as the faecal vaults,

iv) Collection and transport of faeces and urine – either to storage facilities for additional sanitization or for immediate use. Immediate use applies only for the urine in a small system (*e.g.* at household level), otherwise, in large systems, urine should be stored for about 6 months before using it in a garden. All source-separated faeces, whether from small or large systems should be stored before use for a considerably long period (1-2 years).

At the household level, it is clear that all the above have to be done by the members of the household. Except that the household members need to know the above; and how to do it; it is not necessary to discuss the details of '*who should do what*' here, especially for an EcoSan toilet at household level.

Responsibility for cleaning of ecosan toilet

Cleaning the EcoSan toilet is mainly a woman's job as they mainly work at home and look after all house hold work including water and sanitation issue. Although according to the respondent only 8% women do this job and 75% both whenever anyone get time to do the cleaning work. Other members (9%) also do the same job. Figure 4.24 shows that the responsibility for cleaning EcoSan toilet.

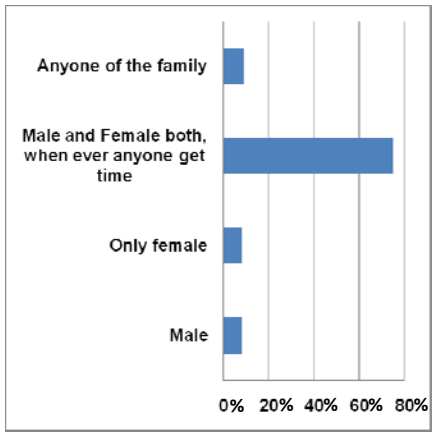
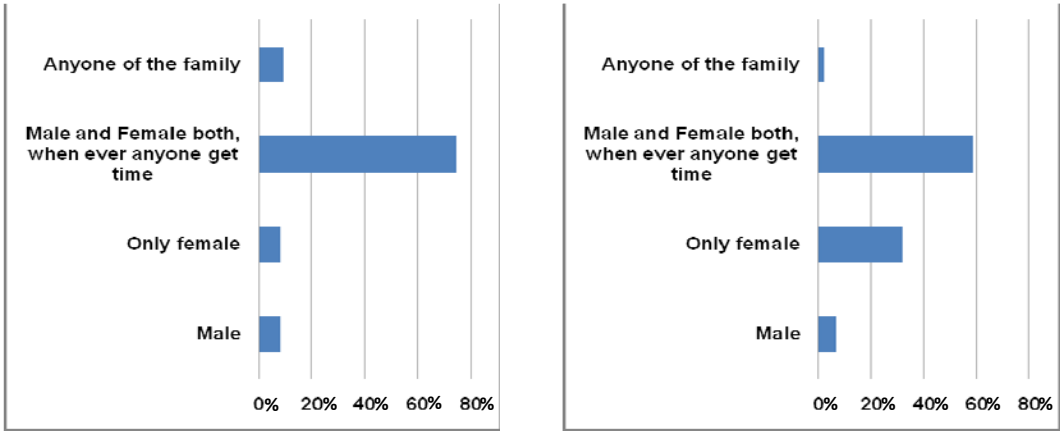


Figure 4.24: Responsibility for cleaning according to household member believes

Responsibility for vault emptying of ecosan toilet

Of the total respondents who had emptied the vault at least once, 75% said it is the responsibility of both male and female members of the family and they do it as per the need. But same 8% believe it is the male's and female's job. Figure 4.25 shows that rresponsibility and general practice for emptying vault.



(a) **(b)**

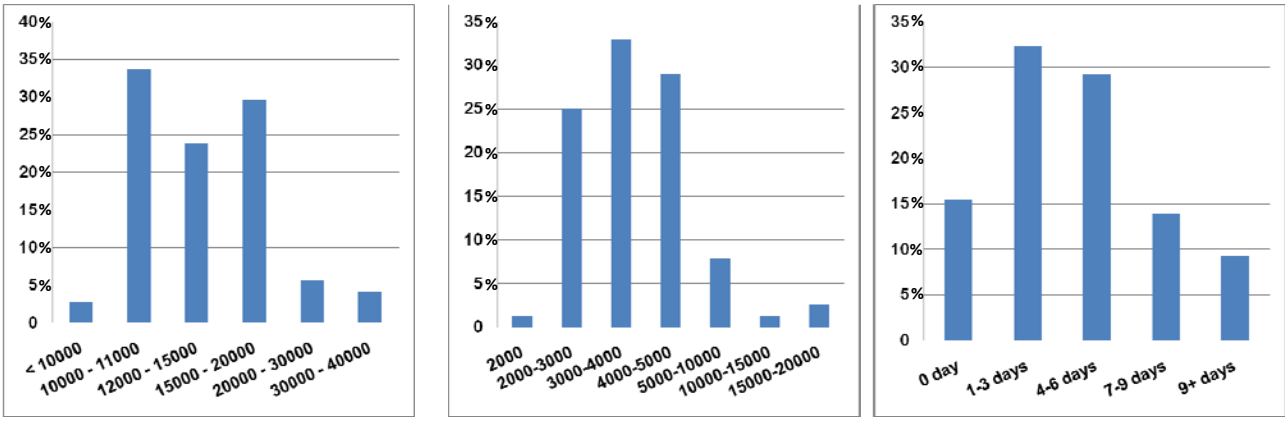
Figure 4.25: Responsibility and general practice for emptying vault (a) Responsibility of vault emptying (b) Generally vault empted by member

In reality 32% female and 7% male doing the empting job and whenever they get time both male and female (59%) of the respondents do the work regularly.

The job is not as hard as it was initially considered to be. It is only a matter of one or two hours work and most users feel that anyone in the family can empty the vault and that gender is not a major issue in this case.

4.2.1.12 Affordability of technology

Affordability of people for EcoSan toilet was determined from the cost of existing sanitation facilities and from the beneficiary contribution to the existing EcoSan toilet. Figure 4.20 showos that affordability of technology considering construction cost sharing, contributing labour cost and proposed cost for EcoSan toilet. Figure 4.26 shows affordability of technology considering construction cost sharing, contribute labour and proposed price.



(a) **(b)** **(c)**

Figure 4.26: Affordability of technology (a) Construction cost of EcoSan toilet (b) Construction cost sharing (c) Contribute labour

Most of the initially piloted EcoSan toilet was 20000BDT and later on the modified design cost 11000BDT and for the both the cases user (around 60%) shared 4000BDT and in addition 4 days labour on average which means total 5000BDT. Considering the benefit 80% user don't think as an expensive sanitation option. Figure 4.27 shows that EcoSan user and none user proposed cost for EcoSan toilet.

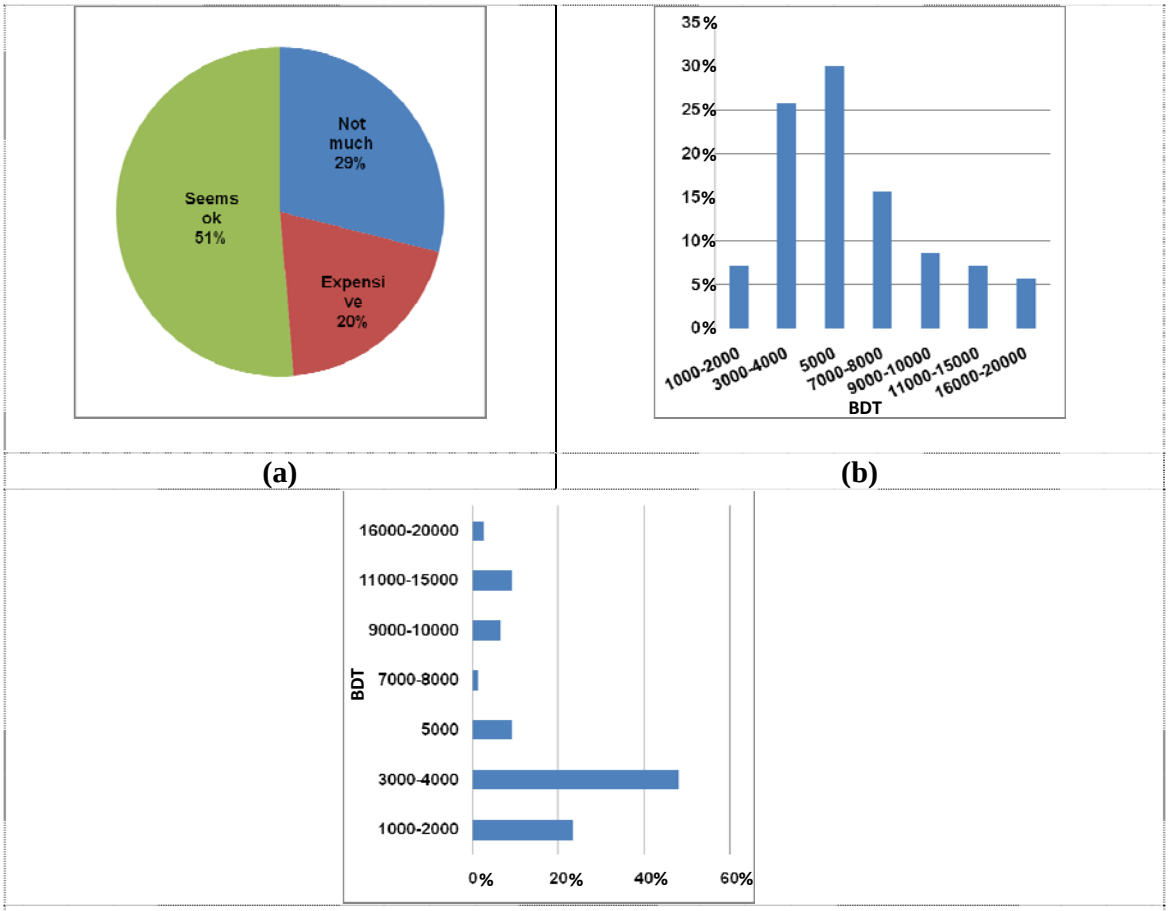


Figure 4.27: EcoSan user and none user proposed cost for EcoSan toilet (a) cost of EcoSan toilet according to user (b) Construction cost without subsidy (c) Non user interested to spend for EcoSan toilet

Considering the affordability 55% user want the same option at 4000-5000BDT and 50% nonuser claim the same at 4000BDT.

4.2.1.13 Availability of construction materials and skilled worker

Availability of construction materials are one of the basic needs for maintenance and promotion of sanitation option. Figure 4.28 shows that availability of construction materials and skilled worker according to user and non user. According to both type of respondent (76%) skilled mason is locally available and around (56%) agreed that except the pan (in case of fibre glass made pan) all construction materials also locally available.

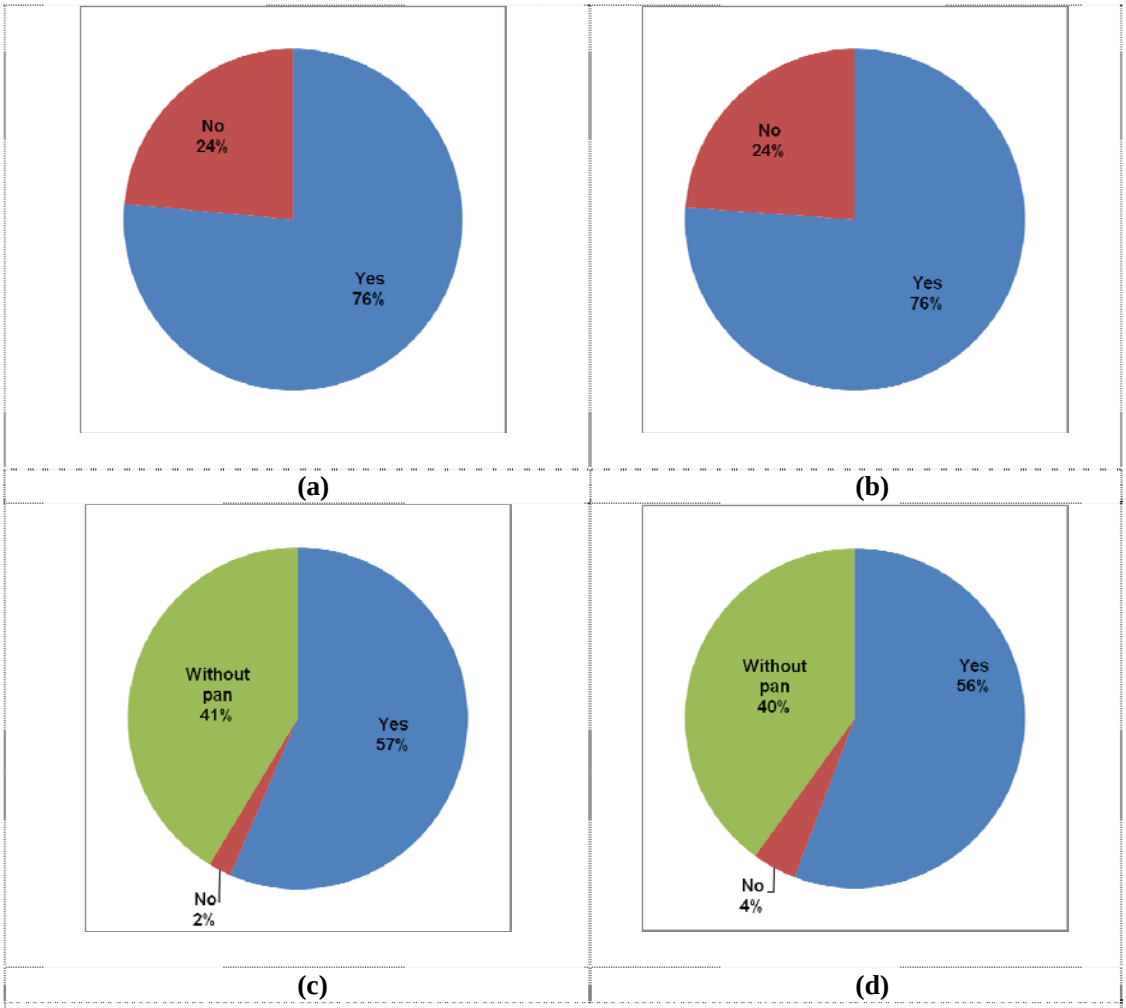


Figure 4.28: Availability of construction materials and skilled worker (a) Availability of skilled masion according to EcoSan user (b) Availability of skilled masion according to non EcoSan user (c) Availability of construction materials according to EcoSan user (d) Availability of construction materials according to non EcoSan user

4.2.2 Institutional and legal aspects of ecosan toilet

Weak, non-existing or sometimes prohibiting legislation on reuse of sanitation products makes it difficult to implement and scale up productive sanitation systems. Ideally, a regulatory framework facilitates the safe reuse of resources from sanitation systems. Catering for nutrient reuse may require changes to existing sanitation, environmental and agricultural policies, or enactment of a new policy. Effective laws and regulations establish both incentives for complying and sanctions for not complying with the requirements.

The Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture (WHO/FAO/UNEP 2006) can be used as a reference when national policies and

legislations are developed. These guidelines aim to protect the health of individuals and communities by recommending safe practice requirements and supporting the development of risk management. It is now high time to put focus on the other aspects of environmental sanitation as defined in national sanitation strategy (GoB, 2005) as the county is approaching towards installation and use of hygienic latrines by all.

It could be necessary to develop public health and agricultural legislation on health barriers along the sanitation chain, from excreta treatment to application of sanitation products, produce restrictions, occupational health, food hygiene and other preventive measures. A legal framework that focuses o desired functions of the sanitation system rather than specific technologies, stimulates innovation, and is not outdated as fast as technical prescriptive regulatory frameworks. This is described by Kvarnström et al. (2011) using Sweden as an example where in 2006 the Swedish Environmental Protection Agency (SEPA) published new national guidelines for on-site sanitation, which focused not on sanitation technology per se but the function of the sanitation technology instead. The Swedish EPA thereby guides the local authorities on what kind of expected results from the sanitation system they should impose on the house owner. The national guidelines especially emphasize the need to reduce the phosphorus loads to the recipient water bodies and the importance of nutrient recycling.

There are several initiative has been taken by different local NGO, International NGO along with government research institute and department. In 2004 JADE first sign memorandum of understanding (MoU) with Bangladesh Academy for Rural Development (BARD) a government institution for piloting EcoSan toilet. GOB has recognized EcoSan toilet as one of the appropriate sanitation options and implemented a project in 2009 to construct 4,498 EcoSan toilets, one for every union throughtout the country (Azad-uz-zaman, et. Al 2011). But, only about 20% Union could come under the installation of the Eco-San toilets. Most of the unions could not install because of insufficient technical knowhow of union authorities (Practical Action Bangladesh, 2011). One House One Farm (Ektee Bari Ektee Khamar) is a project sponsoring Ministry/Division by Rural Development and Cooperative Division, Ministry of Local Government, Rural Development and Cooperatives and Executing Agency Rural Development and Cooperative Division, Ministry of Local Government, Rural Development and Cooperatives with District Administration in particular Deputy Commissioner and his officials. Bangladesh Rural Development Board (BRDB) as the main support agency along with other departments like Co-operatives, Bangladesh Academy for Rural Development (BARD), Comilla, PDBF, SFDF and Rural Development Academy

(RDA), Bogra. Currently JADE-JICA-DPHE running a 3 years from June 2010- September 2013 name "Awareness raising and capacity building on appropriate management of EcoSan toilets in rural areas of Bangladesh" in seven area of Bangladesh. This is actually a joint initiative of government institute, donor and NGO to widely distributed technical guidelines for construction and management, develop proper management system by active CBO, properly preserve the information of benefits and knowledge and experience of EcoSan toilets share through Management information system (MIS).

In this same study in the field level KII was conduct with twelve local representative (member/ chairman) and seven local DPHE personal (sub-assistant engineer) of the same area where the questioner survey conducted. Considering the involvement of the local institution and interest as both the institution is responsible for ensuring sanitation for their area and also yearly they provided sanitation materials (ring and slab for pit latrine option) and for this they have yearly budget. Both the cases local public representative and DPHE personal have ideal about EcoSan toilet and out of seven six sub-assistant engineer of DPHE have technical know how about this toilet and rest one have some knowledge. Figure 4.29 shows the advantages of EcoSan toilet according to public representative and DPHE.

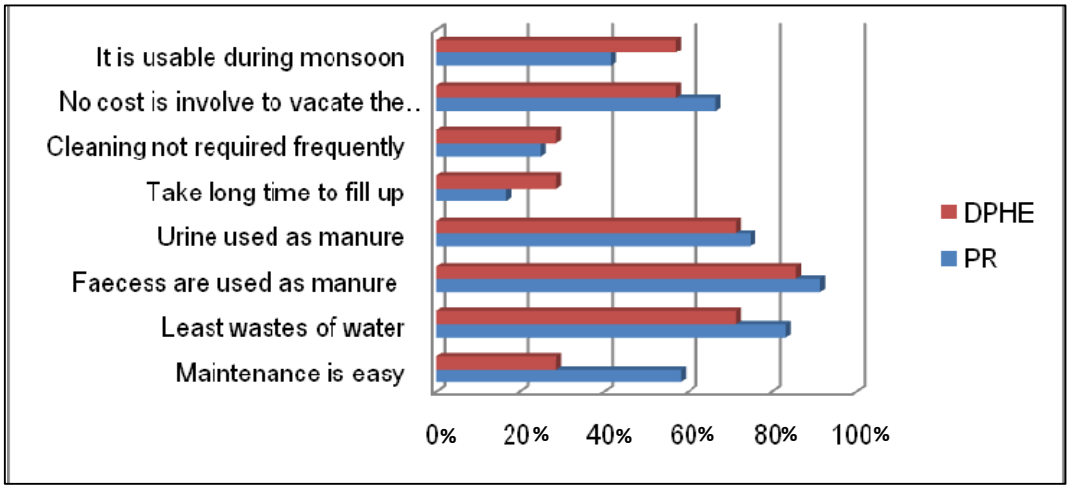


Figure 4.29: Advantages of EcoSan toilet according to PR and DPHE

According to DPHE personal none of the user facing any problem but according to PR four out of twelve believe that user are facing some problem and those are using water, using urine, guest and initially facing problem are the most. Both type of key informant agree that there is good demand of EcoSan toile in community. According to them most of department don't have any idea but public representative (chairman and member) are much aware about it if the toilet is in their working area. About the instruction of local government in 2009

about installing EcoSan all union as demonstration is known to both the key informant. Out of twelve public representatives five mentioned that EcoSan toilet was constructed and according to three DPHE engineer none toilet was installed and rest of the informant informed that they don't know and for the reason they mentioned mainly the fund was allocated in time and there was also lack of skilled mason to construct that type of toilet. Those are installed are mainly installed in the public representatives house and five of them were successful farmer. Most of installed toilets are active only one engineer and one PR informed that toilet are not functional. Out of five PR information two user are not using urine and dry faeces. Although there is a demand of EcoSan toilet in the community only one informant informed that one person seek DPHE technical support to install toilet. Except two engineer of DPHE all informant believe that EcoSan toilet is accept socially and religiously and also there is good demand (95%) of buying product which EcoSan by product. Out of nineteen sixteen believe that EcoSan is environment friendly toilet and according to their recommendation this type of toilet should be in the all HH of community. Four sub assistant engineer of DPHE out of six agree with promote EcoSan with the help of credit with low interest rate, they also agree with that from the ADP this type of latrine can be provided and also all six agree with that same initiative can be taken by using the subsidy for agricultural fertilizer. This group also believe that requirement of land to install latrine and regular need of ash is hindering the scaling up and DPHE need to take the leading role to promote it but public representative believe that local government can take the leading role than DPHE.

4.3 Financial and economic aspect of ecosan toilet

4.3.1 Introduction

Financial and economic analyses are crucial in planning and delivering affordable and sustainable sanitation services. These analyses enable assessment of intervention efficiency for different sanitation options. Financial analysis focuses on the cash costs and cash returns of sanitation spending, while economic analysis also includes the broader societal costs and benefits, including both cash and non-cash. These various analyses assist decision makers to maximize the return on limited spending on sanitation programs, enabling the selection of appropriate approaches for a range of socio-economic, climatic, geo-physical and cultural contexts.

Furthermore, economic benefits can valuably support sanitation advocacy efforts, with the aim of increasing political support and household/community knowledge to lead to greater prioritisation of sanitation and hygiene.

An established framework exists for conducting financial and economic analyses, enabling the comparison of sanitation interventions with respect to monetary as well as non-monetary outcomes, and from several perspectives. Outcomes of sanitation intervention are measured in monetary units and give rise to cost-benefit analysis (CBA), while measurement of impacts in physical units (e.g. health gains) gives rise to cost-effectiveness analysis (CEA). Where sanitation projects achieve similar or identical outcomes, cost comparison helps identify the most viable option.

Costs and financing play an important role in planning sanitation schemes and selecting appropriate technologies. A few studies have been done to assess the feasibility aspects of EcoSan toilets and to compare them to other toilets, but as there are many different types and variations of toilets and the cost of materials vary according to time and place, a direct comparison of results from different studies is difficult.

Furthermore, while construction costs may be fairly straight forward, operation and maintenance costs and benefits are difficult to estimate. This section summarises some of the studies related to the financial aspects of EcoSan toilets and presents a financial analysis for EcoSan toilets in Bangladesh.

Financial analyses assess the costs borne by the end users and the direct revenue from the project, while economic analyses also assess the overall costs and benefits to the society as a whole. The analysis is done over the expected lifetime of the facilities. There are several methods for financial analysis. These include Net Present Value, Cost-Benefit Analysis, Least Cost Analysis and Cost-Effectiveness Analysis. (Rockström et al. 2005) modified the ‘sanitation ladder’ originally produced by van de Guchte and Vanderweerd (UNEP, 2004) by including the cost of EcoSan toilets within it in order to compare the cost of various methods of conventional and ecological sanitation. Based on secondary information from several pilot projects, the analysis showed that in the rural context, conventional systems; with EcoSan systems. In rural areas with on-site sanitation systems, conventional systems with septic tanks

cost 8 to 10 times more and pour-flush latrines cost four to eight times more than EcoSan toilets.

4.3.2 Economic analysis: elements and indicators

Economic analysis requires the valuation of economic costs and benefits. It is limited to the availability of reliable data.

Important economic impacts are:

i) Labour (economic cost: household labour for investment, operation and maintenance; economic benefit: economies of time).
ii) Reuse of nutrients, water and energy.
iii) Health impact (avoided deaths and avoided morbidity).
iv) Perceived improvement of living quality such as privacy, dignity, convenience and status.
v) Environmental impact such as reduced water pollution or increased attractiveness for tourism.

Economic analysis of selected factors (e.g. reuse of nutrients) can use the long run household costs and benefits per person served per year, as% of local or regional per capita household income. Only larger programmes will justify research and full cost-benefit analysis. In these cases, the ratio of total benefits divided by total costs or the internal rate of return can provide additional information for policies and decisions.

Financial and economic analyses are key tools, which provide practical information and guidance on sanitation options which perform well with respect to financial and economic criteria. The narrower cost-effectiveness analysis (CEA) can be used if valuation of benefits is difficult; while cost-benefit analysis (CBA) is a broader method that combines multiple impacts of improved sanitation in a single framework expressed in monetary units (e.g. economic gain per unit of investment).

In providing the results of financial and economic analyses to potential users, traditional measures such as the benefit-cost ratio (BCR), internal rate of return (IRR), or net present value (NPV) – which summarize succinctly the efficiency aspects of alternative programs – should be supplemented with easy-to-understand and relevant information that provide answers to key questions of target audiences. Net Present Value (NPV) is an aggregated value used in whole life cycle analysis to measure the resultant financial and economic

benefit of a good or service when all costs and benefits are taken into consideration. A positive NPV indicates a net benefit and a negative NPV a net loss (WSP 2009).For example, a family may be considering a sanitation upgrade, but does not know if the more expensive models are worth the higher price. Therefore, financial and economic analyses need to provide the decision maker with very specific information about the real costs and durability of different technologies - from the decision maker perspective (e.g. household). This means not just knowing the purchase price, but also operation and maintenance costs, the economic life-time of the technology and the associated additional (direct or indirect) benefits to the user such as health, comfort and protection of the local environment (SuSanA 2011).

4.3.3 Cost of EcoSan toilets

The cost components that are normally considered in financial analysis are as follows:

i) Investment or capital cost
ii) Running or recurring cost
iii) Opportunity cost of capital

In Bangladesh, most people tend to think that EcoSan toilets are more expensive than pit latrines or double pit pour-flush latrines. The initial cost of EcoSan toilets is slightly higher than simple pit latrines. The slightly higher initial cost is generally due to the need to construct two water-tight vaults and urine collection system above ground level.

Furthermore, almost all of the EcoSan toilets that have been constructed so far in Bangladesh have been built with a brick and cement super structure which is normally more durable but also more expensive than those made from local materials such as bamboo and straw. Therefore, the cost of EcoSan toilets in Bangladesh seems a bit high because it generally includes the cost of a relatively expensive superstructure.

4.3.4 Financial benefits of EcoSan toilets

Unlike conventional toilets, urine diverting EcoSan toilets generate benefits, primarily in the form of organic fertiliser that can replace chemical fertilisers. Experiments done by different research organization (e.g. BARD) have shown that urine can replace the use of chemical fertilisers and it can also significantly improve the quality of compost if it is added to compost piles. When users of EcoSan toilets were asked if there was any reduction in use of chemical fertiliser after constructing the EcoSan toilets, about half of the respondents said “yes, there is a reduction”. But they could not answer about the amount saved. This may be due to the fact that Bangladeshi farmers do not usually keep any records of income and

expenditures. Therefore, although many farmers see a financial benefit from using the EcoSan toilets, the benefits are difficult to quantify based on their experience.

Financial benefits can be estimated based on the nutrients present in the urine. This study estimates that the financial value of nutrients and as pesticide in urine produced by one family is equal to BDT. 2500 per year. Figure 4.30 shows that monetary benefit from dry faeces and urine as fertilizer and insecticide.

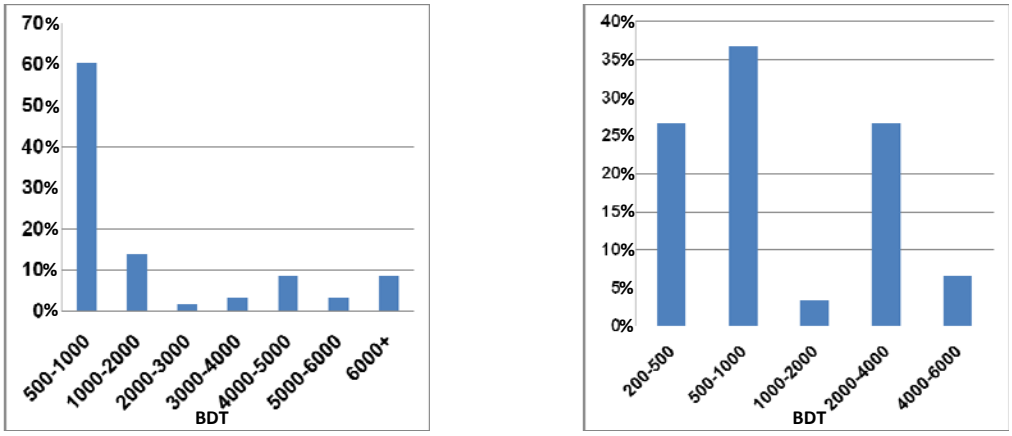


Figure 4.30: Monetary benefit from dry faeces and urine as fertilizer and insecticide
(a) Monetary benifit from faeces fartilizer (b) Monetry benifit from insecticide

4.3.5 Financial analysis

On average, an adult produces 550 litres of urine annually. The volume of the urine contains four kg of nitrogen, 400 grams of phosphorus and one kg of potash. Faeces have similar nutrients and effects in soil as that of compost. The nitrogen, phosphorus and potash contents of urine and faeces increase productivity of crops and vegetables.

Thus they bear certain financial values and hence, a financial analysis has been carried out to examine financial viability of an EcoSan toilet and the pay-back period. The following key assumptions are made for financial analysis:

i) The construction time for EcoSan toilets is less than one year.
ii) All costs and benefits are expressed in 2010 prices.
iii) The generation of benefits are the values of urine and faeces collected in the toilet.
iv) Financial analysis of the toilet is carried out over a period of 20 years.
v) The residual value of the civil structure of the toilet is assumed to be 60% of initial cost in the twentieth year.

4.3.6 Project costs

4.3.6.1 Fixed investments

The total construction cost, based on market prices in 2010, is estimated at 11,000 BDT.

4.3.6.2 Operation and maintenance costs

The operation and maintenance costs of the toilet include operation costs, depreciation and salvage value of the toilet. The operation costs include the cost of additives and labour wages for removing faeces from the tank of the toilet. Every time after use of the toilet certain additives (ash or rice husk) should be sprayed. The total cost of the additives is estimated at BDT. 200 per annum. In addition, faeces should be removed from the tank of the toilet every sixth months. The total cost of the activities is estimated at BDT. 150. The depreciation costs include the depreciation value of the toilet as a whole. The depreciation value is estimated at two% of the total investment cost. The estimated value is BDT. 220. The salvage value of the infrastructures in the twentieth year of operation is estimated at 60% of the present value of the infrastructures.

4.3.7 Benefits from ecsan toilet

4.3.7.1 Benefits from the use of urine as fertilizer

An average person produces 550 litres of urine per year. The volume of urine contains, on average, four kgs of nitrogen, 400 grams of phosphorus and one kg of potash. Thus an average family of six members produces 24 kgs of nitrogen, 2.4 kgs of phosphorus and six kgs of potash. The average prices of nitrogen, phosphorus and potash on the market in 2010, as calculated based on their contents in urea, DAP and muriel of potash are BDT 20/Kg, BDT. 40/Kg, and BDT. 18/Kg respectively. Therefore, the total annual value of urine produced by an average family is estimated at BDT. 684.

4.3.7.2 Benefits from the use of faeces as compost

Annual production of soil conditioner (from faeces) from an EcoSan toilet is estimated at 100 kgs. The value of soil conditioner (compost) in Bangladesh is estimated at BDT. 5/kg. Therefore, the annual total estimated value of the soil conditioner is BDT. 500.00.

4.3.8 Financial evaluation

Financial analysis considers the costs and benefits for individuals rather than society as a whole. Therefore, the benefits to society due to a clean and hygienic environment are not

considered. The general approach used for financial evaluation in this study follows conventional financial appraisal methodology for project schemes. The methodology takes into account factors such as initial costs, maintenance costs and potential benefits in terms of savings and residual value of the project investments. Annual costs and benefit streams are considered for the next 20 years. Costs and benefits are estimated at market prices which include government taxes, duties and subsidies.

Two indicators of financial viability, namely: 'Pay Back Period' and Financial Internal Rate of Return (FIRR), are calculated to test the viability of the project. The 'Pay Back Period' indicates when the investors will obtain their investments from the operation of the project. The FIRR is the discount rate at which the present value of costs is equal to the present value of benefits. If it exceeds the required rate of return, then the project is considered. The 'Pay Back period' for investment in an EcoSan toilet comes to 5.09 years, i.e. the investor in the EcoSan toilet gets back all his investments (BDT 11,000) within a period of just over four years. The calculated FIRR is 8.11%. The investment is worth it since the present average interest rate for a commercial bank home construction loan is 7.50%. This means that the family who construct an EcoSan toilet from a bank loan will be able to pay the loan if the family sells urine and soil conditioner at market value.

In case of not considering any cost sharing the investment cost will be 15,000 BDT and according to the user life time of eocsan toilet is 20 years. Considering all the cost of O&M and benefit of different system from the two figures in Appendix G it is clearly represent that breaking point. In this case of ecosan toilet it is 10.5 years and for others system has the recovering option. In twenty years period except ecosan toilet and Septic tank system, twin pit latrine, pit latrine with ring and slab and pit latrine without ring has to be construct newly for three times, four times and seven times respectively without considering natural flood occurs every year. This is evident that among the considerable improved sanitation option ecosan toilet is can be claimed as one sustainable option considering the context of Bangladesh.

Table 4.24 shows the comparison of installation cost, O and M cost and benefit of resource utilization for different types of toilets.

Table 4.1: Comparison of investment installation cost, O and M cost and benefit of resource utilization for different types of toilets

	EcoSan Toilet		Septic tank system		Twin pit latrine		Pit latrine with ring and slab		Pit latrine without ring	
	High	Low	High	Low	High	Low	High	Low	High	Low
Installation cost										
Construction cost (Project cost)	25,000	11,000	45,000	25,000	12,000	5,000	8,000	4,500	3,000	
Cost sharing	5000	3000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Labour Contribution	1000	1000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
O and M cost										
Maintenance cost	200	200								
Desludging cost	n/a	n/a	500	500	500	500	500	500	500	500
Benefit of resource utilization										
Dry feces as fertilizer	500	350	0	0	0	0	0	0	0	0
Urine as fertilizer	1000	684	0	0	0	0	0	0	0	0
Urine as pesticide	1000	500	0	0	0	0	0	0	0	0

4.3.9 Economic costs and benefits of sanitation

Economic versus financial costs: while financial costs are those that need to be financed with cash, economic costs also include in-kind contributions of labour and materials. Together, financial and non-financial costs reflect the full 'opportunity' cost of resources employed: that is, the opportunity lost from using cash, labour effort and materials in sanitation rather than in another productive use.

The importance of this distinction is that financial costs to households can be reduced by encouraging in-kind contributions of household members, and hence not only increasing participation (which is likely to increase use of sanitation, and make it easier for the household to maintain and repair their sanitation facility), but also reducing the requirement for cash funds. Populations, especially in rural areas, have access to materials such as sand, stones, wood or plant materials for latrine construction. Experience has shown that family members are willing to contribute their time and effort as substitute for local workmen who must be paid in cash. Also, for toilets with re-use options, or simply pit emptying, there will be costs for the work involved, transportation and storage, whether covered through cash payment or in-kind contribution. The most common approach for 'shadow price' valuation of own labour is the price of local non-qualified labour (SuSanA 2011).

4.3.10 Economic benefits of sanitation

In evaluating and comparing sanitation solutions, it should be noted that many benefits are common to re-use as well as disposal-oriented sanitation options. For example, sanitation improvements that focus exclusively on the condition of the latrine, but not on what happens to human excreta after storage, can also have major health benefits, especially when improved hygiene practices are adopted. In developed countries, well-designed pit latrines with no intended excreta re-use may have some water resource and environmental benefits when compared with open defecation practices and poorly planned pit latrines (e.g. near a water source). Furthermore, household members who have access to a private pit latrine will enjoy welfare gains (privacy, convenience) – especially women and the elderly – and users will spend less time accessing the toilet when compared with those practicing open defecation or using a shared toilet.

The economic advantages of sustainable sanitation options compared to unimproved sanitation options (e.g. pit latrines without a slab; wastewater collection without treatment)

focus on better environmental and health performance. Sustainable sanitation options reduce release of pathogens from human excreta to the environment through leaking pit latrines, excreta flushed directly into water bodies, or incompletely treated wastewater. Human excreta in groundwater or surface water have potentially major implications for health and affect productivity or usability of the surface water body, e.g. for fishing or domestic water supply.

A further financial or economic gain can be realised with re-use-oriented sanitation systems: human excreta fertiliser and biogas. Human excreta can be used as fertilizer and soil conditioner (after composting). Based on the local price of mineral fertilizers, the estimate of the economic value of the nutrients (N, P, and K) contained in urine and faeces shows that a person produces fertilizer worth between BDT. 5 and BDT. 10 according to the respondent.

The use of human excreta as fertilizer is especially relevant in land-locked countries where the cost of imported fertilizer is significantly higher than the world price; and given the increasing scarcity (and price) of phosphorus, the re-use value of human excreta also increases.

Available estimates of economic benefit of excreta re-use in the literature are largely based on hypothetical returns using expected excreta production, quality and prevailing market prices, as opposed to actual household economic impacts (Rockström et al. 2005; Oldenburg 2007; Renwick et al. 2007). Established markets for trade in human excreta are not yet documented, and it is not clear whether the same nutrient or fuel volume/weight would receive the same prices as, say, chemical fertilizer, conventionally produced compost or liquefied petroleum gas (LPG).

Many projects promoting excreta re-use as fertilizer or soil conditioner involve own-use of the products by the household. So far, few data exist to suggest the actual financial or economic value of these products. In the absence of in-depth research, a careful use of shadow prices is most appropriate to reflect the upper limit of economic value (i.e. equivalent fertilizer saved or increased crop or vegetable production). If the own-use of excreta products fully coincides with nutrient requirements of crops, nutrients can be valued at shadow prices of mineral fertilizers on local markets minus the value of additional own labour required. If

nutrients are transferred to other farmers, the effective payment (price) for transaction can be included in the financial analysis.

Other economic benefits which need to be assessed:

i) Water savings can be valued at the cost of provision of additional drinking water.
ii) Treated wastewater or grey water may be re-used for irrigation or aquifer augmentation.
iii) Households who re-use their waste do not need to pay for pit emptying services or build a new pit when the old one is full.

4.4 Technology and operation aspect

4.4.1 Introduction

These aspects reflect the functionality through checking major components of EcoSan latrine (stair, door, floor of the toilet, sitting pedestal, feces hole, lid of feces hole, urination place, urine drain pipe, connection between urine drain pipe and container, urine container, anal washing place, anal washing drain pipe, evaporation bed, roof, gas pipe, feces vault, heat panel and surrounding mortar of heat panel). The ease with which the system can be constructed, operated, and monitored using the available human resources (e.g. the local community, availability of skill mason) and availability of construction materials.

4.4.2 Hardware components for implementation and construction:

Typical design of Eco toilet

Components of EcoSan toilet

Toilet superstructure

Stair and Door shutter

Roof

a. Inside floor and squatting pan

b. Pan cover

c. Feces collection tank (vault/chamber)

d. Vent pipe

e. Urination place, pipe network, collection tank and system

f. Feces emptying door/heat panel

g. Anal cleansing place, pipe network and drainage

h. Evaporation bed

Provision of hand-washing and menstruation Hygiene management facilities

Odors and flies

Absorbents agents

4.4.3 Typical design of Eco toilet

Eco-toilet safely recycles excreta resources (plant nutrients and organic matters) for crop production in such a way that the use of non-renewable resources is minimized. Instead of polluting the environment, human urine and feces are used to improve soil structure and nutrient quality.

Figure 4. 31shows the typical design of Eco toilet and its different component.

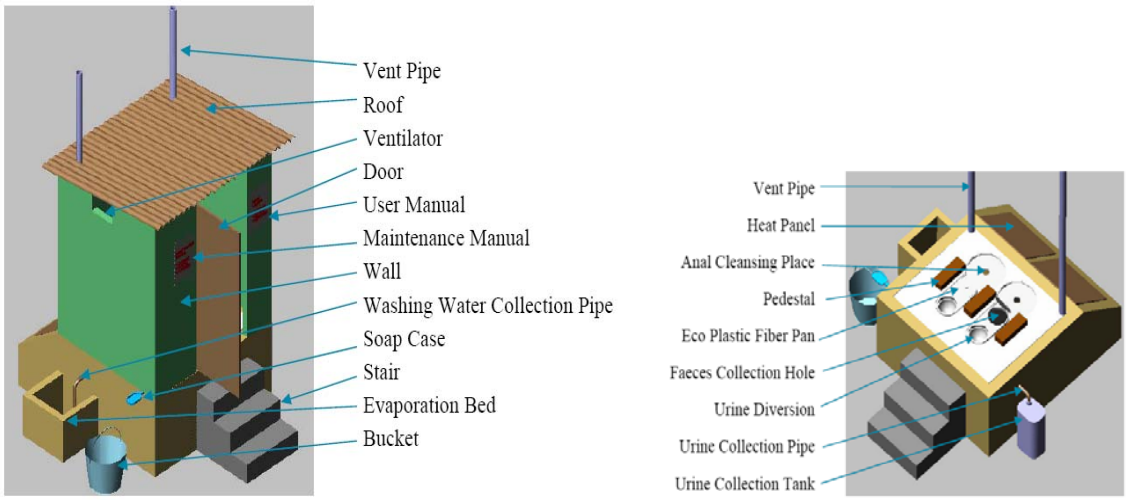


Figure 4. 31: Typical design of Eco toilet *source: PAB*

4.4.4 Components of EcoSan toilet:

4.4.4.1 Toilet superstructure

4.4.4.1.*i Stair and Door shutter*

Toilets are places of privacy; the toilet user must feel safe, comfortable and unwatched. During field visits, (out of 87 toilets) 22 toilets were found without a proper door. Instead, these EcoSan toilets used a curtain made of CI sheet or plastic. Although these allow for some privacy, they cannot be locked and lead to potential embarrassment for the users. To ensure acceptability of EcoSan technology, it is better to use a solid door made of wood or metal. Figure 4.32 shows that stair and door shutter condition of surveyed EcoSan toilets.

