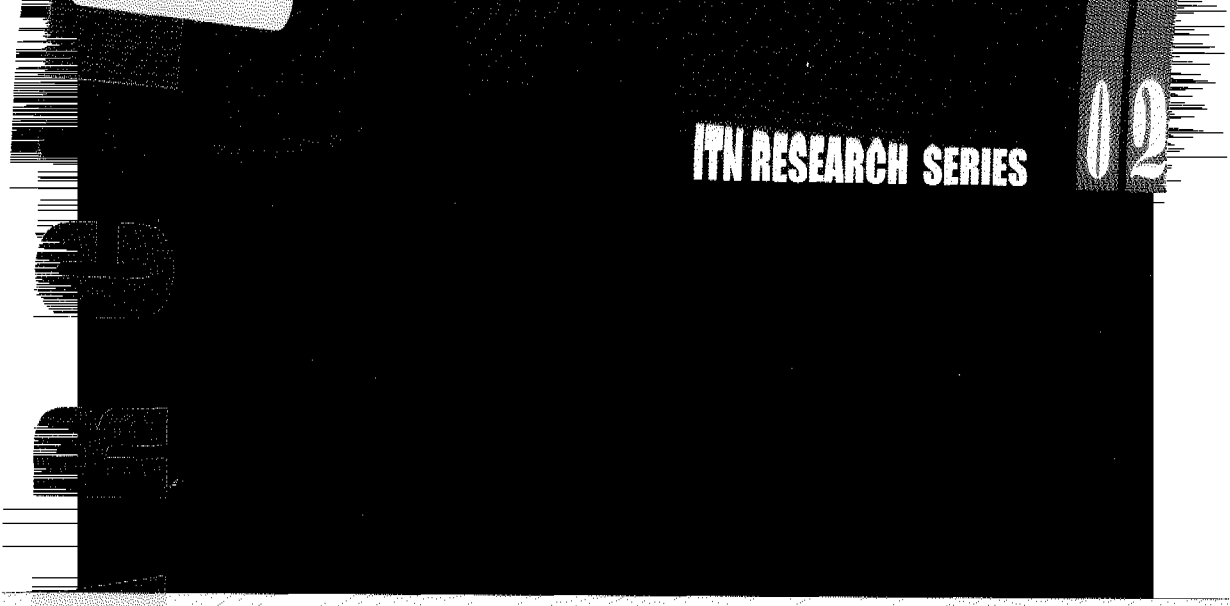

SANITATION STRATEGIES AND TECHNOLOGIES

Flood-prone and High Water Table Areas of Bangladesh

ITN-BANGLADESH
Center for Water Supply & Waste Management
BUET, Dhaka, Bangladesh

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With Compliments
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SANITATION STRATEGIES & TECHNOLOGIES

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Principal Investigator : **Dr. Noor M. Kazi**

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ITN Research Series ***02***

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Flood-prone and High Water Table Areas of Bangladesh

Published by

ITN-Bangladesh
Cente for Water Supply and Waste Management
(A project financed by DANIDA)
Civil Engineering Building (3rd Fl.)
BUET, Dhaka-1000
Bangladesh

January, 2003

Cover Design by: Mr. Khairuzzaman Biplob

Printed by : Mati ar Manush, 173 Fakirapool (1st. Fl.), Dhaka-1000; Ph.- 0171 661841

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FOREWORD

Bangladesh achieved a remarkable success by providing impressive coverage in water supply while sanitation is lagging far behind. In rural socio-economic context, pit-latrine is considered as an appropriate sanitation option in Bangladesh. However, annual flooding, high water table, excessive rainfall and adverse soil condition in many areas often causes overflow and collapse of pit-latrines rendering them unsuitable for the intended purpose. ITN-Bangladesh undertook this research project to workout a suitable sanitation strategy supported by appropriate sanitation technologies for flood-prone and high water table areas of Bangladesh.

The report presents a very good review of technological and social aspects of sanitation in Bangladesh. In the process of development of sanitation strategy, extensive socio-economic and technical survey have been conducted in three flood-prone areas characterized by normal rainwater flood, flash flood and tidal flood. Software input in the form of capacity building, community participation, motivation, integrated approach, affordability have been given priority in the proposed sanitation strategy. The technical solution to flooding and over-flowing of latrines has been given based on the concept of 'raised latrine' constructed above flood level in flood-prone and high water table areas. The technologies include 'Earth Stabilized Raised Pit Latrine', 'Step Latrine', 'Mount Latrine' and 'Sand Enveloped Pit Latrine'. However, these latrines are needed to be experimentally installed in representative study areas to assess stability, suitability, and acceptability in rural conditions.

I hope this document will provide some guidelines for safe disposal of excreta in flood-prone and high water table areas of Bangladesh.

M. Feroze Ahmed
Centre Director

PREFACE

The present research essentially focuses on two broad aspects of sanitation - strategies and technologies, with the aim of investigating a sustainable sanitation package for the high-water table and flood-prone areas of Bangladesh.

This report is based on the outcome of the socioeconomic and technical survey on sanitation that has been completed in three project areas in Dhaka, Patuakhali and Sylhet. The report also overviews various sanitation technologies and the existing sanitation facilities in Bangladesh. The problems of high water table and flooding were kept in mind while over-viewing the available technologies in order to adapt an appropriate sanitation technological option for such problem areas of Bangladesh.

Based on field data and outcome of local level workshops in the three different study areas in Dhaka, Patuakhali and Sylhet and the final workshop in Dhaka, comprehensive recommendations on sanitation strategies and technologies are made.

ACKNOWLEDGEMENT

The author is deeply indebted to Professor Md. Mujibur Rahman, Chairman, Research sub-committee, International Training Network (ITN) Centre for Water Supply and Waste Management, BUET, for his suggestions on this research, continuous monitoring, invaluable advice and constant encouragement in this work. The author is very grateful to Professor M. Feroze Ahmed, Project Director, ITN, Bangladesh for his support to carry out the research at ITN. Sincere thanks are also due to all the staff of ITN for their assistance.

Sincere gratitude and thanks are due to Professor Abul Hossain Bhuyan, North South University, for his contribution towards the social anthropological aspects of this work. Contribution of Mr. Firoze Zaman and Mr. Mohaddes Hossain in carrying out the field work is also gratefully acknowledged. Thanks are also due to all the colleagues who helped in completing this work.

The research was made possible by the financial support from the ITN that is also gratefully acknowledged.

Noor M. Kazi
Principal Investigator

ABBREVIATIONS AND ACRONYMS

BARC	Bangladesh Agricultural Research Council
BOD	Biochemical Oxygen Demand
BUET	Bangladesh University of Engineering and Technology
CBO	Community Based Organisation
DCC	Dhaka City Corporation
DALYs	Disability Adjusted Life Year
DANIDA	Danish International Development Agency
DPHE	Department of Public Health Engineering
DUIIP	Dhaka Urban Infrastructure Improvement Project
EIP	Environmental Improvement Project
FAO	Food and Agricultural Organisation
GOB	Government of Bangladesh
HGW	High Ground Water
ITN	International Training Network
LGED	Local Government Engineering Department
MOWR	Ministry of Water Resources
MPERD	Ministry of Planning, External Resources Division
MPO	Master Plan Organization
NEMAP	National Environmental Management Plan
NGO	Non-Government Organization
O&M	Operation and Maintenance
ROEC	Reed Odourless Earth Closet
SRDI	Soil Resources Development Institute
TSS	Total Suspended Solids
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
VIP	Ventilated Improved Pit
VSC	Village Sanitation Centre
WASA	Water Supply and Sewerage Authority
WB	World Bank
WEDC	Water, Engineering and Development Centre

EXECUTIVE SUMMARY

This study investigated sanitation strategies and technologies for high-water table and flood-prone areas of Bangladesh. Multiple data collection technique including a socioeconomic and technical survey at field level was used in the study. The field survey was conducted in three different areas namely, Dhaka, Patuakhali and Sylhet representing four different types of floods occur in Bangladesh every year such as normal river flood and rain water flood, tidal flood and flush flood respectively. The study also reviewed the available technological options of sanitation in Bangladesh. Low-cost sanitation technologies for similar condition in other countries were also reviewed and examined critically to find the suitable options for our conditions. Based on the analysis and the outcome of the socioeconomic and technical survey, recommendations are made on both sanitation strategies and technologies.

Sanitation Strategies

The following strategies are recommended to consider in planning a sanitation program particularly in high-water table and flood-prone areas of Bangladesh:

Improved Understanding: Improved understanding of sanitation is the pre-requisite of a successful sanitation program. People should have a clear understanding of the adverse impacts of improper sanitation and the benefit of improved sanitation. The understanding of health and sanitation of general people can be improved in several ways such as training at community level, local level workshops, video films and group discussions.

Technical knowledge: After having the knowledge on health and sanitation, people should know the ways and means to face the sanitation problems. They should know the technology of low cost sanitation options particularly for high-water table and flood-prone areas. The trained people can also advise the other local people to take sanitary latrine even in the situation of high-water table and flooded areas. This can be achieved by giving extensive training program and demonstration to the concerned local groups as well as the local people.

Cost of Sanitation Facilities: Cost of sanitation facilities is an important factor to be considered in planning a successful sanitation program. It should be affordable to the people. Providing sanitation facilities to the poor at free of charge and a tax concession to the well to do people is a good strategy to increase sanitation coverage.

Community Participation: Community-type built-up latrine may be considered for high-water table and flood-prone areas where individual household latrine is not affordable for the poor people as it incurs a higher cost. Community participation in each step is very essential for the success of such program.

Motivation: Motivation is required to improve unhygienic sanitation practices. Often social status, cleanliness for religion and privacy factors predominate over health and hygiene factors where people do not have adequate knowledge on health and sanitation. These issues can be applied strategically in motivating people to accept an improved option of sanitation. The acceptance of any improved sanitation option by the community is key factor for a successful sanitation program. Motivation is utmost important for the acceptability of an improved sanitation option. Social mobilization is required to motivate the general people.

Integrated Approach: An integrated approach combining water, sanitation and hygiene education is needed for achieving overall success in the improvement of general health, the quality of life and the environment.

Capacity Building: Sanitation facilities should be improved through formulating appropriate policies and undertaking program in this area. Capacity building of the local authority as well as the CBOs towards the sustainable development of overall sanitation program should be strengthened.

Promotion of Private Sectors: CBOs, NGOs and private sectors should be involved effectively in sanitation program and they should be promoted in the production and sale of sanitary latrines by providing soft loans or grants. Private sectors should be encouraged and supported to establish sanitation production centre at the critical problem areas (remote village, high-water table and flood-prone areas) for effective coverage.

Alternative Use of Excreta: Attempt should be taken to establish facilities of producing compost and bio-gas from human and animal excreta. This will provide improved cultivation, supplemented energy and reduce the load of pollution to the environment as well.

Sanitation Technologies

Technically correct solution to the problem of latrine flooding is to construct "Raised Latrine". Lining of the pit may be extended above the ground level to prevent the latrine from flooding. The raised pit latrine also increases the volume of the pit for accumulation of excreta. Where insufficient infiltration area can be obtained below ground level, the raised portion of the pit can be surrounded by a mound of soil for infiltration. There are many ways to raise the latrine depending on local conditions. Raised pit latrine can be used in combination with any other type of pit latrine (VIP, pour-flush, double pit). The following latrines are found suitable for the flood-prone areas.

Earth Stabilized Raised Pit Latrine: Earth stabilized raised pit latrine is suitable for the areas that are flooded during monsoon months. This type of latrine can be used

in areas experienced with any four types of flood viz., river flood, rainwater flood, flush flood and tidal flood that occur in Bangladesh every year. Pit volume is increased as it is raised which renders the extended life of the latrine. This latrine requires more space area to stabilize soil around the raised portion of the pit lining. In this type of latrine, any type of pit lining whether it is porous or non-porous can be used above the ground level for raising the pit.

Step Latrine: The principle of step latrine is same as of the earth stabilized raised pit latrine. Step latrine is suitable for flood-prone areas where limited space is available for latrine construction. Non-porous lining is used above ground level to prevent sullage leaking. Steps will be required to gain access to this latrine. Moreover, the lining above ground level must be strong and durable to support the infrastructure.

Mound Latrine: Mound latrine is one of the technological options for flood-prone areas where space is limited and watertight linings are not available. In this type of latrine, pit lining is also extended above ground level to prevent the latrine from flooding. The extended section of the pit is surrounded by a mound of soil.

The above three technological options of sanitation may also be used in high-water table areas if the groundwater collection point for drinking purpose is at a safe distance. If the source of drinking water is shallow groundwater and located near the pit or at the downstream of it, sand envelope as described below, surrounding the pit should be provided in order to avoid or reduce the contamination of groundwater.

Sand Enveloped Pit Latrine: The risks of contaminating groundwater can be minimized by placing a 500 mm thick envelope of sand around the pit and constructing an impermeable pit bottom. The impermeable bottom can be made from plastic sheet or puddle clay. The minimum horizontal distance of separation from drinking water sources should be 10 metre.

The sand envelope should be taken up to 0.3 metre above the top of the inlet pipe and suitably confined to exclude any surface drainage including rain water, directly entering the sand envelope. In mound type latrine, 1m high earth filling should be provided for at least 0.25 m beyond the sand envelope with the edge chamfered to lead away the rain or surface water. Sand envelope around the pit can be provided with any of three technological options as discussed above depending on the actual site conditions.

Survey results reveal that the average cost of latrine installation is in the range of Tk. 1220 - 1246. For an improved sanitation facility, people are willing to pay Tk. 530 on average. Therefore the suggested latrine options are financially feasible in the study areas.

1. INTRODUCTION

1.1 BACKGROUND

Floods are natural phenomena that occur every year in Bangladesh. Several recent studies reveal that the lacking of appropriate sanitation facilities in flood-prone areas particularly during flood period is the most contributing factor to health and severe environmental degradation. Effluent dispersion from latrines into the groundwater is a significant pollution problem in high-water table areas in the coastal belt of Bangladesh. Only the provision of physical sanitation facilities are not enough for the inhabitants of flood-prone and high-water table areas to protect themselves from diseases as well as the environment from further degradation. Specific strategies and appropriate technologies are required to cope with the sanitation problems in such areas of Bangladesh.

To analyse the existing situation and current practices of sanitation, this study was carried out during 1998-99 by the International Training Network (ITN) Center, Bangladesh University of Engineering and Technology (BUET) with the aim of investigating the strategies and appropriate technologies suitable for high-water table and flood-prone areas of Bangladesh. The study recommended low-cost and sustainable remedial options of sanitation to improve the situations.

1.2 OBJECTIVES

The general objectives of the research project were to develop sustainable sanitation strategies and adapt low-cost appropriate sanitation technologies suitable for use in high-water table and flood-prone areas of Bangladesh.

Specific objectives were as follows:

i) Collection of information and analysis of the existing situation of sanitation in high-water table and flood-prone areas of Bangladesh.
ii) Monitoring and analysis of the existing situation of sanitation of these areas before, during and after seasonal floods.
iii) Development of sanitation strategies and improvement policies for high-water table and flood-prone areas in terms of software input in sanitation programme related to health promotion, personal hygienic practices, community involvement, socioeconomic status, custom, culture and people's beliefs.

iv) Development of low-cost, appropriate technology for hardware input in sanitation programme with the aim of finding options suitable for use in high-water table areas as well as flood-prone areas in Bangladesh specially during seasonal floods.
v) Cost estimates of different appropriate options

1.3 SCOPE OF THE WORK

The research was carried out in three selected areas within the available time and financial resources covering two broad aspects - Strategy and Technology for sanitation in high-water table and flood-prone areas of Bangladesh.

Technological aspects of sanitation focused on the following issues:

- Characteristics and extent of floods in the project areas;
- Groundwater characteristics;
- Soil characteristics;
- Existing technological options for excreta disposal;
- Technology options for excreta disposal now in practice in high-water table areas;
- Technology options for excreta disposal now in practice in flood-prone areas;
- Environmental impacts and limitations of each of the technologies in practices;
- Development/identification of different options of appropriate technologies-mentioning comparative advantages; construction methods; operational principles; O & M; typical design diagram; costing etc.

Strategic aspects covered the following issues:

- Health and hygiene practices of the community;
- Level of people's knowledge on health and hygiene;
- Livelihood and income activities;
- Custom, culture and people's belief in sanitation practices;
- Coping strategies of sanitation problems with special reference to high-water table and frequent flooding;
- Capability and willingness of the community to pay for sanitation facilities;
- Health impact of sanitation on the community.

1.4 AREAS OF APPLICATION

The technological options developed in this research can be applied in facilitating low-cost sanitary latrines suitable for use during flood-period under hardware input in sanitation programme in high-water table and flood-prone areas in Bangladesh.

The strategies recommended in this work can be applied as software input in sanitation programme in high-water table and flood-prone areas in order to achieve sustainable remedial options to improve the situations. The strategies can be applied for the following purposes:

- to improve the existing situation of sanitation and health promotion for the target group which are the basic elements of primary healthcare;
- to break the cycle of bacterial contamination and prevent fecal pollution of the environment;
- to ensure safe disposal of human excreta and prevent transmission of diseases;
- to improve overall sanitation situation related to defecating habits, healtheducation, personal hygienic practices, community involvement, socioeconomic status, custom, culture and people's beliefs.

1.5 METHODOLOGY

A socioeconomic survey in the target areas was conducted in the project areas with the aim of developing sanitation strategies. Available technical options for sanitation in Bangladesh were reviewed and analysed critically with special reference to their suitability in high-water table and flood-prone areas. Effectiveness of the various existing sanitation options in such areas were observed and monitored before, during and after flood to address and assess the extent of problems. Low-cost appropriate sanitation technologies for similar conditions in other countries were also reviewed and examined critically keeping the suitability in high-water table and frequent flooding areas in mind. Based on this analysis, low-cost sanitation options suitable for the conditions mentioned above were adapted. The effectiveness and suitability of these potential technologies were examined and analysed with reference to various social and technical parameters. Based on the analysis and outcome of socioeconomic and technical investigation, recommendations were made on both technologies and strategies.

The study used multiple data collection technique to collect the primary as well as secondary information. Data for the study were collected in two different aspects - technical and socioeconomic. To collect these two aspects of data, several methods such as literature review, observation, interview, group discussions, case studies, local level workshops, interview of key informants and questionnaire survey were followed. Field level data collection covered pre, during and post-flood period. Data collected through various methods were then gathered for analysis. Survey data were coded and analysed with the help of SPSS / PC+ statistical package.

Selection of Project Areas

Based on the different types of floods occurred annually in Bangladesh viz., normal river flood, rain water flood, flash flood and tidal flood (2), three different project areas, as shown in Figure 1.1, are identified to represent the flood-prone areas of Bangladesh. The identified project areas are as follows:

(i) Dhaka: characterised by normal river flood and rainwater flood.
(ii) Patuakhali: characterised by tidal flood.
(iii) Sylhet: characterised by flash flood.

Data Collection

Field Survey: Technical and socioeconomic data were collected through a survey and a few case studies. The survey used a structured interview schedule in the form of a questionnaire. A total of 150 households, 50 for each study area were interviewed using an interview schedule containing structured and non-structured questions. Only those were involved in the samples who were living in high-water table and flood-prone areas. Purposive sampling technique was used to identify households in the project areas. More precisely, purposive sampling were used to identify the proper sample to conduct interview. Only those households were included in the survey who were already using various types of latrines having flooding and high-water table problems.

Purposive sampling size was determined on the basis of knowledge of problem areas, judgement and experience. The problem area and condition of project sites of the present investigation were clearly identified. All the latrines that were considered under this study were of similar conditions. Samples of similar situation (i.e., households with high-water table and flood affected latrines) were selected for interview which justified the sample size of 50 in each project area.

Observation: Observation was made to gain insight into the sanitation situation and identify problems and opportunities in this sector in high-water table and flood-prone areas with special reference to frequent flooding.

Group Discussions: Group discussion is one of the effective ways in exploring grass-root level information. This was conducted in different project areas in order to collect local level information of sanitation situation before, during and after flood.

Interview of key informants: Key informants from various social strata of the areas were interviewed with the aim of identifying the problems and opportunities. The potential groups of the key informants were as follows:

- Local Level Administrators;
- Concerned Departments, Institutions and Agencies;
- Representatives of the local communities.

