STUDIES ON SEPTIC TANK EFFLUENT QUALITY AND SOAKAGE

A Thesis

by

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I hereby declare that the research work reported in this thesis work was performed by me as a partial fulfillment of the requirement for the degree of Master of Science in Civil Engineering from Bangladesh University of Engineering & Technology (BUET), Dhaka.

This thesis contains no material which has been accepted for the award of any other degree or diploma from any other institution and to the best of my knowledge and belief, this thesis contains no material previously published or written by any other person, except when due reference is made in the text of the thesis.

A H M SHAHIDULLAH

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ABSTRACT

The study is an experimental investigation aimed at looking into the effluent quality of septic tanks designed for different combination of domestic wastewater. The study also looked into the matter of soil absorption capacity of effluent of different quality.

In Bangladesh, sanitation programs are largely limited to on site options and exclude conventional sewerage technology, because of its high initial costs. The primary on-site sanitation options include septic tanks system. But many of the septic tank systems malfunction or fail for various reasons.

Septic tanks are designed normally either to receive toilet wastes or all type of wastes. The design criteria is the volume of sewage only. No consideration is given on the quality of septic tank effluent which is discharged to soakwells. In this study, effluent characterestics are determined in three different composition of domestic wastewater. These are toilet wastes only,toilet and kitchen wastewater, and toilet kitchen and bathroom wastewaters.

The test results show that qualitatively toilet wastes together with kitchen wastewater produce better effluent than toilet wastes only. The waste quality parameters like BOD, COD,TOC and SS are reduced to 40% of the original value Similarly all purpose septic tanks receiving toilet, kitchen and bathroom wastewater produce much superior quality effluent. In addition, organic contaminant removal efficiency of these septic tanks are very high, about 70%. But the major disadvantage of this combination is that the size of the septic tank and soak wells which increase enormously compared to other cases.

The most important factor to be determined when considering absorption system is whether the soil is suitable for the absorption of the effluent. Soil percolation capacity tests were conducted for determining the absorption capacity of soil. Percolation tests conducted with the three types of effluent on the same type of soil, as mentioned earlier. The absorption rate is more for effluent with toilet and kitchen;toilet, kitchen and bathroom than with toilets only. The toilet wastewater contain high amount of BOD,COD,TOC and SS which forms slime which deposit in the infiltrative layer and gradually reduce the absorption rate.

Finally an attempt has been made to propose a new approach for the design of septic tank where effluent quality has been taken into consideration. New approach is based on toilet and kitchen wastewater septic tank with 3 days detention time. This will ensure better functioning of the system and chances of failure of soakage pit will be reduced. In addition possibility of contamination of surface and ground water would be reduced as the effluent quality improves using this method. The bathroom wastewater may be discharged to surface drains as it contain insignificant quantity of contaminent. However all wastewater septic tank is recommanced when situation permits.

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LIST OF ABBREVIATIONS

ASAE	-	American Associations of Agricultural Engineers.
ASCE	-	American Associations of Civil Engineers.
BR	-	Bangladesh Railways.
BOD	-	Biochemical Oxygen Demand.
COD	-	Chemical Oxygen Demand.
DOF	-	Department of Environment.
DO	-	Dissolved Oxygen.
DW&CE	-	Director of Works & Chief Engineer.
EQS	-	Environmental Quality Standard.
FC	-	Fecal Coliform.
GE	-	Garrison Engineer.
lpcd	-	Liters per Capita per Day.
$l/m^2/d$	-	Gallons per Day.
LGED	-	Local Government Engineering Department.
L/M,d	-	Litre per Meter Square per Day.
MES	-	Military Engineer Services.
NO_3	-	Nitrate.
PO_4	-	Phosphate.
PWD	-	Public Works Department.
ppm	-	Parts per Million.
S & A	-	Shahidullah & Associates Ltd.
SS	-	Supended Solied.
TSS	-	Total Suspended Solids.
TC	-	Total Coliform.
TOC	-	Total Organic Carbon.
Vol	-	Volume.
WC	-	Water Closet.
WHO	-	Word Health Organization.