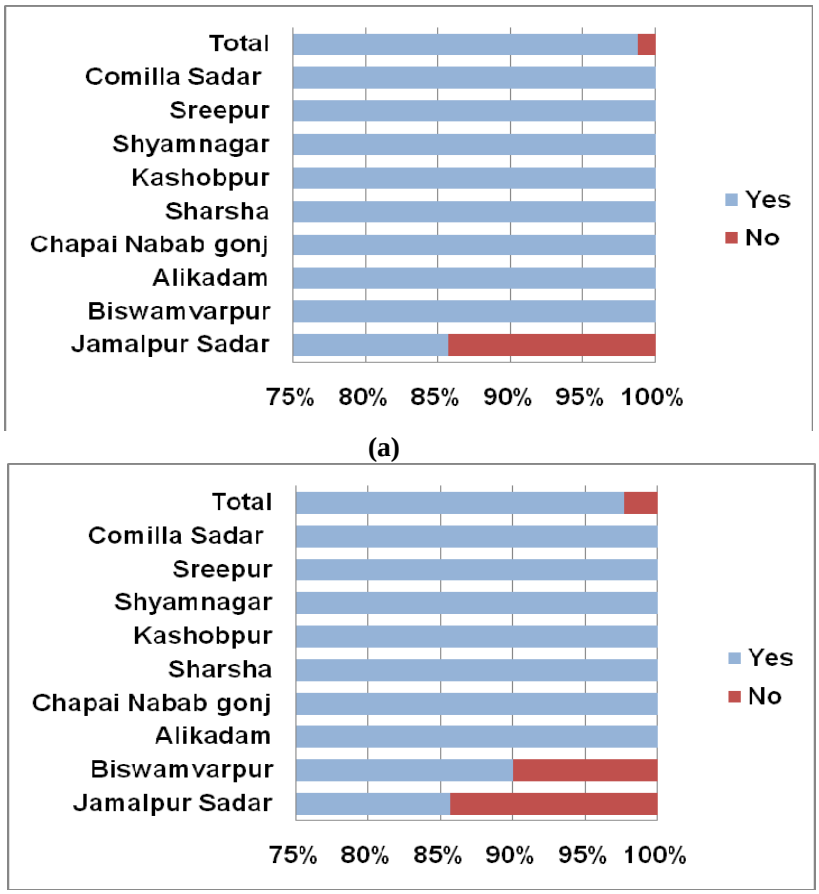


Figure 4.32: Stair and Door shutter condition of toilet (a)Stair condition (b) Door condition

The comparative scenario through above figures in Jamalpur Sadar Upazila around 15% toilet access stair is not in good condition. 10% of Biswamvapur and 13% of Jamalpur Sadar Upazila door found with some problem like corrosion.

4.4.4.1.*ii Roof*

EcoSan toilets are, at their essence, dry toilets: the feaces vault, urine tank and inner toilet area should be completely watertight. However, during field observations, all 87 toilet have roof and among them in Sreepur (90%), Shymnagar (20%) and Biswamvapur (20%) toilet have some leaky roof. Any leakage in the roof may lead to dampness in the vaults and generally create an unpleasant or smelly environment within the toilet room. Figure 4.33 shows that the roof condition of survey toilets.

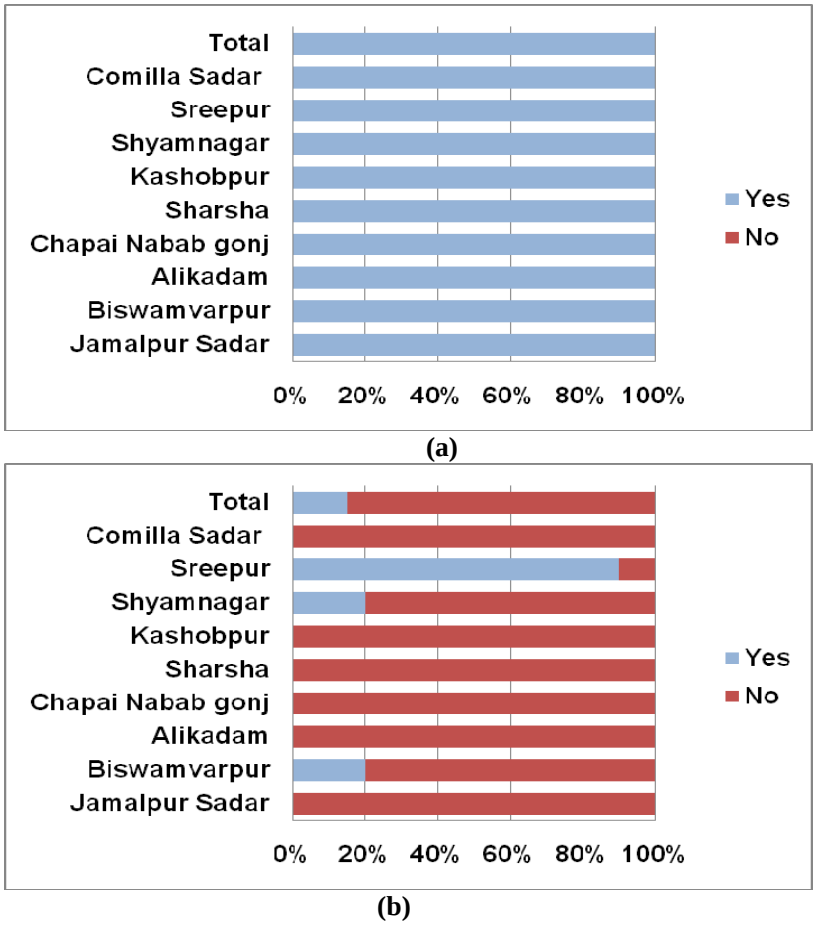
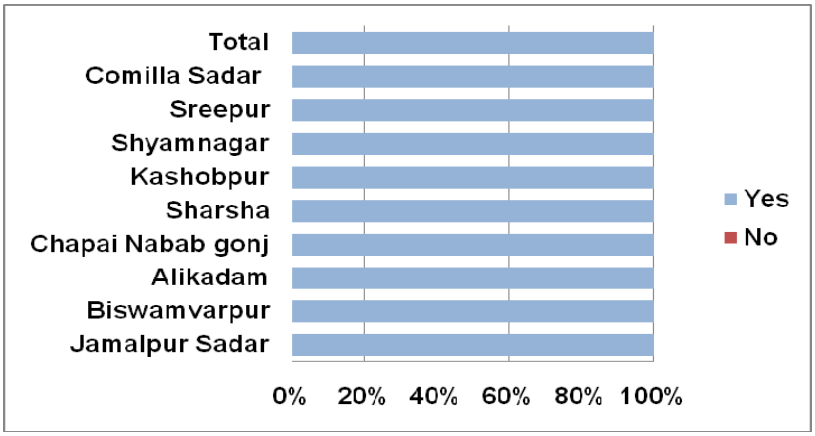


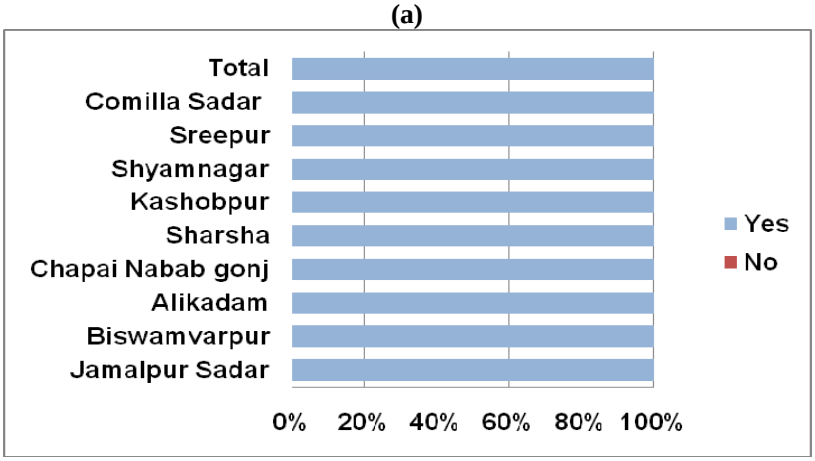
Figure 4.33: Roof condition of toilet (a) Roof (b) Rainwater comes in through roof

4.4.4.1.*iii* *Inside floor and squatting pan*

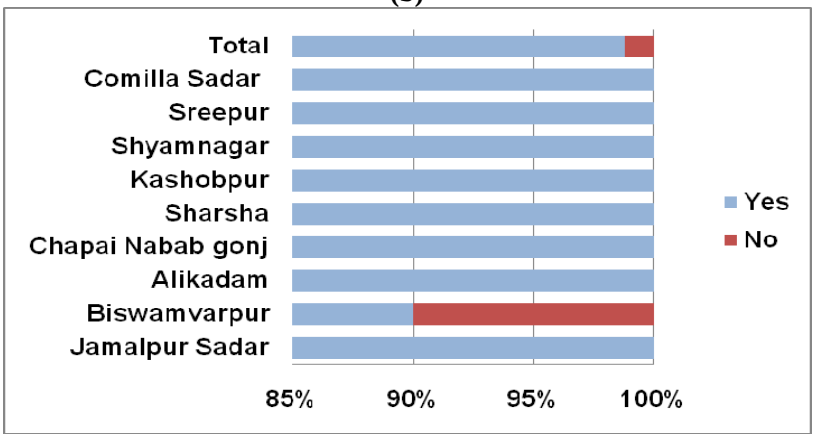
Pan is the major component of EcoSan toilet as it diverts the urine and feces for separate collection. The pan used in EcoSan is quite different from the usual pan with separate holes for urine and feces. Several types of pans are available in Bangladesh. Some of Squatting pan are made of Cast in-situ type especially made urine diverting pans are not available in the market; pans can be cast in-situ during construction. This is done simply by making separate holes for feces and urine during concreting of the vault slab. Another type is Fiber glass pan but as it is made of fiber glass it is lighter and looks more attractive. Figure 4.28 shows that inside floor, sitting pedestal and feces hole condition of survey toilets.



(a)



(b)



(c)

Figure 4.28: Inside floor, sitting pedestal and feces hole condition of toilet (a) Inside floor (b) Sitting pedestal condition (c) Faeces hole condition

It is evident from the Figure 4.28 that, inside floor and sitting pedestal is quite satisfactory in all nine areas but 10% toilet's feces or squatting hole of the Biswamvapur found with some problem.

4.4.4.1.*iv Pan cover*

Pan cover is used in a dry EcoSan to cover the hole in the pan leading to the vault to prevent fly breeding and avoid water getting into the vault. It also helps in controlling odor from vault. The lids may be made of cement, metal, PVC and plastic. A small hook can be used to open and close the lid. Figure 4.29 shows that pan cover condition of survey toilets.

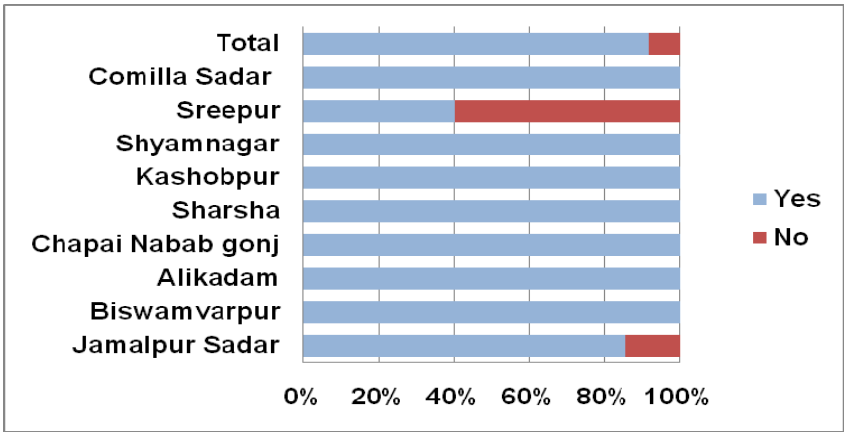


Figure 4.29: Pan cover condition of toilet

The comparative scenario showed in Figure 4.29 that most of the toilet in seven areas has proper lid or pan cover and some different scenario found in Sreepur and Jamalpur area. Only 40% has proper lid is available in Sreepur and 83% in Jamalpur.

4.4.4.1.*v Feces collection tank (vault/chamber)*

The feces collection tank or vault is designed for a HH size of 6. It is generally constructed above the ground. There may be one or two vaults in a dry EcoSan toilet. In a single vault EcoSan toilet, a plastic container is placed inside the vault to collect feces but most common toilet is double vault is made of brick with water proof plaster coated inside the vault.

Most EcoSan toilets built so far have two vaults, each with its own seat riser or squatting slab or with a movable device. The advantage with the double-vault design is that each vault is used alternately for a certain period. When the first vault is full it is left dormant and the second vault is used. The contents of the dormant vault are emptied when the second vault is nearly full. The assumption is that after a specified period (6–12 months depending on climate) without new faecal material added, the contents of the dormant vault should be safe to handle. A single vault toilet with two or more moveable containers would offer the same advantage. For EcoSan systems with communal management moveable containers probably

offer a more rational solution than fixed vaults or processing chambers. Figure 4.30 shows that feces chamber/volt condition of survey toilets.

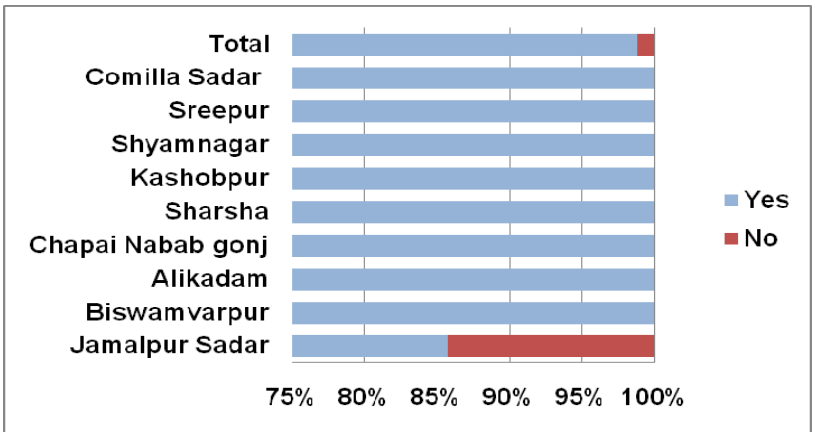


Figure 4.30: Feces chamber/volt condition of toilet

Figure 4.30 shows that out of nine surveyed areas only in Jamalpur 15% toilet's vault are not functioning properly. Water leaking due to construction fault or water proof layer is not working properly is the main reason.

4.4.4.1.*vi Vent pipe*

The vent pipe is made of PVC and has a diameter of 75mm with cowl on top. It is provided for air circulation inside the feces chamber in order to reduce odors inside the latrine. The vent pipe should rise above the roof level of latrine.

Ventilation serves several purposes: it removes odour, it dries out the contents and, in composting toilets, provides oxygen for the decomposition process. The need for a vent pipe is determined by climate, wetness of the input into the processing chamber and standard desired. (With a well-functioning vent pipe from the processing chamber, the toilet/bathroom can be completely odour free, as air from the room is evacuated via the drop hole in the seat-riser/squatting-pan.) A vent pipe should have a diameter of 10 – 15 cm. The pipe should be as straight as possible as bends reduce draft, and reach 50–90 cm above the roof. Composting is basically an aerobic process. Many of the microorganisms responsible for the decomposition need oxygen. Air must therefore be brought into the pile. Aeration can also be accomplished with the addition of a bulking agent that creates air pockets inside the pile. Figure 4.31shows that the ventilation pipe condition of survey toilets.

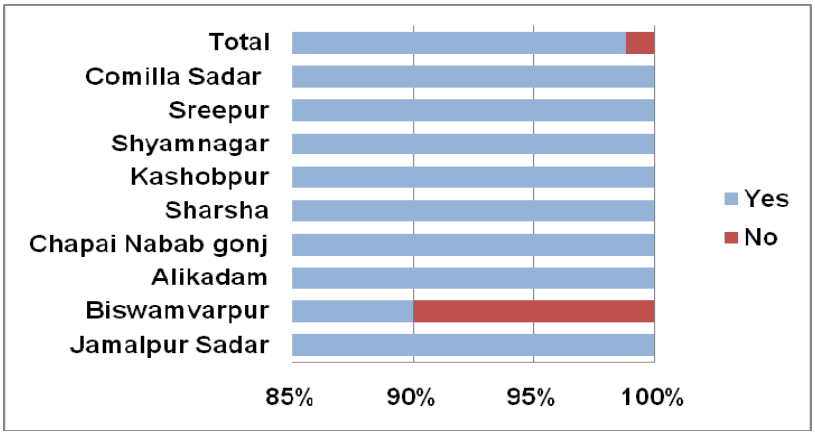


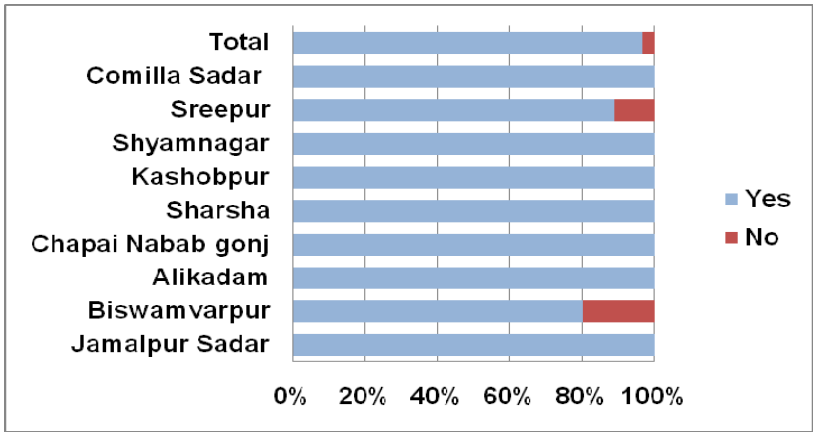
Figure 4.31: Ventilation pipe condition of toilet

The comparative scenario showed in above Figure 4.31 that only in Biswamvarpur area one out of ten surveyed toilets found that ventilation pipe not working properly or broken but rest other area's toilets found in good condition.

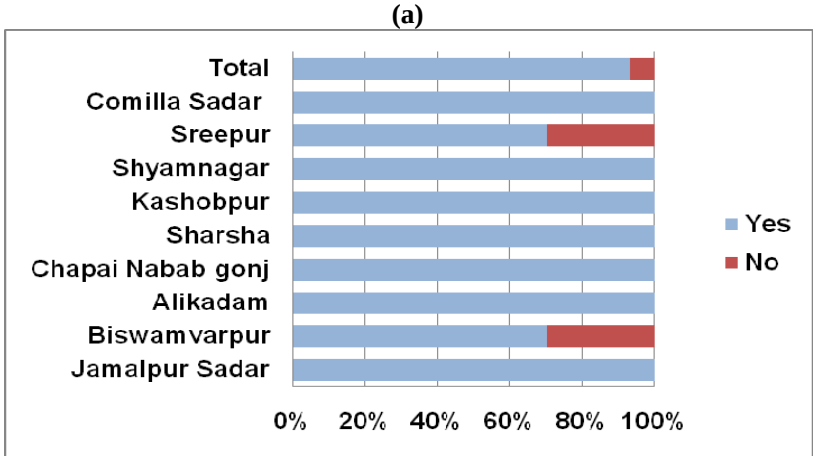
4.4.4.1.*vii Urination place, pipe network, collection tank and system*

Both for the fiber pan and cement pan Urination place is the urine pipe consists of a 50 mm diameter PVC pipe. It is connected to the urine collection tank from urine diversion hole of pan. Urine pipe should be concealed into the plastic container or jerry can cover for safety. Urine collection tank is usually a plastic container of 100 liters capacity. It must have air tight cover to prevent the loss of nutrient in the urine. In the container, the urine pipe should be dipped in the urine up to one fourth the container height in order to avoid splashing of urine and odour problems.

The urine pipe consists of a 50 mm diameter PVC pipe. It is connected to the urine collection tank from urine diversion hole of pan. Urine pipe should be concealed into the PCC of the chamber cover for safety. Urine collection tank is usually a plastic container of 15-20 liters capacity. It must have air tight cover to prevent the loss of nutrient in the urine. In the container, the urine pipe should be dipped in the urine up to one fourth the container height in order to avoid splashing of urine and odor problems. Figure 4.32 shows that the condition of all components urine diversion and drainage system survey toilets.



(a)



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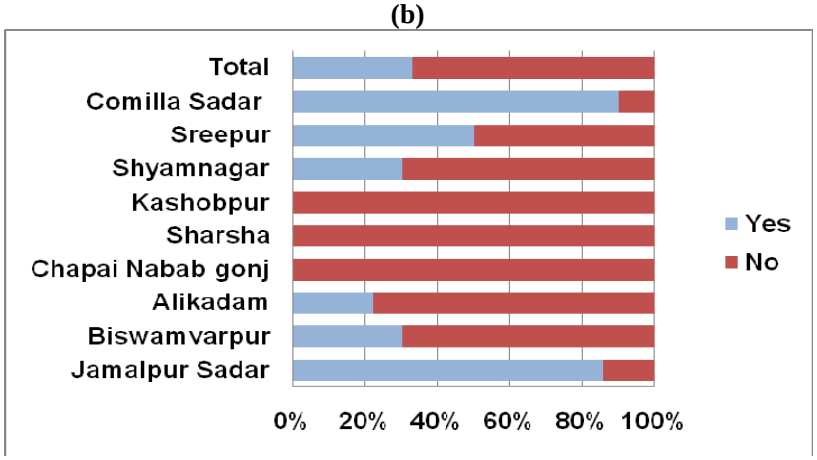
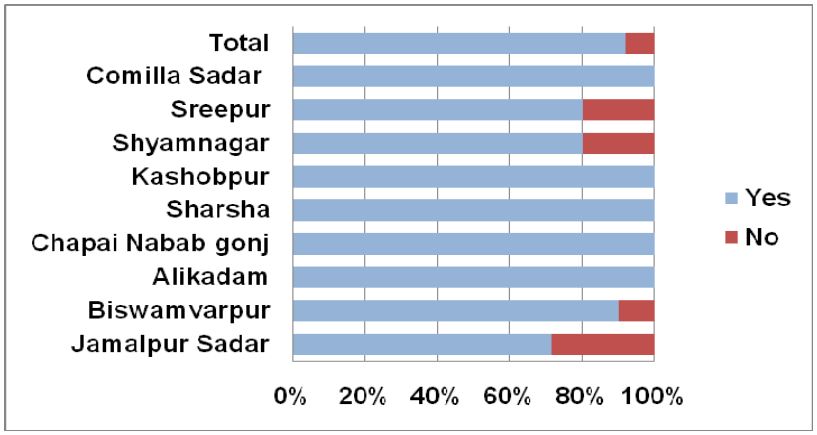


(c)

Figure 4.32: Condition of all components of urine diversion and drainage system toilet (a) Urination place (b) Urine drain pipe (c) Leak in urine drain pipe



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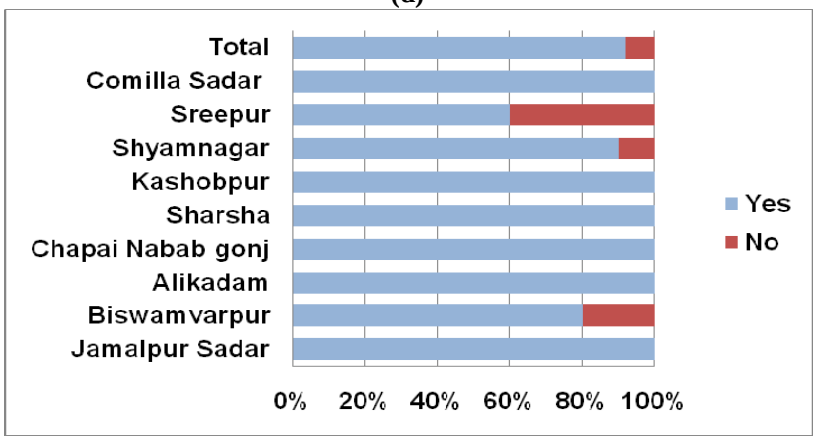


(e)

Figure 4.32: Condition of all components of urine diversion and drainage system toilet (d) Urine container (e) Urine drainage system

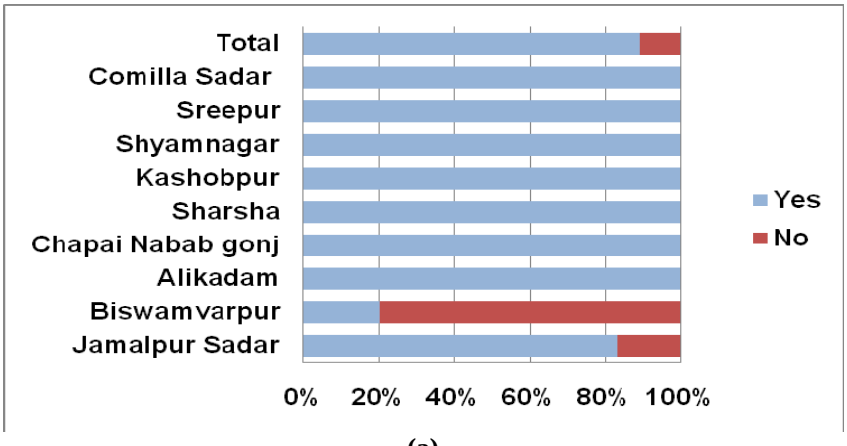
From the above figure 4.32 it is found that in Sreepur (10%) and Biswamvapur (20%) urination place is not found satisfactory. Among all the surveyed toilet 25% of both the area Sreepur and Biswampur don't have drain out urine pipe is not in proper place. Out of nine survey area in six area urine drain out pipe found leaks which create bad environment. Among them in Commila Sadar and Jamalpur Sadar have the highest number (around 82%) of pipe have leak. To collect urine in a jerry can is common design for all type of model. In four areas Sreepur (20%), Shymnagar (20%), Biswamvarpur (10%) and Jamalpur Sadar (23%) toilet don't have proper jerry can to collect and preserve urine. Overall the urine drainage system is not found satisfactory in Sreepur (40%), Shyamnagor (10%) and Biswamvarpur (20%).

4.4.4.1.*viii Feces emptying door/heat panel*

Each feces vault should have an opening for emptying the vault. The size of opening should not be less than 30 cm in length and breadth. Concrete slab, slate, wooden planks, or transparent PVC sheet can be used for shutting the opening. CI sheet cover is most common in Bangladesh. Surrounding of each heat panel air tight by mortar is strongly needed.

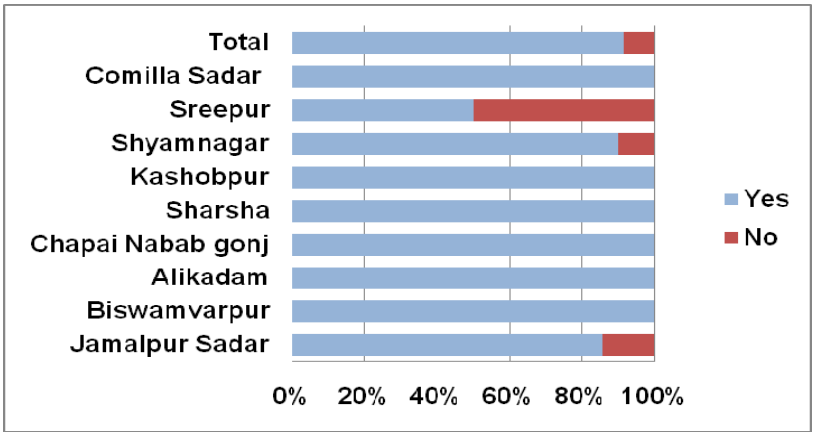
Solar heaters can be fitted to the processing chambers of the toilet to increase evaporation. This is more important in humid climates and where urine and water are mixed with the feces. It is also more important in a system based on dehydration than in one based on decomposition.

The main purpose of the solar heater is to increase evaporation from the material in the processing chamber. It is also likely to slightly increase the temperature of the pile in the chamber and there are indications that pathogen destruction is faster in solar heated than in non-solar heated chambers. The increase in pile temperature is, however, unlikely to be high enough for high-temperature composting. The solar heaters used in some of the EcoSan toilets described in the previous chapter consist of a black-painted metal sheet covering the part of the processing chamber exposed to the sun. This metal sheet may also acts as an access lid to the processing chamber. The solar heater must be fitted so that it prevents water as well as flies from entering the processing chamber(s). It should be tight enough to prevent air leakage. Figure 4.33 shows that the heat panels condition of survey toilets.

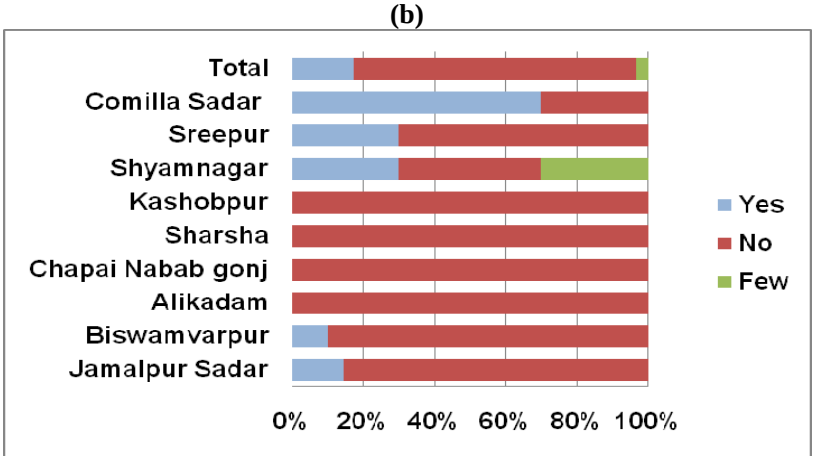


(a)

Figure 4.33: Heat panels condition of toilet (a) Heat panel



(b)



(c)

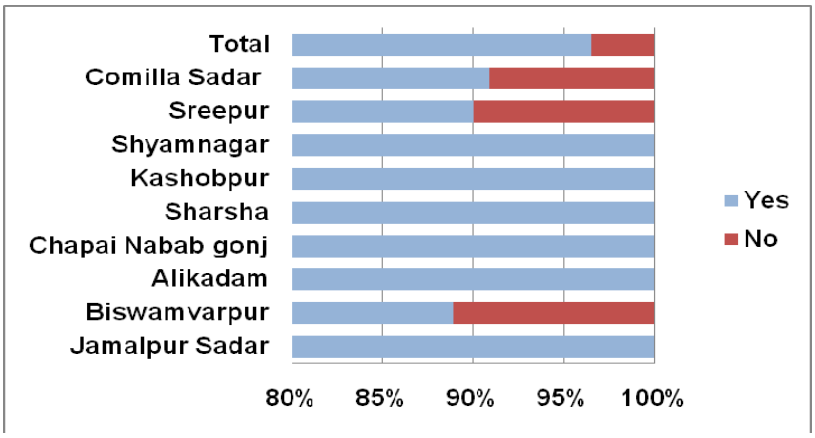
Figure 4.33: Heat panels condition of toilet (b) Morter to seal heat panel (c) Leak in heat panel

The comparative scenario through above figure 4.33 in Biswamvarpur and Jamalpur it is found that%age of good condition of heat panel in both areas is about 20% and 82% respectively. On the other side mortar not found to seal the vault with heal panel is found 50% of the Sreepur and less or around 10% in Shyamnagar and Jamalpur respectively. Due to rust small leak create in the iron sheet heat panel found in Comilla Sadar, Sreepur, Shyamnagar, Biswamvarpur and Jamalpur Sadar respectively 75%, 23%, 23%, 8% and 10%.

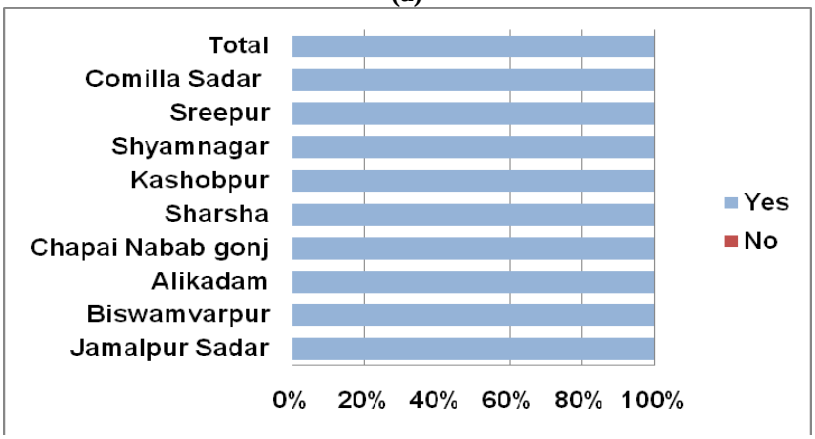
4.4.4.1.*ix Anal cleansing place, pipe network and drainage*

In some cultures, washing after defecation is mandated by tradition or religion, Like Bangladesh, Nepal and India. In some Islamic cultures, people traditionally wash away from the toilet opening. The water used for anal cleaning can be treated in an evapo-transpiration bed. There are basically two type of design and both the cases user have to shift one step back or other side for the cleansing purposes. So it is very important for the design consideration

and user comfort ability. The drainage system of the waste water is similar to the urine drainage and the finally the anal washing waste water finally pass thorough the evaporation bed.



(a)



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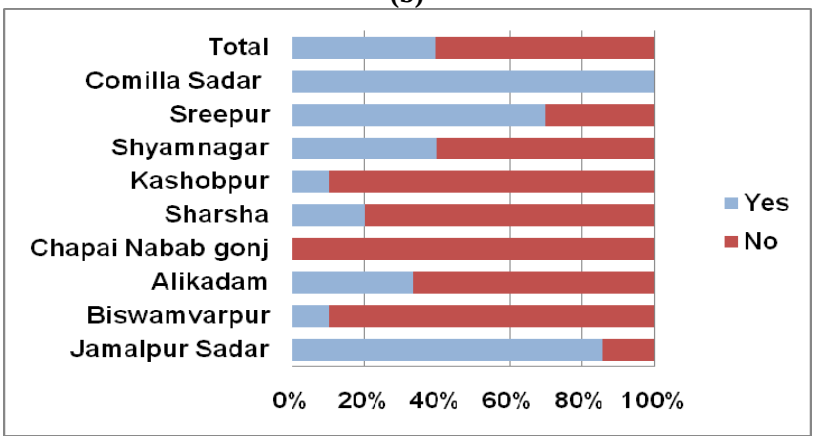
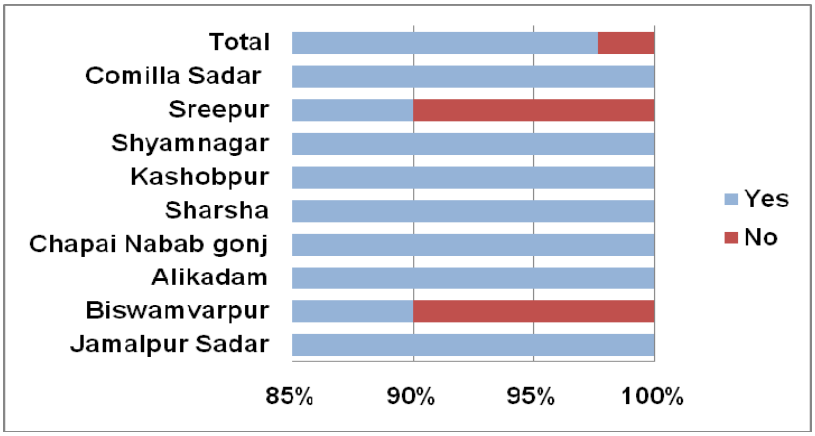


(c)

Figure 4.34: Condition of anal cleansing place, pipe network and drainage of survey toilet (a) Anal washing drain pipe (b) Anal washing place (c) Leak in anal washing drian pipe



(d)

Figure 4.34: Condition of anal cleansing place, pipe network and drainage of survey toilet (d) water drianinage system

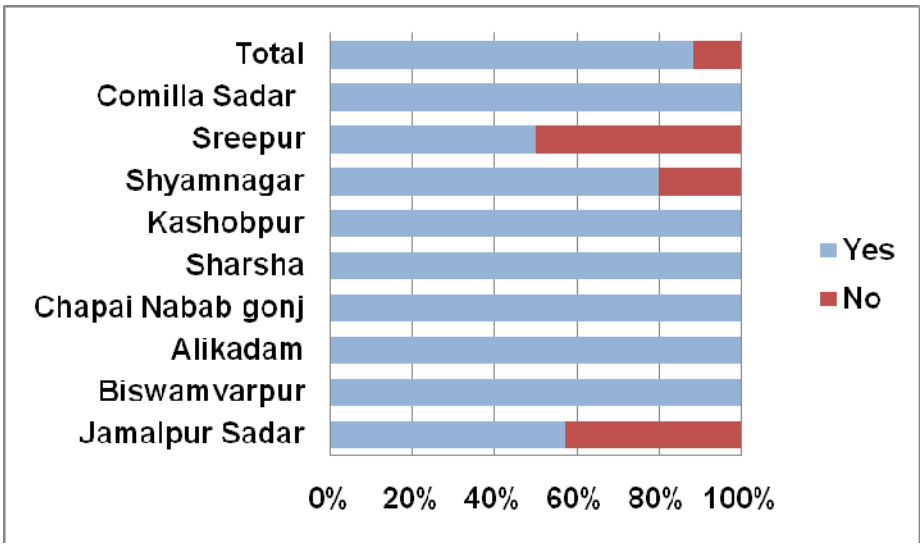
Both for the fiber pan and cement pan anal cleansing place is the drainage pipe consists of a 50 mm diameter PVC pipe. It is connected to the evaporation bed from anal cleansing water diversion hole of pan. Figure 4.34 shows that the condition of anal cleansing system of survey toilets.

Average 40% of the anal washing drains pipe found with some leak or not fixed properly in all nine areas except Comilla Sadar and anal cleansing place found clean in all area. 10% of waste water drainage system is not working properly in two area Sreepur and Biswamvapur area.

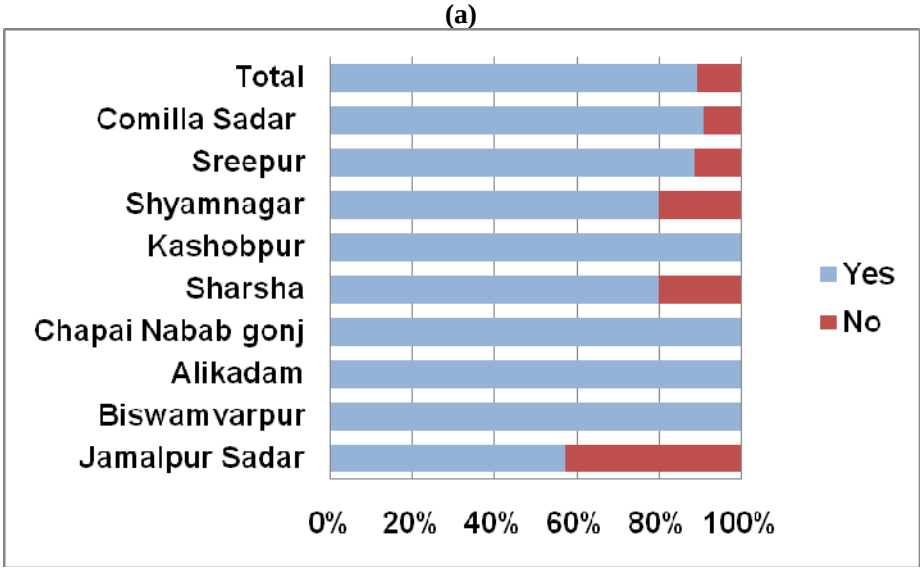
4.4.4.1.*x Evaporation bed*

Waste water shall be disposed directly in a soil infiltration bed or a seepage bed/trench or evaporation bed with gravel packing. A bed filled with prepared aggregate (i.e. gravel, broken stones, sand or similar inert material) through which effluent is allowed to seep into the ground. Assuming a minimum percolation rate of 25 mm/hr and a daily loading of 50 litres of wash water combined with urine the seepage bed shall be designed. The effective area shall be a minimum 2.5 sq. m. The effective area can be increased according to the users needs. The seepage bed shall not be at a depth greater than 0.5 m from the surface and not less than 0.15 m from the surface. The seepage bed is usually rectangular in shape. However, any convenient shape may be accepted. Sand, gravel, stone chips or any other suitable inert material, which is insoluble in water and resistant to the corrosive nature, may be used as aggregate. The depth of aggregate in the bed shall be greater than 0.4 m and less than 0.15 m. The nominal aggregate size shall be greater than 0.02 m and less than 0.01 m. A minimum

depth of .05 m of topsoil shall be provided above the bed as a soil cover. The soil cover may be vegetated with shallow rooted plants. The minimum internal diameter of distribution pipes shall be .05 m. Perforations in pipes shall be between 5 – 10 mm diameters. Figure 4.35 shows that evaporation bed condition of survey toilets.



(a)



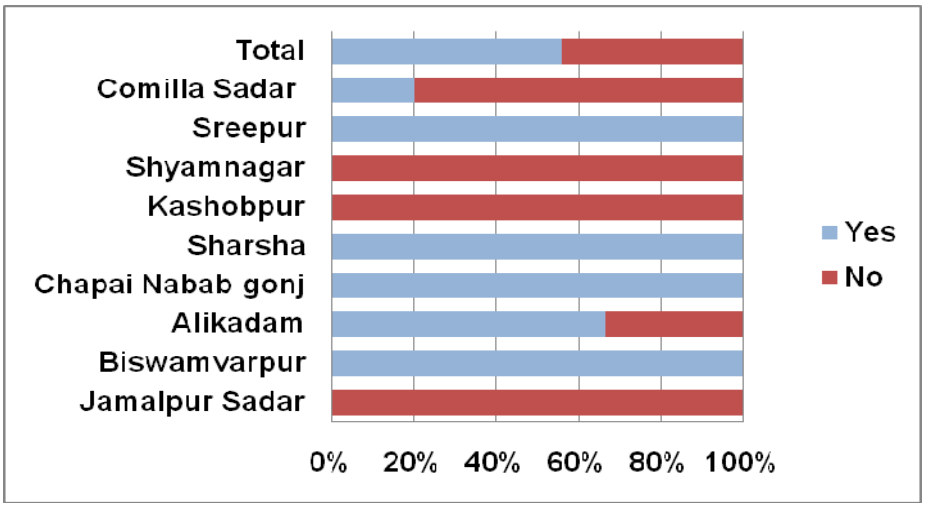
(b)

Figure 4.35: Condition of evaporation bed of survey toilet (a) Evaporation bed (b) Functioning of evaporation bed

According to Figure 4.35 in Sreepur, Shyamnagar and Jamalpur Sadar the condition of the evaporation bed is not satisfactory and found 50%, 20% and 22% respectively have nonfunctional evaporation bed. More over within those have evaporation bed 10%, 11%, 20%, 20% and 22% respectively of Commilla Sadar, Sreepur, Shyamnagar, Sarsha and Jamalupur Sadar are not functioning properly.