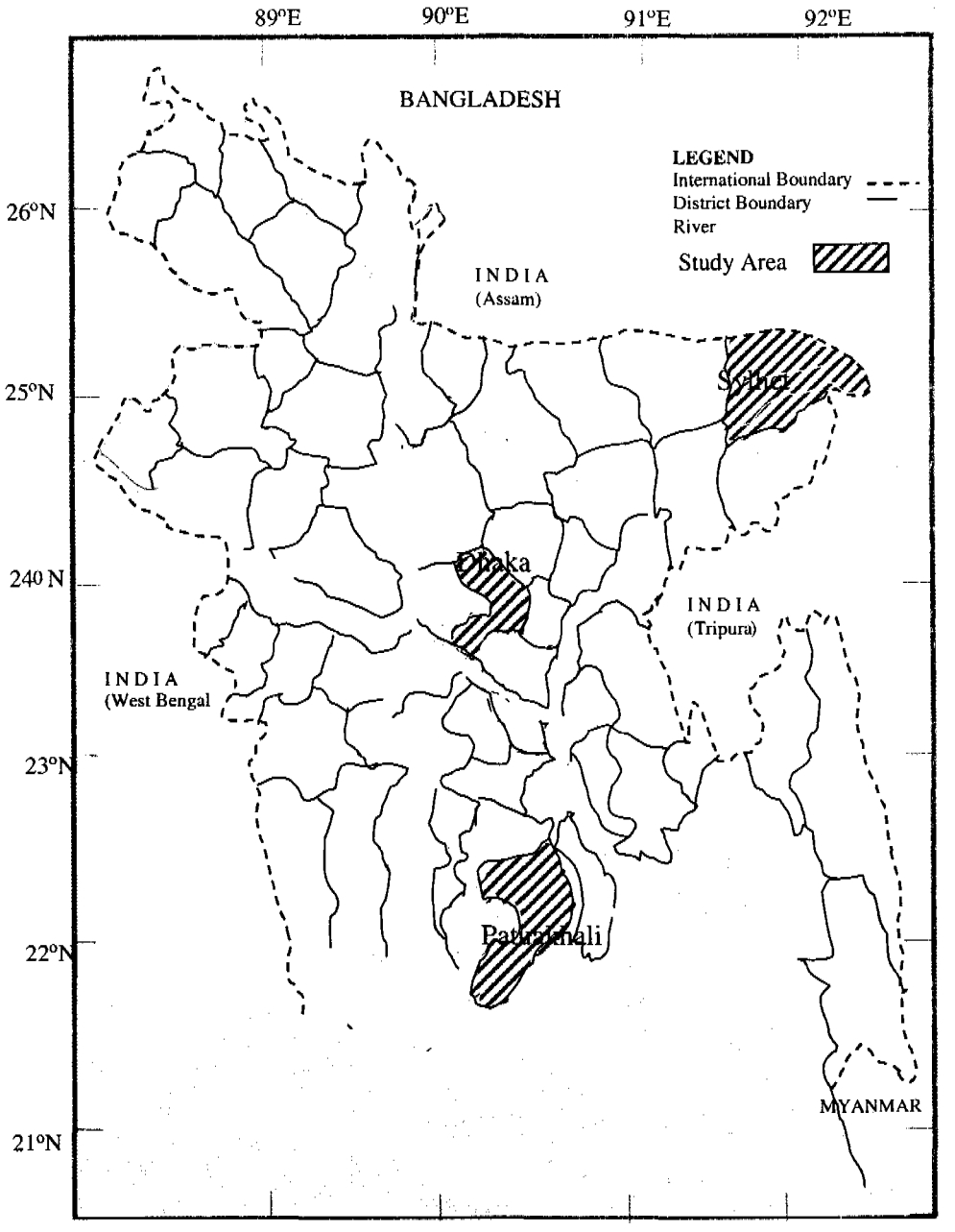

Figure 1.1 Location of the Study Areas

Local Level Participatory Workshops: Local level workshops at community level investigated the ways in which the inhabitants of high-water table and flood-prone areas deal with sanitation problems before, during and after flood period and to make suggestions to improve the situation. Before starting the discussion, information that were collected from the study areas were presented before the participants.

Data Analysis

The use of multiple methods is very useful in gathering information, but presenting these methods in a consolidated manner is a difficult task because of different measurement levels. Keeping this in mind the present study simplified the matter without loosing the essence of each set of data. Although two types of data, namely quantitative and qualitative were collected using several methods (survey, observation, group discussions, key informant interview, local level participatory consultations and field tests) but presented in a way that the findings reach to the readers as well as the policy makers supplementing each other.

Quantitative data was analysed into frequency distribution that was used to describe the general nature of the variables. This includes simple percent distribution, measures of central tendency and dispersion.

Data of in-depth interview case study and group discussion are analysed qualitatively to explain the explicit and implicit meanings of the problems. Suggested technical options are assessed before making recommendations.

Data Management

All filled-in interview schedule, in-depth interview reports and reports of group discussions were edited by the Principal Researcher immediately after collection. Survey data was coded and analysed with the help of SPSS / PC+ statistical package.

1.6 PROJECT AREAS

Patuakhali

Patuakhali town is located on the river Lohalia 110 km south-east of Khulna in the Barisal Division. The area of the Pourashava is 12.66 km with a 1995 population of 45,340 based on the 1991 census. The Pourashava is connected by pucca road with Barguna and Barisal and the river route is popular from Dhaka. The town and the surrounding areas have an agricultural based economy with a limited number of cottage type industries. A quarter of the population live in slums, a number of which are squatter settlements.

Various defecation options are used in Patuakhali such as septic tanks, public toilets, pit latrines, surface latrines and open space. The existing defecation options in Patuakhali town are shown in Table 1.1. It can be seen from the table that 52% of the population do not have the benefit of a `sanitary' toilet facility (LGED, 1997).

There are two sanitary problem areas in Patuakhali. Problem area 1 is characterised by the long-period flooding and covers most of the Patuakhali town areas. Problem area 2 is characterised by the short-period flooding. This area is adjacent to the river Patuakhali and Lohalia and covers a significant part of the town. These two areas have a very high ground water table and the toilets are often flooded. Ground water table lies at ground level during most of the rainy season and goes down as low as 3 m and occasionally even 5 m by mid February to March. Installation of sanitary latrine is a big problem here because of high water table. Moreover, the soil has a very high content of clay and a very low permeability and soaking is therefore another problem in Patuakhali.

During the visit to Patuakhali by the Principal Researcher and his team site inspections were made and a meeting was held with the staff of DPHE-DANIDA

Table 1.1. Existing Defecation Options in Patuakhali (1997)

Type	No. of Households	No. of Users	Coverage (%)	Remarks
SPL	2138	12831	28.0	Sanitary Facilities
TPL	212	1269	3.0	
ST	1262	7527	16.0	
PL	763	4579	10.0	Unsanitary Facilities
SL	1270	7617	17.0	
NF	1912	11472	25.0	
Total	7557	45340	100%	

SPL: Single Pit Latrine TPL: Twin Pit Latrine ST: Septic Tank
PL: Pit Latrine SL: Surface Latrine NF: No Facility
Source: Feasibility Report on Municipal Services Project, Patuakhali Pourashava,LGED.

Urban Water and Sanitation project working in Patuakhali. The site inspections were done at Katpatti and Sher-e-Bangla Road areas where the water table is high and latrines encountered with frequent flooding. Sher-e-Bangla Road area is

located on the southeastern part of the town. The level of this area is lower than other part and the whole area is vulnerable to inundation.

Private owners own the lands and the urban poor are living in this area. Katpatti area is located on the northwestern side of the town and very close to the river Patuakhali and Lohalia. This area is severely vulnerable to the tidal effect of these two rivers.

Following observations were noted during the site visit to these two areas:

- The areas have a very high ground water table and toilets are often flooded;
- The soils have a very high content of clay and very low permeability and therefore soaking is a problem;
- The river water back-flows through the khals and drains during high-tide in monsoon and a major part of the town area inundated which leads to filling of latrine pits and septic tanks and makes them out of order;
- Emptying of single pit latrines and dumping of night soil create a serious health hazards.
- Quick filling and flooding of latrine may be a de-motivational factor of latrine usage in the community.

In addition to the above points, the following observations were made during the visit:

- Latrines are not maintained properly;
- Most of the latrines are situated next to ponds, ditches, drains, khals or rivers and create very unhygienic condition through leaching;
- Drainage and khals are not working properly due to obstructions made by the local people either for business and settlement or fish cultivation. This leads to the water stagnant problem in the areas and contributes to rise in water table;
- People are not careful about health, hygiene and cleanliness;
- There are only a few sanitary latrines with superstructures that were also not done properly;
- Children do not use ring-slab latrines, most of them defecate either drain sides or here and there;
- In some places, women used the sanitary latrine installed near their home, and men use a public toilet because of insufficient sanitary latrines in the community;
- There is often a bad smell in relation to the private latrines.

These two areas in Patakhali were identified as potential sites for this investigation. Social and technical survey was conducted in these areas with the aim of investigating strategies and technologies for sanitation in flood-prone and high water table of Bangladesh. Patuakhali is also identified as an ideal site for implementing the proposed sanitation technologies considered under the framework of this research study.

Dhaka

The sanitation situation of Dhaka, the capital city of Bangladesh, is highly unsatisfactory. Dhaka accommodates a huge population of nearly 6 million with another 1 million daily commuters during the day-time in its Dhaka City Corporation (DCC) area of 360 sq.km. (6). About 18% of the city population are currently serviced by the existing sewerage system of Dhaka Water Supply and Sewerage Authority (WASA). Septic tank and pit-latrine cover 40% and 15% of the population respectively (4). The remaining people do not have any acceptable sanitation facilities for safe disposal of excreta. There are a very few public toilets in Dhaka that cover only nearly 2% of male adult and there is hardly any public toilet for females.

Some 30-40% of the DCC's population live in the slum and squatters in Dhaka. They do not have adequate and acceptable sanitation facilities. In some of these areas a single kutcha pit latrine is shared by even up-to 20-25 families (4). Pollution of water due to improper sanitation is very common and environmental related diseases are also widespread.

Rainfall flood and normal river flood to some extent occur in Dhaka every year particularly in low-lying areas, although Dhaka city is protected by the flood protection structures (3). Latrines in low-lying areas are inundated during monsoon.

Some flood-prone low-lying areas such as Rasulpur, Islambagh, Shahidnagar, Mugdapara and Badda were visited to identify potential site for this investigation. With funds from the World Bank, about 400 latrines were installed in Rasulpur area under the programme of Environmental Improvement Project (EIP) of the Dhaka City Corporation (9). Rasulpur and some parts of Badda are vulnerable to frequent flooding in relation to the sanitation problem during monsoon. These two areas were identified as the potential sites for this research project.

Sylhet

Sylhet Pourashava was considered as one of the study areas as it is experienced with the flash flood in order to the investigate the sanitation strategies and technologies for such flood-prone areas. Sylhet Pourashava and the ITN sub-centre at the Shahjalal Technological University in Sylhet was contacted and arranged a meeting to discuss the research topic and identify the specific sites for investigation. The study was carried out in the areas of Sadipur, Masimpur, Mehedibagh, Charerpar and Sagardighirpar.

2. TECHNOLOGICAL ASPECTS OF SANITATION IN BANGLADESH

2.1 OVERVIEW OF SANITATION TECHNOLOGIES

Various sanitation options are available, choice of which depends on local conditions. Several factors of biological and engineering in nature and also human behaviour are considered in selecting the most suitable and appropriate sanitation option for a particular locality of specific socioeconomic conditions.
Based on the location of excreta treatment, sanitation system is divided into two categories - on-site and off-site system. Excreta are treated at the site of the latrine in on-site system. Pit latrine, septic tank, aquaprivy are some of the examples of on-site sanitation option. The other category of sanitation option is off-site system, where excreta are treated at some other locations. Vault latrine, bucket latrine, conventional sewerage system are the examples of off-site system.

Based on the water use, sanitation system is divided into two categories - dry system and wet system. Wet system of sanitation is water dependent such as pour-flush latrine and conventional sewerage system. Dry system options are not water dependent such as pit latrine and compost latrine.

Different types of sanitation options are overviewed in this section. Each option has its own advantages and disadvantages and the most appropriate one may be selected considering technical, social and economic factors for a specific problem area. Classification of sanitation options is shown in Figure 2.1.

Hanging Latrine

A hanging latrine consists of a small fenced room or shed with a hole in the bottom through which feces fall on the ground or into the water. The latrine consists of a platform with a squat hole built over a body of water and a superstructure that provides privacy. This type of latrines is used where streams, canals, rivers and other water-bodies are used for excreta disposal. A typical hanging latrine used in Bangladesh is shown in Figure 2.2.

Major health problem results from the hanging latrine system. The water receiving the wastes becomes heavily polluted, and the persons who use the water downstream for washing, drinking or cooking are exposed to the pathogens in the water. This system is not recommended because it facilitates transmission of diseases, as in Bangladesh, a significant portion of the population usually use water from open water bodies in some form of their daily life.

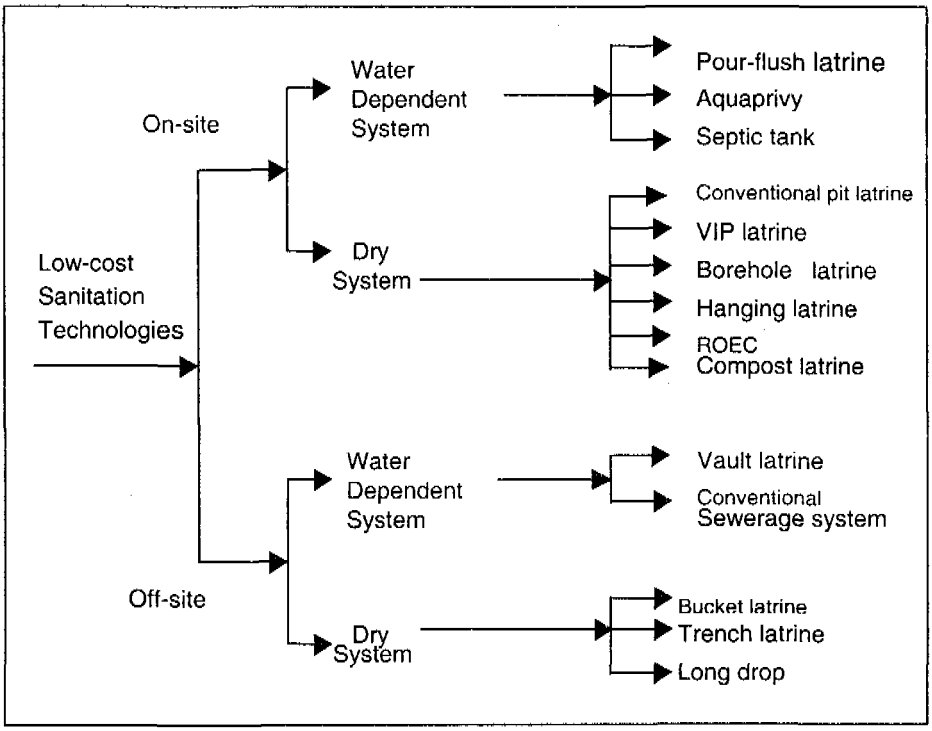

Figure 2.1 Classification of sanitation Technologies

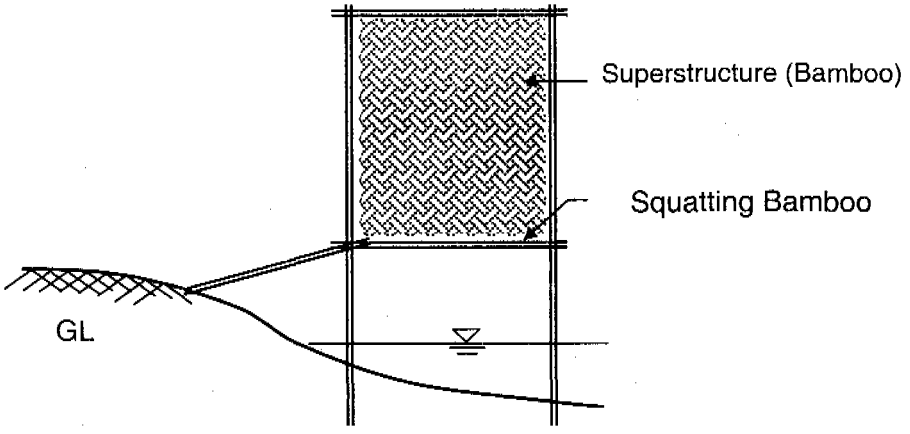

Figure 2.2 A typical Hanging Latrine

Trench Latrine or "Feuillees"

This is one of the temporary systems of human excreta disposal. In this type, very small and shallow pits are dug into the top layer of the ground. The excavated earth is piled loosely around the hole. Each user is expected to throw a scoop of loose earth over the feces deposited. The urine usually falls outside the pit and drains away. After 100-150 droppings, it is thoroughly covered with an equal volume of earth. Under tropical conditions, the decomposition of feces is completed in about 8 weeks, and the resulting humus may be dug out and utilised as fertilizer. A new hole is dug at a distance away from the pit and is used in the same manner. While the trench latrine is designed for temporary use only, sometimes they are used in the rural and semi-urban areas. A "Feuillee" is shown in Figure 2.3.

The trench latrines offer serious disadvantages and health hazards for the communities as a whole. The most hazards include:

- soil pollution as worms (especially the hookworms) have full access to surrounding grounds;
- enormous fly breeding;
- surface and groundwater pollution;
- easy access to and scattering of the excreta by rodents and insects;
- odour and nuisance and unaesthetic view.

On the positive side, they are easy and cheap to build. However, unless for temporary use, it is highly recommended not to use these type of latrines.

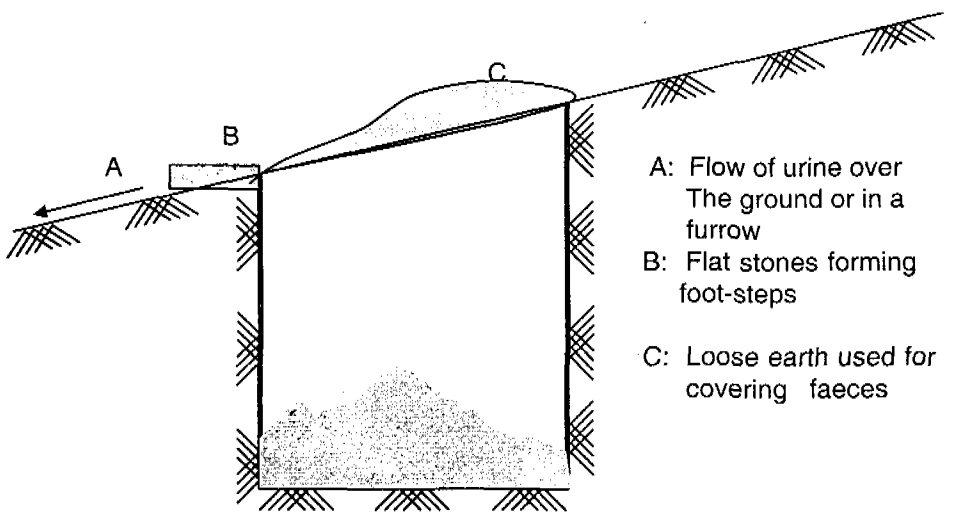

Figure 2.3 A Trench latrine or "Feuillee"

Borehole Latrine

This latrine is similar to a pit latrine, as shown in Figure 2.4, except that the hole is bored with an auger, resulting in depths up to 8 metres, and a diameter of about 0.4 metre (WB, 1986). This small volume causes a short latrine lifetime. To prevent the collapse or caving of the pit walls, sometimes linings are provided. In areas where the groundwater level is high, or which are subject to flooding, the latrine floor is elevated above the surrounding ground. This design is used in a WHO-aided project in Bangladesh (Islam and Kitawaki, 1996). However, ventilation is impossible because of the depth and diameter of the hole, and this generates odour and insect problems. Groundwater pollution is probable because borehole depths generally result in penetration of the water table. Because of these disadvantages, the borehole latrine is not recommended.

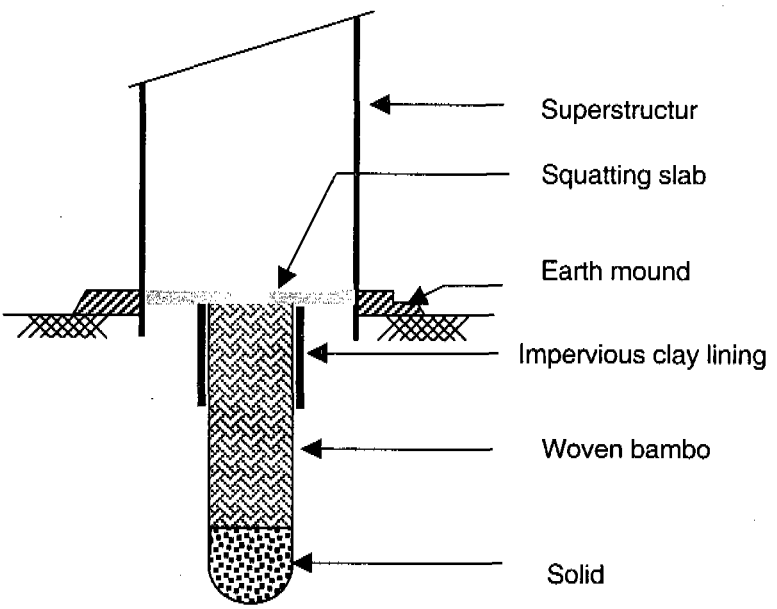

Figure 2.4 Bore-hole Latrine

Earth mound Bucket Latrine

This is one of the oldest and least hygienic systems of human excreta disposal. In this system, a squatting plate or seat is placed immediately above a bucket of normally 20 -30 litres capacity, into which the faeces fall and which is removed for emptying and cleaning at frequent intervals. A typical bucket latrine is shown in Figure 2.5.

The bucket is positioned adjacent to an outside wall and is accessible from the

street or lane. The bucket can be removed through a small door at the back of the latrine that usually faces onto a road or alleyway. The latrine may even be built into the house.

The design of latrine is usually poor. As a result, they are not easy to wash and keep clean, and have no provision for split liquid to drain away. Generally, the latrines smell very badly and are breeding sites for insects.

A collector calls regularly and empties the bucket. The act of emptying the bucket into the barrow or cart typically involves spillage and the area becomes heavily contaminated. The same occurs at the depot where the contents of the carts are emptied for transportation in trucks or for treatment, composting or agriculture.

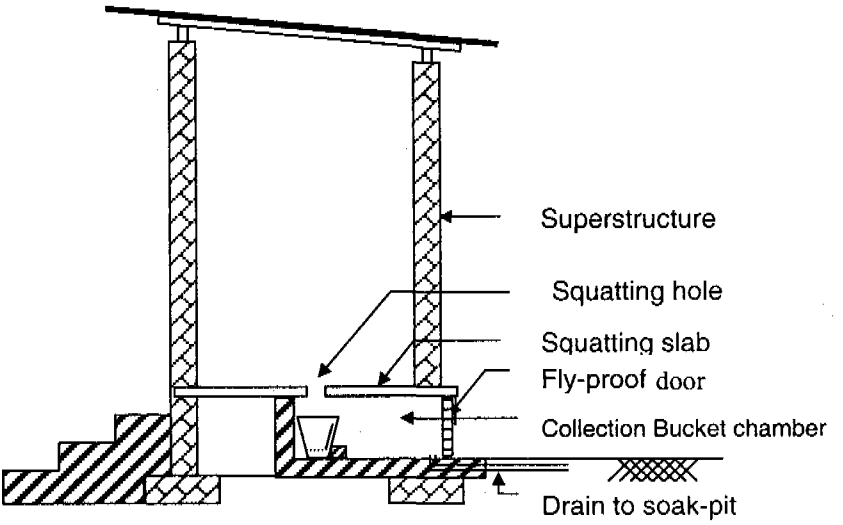

Figure 2.5 A typical Bucket Latrine

Ideally, bucket should be sealed with a lid and carried to the depot before being emptied, a new disinfected bucket being substituted. The practice of emptying the bucket and immediately replacing it should be rejected. At the depot, bucket should be washed thoroughly and painted with a disinfectant. It may be helpful to have a colour code so that all buckets collected on a specific day are red, for instance, and all replacement buckets on that day are yellow. This will help to distinguish the buckets that have been disinfected from those which have not.