CHAPTER - 1

INTRODUCTION

1.1 Background

The most common type of individual sewage disposal system consists of a septic tank and soakage pit. This is the most convenient and satisfactory method of sewage disposal within the confines of the individual. The safe disposal of sewage and household wastewater is necessary to protect the health of the public to prevent the occurance of nuisences and to protect the environment in general. Each household equipped with running water and modern plumbing is faced with the disposal of waterbone wastes. In areas without community sewerage this need has been met through the installation of individual sewage disposal systems.

In Bangladesh, sanitation programs are largely limited to on site options and exclude conventional sewerage technology, because of its high initial costs. Sewerage system exists only in parts of Dhaka serving about 18% of 6.5 million city population (Rashid & Rahman,1994). The primary on-site sanitation options include septic tanks and pit (water sealed) latrines. Septic tank system is considered as the most satisfactory method of waste disposal and is being installed in large numbers in the cities and other urban centers of the country. Of the total sanitation coverage of 73% in Dhaka, about 40% population are served by individual septic tanks. About 31% of 2.0 million in Chittagong and about 22% of 8.5 million in the district towns are served by septic tanks(Rashid and Rahman,1994).

The primary purpose of a septic tank is to receive and treat household wastewater in order to produce effluent satisfactory for disposal into the ground or by other means. A septic tank should be designed to ensure removal of settleable solids and soluble organic matter by anaerobic decomposition. The partially clarified liquid which is discharged from the septic tank is still high in BOD and contains a large number of microorganisms which requires further treatment for safe disposal. In Bangladesh, the usual practice is to receive wastewater in the tank designed for specific retention and then dispose of the effluent largely by soak pits.

Normally septic tank volume is determined considering liquid holding time, storage of sludge and scum, and prevention of direct flow of wastewater out of tank. As the solids are separated and retained in the tank, the organic matter in the sludge and scum is anaerobically digested and stabilized. This retention volume of the tank is important. Depending on the desludging period, which may be one year or three years, the tank volume varies. So, the design volume of a septic tank is based on the liquid holding period and desludging interval of the tank. In current design practices septic tank effluent quality is not given any consideration. This effluent quality may affect the ultimate disposal system. In this study major emphasis is given on the effluent quality of septic tanks.

Septic tank design in Bangladesh has not been standardized yet and the organizations like PWD,LGED,MES etc have their own design specifications primarily based on quantity considerations. Septic tank effluent quality, the most important design parameter, has received very little attention so far. Effluent quality significantly influences the ultimate disposal of the effluent. Although a large number of septic tanks are being used in urban areas of the country, most of them do not have proper effluent disposal facilities. Septic tanks, discharging directly into open water bodies, drains or ditches are common. On the other hand septic tank connected to soak pits have problems of soakage overflows. Soak pits receiving septic tank effluents are either under designed or the pits face the problem of early clogging apparently related to the effluent quality.

1.2. Objectives of the Research

The study aims at looking into the effluent quality of septic tanks designed for different purposes e,g water closet only septic tanks,all purpose septic tanks and septic tanks receiving toilet wastes and sullage only. The study would also intended to look into the matter of soil absorption capacity for effluents of different quality.

The primary objective of this research is to assess the effluent quality of septic tanks of different configuration considering various sources of wastes. The study would also assess the absorption capacity of soak pits for different effluent quality.

The research would give guidance in the design of septic tank system with emphasis on the effluent quality. This would also increase the awareness of the designers in the final disposal of effluent into the soakage pits or to use other means. The objectives of this research work are selected as follows:

(i) to determine effluent quality of septic tanks for different combination of domestic wastewater.

(ii) to assess the overall efficiencies of septic tanks for treating different composition of domestic wastewater.