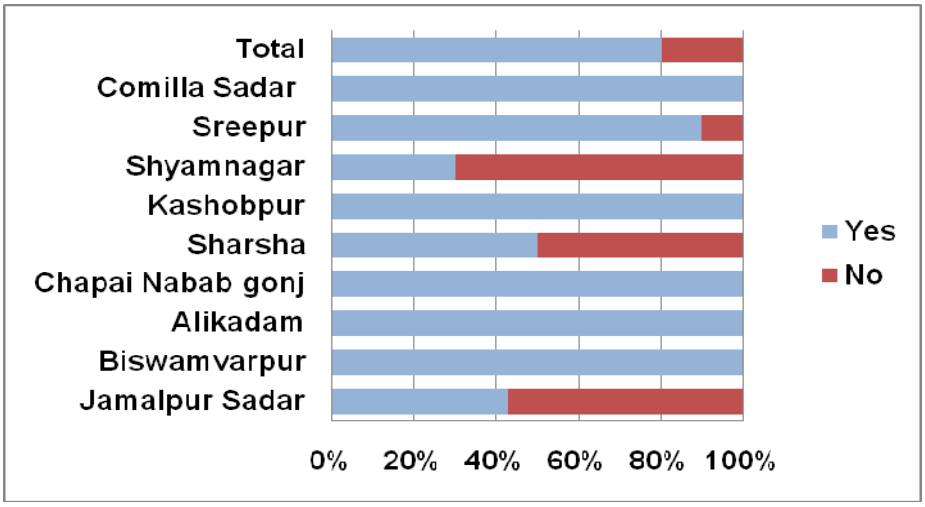
4.4.5 Provision of hand-washing and menstruation Hygiene management facilities

Having access to sufficient quantities of safe water, access to a private and clean place to defecate, living in an environment free from human excreta and other harmful waste, and being able to behave hygienically, are basic requirements essential for health and dignity for all. Handwashing is one of the most effective means of preventing diarrheal diseases, along with safe stool disposal. Although there are differences by country, culture, ethnic group, social class or family, the oppression of women has its effect on issues concerning reproductive health and other issues related to the reproductive system and its functions and processes. Most striking is the restricted control, which many women and girls have over their own mobility and behaviour during menstruation due to their 'impurity' during menstruation, including the myths, misconceptions, superstitions and (cultural and/or religious) taboos concerning menstrual blood and menstrual hygiene. Figure 4.36 shows that the provision of hand-washing and menstruation hygiene management facilities in the survey toilets.



(a)

Figure 4.36: Provision of hand-washing and menstruation hygiene management facilities
(a) Available facility to hang sanitatry napkin

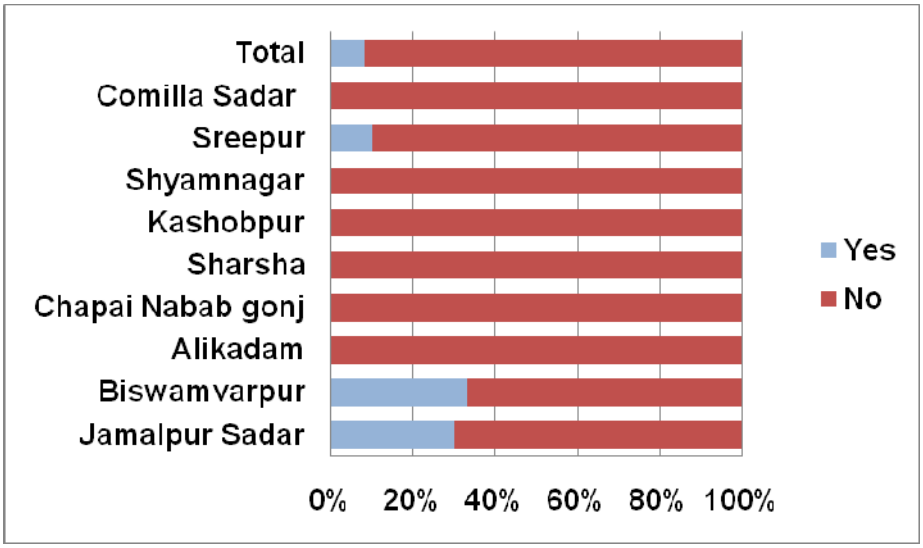


(b)

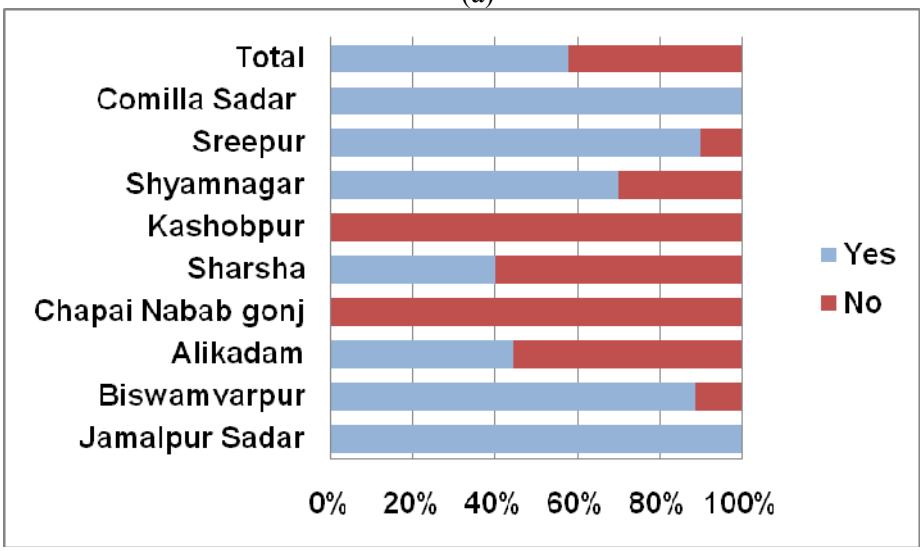
Figure 4.36: Provision of hand-washing and menstruation hygiene management facilities
(b) Available hand washing facility near toilet

4.4.6 Presence of odours and flies

Sceptics claim that EcoSan toilet is an inferior alternative: it will be smelly, fly-producing and incompatible with modern living. This is a valid concern as EcoSan systems are sensitive to bad design and careless operation. If they are not designed, built and operated properly, taking into account natural environment, traditional beliefs and the chosen process (dehydration or decomposition), they may indeed smell and can even provide a habitat for flies. Fly breeding in toilets is basically related to the wetness of the contents of the processing vault. In a properly functioning dehydration system there would be no fly breeding, but if something goes wrong and the contents turn wet, fly breeding might occur. The risk of fly breeding is greater in a composting system for two reasons: it works with a much higher process moisture content and fly eggs may be introduced into the processing vault with kitchen scraps. When a properly selected and well built eco-toilet fails, the most common fault is that the process has turned wet. In a system based on dehydration the moisture content of the contents of the processing vault should quickly be reduced to less than 25% through the addition of dry additives and ventilation – in some cases helped by the addition of a solar heating device. In a system based on decomposition the corresponding moisture content should ideally be between 50% and 60%. If this is achieved and fresh feaces are covered with an absorbent, there is no smell, no fly-breeding and rapid pathogen destruction. Figure 4.37 shows the presence of odor inside toilet and tree shadow fall on heat panel.



(a)



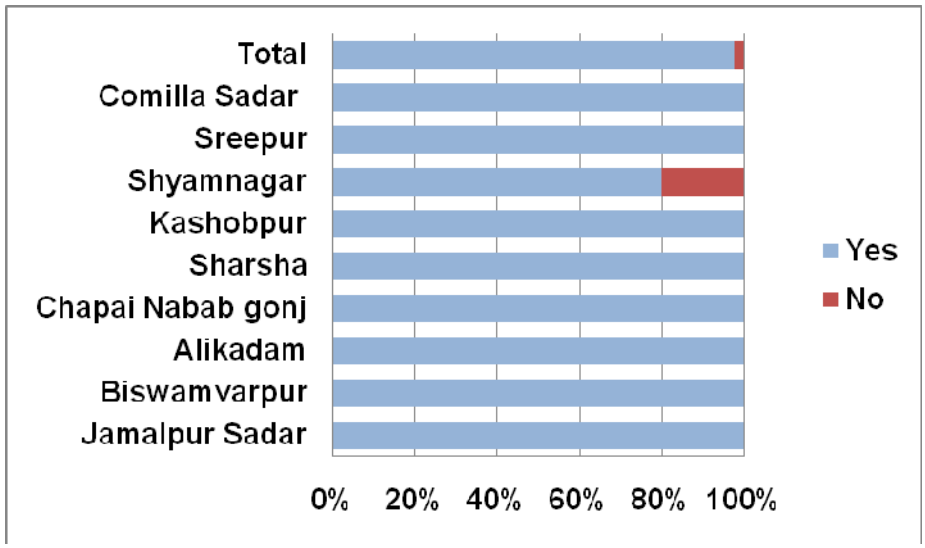
(b)

Figure 4.37: Presence of odor inside toilet and tree shadow fall on heat panel (a) Odor inside toilet (b) Shadow of tree fall on heat panel

The comparative scenario showed in Figure 4.37 indicates that in some cases like Biswamvapur (32%), Jamalpur Sadar (30%) and few toilet of Sreepur (10%) cases odor and flies found which represent the dehydration system is not working properly. To help dehydration process use of absorbents agents or solar heating system may not properly working. In Keshobpur and Champai Nababgonj almost all toilet cases surrounding tree shadow fall on the heat panel and this is also common in other area like Sarsha, Alikadam and Shyamnagar.

4.4.7 Presence of absorbents agents

Absorbents such as ash, lime, sawdust, husks, crushed dry leaves; peat moss and dry soil are used to reduce smells, absorb excess moisture, and make the pile less compact as well as less unsightly for the next user. Absorbents should be added immediately after defecation in order to cover the fresh feces. They are used in both dehydrating and in composting toilets. Figure 4.38 shows that availability of absorbents agents inside the toilet.



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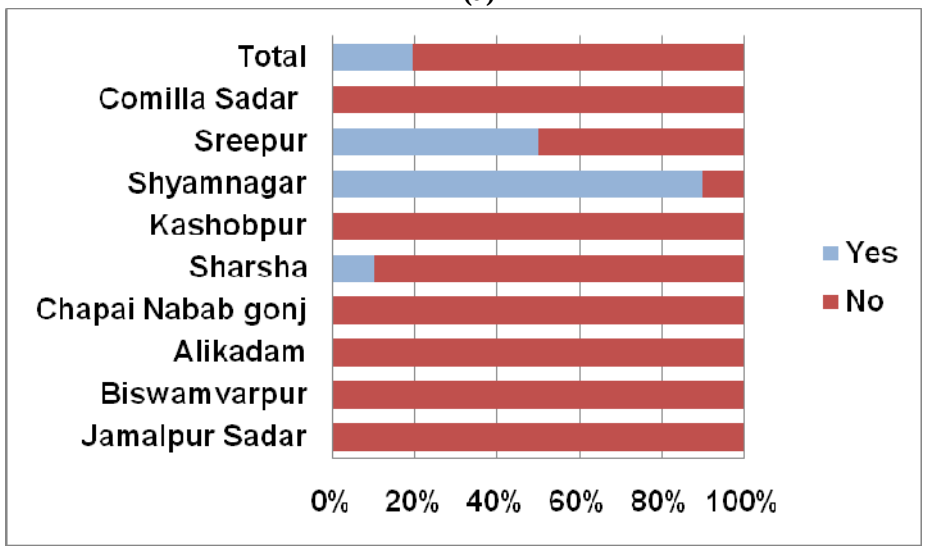


(b)

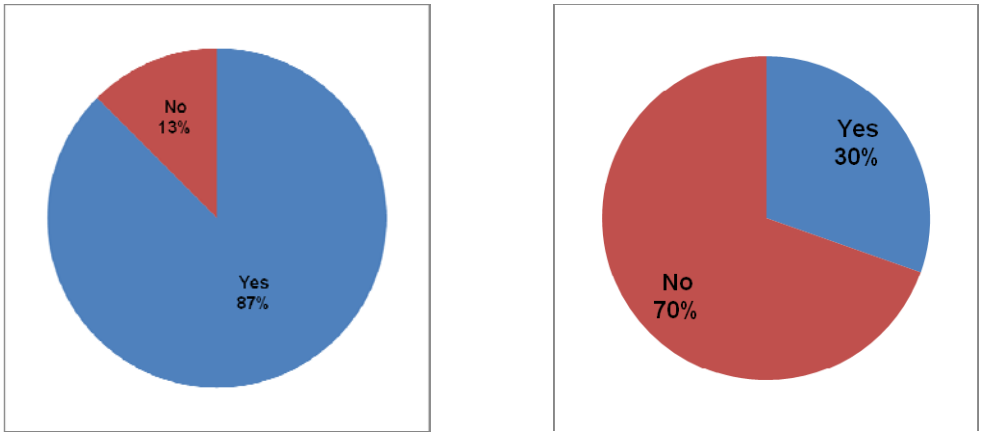
Figure 4.38: Availability of absorbents agents (a) Availablity of ash inside toilet
(b) Availablity of saw dust inside toilet

According to Figure 4.38 the availability of saw dust or ash represents ensuring the use of absorbents agents which help to reduce smells. Most of the area it is found that ash is the

mostly used absorbent agents but in Shymnagar and few cases from Sreepur, saw dust is commonly used.

4.4.8 Functional during disaster

Most of the tradition latrine is not functional during disaster like flood and most of the cases need to rebuilt and have to spend good amount of money to make the system functional. 87% of the respondents believe the EcoSan latrine will be suitable for use during natural disasters like floods and cyclones and 70% of non user believes their option cannot be use during disaster. Figure 4.39 shows that EcoSan and other toilet remain functional during disaster.



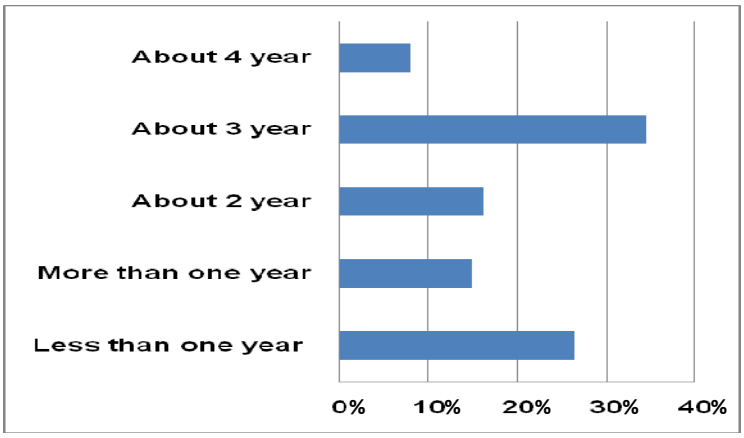
(a) **(b)**

Figure 4.39: Toilet remain functional during disaster (a) EcoSan toilet remain function during disaster (b)Other toilet remain functional during disaster

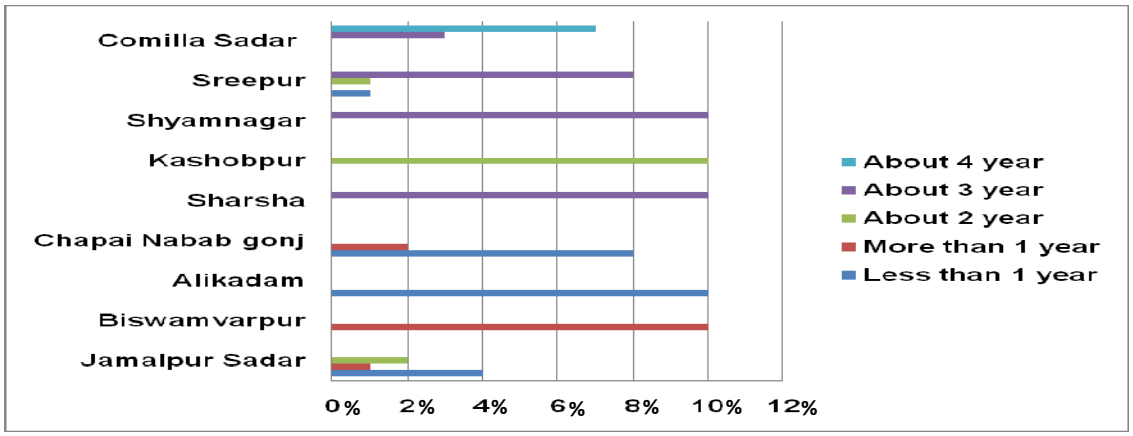
4.4.9 Urine and faeces management

4.4.9.1 Faeces management

All of the EcoSan toilets surveyed for the analysis are two vault urine diversion dry toilets. The vault sizes of almost all the toilets surveyed are 0.35 cubic metres. The chambers are made of brick masonry and the opening to remove dry materials is kept at the rear side of the toilets with the cover. To help the drying process and to reduce odours, there is a ventilation pipe in each vault. One chamber is used at a time. Once the chamber in use is filled up, it is closed and the next is used. It was advised by the promoter to keep the filled chamber closed for at least six months or until next chamber is full, for the sanitisation of content. Figure 4.40 shows that EcoSan toilet usages history details and practice of using faeces and time requires.



(a)



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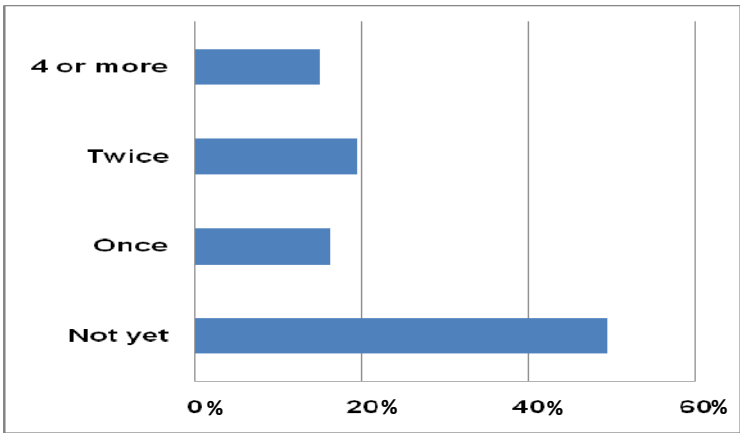
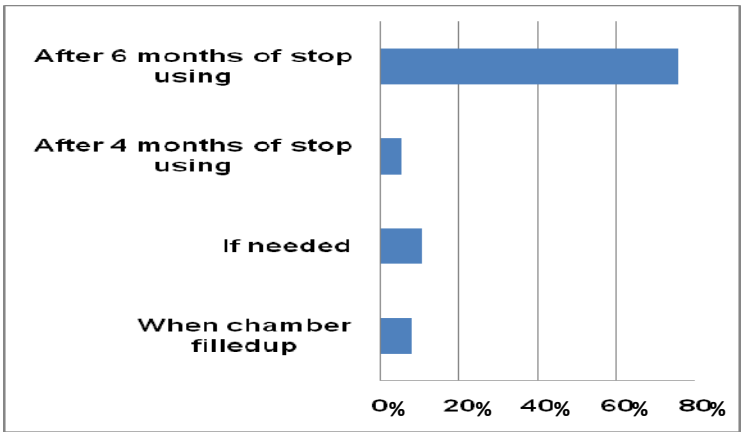


(c)

Figure 4.40: EcoSan toilet usages history details and practice of using faeces and time requires (a) Using duration of EcoSan toilet (b) Area wise duration of EcoSan toilet duration (c) Times of using faeces as fartilizer



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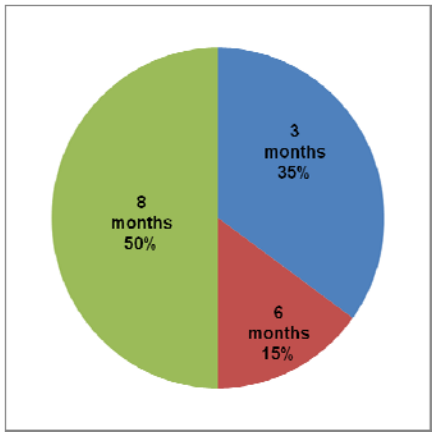


(e)

Figure 4.40: EcoSan toilet usages history details and practice of using faeces and time requires (d) Prectice of dig out faeces from chamber (e) Time requires to fill up faeces chamer

Among the 87 respondents, 21 (24%) people were not properly aware of the filling time of the vault. Some 43 toilets are new and none of the vaults are full yet. It was found 16% for once, 20% for twice and 15% for four or more vaults filled.

In addition, 50% vaults were filled within eight months, 15% within six months and 35% within three months period of use. The filling time of vaults may depend on many factors such as the population using the toilets, quantity of additives use, frequency of moving the piles, ventilation, temperature etc. In this study, the average family size is 5.57. With this population size, it was estimated that one vault would be enough for more than six months.

4.4.9.1.a Time of emptying the vault

The promoters of the EcoSan toilet have suggested that the EcoSan user empty the vault only after six months of its closing. This is very important for sanitisation of the faeces. Studies have shown that storage for six months with a relatively high pH kills almost all of the pathogens in faeces. Figure 4.41 shows that faece dig out practice.

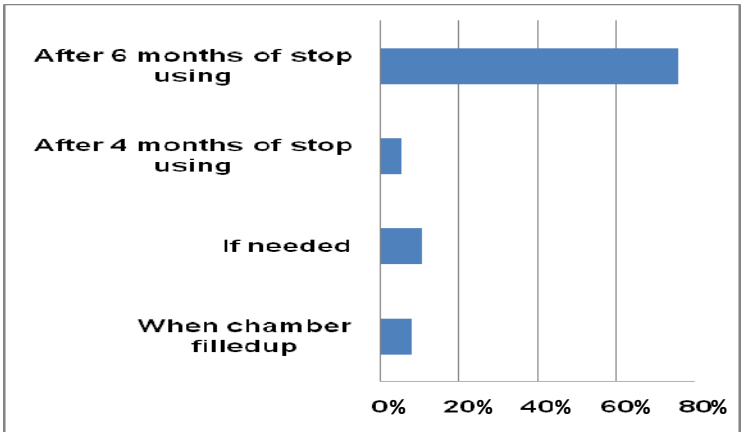


Figure 4.41: Faece dig out practice

In the survey it was found that about 8% of all the EcoSan users remove the contents of the vault when the next vault is full. About 5% emptied their content in around four months after closing the vault. Likewise, there are some (11%) families who empty the vault as per their need - they take it out at any time they require it. This means that there is no certainty of time - they have to remove the content once the other vault is nearly filled up. But this practice, only 76% following the time of more or less six months. Figure 4.42 shows the practice of using dry faeces from EcoSan toilet as fertilizer.

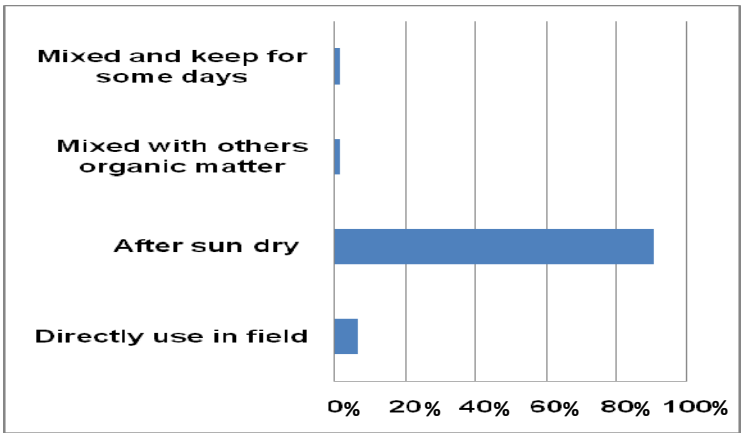


Figure 4.42: Practice of using dry faeces from EcoSan toilet as fertilizer

There are some (7%) families who empty the vault immediately after filling - they handle the faeces without drying it. Only 2% of them answered that they mix the faecal matter with other compost materials. 91% of all EcoSan users are doing it in the proper manner. Some 43 families have not emptied the vault – they have closed one vault and are using the next. The total respondents for the vault emptying time are 166.

4.4.9.1.b Conditions during the vault emptying process

It is a common belief among people that the faeces will smell strongly when taken out of the vaults and that the process of removing faeces from the vaults is a tedious and disgusting job. From a health and safety point of view as well, the faeces at the time of removal from the vaults need to be dry and stable, without any foul smell, in order for them to be considered safe for handling and use. Therefore, the condition of the faeces at the time of removal from the vault and the attitude of the users towards the vault emptying process are critical factors in the proper use and further promotion of these toilets.

4.4.9.1.b.*i Odours during emptying*

Among the 87 EcoSan users surveyed who had experiences of vault emptying; only about zero% experienced a very bad smell during emptying. Some 16% of the respondents experienced a light smell and very often 11% found bad smell, whereas about 73% of respondents said there was no smell at all whilst emptying the vault. If the material in the vault is kept completely dry for about six months and an adequate amount of additives are used, there should not be any bad smell at the time of removal. Figure 4.43 shows the presence of odor while empting vault.

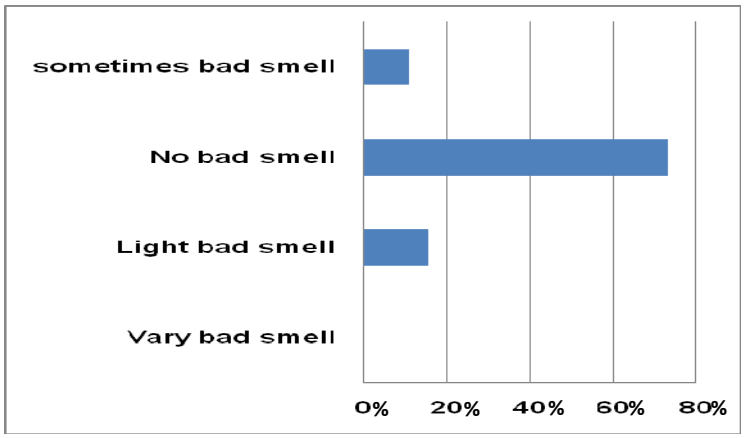


Figure 4.43: Presence of odor while empting vault

Therefore, there must be some problems in the toilets of the 16% users who reported a bad smell. During the study it was observed that some toilet did not have proper ventilation. The users who complained about bad odours had the units where the ventilation pipes were not properly installed or adequate additive materials they didn't use.

4.4.9.1.b.*ii Moisture in the content of the vault during emptying*

Only eleven% respondents complained about high moisture content in the faecal matter when the vault was emptied but not regular basis. About 83% of respondents said there was quite normal moisture content and the rest - about 6% – said the content was completely dry with minimum water content and there was no smell at all. Figure 4.44shows that the moisture content of faeces while empting the vault.

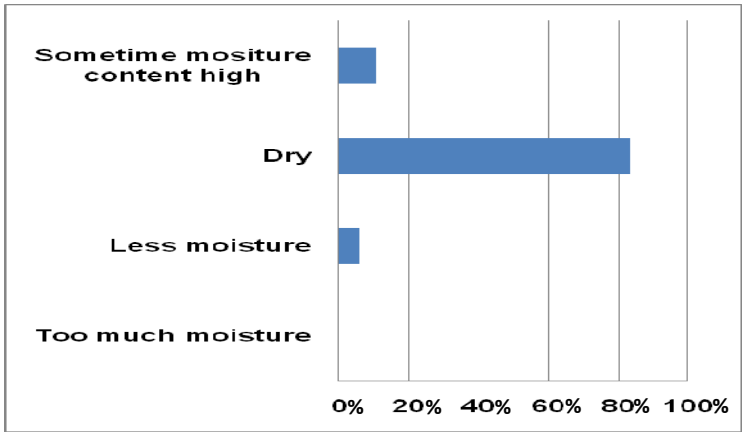
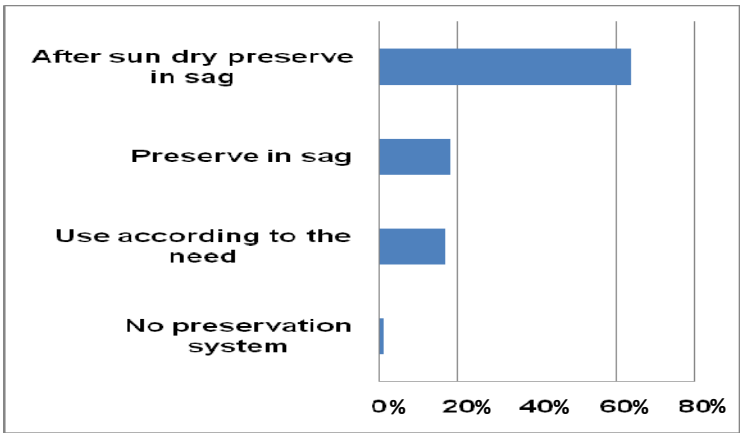


Figure 4.44: Moisture content of faeces while empting the vault

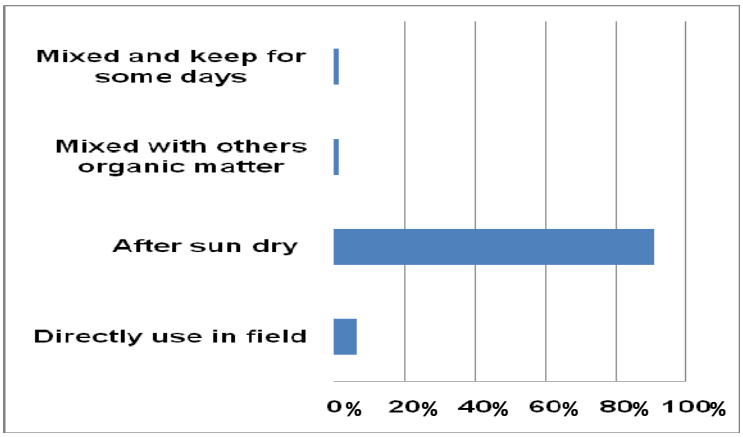
This shows that, if properly used, the moisture content and smell in the vault can be minimised to a large extent and it will be easy to handle the content. After storage for about six months, the content is almost completely converted to inert material.

4.4.10 Use of dry faeces

Among surveyed households, 8% have emptied their vault at least once. Among the users who have emptied the vault at least once, 7% said they take it straight to the field while about 64% said they stored the contents in the sun or a shed for a few days before applying it in the field. Figure 4.45 shows that preservation and usages practice of dry faeces.



(a)



(b)

Figure 4.45: Preservation and usages practice of dry faeces (a) Perservation prectice of faeces as fartilizer (b) Using parctice of faeces as fatilizer

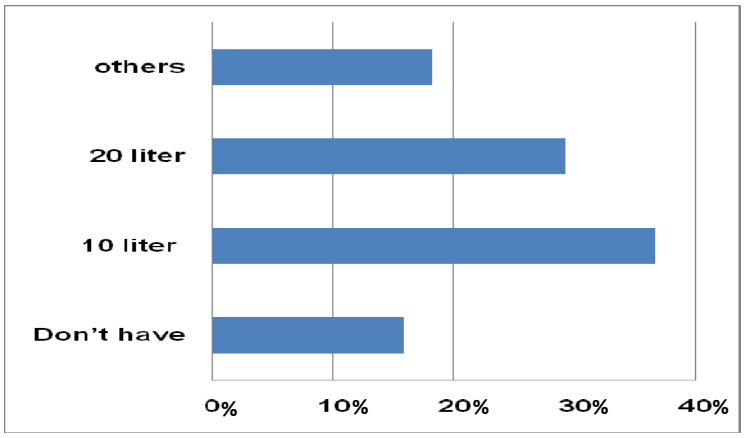
The rest of the households, or 2% of the total, said they mix the contents with other composting materials and put it in the compost pit for co-composting. Most of the families are aware of the need to store the content for a few days before applying it to the field but, due to various constraints, they are not following the rules. The major constraints are space and the need for manure.

4.4.11 Management of urine

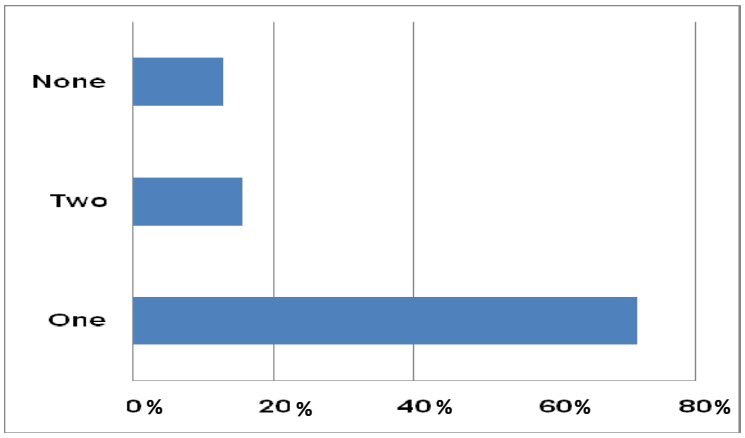
Collection of urine and faeces separately is one of the main principles of EcoSan toilets. To close the nutrient loop, the urine collected should be recycled by using it in agricultural fields. Human urine is rich in nutrients that plants need. Proper management of this resource requires appropriate and properly functioning urine collection pipes and tanks, as well as regular use of the collected urine in the fields.

4.4.11.a Urine collection tank

Although urine separation and collection is one of the main objectives of EcoSan, out of the 87 EcoSan toilets observed, 14 toilets (16%) did not have any type of urine collection tank. A good%age of toilets in Jamalpur Sador, Sreepur and Shymnagor Upazila did not have urine collection tanks. The users in these communities said that they use small jerry cans or mud pots for the collection of urine, but at the survey, these were not in use. This is one of the main problems observed with the EcoSan toilets. In other 18% toilets that did have urine collection systems, the collection container plastic tanks and jerry cans. Figure 4.46 shows the urine preservation practice and availability of jerry can.



(a)



(b)

Figure 4.46: Urine preservation practice (a) Urine prservation container size (b) Number of jerry available for urine preservation

The size of the urine tanks varied from two litres to 20 litres. Some of the users are using small plastic jerry cans and mud pots while most of the newer toilets are using 20 litre capacity plastic jerry cans. Among the total of 87 toilets with urine collection tanks, some 29% have a capacity of ten litres and 37% have a capacity of 20 litres. Similarly, 72% have

only one urine tank and 15% have two jerrican to preserve urine and the remaining 13% of the toilets don't have any. The small jerry cans and mud pots used for urine collection were not working satisfactorily. There is no uniformity in the pipes connecting the urinals and the urine tanks. Some pipes are connected openly with the tank and some are immersed in the tank. It is ideal to have an airtight connection between the pipe and the tank to reduce the loss of nitrogen from the urine.

4.4.11.b Use of urine

Most of the EcoSan toilet owners are very much aware of the importance and nutrient value of urine. At least 58% of surveyed households are using urine as fertilizer. About 97% of the respondents said that they use the collected urine and mixed with water then directly use in the field, 1% directly used in the field without mixing with water and 2% give to others. Figure 4.47 shows that the knowledge and practice level of urine and faeces as fertilizer.

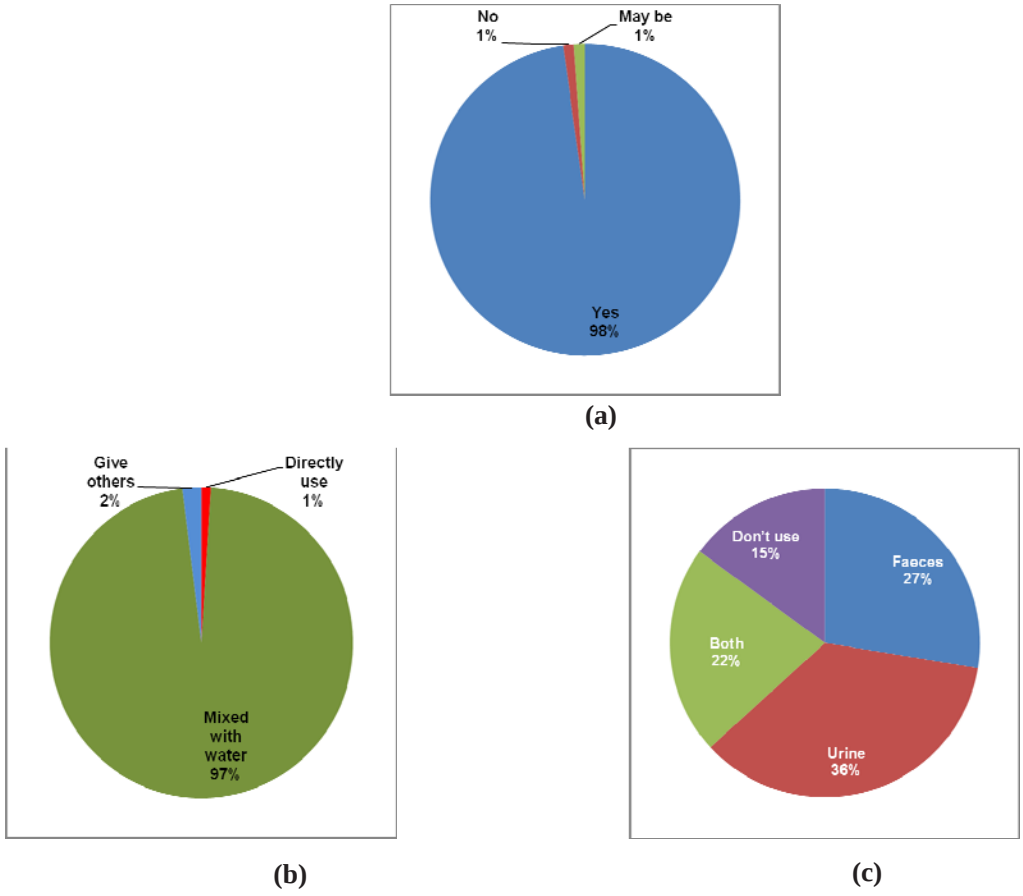
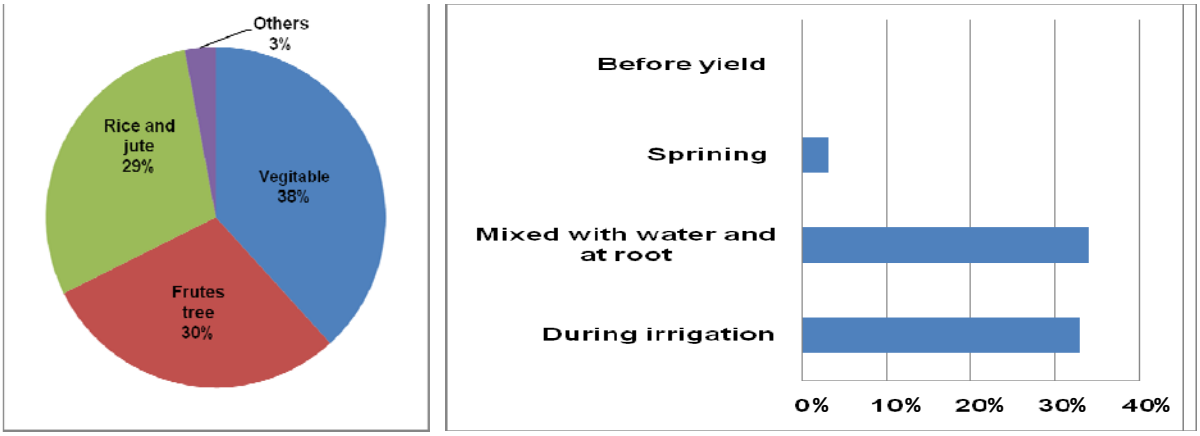


Figure 4.47: Knowledge and practice level of urine and faeces as fertilizer (a) Know urine and faeces is kind of fertilizer (b) Practice of using urine (c) Practice of using urine and faeces

Some of the families do both direct application and co-composting. They take urine to the field when needed and they put it in the compost when they do not need it. About 20% of the total respondents did not hesitate to say that they pour the urine down the drain when the tank is full and they do not need it for the field. A small portion of respondents have also given the urine to neighbours who need it. The farmers are accustomed to and feel comfortable carrying solid materials, like compost, to the fields. However, they hesitate to carry the liquid urine. As a result many of them prefer to mix the urine with compost or other materials, like ash, for ease of transportation. Efforts to improve the collection, storage and use of urine are necessary in almost all of the study areas. Very few families are found to collect, store and use the urine in a manner that minimises nutrient loss. Toilet owners who do not have a urine collection tank, sometimes collect the urine in temporary urine collection vessels and take it to nearby fields. EcoSan toilet owners with permanent and relatively large urine tanks take the urine to any field they want, felt uncomfortable carrying the liquid urine over long distances. However, according to the users, the application of urine in various crops is increasing and the interest of farmers in using the urine is increasing. The majority of farmers with EcoSan toilets - 70% - use the urine for their vegetable farming. However, urine alone is not sufficient for most families. Figure 4.48 shows that the user practices of using of urine in different crops and method following.



(a) **(b)**

Figure 4.48: User practices of using of urine in different crops and method following
(a) Urine using practice in different crops (b) Method followed to use urine

About 36% of farmers are using urine in all kind of vegetables, while 30% use the urine in fruit trees and 29% for annual crops like paddy and jute. Lack of collection jerrycan of adequate capacity and transportation of urine to distant fields are some of the hindering factors for the optimal use of urine. There is also some confusion about the methods for use.

Therefore, there is a need for appropriate guidelines for urine application directly in the field and amount based on crops or vegetable types and field area.

4.4.12 Source of additive materials

Ash, rice husks and saw dust are the primary additive materials used for the EcoSan toilets. Of these, ash is the most commonly used with more than 95% of households using it. Figure 4.49 shows that the source and use of different types additive materials.

(a) **(b)**

Figure 4.49: Source and use of additive materials (a) Type of additive materials use (b) Source of additive materils

Depending on their availability, people may use more than one additive material. Since most EcoSan users are involved with agriculture and use firewood or other burning materials for cooking, they have plenty of ashes to use in toilets. However, 5% of users are using saw dust as additives and some of those use husks in combination with ash. These users try to use ash as much as possible. Often their ash is produced from burning rice husks or saw dust in stoves. People are comfortable with this practice because ash is traditionally mixed with animal manure and compost to add to fields as a soil conditioner. With time, life styles and practices are changing. As ash has a good value in the market and the demand is increased creating an adverse situation. The demand for ash is increasing while the supply is decreasing. Fortunately, there are still outside sources of ash available to most users who don't have adequate ash supplies. In some area, there are beaten rice mills where risk husks and saw dust are used for burning and ash is produced in large quantities. Originally, it was easy for those needing ash to go to the mill and collect ash free of charge. However, once the demand increased, they started charging for it. However, the availability of additive materials may become a significant problem in the near future. As per the survey results, it was found

that some 92% of EcoSan users use their own ash for most of the time but among that 10% also go to mills and neighbours borrow when they do not have enough of their own and 2% go to buy from market. There are 5% families who rely solely on an external source of ash. The external source is only supplementary for some days of the year.

The cost of ash in rice mill is not very high; until recently it was free. The cost of ash varies between BDT 3 to 10 per kg depending upon the time and demand. About 93% of the EcoSan users have not facing any problem with getting additive materials, but that leaves about 7% facing some kind of problem in getting them for some months of the year. The problem is going to be increased in the days to come. Therefore, it is uppermost importance to find reliable alternatives for the ash as additives in EcoSan toilets.