A bucket system can only work well under situations of tight institutional control, where all operations are carefully supervised. It should be regarded as a temporary measure suitable for camps, for instance, while more permanent solutions are being constructed.

Excreta collected in this system may be disposed off by a number of methods. One

of the simple methods is to bury in earth trenches. Anaerobic digestion is another alternative. Disposal directly into the sewer is also used in many areas.
Due to the inherent health hazards the bucket latrine system is not recommended. They should be placed in the long-term by a more appropriate sanitation facility.

Pit Latrine

Conventional Pit Latrine: This type of latrine is simply a hole in the ground into which people defecate by some way. It consists of three components: a pit, a squatting facility with foundation and a superstructure. Excreta are deposited in the pit, and when this is filled, the superstructure and the squatting facility are removed and the pit is covered with soil or ash. A new pit is dug nearby. This type of latrine is traditionally used in rural areas in many developing countries of the world. The main disadvantages of this type of latrine are that they smell badly and they are often poorly built and dangerous to use. Other disadvantages of the pit latrines are the high frequency of superstructure collapse and the problem that children may refuse to use the latrine because they are afraid of falling into the pit. However, simple pit latrine can be improved by providing a prefabricated slab. From health and environmental points of view, this type of latrine is not generally recommended. However, the method is much better than open defecation that contributes severe health and environmental degradation. A conventional pit latrine used in Bangladesh is shown in Figure 2.6. This pit latrine can be improved in many ways to make it is more safe and hygienic.

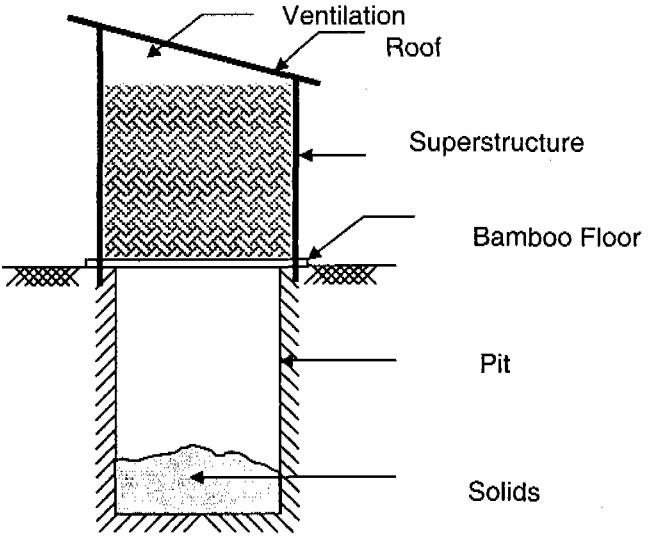

Figure 2.6 A conventional Pit Latrine

Improved Pit Latrine: The simplest improvement is to provide a prefabricated floor in the form of a squatting slab with foot-rest as shown in Figure 2.7. The floor slab may be made of reinforcement cement concrete. However, the steel reinforcement may be reduced or even avoided by making the 40 mm thick slab slightly domed or conical shape to make it cheaper (Cairncross & Feachem, 1977). Local materials such as bamboo and wood may also be used to improve the latrine.

The improved type of pit latrine has the following advantages:

- the latrine is structurally safe;
- prevention of transmission of hookworm when the floor is made of cement;
- easy to use particularly for children and elderly people;
- easy to clean;
- flies can be controlled through the use of a tight-fitting lid.

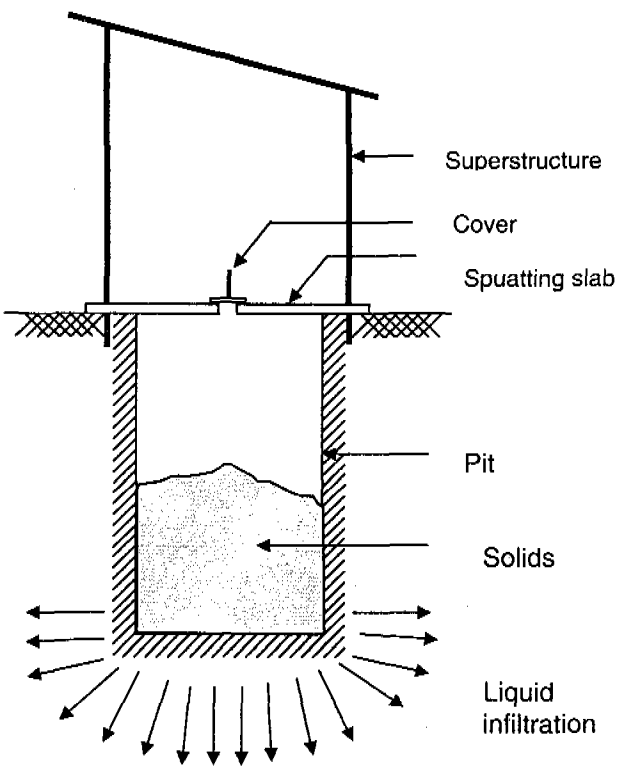

Figure 2.7 An Improved Pit Latrine

Strengthening of pit: A lining is built and a ring beam is installed around the upper part of the pit to make it stronger against collapse. It is particularly important in loose soils or where the pit is full of water. However, the lining cannot prevent the seepage of fluids into the ground.

Flies control: Flies are attracted by the bad smell of feces and they often lay their eggs in feces, and poorly built latrines can lead to an increase in population of flies carrying fecal pathogens. A cover with handle may be used to cover the hole of latrine.

Location of Pit Latrine: The ideal locations of a pit latrine are as follows:

- Pit latrine should be located close to house at an elevated place to avoid flooding and stagnant of rainwater;
- It should be on the firm ground so that the pit will not collapse;
- Pit should be located at least 10 m away from tube-well, deep-well, pond, ditches and other water bodies and
- It should be located at a convenient place where adequate quantity of air and light are available and the access is easy for the children and the elderly people.

On-site Treatment: The pit must be stop to use when it is full with a freeboard of 0.5 m and a new pit can be dug at a distance of 2 m minimum from the existing one. A cover of soil or ash is placed on the filled pit and left for 1.5 years. The feces will be converted to compost after this period.

Design Considerations:

Size of slab: (a) Square: 100cm. x 100 cm.
(b) Circular: 150 cm. diameter

Volume of pit: Volume of pit should be as large as possible. However, it should not exceeds 1.5 m. wide because of constructing a cover to span more than this is expensive (WB, 1986). Other factors to be considered are the sludge accumulation rate (r), number of people (p) and design period (n). Volume of pit can be calculated as follows:

$$V = r \times p \times n$$

A freeboard of 0.5 m. is to be provided with this volume. A further 50% should be added where bulky materials are used for anal cleaning. The volume may be reduced to 0.04 m^3/person/year. The pit volume should be at least 0.06 m^3/person/year.

Ventilated Improved Pit (VIP) Latrine: VIP latrine is one in which the bad smell and breeding of flies, mosquitoes and other disease-carrying insects are reduced significantly. VIP latrine has four basic components: the pit; the slab; the superstructure and the vent pipe. Two important features of VIP latrine are given below:

- it is designed to be safe for the users and is built to last for a long time, at least two years;
- it has a superstructure that is slightly offset from the pit and a tall, vertical vent pipe with a fly screen that is fitted outside of the latrine superstructure.

Research has shown that VIP latrines are just as hygienic as conventional sewerage system but they are much less expensive (World Bank, 1986).

The vent fitted with a fly screen does three functions - it controls odours, excludes flies and traps flies. Due to the action of wind passing over the top of the vent pipe, the air inside rises and escapes to the atmosphere, so creating a downdraught of air through the squatting plate. This circulation of air effectively removes the odours emanting from the fecal material in the pit.

The vent pipe also plays a significant role in controlling flies. Female flies are attracted by the odours from the vent pipe during searching a suitable place for eggs laying but are prevented from flying down the pit by the fly screen at its top. Some flies may enter the pit through the drop hole and lay their eggs. When new flies emerge they straight fly towards the light at the top of the vent pipe. Vent pipe is provided with a fly screen at its top, and the new flies will not be able to escape and they will eventually fall down and die in the pit. Various types of VIP latrines and their components are shown in Figure 2.8.

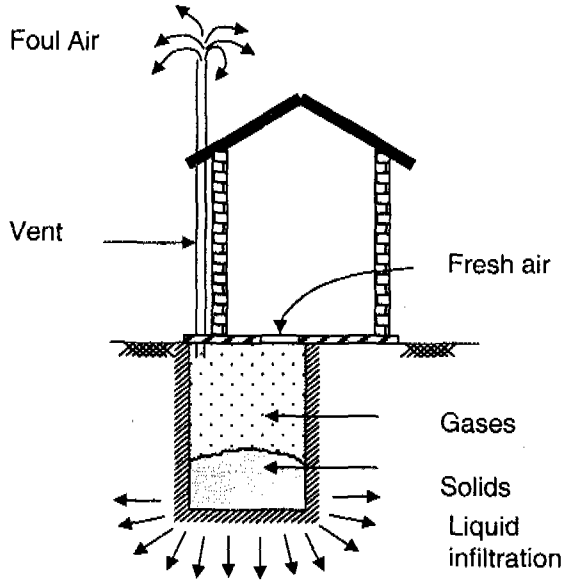

Figure 2.8 Ventilated Improved Pit Latrine

Advantages and Disadvantages:

Advantages: The main advantages of well-maintained VIP latrines are:

- low operational cost;
- easy construction and maintenance;
- all types of anal cleansing materials may be used;
- absence of odours and minimal fly and mosquito nuisance;
- minimal water requirements;
- low level of municipal involvement;
- minimul risk to health.

Disadvantages: The disadvantages that may limit the use of VIP latrine are:

- lack of space for relocating the pit in dense urban areas;
- potential for groundwater pollution;
- difficulty of construction in rock or boulder-laden subsoil;
- does not dispose of large quantities of sullage water.

The above mentioned disadvantages can be overcome through possible mitigating measure as follows:

- Twin pit latrines are the best solution for the space problem in urban areas;
- Pit latrine should not be built within 10 m. of a well or other drinking water sources and should not be located uphill from it;
- A built-up latrine is appropriate for areas of high water table.

Types of VIP latrine: There are three types of VIP latrines:

i) Single-pit VIP latrine: It is suitable for rural areas where the soil is deep and thepit size is unlimited;
ii) Double-pit VIP latrine: This latrine is more appropriate in urban areas and where people can afford to pay for a permanent latrine that does not require relocating every few years.
iii) Multiple-pit VIP latrine: This is suitable for communal institutions such as schools.

Operational principle: The solids in the feces are digested biologically and reduced to a fraction of their original volume. Odourous gases are produced and drawn out of the pit by the vent pipe. The liquid containing soluble materials infiltrates the surrounding soil.

Reed Odourless Earth Closet (ROEC)

A variation of the VIP latrine is the Reed Odourless Earth Closet. In the ROEC the excreta are deposited into the pit via a chute located at the base of the squat hole or

seat. The ROEC is fitted with a vent pipe to control odour and insect nuisance. This latrine is common in southern Africa. However, the major problem of the ROEC is that the chute is easily fouled with excreta, thereby providing a site for insect and odour nuisance. The chute has to be regularly cleaned with a long handled brush. Despite the disadvantages, there are several advantages of the ROEC. The pit is larger and thus has a longer life than the VIP. In addition, the pit can be easily emptied, so that the superstructure can be a permanent facility. Another advantage is that the pit is displaced, children have no fear of falling into it. Moreover, it is not possible to see the excreta in the pit, which encourage the use of the latrine. A ROEC is shown in Figure 2.9.

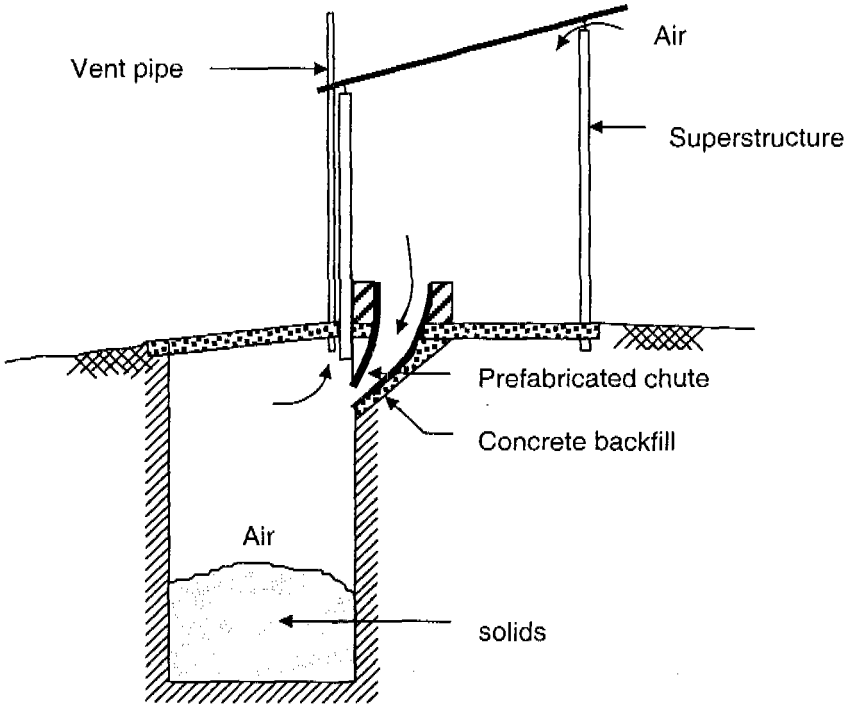

Figure 2.9 The Reed Odourless Earth Closet

Compost Latrine

mpost latrines are suitable when there is an urgent need for fertilizer or when there is high degree of environmental concern. The most common type of composting latrine is the batch or double vault components. The excreta in the sealed vaults are digested anaerobically for at least a year.

For efficient composting, the correct balance of nutrients must be present for the microbes that digest and degrade the material.

Advantages and Disadvantages

Advantages:

- very useful where there is a tradition of using human excreta on the land and need for a soil conditioner;
- no flushing water is required and suitable where people prefer bulk materials for anal cleansing;
- can be built on rock as the latrines need not penetrate the subsoil;
- low pollution risk.

Disadvantages:

- a correct balance of nutrients is required and thus substantial amounts of biodegradable organic matter must be locally available;
- much attention is required for operation and maintenance of the system;
- if the wastes are not stored for a long enough period of time, pathogenic organisms will persist in the compost, resulting in health risks for those handling it;
- a strong commitment of the community is required to use the composts produced from this type latrines.

Pour-flush Latrine

These latrines are much cheaper than conventional flush latrines. They have a water-seal beneath the squatting plate and therefore they are as hygienic as a conventional cistern-flush toilet.

Components: The basic components of a pour-flush latrine are: the superstructure; the squatting plate; and the receptacle. Various components and types of pour-flush latrines are shown in Figure 2.10. The receptacle takes any of the following form:

- a simple pit, called a leaching pit;
- a septic tank, leading to a soak-away;
- a septic tank, leading to a drainfield;
- a septic tank, leading to a borehole sewer.

Types: There are two general types of pour-flush latrine:

i) Single-pit Pour-flush Latrine: Where the water-seal trap is built into the underside of a concrete slab that is placed, in most cases, directly over a pit.
ii) Double-pit Pour-flush Latrine: Where the excreta are transported from the toilet component to a nearby leach pit by flushing water which is poured by hand into the toilet bowl.

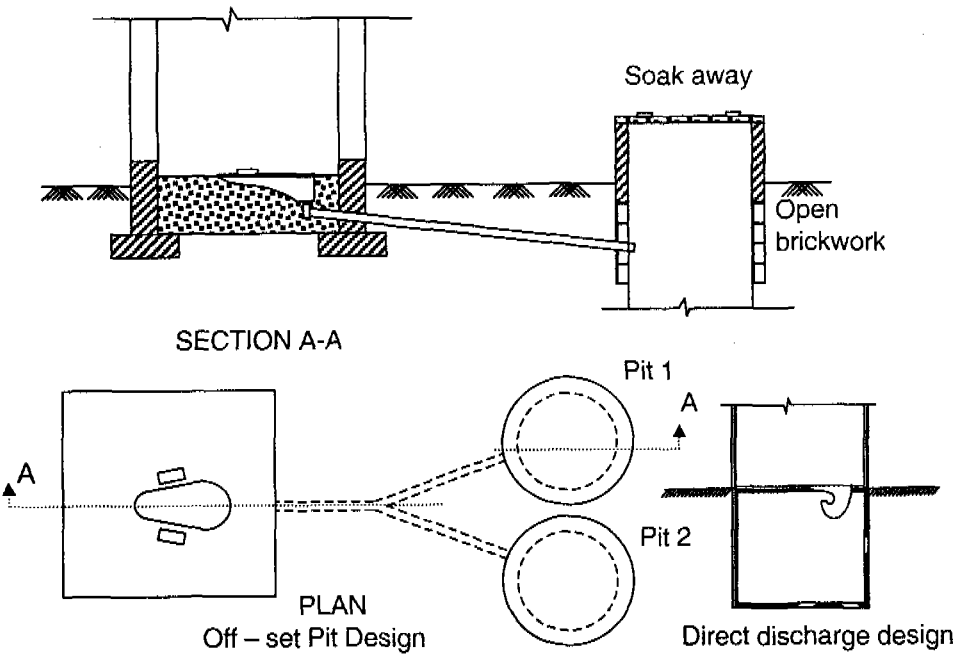

Figure 2.10 Various components of Pour-flush Latrine

Conditions: The conditions that must be satisfied to install a pour-flush latrine are:

- At least 6 litres of water per capita per day must be available for sanitation facilities;
- The soil characteristics must be suitable for leaching pit;
- There should not be any source of water for households purposes situated within 10 m radius of the location of the leaching pit;
- If the soil is more of a gravel or limestone type, the distance of the leaching pit just be even further than 10 m from the water source;
- Soils which do not allow percolation at rates ranging from 0.1 minute per inch to 120 minute per inch, pour-flush latrine incorporating seepage pits must be avoided where appropriate percolation rates do not pertain (Islam & Kitawaki, 1996).

Design Principles

Pit volume: $V = 1.33\ CPN$

where,
V = volume of the pit;
C = sludge accumulation rate, 0.04 m^3/person/year;
P = number of person using the latrine;
N = number of years the pit is to be used before emptying.

Dimension: Diameter = 0.6 m and Depth = Variable (2 m minimum)

Advantages and Disadvantages

Advantages:

- inexpensive;
- long-term, appropriate and hygienic option;
- required low volume of water for flushing;
- can be upgraded;
- eliminate odour, insect and fly breeding
- safe for the children and elderly people;
- easy construction and maintenance;
- low level municipal involvement;
- can be located inside the house.

Disadvantages

- require separate sullage disposal system;
- water must be available throughout the year;
- clogged easily where bulky anal cleansing materials are used;
- in areas with high groundwater, hard rock or impermeable soil, construction is more difficult and expensive.

Long Drop Latrine

This latrine system is used in multistoried buildings. It comprises a shaft incorporated into the walls of the building, and a water-tight excreta chamber at the base of the shaft. A vent is provided to dissipate odours. The contents of the chamber can be removed manually, but care should be exercised in light of the health risks associated with fresh excreta. Mechanical removal will help to reduce this risk. The removed waste should undergo treatment by either composting or waste stabilisation ponds. Figure 2.11 illustrates the long drop latrine. This type of latrine is popularly used in Yemen.

This is not a safe system and it is not recommended that this latrine technology be upgraded to a pour-flush or vault system.

Vault System

Among various off-site water dependent systems, vault toilet is widely used particularly, in Japan, Korea and China. The vault toilet system utilises a water-tight vault located either offset from or beneath a water seal device for storage of excreta over a period between 2 weeks to 1 month. These excreta later collected and

transported to treatment plant. Vault system latrine is shown in Figure 2.12

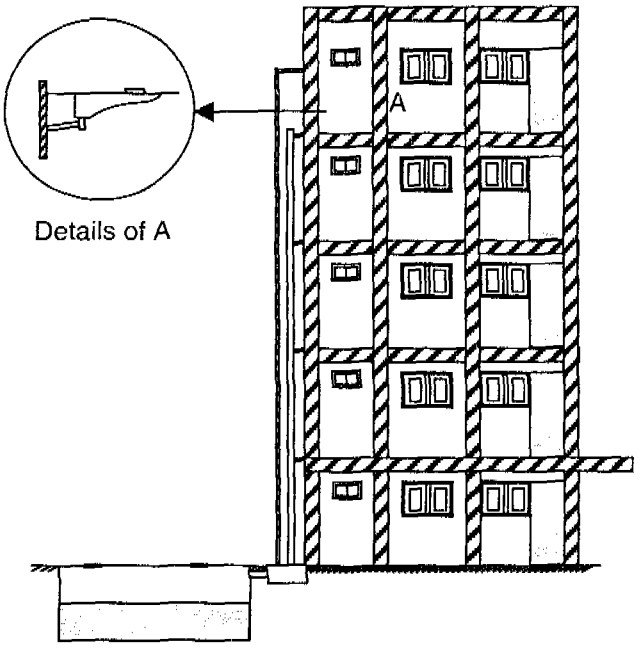

Figure 2.11 The Long Drop Latrine

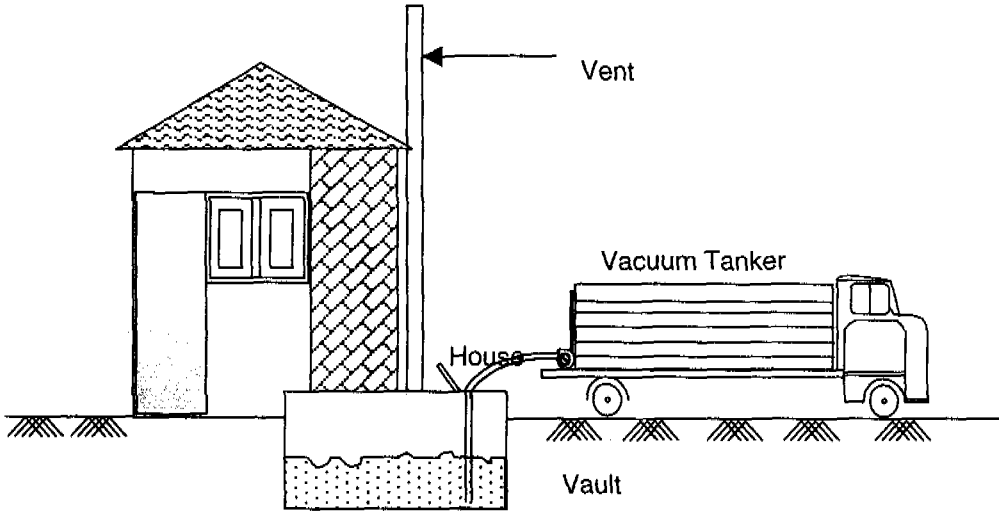

Figure 2.12 The Vault Latrine

Vault systems are suitable for use in densely populated urban areas where on-site sanitation system cannot be used, where water-borne sewerage is too difficult and expensive to install, and where institutional ability to organise and maintain a collection system exists. This system requires a very efficient collection, night-soil treatment and disposal system, organisational skill and regular maintenance.