(iii) to assess the soil absorption capacity for different composition of domestic wastewater.

(iv) to suggest changes in septic tank design considering effluent quality and soil absorption capacity.

1.3 Methodologies

The methodologies of the research works is explained below:

Literature review is carried out by collecting and studying the recent journals in the field of septic tank effluent quality and absorption. Laboratory tests are carried out to determine physical, chemical and bacteriological constituents of septic tank effluent. Septic tank effluent are collected from different arrangement of domestic wastewater connection to tank as under:

-Toilet wastewater only.

-Toilet and kitchen wastewater.

-Toilet,kitchen and bathroom and wastewater(all purpose).

Raw sewage is collected from different arrangement of domestic wastewater discharged to septic tanks as mentioned earlier. Raw sewage is also collected separately from toilet, kitchen and bathroom.

Also the performance of soakage pits under different composition of wastewater are tested by percolation tests. All the above mentioned tests, are carried out in different capacity septic tanks under different organic and hydraulic loading.

Finally a better arrangement of septic tank and absorption pit has been suggested. For the purpose of field test, standard septic tank system of MES Army, Dhaka has been taken as ideal and all studies are related to that system.

1.4 Organization of the Thesis

The study is presented in six chapters. Chapter 2 contains a brief and selective review of the relevant literature.Since, not much work been done on this topic in Bangladesh a number of research papers have been collected from abroad. Relevant portions of these research works have been critically examined and presented in chapter 2.

In Chapter 3, the detail experimental conditions are described for determining septic tank effluent quality. Also the field testing programme and data collection programme are elaborated here.

In Chapter 4,results of the experimental conditions are presented and discussed.

In Chapter 5, a guide-line is recommended as the basis for new septic tank design.

Chapter 6 contains the conclusions of the present study and recommendations for future works.

CHAPTER - 2

LITERATURE REVIEW

2.1 Introduction

Throughout history major factors influencing the health and well being of a community have been the proper disposal of sewage and protection of water supplies from contamination. Safe disposal of sewage and household waste water is necessary to protect the health of the public and to prevent environmental pollution. In lieu of a high cost conventional sewerage system, the septic tank system is considered to be the most satisfactory method of household wastewater disposal.

A septic tank is a water tight chamber usually located just below ground level, that receives both excreta and flush water from toilets and other household wastewater including sullage. Large populations in both rural and urban areas rely on septic tank soil absorption system as the principal means disposal of domestic waste materials. The main functions of the septic tank are; to separate solids from the liquid, to store solids and provide digestion of organic matters, and to discharge the partially clarified liquid for further treatment and disposal.

The process occuring within the tank are complex and interrelated. However, the primary processes can be identified as under:

Separation of Suspended Solids: This process results in the formation of three distinct layer;a sludge layer at the bottom, a floating scum layer at the top and a relatively clear liquid zone in the middle. This phase is basically a coagulation process followed by sedimentation and flotation,depending on particle size and density.

Digestion of Sludge and Scum: Organic matter in the sludge and scum is anaerobically digested, which is ultimately converted to carbon dioxide and methane. The reaction is represented by the following simplified equation:

$$C_x H_y O_z + H_2O \text{ ----- } CH_4 + CO_2 + NH_3 \quad (2.1)$$

(Organic matter) (Methane)

Gas formation in the sludge layer causes flotation of the sludge flocs which resettle after gas release at the surface. Densification of the sludge layer occurs due to accumulation of over burden.

Stabilization of the liquid: During reaction in the tank,organic matter in the clarified liquid are stabilized by anaerobic bacteria.

Reduction of Microorganisms: Some microorganisms are separated out in the sedimentation process. Some die off naturally in the adverse environment in the tank. Thus there is an overall reduction in the number of micro-organisms. However a large number of them can be present in effluent, sludge and scum can cause health hazard if not properly disposed off.