4.4.13 Major problems encountered

Among the 87 respondent households, around 47% said there are no problems with EcoSan toilets. However, since this toilet is little different from other conventional toilets, the people using it for the first time, such as guests, may have fallen into some difficulties. Of the total number of respondents, 27 or 31%, of the total expressed this as one of the major problems. Each guest has to be instructed before the use of the toilet which is not easy and sometimes it is also uncomfortable. Some people misused the toilets, thereby creating problems. Smell, insects, cleaning and uneasiness are some of the problems that EcoSan users mentioned. But the number of people who mentioned these problems was comparatively small. Only 11% of the respondents complained about the problem of smell and only 12% mentioned difficulties in cleaning. People who are used to flush toilets, which are easier to clean, find the cleaning of EcoSan toilets to be a bit difficult as there is a risk of pouring the water into the faeces hole.

4.5 Functionality analysis

Functional analysis is a branch of mathematical analysis, the core of which is formed by the study of vector spaces endowed with some kind of limit-related structure (e.g. inner product, norm, topology, etc.) and the linear operators acting upon these spaces and respecting these structures in a suitable sense. The historical roots of functional analysis lie in the study of spaces of functions and the formulation of properties of transformations of functions such as the Fourier transform as transformations defining continuous, unitary etc. operators between function spaces. This point of view turned out to be particularly useful for the study of

differential and integral equations (wikipedia). Problems experienced with like the odour are not a result of a fault with the technology, but a lack of sufficient level of awareness and knowledge on proper functionality and maintenance of the EcoSan toilet among users. It is very import to analysis the functionality of any sanitation technology to promote.

4.5.1 Functionality analysis through Diagnosis survey

Diagnosis data have been collected in 2 ways. Firstly, check each significant part of the toilet and note the condition using a checklist of all survey toilets. In this way the surveyor visited total 87 toilets in the selected nine areas and collected functional data. In addition questionnaire survey was conducted through personal interview using a structured questionnaire with the user of the family to collect management related data.

4.5.2 Diagnosis survey items and its specification

Table-4.2 and table-4.3 show the items related to function and management and corresponding weight and figure 4.50 shows the sample specification of the items.

Table 4.2: Function related items observed through checklist and corresponding weight

Sl. No.	Function items	Weight
1	Stair	1
2	Door	1
3	Floor of the toilet	1
4	Sitting Pedestal	1
5	Faeces hole	1
6	Lid of faeces hole	1
7	Urination place	1
8	Urine drain pipe	2
9	Connection between urine drain pipe and container	2
10	Urine container	2
11	Anal washing place	1
12	Anal washing drain pipe	2
13	Evaporation bed	2
14	Roof	1

Contd. Table 4.2: Function related items observed through checklist and corresponding weight		
Sl. No.	Function items	Weight
15	Gas pipe	2
16	Faeces vault	1
17	Heat panel	2
18	Surrounding mortar of heat panel	2

Table 4.3 : Questionnaire items corresponding weight

Sl. No.	Management items	Weight
1	Clean Regularly	2
2	Insect problem	2
3	Odor problem	2
4	Use urine and faeces	2
5	Ash available	2
6	Urine and faeces preservation practice	2
7	Bear repairing cost	2
8	Urine drainage system is functional	2
9	Sock pit is functional	2
10	Anal cleansing drainage is functional	2

Items	Bad condition	Good condition
Connection between urine drain pipe and container		
Evaporation bed and drain pipe		
Heat panel		

Figure 4.50: Specification of different component

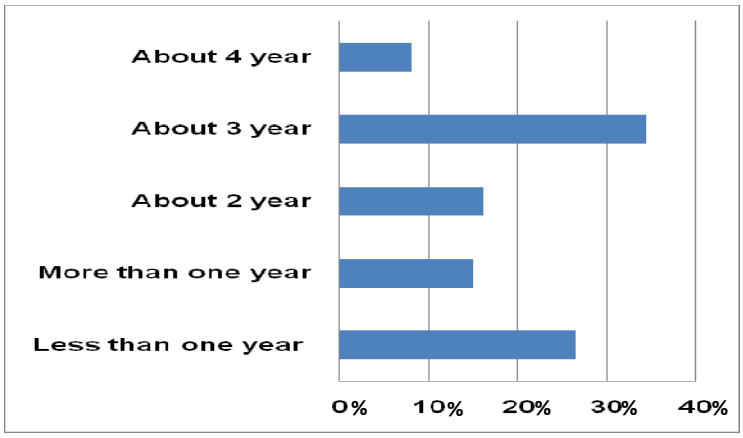
4.5.3 Results of diagnosis survey

Table-4 shows the area-wise distribution of toilets (total 87) and the proportion of toilet being used (100%) at the time of survey. This use doesn't mean all the family members are using the toilet. Table 4.4 shows the number list of toilet survey in study area.

Table 4.4: Study area and number of toilet survey

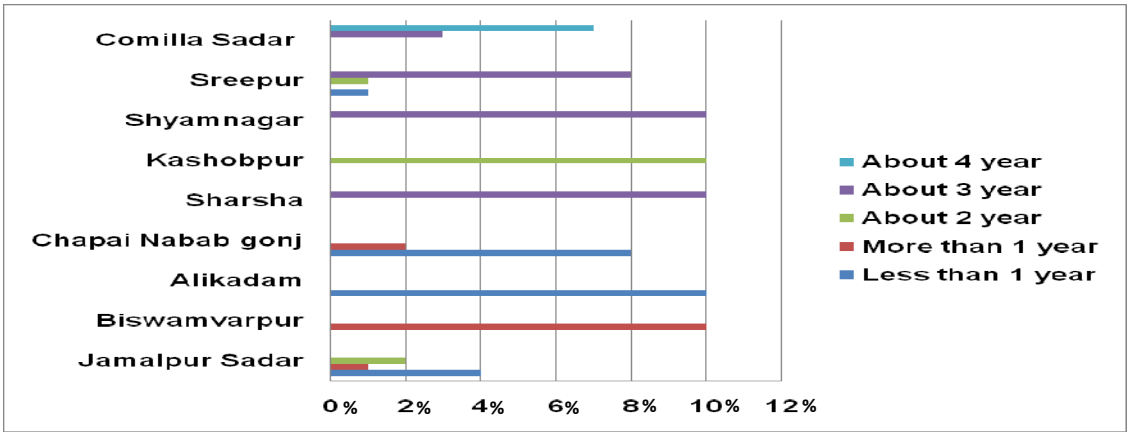
Study Area	**Number of Toilet Survey**
Jamalpur Sadar	7
Biswamvarpur	10
Alikadam	10
Chapai N.gonj	10
Sharsha	10
Kashobpur	10
Shyamnagar	10
Sreepur	10
Comilla Sadar	10
Total	**87**

Many of the cases it is found that children are not using the toilets. Mainly they are afraid of using such toilets because of the hole. Figure 4.51 shows the duration of survey EcoSan toilet use based on area wise and time.



(a)

Figure 4.51: Duration of survey EcoSan toilet use based on area wise and time
(a) Duration of EcoSan toilet using



(b)

Figure 4.51: Duration of survey EcoSan toilet use based on area wise and time
(b) Area wise duration of EcoSan toilet using

It is found from the survey that toilets are being used for maximum 42 months in Comilla Sadar and minimum for 11 months. Overall 8% and 26% of the total surveyed toilet have been using for four and less than one year respectively.

Some households have installed EcoSan toilet without being well informed about it's use and maintenance pattern, those families were found not much interested to use at the time of survey.

Function-management score has been obtained using function and management model (equation 1, 2) (Azad-uz-zaman, Q.,2011). This is a weighted calculation considering the contribution of each item is not same.

Function – model: $S_{F}j=\sum W_i * F_{ij}$ ..... (1)

Here, S_{Fj}: j-area's score, W_i: item i's weight, F_{ij}: item i's goodness (%), i=1,2,…18, j=1,2,….9

Management-model: $S_{Mj}=\sum W_i * M_{ij}$ .....(2)

Here, S_{Mj}: j-area's score, W_i: item i's weight, M_{ij}: item i's goodness (%), i=1, 2…12, j=1, 2….9

Study Area	Management	Function
Jamalpur Sadar	2157	1756
Biswamvarpur	2110	1700
Alikadam	2160	1780
Chapai N.gonj	2380	1900
Sharsha	2400	1800
Kashobpur	2420	1860
Shyamnagar	2210	1800
Sreepur	1950	1800
Comilla Sadar	2280	1920
Ideal Situation	**2600**	**2000**

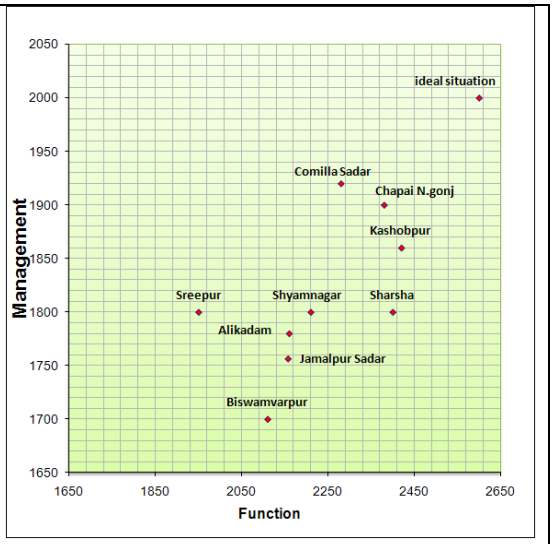


Figure 4.52: Comparison of different areas among areas

Figure 4.52 shows areas wise comparison among the all surveyed area depending on toilet management and functionality. It is observed that considering the management issue Kashobpur (2420) and Sreepur (1950) are in the best and worst position accordingly. On the other side considering the function Chapai N.gonj (1900) and Biswamvarpur (1700) have the best and worst situation accordingly. Considering both management and function issue Chapai N.gonj (2380,1900) and Sreepur (1950, 1800) have combatively best and worst situation. But considering the duration of using toilet Comilla Sadar has achieved the best position among all study area.

4. 6 Environmental and health aspect of ecosan toilet

4.6.1 Environmental aspect of ecosan toilet

4.6.1.1 Introduction

The main goal of Eco-toilet is to return the valuable nutrients from urine and faeces back to the environment and avoid the pollution often caused by conventional sewerage management. The waste in Eco-Toilet is sanitized as the pathogens die off and the resultant safe soil conditioner (from faeces) and fertilizer (from urine) is then recycled and used to assist crop production (Sidhu, JPS. et al. 2008). Reusing human excreta demands reassurance that the composted excreta is free of pathogenic burden, as excreta may contain bacteria, protozoa and helminthes. A fair amount of international literature on the subject also suggested that the reuse of excreta from eco-toilet is safe for human health if composted properly. The use of animal excreta in agriculture has the potential for both positive and negative environmental impacts. The present section reviews the potential environmental impacts associated with the use of urine, faeces, which will differ depending on local conditions. It is important to minimize the environmental impact associated with the direct use of excreta in agriculture in both the 1ocal and global context. For large-scale implementation, environmental impact assessment is a useful tool for the analysis. A procedure for measuring the environmental impacts of different sanitation approaches involves the analysis of material flows or a life cycle analysis for the production of different crops, which may also lead to a better understanding of the environmental impacts of different agricultural practices. The environmental impact of different sanitation systems can be measured in terms of the use of natural resources, discharges to water bodies, air emissions and impacts on soils. Most relevant in relation to the use of excreta are the potential environmental impacts on soil and water bodies (WHO 2006).

4.6.1.2 Impacts on soil

The benefits of recycling biosolids onto agricultural land include providing essential nutrients for crop needs and organic matter for improving soil tilth, water-holding capacity, soil aeration, and an energy source for earthworms and beneficial microorganisms (Evanylo, G.K., 1999). Relevant substances to consider in terms of environmental impacts on soil me salt so heavy metals, organic compounds and nutrients.

4.6.1.2.a Presence of metals

The contents of heavy metals and other contaminants such as pesticide residues are generally low or very low in excreta, and depend on the amounts present in consumed products. The urine is filtered from the blood by the kidneys. It contains substances that have entered the metabolism and therefore the levels of heavy metals in urine are very low (Jönsson et al., 1997; Jönsson et al., 1999; Johansson et al., 2001; Vinnerås, 2002; Palmquist et al., 2004). The content of these substances is higher in the faeces compared with the urine. The major reason for this is that faeces consist mainly of non-metabolized material combined with some metabolized material. The main proportion of the micronutrients and other heavy metals passes through the intestine unaffected (Fraústo da Silva and Williams, 1997). Even so, the concentrations of contaminating substances in faeces are usually lower than in chemical fertilizers (e.g. cadmium) and farmyard manure (e.g. chromium and lead).

A large proportion of the hormones produced by our bodies and the pharmaceuticals that we consume are excreted with the urine, but it is reasonable to believe that the risk for negative effects on the quantity or quality of crops is negligible. All mammals produce hormones and, during the course of evolution, these have long been excreted in terrestrial environments. Thus, the vegetation and soil microbes are adapted to, and can degrade, these hormones. Furthermore, the amount of hormones in manure from domestic animals is far larger than the amount found in human urine. Thus, even though theoretical estimations based on tests with fish have indicated a risk of eco-toxicity from oestradiol (Ambjerg-Nielsen et al., 2004) when applying urine, both fertilizer experiments and evolutionary history strongly indicate that there is no real risk.

By far the majority of all pharmaceutical substances are derived from nature, even if many are synthetically produced, and they are thus found and degraded in natural environments with a diverse microbial activity. This has been verified in ordinary wastewater treatment plants, where the degradation of pharmaceutical substances improved when the retention time was prolonged from a number of hours to a number of days. Urine and faecal fertilizers are mixed into the active topsoil, which has a microbial community just as diverse and active as that in wastewater treatment plants, and the substances are retained for months in the topsoil. This means that there is plenty of time for the microbes to degrade any pharmaceutical substances and that risks associated with them are small.

Concerning both hormones and pharmaceutical substances, it thus seems far better to recycle urine and faeces to arable land than to flush them into recipient waters. Since the aquatic systems have never before been exposed to mammal hormones in large quantities, it is not surprising that the sex development of fish and reptiles is disturbed when they are exposed to wastewater effluent. Furthermore, the retention time of the wastewater in the treatment plants is far too short for many pharmaceutical substances to degrade and recipient waters are also usually connected to water sources. Thus, it is not surprising that pharmaceutical substances have been detected for decades, not only in e.g. the recipient waters of Berlin but also in the groundwater, which is Berlin's source of drinking water (Herberer et al., 1998).

There are many indications that the possible risk from pharmaceutical substances in the agricultural system is small and far smaller than the risks associated with the present system. One such indication is that in many countries the human consumption of pharmaceuticals is small compared to that by domestic animals, as in most countries most commercial feeds contain antibiotic substances, added as growth promoters. Furthermore, the human use of pharmaceutical substances is small compared to the amount of pesticides (insecticides, fungicides, bactericides and herbicides) used in agriculture, which are just as biologically active as pharmaceutical substances. Table 4.5 shows the WHO standard for concentrations of metal and heavy metals in urine and faeces and Table 4.6 shows the laboratory test result of four sample of JADE and compare it with WHO and Ministry of agriculture limits.

Table 4.5: Concentrations of heavy metals in urine and faeces (WHO)

	Unit	Cu	Zn	Cr	Ni	Pb	Cd
Urine	µg/kg ww	67	30	7	5	1	0
Faeces	µg/kg ww	6667	65000	122	450	122	62

Sources: Teinecke et. al. (l999);VinnerAs (2002).

ww: wet weight

Table 4.6: Case -1: JADE, four Sample: Keshabpur, Sharsha, Niamatpur

	KP-1	KP-2	SP-1	NP-2	WHO limit	Ministry of Agriculture: limits (maximum)
Zinc (ppm)	90.91	111.93	85.69	148.74	65000	Zn = 0.01%
Copper (ppm)	43.52	29.82	58.36	31.05	6667	Cu = 0.05%
Lead (ppm)	0	2.6	2.48	4.17	122	Pb = 30 ppm
Cadmium (ppm)	0.092	0.104	0.074	0.196	62	Cd = 5 ppm
Nickel (ppm)	12.15	12.04	11.95	10.68	450	Ni = 30 ppm
Chromium (ppm)	11.05	13	12.59	9.62		Cr = 50 ppm
Arsenic (ppm)	1.51	3.28	2.38	1.6		As 20 ppm

Table 4.7: Case-2 : Oxfam, ICDDR,B; Environmental Microbiology Laboratory, Sample: Sundorgonj, Gaibandha

Parameters	Unit	Actual Concentration	Standard Range
As		Below detection limit	
Lead (Pb)	ppm	2.51	Maximum 30 ppm
Cadmium (Cd)	ppm	0.46	Maximum 5 ppm
Chromium (Cr)	ppm	21.90	Maximum 50 ppm
Nickel (Ni)	ppm	20.64	Maximum 30 ppm

Table 4.7 shows the laboratory test result of four sample of Oxfam and compare it with standard limits.

In both the cases of testing five faeces sample to check the presence of Zinc, Copper, Lead, Cadmium, Nickel, Chromium, Arsenic it is found that the result is below or within WHO and Bangladesh standard.

4.6.1.2.b Nutrients back to environment

4.6.1.2.b.*i Urine*

Urine contains large quantities of nitrogen (mostly as urea), as well as significant quantities of dissolved phosphates and potassium, the main macronutrients required by plants, with urine having plant macronutrient percentages (i.e. NPK) of approximately 11-1-2 by one study or 15-1-2 by another report, illustrating that exact composition varies with diet (Jönsson and Vinnerås 2004).

Most of the plant nutrients in human excreta are found in the urine. Based on data from five countries (China, Haiti, India, South Africa and Uganda) estimate that on average each person produces about 5 kg of elemental NPK in excreta per year, about 4 kg in the urine and 1 kg in the faeces. Urine is therefore worth using as fertilizer, especially as its content of NPK is readily available to the plants.

In Sweden the total yearly production of human urine contains elemental nitrogen, phosphorous and potassium equivalent to approximately 20% of the amounts of these nutrients used as mineral fertilizers in 1999/2000. The concentrations of heavy metal in human urine are negligible – an important advantage over chemical fertilizer. When urine is collected for use as a fertilizer, it is important that the storage method prevents odours and the loss of nitrogen to the air. Swedish research indicates that most of the nitrogen in urine, which is initially in the form of urea, is quickly converted to ammonia within the collection and storage device (if this device has been used several times and is not more or less sterile). Ammonia loss to the air can be minimized by storage in a covered container with restricted ventilation (WHO 2006).

Undiluted, it can chemically burn the roots of some plants, but it can be used safely as a source of complementary nitrogen in carbon-rich compost.

When diluted with water (at a 1:5 ratio for container-grown annual crops with fresh growing medium each season, or a 1:8 ratio for more general use), it can be applied directly to soil as a fertilizer. The fertilization effect of urine has been found to be comparable to that of commercial fertilizers with an equivalent NPK rating. Urine contains most (94% according to Wolgast) of the NPK nutrients excreted by the human body. Conversely, concentrations of heavy metals such as lead, mercury, and cadmium, commonly found in solid human waste, are much lower in urine. The more general limitations to using urine as fertilizer then depend mainly on the potential for buildup of excess nitrogen (due to the high ratio of that macronutrient), and inorganic salts such as sodium chloride, which are also part of the wastes excreted by the renal system. The degree to which these factors impact the effectiveness depends on the term of use, salinity tolerance of the plant, soil composition, addition of other fertilizing compounds, and quantity of rainfall or other irrigation.

When urine is applied to open soil before planting it can be undiluted. If used on growing plants it can be applied without or with dilution, typically one part urine to 2–5 parts of water. Care should always be taken to apply the urine to the soil and not on the plants. Table 4.8: shows the distribution of N, P and K and Table 4.9 shows NPK percentage in human urine.

Table 4.8: Distribution of N, P and K in Human urine

Item		DU Test (Sre-3)	BUET Test (Sre-8)	DU Test (Sre-10)	BUET Test (Sre-13)	DU Test (Sre-16)	DU Test (Sre-17)	DU Test (Sre-19)	DU Test (Sre-21)	KU test	SEPA PEPORT 4425 (SIDA)	Nonaka and Haryu 1973	Japanese Biochemistry Association Data Book 1979	Encyclopedia of Medical Sciences 1983	Mean
N	%	0.03	0.3247	0.13	0.3361	0.11	0.09	0.19	0.11	0.471	0.88	0.4	0.85	1.04	0.38
P	%	0.005538	0.0784	0.007725	0.0732	0.0034	0.0032	0.0019	0.006	0.0645	0.08	0.04	0.16	0.05	0.04
K	%	0.0725	0.08014	0.0572	0.0974	0.0603	0.0481	0.0363	0.0331	0.158	0.20	0.16	0.15	-	0.10

Source: JADE 2010, Annual Report

DU=Dhaka University ,

BUET= Bangladesh University of Engineering and Technology

KU= Khulna University

Table 4.9: NPK percentage in urine

ITEM		MEAN
Nitrogen (N)	%	0.38
Phosphorus (P)	%	0.04
Potash (K)	%	0.1

4.6.1.2.b.*ii Faeces*

Human faeces consist mainly of undigested organic matter such as fibres made up of carbon. Although faeces contain fewer nutrients than urine, the humus produced from faeces actually contains higher concentrations of phosphorus and potassium. After pathogen destruction through dehydration and/or decomposition the resulting inoffensive material may be applied to the soil to increase the amount of available nutrients, to increase the organic matter content and to improve the water-holding capacity. The simplest form of recycling is when the individual household can use the product as fertilizer in its own garden or on its own farm land. In urban situations many householders will have neither the land nor the inclination to use the product themselves. Table 4.10 shows the percentage of O, M, N, P, K presence in faeces found in the sample of JADE.

Table 4.10: Percentage of O, M, N, P, K presence in faeces

Item		Mean
P^H		8.95
Organic Matter	%	3.20
Nitrogen (N)	%	0.35
Phosphorus (P)	%	0.48
Potash (K)	%	2.75

Source: *JADE 2010, Annual Report*

Variation of NPK and improvement factors

Since it is quite difficult to analyze human urine for nutrient content, there is a need for a method to calculate the composition of urine from easily available data. Such a method, which uses the FAO statistics (see www. fao.org) on the available food supply in different countries, has been developed by Jönsson and Vinnerås (2004). This method uses equations

derived from the FAO statistics and an estimation of the average excretion by the Swedish population, where many measurements on excreta have been made.

Based on this estimate of average excretion, on the food supplied to the Swedish population according to the FAO statistics and on statistical analysis of different foodstuffs, relationships (equations 1 and 2) have been developed between the food supplied according to FAO and the excretion of N and P.

N = 0.13* (Total food protein) …….....Equation 1

P = 0.011* (Total food protein + vegetal food protein)..... Equation 2

In equations 1-2 the units of N and P are the same as those of the food protein. As is shown by equation 2, there is a strong positive correlation between the contents of protein and phosphorus in the food stuffs.

Furthermore, vegetal food stuffs contain on average twice as much phosphorus per gram of protein as animal ones, which is why the vegetal protein is counted twice in equation 2.

These equations are useful for estimating the average excretion of N and P in different countries. Examples of inputs and results of such estimates for a few countries are given in below tables 4.11.

Table 4.11: Estimated excretion of nutrients per capita in different countries.

	Nitrogen (kg/cap, year)	Phosphorus (kg/cap, year)	Potassium (kg/cap, year)
China	3.5	0.4	1.3
Haiti	1.9	0.2	0.9
India	2.3	0.3	1.1
South Africa	3.0	0.3	1.2
Uganda	2.2	0.3	1.0
Sweden	4.0	0.4	1.0

Source: Jönsson and Vinnerås 2004

For improvement urine should be handled in closed tanks and containers and should be spread directly onto the soil, not on the plant, in N doses equivalent to what is recommended for urea and ammonium fertilizers. Air contact should be minimized and the urine should be incorporated into the soil as quickly as possible.

4.6.1.3 Impacts on water bodies

Application of excreta to agricultural land will reduce the direct impacts on water bodies. However, as for any type of fertilizer, the nutrients may percolate to groundwater if applied in excess or be flushed into surface water after excessively rainfall. This impact will always be less compared with that of the direct use of water bodies as the primary recipient.

The impact of reuse of human excreta in agriculture on groundwater quality depends on factors such as agricultural application rate, the type of irrigation water the soil type, aquifer vulnerability, the agricultural practices and the type of crops, as well as the recharge and groundwater use (Foster et al., 2004).

In order to avoid negative effects of using excreta as agricultural fertilizers, the following should be considered (Foster *et. al.* 2004):

i) improve agricultural practices;
ii) establish criteria to operate wells used to supply water for human consumption in the surroundings (establish safe distances to the agricultural site, depth of extraction and appropriate construction);
iii) routinely monitor groundwater.

Surface water bodies are affected by agricultural drainage and runoff, Impacts depend on the type of water body (rivers, agricultural channels, lakes or dams) and their use, as well as the hydraulic retention time and their function within the ecosystem.

A highly organic load will, independently of the source, affect the dissolved oxygen levels, thus impacting aquatic organisms. Additionally, the nitrogen or phosphorus washed into water bodies will lead to eutrophication and subsequent oxygen depletion and will facilitate the growth of toxin-producing algae (Chorus and Bartram, 1999).

Organic chemicals originating from excreta and greywater will only minimally impact surface water bodies due to their adsorption to soil particles after application.

The soil will act as a filter before the respective pollutants reach groundwater and surface waters Nitrogen can contaminate groundwater and surface water bodies by infiltration and agricultural runoff. The amount of nitrogen leached depends on crop demand, hydraulic load due to rain and agricultural water, soil permeability and nitrogen content in soils. Agricultural runoff containing phosphorus can cause eutrophication in surface water bodies (reservoirs and lakes). High concentrations of biodegradable organic matter in agricultural runoff water can lead to the consumption of dissolved oxygen in lakes and rivers (WHO 2006).

Phosphorus is an essential element for plant growth, and mined phosphates are a common input into agricultural production in order to increase crop productivity. Soil phosphorus

content varies with parent material, texture and management factors, such as rate of application, type of phosphorus applied and soil cultivation (Sharpley, 1995). It is usually present in soils in relatively important quantities. World supplies of accessible mined phosphate are diminishing. It is predicted that phosphate-carrying rockslmineral reserves will run out in 60-130 years. The mining of phosphate causes environmental damage because it is often removed close to the surface in large open mines, leaving behind scarred land. Moreover, phosphate-carrying rocks/minerals also contain varying amounts of non-desired elements, such as cadmium. Approximately 25o/a of the mined phosphorus ends up in aquatic environments or buried in landfills or other sinks (Tiessen, 1995). The discharge into aquatic environments causes eutrophication of water bodies, leading to more environmental damage. To reduce the phenomenon of eutrophication, wastewater treatment plants require additional phosphorus removal treatment capacity, which adds to the costs and complexity of the treatment process.

Urine alone contains more than 50% of the phosphorus excreted by humans, Thus, the diversion of urine and its use in agriculture can aid crop production and reduce the need for costly, advanced wastewater treatment processes to remove phosphorus from the effluents (EcoSanRes2, 005).

4.6.1.4 Environmental implications

Continuous use of inorganic fertilisers on farmlands has led to serious environmental consequences such as soil acidification, eutrophication of surface waters, ‘dead zones’ along coastal estuaries and high nitrate concentrations in groundwater with a potential negative impact on humans. Although conventionally the loss of the most important macronutrients has been partly compensated through application of chemical fertilisers, they cannot replace the loss of organic matter, microorganisms and many micronutrients equally at stake in degraded topsoil. In the developing world the ‘mining’ of soil nutrients is severe and yields have fallen, as nutrients removed by the crops are often not replaced.

This problem is most serious in Sub-Saharan Africa, the Caribbean and parts of Asia (FAO 2004). Many soils have been depleted or damaged by inappropriate agricultural practices leading to erosion and fertility losses. At present the earth is losing 75 billion tons of nutrient-rich topsoil annually, or 13-40 times the rate of soil renewal (Pimentel, 1998) resulting in reduced productivity and hence decreased food security.

4.6.1.4.a User and non user perspective as environmental friendly option

91% of the users and 74% non user believe that the latrine is environment friendly option. Non users also believe that their currently used latrine is not environment friendly option. Figure 4.53shows that user and non user perspective towards EcoSan toilet as environmental friendly option.

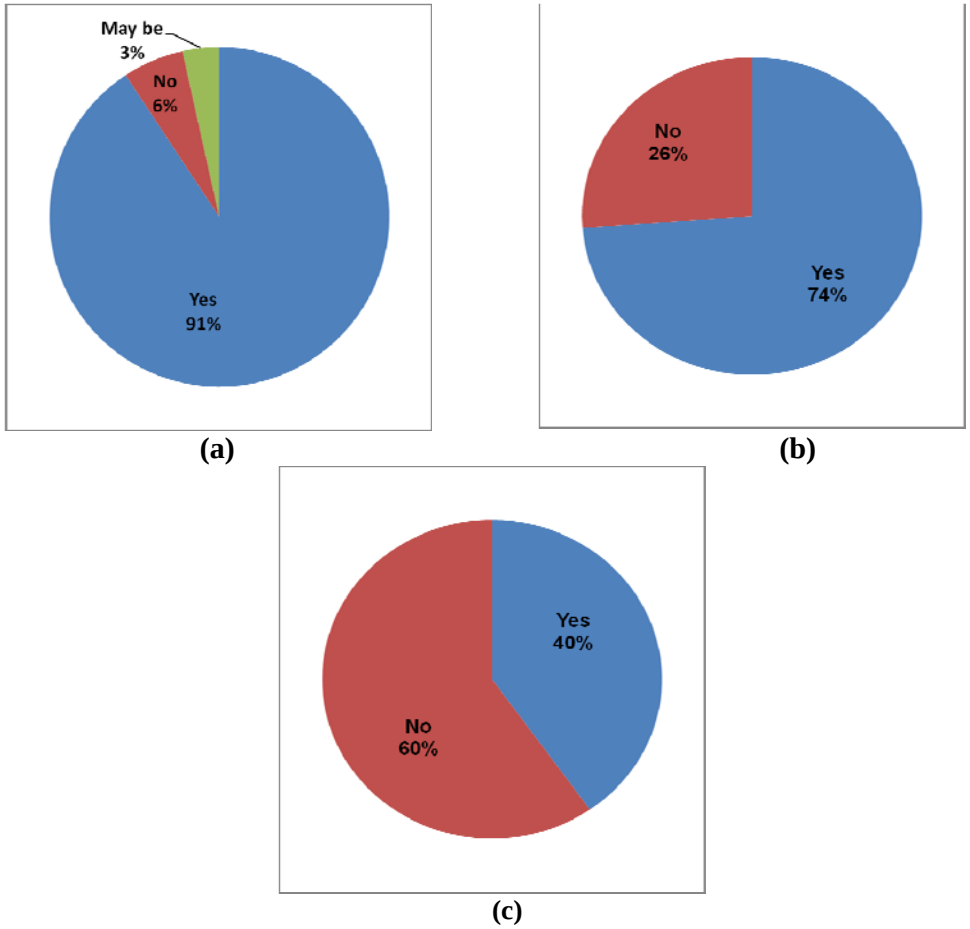


Figure 4.53: User and non user perspective EcoSan toilet as environmental friendly option (a) Accroding to user EcoSan toilet is environmet friendly option (b) Accroding to non user EcoSan toilet is environmet friendly option (c) Accroding to non user their toilet is environmet friendly option

4.6.1.4.b Scope of spreading pollution during disaster

Around 91% user informed that during flood faeces chamber don't inundate by the flood water and in case of other option non user informed that 66% get flooded and faeces comes out from the pit that creates unhygienic condition and spread diseases. Interestingly, JADE said the superstructure of the EcoSan latrines is so stable and well-built that people took shelter in these toilets during cyclones in coastal belt areas. Figure 4.54 shows that spreading pollution during disaster from EcoSan and other toilet in previous years.

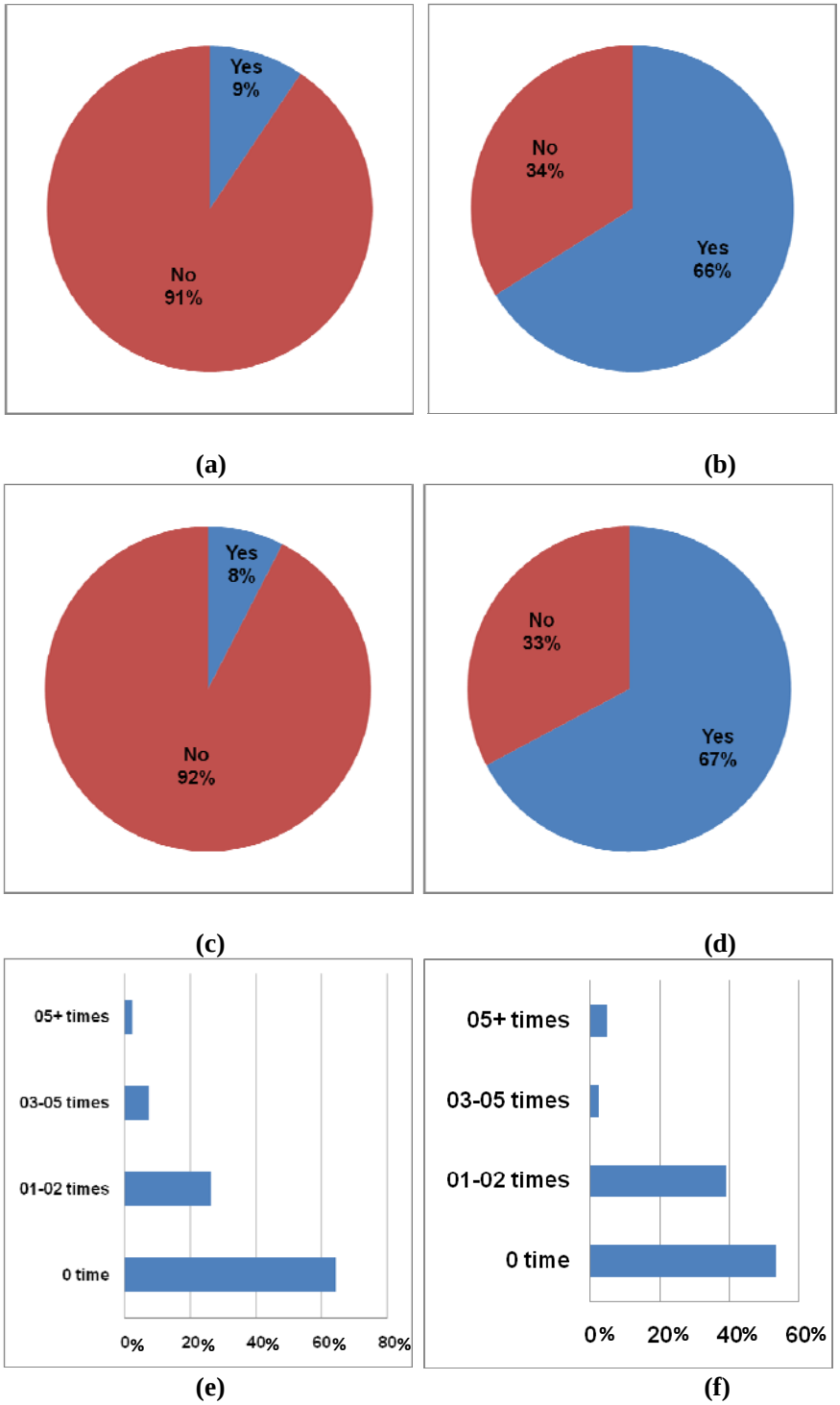


Figure 4.54: Spreading pollution during disaster from EcoSan and other toilet in previous years (a) EcoSan toilet innunded during flood (b) Other toilet innunded during flood (c) Faeces comes out from EcoSan toilet during flood (d) Faeces comes out from other option during flood (e) According to user house flooded in last years flood (f) According to non user house flooded in last years flood

4.6.1.4.c Scope of ground water pollution

Since the EcoSan are placed aboveground level, the chance of groundwater contamination is less for low water table areas. According to Sphere standard the distance between depth of water table and the bottom of the pit level should be at least 5 feet (1.5 meter). So considering this standard EcoSan toilet reduces the risk of groundwater contamination due to its elevated heights of the rings. In this regard Ecoan toilet is suitable for low water table area (8 feet or less during wet season). In Oxfam project areas significant amount of microbial contamination were observed in some tube well water. People were used to traditional pit latrine which was one of the causes of such contamination. Since the project areas are mostly Char area and the water table in these areas are high especially during rainy season (APPENDIX – D), according to Sphere Standard it is difficult to maintain approximate 5 ft (1.5 meter) in between the distance of water table depth and the depth of pit bottom level. EcoSan latrines have two concrete and brick-lined vaults that store and stabilize the faeces during use, completely eliminating the possibility of seepage and contamination of groundwater sources. So, EcoSan is a suitable technology for high water table areas where groundwater could be protected from microbial contamination. According to the table: 4.11, 76 percentages of EcoSan toilet surrounding water bodies are in range of no or without risk. Besides during flood there is little chance of contamination of surface water as well.

Table 4.11: Ground water pollution risk analysis

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

Source: *Oxfam*

JADE took another initiative to assess risk of presence of parasite of the surrounding condition of the rural leaving environment like around the pit latrine, around cowshed, around field by urine use, field by chemical fertilizer use, beside pond, around shallow tube well and around EcoSan toilet by doing some sub surface water. Table 4.12 it is proven that presence of E – coli is very much less than conventional pit latrine. From the figure 4.55 it is

found that 94%% of the respondents believe the EcoSan latrine not polluting surface and subsurface of water bodies. In both dry and wet season the sub surface level water table has been measured in Oxfam field the result is in APPENDIX – D.

Table 4.12: Comparison of microbiological contamination in different sites

Sample no.	Sample Type	Result CFU/g	Parasite sum
1	Around EcoSan toilet	1,200	6
2		14,800	5
3		820	4
4		1,130	5
5	Around pit latrine	6,840	8
6		910	5
7		24,080	6
8		970	3
9	Around cowshed	390	10
10		70	8
11	Field by urine use	0	8
12		0	10
13		0	10
14		10	7
15	Field by chemical fertilizer use	170	4
16		860	9
17		500	5
18		80	7
19	Beside pond	710	9
20		130	6
21		250	6
22		10	6
23	Around shallow TW	2,860	3
24		4,520	2
25		4,500	3

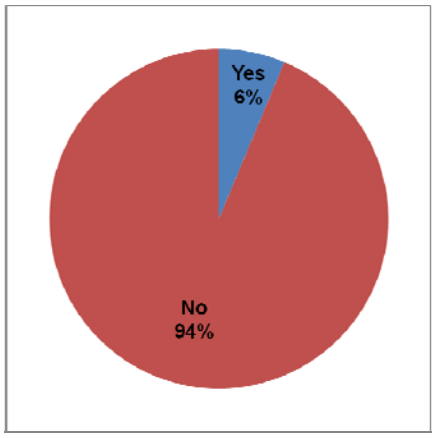


Figure 4.55: Surface and subsurface water pollute by EcoSan toilet

4.6.2 Health Aspect of ecosan toilet

4.6.2.1 Introduction

Human excreta have been introduced as the compost manure in Bangladesh from long past but its use is not universal yet due to traditional cultural barrier, religion and gap of behavioural knowledge and technology. Farmers those who are using it as manure in their farmland there is no scientific consideration. They are using it indiscriminately as they have not been suggested any guideline yet. It is evident that human excreta contain lots of pathogens and others harmful materials which are responsible for many health threats. So it is very necessary to sanitize human excreta before use in the farm land as manure.

In recent time scientific approach to use human excreta as manure has been started in Bangladesh on the basis of some international study. In this case excreta being processed in EcoSan toilet which is differ than any others conventional toilet in Bangladesh. Urine has been separated form faeces and both of them stored in two different places. Faeces used to conserve in a specialized chamber mixing with ash and kept it six months for treatment just after stopping defecation. As a whole, after one year cycle (six months defecation period plus six months treatment period) treated dried excreta are advised to use as manure. As urine contains no mentionable health threaten substances so it is advised to use each fifteen days interval of storage time.

Using urine and treated faeces in the farm land and tress gain in yield of crops and fruits has been found by the farmers and also by some researchers. As there is a scarcity of chemical fertilizer in Bangladesh, farmers are found very interested to use treated human excreta in their farm land. They are now taking it as a good source of organic fertilizer. But still now there is no specific study on conservation period of faeces to make it sanitize in Bangladesh perspective.

In some study it is found that before use of faeces proper sun dry and also long conservation period can reduce the prevalence of pathogen. In Bangladesh context (climate, food practice, toilet types, etc), it is not yet determined the way of sanitizing properly before use of human excreta to the farm land.

4.6.2.2 EcoSan toilet and Health

The extent to which any latrine risks human health and/or deters people from using the excreta depends on three basic factors:

i) how the design reduces pathogens to a safe level;
ii) the degree of human activity (interaction) required to operate and maintain the latrine; and
iii) the way in which users/operators follow safe management principles.

All types of latrine and waste disposal system are potentially hazardous, particularly when their management systems break down. The safety of ecological sanitation should be viewed in this context, rather than in isolation from the human environment in which it operates. Ecological sanitation is often considered to pose a health risk based on the transmission of disease associated with using excreta to fertilize crops. A review of these health aspects has found that:

i) crop fertilization with raw excreta causes excess infection with intestinal nematodes, in both field workers and consumers of the crops;
ii) the fertilization of rice paddies with excreta may lead to excess schistosomiasis infection among rice farmers; and
iii) faecal matter used on grazing land can lead to cattle becoming infected with *Cysticercabovis*.

The findings indicate that the risk of infection is from the use of incorrectly or poorly treated excreta. There is therefore a need for ecological latrines to form a barrier to the spread of disease and reduce pathogen levels as part of the treatment process. (WELL 2006)

4.6.2.2.a Pathogen reduction in the toilet:

The following factors have a positive effect on reducing pathogens in ecological latrines:

i) increasing the storage time;
ii) reducing the moisture content;
iii) increasing the pH of the contents of the pit/vault;
iv) increasing the temperature of the contents of the pit/vault; and
v) encouraging the presence of other micro-organisms to destroy pathogens by predation.

Storage: All designs of ecological latrines use a pit or vault to store excreta. Storage time has a significant impact in reducing pathogens to safe levels, making this one of the primary means by which ecological latrines reduce the level of pathogens in waste. The storage time depends on the pit/vault volume, the quantity of additives used, the number of people using the latrine and their diet.

Moisture, pH and temperature: In principle, pathogens die off upon excretion, as the environmental conditions outside the human host are generally not conducive to their survival. The moisture content, pH and temperature of the environment are all known to have an impact on pathogen reduction.

The ***ideal conditions*** to kill pathogens are reported as:

i) low moisture content (<25%);
ii) high pH (>10); and
iii) high temperature (>36°C).

Ecological latrines use the following techniques to encourage pathogen reduction:

i) providing sufficient *storage time* with suitably sized pits or vaults.
ii) reducing the *moisture content* by:
    – separating urine from faeces. Although this reduces the moisture content, it can still vary with the use of the latrine for bathing, 'wateriness' of stools, etc;
    – heating faeces with a solar drying plate, to evaporate moisture from the faeces; or
    – adding dry material such as ash, soil or lime to absorb moisture from the faeces.
iii) increasing the pH by adding dry wood ash or lime.
iv) increasing the *temperature* by:
    – heating the faeces using a solar drying plate; or
    – adding wood shavings or living material (such as leaves), to help the composting process to be as aerobic as possible.
v) encouraging *predation* by the addition of soil containing a variety of micro-organisms capable of killing or consuming the pathogens.