Advantages and Disadvantages

Advantages

- vualts can be conveniently located in the house;
- use of night-soil in agriculture after treatment is possible;
- initial costs are less than other wet sanitation systems having tanks, such as septic tanks or aquaprivies;
- water requirements are minimised as the user is conscious of saving on vault charges;
- the high degree of planning flexibility is inherent in the vault system;
- hygienic to the users.

Disadvantages

- the high degree of organisation is required to run vault collection services efficiently and hygienically. Any breakdown of this service can lead to public health risk;
- there can be health risk to the collection workers unless mechanical equipment are used for collection;
- vault systems have high operating costs and so this system, although *cheaper than sewerage, is more expensive than other on-site* sanitation systems;
- the system is not designed to handle sullage.

Aquaprivy

Aquaprivies are essentially based on the principle of septic tank action whereby the excreta are decomposed anaerobically. It consists of a squat plate with a drop pipe of 100 mm diameter extending 100 to 150 mm into a water-tight tank to a point below the water level to form a water-seal. This water-seal has to be maintained to prevent odour, fly and mosquito nuisance in the toilet by adding sufficient water per toilet visit to the tank via the drop-pipe to replace any losses.

Feces and urine fall into the tank where they undergo anaerobic decomposition as in the septic tank. The solids are reduced in volume to about a quarter of the feces deposited (Aziz, 1972). The effluent is led off from the tank to undergo further treatment either in the seepage pit or the sub-soil absorption field. The solids remaining in the tank have to be removed periodically.

Absolutely water-tight tank is required to maintain the level of water in the tank, otherwise the water seal may break and which will cause odour, fly and mosquito nuisance in the toilet. A pour-flush latrine with an outlet to a soakway is a technology that overcomes the problems of maintaining the water-seal.

A washing sink may be incorporated with the aquaprivy. Sullage from the sink provides required quantity of water to maintain the water level in the tank. Water must be available in such case to use the sink. This type of aquaprivy is called "Self-topping" aquaprivy. Various types of aquaprivies are shown in Figure 2.13.

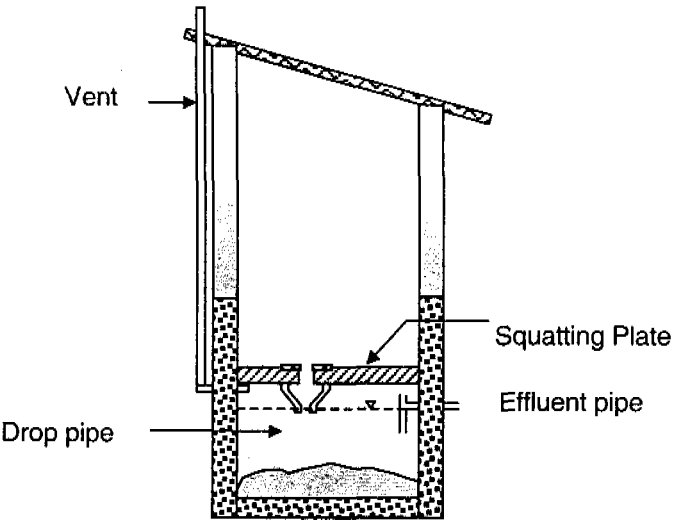

Figure 2.13 The Aquaprivy

Design Considerations

Volume of the tank: The volume of tank is usually calculated (WB,1986) on the basis of 1.5 litres of excreta per day per person plus an additional 4.5 litres per day per person for maintenance of the water seal. Thus, the aquaprivies effluent flow is about 6 litres per person per day. The accumulation rate of sludge in the septic tank is considered to be 0.03 to 0.04 m^3 per person per year, which should be removed when the tank is 2/3 full.

Soak-pit: A factor of safety is to be considered so that the design flow would be 8 litres per person per day. The side wall area of the soakway should be calculated assuming an infiltration rate of 10 m^2 per day.

Advantages and Disadvantages

Advantages: The main advantages of aquaprivies are :

- no clogging by bulky anal cleansing materials;
- possible location inside the house;
- low odour and insect problems;
- minimal risk to health;
- low annual cost;
- potential for upgrading;
- sullage disposal potential.

Disadvantages: The main disadvantages of the aquaprivies are:

- the water-seal is often broken;
- required skill construction;
- expensive as water-tight tank is required.

Septic Tanks

A septic tank is a water-tight tank which is designed to separate and digest the solid matter of human excreta. The liquid effluent flowing out of the tanks remains to be disposed of, normally by a soakage pit or drainfield, and the sludge accumulating in the tank must be periodically removed.

Septic tank receives both excreta and flush water from toilets. As shown in Figure 2.14, settleable solids settle to the tank bottom, accumulate and are then anaerobically digested and form gases and liquids. During this process, pathogenic organisms are completely destroyed; the solid is reduced in volume and changed in

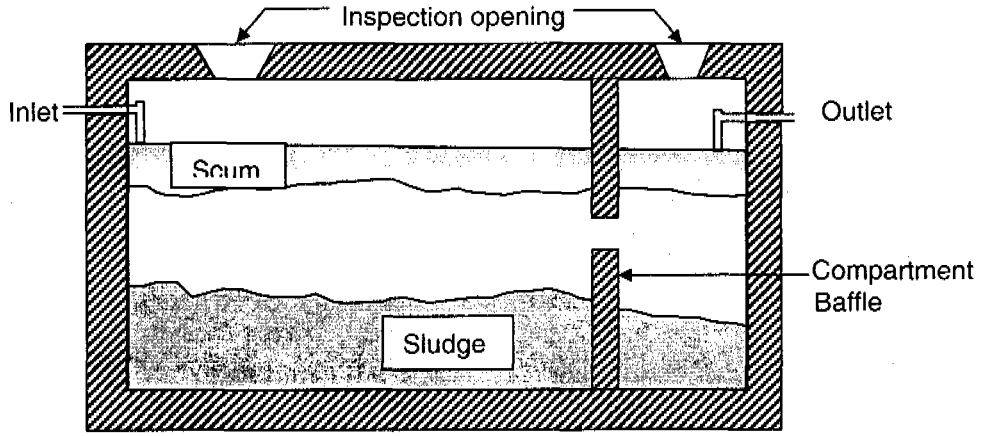

Figure 2.14 Various components of a Septic Tank

characteristics. When the supernatant liquid comes out of the tank, it is more or less free from disease producing organism. A scum of light-weight material rises to the top. The clarified liquid flows through an outlet structure just below the floating-scum layer and is normally treated through a soil absorption system.

The liquid is again allowed to pass through a soak pit where inverted filters are provided at the bottom for further decomposition of organic substances present in the supernatants liquid. Final treatment is done by the filter bed so that the effluent cannot pollute the groundwater sources.

The effectiveness of the treatment depends on the local climate, especially on temperature. BOD may be reduced by 30 - 50% and total suspended solids (TSS) by 50 - 70% (Islam & Kitawaki, 1996).

Advantages

- It is flexible and adaptable to a wide variety of individual household waste disposal requirements;
- It has no moving parts and therefore requires little mechanical maintenance;
- This system can be easily upgraded into small bore or conventional sewerage system.

Disadvantages

- Septic tanks are more expensive than other on-site waste treatment systems and are generally only found in wealthy areas;
- It requires a permeable sub-soil structure to disperse the effluent;
- Space for drainage fields is also required, and all drinking water withdraw point must be set away from the septic tank system;
- Septic tank systems also require piped water supply.

Design Considerations

A septic tank should be designed to remove almost all settleable solids and to decompose organic matter anaerobically. To accomplish this, the tank must provide the following components properly:

Volume: For effective sedimentation of the sewage solids, the liquid retention time should be at least 24 hours. Two-thirds of the tank volume is normally reserved for the storage of accumulated sludge and scum, so that the size of the tank should be based on three days retention time. This ensures that at least one day of retention still remains just before each desludging operation.
In Bangladesh, septic tanks are designed for per capita sewage production of 230 litres per day for residential purposes and 45 litres per day for commercial, industrial and other industrial purposes.

Shape: A rectangular shape for a single compartment tank is most favoured with a length two to three times its width, and a depth of 1 to 2 metres (WB, 1986). The rectangular tank is better than a square tank. However, cylindrical tank is also possible.

Inlet and Outlet: The inlet to a septic tank can be a sanitary Tee or an Elbow with diameter greater than 10 cm (WB, 1986). Its vertical leg should extend to about 20% of the liquid depth. The outlet of a septic tank can also be a Tee placed in such a way that the bottom of the horizontal leg is below the level of the inlet pipe. Its vertical leg must extend up to the top and bottom of the scum layer and to about 40% of the liquid depth.

Compartments: A two-compartment septic tank yields better performance than a single-compartment tank of equal capacity in reducing pollutants. Three-compartment septic tank may also be designed for high density area in which the first compartment reduces only the toilet wastes which after settlement passes to the second compartment for further settlement and then to the third compartment. The third component also receives all the households sullage.

Ventilation: Since the digestion process is anaerobic, requiring no oxygen, no direct ventilation is necessary. However, provision should be made to permit the escape of the gases produced in the tank, through a ventilation pipe.

Small Bore Sewerage

This is a low cost sanitation technology that has all the advantages of water-borne sewerage system. The system is suitable for densely populated urban areas. It is basically consists of a settling tank, generally called "Interceptor" connected with a sewer network from a small community and equipped with a lift pump at the outlet. Various components of small bore sewerage system shown in Figure 2.15.

The inceptor tanks remove solids from the wastewater by allowing it to remain still while the heavy solids sink to form a sludge layer and lighter ones rise and form a scum blanket, The solids are digested anaerobically in the sludge layer. This sludge has to be removed, usually once every five to ten years (WB, 1986).

This system is designed to handle only the liquid portion of domestic wastes. Most of the solids are settled out in the inceptor tank and it is not necessary to ensure a self-cleaning velocity in the sewers as in conventional sewerage system. The small-bore sewer can be much smaller in diameter and slope much less steeply than conventional sewers.

Advantages and Disadvantages

Advantages: The following are the main advantages of a small-bore sewerage system:

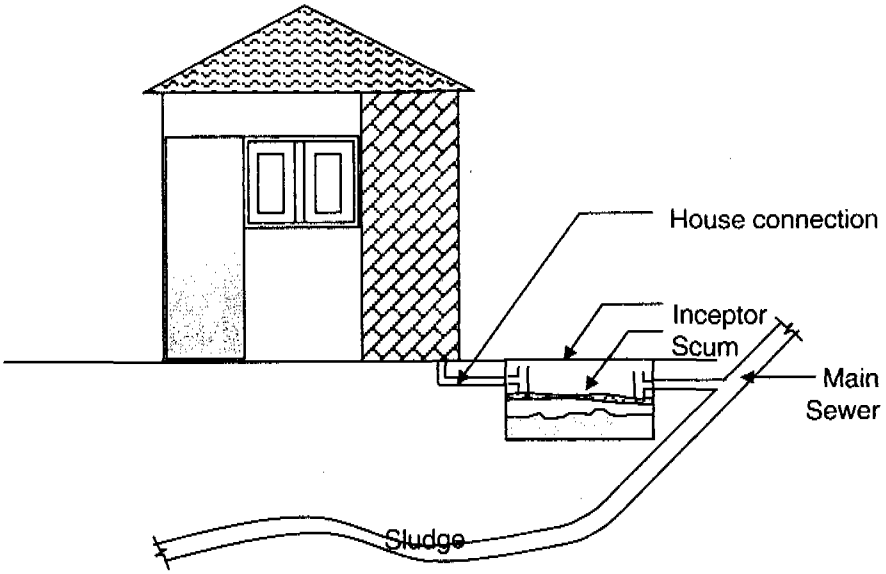

Figure 2.15 Small Bore Sewerage System

- Small bore sewerage systems are as convenient to use and have all the advantages of conventional sewerage system;
- The system does not require large quantity of water to operate it because the sewers carry only liquid portion;
- The sewer may be laid with curvilinear alignment and a variable or inflective slope as it does not contain any sewage solid that need an uniform gradient to maintain self-cleaning velocity. This reduces excavation costs, since the sewer can follow the natural topography more closely than conventional sewers;
- Fluctuation loads are lower than conventional sewerage system that reduce the size of sewers and the capacity of pump. In addition, the system does not require expensive manholes which can be replaced by less costly flushing points;
- The operation and maintenance of small bore sewerage system requires minimal skills and resources. Routine maintenance is limited to the removal of solids from each interceptor tank and flushing of the sewers every five years or so. Trained personnel with simple equipment can perform both of these activities;
- Screening, grit removal and primary sedimentation of sewage are not required at the treatment works because, these activities are already performed in the inceptor tanks;
- This system offers the opportunity to upgrade on-site sanitation at a

moderate cost at such time that on-site sullage disposal is no longer possible;

- Small bore sewerage system is cheaper than the conventional sewerage system. However, it is still expensive than other on-site sanitation system. This system is suitable where existing sanitation system are unable to handle volumes of sullage produced in a community.

Disadvantages: The principal disadvantages of the small bore sewerage system is the need of periodic evacuation and disposal of solids from each interceptor tank in the system. Special precautions should be taken to prevent illegal connections to the system, since it is likely that interceptor tanks would not be installed in such connections, thereby introducing solids into a system which do not designed to handle solids. This could create serious operational problems.

Conventional Sewerage System

This is the most expensive option of sanitation that needs sophisticated technical design and regular operation and maintenance. Conventional sewerage is practical and applicable to downtown, commercial, residential and industrial areas that can afford them.

The most common treatment flow starts with primary treatment to remove big particles like sedimentation tank and grit chamber followed by main or secondary treatment which includes pond system, trickling filter, activated sludge, oxidation ditch, etc. Sometimes these can be followed by tertiary or advanced treatment like filter, activated sludge, oxidation ditch, etc. Finally, the effluent must be disinfected by chlorination or ozonation.

The sewage treatment processes used in the industrial countries have frequently not been successful in developing countries. This is mainly due to the difficulty of maintaining the energy-intensive, complex machinery in working order. Sewage treatment process in developing countries should be effective, low-cost and simple to construct and operate. The most appropriate treatment process in the developing countries is probably the waste stabilisation pond system.

2.2 COMPARISON OF DIFFERENT SANITATION SYSTEM

Comparison of different sanitation technologies is illustrated in Table 2.1. The table also indicates the applicability of different options in rural and urban areas. The cost of construction and operation and the required soil conditions for each type of technology are also highlighted in the table.

2.3 SANITATION OPTIONS IN BANGLADESH

This section describes different sanitation options currently being practiced in Bangladesh. Different types of sanitary facilities or sanitation practices are available in Bangladesh. These are discussed below:

Indiscriminate Defecation

The sanitation coverage in the rural areas, where 80% of the population live, is only 40% while 43% of urban households have the sanitary facilities across Bangladesh. *A vast multitude of rural and urban poor practice indiscriminate defecation.* They do not have essentially any latrine which means that people defecate at different places, in open fields or ditches without fencing or a hole or container to store or isolate the faeces.

Hanging Latrine

A Hanging latrine consists of a small fenced room or shed with a hole in the bottom through which faeces fall on the ground or into the water. The latrine consists of a platform with a squat hole built over a body of water, and a superstructure which provides privacy. This type of latrines is used where streams, canals, rivers and other water bodies are used for excreta disposal. Major health problem result from the hanging latrine system. The water receiving the wastes becomes heavily polluted, and the person who use the water downstream for washing, drinking or cooking are exposed to the pathogens in the water.

This system is not recommended because it facilitates transmission of diseases, as in Bangladesh, a significant portion of the population usually use water from open water bodies in some form of their daily life.

Conventional Pit Latrine

One of the commonly used options for rural sanitation in Bangladesh is the conventional pit latrine. It consists of a lined pit covered with a slab that contains a hole through which the feces enter into the pit. The solid waste will remain within the pit, the liquid waste will percolate into the sub-soil via the permeable walls of the pit. The slab is housed within a superstructure. This latrine is suitable for rural areas where population density is low. Rural people install this type of latrine because of many reasons such as low construction and operating cost, ease of construction and no water required for operation.

Table 2.1 Comparison of different sanitation systems

Sanitation System	Location of excreta treatment		Water requirement		Area of Application		Costs		Ease of construction	Required soil condition
	On-site	Off-site	Dry System	Wet System	Rural	Urban	Construction	Operation		
Hanging Latrine	√		√		Not recommended	Not recommended	Low	Low	Very easy	None
Bucket Latrine		√	√		Not suitable	Suitable under tight institutional control	Medium	Medium	Requires builders	None
Conventional Pit Latrine	√		√		suitable	Not in high-density areas	Low	Low	Very easy except in wet and rocky ground	Stable, permeable soil, water table>1 metre deep
VIP Latrine	√		√		Suitable	Not in high-density areas	Low	Low	Very easy except in wet and rocky ground	Stable, permeable soil, water table>1 metre deep
Borehole Latrine	√		√		Suitable	Suitable for temporary use	Low	Low	Very easy	Permeable soil
Trench Latrine	√		√		Suitable for temporary use	Not Suitable	Low	Low	Very easy	Stable permeable soil, water table depth> 1 metre
ROEC Latrine	√		√		Suitable	Not in high-density areas	Low	Low	Requires technicians	Stable permeable soil, water table depth> 1 metre
Compost Latrine	√		√		Suitable if appropri-atly managed	Not in high-density areas	Low to medium	Low	Requires builders	Stable soil

Table 2.1 Comparison of different sanitation systems (Contd)

Sanitation System	Location of excreta treatment		Water requirement		Area of Application		Costs		Ease of construction	Required soil condition
	On-site	Off-site	Dry System	Wet system	Rural	Urban	Construction	Operation		
Pour-flush Latrine	√			√	suitable	Not in high- density areas	Low to medium	Low	Requires builders	permeable soil, water table>1 metre
Vault Latrine		√		√	Not suitable	Suitable where mechanised poeration available	Medium	Very High	Requires builders	None
Long drop Latrine		√		√	Not suitable	Suitable, strong maintenance required	Medium	Medium	Requires builders	None
Aquaprivy	√			√	Suitable	Suitable in low-density areas	High	High	Requires builders	permeable soil, water tabledepth> 1 metre
Septic Tank	√			√	Suitable	Suitable in low-density areas	High	High	Requires builders	Permeable soil
Small Bore Sewerage	√			√	Not Suitable	Suitable in medium to high density areas	Medium to High	Medium to High	Requires Engineers	Stable soil, no rock
Convention -al Sewerage		√		√	Not Suitable	Suitable where affordable	Very High	Very High	Requires Engineers	Stable soil, no rock

Bucket Latrine

Urban sanitation is still characterised by a large percentage of bucket latrine or service latrines. Investigation showed that district and municipal towns are covered significantly by bucket latrine. The municipalities however discontinued serving these latrines. Individual households employ private sweepers who do not dispose of the excreta properly and dumping indiscriminately in open fields, ditches, drains or other water bodies is common.

Pour-flush Latrine

Pour-flush latrine is identical to a pit latrine but contain a pan with a water seal through which feces reaches the pit. For rural sanitation, DPHE has developed a low-cost pour-flush latrine that was being sold at subsidised prices to the population. These are manufactured in the Village Sanitation Centre (VSC). The VS programme has been highly successful in increasing the number of water seal latrines from 36,000 in 1980/81 to 89,000 in 1984/85 (MPERD, 1991). There are over 1,000 public VSC in Bangladesh are now supplying sanitary latrines to the rural areas as an integral part of water supply.

Pour-flush latrine is gradually becoming popular in urban areas as well. For densely populated areas, a twin-pit off-set latrine has been developed. This latrine has a permanent structure with a squatting slat and a water seal pan from which the night soil is piped to two pits alternatively by a dividing box.

DPHE manufacture the ring and slab of pour-flush latrine for rural areas. The cost of materials for five ring and one slab is Tk. 515/. A subsidy of Tk. 110/ was given until June, 1998. Since July 1998, the full cost of materials are being recovered. Recently, DPHE has changed the strategy for sustainable sanitation programme. The full recovery of the cost of materials ensures the people's participation and ownership of the latrine which are very essential for a sustainable sanitation programme (DPHE, 1998).

Septic Tank

Wealthy people mainly in urban areas use septic tanks. This option is suitable for low-density area and the cost of construction and operation is high. Only high and medium income households usually go for this form of excreta disposal. In district towns coverage by septic tanks was approximately 19% (1986 estimate). The coverage in municipal towns was lower at 5% and Thana is at 10%. 1993-94 study shows that the coverage by septic tank is 49.4% and 4.2% in urban and rural areas respectively.