Baumann (1977) conducted a study on septic tank performance to review fundamentals of treatment. As per his studies in normal domestic sewage, the suspended solids average about 300 mg/l of which 60 percent(180 mg/l) are settleable and 40 percent (120 mg/l) colloidal in nature and will not settle. Since suspended solids are typically about 70 percent volatile and 30 percent non-volatile or ash, under ideal conditions of anaerobic digestion in a septic tank over a period of a year or more, the sludge in the tank might be expected to convert to conditions of 40% volatile and 60% percent ash. Since the ash content would not change by digestion, it will remain in the tank along with biologically resistant organic material. If the tank is effective in retaining the settleable solids, in three years about 40% of tank volume will be filled with digested sludge. Therefore, unless the septic tank is cleaned out at least at 3 years intervals the accumulation of digested sludge will begin to interfere with the removal and retention of settleable solids.

The same study on the scum accumulation shows that sewage contain 20-40 mg/l of fats or grease. Since it is lighter than water it float and accumulates as scum on the surface of the septic tank and tend to dry out and harden. It will digest more slowly than the solids which accumulates on the bottom of septic tank.

In Fig 2.1, the clear space beneath the scum layer and above the sludge surface represents the volume designated for use as the sedimentation tank for the purpose of removing the settleable solids entering the tank. Once in the tank, the highly concentrated organic matter will deplete all the dissolved oxygen in the wastewater and anaerobic condition will prevail. The schematic action that occure will convert organic material as follows :