It is important to note that the "ideal conditions" needed for pathogen reduction require good user management, and there will be variation in conditions within even a small project.

In a dehydrating latrine, while the pH may reach relatively high levels (above 9), the temperature and moisture content rarely reach levels to have a significant impact. In warm, humid climates achieving the correct moisture content becomes almost impossible. The main factor influencing the level of pathogen reduction is therefore storage time.

Even in a well-managed composting latrine, environmental conditions mean that the moisture content is not low enough to desiccate the pathogens, the temperature is not high enough to destroy them and the pH does not achieve the correct levels if soil and ash are added. Again, the main factor for pathogen destruction in a composting latrine is storage time.

Implications of such findings are that:

i) minimum storage times should be one year; and
ii) until there is evidence that pathogens are consistently destroyed, ecological latrine users should be encouraged to bury the solids removed from the pit/vault.

Ecological latrines only reduce pathogens to safe levels given sufficient storage times and proper management of the latrine. The reality of life in poor communities makes it difficult however, even with the users' best intentions, to ensure that sufficient storage and correct management occurs with all the ecological latrines that are built.

The safety of ecological sanitation is not dependent solely on the ability of an ecological latrine to reduce the pathogen level to a safe standard, but also the risk posed by post-latrine handling of the excreta and the hygienic behaviour of the household and wider community.

4.6.2.2.b Post-toilet handling

Independent of the latrine type, stored excreta from all ecological latrines are intended to be taken from the pit and applied to land and how this process is carried out has a significant impact on the risks associated with using human waste as a fertilizer.

The removal and application process involves three areas of risk:

i) those responsible for emptying the pit and applying excreta to the land become infected through direct contact;
ii) children and adults walk, work or play in the area where excreta is deposited or applied to land, and poor hygiene practices lead to contamination and infection; and

iii) contamination of crops, which is particularly important for crops that may not be cooked before eating, such as tomatoes or lettuce.

The risk of contamination to members of the community depends on how the removed excreta are applied to the land, as well as the amount of time people from the community spend on that land. When excreta are deposited near people's homes, or on land where people often congregate, the risk of contamination is increased.

A high risk of contamination occurs if the contents are spread by hand to the land and used as a top dressing. Exposed helminth eggs and pathogens will be a health risk to anybody walking on the land, although this risk will diminish with time as pathogen die-off is accelerated through the effects of sunlight and desiccation.

If excreta or excreta-derived products are applied to the field before planting crops:

i) farm and sanitation workers should be adequately protected during the process;
ii) the excreta should be placed in trenches and covered with at least 25cm of soil; and
iii) root crops should not be planted directly over the trenches.

The degree of risk is also related to the growing time of the crop and survival time of the contaminating pathogen, either in the soil or on the crop. Only when pathogen survival times are shorter than crop growing cycles, is the potential risk posed to both crop handlers and consumers reduced. The high persistence and low infective dose for Ascaris (see Table 4.13) makes this pathogen the greatest cause for concern (WELL 2006).

Table 4.13: Survival rates of certain excreted pathogens in soil and on crops, at 20-30ºC

Common infections	Survival time in soil (days)	Survival time on crops (days)
Virus: Enteroviruses	<100 but usually <20	<60 but usually <15
Bacteria: Faecal coliforms	<70 but usually <20	<30 but usually <15
Helminths: *Ascaris lumbricoides*	Many months	<60 but usually <30

Parameters tested in different laboratories: Availability of some heavy metals and all possible pathogens/parasites in human excreta which can create health hazard is tested.

Physical and Chemical Elements:

A. Metals: Lead (Pb), Arsenic (As), Manganese (Mn), Chromium(Cr), Cadmium (Cd), Nickel (Ni)

B. Physical Parameters: pH , Moisture Content

Bacteria:

E.coli, Vibrio cholerae, Salmonella spp., Shigella and Clostrodium perfrengens, etc

Parasite:

Ascaris, Ancyclostoma, Necator, Helmenthis, Hymenolepis, Strongyloides, Toxocara, Trichuris, Taenia spp. etc

Protozoa:

Giardia, Cyclospora, Cryptospordium, Entamoeba spp. etc

Data Sources:

The data has also been collected from secondary source different organization like Japan Association of Drainage and Environment (JADE), Practical Action Bangladesh, Oxfam and ITN, BUET. Collection, conservation, and test were conducted in a very controlled way. Only in JADE case Test procedure was conducted basically on time series basis.

Samples and its collection procedure:

The samples were collected by different organization from some separate toilets of the different project areas and for this study analysis purpose geographical variety has been considered.

In all cases dried faeces were collected according to the demand of the laboratories. For the JADE case first the sample will be collected from upper, middle and bottom layer of the chamber. Then stuff from each layer was mixed on the big polythene paper. After mixing the stuff properly each sample were collected in separate fresh transparent polythene bag/pot.

The main criteria to select the faeces sample were maturation/storage period. In this case maturation period was considered 6 month after sealing the faeces chamber. Before going to test in laboratory, all samples were dried in the sun properly to control moisture content in the samples.

JADE tasting method was based on time series analysis, for that reason same sample were tested after every months for the same parameter in the same laboratory by the same professional.

Laboratory involves for testing:

In case of Oxfam and JADE, the laboratory test was done in soil, water and environment department, University of Dhaka and the laboratory of microbiology department of ICCDDR, B two laboratories for different parameters. Practical Action Bangladesh tested their sample in Institute of Epidemiology, Disease Control and Research (IEDCR) laboratory. ITN-BUET research Laboratory tests were performed at the Institute of Epidemiology, Disease Control and Research (IEDCR), Mohakhali, Dhaka for pathogen detection Nutrient concentrations were tested at the Environmental Engineering Laboratory of Waste Concern, Banani, Dhaka.

4.6.2.2.b.*i Health implications*

With regards to health food insecurity and permanent nutrient deficiency often causes weakness and fatigue, inhibits mental and physical development, particularly in children, and makes people susceptible to other fatal diseases such as diarrhoea and tuberculosis. At the same time preventing water related diseases like diarrhoea would lead to a more efficient use of available nutrients and food with a positive effect on the overall food security situation. Diarrhoea and parasitic intestinal worm infections like *Ascaris, Trichuris* and hookworm rob their hosts of calories and prevent food from properly nourishing its consumers. There is good evidence that the health impacts of water and sanitation interventions extend far beyond diarrhoea and helminth worm infections and include many other important diseases such as acute respiratory infections, malnutrition, schistosomiasis, Guinea worm, trachoma (DFID 2011) and tropical enteropathy (Humphrey 2009). Particularly the underestimated phenomenon known as tropical enteropathy, a subclinical disorder of the small intestine, is assumed to be one of the key causes of child malnutrition which is caused by ingestion of large quantities of faecal bacteria in conditions of poor sanitation and hygiene (ibid). Improving sanitation conditions and promotion of hand washing after faecal contact could reduce or prevent diseases like diarrhoea and tropical enteropathy and its adverse effects on growth. Table 4.14 shows the comparison of presence bacteria, parasitic protozoa, helminths in the different faeces sample of different organization and Table 4.15 and Table 4.16 shows the comparison of physical and chemical properties in the different faeces sample of different organization respectively. Table 4.17 shows the comparison of Parasitological Findings in without and with dried specimens and Table 4.18 shows the comparison of bacteriological findings in without and with sundried specimens. Sixteen samples from JADE filed has been tested in dry faeces condition in laboratory the testing result is in APPENDIX – C.

Table 4.14: Comparison of presence bacteria, parasitic protozoa, helminths in the different faeces sample of different organization				
Pathogen	**Symptoms**			
Bacteria		Oxfam (one sample)	JADE (four sample)	PAB (two state before and after sundry)
Aeromonas spp	Enteritis			
Campylobacter jejuni/coli	Diarrhoea, cramping, abdominal pain, fever, nausea, joint pain, Guillain-Barré syndrome			
Escherichia coli (EIEC, EPEC, ETEC, EHEC)	Enteritis		Absent (three months observation)	
Plesiomonas shigelloides	Enteritis			
Salmonella typhi/paratyphi	Fever - headache, malaise, anorexia, slow pulse, enlarged spleen, cough			
*Salmonella sp*p.	Diarrhoea, fever, abdominal cramps	Absent / 10 g	Absent (three months observation)	
Shigella spp.	Dysentery (bloody diarrhoea), vomiting, cramps, fever	Absent / 10 g	Absent (three months observation)	
Vibrio cholera	Cholera - watery diarrhoea, lethal if severe and untreated	Absent / 10 g	Absent (three months observation)	
Yersinia spp.	Fever, abdominal pain, diarrhoea, joint pains, rash			
Clostridium perfringens		Absent / g		

Contd. Table 4.14: Comparison of presence bacteria, parasitic protozoa, helminths in the different faeces sample of different organization				
Pathogen	**Symptoms**			
Bacteria		Oxfam (one sample)	JADE (four sample)	PAB (two state before and after sundry)
Total coliform		43 MPN/g		
Parasitic protozoa				
Cryptosporidium parvum/hominis	Watery diarrhoea, abdominal cramps and pain	0 (Count/gm)		0 frequency 0%
Cyclospora cayetanensis	Often asymptomatic, diarrhoea, abdominal pain	0 (Count/gm)		
Entamoeba histolytica	Often asymptomatic, dysentery, abdominal discomfort, fever, chills	720 (Count/gm)	3000max 2200min (1st month) 300max 0min(2nd month) 0 max –0min (3rd month)	60 frequency 100% Median 5.00 Std 2.293 Sundry specimen 15 frequency 100% Median 3.00 Std 1.710
Giardia intestinalis	Diarrhoea, abdominal cramps, malaise, weight loss	0 (Count/gm)	5300max 3300min (1st month) 300max 100min(2nd month) 0 max –min (3rd month)	
Toxocara SPP.			0max 0min (1st month) 0max 0min(2nd month) 0 max 0min (3rd month)	
Helminths				
Ascaris lumbricoides	Generally no or few symptoms, wheezing, coughing, fever, enteritis, pulmonary eosinophilia	160 (Count/gm)	700max 300min (1st month) 0max 0min(2nd month) 0 max 0min (3rd month)	60 frequency 100% Median 8.00 Std 5.846 Sundry specimen 15 frequency 100% Median 7.00 Std 2.219

Contd. Table 4.14: Comparison of presence bacteria, parasitic protozoa, helminths in the different faeces sample of different organization				
Pathogen	**Symptoms**			
Bacteria		Oxfam (one sample)	JADE (four sample)	PAB (two state before and after sundry)
Taenia solium/saginata			0max 0min (1st month) 0max 0min(2nd month) 0 max 0min (3rd month)	
Trichuris trichiura	Unapparent through vague digestive tract distress to emaciation with dry skin and diarrhoea		0max 0min (1st month) 0max 0min(2nd month) 0 max 0min (3rd month)	55 frequency 91.7% Median 3.00 Std 1.310 Sundry specimen 14 frequency 100% Median 3.00 Std 1.141
Hookworm	Itch, rash, cough, anaemia, protein deficiency			6 frequency 10% Median 2.00 Std 0.837
Shistosomiasis spp				
Ancylostoma spp.		0 (Count/gm)	400max 0min (1st month) 0max 0min(2nd month) 0 max 0min (3rd month)	
Necator spp.		0 (Count/gm)	400max 0min (1st month) 0max 0min(2nd month) 0 max 0min (3rd month)	
Hymenolepis spp.		40 (Count/gm)	100max 0min (1st month) 0max 0min(2nd month) 0 max 0min (3rd month)	

Table 4.15 : Comparison of physical properties in the different faeces sample of different organization

Physical properties							
SI. No.	**Parameters**	**Unit**	**Standard Condition**	**ITN, BUET**	**PAB**	**JADE**	**Oxfam**
1	Colour	-	Dark brown to black	Dark brown	Black (15%), Ash (8.3%), Grey (5%), Muddy (15%), Blackish (23.3%), Chocolate (31.7%), Greenish black (1.7%)		
2	Physical condition	-	Dust/Powder	Dust			
3	Odour	-	Odorless	Odorless	No odour (6.7%), Reek (93.3%)		
4	Moisture Content	%	Maximum 15	51.17	Min 22.30 Max 80.00 Mean 48.89, Median 50, Std Deviation 14.39		Actual condition 88.20%

Table 4.16 : Comparison of chemical properties in the different faeces sample of different organization

Chemical Properties							
SI. No.	Parameters	Unit	Standard Range	ITN, BUET	PAB	JADE	Oxfam
1	pH	-	6.0 - 8.5	8.28	Mean: 6.2167, Median: 6.0; SD ±0.7093	Mean 9.37	8.35
3	Organic Carbon	%	10-25	5.44			3.13
4	Total Organic Matter	%	25-50	9.36			
5	Total Nitrogen (N)	%	0.5-3.0	2.66		Mean 0.36	0.55
6	Phosphorus (P)	%	0.3-3.5	0.42		Mean 0.021	0.243
7	Potassium (K)	%	0.5-1.8	1.42		Mean 2.75	0.643
8	Carbon-Nitrogen ratio	-	1-30	5.56			
9	Zinc (ppm)					Mean 109.32	
10	Copper (ppm)					Mean 40.69	
11	Lead (Pd)	ppm	Maximum 30 ppm			Mean 2.31	2.51
12	Cadmium (ppm)	ppm	Maximum 5 ppm			Mean 0.12	0.46
13	Nickel (Ni)	ppm	Maximum 30 ppm			Mean 11.71	20.64
14	Chromium (Cr)	ppm	Maximum 50 ppm			Mean 11.57	21.90
15	Arsenic (As)	ppm				Mean 2.19	
16	Manganese (Mn)	ppm	Maximum 5 ppm				0.46

Table 4.17: Comparison of Parasitological Findings in without and with dried specimens

Without dried up specimens			**Dried up specimens**		
Detection of parasite	**Frequency**	**%**	**Detection of parasite**	**Frequency**	**%**
Cyst of protozoa			Cyst of protozoa		
Yes	60	100.0	Yes	15	100.0
Entamoeba Median 5.00 Std 2.293	60	100.0	Entamoeba Median 3.00 Std 1.710	15	100.0
Cryptosporidium	0	0.0	*Cryptosporidium*	0	0.0
Helminths	**Frequency**	**%**	**Helminths**	**Frequency**	**%**
Yes	60	100.0	Yes	15	100.0
Hookworm Median 2.00 Std 0.837	6	10.0			
Roundworm Median 8.00 Std 5.846	60	100.0	Roundworm Median 7.00 Std 2.219	15	100.0
Trichuris trichiura Median 3.00 Std 1.310	55	91.7	*Trichuris trichiura* Median 3.00 Std 1.141	14	93.3

Source: IEDCR study report, 2011

According to the table 02, 03 and 04 of Appendix –F, the risk factor considering presence of parasite and protozoa in three different layers of feces vault of ten samples each case has been examined by JADE. From the laboratory result it is found that four sample of upper layer have moderate infection, four sample of middle layer have moderate infection and ten moderate and one heavy infection found in bottom layer. In the same appendix -F table 01 try to give the presence of parasite and protozoa in different environment and its risk level where it is found that seventeen heavy and thirty three moderate infection.

Table 4.18: Comparison of bacteriological findings in without and with sundried specimens

	Without sundried specimen		sundried specimen	
Growth of bacteria	**Frequency**	**%**	**Frequency**	**%**
Growth of bacteria	54	90.0	14	93.3
No Growth of Bacteria	6	10.0	1	10.0
Pathogenic bacteria	0	0.0	0	0.0
Total	60	100.0	15	100.0

Source: IEDCR study report, 2011

There was growth of bacteria in 90.0% cases without sundried specimen and 93.3% cases with sundried specimen , all of which were nonpathogenic organisms. No faecal coliform, salmonella, Shigella or Vibrio was found in all tested specimens. Parasitic examination reveals parasite in each of the specimens. Cyst of *Giardia intestinalis* was found in five samples. Cyst of Entamoeba was found in all samples ranging from 3000 to 720 parasites per gram. Cryptosporidium was not found in any sample. Ova of Hookworm were found in six specimens of PAB specimen ranging from 1, 2 and 3 per gram of compost having frequencies of respectively 16.7%, 50.0% and 33.3% respectively. Ova of Hookworm were found in each of three specimen collected from one latrine.

Ova of Ascaris lumbricoides were found in all specimens ranging from 700 to 2 per gram with more than half of the specimens having less than 10 parasites per gram. Ova of Trichuris trichiura were found in PAB specimen and 55 specimens ranging the parasite load from one to seven per gram of compost with more than eighty percentage having the load within four per gram. No ovum of Tapeworm was found in any specimen.

The colour and odour of the composted excreta of Eco-Toilet were more or less acceptable. Though there was reek odour mostly but intensity of odour was mainly weak. The mean pH was bases and in one case it was acidic though ash was said to be added following defaecation. The moisture content was high and some specimens were found to be wet. Bacteriological examination revealed no pathogenic organism. Parasitological examination revealed at least one type of parasite in each of the specimens. Cyst of *Entamoeba* was found in all specimens with varying number. All the *Entamoeba* found in the specimens were not pathogenic. Ova of *Ascaris* were found in almost all specimens but *Trichuris* was found in

one case. Though many of the ova were not found to be viable based on physical characteristics, but still some of them even in the dried specimen seemed to be capable of infection. Though examined a number of specimens selected randomly after one month of preservation in airtight containers. These specimens revealed no parasite or few distorted parasite in both PAB and JADE cases.

The composted excreta of Eco-Toilets had pathogenic burden of with parasite specially that of Ascaris *lumbricoides* and *Trichuris trichiura.* Bacteriologically, these seem to be safe to be used as fertilizer. Storage of the compost in airtight container for two weeks or more may reduce the pathogenic burden of parasite. As the parasite load varies from area to area and from urban to rural settings, pathogenic load need to be assessed in those settings. Comparison of microbial exposure and health risk in different sanitation technologies and systems given in APPENDIX – E.

4.6.2.2.c Hygienic behavior

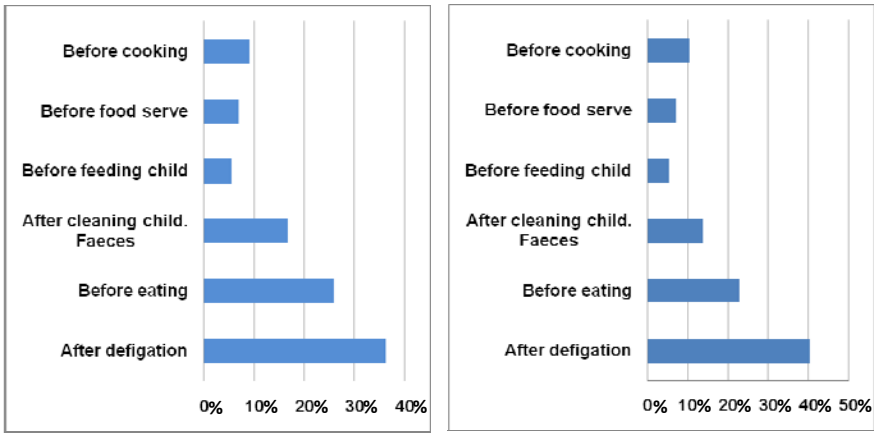
One of the most effective methods of breaking the faecal-oral route and avoiding infection is through the simple act of hand washing with soap. If everyone who came into contact with excreta immediately washed their hands (or feet if walking barefoot), the risks presented by ecological sanitation would be significantly reduced. However, good hand washing is a difficult behaviour change to achieve effectively and it cannot be relied on to ensure safety to the user.

4.6.2.2.c.*i Households Hygiene Situation*

Household members hand washing practice

Measurement of microbiological contamination of hands is another proxy measure of hand washing behaviour. The underlying assumption is that hands that are washed with soap will be less contaminated with faecal organisms than hands that are not washed with soap. The details of measuring hand contamination, e.g., by fingertip rinses or hand imprints on semi-solid media, among others, are beyond the scope of this paper but are covered in numerous peer-reviewed publications. As a proxy measure, hand contamination offers a level of objectivity greater than self-report. In Bangladesh, hands tested immediately after thorough washing with soap have been found to have substantially lower contamination with faecal coli forms than unwashed hands, although even this finding is challenged by other research, in which there has been no reduction in bacterial contamination between pre- and post-hand

washing measurements. Figure 4.56 shows that hand washing practice in user and non user HH.



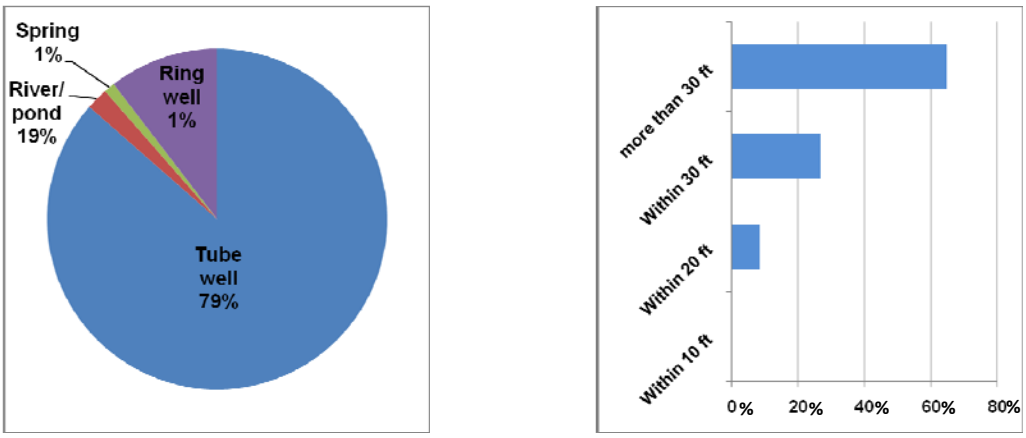
(a) **(b)**

Figure 4.56: Hand washing practice in user and non user HH (a) user (b) Non user

In the survey it is found that for both the cases user and non user around 40% respondent HH member wash hands after defecation and 25% before taking food.

Households safe water use situation

The study has tried to capture mainly the safe water use in different purposes. Through the questionnaire survey conducted in both EcoSan toilet user and non user. The idea was that to identify relation with safe water use practice and diarrhoea diseases in the entire surveyed household. Figure 4.57 and Figure 4.58 shows the dirking and cooking water source and boiling practice of EcoSan toilet user HH and non EcoSan user respectively.



(a) **(b)**

Figure 4.57: Dirking and cooking water source and boiling practice of EcoSan toilet user HH (a) Drinking water source (b) Unhygenic latrine near drinking water sourec

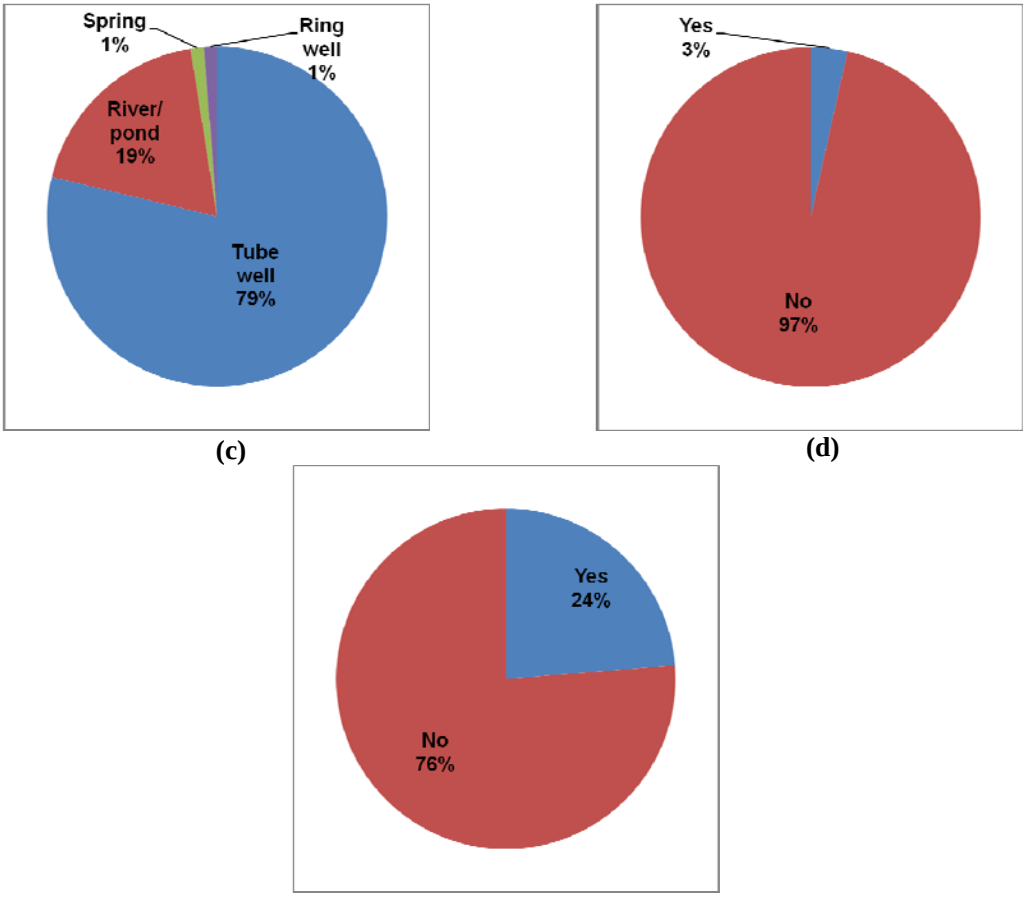


Figure 4.57: Dirking and cooking water source and boiling practice of EcoSan toilet user HH
(c) Cooking water source (d) Unhygenic latrine near water sourec (e) Prectice of use boil water

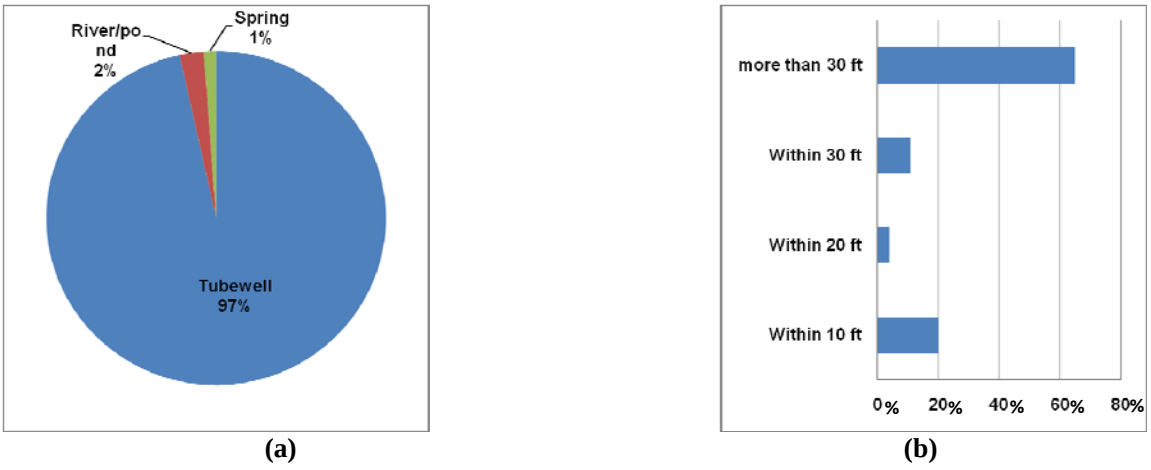
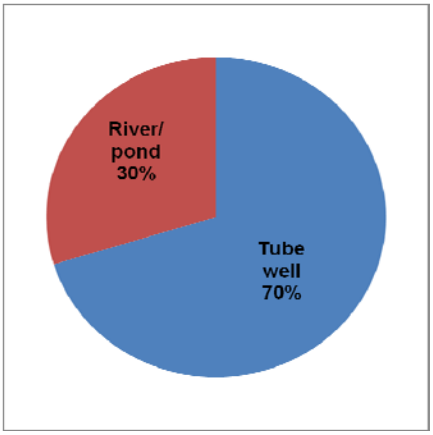
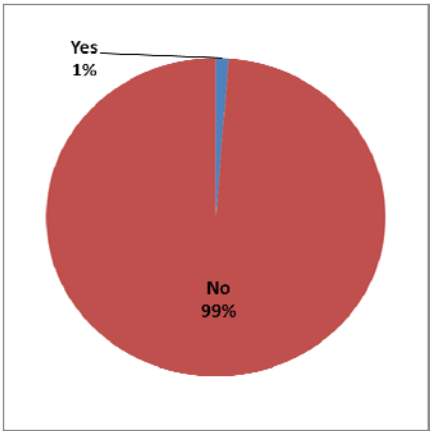


Figure 4.58: Dirking and cooking water source and boiling practice in non EcoSan toilet user HH
(a) Drinking water source (b) Unhygenic latrine near drinking water sourec



(c)

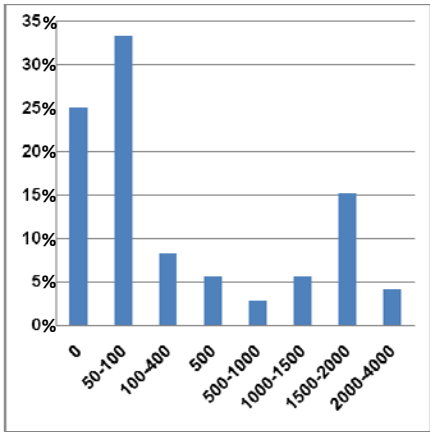


(d)

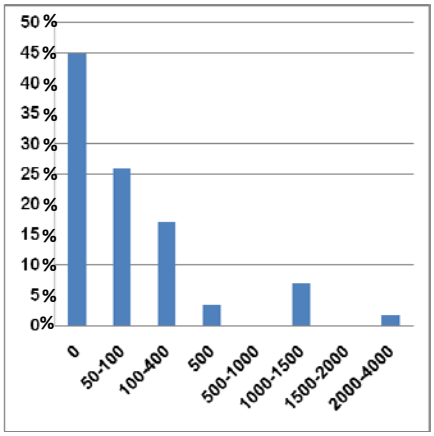
Figure 4.58: Dirking and cooking water source and boiling practice in non EcoSan toilet user HH (c) Cooking water source (d) Prectice of use boil water

The comparative scenario showed in Figure 4.58 indicating that most of the households are using tube well water for both drinking and cooking purpose. Near the water source the presence of unhygienic latrine or hanging latrine presence is less than 3%. These percentage have great opportunity to be contaminated by faecal coli form. Figure 4.59 shows that diarrhoea disease and medical expense trend of EcoSan user.

4.6.2.2.c.*ii* *Diarrhoea Disease Trend and Medical expense*



(a)



(b)

Figure 4.59: Diarrhoea disease and medical expense trend of EcoSan user (a) Monthly expenditure for diarrhoeal disease before using EcoSan toilet (b) Monthly expenditure for diarrhoeal disease after using EcoSan toilet

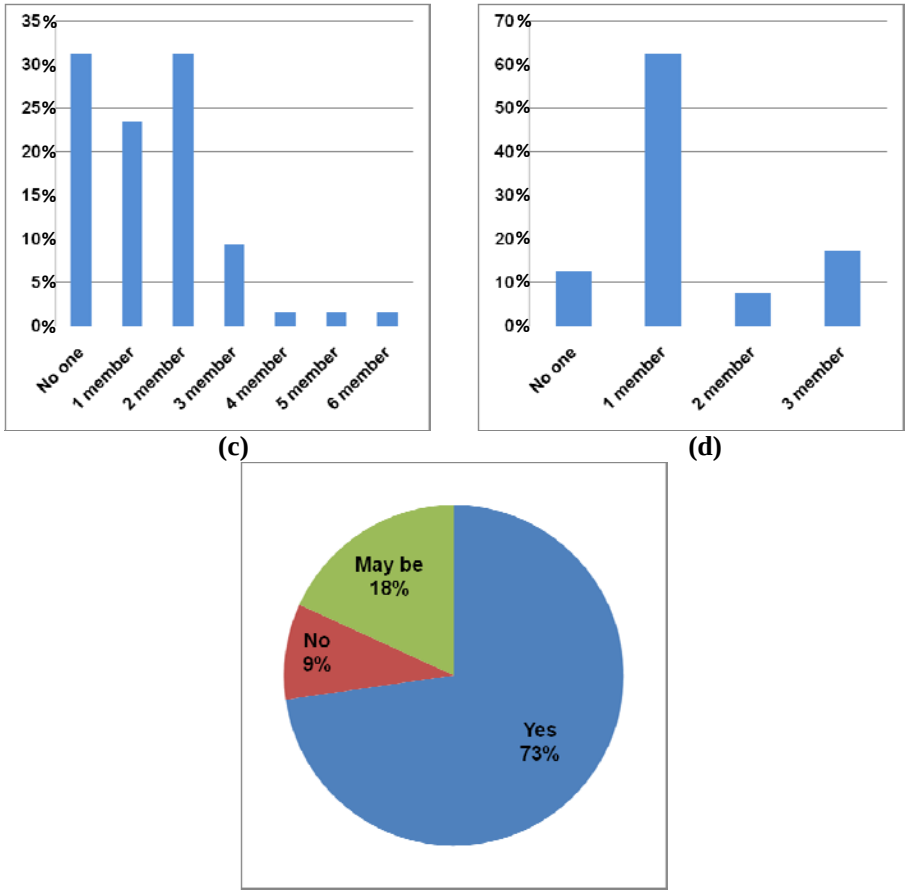


Figure 4.59: Diarrhoea disease and medical expense trend of EcoSan user (c) Monthly diarrhoea affected member before using EcoSan toilet (d) Monthly diarrhoea affected member after using EcoSan toilet (e) Reduce diarrhoea disease due to EcoSan toilet

The above figure 4.59 indicates the yearly changes in medical expenses before and after using the EcoSan toilet. 20% increase in no medical expenses for diarrhoea diseases and big change in number of household member affected reduce. 40% increase in only the case for one member. 73% respondent believe that sanitation system EcoSan toilet help to reduce the diarrhoea diseases. Figure 4.60 shows that diarrhoea disease and medical expense trend of non EcoSan user and latrine as cause.

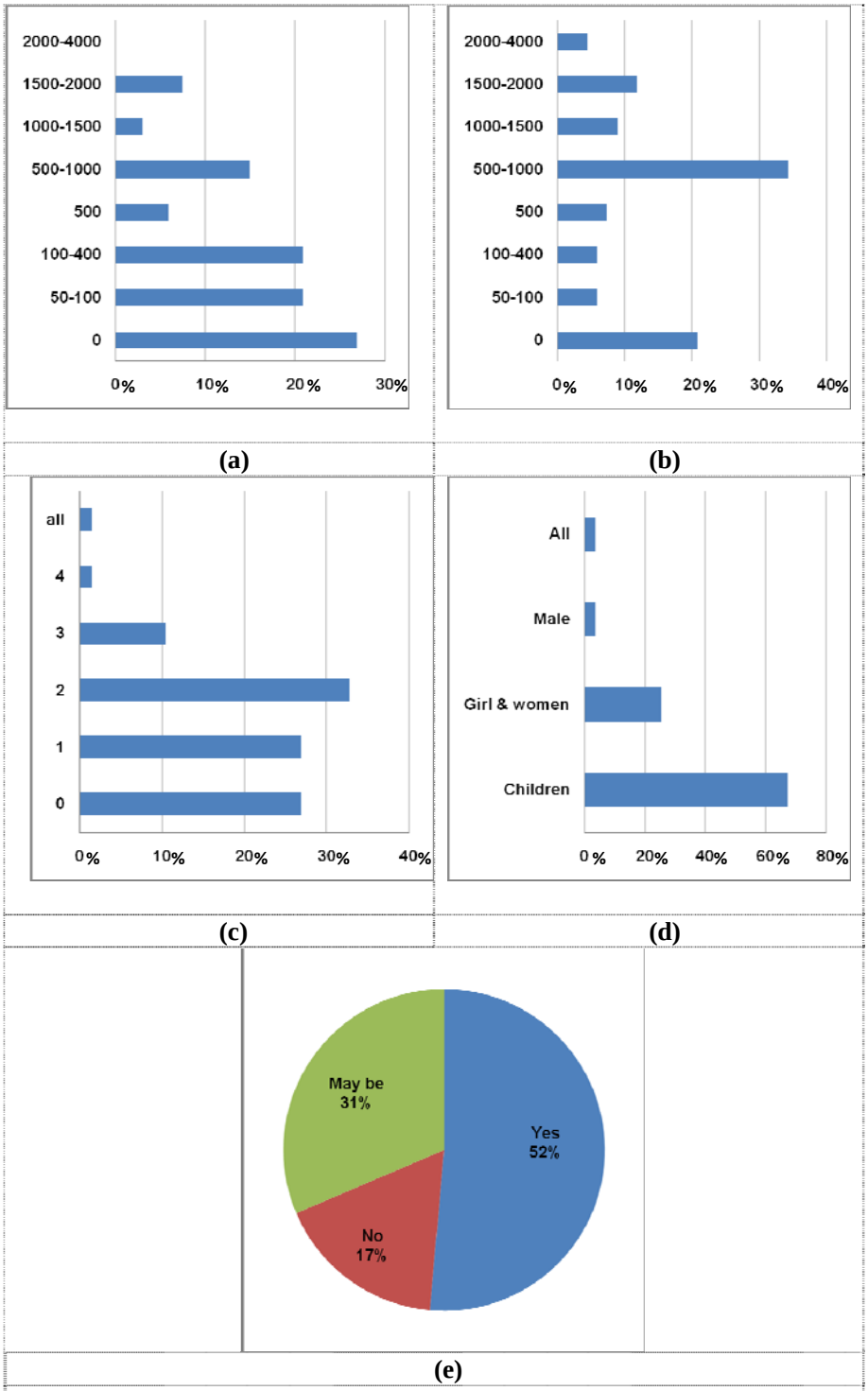


Figure 4.60: Diarrhoea disease and medical expense trend of non EcoSan user and latrine as cause (a) Monthly expenditure for diarrhoeal disease (b) Yearly expenditure for diarrhoeal disease (c) Members of family mostly affected by diarrhoeal disease in last two months (d) Members of family mostly affected by diarrhoeal disease (e) Latrine is one of the reason of Diarrhoea

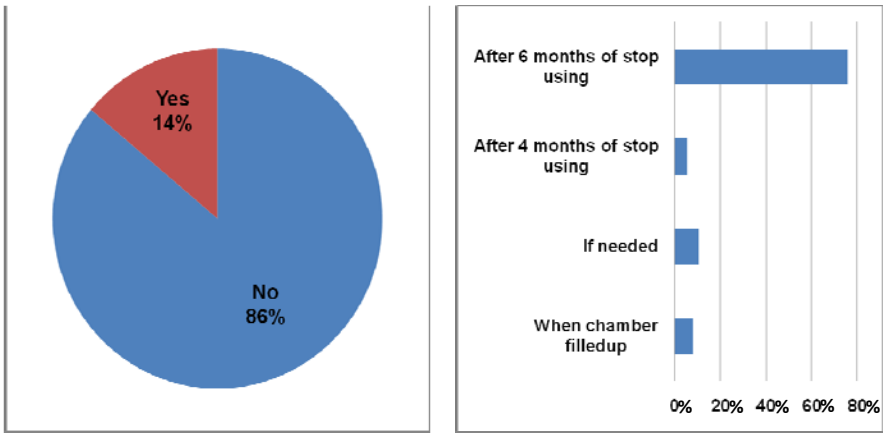
The above figure indicates the yearly 50% have to spend about 1000BDT and 20% have to spend 2000BDT medical expenses for diarrhoea diseases. Most of the non EcoSan user respondents believe that children and women are mostly affected and 80% believe that latrine is one of the main causes of diarrhoea.

4.6.2.2.c.*iii Handling of faeces and urine*

Safe handling of EcoSan by-products operates on the principle of: reducing contact with the material. Although there is no high risk associated with treated urine it is recommended that agricultural fieldworkers wear appropriate protective clothing (shoes and gloves). Urine is one of the by products from EcoSan toilets. Urine is one of the cleanest fertilizers available to the agricultural community. Urine is normally sterile in the urine bladder, but "picks up" organisms that occur in the lower parts of the urinary tract.

Faeces are good soil conditioner due to their possession of very high organic matter. The content of organic matter in faeces increases the water holding/ retention and ion-buffering capacities of soils, which is of importance for improving soil structure and stimulates microbial activity. The main cause of disease is the entry of disease causing pathogens into some one's body. When a person excretes a pathogen which is not contained or destroyed, it contaminates the environment through fingers, fluids, food and flies, which become pathways of disease transmission. Uncontained pathogens also contaminate crops, soil, surface water and ground water. Some of the human illnesses that arise from using untreated or poorly treated faeces include inflammation of the intestines, diarrhoea, abdominal pain, fever, nausea; arthritis; Typhoid/paratyphoid fever - headache, dysentery, vomiting, Cholera, joint pains, Hepatitis and Poliomyelitis.

These illnesses may result in poor health, death or effects that last a lifetime. Safe handling using multi-barrier approaches which involve treatment of the faeces, risk reduction during handling and in agricultural practices as well as the individual behavioural (hygiene) aspects, minimize the risks associated with reuse of excreta. Safe handling of EcoSan by products aims at maximizing the protection of human health and the beneficial use of important resources. The faeces in the EcoSan are sanitized on the principle of dehydration and elevated pH due to ash or lime addition. Dehydration deprives the pathogens of the moisture they need to survive. The long storage period and increased pH further reduces the pathogen content. Figure 4.61shows that handling of faeces and urine by the user.



(a) **(b)**

Figure 4.61: Handling of faeces and urine (a) Practice of using safety gear (b) Practice of diging out faeces

According to the respondent only 24% using proper safety gear to spray urine and spreading dry faeces and 13% wearing something like plastic bag, but 63% are not using anything for this purpose. Only 76% follow the basic instruction of digging out dry faeces after six month of stop using the chamber.

4.6.2.3 Overall risk

Programmes promoting ecological sanitation are typically weak when it comes to assessing the health risks associated with post-latrine handling of the excreta. While much effort is placed on proving the safety of the treatment process in the latrine on 'technical' grounds, little effort is given to consideration of the whole process from a social, user based perspective.

On the basis that the equation in Box 1 is correct and assuming that hygiene behaviours are not sufficiently well practised to provide a secure barrier to the spread of disease, the overall risk from ecological sanitation can be derived for different latrine designs in different settings, given the risks from pathogen survival and post-latrine handling. Similar assessments can be carried out to meet the requirements of other specific circumstances.

Even though some pathogens may be excreted in urine, the faecal cross-contamination that may occur by misplacement of faeces in the urine-diverting toilet is related to the most significant health risk.

Pharmaceuticals and hormones can also be excreted with urine, but the risk of negative effects to plants or human beings is minimal in comparison with the risk when using animal manure, sewage sludge or conventional fertilizers.