Small Bore Sewerage System

This system is not very common sanitation option in Bangladesh although the system has several advantages and cheaper in comparison to the conventional sewerage system. Dhaka Water Supply and Sewerage Authority (DWASA) has recently completed such a project in Mirpur area in Dhaka for a small community under Dhaka Urban Infrastructure Improvement Project (DUIIP) funded by the ADB (DWASA, 1998). An initiative has been taken by the Local Government Engineering Department (LGED) to improve the existing septic tanks connected with drains at Khalishpur, a densely populated area of Khulna by constructing small bore sewerage system (LGED, 1998). This sanitation option is becoming more popular in Bangladesh particularly, in densely populated areas where septic tanks exist.

Conventional Sewerage System

Dhaka is the only urban area in the country having water-borne sewage disposal system. The sanitation facilities of Dhaka city that are connected with the sewerage system covers only 35% of the population. Sewage is collected from these areas through a sewer network and lift pumping stations and transported to the sewage treatment plant at Pagla. After treatment of raw sewage, the treated effluent is discharged into the river Buriganga.

Government has undertaken the programmes to increase the coverage of sanitation facilities connected with sewerage system from existing 35 to 40 per cent of the population of Dhaka city by the end of the Five Fifth Year Plan period i. e. at the end of 2002 (MOP, 1998).

Chittagong city will also be provided with the conventional sewerage system by the terminal year of the Fifth Five Year Plan.
Table 2.2 shows the various sanitation facilities being practiced in Bangladesh.

Table 2.2 Sanitation facilities in Bangladesh

Sanitation facilities/options	Coverage (% Households)		
	Urban	Rural	Total
Septic tank/Modern toilet	49.4	4.2	9.3
Water seal latrine	22.8	14.8	15.7
Pit latrine	8.4	16.6	15.7
Open latrine	9.1	20.7	19.3
Hanging latrine	4.9	10.0	9.4
No facility/bush	4.8	33.4	30.2
Other	0.6	0.4	0.4
Total	100	100	100

Source: Demographic and Health Survey 1993-94, Mitra and Associates (NIPORT, MOH & FW).

2.4 SOIL CHARACTERISTICS

Nationwide top soil information is available at the Soil Research and Development Institute (SRDI) which was prepared under a project of BARC/FAO/SRDI during 1983-84. A total of 20 topsoil condition classes were defined through the soil survey. UNICEF, in collaboration with DPHE, has recently completed a study on soil and hydrological conditions of Bangladesh to use in the promotion of low-cost sanitary pit latrine technology in the country. In this study, the above 20 top soil condition classes
were categorised into six broaden classes based on the dominant topsoil class. These six classes were further grouped into three major categories based on its stability for latrine construction. The study also suggested the lining requirement for pit latrines depending on the soil sub-classification as shown in Table 2.3.

Table 2.3 Soil Class Vs. Lining Requirements

Class Code	Soil Classification	Lining Requirement
1	Stable Soil	Not required
2	Semi-stable soil	May be required
3	Not stable Soil	Essential

Source: DPHE-UNICEF study on "Computer based data maps on Soil and Hydrological conditions of Bangladesh".

It was found that both the stable and unstable types of soils are available in Patuakhali and lining is essential for pit latrine in unstable soil. Patuakhali has level clay landscape crisscrossed by numerous intersecting tidal rivers and creaks. The landscape of this area is formed under the influence of tidal flooding. The land is flooded at high tide twice daily by brakish water near the sea and by sweet water in the inland. The soil in Patuakhali town has a very high content of clay and very low permeability. Soils of Sylhet are also characterised by both the stable and unstable in nature and pit lining is also reqiured for latrine construction in unstable soil in Sylhet. In comparison to Patuakhali and Sylhet, the soil of Dhaka is of better quality in terms of the stability.

2.5 FLOOD CHARACTERISTICS

Floods are natural phenomena that occur annually in Bangladesh and the normal seasonal flood inundates one third of the country's land. Bangladesh experiences mainly four types of floods (MOWR, 1995). Flood types are discussed below in context to the study areas of this study:

Flash Flood

This type of floods are characterised by sharp rise and full in water levels causing high flows from nearby hills or mountains. They occur suddenly and are of relatively short duration. The flash flood overtops river banks and water readily enters the floodplain. Sylhet is frequently characterised by flash flood. These floods do not occur every year and are very unpredictable.

Tidal Flood

This type of flood occurs in the coastal belt of Bangladesh, often with storm surges generated by tropical cyclones. The land is flooded at high-tide twice daily by saline water near the sea and by sweet water in the inland. Patuakhali is mainly characterised by the tidal flood.

Rainwater Flood

This type of flood occurs due to high intensity rainfall over Bangladesh. Due to inadequate drainage capacity, such rainstorm of 3 to 10 days duration sometime cause localised floods inundating latrines which is one of the reasons of environmental degradation. Duration of such floods depends on the water levels in the main rivers.

Monsoon Flood

Monsoon season floods are large and normally last from July to October. This is the normal river flood arising from over spilling of rivers especially the major rivers which usually rise slowly. Major floods occur when the peak-flow of the Ganges coincides with that of the Brahmaputra. The monsoon season floods are a combination of river inflow, seasonal rainfall and backwater effect from the rivers.

Dhaka is characterised by both the rainwater and monsoon floods which inundate a vast area. Appropriate technologies and strategies should be undertaken for latrines in such areas of Dhaka.

Master Plan Organisation (MPO) of Bangladesh Water Development Board (BWDB) has defined six basic inundation/land types in Bangladesh, where each type represents a specific range of inundation or flood depth during peak rainfall period of the wet season. In the Agro-ecological Zone (AEZ) map database, a total of 11 flood depth categories were prepared, which are basically the combination of above basic six types. The original 11 categories were recorded by the DPHE-UNICEF study in 1996 based on the dominating flooding depth category to prepare a generalised flood depth map. Table 2.6 shows this category along with AEZ landscapes. The newly categorised flood depth information is presented in Figure 2.16, in the flood depth map.

2.6 HYDROLOGICAL CHARACTERISTICS

The water table in Bangladesh is generally high, because of the soil and topography, over most of the country. The highest level varies less than one metre below the surface in the delta areas in the rainy season to fifteen metres or more in the Barindin dry season. Over the greater part of the country, however, the water table is between one and three metres during the rainy season. The natural fluctuation of the water-table varies from one and a half to over seven metres.

Table 2.6 Agro-ecological Zone Land types and DPHE-UNICEF New Categorisation

Code	New Class	Land type in AEZ Database	Description AEZ's Land type
1	Flood Free	Flood Free	Land which is above normal inundation level
2	0-30 cm flood	Medium highland-1 and its bottom land	Land which is inundated less than 30 cm deep and remains in a wetland state
3	30-90 cm flood	Medium highland-2 and its bottom land	Land which is inundated in the range 30-90 cm deep and remains in a wetland state
4	90-180 cm flood	Medium lowland and its bottom land	Land which is inundated in the range 90-180 cm deep and remains in a wetland state
5	180-300 cm flood	Lowland and its bottom land	Land which is inundated in the range 180-300 cm deep and remains in a wetland state
6	>300 cm flood	very lowland and its bottom land	Land which is inundated more than 300 cm deep and remains in a wetland state
7	Permanent Water Bodies	Major rivers/water bodies	

Source: DPHE-UNICEF study on "Computer based data maps on soil and hydrological conditions of Bangladesh.

DPHE-UNICEF carried out a study on high ground water table in Bangladesh with the aim of producing a minimum, i.e. HGW depths map, as because the minimum ground water depth affects the pit latrine. It has been observed that the minimum

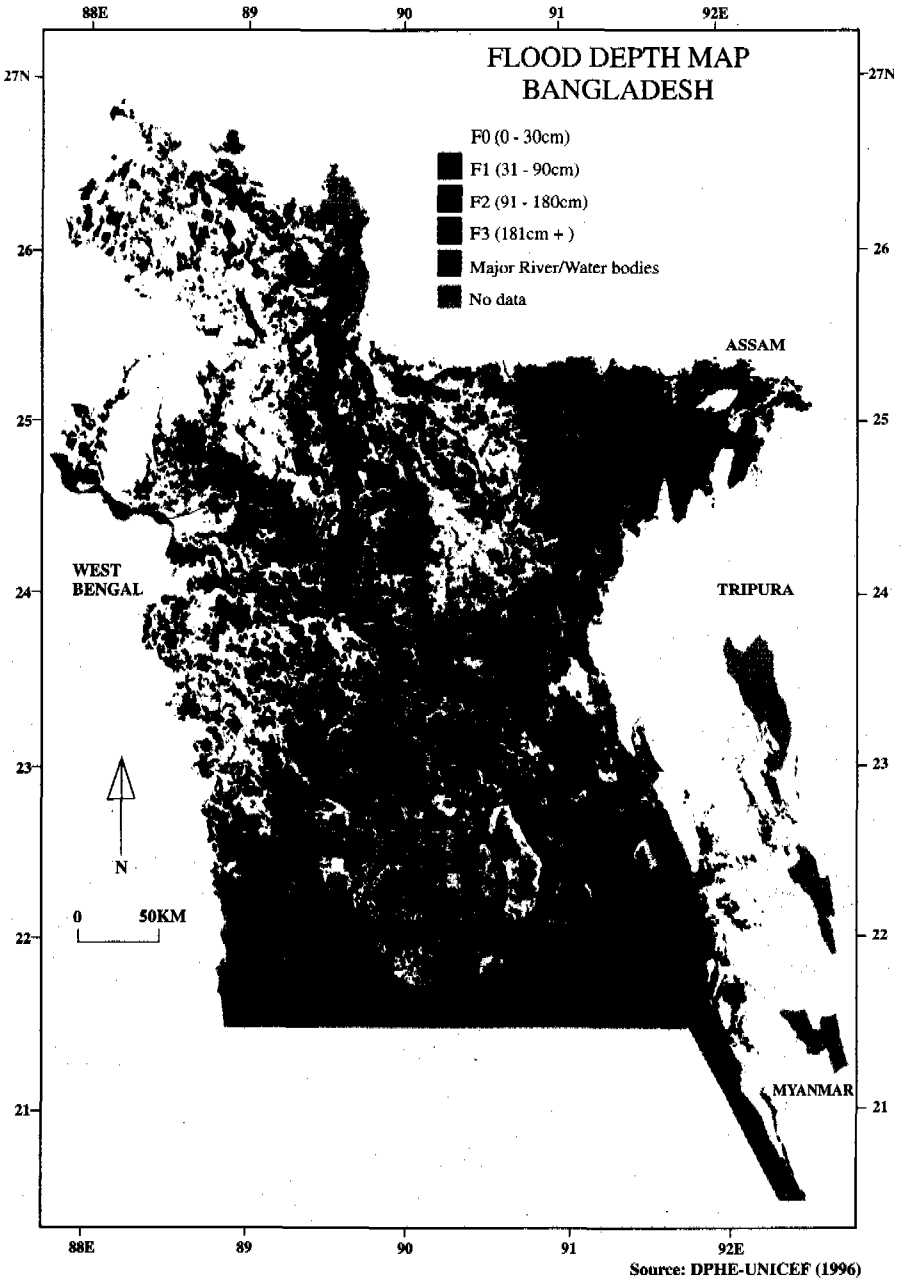

Figure 2.16 Flood Depth Map of Bangladesh

ground water depth occurs during the months of July through October for each year. The representative minimum depth found by the study is lying within the range close to 1-month period data. The study also found that the minimum depth data are varying within a narrow range for the period of July through October of each year and therefore a representative minimum of ground water table data was used to produce the high ground water table map. High ground water table map of Bangladesh is shown in Figure 2.17.

Ground water table depths are classified into three categories:

Category 1: Depth 0 to 1.5 metres
Category 2: Depth 1.5 to 2.0 metres
Category 3: Depth more than 2.0 metres

The ground water in Patuakhali is very high which falls under category 1. Ground water and soil condition need special technological options to design latrines for Patuakhali. All the three categories of ground water table are found in Dhaka and Sylhet. Appropriate sanitation technologies are required for different areas depending the ground water and soil conditions. The technological options are suggested in this work. DPHE-UNICEF study has suggested the safe latrine distance from water sources and the pit latrine lining requirement as shown in Table 2.7.

Table 2.7 Table for application of maps

Topsoil Condition			High Ground Water Table			Pit Lining requirement	Safe Latrine Distance from water source (m)
Stable	Semi-stable	Not stable	0-1 m	1-2 m	>2 m		
√			√			May require	3
√				√		Not required	3
√					√	Not required	3
	√		√			Required	5-7
	√			√		May require	5-7
	√				√	Not required	5-7
		√	√			Essential	10
		√		√		Required	10
		√			√	Required	10

Source: DPHE-UNICEF study on "Computer based data maps on Soil and Hydrological conditions of "Bangladesh".

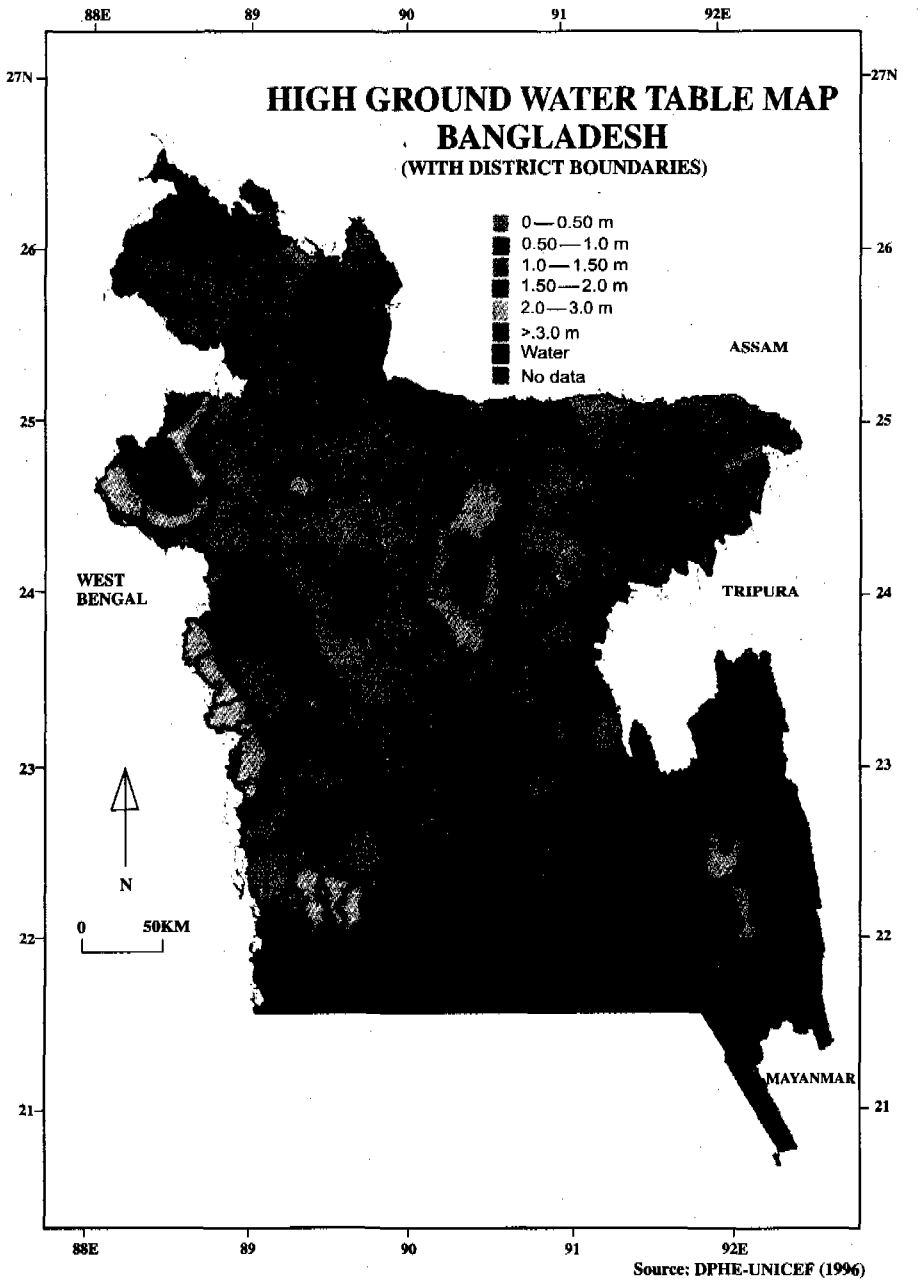

Figure 2.17 High Ground Water Table Map of Bangladesh

2.7 DESIGN PARAMETERS

The principal parameters to be considered in selecting a suitable type of latrine for a specific community are soil characteristics, groundwater conditions, nature and extent of flooding, sources of drinking water and socioeconomic conditions of the community. The technical parameters that were studied and considered in order to adapt a most suitable sanitary pit latrine for the study are discussed below:

Soil Characteristics

Soil properties of a specific site such as composition, porosity and fineness of the soil are very significant for designing an appropriate pit latrine. Soil properties are related to the stability of pit, capacity of latrine and groundwater pollution.

Pit Stability: Soil condition is an important factor for the construction of pit latrine. Mixture of clay and sand is the suitable soil for digging a latrine pit. If the soil is

predominantly sandy, there is a very likelihood of the pit caving in, particularly during the rainy season. In loose soil, the whole depth of the pit will need to be lined.

Capacity of Pit: In a latrine pit, liquid portion of the excreta percolates into the surrounding soil. Soluble compounds in the digested excreta are carried into the surrounding soil by the liquids. The amount of water percolated away into the ground depends on the sub-soil permeability. If the soil is highly clayey, then the pits do not absorb water to the desired extent. If the infiltration capacity of the local soil is not sufficient, the effective volume of a pit is reduced.

Infiltration capacity of sandy soils, with more than 80% sand particles of sizes > 0.05 mm, is the highest, while the least permeable are clayey soils with more than about 35% clay particles of sizes < 0.002 mm. Simple test can be done to distinguish different types of soils whether they are sand, silt and loam or clay. For clayey soils, details site investigation is required to know the real infiltration capacity of the ground. Approximate infiltration capacities of various soils are shown in Table 2.8.

Table 2.8 Approximate infiltration capacities of various soils

Soil Type	Infiltration Capacity (sewage), l/m^2.d
Sands (e.s. > 0.05 mm)	50
Silts and loams (e.s. .002 - 0.05 mm)	30
Clays (e.s. < 0.002 mm)	<10

A typical load of liquid matter to be infiltrated on a pit latrine used by five to ten people, where water is used for anal cleansing, is 28-55 l/day. In a conventional

pour-flush toilet, it would be 50-100 l/day. The surface area required on the sides of a pit below the highest permissible water level can be estimated from this data (Sandy Cairncross). The base of the pit cannot be counted as infiltration area, because it is rapidly blocked by sludge.

Groundwater Pollution: Groundwater pollution largely depends on soil conditions. Bacteria do not penetrate more than 1 - 2 metres in most unsaturated soils, but they have been known to travel over 100 metre in gravel in the water table. The risk due to viral pollution is minimised if adequate interposing soil layer exists (Roy, et al). Pathogenic bacteria do not usually find a suitable environment in the soil for further multiplication and die within a few days, however, hookworm eggs survive as many as five months in wet, sandy soil. Fineness of soils, level of groundwater, movement of groundwater etc. are the parameters of safe distance of a water source. The risk of contaminating groundwater can be minimised by placing a proper envelope of sand around the pit and constructing an impermeable pit bottom.

Groundwater Conditions

When the water table is high, deep pits are not possible and the serviceability of the latrines are much reduced. Over and above, during the rains, there is a possibility of overflow from such pits. The problem of a pit latrine to be constructed in areas where groundwater is high is two folds: (a) reduced capacity of the pit and (b) groundwater contamination.

Pit lining may be extended up-to the squatting slab which is often one or two metres above the ground level. This extra volume above ground level provides a higher capacity of the pit that may be as that with normal pit latrines two or three metres deep. Safe distance water sources must be maintained from this latrine. A sand envelope of proper thickness around the pit and impermeable pit bottom may reduce the risk of groundwater contamination.

The pit should be dug as deep as possible in the dry season to allow for maximum capacity. If the shallow groundwater is not being used for drinking water, water in the pit will actually improve the performance of the latrine by assisting in the natural breakdown of the excreta i.e., this will extend the life of latrine.

A periodic increase in groundwater level may have beneficial effects on a pit. The pit walls are declogged and the absorbative capacity of the soil is restored. Some authors (Morgan and Mara, 1982) claim that the pit latrines should be wet. A wet pit is said to be taken longer time to fill-up than a dry pit (Wagner and Lanoix, 1958). The advantage has to be weigh against the increased mosquito breeding that is likely to be result of introducing wet pits into area where there is a long dry season.

Flooding

Problems of latrine flooding are (a) degradation of environment and the is submerged and excreta comes out with flood water (b) people lose sanitation facilities during flood period and (c) latrine get filled with silts which renders them unusable and people may resort to open defecation and other unhygienic practices. Nature, extent and duration of normal seasonal flood as well as occasional severe flood are significant factors to be considered in selecting a suitable pit latrine for flood-prone areas. Raised latrines are considered to be the "Technically correct solution" to the problem of the flooded latrine. In places that are flooded during monsoon, the basement slab may be raised and step may be provided for easy access to the latrines.

Service Level of Water Supply

Water supply is an important factor to consider when choosing a sanitation technology. Various standards of water supply influence the choice of sanitation technologies. Technology options for sanitation depend on the reliability level of water supply service. If the water source is reliable and near to the house, a sanitation system which needs small amounts of water to operate can be used. Pour-flush latrines are most suitable for use in areas where water is used traditionally for anal cleansing; this requires 6 - 10 litres water per person per day. Existing sanitation installation may be overloaded or flooded if water supply system is improved. Therefore, future planning for improvement of water supply system should be considered in selecting sanitation options.

The relationship of health, water and sanitation is of complex nature. Often, water consumption data is used as an indicator of the level of sanitation for many reasons, for example, the availability of water for hand washing after defecation has a very great influence on the transmission of diseases. Water consumption is also depend on the available sanitation system. It is most important that the sanitation technology chosen should match the level of water supply service if the development is going to be successful.