COHNS + Anaerobic Microorganisms=Energy

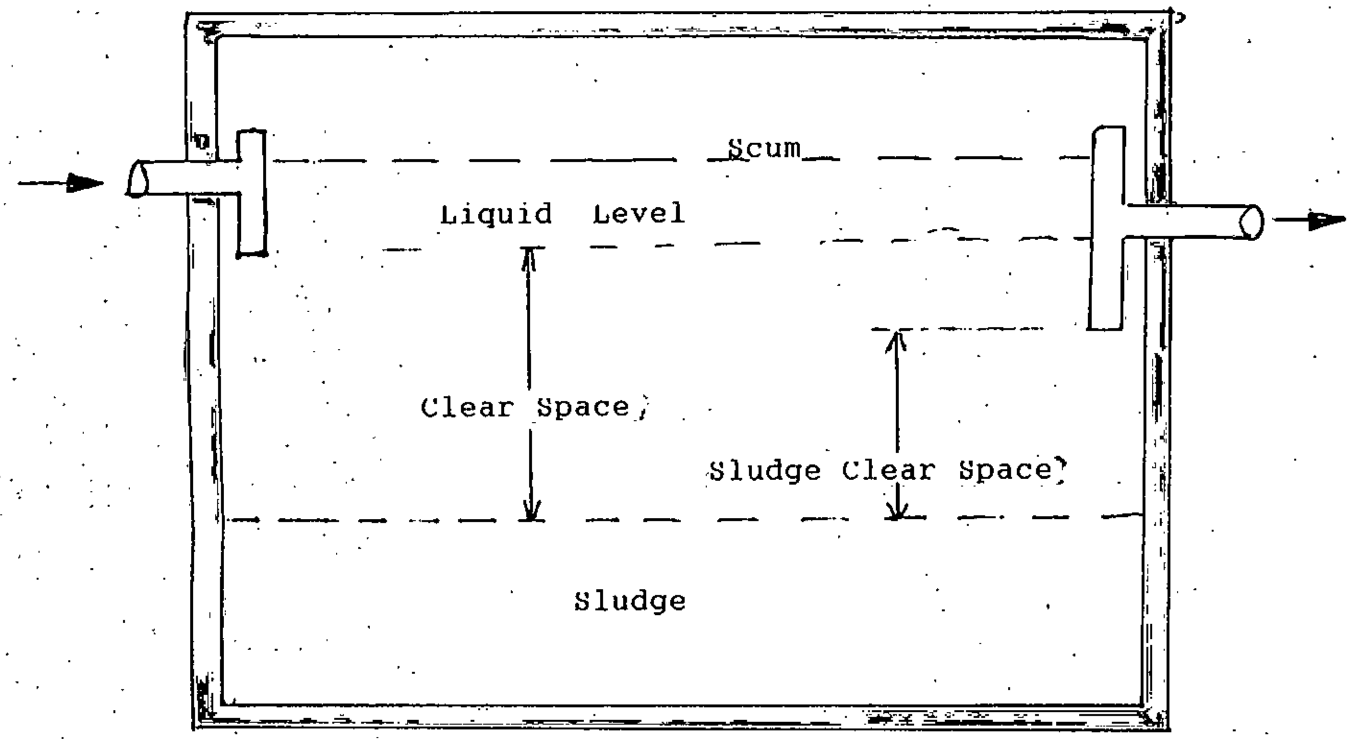
New Anaerobic Microorganism

(2.2)

Carbon C--- CH_4 (Methane)

Oxygen	C--- CO_2 (Carbon dioxide)
Hydrogen	H--- H_2O
Nitrogen	N--- NH_3 (Ammonia)
Sulfur	S--- H_2S (Hydrogen Sulfide)

Thus the organic materials will be converted to gas (CH_4,CO_2,H_2S,NH_3) and escape from the tank after the solubility of the gases in water is exceeded. The escaping gases must pass through the sedimentation volume and will interfere with the effective sedimentation of the settleable solids and seed the entire liquid volume with active anaerobic organisms carried up with the gas bubbles. So, during the period the liquid is stored in the tank, anaerobic decomposition of the colloidal, suspended organic solids and the soluable organic solids is enhanced.



Space Area Sq M	Sludge Clear Space MM
2.3	250
2.8	175
3.3	150
3.8	125
4.3	100

Figure 2.1 Ultimate Minimum Clear Space Required in Septic Tank (Source: Weibel et al, 1954)

2.2 Septic Tank Design

2.2.1 General

The primary purpose of the septic tank is to improve the effluent quality so as to protect and extend the service life of the secondary treatment soil disposal system. A septic tank should be designed to remove close to 100 percent of the settleable solids from the tank effluent and to provide as high a degree as possible of anaerobic decomposition of the colloidal and soluable organic solids prior to discharging the liquid effuent to the absorption pit. The tank design must provide for :

* Sludge storage without interfering with the discharge of liquid free of settleable solids.

* Scum storage in such a way that no scum can accumulate in or be carried into the tank outlet.

* Inlet and outlet baffles to direct the flow to prevent short circuiting of hot and or cold water and keep scum and sludge out of the outlet.

* Gas accumulation and venting provisions to allow the escape of methane (an explosive gas) and hydrogen sulfide (a toxic gas).

* Access to the tank interior for inspection and cleaning. For the design of septic tank following parameters should be considered :

* Hydraulic loading.
* Organic loading.
* Size of the tank.
* Inlet and outlet of septic tank.
* Tank compartmentation.

2.2.2 Hydraulic Loading

Jones (1975) found in a study of 22 homes in USA (10 on a public water supply and 12 on private water systems)that mean daily water use was 49 gallons per person, ranging between 32.7 and 66.1 gallons per person per day. Homes on private and public system had 1 minute peak flow rates of water demand of 17 and 8 gallons, respectively. Peak 15 minute demand of 124 and 87 gallons respectively, were recorded. Most of the hydraulic loading on a septic tank was found to occur in a short period of time, 25 percent in 1 hour or less and 45 percent in 4 hours or less.The rate at which water is used in the home is not, however, the rate at which water enters or leaves a septic tank. Generally, the designer of a septic tank has little control over the reduction in the peak water use rate in the home sewer system before it reaches the tank. He does have significant control over the septic tank design to control the peak discharge rate from the septic tank.