4.7 Assessing sustainability of EcoSan Toilet using sustainability criteria

Sustainability assessment of sanitation systems is no easy task. Factors influencing sustainability vary between communities, influence and interact with each other and change over time, which renders measurements of sustainability a complex issue (Mukherjee, 1999). Even so, attempts have been made to assess the sustainability of wastewater structures. One methodology used is system analysis, using a multidisciplinary set of sustainability criteria (Balkema *et al.*, 2002). This approach has been used extensively among researchers in order to compare different wastewater systems from different perspectives.

The Swedish research team Urban Water has generated computer models to represent situations such as the environmental impact of urban wastewater systems through material flow analysis (Balmér *et al.*, 2002; Hellström *et al.*, 2000). Urban Water has also developed models for microbiological risk assessment (Ashbolt *et al.*, 2005), chemical risk assessment (Malmqvist and Palmquist, 2005), and economic assessments (Hjerpe, 2005). The tools have been tested in different Swedish settings and are considered appropriate for countries with a similar infrastructure to that of Sweden (Malmqvist *et al.*, 2006). Van der Vleuten-Balkema (2003) presented a decision support tool for the selection of sustainable domestic water systems through a computer model that included life cycle assessment, cost–benefit analysis and social inventories. A multi-criterion approach for decision making in water management is proposed by Acreman (2003), taking into account not only economic but also social and ethical values.

System analysis approaches have also been used for assessment of sanitation systems in developing countries. A method to estimate nitrogen flows for different sanitation systems in a Vietnamese context, through a material flow analysis, has been proposed by Montangero *et al.,* (2004). Loetscher and Keller (1999) have developed a computer tool for the estimation of financial costs of sanitation systems in developing countries.

4.7.1 Sustainability criteria used for ecosan toilet in Bangladesh

The list of criteria used within this report is presented in Table 4.18. These kinds of comparison are to be made in actual situations, the sustainability assessment criteria should be identified through a participatory approach with all relevant stakeholders, and properly

weighted as described above.

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

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

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

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

Table 4.19: Expert analysis using sustainability criteria developed by the Sustainable Sanitation Alliance (SuSanA)

		based on assumption on study finding	based on expert opinion	Standard for Bangladesh Code based on expert opinion
(1) Health:				
	risk of exposure to pathogens	+	+	+
	risk of exposure to hazardous substances	+	+	+
	hygiene	+	+	+
	nutrition	0	0	+
	Improvement of livelihood	0	0	++
	downstream effects.	+	0	+
(2) Environment and natural resources:				
	required energy	-	0	0
	water	+	+	+
	other natural resources for construction	0	0	0
	other natural resources for operation	0	+	+
	other natural resources for maintenance	0	0	0
	potential emissions from use	0	0	+
	degree of recycling practiced and the effects of these	+	+	+
	degree of reuse practiced and the effects of these	+	0	+
(3) Technology and operation:				
	functionality	+	+	+
	ease regarding construction,	0	0	+
	operation and monitoring	0	0	+
	suitability to achieve an efficient substance flow management	+	0	+
	robustness of the system	+	0	+

	vulnerability towards disasters	+	+	+
	flexibility and adaptability of the system	0	+	+
(4) Financial and economic issues:				
	investment costs	-	-	-
	operation costs	-	0	0
	maintenance costs	-	0	0
	economic benefits in "productive" sanitation systems	+	+	+
	capacity of households and communities to pay for sanitation	-	-	+
(5) Socio-cultural and institutional aspects:				
	socio-cultural acceptance	+	-	0
	appropriateness of the system	+	+	++
	convenience	++	+	+
	gender issues	+	+	+
	impacts on human dignity	++	+	++
	contribution to subsistence economies	0	0	+
	food security	+	+	+
	legal and institutional aspects	0	0	+

4.8 Experience and views of different organization

To get response from different experienced organizations' views and opinions and as well as identify the prospects and strategies for promotion of EcoSan toilet in Bangladesh, is one of the important parts of this study. Bangladesh Academy for Rural Development (BARD), Practical Action Bangladesh, Bangladesh Association for Social Advancement (BASA), Commitment Consultants, Society for People's Actions in Change and Equity (SPACE), Oxfam GB Bangladesh, Japan Association of Drainage and Environment (JADE), Japan International Cooperation Agency (JICA), UNICEF and DPHE are the ten listed organizations/institutions relevant personnel and as a WatSan taskforce member, Union Parisad member (local government representative/public representative) also interviewed to achieve the objectives of the thesis. Through an interview process strength, weakness, opportunity and threat (SWOT) analysis of EcoSan has been done to determine the current status of EcoSan promotion in Bangladesh and explore future options for scaling up the application of EcoSan in Bangladesh.

4.8.1 Strengths for ecosan toilet promotion

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

i) The number of EcoSan toilets has grown steadily over the past eight years with more than 3000 such toilets established in the country. Although most of these toilets have been built in twenty areas, slowly the application of this technology has been spreading to other parts of the country as well.

ii) Most of the EcoSan toilets are being operated and maintained in a proper manner and most of the toilets are clean and hygienic.

iii) EcoSan toilet designs have been developed and modified over the years to suit the user feedback. Several designs have been developed to cater to different needs and innovations have also been developed locally.

iv) Different types of pans have been manufactured locally to suit local conditions and reduce the price of EcoSan toilets.

v) Several organisations are involved in the promotion of EcoSan and there are many locally trained experts. These include international as well as local organisations and universities that are involved in a various activities related to promotion, capacity building and research.

vi) Some organisations have also conducted innovative research on different issues such as pathogen die-off, application of urine on compost and the effect of urine application in crops.

vii) The technology has been endorsed by the Department of Public Health Engineering (DPHE), Government of Bangladesh and LGRD is involved in its promotion as well. EcoSan has been listed as one of the on-site sanitation measures suitable in the Bangladeshi context.

viii) The social acceptance of EcoSan is very high. Most users of EcoSan are satisfied with the performance of this technology and they are recommending it to others as well. In houses where EcoSan toilets have been established, all family members are using it on a regular basis and they are also involved in cleaning it and managing the faeces and urine.

ix) Women and children also feel quite comfort to use the EcoSan toilets with the modified model. Therefore, there are no gender related problems in the toilets.

x) Many farmers who use EcoSan appreciate the fertiliser value of excreta and are using the collected urine and faeces either directly in their farms. Most farmers have also said that the use of EcoSan products has increased their yields, especially the urine act as pesticide in vegetables.

4.8.2 Weaknesses for ecosan toilet promotion

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

i) Although urine collection and recycling is one of the main principles of EcoSan, 58% of surveyed households are using urine as fertilizer. Even when urine is collected, in many places the collection container is too small. Similarly, in several toilets the urine is not collected and stored properly - resulting in excessive loss of nitrogen as well as a foul smell.

ii) As the demand for fertiliser is seasonal, while the supply of urine and dry faeces are continuous, storage of urine is difficult.

iii) Transportation of urine to the field is difficult, especially in areas where the fields are very far from the homes and remote areas.

iv) Many of the farmers are not aware about urine and dry faeces application rates for different crops.

v) EcoSan toilets are slightly more expensive than ordinary pit latrines or offset double pit latrines. Although EcoSan toilets also provide some benefits in terms of fertiliser, the benefits are difficult to quantify and the high initial cost is a barrier for most poor families.

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

Social status of EcoSan toilets

There is a misconception among potential users that more costly and water consuming toilets are the best, which has led them to install water carriage toilets. At present, most EcoSan toilets are constructed in poorer communities with financial subsidies as a promotional tool. Unfortunately, this feeds the existing misconception that the EcoSan toilets are specifically developed for poorer sections of the community.

Orientation to the outsiders on the use of EcoSan toilet

The major problem raised by the users of the EcoSan toilet is the need to orient and familiarise outsiders or guests with how to use the toilet.

Odour

A few EcoSan toilet users did complain about a bad smell and it is still considered an issue by them. It was observed that a shift from conventional pit or flush toilets to EcoSan will be more easily accepted if there is little or no odour from the excreta. Covering the faeces with additives (such as ash, rice husks, saw dusts, lime, etc) effectively reduces the smell, and zero smell can be achieved by ventilation. Problems experienced with the odour are not a result of a fault with the technology, but a lack of sufficient level of awareness and knowledge on proper functionality and maintenance of the EcoSan toilet among users.

Space constraints

Despite being a good and environmentally friendly technology, a lack of space within people's houses obstructed the installation of some EcoSan toilets. Similarly, the lack of an agricultural field also discouraged the community people to install this type of latrine. The driving factor for the promotion of the EcoSan toilet is due to its economic value rather than its health value.

Level of awareness and knowledge on the importance and management of urine

The level of satisfaction from the use of urine as a fertiliser is low compared to the use of human excreta (faeces). This may be due to a number of reasons:

a. Lack of understanding, knowledge and awareness regarding the effective methods of urine handling, recycling and its use in co-composting. It is either simply not collected and therefore wasted, or collected in small jerry can (in most cases) that are not airtight, leading to nitrogen loss

b. Transportation of urine from toilet to farm area is problematic

c. Confusion regarding quantity of urine application in the field and for cocomposting

d. Low level of knowledge on the importance of urine and dry faeces, its nutrient potential and subsequent impact on agricultural production. Lack of quantitative benefits of urine and dry faeces application is hindering the motivation for the use of urine.

Less consideration of environmental soundness attributed by EcoSan toilet

The environmental benefits of the EcoSan toilets are not considered much by the users. The main reason for this is due to a lack of proper rules and regulations for the prevention of pollution in natural water bodies. People are discharging the highly polluted black water/ excreta directly into the natural water body. In this situation, it is very obvious that the value

of environmental protection that can be derived from this EcoSan technology will be insignificant.

Initial investment

Initial investment for an EcoSan toilet is relatively high compared to other sanitation options. As a result, the people normally expect and demand subsidy to adopt the technology. Subsidy is nothing more than a promotional tool and is financial assistance to the hardcore pore for adopting sanitation facility. People need to be convinced, however, about the future benefits that can be reaped from this technology from an agriculture and an environmental perspective.

Changes in people's perception and behaviour

During the course of promoting the EcoSan toilet within the communities, it is felt that one of the major challenges is to change the existing perception and behaviour of the people. Obviously, it and cannot be expected to change perceptions that are centuries-old overnight. The reason might be that EcoSan toilet technology, as such, is not new for farmers, who have used a combination of night soil with other organic waste as the main fertilisers in their agricultural fields for decades.

4.8.3 Opportunities for ecosan toilet promotion

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

i) The potential for promoting EcoSan, is high as Bangladesh agricultural based country.

ii) Very few communities in Bangladesh traditionally use excreta in their lands and therefore, in these communities, the use of EcoSan products will not be a social taboo. So far the application of EcoSan has mostly focused in only some project area and it is not so much familiar to others agriculture based community.

iii) The demonstration of EcoSan and bi products application in the piloting area/ project area has shown that even in communities that traditionally do not use excreta in their fields, the acceptance of urine as a fertiliser can be very high once the benefits are demonstrated.

iv) EcoSan is suitable for many areas in Bangladesh. As many communities in Bangladesh, especially in the hills and barind area, face water shortages, these communities may be attracted to EcoSan technology as it conserves water. In other low lying area, floods and water logging due to a high ground water table is a problem in many areas. In these areas as well, EcoSan can be a good option.

v) Although Bangladesh is predominantly an agricultural country, access to chemical fertiliser is difficult in many areas of Bangaldesh. Most of the users of EcoSan toilets that have been established so far have appreciated the use of urine as organic manure. Therefore if the value of urine as fertiliser can be explained to farmers, EcoSan toilets and the use of urine as organic fertiliser could be a popular option for many farmers in the country.

vi) The system that has been established for the promotion of biogas through microcredit and subsidy system in Bangladesh presents a good model for institutionalisation of EcoSan promotion in Bangladesh.

vii) National and international interest on sanitation in general and EcoSan in particular, is increasing. This presents opportunities for resource mobilisation and projects related to EcoSan.

viii) The demand for organic food such as vegetables, tea and honey, both in the national and international market, is growing. Therefore the demand for organic manure will probably increase in near future.

4.8.4 Threats for ecosan toilet promotion

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

i) With the growing popularity of the Community Led Total Sanitation (CLTS) approach, which discourages the use of subsidy for toilets, there is a growing trend for promoting toilet without providing subsidies. This approach might create some sense against the sustainable toilet solution.

ii) Although CLTS itself is a very innovative and effective tool, removing subsidy for all types of toilets would lead to more people installing low-cost toilets such as pit latrines. As EcoSan is slightly more expensive than other technologies in terms of initial investment and EcoSan toilets include waste processing as well as other benefits, some subsidy for EcoSan, particularly for poor families, is justifiable and should be continued. The amount of subsidy can be reduced and uniform as in the

case of biogas, but not having any subsidy will mean that less people will choose EcoSan toilets.

iii) Political disturbance and instability in the country has an adverse effect on all development efforts, including promotion of EcoSan toilets.

iv) Wide scale promotion of chemical fertilisers will reduce people's interest about using EcoSan organic fertiliser.

4.8.5 The way ahead for EcoSan promotion

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

4.8.5.a Institutionalise a system for promoting EcoSan

For this, DPHE should take the lead in bringing together key stakeholders/EcoSan promoters to design a system to standardise designs based on local needs, develop a uniform financing system and ensure quality control. The model used for promoting biogas in Bangladesh can be used as an example of such a system. Just as in the case of biogas, a central EcoSan fund can also be set up to provide some financial support, along with technical advice, to anyone who wishes to set up EcoSan toilets.

4.8.5.b Incorporate Agricultural sector to further promote EcoSan

So far only people working in the water and sanitation sector have been promoting EcoSan and this is only seen as a tool for sanitation. Bangladesh has a large network of agricultural extension workers who could also be used for promoting EcoSan. For this, initially, institutions such as the Bangladesh Agricultural Research Council (BARC), Bangladesh

Agricultural Development Cooperation (BADC), Department of Agricultural Extension (DAE) and Department of Agricultural Marketing should be mobilised to conduct research on the application of urine so they can endorse this practice and provide guidelines on the use of urine to farmers. This should be followed by extensive training to extension workers and also demonstration of urine application in several different locations. Lobbying should also be done to gain policy support and budgetary allocations from the Ministry of Agriculture.

4.8.5.c Demonstrate EcoSan all over Bangladesh

So far most EcoSan toilets have been built only in very few areas of Bangladesh constructing small number of toilet. There is a need for larger demonstration projects all over the country, especially in communities where there is likely to be a great demand for EcoSan toilets. These include communities where availability of water and fertiliser is a problem and where the use of human excreta is not a social taboo.

The practical demonstration of the usefulness of the by-products of human excreta in agriculture is seen as an important component of all ecological sanitation programmes. Consequently, the crucial step of linking toilets with a method of producing humus or urine for use in agriculture must be emphasised. This very important management procedure is vital to the success of EcoSan toilets.

In EcoSan toilets, success depends on proper management, and thus depends on user participation to a far greater extent than conventional sanitation systems. It is no longer a case of sit and flush or squat and deposit. Ecological sanitation embraces a philosophy, which the users must believe in and practice daily. Disseminating and convincing of such an understanding and practice takes time.

4.8.5.d Integrate EcoSan in existing projects and programmes

Several sanitation projects and program like ADP and LGSP of GoB and NGO as well as agricultural related projects are being implemented in the country and many more are in the planning stages. Promotion of EcoSan should be included in these projects. Furthermore, institutions such as the DPHE and LGRD should also include EcoSan promotion in their other programmes.

4.8.5.e Promote urine utilisation

This study has clearly indicated that many of the EcoSan toilet users are not effectively utilising the urine. Therefore, a good urine collection system, with 100 litre plastic tanks, and proper training on urine utilisation, should be mandatory for all EcoSan toilets.

4.8.5.f Disseminate the concept of a urine bank

Many people are not able to fully utilise the urine they produce because the demand for fertiliser is seasonal and storage of urine is difficult. Therefore, the possibility of a urine bank that collects urine from different EcoSan users or from places where urine is produced in large quantities, and then stores it properly and distributes it when there is a demand for it, should be explored. The possibility of urine crystallisation for easy storage and use should also be explored together with international research agencies.

4.8.5.g Reduce the cost of EcoSan

Although several efforts have been made to reduce the cost of EcoSan toilets, there is still a need to introduce EcoSan toilet models that cost less. Indoor EcoSan are positive steps in this direction.

4.8.5.h Promote organic fertiliser

The promotion of organic fertiliser will not only improve soil health but also promote EcoSan and the use of urine. EcoSan should be promoted among organic farmers and people interested in organic farming as a source of organic fertiliser.

4.8.5.i Raise awareness on EcoSan

As many people are still not aware of EcoSan, its benefits and its application, campaigns to raise the awareness of general public, local leaders, politicians and policy makers is essential for further promoting EcoSan. The awareness campaigns should use tools of mass communication as well as interpersonal communication. This will also require appropriate communication materials such as leaflets, brochures, banner, poster as well as audiovisual materials and through mass media.

The generation of awareness about EcoSan latrines among users, activists and at the political level is strongly needed. At present, it is insufficient to enhance sanitation coverage.

i) The IEC (Information, Education and Communication) materials for the promotion and use of EcoSan toilets currently being carried out are not sufficient. More

audiovisual, IEC materials and media campaigns on the topics are necessary for generating increased awareness.

ii) The major principles of the EcoSan toilet and its potential benefits should be disseminated among school students who make excellent representatives for EcoSan toilets by encouraging potential users in their community.

iii) A bigger awareness programme on the use of urine and faeces with a nutrient recycle concept should be designed with the aim of providing knowledge on the merits of EcoSan toilets.

This agenda should be set, however, as one of advocacy while promoting and expanding EcoSan latrines. While scaling up, the pros and cons should be disseminated widely, allowing

4.8.5.j Build capacity of the communities

A wide range of people such as technicians involved sanitation promotion, masons, agricultural extension workers, community development workers and policy makers should be trained on various aspects of EcoSan and its use.

4.8.5.k Conduct research and monitoring

As EcoSan is still a relatively new concept in Bangaldesh, there is still need for research in areas such as urine application and optimisation of design. Furthermore, the existing EcoSan toilets should be regularly monitored to assess their performance. Alongside the emphasis on research and development to be placed to adapt technologies to local conditions, here are some areas recommended for further promotion of EcoSan technology:

a. Concept of trading in urine and faeces should be developed. Commercialisation of nutrient recycling from human excreta, thereby linking with livelihood is necessary for further promotion of this technology

b. More research on sanitisation of faeces should be done to find out the effective and easy way of sanitising the excreta

c. Research on reducing the volume of urine is also deemed necessary as a reduction of urine volume may be the best way to ease its transportation.

The outcome of the design process should be a pleasant and affordable toilet facility that sends a hygiene promotion message to other families and is easily replicable.

4.8.5.l Build effective networks for learning and coordination

A network of EcoSan promoters and users in Bangaldesh should be formed to learn from each other's experiences and also develop linkages with research and promotion related activities being done in other countries. Interconnection between the network of EcoSan users, promoters and organic farmers can extract potentialities on urine and dry faeces marketing. That will be a common forum for users, promoters and farmers.

4.8.5.m Role of subsidies

Almost all the projects used some form of subsidy to promote or support widespread use of this new technology. The subsidy approach for promoting EcoSan latrine technology must be adopted as a promotional tool and should be promoted only in such a way that users require some form of "buy-in" from it, on one hand or alternatively, must avoid distorting decision-making to the extent that wrong choices are made.

i) While discussing the role of subsidies in promoting EcoSan toilet, the poorest members of the community should gain access to the benefits that improved sanitation can bring. There are areas for potential improvement and experimentation by developing various options including graded subsidy systems.

ii) Hardware subsidy should be governed by a clear subsidy policy of the promoting organisation, with explicit objectives and political commitment to the total amount of funds that would be necessary if programmes were scaled up.

4.8.5.n Technology

Approaches to technology must be more flexible in terms of choice of toilet type and use of materials. Over designed, expensive or imported components make replication difficult without subsidies.

Every sanitation technology needs some user education and orientation. For new users, EcoSan may introduce another level of complexity at the initial stage. Therefore, users need to be made fully aware of their responsibilities and provided with appropriate instructions and follow-ups until confident in handling operational problems. Need Guidelines on the Safe Use of Urine and Faeces in Ecological Sanitation Systems and Guidelines on the Use of Urine and Faeces in Crop Production based on local context.

CHAPTER – 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Ecosan toilet was introduced to solve the problem with the conventional rural sanitation. To identify locally acceptable of this technology, it is necessary to make it clear the requirements for technology, which include respondent to local characteristics and needs in each local community. It is critical that implementation observes appropriate steps so that the solutions are sustainable based on simple technologies which can be carried out by the communities and maintained and operated over the long term. There are several key factors which determine whether technology is appropriate for the specific situation. Technological viability can be accessed through major our aspect like social, economical, technological, and environmental and health issue. The conclusion of the study are as follows:

a) 98% non user believe that raw materials and mason is locally availability except the glass fiber pan, 75% user and non user believe that this system can sustain for 15-20 years, 74% user believe that ecosan toilet is environment friendly option and 91% ecosan remain useable during disaster, 96% non user has clear perceptions of the system, in terms of gender and reliability issues 99% user feel safe and secure and 93% user feel comfort which represent human dignity, 84% of community interested to build ecosan toilet, 55% community willingness to pay 4000-5000BDT to construct ecosan toilet, 97% of both user and non user want ecosan toilet in house hold of their community which is reflection acceptance to people , still 32% and 37% user believe there is religious and cultural barrier, 22% of the user using both faeces and urine and 36% urine only and 27% faeces only, according to non user 99% local people interest to buy product using urine and compost faeces, according to user more or less 74% community people have demand of ecosan toilet. GO, NGO, INGO, donor and research organization motivated enough to promote it.

b) 20% user consider it as expensive option for them but more than 30% agreed to pay at least 5000BDT, considering construction cost (11,000BDT) durability (15-20 years) yearly benefit (1187BDT) and reduction in medical cost represent cost

effectiveness of this option, only 20% user believe that installation cost (capital) is high, annual operation cost is 200BDT which is no need if the additives is available at home, annual maintenance cost 220BDT, annually cost of by product (urine and compost as fertilizer) is 1184 BDT but according to user it is 2500BDT, potential economic benefits is human excreta polluting groundwater or surface water have potentially major implications for health and affect productivity or usability of the surface water body. The 'Pay Back period' for investment in an EcoSan toilet comes to 5.09 years. In case of not considering any cost sharing the investment cost will be 15,000 BDT and pay back period will be 10.5 years and this is evident that among the considerable improved sanitation option ecosan toilet is can be claimed as one sustainable option considering the context of Bangladesh.

c) These aspects reflect the functionality of major components of ecosan toilet of 87 surveyed toilets and the goodness percentage (stair 95%, door 90%, floor of the toilet 100%, sitting pedestal 100%, faeces hole 90%, lid of faeces hole 90%, urination place 96%, ventilation pipe 90%, urine drain pipe 90%, urine drainage system 90%, urine container 90%, anal washing place 100%, anal washing drain pipe 93%, evaporation bed 88%, roof 85%, feces chamber/vault 95%, heat panel 85% and surrounding mortar of heat panel 95%) which seems functional most of the cases. It means that this technology can be constructed, operated, and monitored using the available human resources.

d) 91% of the users and 74% non user believe that the latrine is environment friendly option. The contents of heavy metals and other contaminants such as pesticide residues are generally low or very low in excreta. According to the test result of five faeces samples in ICDDR,B; Environmental Microbiology Laboratory it is found that the presence of Zinc, Copper, Lead, Cadmium, Nickel, Chromium, Arsenic is below or within WHO and Bangladesh standard. Mean N (0.38%), P (0.04%), and K (0.1%) found in nine urine samples and in case of faeces mean N (0.35%), P (0.48%), K (2.75%) and Organic Matter (3.20%) is found which are important elements for soil nutrient and increase the water holding capacity of soil. The variation of NPK is mostly depending on the diet [N = 0.13* (Total food protein) and P = 0.011* (Total food protein + vegetal food protein)], dilution factor and use of ash. Result variation found due to sample collection method and laboratory

equipments but there is scope of improving by content of NPK like urine should be handled in closed tanks and containers and should be spread directly onto the soil, not on the plant, in N doses equivalent to what is recommended for urea and ammonium fertilizers. Air contact should be minimized and the urine should be incorporated into the soil as quickly as possible. A large proportion of the hormones produced by our bodies and the pharmaceuticals (both natural and synthetic) consume are excreted with the urine, but it is reasonable to believe that the risk for negative effects on the quantity or quality of crops is negligible due to microbes to degrade and is small compared to that by domestic animals, as in most countries most commercial feeds contain antibiotic substances, added as growth promoters. Furthermore, the human use of pharmaceutical substances is small compared to the amount of pesticides (insecticides, fungicides, bactericides and herbicides) used in agriculture, which are just as biologically active as pharmaceutical substances. Application of dry faeces and urine to agricultural land will reduce the direct impacts on water bodies. Around 91% user informed that during flood faeces chamber don't inundate by the flood water and in case of other option non user informed that 66% get flooded and faeces comes out from the pit that creates unhygienic condition and spread diseases. The result of one experiment of Oxfam it was found that 76% of ecosan toilet surrounding water bodies are in range of no or without risk considering groundwater protection from microbial contamination.

Health aspect includes risk of exposure to pathogens and hazardous substances that originate from the sanitation system (from the toilet through the collection and treatment system to the point of reuse or disposal). Exposed helminth eggs (Helminths: Ascaris lumbricoides can survive for many moths) and pathogens will be a health risk to anybody walking on the land, although this risk will diminish with time as pathogen die-off is accelerated through the effects of sunlight and desiccation. But in reality it is evident that processing the dry feces after six months it will be quit difficulty for user to create ideal situation to make it risk free. Considering the characteristics parasite and protozoa and laboratory tested result its will be safer for the user to use the faeces after preserving of one year.

Major parameter are generation or disposal of bi-product, safe handling of urine and excreta, susceptibility of bacteriological contamination, potentiality of use of urine and excreta. Due to lack to practice of using safety gear user still under in health risk and cannot getting the benefit of the system.

e) Checklist survey was carried out in order to get the status of eighty seven toilets in nine different areas of Bangladesh. This checklist includes all the major components of the latrines and the operation and maintenance issues as parameter of technical aspect which is mentioned above. To understand functionality of latrine the function model (Azad-uz-zaman, et. al.,2011) will be used and findings will be compared for different areas. It was observed that considering the management issue Kashobpur (2420) and Sreepur (1950) are in the best and worst position accordingly. On the other side considering the function Chapai N.gonj (1900) and Biswamvarpur (1700) have the best and worst situation accordingly. Considering both management and function issue Chapai N.gonj (2380,1900) and Sreepur (1950, 1800) have combatively best and worst situation where as ideal situation (2000,2600). But considering the duration of using toilet Comilla Sadar has achieved the comparatively best position among all study area.

The results of this study indicate that all the surveyed ecosan toilets are well functional and user are managing the toilet according to their capacity except some components condition are not upto the mark. Utilize the byproduct compost faeces and urine were not properly managed by the user and have deficiency in preservation capacity. But there is good demand of ecosan toilet`s by product in the community. They are well aware about the benefit of using dry faeces and urine in agricultural purpose.

Considering sustainability of Ecosan latrines are well accepted by all the members of the families irrespective of gender. It is gender friendly, as indicated by their satisfactory maintenance shared among male and female counterparts. This appreciation for ecosan toilets extends to the majority of their neighbours, who also showed a positive attitude. Both user and non-user almost agreed (97 percent) that eco-san toilet should be available in all household and people agree to invest four times than the option they are currently using. This demonstrated the good impression of ecosan in the rural settlements of Bangladesh, where agriculture is a common livelihood. In terms of its durability this option is more sustainable then other considering financial cost benefit analysis. There are still some cultural and religious issues which hinder to accept the technology in the community.

Urine and faecal fertilizers are mixed into the active topsoil, which has a microbial community just as diverse and active as that in wastewater treatment plants, and the

substances are retained for months in the topsoil. Nutrients and organic matter from urine and faeces help improve the water-holding capacity and increase the productivity of crops at the same time work as pesticide. These also protecting the natural environment and preventing surface and groundwater pollution. Both ecosan toilet user and non user agreed that this option is environment friendly and can be use in disaster. It is evident that human excreta contain lots of pathogens and others harmful materials which are responsible for many health threats and from the laboratory result it is evident that not the sanitizing process a whole, after one year cycle (six months defecation period plus six months treatment period) treated dried excreta human excreta could not able to make reasonable safe and need proper sundry and also air tight long conservation period can reduce the prevalence of pathogen and it is more safer to use one year of preservation after stopping defecation in that same chamber. Post latrine handling is not considered as important issue by the user which can also reduce the health risk.

5.2 Recommendation

- The SWOT analysis through an interview process clearly determines the current status of EcoSan promotion in Bangladesh and explore future options for scaling up the application of EcoSan in Bangladesh which can be followed by this sector.
- There is still need of in depth research on dosing of urine and dry faeces for different corps for different soil type and also sanitizing process need to be standardized.
- It is required to search proper storage techniques in context of Bangladesh.
- The financing issue remains problematic and to over this different approach like credit with low interest rate, subsidy from agriculture or can be provide through ADP as pilot basis to ensure the financial promotion of biogas through microcredit and subsidy system in Bangladesh presents a good model for institutionalisation of EcoSan promotion in Bangladesh.
- It is expected that if there any funding or investment in this sector by local financer or entrepreneur or bank it will be encouraged the communities to promote and scale up EcoSan toilets.

REFERENCES

Adams, R.A. and Templer, D.I., (1998) "Body elimination attitude and occupation. Psychological Reports", pp. 465-466.

Arnbjerg-Nielsen, K., Hansen, N.J., Hansen, L., Kjølholt, J., Stuer-Lauridsen, F., Hasling, A.B., Stenström, T.A., Schönning, C., Westrell, T., Carlsen, A. and Halling-Sørensen, (2004), B. In press. "Risk assessment of partly composted faeces for use in private gardens", Danish EPA report, Copenhagen, Denmark.

Arnbjerg-Nielsen, K., Hansen, L., Kjølholt, J., Stuer-Lauridsen, F., Hasling A.B., Stenström, T.A., Schönning, C., Westrell T., Carlsen, A. and Halling-Sørensen, B., (2003) "Risk assessment of local handling of human faeces with focus on pathogens and pharmaceuticals'. In: Ecosan – Closing the loop" in *Proceedings of the 2nd International Symposium on Ecological Sanitation, incorporating the 1st IWA specialist group conference on Sustainable sanitation*, 7th-11th April 2003, Lübeck, Germany. pp. 365.

Azad-uz-zaman, Q., Parvez, M.M., and Takahashi, K. (2011) "Diagnosis of EcoSan Toilets and Monitoring Process under CBO Activity", Fourth Seminar on Sharing Experence about EcoSan Toilet in Bangladesh, JICA.

Asano, T., Leong, L.Y.C., Rigby, M.G. and Sakaji, R.H., (1992), "Evaluation of the California wastewater reclamation criteria using enteric virus monitoring data", Water Science and Technology, pp.1513-1524.

Austin, A., (2011), "Health aspects of ecological sanitation", Abstract Volume, *First International Conference on Ecological Sanitation.* 5th-8th November 2011, Nanning, China, pp.104-111.

Austin, A., "Health aspects of ecological sanitation" Abstract Volume, in 2001 *First International Conference on Ecological Sanitation,* 5th-8th November, Nanning, China: 104-111.

Azad-uz-zaman, Q., Parvez, M.M., and Takahashi, K., (2011)"Diagnosis of EcoSan Toilets and Monitoring Process under CBO Activitiy", presented at Fourth Informal Seminar on Sharing Experiences about EcoSan Toilet in Bangladesh, unpublished.

Berger, E.Y., (1960), "Intestinal absorption and excretion", In: Comar, C.L. and Bronner F. (eds), Mineral Metabolism. Academic Press, New York. pp 249-286.

BGS (2001), *Guidelines for Assessing the Risk to Groundwater from On-Site Sanitation*, Commissioned Report CR/01/142, British Geological Survey Keyworth, England.

Biplob, P., Sarker,R.C., and Sarker, D.C., (2011), "Eco-san Toilet for Sustainable Sanitation Practice in Bangladesh", International Journal of Civil and Environmental Engineering IJCEE-IJENS Vol: 11 No: 05, pp. 139-147.

Carlander, A., and Westrell, T.,(1999), "A microbiological and sociological evaluation of urine-diverting, double-vault latrines in Cam Duc Vietnam", Report no. 91, International Office, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Chorus, I. and Bartram, J., eds., (1999), "Toxic cyanobacteria in water". World Health Organization, Geneva.

Chowdhury, M.H., Mamun, and Sakai, A.,(2007) "Ecological Sanitation: An Intermediate Technology for Environmenatl Management", Vol -2, pp.95.

Chowdhury, M.H., Mamun, A.A., Hosaka, H., and Takamura, S., (2006), "Ecological Sanitation and Eco-toilets: Basic Concepts and Issues", – Ecological Sanitation: An Intermediate Technology for Environmental Management. Volume -1.

Chowdhury, M.H., Mamun, A.A., Hosaka, H., Takahashi, K., and Takamura, S., (2006) "Ecological Sanitation and Eco-toilets in Rural Bangladesh: An Experimentation", – Ecological Sanitation: An Intermediate Technology for Environmental Management. Volume -1.

DFID (2011), "Evidence Paper Water, Sanitation and Hygiene"

Drangert, J., (2004a), "Requirements on sanitation systems- the flush toilet sets the standard for ecosan options" in *Proceedings of the 2nd international symposium on ecological sanitation, incorporating the 1st IWA specialist group conference on sustainable sanitation*, 7-11 April 2003, Lubeck, Germany. Eschborn, Deutsche Gasellschaft fur Technische Zusammenarbeit (GTZ), pp. 117-124.

Esrey, S.A., Gough, J., Rapaport, D., Sawyer, R., Simpson-Hébert, M., Vargas, J. and Winblad, U., (1998) "Ecological Sanitation", Swedish International Development Cooperation Agency, Stockholm, Sweden.

Evanylo, G.K.,(1999), "Agricultural Land Application of Biosolids in Virginia: Risks and Concerns", Virginia Cooperative Extension, Publication Number 452-304.

FAO (2004), "Current world fertilizer trends and outlook to 2008/09", Rome

Feachem, R.G., Bradley, D.J., Garelick, H. and Mara, D.D.,(1983), "Sanitation and Disease – Health aspects of excreta and wastewater management", John Wiley and Sons, Chichester, UK, 1983.

Fong, M.S., Wakeman,W. and Bhushan, A., (1996) "Toolkit On Gender In Water and Sanitation." Gender Toolkit Series 2. World Bank, Washington, D.C.

Foster, S.,(2004)"Urban wastewater as groundwater recharge evaluating and managing the risk and benefits", Washington, DC, The World Bank (Briefing Note 12).

Franceys, R. , Pickford, J. and Reed, R.,(1992) "A Guide to the Development of On-Site Sanitation", World Health Organization, Geneva, pp.237.

Franzén, H., and Skott, F.,(1999) "A study of the use and functioning of urine-diverting dry toilets in Cuernevaca, Mexico – Virus survival, user attitudes and behaviours", Report no. 85, International Office, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Fraústo da Silva, J.J.R. and Williams, R.J.P.,(1997) "The Biological Chemistry of the Elements - The Inorganic Chemistry of Life", Oxford, UK.

Gershernson, O., Penner, B.,(2009), "Ladies and Gents: Public toilets and gender", ISBN 978- 1592-13940-8 , Temple University Press, Philadelphia, PA, USA.

Ghiglietti, R., Genchi, C., Di Matteo, L., Calcaterra, E. and Colombi, A.,(1997) "Survival of Ascaris suum eggs in ammonia-treated wastewater sludges", Bioresource Technology, pp.195-198.

GOB (2003), "Sanitation in Bangladesh". paper presented at the Third South Asian Conference on Sanitation, SACOSAN-III, New Delhi.

GOB (2005), *National Sanitation Strategy.* Government of Bangladesh, Ministry of Local Government, Rural Development and Cooperatives, Bangaldesh.

Greed, C.,(2003),"Inclusive Urban Design: Public Toilets", First Edition, ISBN: 075065385X, Architectural Press, Oxford, UK.

Gtz,(2004), "ecosan – closing the loop", in *2003 2nd international symposium Proceedings*, Lübeck, Germany, Eschborn.

Guyton, A.C.,(1992), "Human Physiology and Mechanisms of Disease", W.B. Saunders Company, Philadelphia, USA.

Haug, R. T., (1993), "The practical handbook of compost engineering", Lewis Publishers, USA.

Hooi, Y., Hamzak, H.,(1995) "The design of public toilets in Kuala Lumpur from the aspects of culture, behaviour and social habits of users", In Proceedings *1995 International Symposium on Public Toilets*, Hong Kong, May 25-27, pp. 84- 89.

Humphrey, JH., (2009), "Child undernutrition, tropical enteropathy, toilets, and handwashing", Lancet 374(9694): 1032-5.

Huuhtanen, S., and Laukkanen, A.,(2009) "A guide to sanitation and hygiene in developing countries", Korkeakoski, M., (eds), Global Dry Toilet Association of Finland, ISBN 978-952-67325-3-4, version 2.

JMP (2010) *Joint Monitoring Programme for Water Supply and Sanitation.* WHO / UNICEF.

Jönsson, H., Stintzing, A.R., Vinnerås, B., and Salomon, A.,(2004), "Guidelines on the Use of Urine and Faeces in Crop Production", Stockholm Environment Institute, ISBN 91 88714 94 2, Stockholm, Sweden.

Jönsson, H., Vinnerås, B., Höglund, C., and Stenström, T.-A.,(1999) "Source separation of urine (Teilstromerfassung von Urin)", Wasser and Boden, pp. 21-25, 1999.

Klaesener-Metzner, N (2010). *The role of public toilets for sustainable urban development* (working title), thesis, unpublished.

Kira, A. (1995). "Culture and behaviour of public toilet users". . In Proceedings *International Symposium on Public Toilets*, Hong Kong, pp. 9-12.

Kvamstriim, E., et al. (2004), "Sustainability criteria in sanitation planning" presented at 30th WEDC international conference, Vientiane, Lao People's Democratic Republic, pp. 25-29.

Kvarnström, E., McConville, J., Bracken, P., Johansson, M., and Fogde, M. (2011) "Sanitation ladder – a need for a revamp?" *Journal of Water, Sanitation and Hygiene for Development*, IWA Publishing 2011
Available at:http://www.iwaponline.com/washdev/001/0003/0010003.pdf

Langergraber GM, and Elke, (2005) "Ecological Sanitation--a way to solve global sanitation problems?" Environment International, pp. 433-444.

Lentner, C., Lentner, C. and Wink, A.,(1981) "Units of Measurement, Body Fluids, Composition of the Body, Nutrition. Geigy Scientific tables", Ciba-Geigy, Basel, Switzerland.

McCarthy, J.A., and Shrum, L.J.,(1994) "The recycling of soild-wastes – personal values, value orientations, and attitudes about recycling as antecedents of recycling behaviour", *Journal of Business Research*., Vol. 30, pp. 53-62.

Moe, C., and Izurieta, R., (2003) "Longitudinal study of double vault urine diverting toilets and solar toilets in El Salvador" *Proceedings from the 2nd International Symposium on Ecological Sanitation*. Lübeck, Germany.

Niwagaba, C.,(2007), "Human Excreta Treatment Technologies – prerequisites, constraints and performance", ISSN 1652-3261, Uppsala.

Oldenburg, M., (2007), "Final cost calculation report for the demonstration project Sanitation Concepts for Separate Treatment of Urine Faeces and Greywater (SCST)". OtterWasser GmbH.
Available at: http://www.susana.org/docs_ccbk/susana_download/2-593-oldenburg-2007-cost-berlin-demo-project-en.pdf

Palmquist, H. and Jönsson, H., (2004), "Urine, faeces, greywater, greywater and biodegradable solid waste as potential fertilizers. In: Ecosan – closing the loop" *In Proceedings of the 2nd International Symposium on Ecological Sanitation*, Incorporating the 1st IWA Specialist Group Conference on Sustainable Sanitation, Lübeck, Germany, pp. 587-594, 7th-11th April 2004.

Parkinson, J., Hutton, G., Pfeiffer, V., Blume, S., and Feiereisen, P.,(2011) "Financial and economic analysis", Sustainable Sanitation Alliance (SuSanA) factsheet.

Practical Action Bangladesh (2010) "*Proto Type Engineering Design of Eco-Toilet*. Action Research on Ecological Alternatives in Sanitation in Difficult Areas of Bangladesh" (A GOB-UNICEF Project).

Practical Action Bangladesh, (2011) , "Action Research on Ecological Alternatives in Sanitation in Difficult Areas of Bangladesh"

Pimentel, D., Mclaughlin, L., Zepp, A., et al. (1989). "Environmental and economic impacts of reducing U.S. agricultural pesticide use", Handbook of Pest Management in Agriculture, volume- 4, pp.223–278.

Rockström, J., Axberg, GN., Falkenmark, M., Lannerstad, M., Rosemarin, A., Caldwell, I., Arvidson, A., and Nordstroem, M., (2005), "Sustainable pathway to attain the Millennium Development Goals: Assessing the key role of water, energy and sanitation", SEI, Stockholm, Sweden.
Available at:
http://www.ecosanres.org/pdf_files/MDGRep/SustMDG31Auglowres.pdf

Roy, A.M.,(2009), "Bangladesh Country Paper", presented at Regional Workshop on Sustainable Sanitation in South Asia, Kalutara, Sri Lanka.

Schuen, R., Parkinson, J., and Knapp, A., (2009), "Study for Financial and Economic Analysis of Ecological Sanitation in Sub-Saharan Africa", WSP-Africa

Sharpley, AN., (1995), " Soil phosphorus dynamics: Agronomic and environmental impact", Ecological Engineering, chapter – 5, pp.261-279.

Sidhu, JPS., and Toze, S G.,(2008),"Human pathogens and their indicators in biosolids". CSIRO Landand Water, Queensland Bioscience, July 2008

Smith, P.D., Ravdin, J.I. and Greenberg, H.B. (eds) Infections of the gastrointestinal tract. Raven Press, Ltd., New York, NY, USA: 37-51.

Snowdon, J.A., Cliver, D.O. and Converse, J.C.,(1989) "Land disposal of mixed human and animal wastes: A review" *Waste Management and Research*,

Washington, D.C. 20006, U.S.A. chap-7, pp. 121-134.

Strauss, M., and Blumenthal, U.J.,(1990) “Human waste in agriculture and aquaculture: utilization practises and health perspectives”, IRCWD, Dübendorf, Switzerland.

Svensson, L.,(2000) “Diagnosis of foodborne viral infections in patients. International Journal of Food Microbiology”, pp.117-126

Tauxe, R.V., and Cohen, M.L.,(1995) “Epidemiology of diarrheal diseases in developed countries”.

Tiessen H, eds. (1995), “Phosphorus in the global environment- Transfers, cycles and management”, Wiley (SCOPE 54), New York.

Uddin, M.S., (2011), “Assessment UDDTs as a Flood Resilient and Affordable Sanitation Technology, and their Potential to Contribute to the Fertilizer Demand”, M.Sc. Engg. Thesis, UNESCO-IHE Institute for Water Education, Delft, the Netherlands.