The lowest, and, from the user's point of views the least satisfactory, is water carried by bucket from the source to the house. Where water is scare and carried by buckets, the dry latrine is an appropriate technology. Where water is available closer to the home through stand pipe or yard taps, water-sealed toilets are feasible. These require 6 - 10 litres of water per person per day for flushing. Sullage can be stored in containers and used for flushing. The first and most appropriate technology is the pour-flush toilet that is used widely in northern India and Southeast Asia. Double pits can be used, these are filled and emptied alternatively. Sanitation technology should be designed to be compatible with the amount of water used and wasted.

3. STRATEGICAL ASPECTS OF SANITATION IN BANGLADESH

3.1 EXISTING SITUATION OF SANITATION IN BANGLADESH

Sanitation is one of the key environmental issues in Bangladesh. It has received the highest ranking during the National Environmental Management Action Plan (NEMAP) consultative process in which 17% of the people opined that it was the serious environmental and health problem in Bangladesh. Poor sanitation degrades the water quality that is causing wide spread illness and death due to water-borne diseases. Up to 80% of all illness in Bangladesh are related to water-borne diseases. In statistical terms, 3.6 million DALYs (disability adjusted life year) are lost each year in Bangladesh due to poor water quality and sanitation (WB, 1998).

The existing facilities in the area of sanitation are very inadequate. The sanitation coverage in the rural areas in terms of population is only 40%. 43% of urban households have the sanitary facilities across Bangladesh while in the capital city Dhaka, domestic sewage from approximately 18% of the area enters into the existing conventional sewerage system which covers only 35% of population.

It is generally agreed that the lacking of appropriate sanitation facilities is the most contributing factor for health and severe environmental degradation in Bangladesh. Indiscriminate defecation practices, effluent dispersion from latrines into both the surface and groundwater and poor hygiene practice are the significant pathways of communicable diseases. Water-borne and sanitation related diseases like diarrhea, dysentery, typhoid, warm infections, scabies and malaria accounts for over 80% of all diseases and the infants and young children are the most vulnerable groups. The effect of these diseases become severe because of malnutrition, which is believed to affect 80% of infants and young children in the country. It is now understood that improving the sanitation facilities and poor hygiene practices can control communicable diseases.

Adequate provision of sanitation facilities, safe drinking water and promotion of the general health of people are the basic elements of primary health care. Much attention was given to provide ample safe drinking water to the people for health promotion in the last few decades in Bangladesh. However, this has been fail to create health impact so far, because of the lacking of a common strategy based on the needs of safe water, hygienic latrine, cleanliness and health consciousness. Inadequate and unhygienic sanitation and poor hygiene practice can cause continued transmission of disease even after supplying of safe drinking water. It is felt that no one is safe from health hazards without the combined protective cover of

safe water, hygienic latrine, and cleanliness and health consciousness. An integrated approach is highly essential to get the benefit from the increased coverage of any of the infrastructure.

Drinking water supply and sanitation are directly related to the communicable diseases, health risk and environmental pollution. These two basic elements of primary health care should be ensured to all level of people in the country. The most serious water contamination problem is the fecal pollution originated from indiscriminate defecation and inadequate sanitation facilities. 8% of the rural population still relaying on surface water sources for their drinking water and they are most vulnerable group of fecal pollution of water. In addition, 84% of the rural people are using surface water for household purposes. Coliform count of most surface water is beyond the acceptable standards (WB, 1998). Most of the diseases in Bangladesh are related to water-borne diseases. Diarrhoeal diseases account for the high infant mortality rate in Bangladesh and about 20,000 children die of this disease every year.

WHO/DGHS estimated that, in 1991, there were 230,000 deaths directly causes by water-borne pathogen that caused diarrhoeal diseases, malaria, intestinal worm infestation and skin diseases caused by water pollution.

A very high percent of infant mortality can be associated with water-borne infectious and parasitic diseases. The child mortality rate for children under 5 is 112 per thousand (WB, 1996), of which about one third is due to diarrhoeal disease alone. The leading cause of child mortality is water-borne diseases (WB, 1998). The principal cause of water quality degradation in Bangladesh is inadequate sanitation.

Over 60% of the population of Bangladesh either defecate in the open or use unhygienic latrines and about 25,000 metric tons of fecal matter end up on public lands and waterways every day (DPHE, 1995). Thus the country can be considered as a dumping ground for human excreta that brings with it death and illness. In addition to this human tragedy, inadequate sanitation is taking its toll on our fragile environment. The impact is significant. Improving the sanitation and personal hygiene practice can save more lives.

3.2 SANITATION STRATEGIES PARAMETERS OF BANGLADESH

The principal objective of a sanitation programme is to provide sound health and well being of the community and protect the environment from degradation. With the aim of achieving this objective, several programme on water supply and sanitation have been undertaken in Bangladesh at the local and national levels by the government, as well as the non-government national and international development agencies. Although due importance has been given to the sector of water supply,

sanitation programme has comparatively been neglected. People are reluctant in improving their sanitation facilities as there is no direct impacts of improved sanitation on health. Therefore, good progress in sanitation coverage has not yet been achieved in Bangladesh. Mere technological options and physical progress in sanitation facilities are not enough in obtaining improved health and sound environment, rather strategical options combining both strategies and technologies should also be considered for a successful sanitation programme in Bangladesh. The technical, social and economic factors must be incorporated in sanitation programme. The principal technical factors are discussed in section 2.7; social and economic factors are discussed below:

Social Considerations

Several social factors influence a sanitation programme, on which the success or failure of the programme depends. Such factors are existing practices, people's participation, motivation, level of education, customs, culture and people's belief.

Existing Practices: Provision of sanitation facilities, existing practices of defecation must be studied and understood in designing a successful sanitation programme. The sanitation coverage in Bangladesh in terms of population is nearly 40% and the rest 60% of the population either defecate in the open areas or unhygienic latrines. The local conditions for a particular community may be different from these figures. Existing excreta disposal practices may be studied to assess the impacts of various social factors on a sanitation programme.

Motivation: Motivation is required to improve the existing sanitation practices in Bangladesh. Level of knowledge on health and hygiene of the people particularly in rural areas is very low and they do not understand the needs for improved sanitation facilities. As there is no direct health impact of sanitation, social status and privacy factors predominate over health and hygiene factors in some areas in taking sanitation facilities. Issues like improved health, convenience, social status and cleanliness for religion can be used in motivating people to change their existing sanitation practices. If the improved sanitation is not accepted by the society, the whole programme would be unsuccessful.

Community Participation: Community participation is very essential for a successful sanitation programme. Community should be involved from the beginning stage of a programme. People's contribution towards the cost of sanitation facilities ensures the ownership to upkeep it. Based on the information on various sanitation options provided by the project management, community will decide whether the options are socially acceptable or not and they will make their own choice of sanitation options. Managerial aspect of the community becomes significant when an improved system is to be used communally. It is required to appoint someone for operation and maintenance of sanitation facilities in such cases. The local authority

alone cannot make sure the smooth operation and maintenance of a communal latrine unless the community participate actively.

Customs, culture and People's belief: There are some strange and exotic factors in the community that influence the planning and development of a sanitation programme. These exotic factors can account for user's lack of co-operation. Local custom, culture, taboos and beliefs should be added to the values of planners and administrators to be brought into a sanitation prograame.

Cost Factors

The cost of sanitation facilities must be affordable for the community. Planning and design of a sanitation programme should consider the economic status of the community as well as their willingness to pay for the improved sanitation system. Ownership of the facilities is a crucial issue for operation and maintenance of the system. Community's contribution in cash or kind for a sanitation facility renders the ownership that is required for upkeep and maintenance of it. Strong organisational support is required to recover operation and maintenance cost directly from the users. However, a charge may discourage some people to use the facilities. Special arrangement may be made for this group of people.

It is essential to know how many people intend to pay for improved sanitation and how much subsidies they will require. It is estimated that low and middle-income groups in developing countries are typically able to afford to spend 2 - 3% of their income on sanitation. However, it is not very reliable to estimate the householder's willingness to pay for improved sanitation based on their income. A pilot project or sample survey is more reliable and realistic to estimate the amount people can pay. The cost calculation can be done in two different ways to derive economic and financial costing respectively. Economic costing includes all costs to the economy and used by national planners and policy-makers to make a least-cost comparison between alternatives. Financial costs are concerned with the actual payments to be made by the various parties concerned- mainly the sanitation agency and the householders. These cost comparisons are used for choosing the technology to be used in specific sanitation programme.

3.3 GOVERNMENT PROGRAMMES AND POLICIES

Government has a major concern to improve the sanitation facilities through formulating appropriate policies and undertaking programmes in this area. Parallel to the government policies and programmes, national and international NGOs and development agencies are also active in this sector with their own sets of strategies and plans.

Government Programmes

The aim of development in sanitation sector is to provide the physical facilities of living to improve the quality of life and environment. Government envisages a provision of sanitation facilities in the Fifth Five-Year Plan for the development towards the next century. The objectives are as follows:

(a) Rural Sanitation

- Improvement of health status of the people and the environment through increased access to sanitation facilities;
- Strengthening of the capacity of the sectoral institutions towards sustainable development of overall sanitation;
- Increasing sanitation coverage from present 40% to 70% of the population by the terminal year of the Fifth Plan i.e., in the year of 2002 and
- Increasing sanitation facilities in the wetland areas (Haors and Beels) to avoid water pollution.

(b) Urban Sanitation

- Improvement of sanitary disposal of human excreta;
- Strengthening of local bodies through extensive training programme in order to ensure smooth operation and maintenance of installed facilities;
- Setting up of more sanitary latrines at district and thana levels and in the slum areas; The two metropolitan cities, Dhaka and Chittagong, are facing serious problems of sanitation and special attention has been given to improve the situation of these two cities in the Fifth Plan:
  - -Increasing coverage of sanitation facilities connected with sewerage system from existing 35% to 40% of the population in Dhaka city by the end of the Plan period;
  - -Extending sanitation coverage to 80% of Chittagong city population.

Government Policies

The following policies will be adopted towards the achievement of the above objectives:

(a) Rural

- Effective involvement of local bodies will be ensured in rural sanitation;
- Increased involvement of private sectors and NGOs will be ensured;
- Private sectors will be promoted in the production and sale of sanitary latrine by providing soft loans;
- NGOs will be encouraged to establish production centre for sanitary latrines in remote areas where such centres do not exist at present;

- Social mobilisation will be intensified through rallies and communication techniques for behavioural change towards sanitation;
- Biogas plants based on human and animal excreta will be set up in rural areas;
- Sanitation facilities to the poor will be provided free of cost but well to do persons will have to install facilities at their own cost for which they will get tax concessions and
- Special emphasis will be given for the extension of sanitation facilities in the wetland areas (*Haors* and *Beels*).

(b) Urban

- Special attention will be given to the improvement of sanitation facilities in the urban slums and the fringe areas;
- More community latrines in the district and thana head quarters will be installed and
- The city corporations will be empowered to obtain funds for projects by floating of bonds to supplement government grants.

Program for 21st Century

Government has recently undertaken a project to prepare the National Agenda 21 for Bangladesh. The draft National Agenda 21 includes the following program areas in sanitation sub-sector to combat against the problems into the 21st century:

- Control of Communicable Diseases;
- Reducing Health Risk from Environmental Pollution and Hazard;
- Promoting the Integrated provision of Environmental Infrastructures: Water, Sanitation, Drainage and Solid Waste Management;
- Enhancing Protection of the Environment;
- Drinking Water Supply and Sanitation;
- Sanitation Strategies and Technologies for High Water-table and Flood-prone Areas;
- Strengthening Sectoral Capacity and Enhancing Local Participation and
- Challanges of Urban Sanitation.

4. SOCIOECONOMIC AND TECHNICAL FINDINGS

Exploratory visits were made in the study areas in Dhaka, Sylhet and Patuakhali by the core research team during May 1998 with the aim of identifying the project sites and to make an operational plan to conduct the research. The research team met most of the stakeholders including some local NGOs active in the sector of water supply and sanitation in the study areas and discussed the objectives, issues and options of the present investigation. Preliminary information on project sites and the current status of sanitation were collected during the field visits.

In order to conduct the socio-economic and technical survey, a questionnaire was developed using the preliminary information and the existing conditions of the study areas regarding the sanitation issues and options. The aim of this survey was to find the details information on technical, social and economic aspects of the study areas that would be used in designing a suitable sanitation option for a specific site. A field test was done and changes were made in the questionnaire as required before conducting the field study. The outcome of this survey has been used in designing the various sanitation options, as described in Section 5, for the flood-prone and high water table areas of Bangladesh. The data and information collected by this survey have been analysed with the help of SPSS/PC+ statistical package and presented in this section.

4.1 LATRINE USERS

All members of a family sampled in the study areas used the same latrine. No member of a family use a different latrine located at an another place. Table 4.1

Table 4.1 Number of Households that Using the Latrine by Districts (in %)

No. of Households	Districts			All Districts
	Dhaka	Sylhet	Patuakhali	
1 – 3	86	86	54	75
4 – 6	12	4	30	16
7+	2	10	16	9
Total	**100**	**100**	**100**	**100**

indicates the number of households that are at present using the latrines. Data shows that on average 2.8 families use one latrine. District-wise distribution indicates that the number of users in Patuakhali district is higher than the other two districts. Almost half of the sampled latrines are used by more than 4 families in Patuakhali while the picture in the same range (4-6) in Dhaka and Sylhet is less than 15%.

Table 4.2 presents the number of users per latrine in each district. On average 11 persons are using each latrine. Number of users is more higher in Patuakhali than the other two districts. More than two-thirds of the sampled latrines are used by 1 - 10 members in both the districts - namely Dhaka and Sylhet, while the percentage of latrine in Patuakhali is just more than one-third i.e., 40%. Like the number of households number of users in Patuakhali is also higher than other two districts. This indicates that in Patuakhali, higher number of members use a latrine than the other two districts.

Table 4.2 Number of Persons Using the latrines by Districts (in %)

No. of Users	Districts			All Districts
	Dhaka	Sylhet	Patuakhali	
1 – 10	78	76	40	65
11 – 20	20	16	46	27
21+	2	8	14	8
Total	**100**	**100**	**100**	**100**

4.2 CAPACITY OF LATRINES

Users were asked whether the capacity of the latrine are up to the mark, in response to this question almost half of the households representative answered that the capacity is not up to the level. Reasons of not to have capacity mentioned by the respondents are lack of proper setting, over-use etc. District-wise data indicates that households of Patuakhali and Sylhet districts are more sufferers than Dhaka district. The capacity of latrines in about two-thirds households of Sylhet and Patuakhali are not adequate, while the picture in Dhaka is less than one-fourth.

4.3 DURATION OF USE

Table 4.4 illustrates the duration of the sampled latrines that are in use by the households. Data indicates that on average each latrine was set for about 28

months back ranging from 2 to 72 months. Sylhet and Patuakhali districts have more than 3 years and above aged latrine than Dhaka. This says that Sylhet and Patuakhali householders are using of relatively older latrines than the Dhaka householders.

Table 4.3 Capacity of the Latrines used by the Households by Districts (in %)

Adequate Capacity	Districts			All Districts
	Dhaka	Sylhet	Patuakhali	
Yes	84	38	32	51
No	16	62	68	49
Total	**100**	**100**	**100**	**100**

Before setting-up these latrines 62% (93) of the total households were using hanging latrine followed by open places (38%). Who influenced them to install this latrine in response to this question, more than two-thirds (68%) opined that health consciousness encouraged them to install this health oriented latrine. Health consciousness is followed by demonstration of neighbour's latrine effect (24%) and NGO influence (7%).

Table 4.4 Time of installation of the sampled latrine by Districts (in %)

Duration (Month)	Districts			All Districts
	Dhaka	Sylhet	Patuakhali	
- 6	6	16	4	9
7 – 12	18	28	22	23
13 – 36	66	32	46	48
37+	10	24	28	20
Total	**100**	**100**	**100**	**100**

4.4 LAND OWNERSHIP

More than three-fourth sampled households constructed their latrines on their own places, rest on the Government land (15%). District-wise data shows that almost all the households of Dhaka districts constructed their latrines on their own land while in Sylhet and Patuakhali almost one-fourth householders constructed their latrine on government land. In selecting the places for latrine health consciousness influenced

most (37%) followed by convenience factor (19%). Almost half (44%) of the total sampled households mentioned a number of reasons which influenced them in selecting places. Of the reasons kinship relations and conflict worked as the main factors.

4.5 STRUCTURAL DETAILS OF LATRINES

Households that were sampled in this study were selected in a way that every family has access to an apparently hygienically made latrine using ring and slabs. The survey shows that each household of the sampled area has used on average 5 rings to construct these latrines whose average diameter is about 33 inches. 90% of the sampled latrine's ring height is 12 inches and used one pit per latrine with an average depth of 5 ft. The survey reveals that there are more than two-thirds (37%) of the latrines whose bases are set with surki / khoa followed by sand (27%) and brick (8%). 28% remain without any prepared base.

More than 80% of the latrine slabs are of twelve sq. ft. in size while only 18% are of 16 sq. ft. Of the total sampled latrines, the superstructure of more than half are made of bamboo while only 5% are made of brick. 15% and 16% latrines are made of jute-cloth and tin-sheet respectively. District-wise data indicates that the superstructures of Patuakhali toilets are more poorly made than the other two districts. On average each latrine is of five feet high. Details of the existing latrines in the study areas are presented in Table 4.5.

Table 4.5 Details of the existing latrines in the study areas

Area	Details of Rings			Details of Pit			Slab area (sft.)	Superstructure (All districts)
	No.	Dia. (in.)	Ht. (in.)	No.	Depth (ft.)	Bottom condition		
Dhaka	7.46	33	12	1	7.46	sand=26% surki=38%	9.70	Bamboo=50.% Tinshed=16% Gunnybag=15.3 Wood=12.7% Pucca=5.30%
Sylhet	4.74	36	12	1	4.74	sand=20% surki=42% brick=16%	11.94	
Patua khali	4.76	30	12	1	4.76	sand=36 surki=30 brick=8	9.0	

4.6 COST OF LATRINES

District-wise construction and maintenance costs of latrines are shown in Table 4.6. Construction cost for each latrine was on average Tk. 1255. The maintenance cost per latrine is Tk. 232. Construction cost includes purchasing of ring and slabs, carrying, installation and infrastructure. Maintenance cost includes mainly cleaning and repairing. Cost of each of these items in percentage is shown in Table 4.7.

Table 4.6 Construction and Maintenance cost of Latrine

Areas	Installation / Construction Cost	Annual Maintenance Cost
Dhaka	Tk. 1246/	Tk. 194/
Sylhet	Tk. 1220/	Tk. 191/
Patuakhali	Tk. 1230/	Tk. 222/

Table 4.7 Construction and Maintenance Cost of Latrines

Construction cost (in %)		Maintenance cost (in %)	
Items	**Cost (%)**	**Items**	**Cost (%)**
Rings and slab purchase Carrying cost Setting-up Infrastructure	55 5 13 27	Cleaning Repairing	40 60
Total	**100**	**Total**	**100**

4.7 DEFECTS OF LATRINES

Table 4.8 presents the nature of defects of the latrines found during the survey period. In this case data were collected through observation made by the assigned field investigators. Data shows more than two-thirds latrines are found to be defective in all respects - namely ring joint, ring setting, slab setting and overall infrastructure.

In all cases Patuakhali latrine are more defective than the other two districts. In the case of ring setting and slab setting samples of Dhaka were found to be more defective than Sylhet district. In overall picture it is found that although the

Households are using ring or at least safety latrine but most of the latrines are not properly constructed or installed.

Table 4.8 Defects of Latrines by Districts (in %)

Defects	Districts			All Districts
	Dhaka	Sylhet	Patuakhali	
Ring joint	68	70	90	76
Ring setting	70	52	92	71
Slab setting	72	52	92	72
Infrastructure	68	68	94	77

4.8 LATRINE CONSTRUCTION

Of the total sampled latrines data indicates that 92% are set by the laboures while only 8% by the latrine owners. In response to a question that whether anybody supervises the construction work, 99% responded "no". In other words, latrines were constructed without any supervision. In selecting the location data shows that the head of household selected 97% latrine's locations. In selecting location, privacy factor (37%) influences more than the access factor (35%). District-wise data, as shown in Table 4.9, indicates that the selection of latrines in Patuakhali was dominated by privacy factor (48%) followed by the access factor (32%).

Latrines of Sylhet district were also dominated by access factor (54%) and privacy factor (36%) while the Dhaka samples were mainly dominated by the proximity of canal factor (44%) followed by privacy (28%) and access (20%) factor. In other words, availability of land factor dominates over health factor in selecting the latrine location.

Table 4.9 Factors that Influenced the Selection of Latrine Location by District (in %)

Factors	Districts			All Districts
	Dhaka	Sylhet	Patuakhali	
Nearer to canal	44	4	12	20
Privacy	28	36	48	37
Ease of access	20	54	32	35
Health	8	6	8	7

Materials (mainly ring and slab) of 91% latrines were collected from the local market and DPHE followed by NGO (9%) supply. In collecting the latrines and selecting the places for installing latrines, households generally did not face any problem. In cleaning of the filled-up latrines, indigenous knowledge and practices were used without any hesitation.

4.9 OVERFLOW OF LATRINES

Of the total 150 latrines, 61 (41%) were overflowed during the times other than flooding. Of the overflowed latrines 53% were overflowed because of over use followed by rain water (40%) and the rise of groundwater table (7%). More than two-thirds latrines of Patuakhali were overflowed because of the combined effect of rainwater and the rise of water table. On average latrines were overflowed after twelve months use. Although the average duration for overflowing of all sampled latrine is twelve months, almost half of the latrines in Patuakhali filled-up within six months. This may be happened because of rise of water table in this area.

4.10 FLOODING OF LATRINES

The entire sampled latrines in the study areas are inundated during flood. The type of flood, duration of flooding and depth of inundation are shown in Table 4.10. The Table shows that the normal river flood and rainwater flood inundate the entire sampled latrines in Dhaka, while in Sylhet flush flood and rainwater flood inundate all sampled latrines flood. In Patuakhali, latrines are flooded by tidal and rainwater flood.