UN (2010), “The Millennium Development Goals Report 2010”. United Nations, New York.

UNWater (2006) “Gender, Water and Sanitation: A Policy Brief”, New York, NY 10017, USA
Available at: http://www.unwater.org/downloads/unwpolbrief230606.pdf

Vinnerås, B.,(2002) “Possibilities for sustainable nutrient recycling by faecal separation combined with urine diversion” Agraria 353, Acta Universitatis Agriculturae Sueciae, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Vinnerås, B., Björklund, A., and Jönsson, H., (2003a), “Disinfection of faecal matter by thermal composting – laboratory scale and pilot scale studies”, Bioresource Technology, pp. 47-54.

Von Münch E., (2009), “Basic overview of urine diversion components”.

WaterAid (2008), “Assessment of urine-diverting EcoSan toilets in Nepal”, A WaterAid in Nepal publication

WELL (2006), “Should ecological sanitation carry a health warning? Assessing the health risks of ecological latrines”, briefing note 27

Westerhof, B.,(2005), “Sanitation and Gender: A Gender approach for effectiveness and equality”, IRC, Delft.

WHO (1989), “Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture” , ISBN 92 4 152248 9, World Health Organization, Geneva, Switzerland.

William, S and Warner, (2005), "Cultural Influences that Affect the Acceptance of Compost Toilets: Psychology, Religion and Gender", Center for Soil and Environmental Research, Norway.
Available on: http://www2.gtz.de/Dokumente/oe44/ecosan/en-cultural-influence-affects-acceptance-2000.pdf

Winblad, U. (eds), (1998), "Ecological Sanitation", SIDA, Stockholm, pp.92.

Winrock International (2007), "A cost-benefit analysis of national and regional integrated biogas and sanitation programs in sub-Saharan Africa".

WSP (2009), *Study for Financial and Economic Analysis of Ecological Sanitation in Sub-Saharan Africa*, Water and Sanitation Program-Africa, Nairobi, Kenya 2009.

WHO (2006), "The Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture", Fact Sheet for WHO Country Offices, Robert Bos, Public Health and Environment Department, World Health Organization, Geneva

WHO (2006), "Guidelines For The Safe Use Of Wastewater, Excreta And Greywater", Volume IV, Excreta And Greywater Use In Agriculture, World Health Organization, ISBN 92 4 154685 9 (v. 4), France

WHO (2006), "Guidelines for the Safe Use Of wastewater, excreta and greywater", volume I, Policy and regulatory aspects, France.

APPENDIX – A

Questionnaire survey for "Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects"

QUESTIONNAIRE FOR LATRINE USUERS COMMUNITIES

	Date					
	Upazila					
	Union					
	Word					
	Village					
A	Family information					
1	Name of the respondent					
2	Cell phone No.					
3	Age of the respondent					
4	Sex of the respondent	1	Male	2	Female	
5	Education	1	Primary			
		2	Ssc			
		3	Hsc			
		4	Graduate			
		5	Informal			
		6	None			
		7	Others (specify)			
6	Major income source of the family	1	Agriculture			
		2	Business			
		3	Job			
		4	Day labourer			
		5	Others (specify)			
7	Number of family members	1	Male (18-59):			
		2	Female (18-59):			
		3	Old men (60+)			
		4	Old women (60+)			
		5	Male child (4-10)			
		6	Female child (4-10)			
8	Have your family own any handicapped member?	1	Yes			
		2	No			
9	Have you own land/farm land?	1	Reside in own land			
		2	Reside other's land			
		3	Have own farm land			
		4	Have no farm land			
B	Information about previous latrine					
1	Where did your family members use latrine before?	a. open defectation b. used other's lartine c. only women used latrine d. used own latrine				
2	What type of latrine did you use earlier	a. hanging latrine b. ring less pit latrine c. ring-slab latrine d. twin pit latrine e. septic tank latrine				

3	How much you had to spend for installation of previous latrive?		
4	What were the advantages of previous latrine?	1	Maintenance is easy
		2	Installation cost is low
		3	Fecal matters are used as fertilizer
		4	Take long time to fill up
		5	Cleaning requirement is not frequent like other latrine
		6	Others
5	What are the disadvantages of previous latrine?	1	Wastes of water
		2	Bloked by faeces/fecal matters
		3	Evacuation cost high
		4	Useless during flood
		5	Odour
		6	Others
6	What were the frequencies of previous latrine installation?		
7	What are the frequency of previous pit cleaning/ desludging?	.....month	
8	What was the expenditure for pit cleaning/ desludging for previous latrine?	a. 100-200 Tk. b. 200-300 Tk. c. 300-400 Tk. d. 500 Tk. or more	
9	What was the frequency of cleaning/ desludging previous pan using brush?	.....month	
10	Did you use Harpic for cleaning the latrine?	1	Yes / 2 No
11	Have you any latrine apart from ecosan toilet	1	Yes / 2 No
12	Which persons in your family use the latrine?		
13	Why they use this latrine?		
C	Socio-ethical aspects		
1	Has the society not positive attitude towards your latrine?	1 Yes	2 No / 3 Somebody
2	Did the community know about advantage of your latrine and they visit it?	1 Yes	2 No / 3 Somebody
3	Did the community show their interest to see your latrine and to install it?	1 Yes	2 No / 3 Somebody
4	Religiously is your latrine accepted by the community?	1 Yes	2 No / 3 Somebody
D	Information about the uses & maintenances of ecosan toilet		
1	What are the fequency of cleaning of existing ecosan toilet	.....days	
2	What is your opinion regarding the responsibility of cleaning the ecosan toilet?	1	For men
		2	Only for women
		3	Both men and women as and when required
		4	Any body of the family
3	Who cleans the latrine now??	1	Men
		2	Women
		3	Both men and women as and when required
		4	Any body of the family
4	What material is used to clean the latrine now	1	Ash
		2	Water
		3	Pan with ash
		4	Water with floor
		5	Others
5	Do you think the cleaning cost of this latrine is low?	1 Yes	2 No
6	Do you think the cleaning is not labour intensive?	1	Yes labour intensive
		2	No
		3	Moderate
E	Technological		

1	How many years have you been using this ecosan toilet?		.....year .....month
2	Why you have installed the latrine?	1	It was needed
		2	We get manure
		3	Environment friendly
		4	Less expensive
		5	Neighbours encouraged
		6	Free of cost
3	What are the advantages of ecosan toilet	1	Maintenance is easy
		2	Least wastes of water
		3	Faecess are used as manure
		4	Urine used as manure
		5	Take long time to fill up
		6	Cleaning not required frequently
		7	No cost is involve to vacate the latrine
		8	It is usable during monsoon
		9	Others
4	Did you face any problem during initially use the latrine?	1	Yes
		2	No
		3	Not so significant
5	Do you facing any problem to use the ecosan toilet now?	1	Ash is always required
		2	To use alternative part in six month interval
		3	Spread out the men's urine
		4	Women's urine used to enter into the faeces chamber
		5	Use carefully
		6	Ensured supply of ash and saw dust
		7	Takes time to habituate
		8	Problem for guests
6	What initiative is taken to solve the problem?		
7	Do you feel that odour, fly, mosquito are problem?	1	Frequent
		2	Less than previous
		3	Better
		4	There is no problem regarding this
8	Which persons use the ecosan toilet?	1	Everybody
		2	Women
		3	Both men and women
9	When do the women use the ecosan toilet?	1	As urinal
		2	As defecation
		3	Both
10	When do the men use the ecosan toilet?	1	As urinal
		2	As Latrine
		3	Both
11	Which persons do not use the ecosan toilet?	1	Old aged
		2	Kids
		3	Handicapped
		4	Others
12	Why they do not use the ecosan toilet?		
13	Do the women feel safe to use the ecosan toilet?	1	Yes
		2	No
14	Do the women feel comfort to use the ecosan toilet?	1	Yes
		2	No
15	What kinds of problem did you face during using the ecosan toilet?		
16	Which problems were very frequent?		
17	Do you always suffer from the	1	Yes

	odour of latrine	2	No				
		3	Occasionally				
18	What do you think about the reason of odour?						
19	Do you face any problem during using the pan?	1	Yes	2	No		
20	If any, what types of problem?						
21	Is it a problem for you to shift yourself during anal washing?	1	Yes	2	No		
22	If any problem, to whom it is conceren?						
23	Do you know, in case of women user, some part or portion of urine entered into the faeces pit of the latrine?	1	Yes	2	No		
24	Do you think it creates problem, if the ecosan toilet is attached with your living room?	1	Yes	2	No		
25	Which persons in your family feel comfort to use the ecosan toilet?	1	Men (18-59).....person				
		2	Women (18-59).....person				
		3	Girls (10-18)..... person				
		4	Old men (60+) ..... person				
		5	Old women (60+)..... person				
		6	Kids (4-10)..... person				
26	What are reasons of feeling discomfort?	1	The kids are afraid from large size pit				
		2	Old aged members prefer do not latrine closed latrine				
		3	Old mens prefer open latrine				
		4	Others.....				
27	Have you been facing any problem since to date using this latrine?						
28	Do you think, the problem created due to faulty design/structure?						
29	Have you any recommendation to improve the structure of the ecosan latrine						
30	Whichone is usually used, ash or saw, after defecation?	1	Ash	2	Saw dust		
31	From where do you clooect the ash/sawdust?	1	Own source				
		2	From neighbours				
		3	From neighbours, if not available				
		4	From outside				
		5	Purchased, if necessary				
32	What about the market price of ash and sawdust?	1	Price of ash @..... Tk/kg				
		2	Price of sawdust @.....Tk/kg				
33	Which parts of the ecosan toilet is gone since its start up?						
34	What amount of Taka did you spend to make the latrine OK?						
35	What is your opinion regarding the longevity of this latrine	.....year					
F	Information related to fecal matters used as manures						
1	Do you know the fecal matters are manure?	1	Yes				
		2	No				
		3	Seems to be				
2	Do you ever use fecal matters as manure before using the ecosan toilet?	1	Yes	2	No		
3	How do you respond about the recycling of wastes as manure?	1	Good technique				
		2	Might me				
		3	Not at all good				
		4	Reduce the pressure of chemical fertilizer				

4	Faeces or urine, which one have you been used as manure?	1	Faeces	2	Urine	3	Both			
5	Do you know how to properly utilize the faeces/urine?	1	Yes	2	No	3	Little is known			
6	Faeces or urine, which one, do you feel comfort to use?	1	Faeces	2	Urine	3	Both			
7	How many times did you extract manure from latrine?	1	Never							
		2	Once							
		3	Twice							
		4	Four or more times							
8	How long it requires filling up one chamber of ecosan toilet?	1	3 months							
		2	6 month							
		3	8 months							
		4	1 year							
9	How long you have to wait to extract the faeces after filling up the latrine?	1	3 months							
		2	6 months							
		3	8 months							
		4	1 year							
10	What quantity of manure did you get from a single set of collection									
11	When do you harvest the faeces?	1	After filling the chamber							
		2	After filling the alternative chamber							
		3	When requires							
		4	4 months after stopping the defecation							
		5	6 months after stopping the defecation							
12	Once after stopping the uses of latrine, do you know how long the fecal matters take to become manure?	1	2 months							
		2	4 months							
		3	6 months							
		4	1 year							
		5	More than 1 year							
13	What is your opinion regarding the responsibility towards extracting manures from the latrine	1	Men's responsibility							
		2	Women's responsibility							
		3	Both's responsibility							
		4	Both							
14	Presently who does extract the manure?	1	Men							
		2	Women							
		3	Both men & women							
		4	Any body can perform							
		5	It requires 1-2 hours							
15	Do you think the cleaning of this latrine is not so labour intensive?	1	Yes, labour intensive							
		2	No hard							
		3	Moderately hard							
16	How the manure is extracted from latrine?	1	Pot with bare handed							
		2	Pot with using gas mask and gloves							
		3	Others							
17	How you feel during extraction of manure?	1	I hate it							
		2	I do not hate it							
		3	Feel uneasy							
		4	We enjoy manure extraction							
18	Do you feel odour during manure collection?	1	Very odoured							
		2	Moderate odour							
		3	No odour							
		4	Occasionally							
19	What is the physical appearance of manure?	1	Wet/moisture content high							
		2	Less moist							
		3	Dry							
		4	Occasionally moist							
20	What are the uses of manures after extraction?	1	Direct apply to farm							
		2	Drying prior to application							
		3	Copile with other organic manures							
		4	Keep it in pit with other organics for further composting							

21	How the manure is conserved?	1	It is applied in farm, no arrangement for conservation
		2	Applied in the farm as and when required
		3	Conserved in sac
		4	Conserved in sac after drying
		5	Others

22	If there is any opportunity for drying the faeces/urine?	1	No	2	10 liters can	3	2o liters can	4	Others
23	How many pits you have to conserve the faeces/urine?	1	One	2	Two	3	None		

24	What are the uses of urine?	1	Directly spread in the farm
		2	Used with water
		3	After few days of collection it is applied
		4	Used after composting with other organics
		5	Distributed among others
		6	Trash it out

25	What precautions do you take during spreading the faeces/urine	1	No precausions taken
		2	Globes, mask and gumboot used

26	In what vegetables the fecal matters are used as manure?			
	Faeces as manure		Urine as manure	
	1	Vegetables farm	1	Vegetables farm
	2	Fruits farm	2	Fruits farm
	3	Paddy and jute field	3	Paddy and jute field
	4		4	
	5		5	
	6		6	

27	No meaning?	1	vegetables field
		2	crops field
		3	every type field
		4	others

28	No meaning?	1	vegetables field
		2	crops field
		3	every type field
		4	others

29	When you feel discomfort? During application of faeces or application of urine?	1	Faeces	2	Urine	3	Both		

30	Do you feel, that you have fallen into disease due to application of faeces and or urine as manure	1	Yeas
		2	No
		3	Not known

31	Do you make manure from additional urine?	
32	Do you make manure from additional faeces?	

33	What is the proper tine of applying the fecal matters as manures?	
	Faeces as manure	Urine as manure
	a. during ploughing	a. during irrigation
	b. apply directly to the root	b. apply directly to the root with water
		c. spread over the vegetation
		d. spread before harvesting

34	How the vegetables taste after faeces-manure application	1	Good	2	Moderate	3	Not known		
35	How the vegetables taste after urine-manure application	1	Good	2	Moderate	3	Not known		

36	Do you think, the disease infestation is reduced, if the fecal matters are used as manure?	1	Yes	2	No	3	May be		

37	Do you think, the taste is better, if the fecal matters are used as manure?	1	Yes	No	No	3	Not known				
38	What purpose do you use the fecal-organic vegetables	1	For selling								
		2	Own consumption								
		3	Both for consumption and selling								
39	There is any demand of fecal-organic vegetables in your locality?	1	Yes	2	No	3	Somsbody				
40	Do the community hate fecal-organic manure	1	Yes	2	No	3	Somsbody				
41	Would you like to purchase fecal-organic manure from market?	1	Yes	2	No						
42	If you like to purchase faeces manure from market, how much would you like to pay per Kg?	1	5 Tk.								
		2	8 Tk.								
		3	10Tk.								
		4	More than 10 Tk.								
43	If you like to purchase urine manure from market, how much would you like to pay per Kg?	1	5 Tk.								
		2	8 Tk.								
		3	10Tk.								
		4	More than 10 Tk.								
44	If you trash the urine from ecosan toilet, what is the reason?	1	I hate it								
		2	No agriculture								
		3	Don't know how to use								
		4	No results from previous application								
		5	No additional pit/container for preservation								
		6	Others								
44	Did you only apply the urine-manure in homestead gardening?	1	Yes								
		2	No								
45	How much you saved from fertilizers purchasing, through applying the fecal manure	.....Tk									
46	How much you saved from insecticide purchasing, through applying the urine manure	.....Tk									
47	Considering the advantages about longevity and sustainable structure of latrine, what is your evaluation regarding the expenditure of installing a latrine?	1	Less	2	Higher	3	Reasonable				
G	Health related information										
1	How much you had to spend per month for diarrhea, before using the latrine?	.....Tk									
2	How much you had to spend for diarrhea, before using the latrine?	.....Tk									
3	How many family members were affected by diarrhea before using this latrine?	.....person									
4	How many family members were affected by diarrhea during last two months?	.....person									
5	Do you think this type of latrine helped to reduce the diarrhea infectation in your family?	1	Yes								
		2	No								
		3	Seems to be								
6	What types of diseases have been affected your family members last one year?	Name of the diseases			Winter		Summer		Monsoon		
		Diorhhea									
		Cholera									
		Loose motion									
		Dysentry									
		Jaundice/Hepatitis-A									
		Skin diseases									
		Stomachache									
		Others									
	When do you family members wash their hands with soap	1	After defecation								

7	and or ash?	2	Before meal			
		3	After cleaning the babies faeces			
		4	Before feeding the babies			
		5	Before serving foods			
		6	Before cooking			
8	From where do you collect drinking water?	1	Tube-well			
		2	River/pond			
		3	Falls/haor/baor/wetlands			
9	What is the distance between drinking water source and un hygiene latrine?	1	Within 10 feet			
		2	Within 20 feet			
		3	Within 30 feet			
		4	More than 30 feet			
10	From where do you collect cooking water?	1	Tubewell			
		2	River/pond/wetland			
		3	Falls/haor/baor/wetlands			
11	If there any hanging latrine close to your water sources	1	Yes	2	No	
12	Do you drink boiled water?	1	Yes	2	No	
13	What about the infestation of flies and mosquitoes in this latrine?	1	Less			
		2	Occasionally			
		3	Frequently			
14	Do you use bare hand to spread the fecal manure?	1	Yes	2	No	
15	Did you ever feel sick after applying the manure in the farm?	1	Yes			
		2	No			
		3	Not			
H	Environment related					
1	Do you think your ecosan toilet is environment friendly?	1	Yes			
		2	No			
		3	May be			
2	How it is Yes and or No, please explain					
3	Does the fecal matter inside the chamber usually pollute the surroundings?	1	Yes			
		2	No			
4	Do you think during disaster (flood, cyclone, tornedo) this latrine is being usable?	1	Yes			
		2	No			
5	Do you think the latrine will last long due to its good structure	1	Yes			
		2	No			
6	How frequent the flood seen during last 10 years?					
7	How many times your house has been submerged due to flood?					
8	Did the water enter into the faeces-chamber of latrine during flood?	1	Yes			
		2	No			
9	Did the faeces-chamber pollute the environment during flood?	1	Yes			
		2	No			
I	Institutional information					
1	Did you receive any training before installing the latrine?	1	Yes	2	No	
2	What were topics of the training	1	How to use latrine			
		2	Maintenance			
		3	How to utilize fecal matters as manure			
		4	Others			
3	Has the assisting organization yet been monitoring?	1	Yes	2	No	
4	Has the assisting organization yet been helping to repair the latrine?	1	Yes	2	No	
J	Installation and uses of ecosan toilet					
1	Do you think every household in the village will have ecosan toilet?	1	Yes			
		2	No			

2	If yes or know, what is the reason?									
3	What is the installataion cost of an ecosan toilet?									
4	How much did you spend to install an eco latrine?									
5	How many days did you contribute to install the eco latrine?									
6	Are the skilled massion workers available in your locality?	1	Yes	2	No					
7	Are the larine-goods easily available in the market?	1	Yes	2	No	3	Except pan			
8	Without any subsidy, what is your expectation about the affordable price of this latrine for the local community?									
9	Is it possible to install ecosan toilet in every household of the village without any assistance from government and or other organizations?	1	Yes	2	no					
10	Is it possible to installand popularizing the latrine providing loan with minimum (1%-2%) interest?	1	Yes	2	No	3	May be			
11	Is it possible to run the latrine program with agriculture subsidy/fertilizer subsidy?	1	Yes	2	No	3	May be			
12	Do you know how many hoseholds installed the latrine without any assistance from project?	1	Yes	No. of HH or individual						
		2	No							
		3	Not known							
13	What are constraints behind not poularaizing the ecosan toilet?	1	Costly							
		2	Difficult to use							
		3	Land intensive							
		4	Need saw dust and ash							
		5	Others							
14	Do you have any comments on this toilet?									

Signature of the interviewer
Date:

Signature of respondent
Date:

Questionnaire survey for "Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects"

CHECK LIST TO DETERMINE THE PROPER FUNCTIONING OF LATRINE

	Check list to determine the proper functioning of latrine									
1	Are the stares are OK?	1	Yes	2	No					
2	Are the doors OK?	1	Yes	2	No					
3	Is the inside floor of the latrine OK?	1	Yes	2	No					
4	Is the paddle OK?	1	Yes	2	No					
5	Is the faeces outlet OK?	1	Yes	2	No					
6	Is the faeces lid OK?	1	Yes	2	No					
7	Is urine outlet OK?	1	Yes	2	No					
8	Is urine lid OK?	1	Yes	2	No					
9	Is any leak in the urine pipe?	1	Yes	2	No					
10	Is any obstacle in urine line/is the urine easily store in the jerrycan?	1	Yes	2	No					
11	Is the urine jerrycan OK	1	Yes	2	No					
12	Is washing pan OK?	1	yes	2	No					
13	Is washing pipe OK?	1	Yes	2	No					
14	Is there any leak in the washing pipe line?	1	Yes	2	No					
15	Is washing water entenered into the soak pit without any abstacle?	1	Yes	2	No					
16	Is evaporation bed OK?	1	Yes	2	No					
17	Is evaporation bed properly functioning?	1	Yes	2	No					
18	Is the roof of the latrine OK?	1	Yes	2	No					
19	Is the water leaches from the roof?	1	Yes	2	No					
20	Is the gas pipe OK?	1	Yes	2	No					
21	Is the faeces-chamber OK?	1	Yes	2	No					
22	Is there any leak in the chamber?	1	Yes	2	No					
23	Is heat panel OK?	1	Yes	2	No					
24	Is there any leak in the heat panel?	1	Yes	2	No	3	Slight			
25	Is the heat panel is air tight with cemented morter?ti	1	Yes	2	No					
26	Is the shadow of tree covered the heat panel day long?	1	Yes	2	No					
27	Is there any arrangement for ash inside the latrine?	1	Yes	2	No					
28	Is there any arrangement for saw dust inside latrine?	1	Yes	2	No					
29	Is there any special napkin place inside the latrine?	1	Yes	2	No					
30	Is there any washing place closest to latrine	1	Yes	2	No					
31	Is there any odour generate from inside the latrine?	1	Yes	2	No					

Signature of the interviewer
Date:

Questionnaire survey for "Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects"

QUESTIONNAIRE FOR LATRINE NON USERS COMMUNITIES

	Date					
	Upazila					
	Union					
	Ward					
	Village					
A	Family and personal information					
1	Name of the respondent					
2	Age of the respondent					
3	Sex of the respondent	1	Male	2	Female	
4	Cell phone number					
5	Education	1	Primary			
		2	SSC			
		3	HSC			
		4	Graduate			
		5	Informal			
		6	None			
		7	Others (specify)			
6	Major income source of family head	1	Agriculture	Annual income (Tk):		
		2	Business	Annual income (Tk):		
		3	Job	Annual income (Tk):		
		4	Day labourer	Annual income (Tk):		
		5	Others (specify)	Annual income (Tk):		
B	Informattion about sewerage system					
1	What type of latrine have you been using?	a	One ring-one slab latrine			
		b	Four or more rings with one slab latrine			
		c	Twin pit latrine			
		d	Ring less pit latrine			
		5	Cleaning requirement is not frequent like other latrine			
2	What is the installation cost of this latrine?	Tk.				
3	How long have you been using this latrine?					
4	What are the advantages of this latrine?	1	Maintenance is easy			
		2	Installation cost is low			
		3	Faeces and urine used as manure			
		4	Filling of pits take long time			
		5	Frequent cleaning is not needed			
		6	Others			
5	What are the disadvantages of this latrine?	1	Wastes of water			
		2	Bloked by faeces/fecal matters			
		3	Evacuation cost high			
		4	Useless during flood			
		5	Generates odour			
		6	Others			
6	What were the frequencies of evacuation/cleaning of pits?	.....month				
7	Do you feel frequent odour during using the latrine?	Yes.....no.....occasionally				
8	Does it require huge volume of water to clean the latrine after using?	Yes.....no.....				

9	What was the expenditure for pit cleaning for this latrine?	a. 100-200 Tk. b. 200-300 Tk. c. 300-400 Tk. d. 500 Tk. or more				
10	What was the frequency of cleaning this latrine?					
11	What was the frequency of cleaning this latrine using brush (pan and others)?	.....month				
12	Do you use Harpic to clean the latrine?		Yes	2	No	
13	Do you think this latrine is health friendly?	1	Yes	2	No	
14	What is the reason of "yes" or "not"?					
15	Do you think the latrine is usable during different disasters (flood, cyclone, tornedo)?	Yes.....no.....				
16	How many times your house was inundated during last ten year's flood?					
17	Did you find your latrine OK during flood?					
18	How many times you had to install the latrine during last ten years?					
19	If the water was transmitted/entered into your latrine's chamber during flood?	Yes.....no				
20	If the environment was contaminated by exposed fecal matters from latrine, during flood?	Yes.....no				
21	Do you feel problem if the latrine is attached with your residential room	Yes.....no				
C	Information about the neighbour's latrine					
1	Do you know what special type of latrine has been using by your neighbour?	Yes.....no.....				
2	Please tell the name of the special latrine					
3	How long this special latrine they have been using?					
4	What are the advantages of using ecosan toilet?	1	Maintenance is easy			
		2	Water requirement is low			
		3	Faeces is used as manure			
		4	Urine is used as manure			
		5	Filling of pits take long time			
		6	Cleaning in not frequent like other latrine			
		7	Evacuation cost is low			
		8	Useable even during flood			
		9	Others			
5	If there are any disadvantages of using ecosan toilet?	Y	N			
6	What is your opinion regarding the major problem associated with using this latrine?					
7	Do you think eco-san latrine is health friendly?	Y	N			
8	What is the reason of "yes" or "no"?					
D	Information regarding fecal matters as manure					
1	Do you know the fecal matters are used as manure?	Y	N			
2	Have you ever been used fecal matters as manure?	Y	N			
3	Are fecal matters boost up agri production?	Y	N	May be		
4	D you know how many days needed to turn the fecal matters of eco san latrine into manure?	1	2 months			
		2	4 months			
		3	6 months			
		4	One year			
5	Do you know, whether your neighbours are using faeces or urine as manure?	1	Yes			
		2	No			
6	Do you feel comfort to handle faeces or urine as manure?	1	Yes			
		2	No			
7	Did you ever use faeces or urine as agriculture manure?	1	Yes			
		2	No			
8	Do you think uses of fecal matters as manure could able to reduce frequent diseas	1	Yes	2	No	
9	Do you think fecal manures improve the taste of the vegetables?	1	Yes	2	No	

			s
10	Do you know about the application process of this fecal manure?		Y
			N
11	Are you interested to buy vegetables and crops produced by fecal manures		Y
			N
E	Health related information		
1	What is your monthly expenditure related to diarrhea ? Tk.		
2	What is your annual expenditure related to diarrhea ? Tk.		
3	How many of your family members were affected by diarrhea since last two months? Persons		
4	Which member of your family was frequently affected by diarrhea ?		
5	Do you think this type of larine causing diarrhea in your family frequently?	1	Yes
		2	No
		3	May be
6	When your family members use ash or soap for washing their hands?	1	After defecation
		2	Before meal
		3	After cleaning the babies feces
		4	Before feeding the babies
		5	Before serving the foods
		6	Before cooking
7	From where do you collect drinking water?	1	Tube well/dug well
		2	River/pond
		3	Falls/baor/wetland
8	What is the distance between your drinking water source and unhygene latrine?	1	Within 10 feets
		2	Within 20 feets
		3	Within 30 feets
		4	More than 30 feets
9	From where do you collect water for cooking purpose?	1	Tube well/dug well
		2	River/pond
		3	Falls/baor/wetland
10	Do you drink boiled water?	1	Y
		2	N
F	Installation and scale up of eco latrine related information		
1	Do you think every household of the village should have eco latrine?	1	Yes
		2	No
2	If it is Yes or if it is No please explain the reason		
3	How much do you want to expense to install an eco atrine in your house?		Tk.
4	Is it possible to install ecolatrines in every house holds of the village without government assistance?		Y
			N
4	Is it possible to install ecolatrines in every house holds of the village without government assistance?	1	Yes
		2	No
5	Is it possible to promote ecolatrine by easy instalment credit basis (1% to 2% interest)?	1	Yes
		2	No
6	Is it possible to scale up the ecoltrine with government agriculture/fertilizer subsidy?	1	Y
		2	N
7	Do you know howmany households installed ecolatrine without government assistance?	1	Y
		2	N
8	What are constraints of popularazing the eco latrine?	1	Expensive

		2	Not comfortable to use
		3	Space intensive
		4	Ash or saw dust is essential
		5	Others
9	Is there skilled massionnaires are available in your locality for set up ecolatrine?	1	Y
		2	N
10	Is there necessary eco latrine materials are available in your locality?	1	Y
		2	N
		3	Except pan, all are available
G	Social issues		
1	Do the the community have not positive attitude towards ecolatrine?	1	Yes
		2	No
		3	Somebody
2	Do the community want to examine/aware about the benefit of eco latrine?	1	Yes
		2	No
		3	Somebody
3	Do you know that, due to religious barrier ecolatrine is not acceptable to all communities?	1	Yes
		2	No
		3	Somebody
4	Do you know that, there is demand of fecal mamure in the cropped areas	1	yes
		2	No
		3	Some areas
5	Do the community hate organice vegetables produced from fecal manures?	1	Yes
		2	No
		3	Somebody
6	If the fecal manures are available in the market, are you interested to purchase it?	1	Yes
		2	No
7	If you want to purchase, how much do you like to pay for a 1kg faeces manure	1	5 Tk. Only
		2	8 Tk. Only
		3	10 Tk. Only
		4	More than 10Tk
8	If you want to purchase, how much do you like to pay for a 1kg urine manure	1	5 Tk. Only
		2	8 Tk. Only
		3	10 Tk. Only
		4	More than 10Tk
9	Your comments regarding eco latrine (if any)		

Signature of the interviewer

Date:

Signature of respondent

Date:

Questionnaire survey for "Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects"

KII QUESTIONNAIRE FOR PUBLE REPRESETATIVE

	Name :		
	Designation:		
	Cell phone No.		
1	Do you know anything about ecosan toilet?	1	Yes
		2	No
2	Have you ever use ecosan toilet?	1	Yes
		2	No
3	What are the advantages of ecosan toilet?	1	Maintenance is easy
		2	Least wastes of water
		3	Faecess are used as manure
		4	Urine used as manure
		5	Take long time to fill up
		6	Cleaning not required frequently
		7	No cost is involve to vacate the latrine
		8	It is usable during monsoon
		9	Others
4	Is there difficulties have to face to use this toilet?	1	Yes
		2	No
5	Which type of problem has to face most?		
6	Do community people have interest to this toilet?	1	Yes
		2	No
7	In your union parished whose have clear idea about ecosan toilet?	1	Chairman
		2	Number of male member
		3	Number of female member
8	Do you know anything about the 2009 local government decision about installing ecosan toilet in all union?	1	Yes
		2	No
9	Under the 2009 local government decision is there any toilet installed in your union?	1	Yes
		2	No
10	If no toilet installed, would you please tell me the reason?		
11	If any toilet installed in whose house it was installed?		
12	Does the toilet is still useable?		
13	Does the user using faece and urine from the ecosan toilet as fertilizer?	1	Yes
		2	No
14	Does the user is a successful farmer?	1	Yes
		2	No
15	Do you think every household in your area should have this kind of toilet?	1	Yes
		2	No
16	So far you know, do you anybody asked DPHE for technical support to install this kind of toilet?	1	Yes
		2	No
17	What are the ways to scaling up the promotion of using ecosan toilet?		
18	Why the mechanism is strong?		
19	Can it be possible to promote through providing soft and easy loan?	1	Yes
		2	No
20	Do you think this type toilet can be provided through utilizing ADP fund?	1	Yes
		2	No
21	Ca n it be possible to increase the use of	1	Yes

	ecosan toilet by using government agricultural and fertilizer subsidy?	2	No
22	What are constraints behind not poularaizing the ecosan toilet?	1	Costly
		2	Difficult to use
		3	Land intensive
		4	Need saw dust and ash
		5	Others
23	Do you think this kind of toilet is socially acceptable?	1	Yes
		2	No
24	Do you know that, due to religious barrier ecolatrine is not acceptable to all communities?	1	Yes
		2	No
25	Do you think to use urine and faeces as fertilizer is accepted by the farmer?	1	Yes
		2	No
26	Do you think community people accepted to buy product from using use urine and faeces as fertilizer?	1	Yes
		2	No
27	Do you think ecosan toilet is the only environment friendly toilet?	1	Yes
		2	No
		3	Don't know
28	To poularaizing the ecosan toilet which institution should take more initiative first?	1	Local government
		2	DPHE
29	Do you have any comments on this toilet?		

Questionnaire survey for "Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects"

KII QUESTIONNAIRE FOR DPHE REPRESENTATIVE

	Name :		
	Designation:		
	Cell phone No.		
1	Do you know anything about ecosan toilet?	1	Yes
		2	No
2	Have you ever use ecosan toilet?	1	Yes
		2	No
3	Do you have any technical knowledge about ecosan toilet?	1	Yes
		2	No
		3	Some
4	Do you have any experience in constructing ecosan toilet?	1	Yes
		2	No
5	If the answer is yes, how many?		
6	In your Upazilla how many ecosan toilet has been installed and in which union?		
7	What are the advantages of ecosan toilet?	1	Maintenance is easy
		2	Least wastes of water
		3	Faecess are used as manure
		4	Urine used as manure
		5	Take long time to fill up
		6	Cleaning not required frequently
		7	No cost is involve to vacate the latrine
		8	It is usable during monsoon
		9	Others
8	Is there difficulties have to face to use this toilet?	1	Yes
		2	No
9	Which type of problem has to face most?		
10	Do community people have interest to this toilet?	1	Yes
		2	No
11	In your upazilla which department have idea about ecosan toilet?		
12	Do you know anything about the 2009 local government decision about installing ecosan toilet in all union?	1	Yes
		2	No
9	Under the 2009 local government decision is there any toilet installed in your union?	1	Yes
		2	No
10	If no toilet installed, would you please tell me the reason?		
11	If any toilet installed in whose house it was installed?		
12	Does the toilet is still useable?	1	Yes
		2	No
		3	Don't know
13	Does the user using faece and urine from the ecosan toilet as fertilizer?	1	Yes
		2	No
14	Does the user is a successful farmer?	1	Yes
		2	No
15	Do you think every household in your area should have this kind of toilet?	1	Yes
		2	No
16	Do anybody asked DPHE for technical support to install this kind of toilet?	1	Yes
		2	No

17	If yes, who are they?		
18	What are the ways to scaling up the promotion of using ecosan toilet?		
19	Why the mechanism is strong?		
20	Can it be possible to promote through providing soft and easy loan?	1	Yes
		2	No
21	Do you think this type toilet can be provided through utilizing ADP fund?	1	Yes
		2	No
22	Ca n it be possible to increase the use of ecosan toilet by using government agricultural and fertilizer subsidy?	1	Yes
		2	No
23	What are constraints behind not poularaizing the ecosan toilet?	1	Costly
		2	Difficult to use
		3	Land intensive
		4	Need saw dust or ash
		5	Others
24	Do you think this kind of toilet is socially acceptable?	1	Yes
		2	No
25	Do you know that, due to religious barrier ecolatrine is not acceptable to all communities?	1	Yes
		2	No
26	Do you think to use urine and faeces as fertilizer is accepted by the farmer?	1	Yes
		2	No
27	Do you think community people accepted to buy product from using use urine and faeces as fertilizer?	1	Yes
		2	No
28	Do you think ecosan toilet is the only environment friendly toilet?	1	Yes
		2	No
		3	Don't know
29	To poularaizing the ecosan toilet which institution should take more initiative first?	1	Local government
		2	DPHE
30	Do you have any comments on this toilet?		

Questionnaire survey for "Functionality Analysis of Ecosan Latrines in Rural Areas of Bangladesh Based on Environment and Health Aspects"

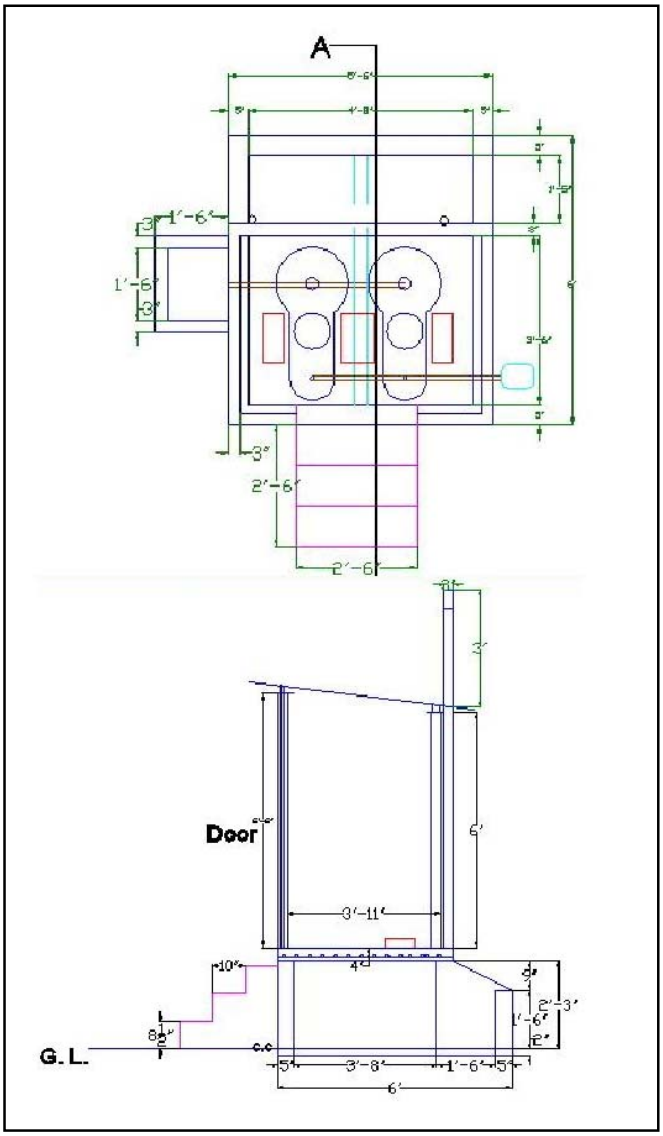
KII QUESTIONNAIRE FOR DIFFERENT IMPLEMENTING ORGANIZATION

1) Factors preventing sanitation improvement in Bangladesh
2) Own Institution/ Organization views about Ecosan Toilet
3) Organization Experiences about Ecosan toilet (include details information about number, place, year of installation, funded/supported by)
4) Learning from implementation/ support
5) Prospects of Ecosan Toilet in Bangladesh and organizational target
6) Strategies for Ecosan Toilet promotion by the organization.
7) What would be the strategies for government for Ecosan Toilet promotion in Bangladesh

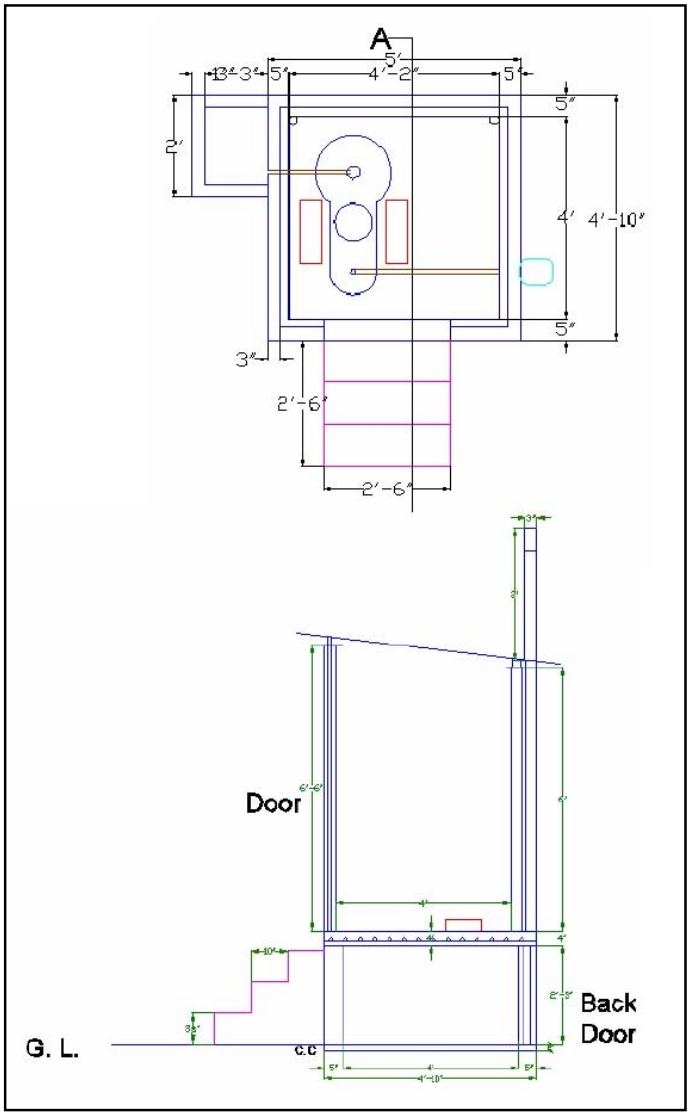
APPENDIX – B

Different types Ecosan toilet model design and technical description

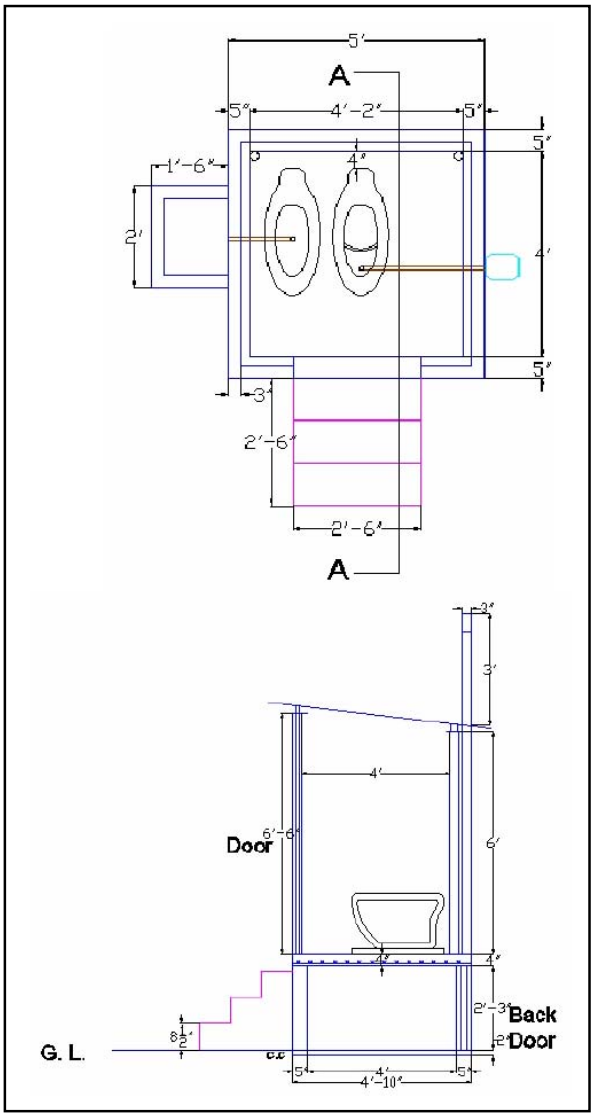
Option 1: Fixed Chamber System Using Plastic Fiber Pan
Characteristics • Two plastic fiber ecopans (alternate use in six month interval), Ecopan separates the faeces, urine, and anal cleansing water • Two fixed chamber (brick made) for faeces storage. • Dark black painted GI sheet is used as the heat panel on back of the chamber, Heat panel facilitate the drying of faeces and moisture reduction ensuring heat trapping from sunlight. • Two vent pipes from two corners are used to remove the odor from the toilet. Require 33 square feet of area. • Substructure should be made of brick.
Construction cost • BDT 12819.00 for brick structure (substructure cost BDT 8369.00) and • Cost BDT 11219.00, if superstructure made by Bamboo.