Table 4.10 Details of Flooded Latrines

Study Areas	Types of Flood	Duration of inundation (ft.)	Depth of inundation
Dhaka	Rainwater & River flood (combined)	0.5 - 3.0	3 days to 2 months
Patuakhali	Rainwater & river flood Tidal flood	1.0 - 1.5 0.5 - 1.0	7 - 12 days 2 - 3 hours
Sylhet	Rainwater & Flash flood (combined)	0.5 - 2.5	2 - 15 days

More than half (56%) of the household members use neighbour's latrine when their latrines are overflowed followed by raising their own latrines (23%) and 21%

households do nothing. All the filled-up latrines were cleaned by the sweepers and wastes were dumped under earth (56%) followed by river (26%) and nearest canal (18%).

Sampled latrines were examined and found that of the Dhaka samples 100.0% were filled up by rain water while the Sylhet are filled up by normal flood water and Patuakhali suffers from both normal flood and tidal flood water.

4.11 PROBLEMS OF LATRINES

The latrine users mainly faced the structural problems. That is because of poor construction, almost two-third (59%) households latrines are loosing their durability followed by overflow by rain water (20%) bad odour (12%) and over use (9%). The general problems of the latrines are poor structure (59%), overflow during rainy season (20%), bad odour (12%) and over use (9%).

To overcome these problems almost all respondents suggested to having sanitary latrine. In addition to the common problems mentioned above, the latrines are inundated during the rainy season and flood period. The respondents suggested raising of latrines to overcome this problem.

4.12 WATER SOURCES

The sampled households used various sources of water for their uses in all three districts. Of the households more than half use tube-well water followed by tube-well and rainwater (15%) and tube-well and pond water (14%). Water uses indicates not only drinking water but also other uses. More than half of the households use more than one sources to collect water. Data collected from the field indicate that of the total households 100% use tube-well water for drinking which they collect from an average distance of 117 yards. Only 7% households, in addition to tube-well water, use river water that they collect from the nearest river. This feature has been found only in Patuakhali. In other words, one fifth (20%) of the Patuakhali households still using river water for their everyday use. Only 14 of the total 150 households use pond water. Use of pond water mainly found in Patuakhali and Sylhet districts. To store water more than 90% use earthen pot. Households were asked whether the amount of water at present they are using is adequate for their family consumption. Only 19% opined "No".

Almost two-thirds households mentioned that they face problems during the rainy season in collecting water and of the problems more than two-thirds informed ease of access barrier is the main problem followed by shortage (26%) of water. Households solve their water problem by collecting safe drinking water from a distant of flood-free source (50%) followed by use of alum with the available water (41%).

4.13 HEALTH AND HYGIENE KNOWLEDGE

Table 4.11 indicates the level of knowledge of health and diseases of the households. Data says that 90% of the households suffered from some sort of diseases in the last year. When the representative of the households were asked to provide information on health. 47% could not identify a reason behind the suffering, while 48% mentioned flood- water is responsible for these sufferings. District-wise data shows that the number of ignorance in Patuakhali is more than the other two districts. Those who suffered from diseases, 59% consulted with local MBBS doctors followed by local quack, 39%.

Table 4.11 Causes of disease suffered by the households by districts (in %)

Causes of Diseases	Districts			All Districts
	Dhaka	Sylhet	Patuakhali	
Don't know	44	24	66	47
Flood	54	65	30	48
Virus	2	11	4	5

4.14 HEALTH AND DISEASES

Table 4.12 presents a comparative status of health and disease conditions of the households before and after flood. Data shows that most of the water-borne diseases have increased significantly after the rainy as well as flood season.

Table 4.12 Types of Diseases appeared before and after rain and flood (in %)

Diseases	Before flood/rain	After flood/rain
Fever	77	13
Stomach pain	1	27
Dysentery	7	10
Diarrhoea	7	23
Others	8	27

Almost half (49%) of the households, do not have any child member in their family. Those who have child under five years of age how do they manage children defecation in response to this question, 90% informed that they use front place of their house. And after that 63% households dispose children faeces at the nearest canal or low-lying areas followed by nearest jungle (37%). In removing children faeces, 60% of households use spade followed by use of paper (40%). After

cleaning the faeces whether they wash their hands, in response to this question, 51% households responded positively. 42% clean their hands by soap and 58% by soil. In the case of responded oneself more than 90% answered that they cleaned their hands after defecation by using soap and soil both.

4.15 LITERACY LEVEL

Educational background of the sampled households indicates that 83% of the households have illiterate members. Of the total households more than two-thirds have members who can sign narne and crossed primary and secondary education. Only 7% of the total household member acquire post-secondary education. Data indicates that only few households have member who crossed post-secondary education level. Table 4.13 shows the literacy level of the households.

Table 4.13 Literacy level of the Households (in %)

Literacy Position	Yes (in %)	No (in %)
Illiterate	83	17
Only can sign name	75	25
Primary	85	15
Secondary	83	17
Post-secondary	7	93

4.16 WILLINGNESS TO PAY FOR IMPROVED LATRINE

In order to have improved sanitation facilities, each family is willing to pay on average Tk. 530. District-wise response indicates that Sylhet households are willing to pay more money than Patuakhali and Dhaka residents.

4.17 COMMUNITY RESPONSE FOR IMPROVEMENT

Of the total respondents 73% identified pucca and germ free latrines are safe latrines followed by germ free (20%) and pucca (5%) latrine. In other words, more than 90% latrine owners have knowledge about safe hygienic latrine. Depending on the level of existing consciousness, 99% opined that the latrine they were using was unhygienic. Almost all respondents (99%) know that most of the diseases are break out from faeces and spread through flies (64%) and air (28%). How to overcome these problems in response to this question, 52% respondents mentioned an embankment can improve the situation followed by canal digging (30%) and proper drainage system.

5. SANITATION STRATEGIES AND TECHNOLOGIES FOR FLOOD-PRONE AND HIGH-WATER TABLE AREAS

5.1 SANITATION STRATEGIES

Sanitation is one of the elements of primary healthcare that is identified as the serious environmental and health problem in Bangladesh. Unfortunately, a vast multitude of people does not have access to sanitary latrines. Sanitation coverage in the rural areas is only 40% in terms of population, while 43% of urban households have the sanitation facilities across Bangladesh. Over the decades, Bangladesh has achieved a considerable success in providing water supply, but this improvement did not result proportionately in the improvement of general health because of lack of hygienic practices and adequate sanitation facilities. The level of knowledge of the general people on health and hygiene is very low. A wariness of the relationship between use of safe water, proper disposal of excreta, practice of personal hygiene and good health is also very low. Therefore, mere the provision of sanitation facilities are not enough to achieve the goal of sound health and environment; rather an integrated approach combining technologies and strategies is needed for achieving overall success in this sector.

Based on the findings of this research, the following strategies are recommended to consider in planning a sanitation programme particularly in high-water table and flood-prone areas of Bangladesh:

Improved Understanding

The level of knowledge on health and sanitation of the people of rural Bangladesh is very low. As the impacts of improved sanitation on health is not direct, people are reluctant in improving their sanitation facilities. People should have a clear understanding of the adverse impacts of improper sanitation and the benefit of improved sanitation. Improved understanding of sanitation is the pre-requisite of a successful sanitation programme. Once the people realise the bad consequences of improper sanitation, and the benefit of improved sanitation, they would spontaneously be interested to participate in any sanitation programme.

The understanding of health and sanitation of general people can be improved in several ways. Training at community level, local level workshops, video films, group discussions etc. are very effective media to increase the knowledge of people of water supply, sanitation and their implications with health and environment.

Technology Transfer

After having the knowledge on health and sanitation, people should know the ways and means to face the sanitation problems. Specially, the concerned groups of people including members of local authorities, VSC, NGOs and CBOs should know the technology of low cost sanitation options particularly for high-water table and flood-prone areas. The trained people can advise and encourage the local people to take sanitary latrine even for the high-water table and flood-prone areas.

This can be achieved by providing extensive training programme and demonstration to the concerned local groups as well as the local general people. The sanitation option should be based on local technologies. It should also be acceptable and affordable to the users. Trained people can also supervise the latrine construction work to minimise the construction defects. The survey results reveal that in case of 99% households, nobody supervised the work during construction of their latrine and consequently they have constructed defective latrines.

Cost of Sanitation

Cost of sanitation facilities is an important factor to be considered in planning a successful sanitation programme. It should be affordable to the people, otherwise they will not be interested in taking a sanitation option. Providing sanitation facilities to the poor at free of charge and a tax concession to the well to do people is a good strategy to increase sanitation coverage. However, people's contribution in any other form should be ensured which is crucial issue for operation and maintenance.

Community Participation

Community-type built-up latrine may be considered for high-water table and flood-prone areas where individual household latrine is not affordable for the poor people as it incurs a higher cost. Community participation in each step is very essential for the success of such programme. Community's contribution in cash or kind will ensure the ownership of the facility which is also very important for up-keeping it. Active participation is required for smooth operation and maintenance of the facilities. It is essential to appoint someone to look into the managerial aspects of the communal latrine. Installation of community latrine at Thana level is one of the Government's policies of the current Five Year Plan (1997 - 2002).

Motivation

Motivation is required to improve unhygienic sanitation practices. Often social status, cleanliness for religion and privacy factors predominate over health and hygiene factors where people do not have adequate knowledge on health and sanitation.

These issues can be applied strategically in motivating people to accept an improved option of sanitation. The acceptance of any improved sanitation option by the community is key factor of a successful sanitation programme. Motivation is utmost important for the acceptability of an improved sanitation option.
The following issues may be addressed to motivate people to improve their existing sanitation practices:

- More local and mobile Village Sanitation Centre (VSC) should be established. People feel inspired when see a mason producing ring-slab at their local market and others from the neighbourhood also buying those.
- Motivation of the people about using sanitary latrine is a continuous process. The benefit of having a hygienic sanitation facility needs to be clear to the people.
- Repeated stimulation can make people understand the importance of improved sanitation facilities and turn them interested to take it.
- Trans-sectoral approach can be applied to motivate people; reinforcement through multifarious activities interconnecting one programme with others is very useful.
- Village doctors can move door to door for their profession and knock at the sense of village people for leading hygienic life.
- Schoolteachers can use their positions to motivate people. They can impart knowledge on health and hygiene to the students who are also encouraged to convey the message to their parents and other family members.
- Group discussion or "Courtyard Meeting" is also an effective way of motivating people. In such a meeting, the benefit of improved sanitation can be explained and discussed. The causes and effects of various diseases such as diarrhoea, dysentery, jaundice, typhoid and worms can also be explained to the participants.
- Awareness on health and hygiene should be raised for a successful sanitation programme. Posters, leaflets and video films can be used to raise the level of awareness at the local level. Among all communication materials, video film is very attractive and effective as well in motivating people.
- Rally of school children for sanitation campaign is effective in motivating people.
- Community leaders and religious leaders can play active role in motivating people to change their existing habits and take improved sanitation facilities.
- Rallies and communication techniques may be applied to intensify the social mobilisation for changing the existing improved sanitation practices.

Integrated Approach

An integrated approach combining water, sanitation and hygiene education is

needed for achieving overall success in the improvement of general health, the quality of life and the environment. Provision of either only safe water or only improved sanitation facilities is not adequate for achieving this goal. A package programme including water, sanitation, training and livelihood may be undertaken for a successful sanitation programme.

Capacity Building

Sanitation facilities should be improved through formulating appropriate policies and undertaking programme in this area. Capacity building of the local authority as well as the CBOs towards the sustainable development of overall sanitation programme should be strengthened.

Promotion of Private Sectors

CBOs, NGOs and private sectors should be involved effectively in sanitation programme and they should be promoted in the production and sale of sanitary latrines by providing soft loans or grants. Private sectors should be encouraged and supported to establish sanitation production centre at the critical problem areas (remote village, high-water table and flood-prone areas) for effective coverage.

Alternative Use of Excreta

Attempt should be taken to establish facilities of producing compost and bio-gas from human and animal excreta. This will provide improved cultivation, supplemented energy and reduce the load of pollution to the environment as well.

5.2 SANITATION TECHNOLOGIES

The present research investigated sanitation technologies for two problem areas - high-water table areas and flood-prone areas. The major problems of sanitation in these two areas are inadequate latrine capacity and groundwater contamination due to high-water table and reduced/lost accessibility and surface water contamination due to flooding of latrines. To overcome these problems, some technological options of sanitation are considered and adapted to suit our local conditions. Raising of latrine is the basic principle of these technological options. However, some other technological provisions are made to protect the groundwater as well as surface water from contamination. Earth stabilised raised pit latrines, step latrine and mound latrine is found suitable for flood-prone areas while sand enveloped pit latrine is suggested along with the other options for high-water table areas. The possible technological options and their areas of application are discussed in the subsequent sections:

Latrines for Flood-prone Areas

Technically correct solution to the problem of latrine flooding is to construct "Raised Latrine". There are many ways to raise the latrine depending on local conditions. Flooding of latrines creates several problems such as environmental degradation as the excreta comes out when it is submerged, people lose sanitation facilities during flood period and latrine pits get filled with silt.

Lining of the pit may be extended above the ground level to prevent the latrine from flooding. If the lining is porous, then there needs to be filled of earth around the extended portion of linings, which will stabilise the lining and provide access to the users. Excavated soil is heaped round the lining above ground level and the latrine is then "Mound Latrine". Plastering both sides can seal porous lining. The fill will not be necessary to non-porous linings. In this case, step will need to be made to access the latrine. Access to a raised latrine is usually gained by steps and the latrine is called "Step Latrine". Impervious lining should be above and immediately below the ground level. The water-tight lining usually extends about half a meter below ground level.

The raised pit latrine also increases the volume of the pit for accumulation of excreta. Oil drum can be used to extend the pit linings above ground level at the start of the monsoon. An earth bank may be raised around the pit linings.

Where insufficient infiltration area can be obtained below ground level, a mound of soil can surround the raised portion of the pit. The section of the lining above ground (excluding the top 0.5 m) can be used for infiltration provided the mound is made of permeable soil, well compacted with a stable side slope, and is thick enough to prevent filtrate seeping out of the sides. Earth mound is not recommended on clay soils, as the filtrate is likely to seep out at the base of the mound rather than infiltrate the ground.

Raised pit latrine can be used in combination with any other type of pit latrine (VIP, pour-flush, double pit). A common application is where the groundwater level is close to the surface. A slight raising of the pit may prevent splashing of the users or blockage of the pit inlet pipe by floating scum.

In some cases, it is necessary to combine groundwater contamination measures with raised latrine in high water table and flood-prone areas.

People should be encouraged to construct pit latrines in such areas and to obtain drinking water from a "Safe" source. If the householders collect their drinking water from groundwater source close to such latrines, appropriate measures should be taken to prevent groundwater contamination. Some technological options for latrine installation in the flood-prone areas are discussed below:

Technology Option 1: Earth Stabilised Raised Pit Latrine

Earth stabilised raised pit latrine is suitable for the areas which are flooded during monsoon months. This type of latrine can be used in areas experienced with any four types of flood viz., river flood, rainwater flood, flush flood and tidal flood that occur in Bangladesh every year. Pit volume is increased as it is raised which renders the extended life of the latrine. This latrine requires more space area to stabilise soil around the raised portion of the pit lining. In this type of latrine, any type of pit lining whether it is porous or non-porous can be used above the ground level for raising the pit. Details of the earth stabilised raised pit latrine is shown in Figure 5.1.

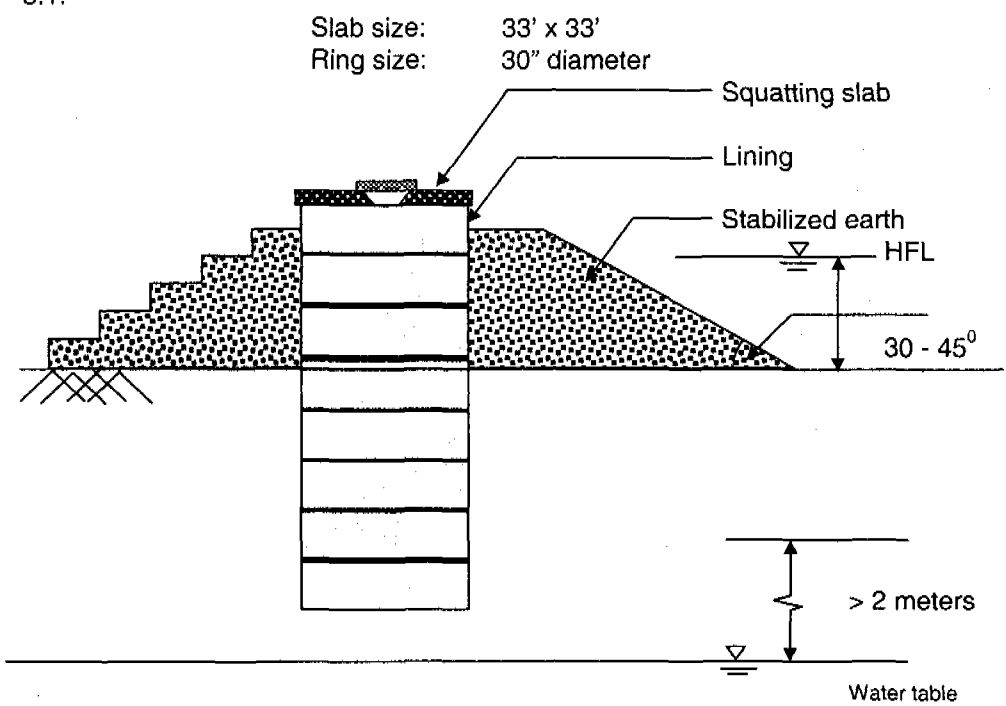

Figure 5.1 Earth Stabilized Raised Pit Latrine

After excavating a pit of required depth, a lining is extended up to the squatting slab which may be often three or four feet above ground level in such a way that the slab is at least 1 ft. above the flood level. Earth is stabilised around the extended lining above ground level at a slope of 30 - 45 degree that also provides easy access to the latrine. This section of lining above ground level can be used as infiltration area provided the lining is porous and surrounded soil is permeable, well compacted with a stable side slope and is thick enough to prevent filtrate seeping out of the sides. A permeable base of stabilised soil is also required to avoid seeping out rather than infiltrate into the ground.

Safe distance of drinking water source from such a pit latrine is 3 metre if the depth of groundwater table from the bottom of the pit is at least 2 metre and the effective size of soil is less than 0.02 mm. If the bottom of the pit extends to the groundwater table, special measure should be taken to prevent groundwater contamination that will be described in case of latrine in high groundwater water table areas.
This type of raised pit latrine can be used in combination with any other type of pit latrine such as single pit, double pit and pour-flush latrines.

Technological Option 2: Step Latrine

The principle of step latrine is as the same as of the earth stabilised raised pit latrine. This latrine is also raised to avoid floodwater intrusion into the pit during monsoon months. Pit excavation is done during dry season and lining is extended above ground level as per requirement up to the squatting floor slab of latrine. Non-porous lining is used above ground level to prevent sullage leaking. The extended portion of the pit is often made water-sealed by plastering both sides. Water-sealed section of the lining should also be extended 1 - 1.5 ft. immediately below the ground level.

This type of latrine requires relatively smaller horizontal space than earth stabilised latrine. However, steps will be required, as shown in Figure 5.2, to gain access to this latrine. Moreover, the lining above ground level must be strong and durable to support the infrastructure. Step latrine is suitable for flood-prone areas where limited space is available for latrine construction.

Technological Option 3: Mound Latrine

Mound latrine is one of the technological options for flood-prone areas where space is limited and watertight linings are not available. In this type of latrine, pit lining is also extended above ground level to prevent the latrine from flooding. A mound of soil surrounds the extended portion of the pit as shown in Figure 5.3. The mound should be thick enough to prevent filtrate seeping out of the sides and side slope should be stable. Part of the section of the lining can be used as leaching area provided it is made of permeable soil. However, it is not recommended on clay soils to avoid seeping out at the base of the mound rather than infiltrate the ground. Earthen steps may be provided to gain access to this latrine.

Latrines for High Groundwater table Areas

Where groundwater is the source of drinking water and being collected from deeper than shallow water table, then there is no risk of water contamination from pit latrines in areas where groundwater table is high. Groundwater pollution is a great concern if

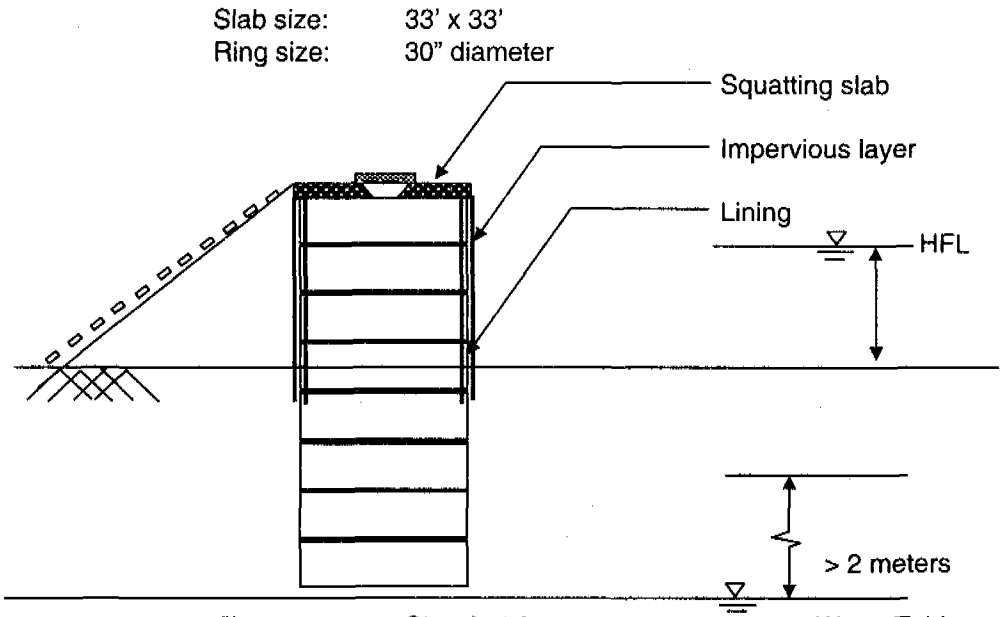

Figure 5.2 Step Latrine

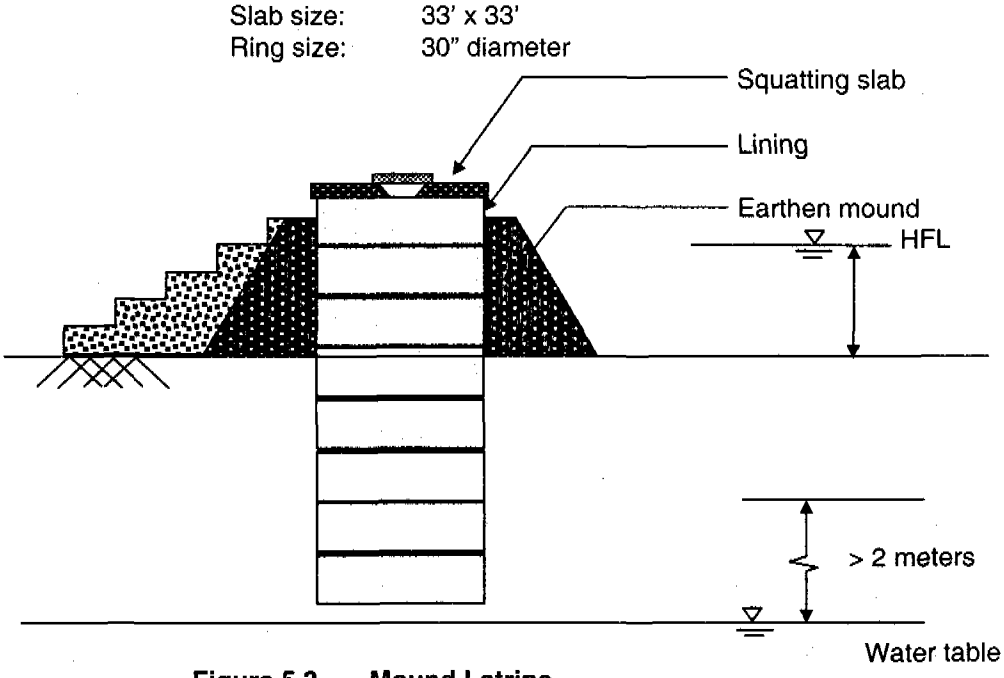

Figure 5.3 Mound Latrine

water is collected from very shallow water table in such areas and appropriate measures should be taken to avoid the contamination or alternative sources of water supply to be ensured for the community. In addition to groundwater contamination, high water table also reduces the capacity of the pit of a latrine. Moreover, there is a possibility of overflow from such a pit during rainy season. Use of raised pit latrine for extended capacity is also the technical solution to the problems of latrines in high groundwater table areas. However, appropriate measures should be taken to prevent groundwater contamination. Technological options of latrine installation in the high-water table areas are discussed below:

The three technological options of raised latrine usable for flood-prone areas are equally suitable for the areas where water table is high provided there are sources of safe water. The extended portion of the lining provides required volume of the pit for sludge accumulation. Raising of the pit also prevent splashing of the users or blockage of the pit inlet pipe by floating scum. Water in the pit actually improves the performance of the latrine by assisting in the natural breakdown of the excreta that extends the life of latrine. Moreover, a periodic increase or decrease in groundwater level may have beneficial effects on a pit. The pit walls are de-clogged and the absorptive capacity of the soil is restored.

The pit is excavated in dry season as deep as possible in areas with high groundwater table. During monsoon or where water table is very high, cylindrical pre-cast concrete or burnt clay liners can be sunk as the pit is dug. These latrines must either be made with holes in them or with porous concrete to permit infiltration from the pit.

Three types of raised pit latrines, as discussed previously, are suitable even if the bottom of the pit extends to the groundwater level provided the groundwater collection point for drinking purpose is at a distance of greater than 10 metre and not located at the downstream of the pit. If the source of drinking water is shallow groundwater and located near the pit or at the downstream of it, an appropriate measure must be taken to prevent or reduce the contamination of groundwater. Sand envelope surrounding the pit is an appropriate measure to solve this problem. Sand enveloped pit latrine is described in technological option 4 and 5.

Technological Option 4: Sand Enveloped Pit Latrine

Groundwater pollution is occurred in areas where the bottom of the pit extends below the water table. If there are drinking water sources such as tube-wells or dug-wells nearby, a sand filter around the pit can be dug to limit disease-causing micro-organisms from leaking the water supply.

The risks of contaminating groundwater can be minimised by placing a 500-mm

thick envelope of sand around the pit and constructing an impermeable pit bottom as shown in Figure 5.4. The impermeable bottom can be made from plastic sheet or puddle clay. The minimum horizontal distance of separation from drinking water sources should be 10 metre.

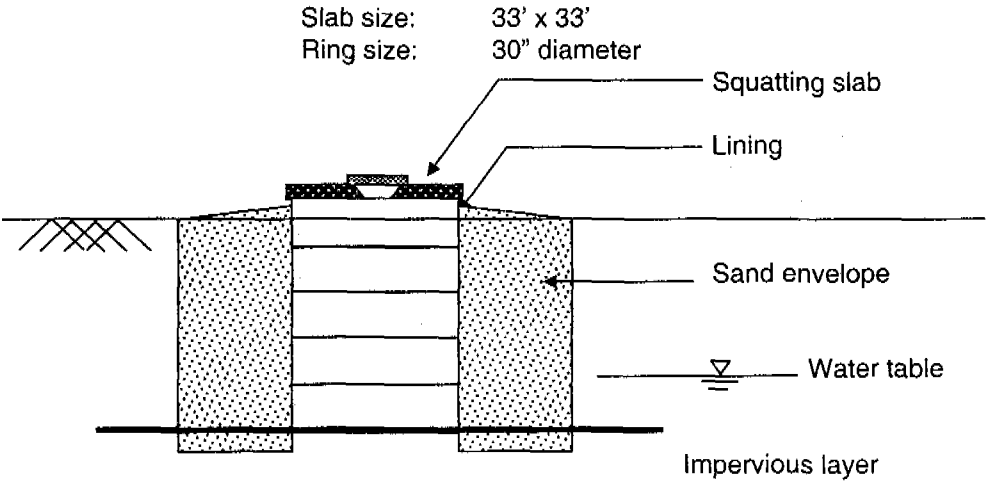

Figure 5.4 Sand Enveloped Latrine

The sand envelope should be taken up to 0.3 metre above the top of the inlet pipe and suitably confined to exclude any surface drainage including rainwater, directly entering the sand envelope.

Technological Option 5: Sand Enveloped Raised Pit Latrine

Sand envelope around the pit can be provided with any of three technological options as discussed above depending on the actual site conditions and the latrine is called Sand Enveloped Raised Pit Latrine. Thus sand enveloped raised pit latrine can also be used in flood-prone areas as the pit is raised as shown in Figure 5.5. The extended portion of the lining above ground level can be water-sealed or earth mound can be made to prevent sullage leaking as discussed in case of the step or mound latrine. In mound type latrine, 1m high earth-filling should be provided for at least 0.25 m beyond the sand envelope with the edge chamfered to lead away the rain or surface water. Comparison of these technological options of sanitary latrines are shown in Table 5.1

5.3 DISCUSSION

Cost: The costs of each type of latrine described above are shown in Table 5.2.

DPHE produces sanitary latrine consisting of 5 rings and 1 slab which costs Tk. 515. The DPHE prices of ring and slab are Tk. 86 and Tk. 85 respectively. More rings are

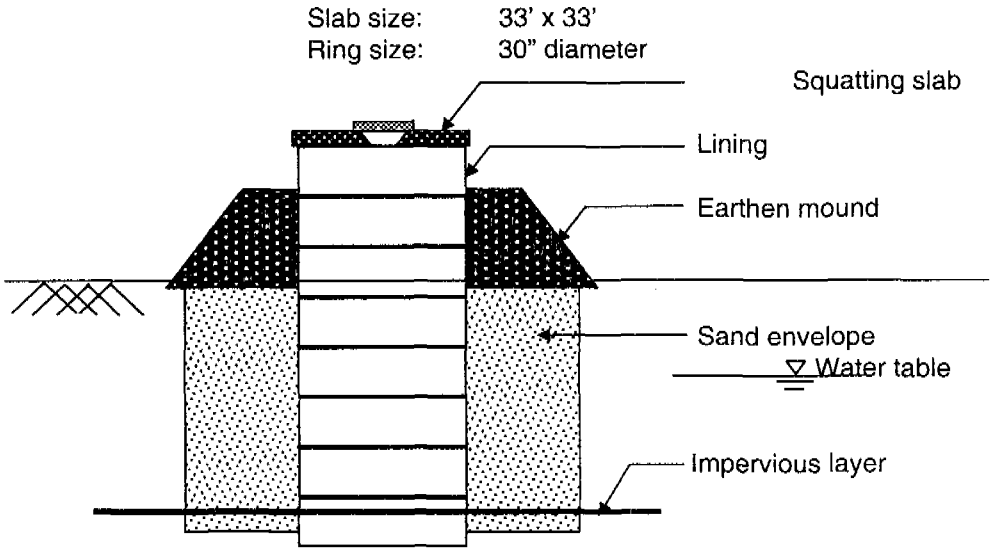

Figure 5.5 Sand Enveloped Raised Pit Latrine

Table 5.1 Comparison of technological options of sanitary latrines

Technological Options	Area of application	Cost	Ease of construction	Required soil conditions
Earth Stabilised Raised Pit Latrine	Flood-prone areas	Low to medium	Easy	Permeable soil
Step Latrine	Flood-prone areas	Low to medium	Requires builders	Permeable soil
Mound Latrine	Flood-prone areas	Low to medium	Easy	Permeable soil
Sand Enveloped Latrine	High-water table areas	Low to medium	Easy	Permeable soil
Sand Enveloped Raised Latrine	Flood-prone and High-water table areas	Medium	Requires builders	Permeable soil

Table 5.2 Cost of various latrines

Latrine Options	Materials and cost				Remarks
	Item	Quantity	Rate	Total Cost	
ESRP Latrine	Ring Slab Earth cutting Earth filling	8 nos. 1 no. 30 cft. 84 cft.	Tk. 86 each Tk. 85 each Tk. 0.85/cft. Tk. 0.80/cft.	Tk. 688.00 Tk. 85.00 Tk. 25.50 Tk. 67.50 Tk. 866.00	Increased cost: Tk. 326 Increased capacity: 60%
Step Latrine	Ring Slab Earth cutting Plastering Step	8 nos. 1 no. 30 cft. 60 cft. L.S.	Tk. 86 each Tk. 85 each Tk. 0.85/cft. Tk. 5.30/sft. L.S.	Tk. 688.00 Tk. 85.00 Tk. 25.50 Tk. 31.50 Tk. 100.00 Tk. 930.00	Increased cost: Tk. 390 Increased capacity: 60%
Mound Latrine	Ring Slab Earth cutting Earth filling	8 nos. 1 no. 30 cft. 50 cft.	Tk. 86 each Tk. 85 each Tk. 0.85/cft. Tk. 0.80/cft.	Tk. 688.00 Tk. 85.00 Tk. 25.00 Tk. 40.00 Tk. 838.00	Increased cost: Tk. 298 Increased capacity: 60%
Sand Enveloped Latrine Type - 1	Ring Slab Earth cutting Sand Polythene	5 nos. 1 no. 30 cft. 100 cft. 50 sft.	Tk. 86 each Tk. 85 each Tk. 0.85/cft. Tk. 5.50/cft. Tk. 1.0/sft.	Tk. 430.00 Tk. 85.00 Tk. 25.50 Tk. 550.00 Tk. 50.00 Tk. 1140.00	Increased cost: Tk. 600 Same capacity
Sand Enveloped Latrine Type - 2	Ring Slab Earth cutting Earth filling Sand Polythene	8 nos. 1 no. 30 cft. 50 cft. 100 cft. 50 sft.	Tk. 86 each Tk. 85 each Tk. 0.85/cft. Tk. 0.80/cft. Tk. 5.50/cft. Tk. 1.0/sft.	Tk. 688.00 Tk. 85.00 Tk. 25.50 Tk. 40.00 Tk. 550.00 Tk. 50.00 Tk. 1438.00	Increased cost: Tk. 898 Increased capacity: 50%

required to raise a pit to avoid flood-water intrusion into the pit. This will incur a higher cost of latrine. However, the extended portion of the pit will also increase the capacity of the latrine. Survey results reveal that the average cost of latrine installation is in the range of Tk. 1220 - 1246 and people are willing to pay Tk. 530 on average for an improved latrine facilities. The required number of rings for raising the pit including necessary works can be easily procured with this amount of money and one of the suggested latrines can be installed in the study areas.

Capacity: Technical survey shows that on average each latrine is used by 2.8 families or on average 11 persons are using each latrine. Almost half of the households informed that the capacity of their latrines is not adequate as per requirement. Of the total 150 latrines, 41% were overflowed and of the overflowed latrines, 53% were overflowed because of normal use, as the capacity is inadequate. Most of the latrine options offer an extended capacity that will overcome this problem.

Defects of Latrine: Data shows more than two-thirds latrines are found defective in all respects mainly, ring joint, ring setting and slab setting. The above technical options offer improved type of latrines in which the above defects can be removed if the strategies are followed properly.

Acceptability: Group discussions, interview and local level workshops indicate that the technological options are acceptable to the community, although these incur a higher cost. The cost of installation of such a latrine is within the capacity of local people and thus it is affordable. Regarding accessibility, people opined that the use of raised pit latrine is much better than having no latrine at all during flood period.

Technology: The technology of these latrines is very simple and local people can install such latrines if they are trained. Capacity building of the local community is an essential part for the promotion of such latrine technologies.

Suitability: Latrines suitable for the project areas in Dhaka, Patuakhali and Sylhet are shown in Table 5.3. Latrines suitable for flood-prone areas can also be used in the high-water table areas if the drinking water is not collected from shallow groundwater source. It is found that the sand enveloped latrines and sand enveloped raised latrines are suitable for Patuakhali areas. Earth stabilised latrines, step latrines and mound latrines are found to be suitable for flood-prone areas of Dhaka and Sylhet.

Table 5.3 Suitable latrines for the project areas

Project areas	Local conditions					Suitable latrines
	Soil	Ground water	Flood		Willing-ness to pay	
			Type	Depth (cm.)		
Dhaka	Stable Semi-stable	> 2 metre	Normal Rain water	0 - 181	Tk. 483	-Earth stabilised latrine -Step latrine -Mound latrine
Patuakh-ali	Stable Unstable	0 to 1 metre	Normal Tidal	0 - 90	Tk. 690	-Sand enveloped latrine -Sand enveloped raised latrine
Sylhet	Stable Semi-stable Unstable	0 to > 2 metre	Flush Rain water	0 - 181	Tk. 486	-Earth stabilised latrine -Step latrine -Mound latrine

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The following conclusions are made from this research:

- The major problems of sanitation in high-groundwater table and flood-prone areas of Bangladesh are inadequate latrine capacity and groundwater contamination due to high-water table and reduced / lost accessibility and surface water contamination due to flooding of latrine.
- The level of knowledge on health and sanitation of the people is very low. Educational background of the sampled households indicates that 83% of the households have illiterate members. Data shows that 90% of the households suffer from some sort of diseases. 47% households could not identify a reason behind the suffering. The number of ignorance in Patuakhali is higher than the other two districts.
- On average, each latrine of the study areas is used by 2.8 families. The number of users in Patuakhali is higher than Dhaka and Sylhet. Almost half of the sampled latrines are used by more than 4 families in Patuakhali while the figure in the same range (4-6) in Dhaka and Sylhet is less than 15%. On average 11 persons are using each latrine in the study areas.
- The capacity of latrines in all the three project areas is inadequate. On average, 49% households of the project areas informed that the capacity of their latrine is not adequate, while 68% households opined the same in Patuakhali. The position of Sylhet is better than Patuakhali which is also better than the average figure.
- Almost all the households of Dhaka districts constructed their latrines on their own land while in Sylhet and Patuakhali almost one-fourth households constructed their latrines on the government land.
- Each household of the sampled area has used on average 5 rings of the average diameter of 33 inches with a slab of 12 sq. ft. and one pit of an average depth of 5 ft. There are more than two-thirds (37%) of latrines whose bases are made of surki / khoa followed by sand (27%) and brick (8%). 28% pits remain without any prepared base.
- The average cost of construction and maintenance of each latrine in the study areas Tk. 1255/ and Tk. 232/ per year respectively. 55% of the total cost of construction is spent on purchasing ring and slab and while 29% for superstructure. 60% of total maintenance cost is spent for repairing and the rest 40% for cleaning.

- On average, over 70% latrines in the project areas have construction defectives, while the figure in Dhaka, Sylhet and Patuakhali are 69%, 60% and 92% respectively. 99% latrines in the study areas were constructed without any skill supervision.
- In order to have an improved sanitation facilities in the study areas, each family is willing to pay on average Tk. 536/. District-wise response indicates that householders in Sylhet are willing to pay more money than Patuakhali and Dhaka residents.
- Local people of the study areas do not have the idea of sanitation technological options suitable for flood-prone and high-water table areas.

6.2 RECOMMENDATIONS

The following recommendations are made from this study to improve the situation of sanitation in the flood-prone and high water table areas of Bangladesh:

- The technological options of sanitation adapted and suggested in this study may be promoted to overcome or minimise the sanitation problems in flood-prone and high water table areas of Bangladesh.
- Earth stabilised raised pit latrine, step latrine and mound latrines are found to be suitable using in flood-prone areas. These three types of technological options are also suitable for high-water table areas where drinking water is not collected from shallow groundwater source. Sand enveloped pit latrines can be used in high-groundwater table areas where shallow groundwater is the source of drinking water.
- Improved understanding of sanitation is the pre-requisite of a successful sanitation programme. The understanding of health and sanitation of general people can be improved in several ways. Training at community level, local level workshops, video films, group discussions etc. are very effective media to increase the knowledge of people of water supply, sanitation and their implications with health and environment.
- An integrated approach combining water, sanitation and hygiene education is needed for achieving overall success in the improvement of general health, the quality of life and the environment. A package programme including water, sanitation, training and livelihood may be undertaken for a successful sanitation programme.
- People should be encouraged to construct pit latrines even in the flood-prone and high water table areas to protect the health and environment. However, they should now the technological options that can be adapted for the local conditions. Demonstration of technological options and extensive

training programme may be undertaken to achieve this goal.

- Sanitation facilities may be provided to the poor at free of charge or subsidised rate and tax may be reduced to the well to do the people to increase sanitation coverage. However, people's contribution in any other form should be ensured for their ownership which is very crucial issue for operation and maintenance of the system.
- Community-type built-up latrine may be installed in high-water table and flood-prone areas where individual household latrine is not affordable to the poor. Community participation must be ensured in all steps of such programme.
- The acceptance of any improved sanitation option by the community is the key factor of a successful sanitation programme. Motivation is imperative for the acceptability of an improved sanitation option. Social status, cleanliness for religion, privacy factor etc. may be strategically applied to motivate peoples. Mass campaign is also very effective in motivation programme.
- Sanitation facilities should be improved through formulating appropriate policies and undertaking programme in this area. Capacity building of the local authority as well as the CBOs towards the sustainable development of overall sanitation programme should be strengthened.
- Private sectors should be encouraged and supported to establish sanitation production centre at the critical problem areas for effective sanitation coverage.
- More work is required to develop an effective method of excreta disposal from latrines. Attempt should be taken to establish facilities of producing compost and bio-gas from human and animal excreta.

7. REFERENCES

Aziz, M. A. (1972), *Sewerage Engineering and Environmental Health*, Bangladesh University of Engineering and Technology, Dhaka.

Cairncross, S. and Feachem, R. G. (1977), *Environmental Health Engineering in the Tropics*, John Wiley & Sons, England.

Department of Public Health Engineering (1998), Sanitation Division, Dhaka, Personal contact.

Department of Public Health Engineering (1995), *Improving Sanitation and Hygiene*, A Leaflet Sanitation Division.

DPHE-UNICEF (1996), *Computer Based Data Maps on Soil and Hydrological Condition of Bangladesh*, Dhaka.

Dhaka City Corporation (1998), Environmental Improvement project (EIP), Personal communication.

Dhaka Water Supply and Sewerage Authority (1998), MODS Zone – 4, Personal contact.

Hofer, T. (1998), *Floods in Bangladesh: A Highland - Low land Interaction*, Institute of Geography, University of Beme, Switzerland.

Islam, N. (1998), *The Future of Dhaka*, Paper presented in "Dhaka City Management Reform Workshop", Dhaka, 15 – 17 March, 1998.

Islam, N. (1996), *Megacity Problems: The Case of Dhaka, Dhaka From City to Megacity*, Urban Studies Programme, University of Dhaka.

Islam, N & Kitawaki, N (1996), *Appropriate Technology for Water Supply and Sanitation*, International Environmental Planning Centre, The University of Tokyo, Japan.

Local Government Engineering Department (1997), *MSP and Strengthening Institutional and Financial Management Components : Khulna City Corporation.*

Ministry of Planning (1997), *Fifth Five Year Plan*, Government of Bangladesh.

Ministry of Planning and External Relation Division (1991), *Report of the Task Forces on Bangladesh Development Strategies for the 1990's*, The University Press Ltd., Dhaka.

Ministry of Water Resources, Flood Plan Coordination Organization (1994), *Report on the Flood Action Plan*, Dhaka.

Pickford, John (1997), *Low-Cost Sanitation in areas with Shallow Groundwater*, WEDC, Loughborough University, of Technology, U.K.

Roy, et al. (---), *Manual on the Design, Construction and Maintenance of Low-Cost Pour-Flush Waterseal Latrines in India*, TAG Technical Note Number 10, UNDP, India.

Webster, Mike (1998), Personal Communication, WEDC, Loughborough University of Technology, U.K.

World Bank (1998), *A Review of Key Environmental Issues in Bangladesh*, Workshop Discussion Draft, Dhaka.

World Bank (1996), *Information and Training for Low-cost Water Supply and Sanitation*, Washington D. C., 20433