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



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



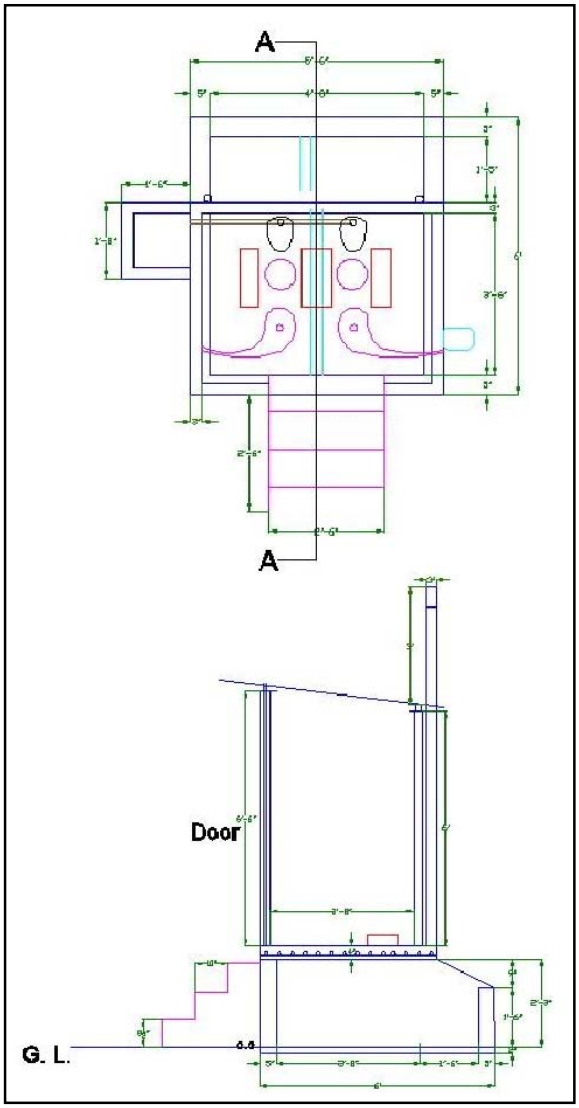
Option 4: Fixed Chamber System Using Modified Traditional Eco Pan

Characteristics

- Option modified from traditional ecopan introduced by BARD.
- Slab on PL (plinth level) constructed such a way which provides facilities for urinal separation and faces.
- Anal cleansing facility is provided back instead of middle of the slab (it reduce the space requirement).
- Two pans and two fixed chamber is used.
- Two vent pipes in two corners are used removing the odor from the toilet.
- Dark black painted GI sheet is used as the heat panel on back of the chamber.
- Option requires 33 square feet of area. Substructure should be made on brick.

Construction cost

- Construction cost BDT 11679.00 for brick structure (substructure cost BDT 7229.00)
- Cost BDT 10079.00, if superstructure made by Bamboo.



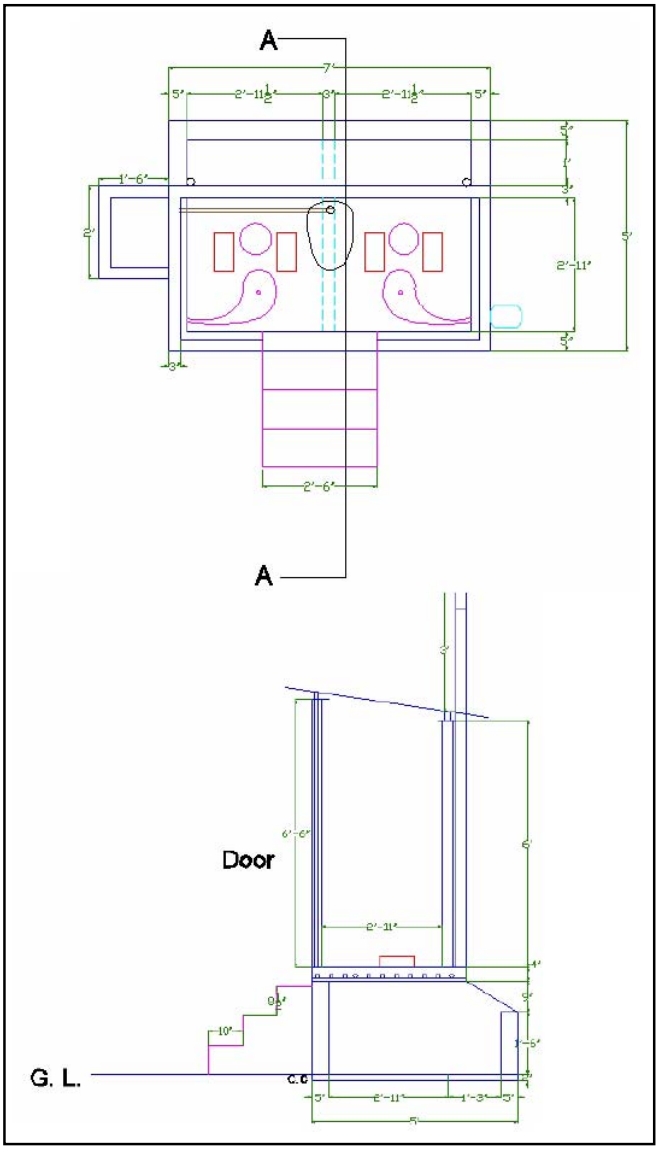
Option 5: Fixed Chamber System Using Traditional Eco-Pan

Characteristics

- Traditional eco-toilet.
- Slab on PL (plinth level) constructed such a way which provides facilities for urinal separation and faces.
- Anal cleansing facility is provided middle of the slab two pans and two fixed chamber is used.
- Two vent pipes in two corners are used removing the odor from the toilet.
- Dark black painted GI sheet is used as the heat panel on back of the chamber. Option requires 35 square feet of area. Substructure should be made on brick.

Construction cost

- Construction cost BDT 12279.00 for brick structure (substructure cost BDT 7789.00)
- Cost BDT 10639.00, if superstructure made by Bamboo.



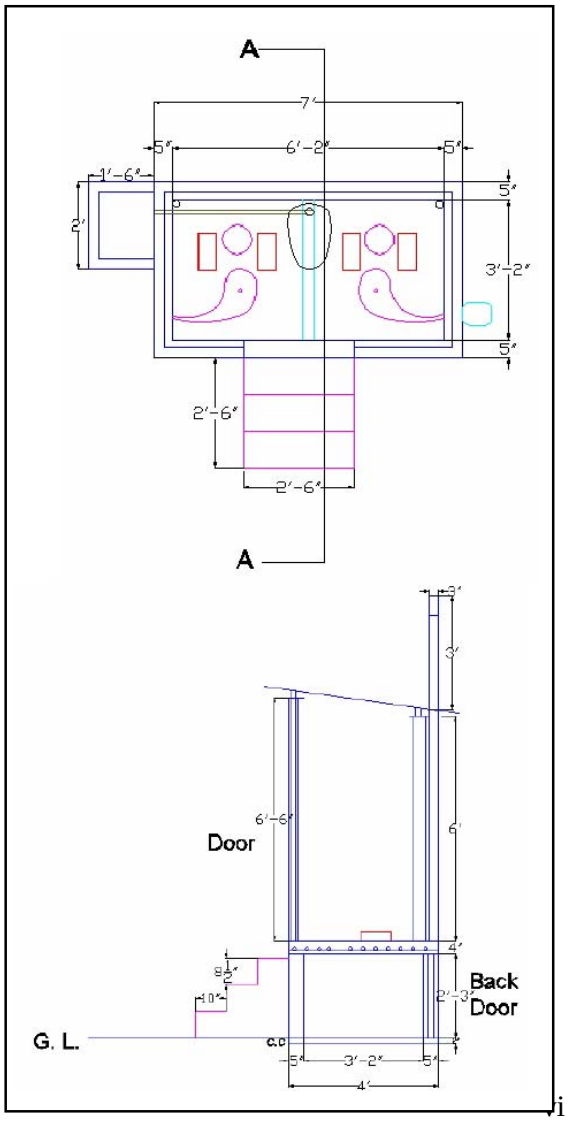
Option 6: Movable Plastic Drum System Using Traditional Eco-Pan

Characteristics

- Option modified from traditional ecopan introduced by BARD.
- Slab on PL (plinth level) constructed such a way which provides facilities for urinal separation and faces.
- Anal cleansing facility is provided back instead of middle of the slab (it reduce the space requirement).
- Two pans and two movable drums are used.
- Two vent pipes in two corners are used removing the odor from the toilet.
- A back door is provided for taking in and out of the plastic drum instead of heat panel. Option requires 25 square feet of area.
- Bamboo/Mud or other available materials can be us for Substructure of the toilet.

Construction cost

- Construction cost BDT 12436.00 for brick structure (substructure cost BDT 7946.00) and Cost BDT 10796.00, if superstructure made by Bamboo.



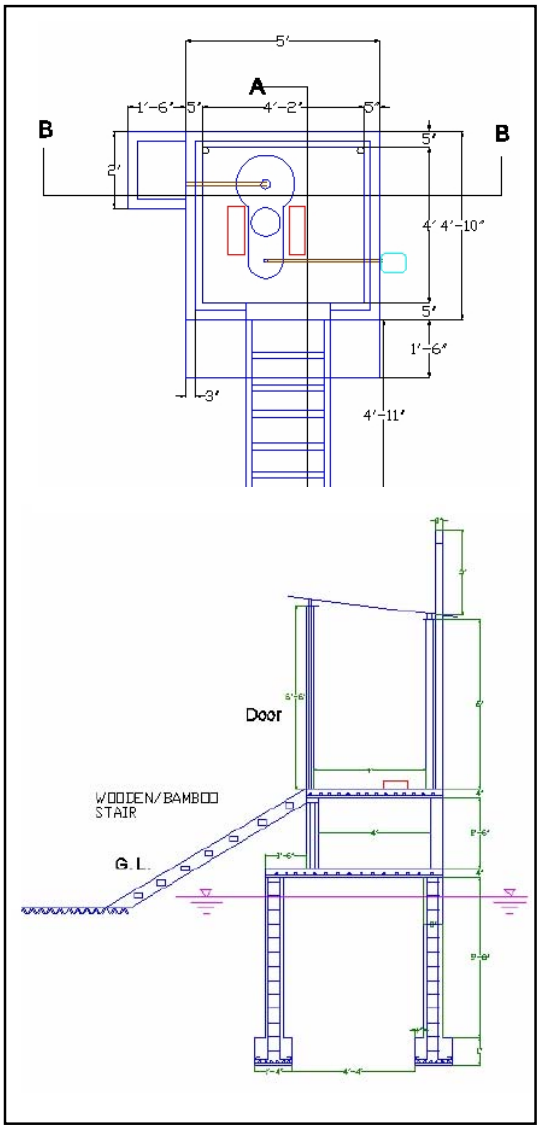
Option 7: Elevated Movable Plastic Drum System with RCC Column

Characteristics

- Option specially designed for haor and flood prone area
- The toilet has an elevated platform by R.C.C column and slab. One plastic fiber ecopan and two movable plastic drum is used
- One ladder is provided to reach the elevated platform from ground level.
- No heat panel is used
- A back door provided for taking in and out of the plastic drum instead of heat panel This option requires 25 square feet of area. Entire structure made by brick and concrete

Construction cost

- Construction cost BDT 17500.00 for brick structure (substructure cost BDT 13110.00)
- Cost BDT 15960.00, if superstructure made by Bamboo.



Option 8: Single Pit Urine Diversion Toilet

Characteristics

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

Construction cost

- Cost BDT 5405.00 for bamboo made super-structure.

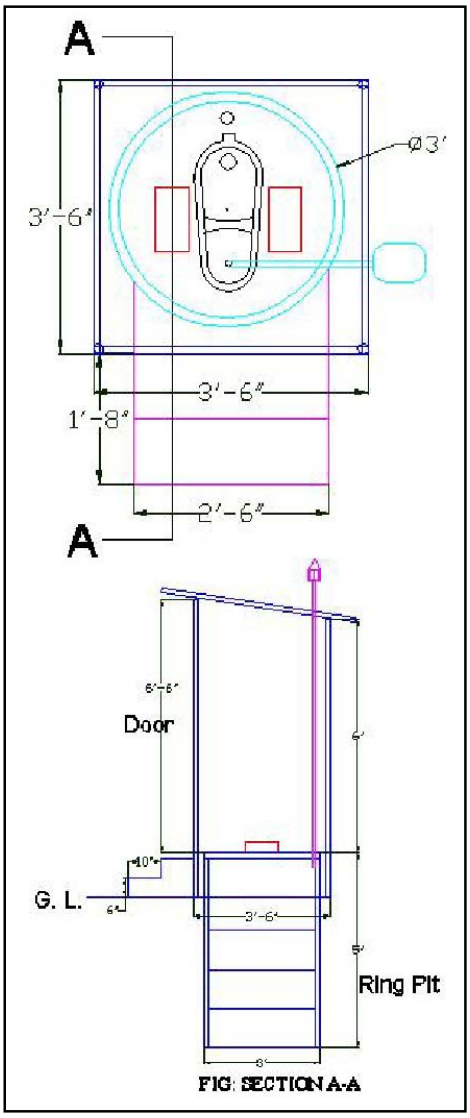


FIG: SECTION A-A

Option 9: Twin Pit Urine Diversion Toilet

Characteristics

- Popularly known as twin pit but little modification that is one special pan provides facilities for separation urine and faeces with water sealing component. One urine diversion pan is used for this option. No separate facilities for anal cleansing.
- Faeces and anal cleansing water will go directly to the ring pit (10 nos). Two ring pits is used alternately in six month interval after filling of one. The area required to construct this option is 25 sq feet.

Construction cost

- Construction cost BDT 11200.00 for brick structure (substructure cost BDT 7600.00)
- Cost BDT 9220.00, if superstructure made by Bamboo

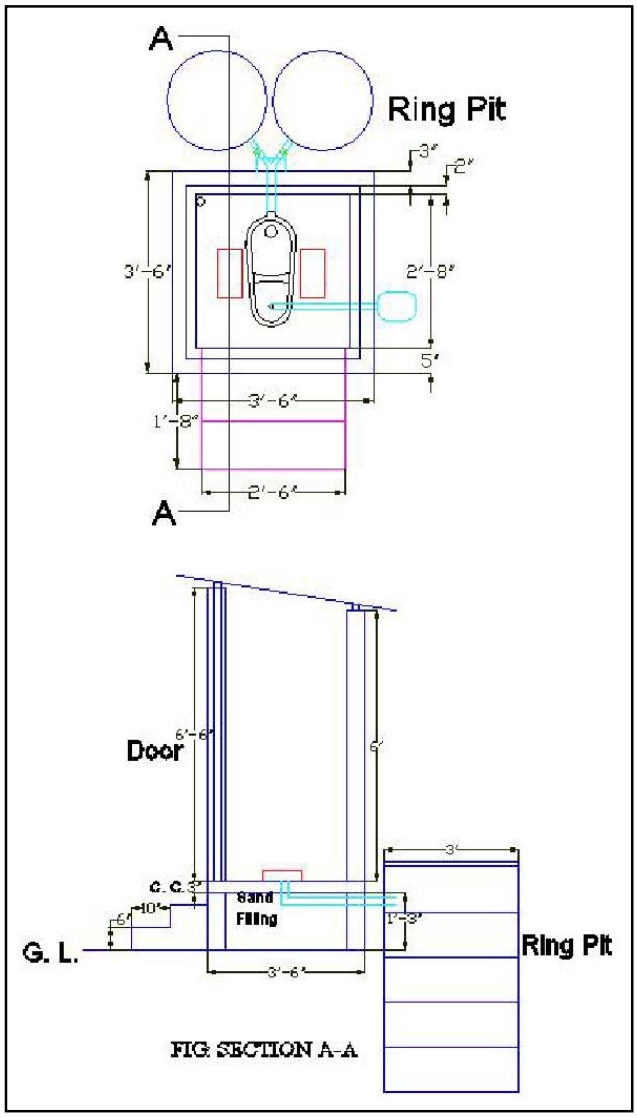
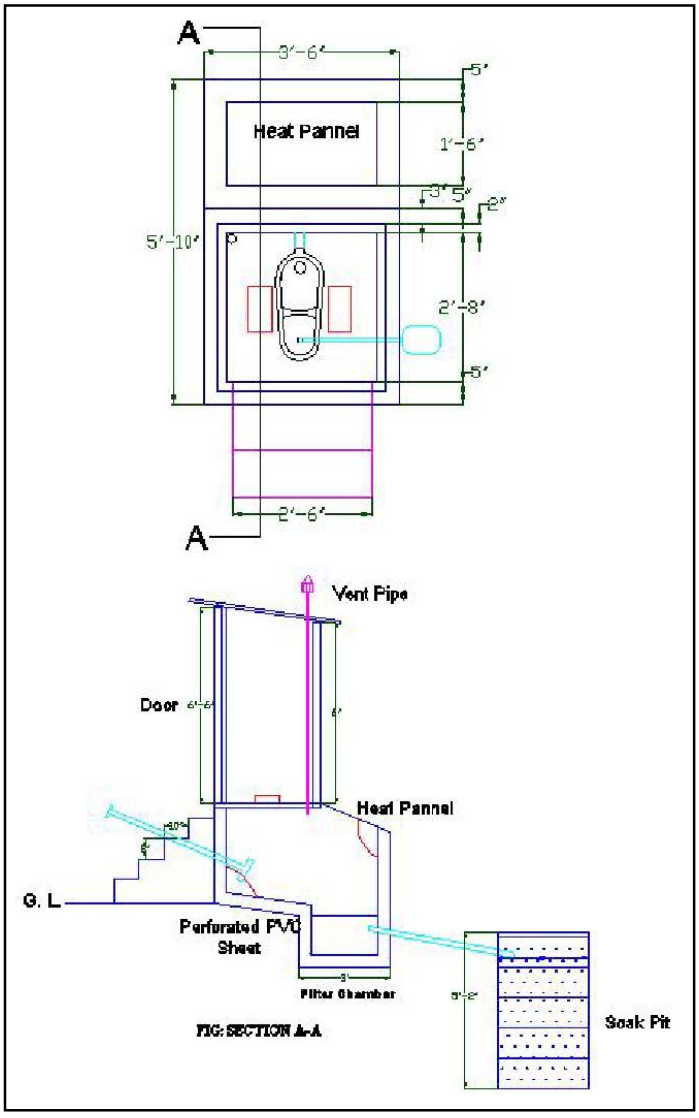
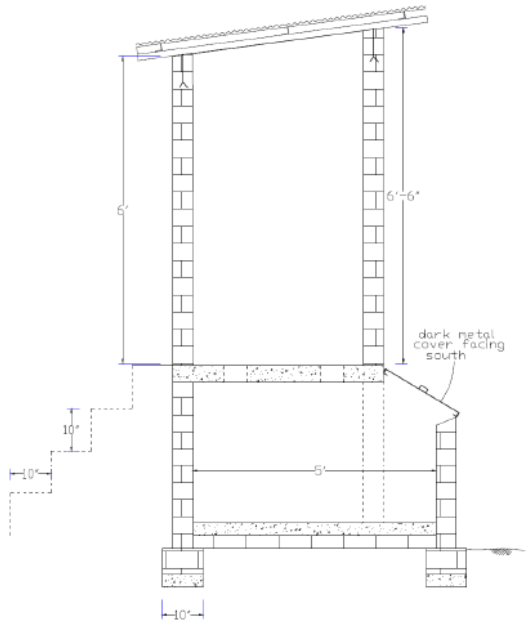


FIG: SECTION A-A

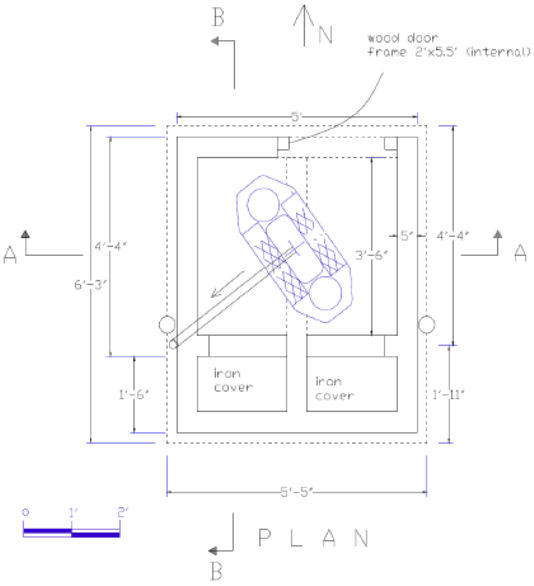
Option 10 : Waste Concern Model using Urine Diversion Pan
Characteristics • UNICEF designed implemented by waste concern. • Urine will go directly to the urine container by separate pipeline • Faeces and anal cleansing water goes to the sub-structure chamber. • Anal cleansing water goes to soak pit through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

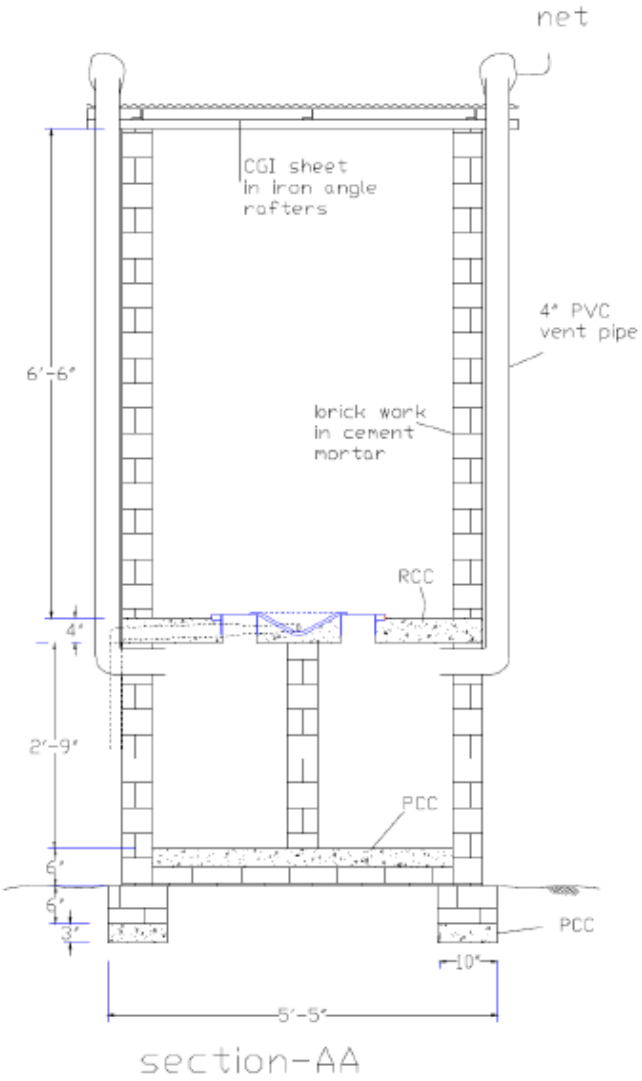


Option 11: UDDT, Terre des hommes Lausanne
Characteristics • Separation of excreta and urine/liquids • Containment of excreta in a vault where it can dehydrate • Infiltration of urine and anal wash water in the soil (urine is not collected and used as a fertiliser because there is no demand for it •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



section-BB





section-AA

APPENDIX – C

Dry faeces laboratory testing result

Item		Raicho T-4 (2005)	Hatigara T-1 (2005)	Joypur North T-1 (2005)	Joypur South T-1 (2005)	Srinagar T-19 (2007)	Srinagar T-8 (2007)	Srinagar T-3 (2007)	Srinagar T-13 (2007)	Srinagar T-10 (2007)	Srinagar T-16 (2007)	Srinagar T-17 (2007)	Srinagar T-21 (2007)	Keshabpur T-25 (2009)	Keshabpur T-2 (2009)	Sharsha T-3 (2009)	Niamatpur T-11 (2009)
P^H		9.7	8.3	8.67	9.5	9.26	8.78	7.98	9.02	8.24	8.17	8.77	9.47	9.97	8.68	9.22	9.61
Organic Matter	%	3.65	3.81	3.00	3.00	4.11	1.89	4.66	1.78	1.75	3.76	4.89	2.08				
Nitrogen (N)	%	0.18	0.19	0.57	0.55	0.17	0.31	0.27	0.28	0.20	0.28	0.20	0.35	0.28	0.3	0.37	0.49
Phosphorus (P)	%	0.43	0.41	0.45	0.57	0.56	0.66	0.55	0.63	0.66	0.60	0.50	0.71	0.39	0.15	0.21	0.09
Potash (K)	%	2.00	1.58	1.67	1.91	2.73	3.69	2.92	3.30	3.52	2.71	3.31	3.63	2.84	2.02	3	3.13

Source: JADE 2010, Annual Report

APPENDIX – D

Water Table Measurement Sheet

Sl. No	Name of tube well Owner	Village	Union	Sub-district	District	Average depth	Water table	
							Dry season (December ’09)	**Rainy season** (July ’10)
01	Md. Moshiur Rahman	Belka Nowabgonj	Belka	Sundargonj	Gaibandha	30-40 ft	11'-6"	6'-2"
02	Kolimon Beowa	Belka Nowabgonj					11'-0"	5'-8"
03	Md. Nazrul	Belka Nowabgonj					12'-10"	
04	Md. Ilius Ali	Belka Nowabgonj						5'-7"
05	Md. Mozahar Ali	Taluk Belka						5'-10"
06	Most. Nobijan	Taluk Belka						6'-0"
07	Most. Monoara Begum	Taluk Belka						6'-1"
08	Fuljan / Moynal 75’	Teguree	Gorjan	Chowhali	Sirajgonj	60-70 ft	17’ - 2”	7’- 11”
09	Sharmin / Monjil 60’	Teguree					14' - 4"	8’ – 4”
10	Sufia / Kader 65’	Fulhara					15' - 1"	8’ - 3”
11	Khodeja/ Gofur 60’	Fulhara					16' - 9"	7’ – 9”
12	Abu Shama	Fulhara					17' - 10"	
13	Hafiza / Bablu	Muradpur					19' - 10"	
14	Bilkis / Mozam – 65’	Muradpur					19' - 5"	7’- 3”
15	Saleha / Momin – 60’	Muradpur					20' - 2"	7’-6”
16	Kadar Van / Hachen	Kadamtola	Panchgachi	Kurigram Sadar	Kurigram	30-40 ft	15' - 4"	7' - 2"
17	Shuli / Saeb Ali	Char Krisnapur	Mogholbasa				13' - 10"	5' - 7"
18	Amena / Hasu mandal	Char Sitai jhar	Mogholbasa				12' - 1"	5' - 2"

Source: Oxfam

Table: Comparison of microbial exposure and health risk in different sanitation technologies and systems

APPENDIX – E

Technology	Barrier efficiency and robustness			Exposure pathways	Likelihood of occurrence	Diarrhoea Risk				Helminths Risk				Risk Management
	Input pathogens	Treatment	Typical malfunction			User	Worker	Farmer	Community	User	Worker	Farmer	Community	
User Interface technologies														
UDDT/ urinal	Viruses	NA	-faeces clog urine collection pan -no provision for anal cleansing water -poor construction makes it difficult to clean	Ingestion of excreta										- good design to facilitate urine and faeces separation -dedicated collection point for anal-cleansing water -coated concrete or prefabricated plastic
	Bacteria	NA		Dermal contact										
	Protozoa	NA		Contact with flies										
	Helminths	NA		Ingestion of urine										
Pour flush toilet	Viruses	NA	-poorly designed U-trap is prone to clogging -bulky cleansing materials cause clogging -used with insufficient water	Ingestion of excreta										-properly designed U-trap with sufficient bend angle -separate receptacle for dry-cleansing materials -fresh, rain or welltreated greywater made available
	Bacteria	NA		Dermal contact										
	Protozoa	NA		Contact with flies										
	Helminths	NA		Ingestion of urine										
Collection & Storage/Treatment Technologies														
Single pit	Viruses		-excessive flies and mosquitoes -built in unsuitable area -unstable and prone to collapse	Dermal contact										-install vent -circular with lining -site where there is a low groundwater table, low risk of flooding
	Bacteria			Contact with flies										
	Protozoa			Falling into pit										
	Helminths			Surface/groundwater contamination										
				Contact with overflowing/ leaking contents										
Single VIP	Viruses		-excessive flies and mosquitoes -built in unsuitable	Dermal contact										- keep toilet room dark - ensure vent is high enough and in direct sunlight
	Bacteria			Contact with flies										
	Protozoa			Falling into pit										

			area -unstable and prone to collapse	Surface/groundwater contamination										-uncover toilet to allow airflow -circular pit with lining -site where there is a low groundwater table, low risk of flooding
	Helminths			Contact with overflowing/ leaking contents										
Double dehydration vaults	Viruses	4	-Faeces are too wet and do not dry	Ingestion of dehydrating material										-water-tight chambers away from surface water -additional desiccation material
	Bacteria	6												
	Protozoa	1-2		Dermal contact										
	Helminths	1-2												
Twin pit pour flush	Viruses		-Filling is too rapid -liquid does not infiltrate -Liquid infiltrates into groundwater	Ingestion of stored material										-design based on soil type (proper site analysis) -better design capacity (i.e. amount of water used, number of users -separate collection of dry cleansing material -appropriate pit lining
	Bacteria			Dermal contact										
	Protozoa			Contact with flies										
				Contaminated groundwater/ surface water										
	Helminths			Contact with overflowing/ leaking contents										
Conventional and improved septic tanks	Viruses	0.5	-overflowing/ leaking -inadequate treatment	Ingestion of wastewater										- proper pre-treatment (grease trap) -separate collection of dry cleansing material -avoid use of harsh chemicals -construct chamber to be water-tight
	Bacteria	1		Contaminated groundwater/ surface water										
	Protozoa	2												
	Helminths	2		Contact with overflowing and leaking content										

Source: SEI 2011, Microbial Exposure and Health Assessments in Sanitation Technologies and Systems

APPENDIX – F

Table 01: Presence of parasite and protozoa in different environment and its risk level

Parasite/protozoa	Around eco-toilet sites				Around pit Latrine				Beside Cow shed		Field by urine use				Field by chemical fertilizer use				Beside Ponds				Beside Shallow Tubewells		
Ascaris Lumbricoides (eggs)	2	3	2	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3	2	1	2	2	2	1	2
Trichuris trichura (eggs)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ancylostoma/ Necator (Hookworm) Larvae	1	1	1	0	2	0	0	1	0	1	0	2	3	2	1	2	2	2	2	1	1	0	1	1	0
Stongyloides Larvae	2	1	0	2	2	0	2	0	0	1	2	1	0	0	0	2	0	2	2	1	1	1	0	0	0
Hymenolepis egg	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	2	0	1	0	0	1
Taenia spp./Diphyllidium latum Larva	0	0	1	0	1	0	0	0	1	0	3	0	1	0	0	0	0	0	2	1	2	2	0	0	0
Trichomonas hominis	0	0	0	0	0	2	0	0	2	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	
Entamoeba spp	1	0	0	0	0	0	2	0	3	2	0	2	0	2	0	2	0	0	0	0	0	0	0	0	0

Source: JADE, 2011

Note:
0 = No infection, 1 = Mild Infection, 2 = Moderate Infection, 3 = Heavy Infection

Table 02: Presence of parasite and protozoa in upper layer of feces collection tank/vault and its risk level

Upper Layer								
Toilet no.	**Ascaris lumbricoids**	**Tricuris tricura**	**Ancyclostoma**	**Necator**	**Strongyloids**	**Hymenolepis**	**Taenia spp**	**Toxocara**
S:1	1	0	1	0	1	1	1	1
S:2	1	0	1	0	1	0	1	1
S:3	1	1	0	0	1	0	1	0
S:4	1	0	2	0	2	0	1	0
S:5	2	0	1	1	1	1	1	0
S:6	1	0	0	0	1	0	1	0
S:7	1	0	1	0	0	0	0	0
S:8	2	0	0	0	0	0	0	0
S:9	1	0	0	1	1	1	1	0
S:10	1	1	0	0	1	0	1	1

Source: JADE, 2011

Note: 0 = No infection, 1 = Mild Infection, 2 = Moderate Infection, 3 = Heavy Infection

Table 03: Presence of parasite and protozoa in middle layer of feces collection tank/vault and its risk level

Middle Layer								
Toilet no.	**Ascaris lumbricoids**	**Tricuris tricura**	**Ancyclostoma**	**Necator**	**Strongyloids**	**Hymenolepis**	**Taenia spp**	**Toxocara**
S:1	0	0	1	0	1	0	0	0
S:2	2	0	1	0	1	0	0	0
S:3	2	0	1	1	1	0	1	1
S:4	1	1	0	0	1	0	0	0
S:5	1	1	1	0	2	0	0	1
S:6	1	1	1	0	1	0	0	0
S:7	1	1	0	0	1	0	1	0
S:8	1	1	1	0	1	0	1	0
S:9	0	1	0	0	1	0	0	1
S:10	2	0	1	0	0	0	0	1

Source: JADE, 2011

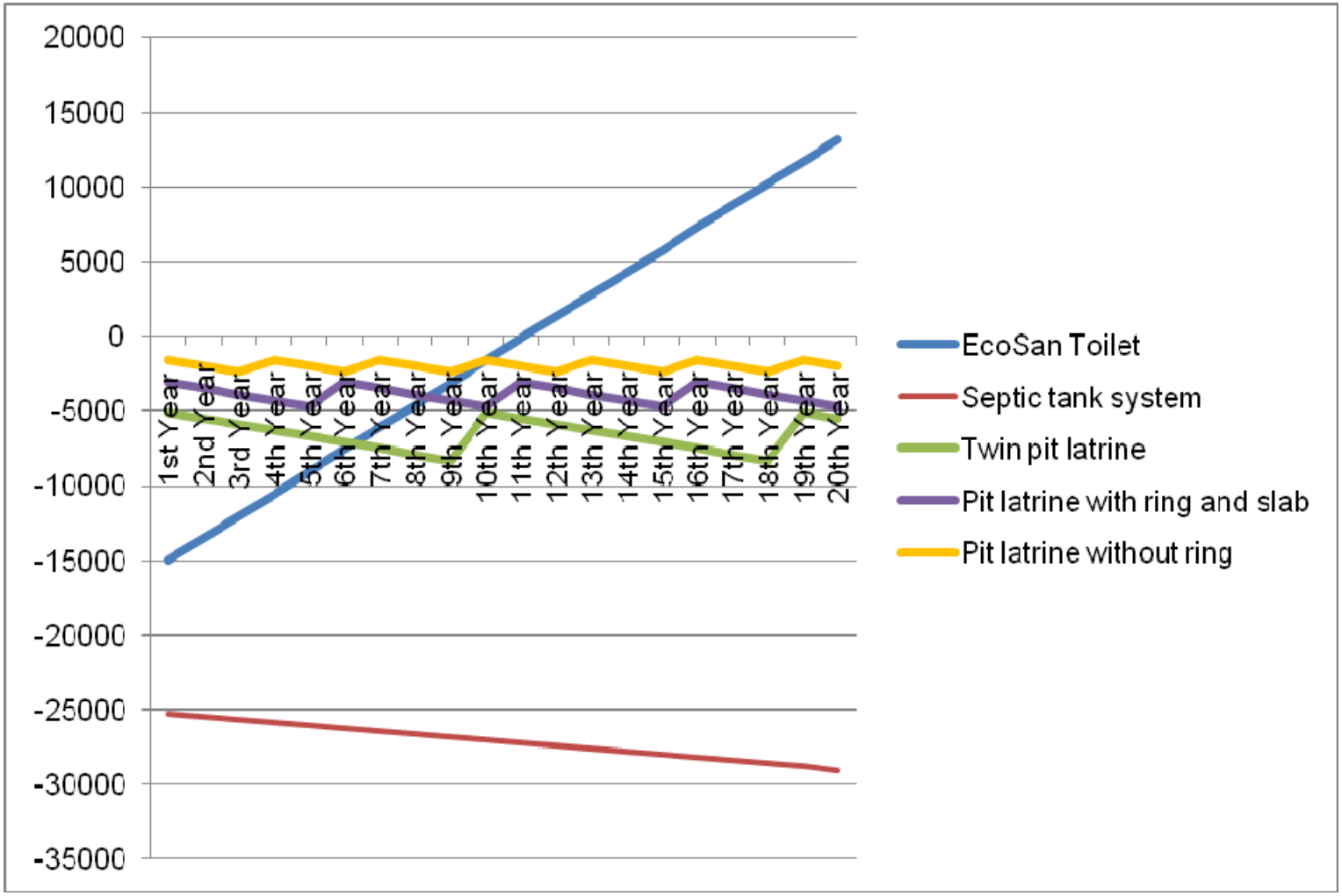
Note: 0 = No infection, 1 = Mild Infection, 2 = Moderate Infection, 3 = Heavy Infection

Table 04: Presence of parasite and protozoa in bottom layer of feces collection tank/vault and its risk level

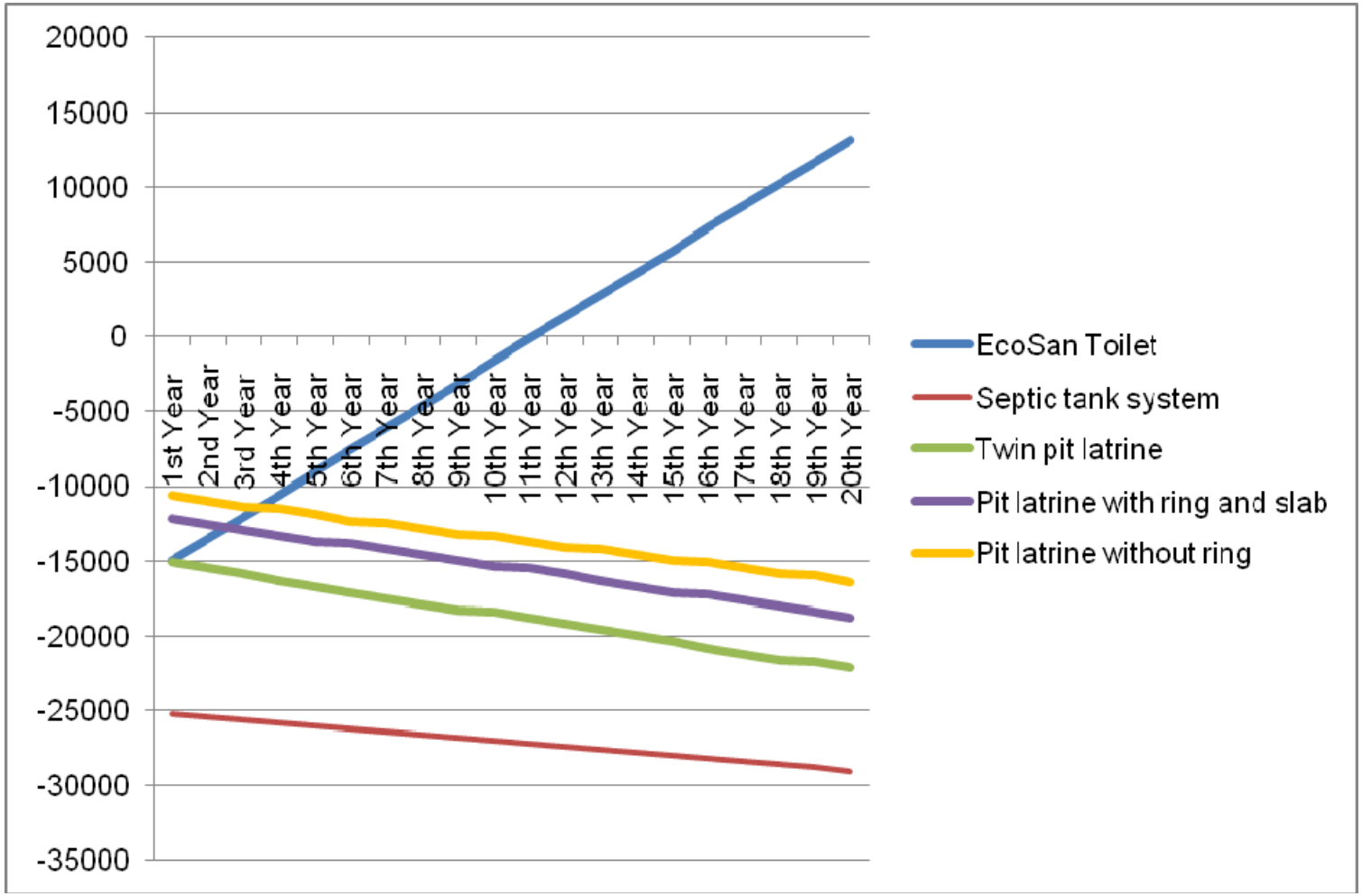
Bottom Layer								
Toilet no.	**Ascaris lumbricoids**	**Tricuris tricura**	**Ancyclostoma**	**Necator**	**Strongyloids**	**Hymenolepis**	**Taenia spp**	**Toxocara**
S:1	2	0	2	1	1	0	1	0
S:2	1	1	2	1	1	1	1	0
S:3	2	0	2	1	1	1	0	0
S:4	3	0	2	0	0	1	0	0
S:5	2	1	1	1	2	0	0	0
S:6	1	1	1	0	2	0	1	0
S:7	2	1	1	0	2	1	0	0
S:8	1	1	1	0	2	0	1	0
S:9	2	1	1	1	1	0	0	0
S:10	0	1	1	1	1	1	0	0

Source: JADE, 2011

Note: 0 = No infection, 1 = Mild Infection, 2 = Moderate Infection, 3 = Heavy Infection


20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
-35000
1st Year
2nd Year
3rd Year
4th Year
5th Year
6th Year
7th Year
8th Year
9th Year
10th Year
11th Year
12th Year
13th Year
14th Year
15th Year
16th Year
17th Year
18th Year
19th Year
20th Year
EcoSan Toilet
Septic tank system
Twin pit latrine
Pit latrine with ring and slab
Pit latrine without ring

(a)



(b)

Figure: Financial requirements for different types of sanitation system in twenty years calculation (a) Requirement wise investment (b) Considering investment at the beginning