Septic tank should be designed to control the peak discharge rate from septic tank. Normally, the invert of the inlet of a tank is set at an elevation 3 inches higher than the invert of the outlet of the tank since all water that enters a septic tank must rise above the invert of the outlet before water can leave the tank. The rise of the water serves to put water into storage, the volume of storage being equal to the surface area of the tank times rise in elevation of the water. So when the surface area increases the discharge rate from the tank fall. So a large surface area is preferred. The rate at which water is used in homes is discharged to septic tank at a lower rate. This is done by placing the used water in storage until the depth of water rises to a high enough level to cause a pipe flow equal to the flow of wastewaster. Due to this the time of discharge is lengthened and the peak discharge rate is reduced. This fact suggest that both the minimum and maximum slopes of the house line to the septic tank should be restricted. The discharge rate from the septic tank will be low for the smallest size of outlet pipe to control less flow. A 2 inch tank discharge would be preferable, hydraulically, to either a 3 inch or 4 inch pipe. However, reducing the discharge rate in this way may cause poorer distribution of effluent in the absorption pit and contribute to progressive clogging there due to growth of anaerobic organisms utilizing the soluable and colloidal organic solids in the septic tank effluent.

Johnes (1975) also indicated that when a water closet is flushed, it discharges about 4 gallons of water at about 35 gpm, most of the water entiring the septic tank within about 15 seconds. This represents the most frequent type of high rate discharge into a septic tank. The flow will produce a maximum rise 0.2 inch in a tank with a surface area 32 square feet. More than 20 minutes would be required for the water to discharge from the tank with a 4 inch outlet at a rate of 0.21 gpm.

Thus, the outlet velocity in the sludge clear space and in the vertical pipe would be very low. So, an important part in the design process would be the selection of hydraulic loading rates that would yield acceptable hydraulic performance.

2.2.3 Organic Loading

The organic loading is an important part of the treatment process in the septic tank. The total suspended solids (TSS) in sewage entering a septic tank range from 150 to 300 mg/l. A part of the settleable solids settles out and float in the scum layer. The remaining are carried out with the septic tank effluent. Table 2.1 give typical effluent concentrations. As can be seen, the effluent is generally high in BOD, organic nitrogen, phosphorus and coliform. It has been observed that the reduction of BOD and TSS can be improved by prolonging the retention time. Removal of BOD and TSS in excess of 80% can be achieved by providing a retention time greater than 20 days. However such a long retention time is impractical.

Table 2.1 Septic Tank Effluent Concentration and Percent Removal.

	Effluent concentration in mg/l	Percent Removal
BOD	160	30
COD	320	50
TOC	130	45
Total Phosphorous	18	40
Total Nitrogen	32	8
Organic Nitrogen	8	20
Total Solids	380	45
TSS	90	70
Coliforms	10^5-10^6/100ml	-

(Source : Selvato, 1982)

Septic tank pretreatment is normally employed to provide preliminary treatment of wastewater prior to discharge into a subsurface soil absorption system. In the septic tank,treatment is accomplished primarily by solids-liquid separation. The composition of septic tank effluent varies widely depending on the characteristics of wastewater producing source. Increased organic loading to the septic tank requires increased detention time for digestion. Improperly designed septic tank produce a poor effluent which over clogs the seepage field and causes system failure (Lack. R,1974).Low quality effluent is caused by the presence of excessive suspended solids, biochemical oxygen demand (BOD) and other nutrients.

Kalberatten et al (1980),carried out study on three chamber septic tank for use in medium density housing area. There is separation of toilet wastewater, from the remaining household wastewater or sullage. Toilet wastes only are discharged into the first chamber and sullage directly into third chamber, the second chamber provides additional and more quiescent settling for fecal solids. First chamber designed for 0.15 M^3/User requires desludging apprpximately every 2 years. The second and third chambers provide 1 day detention time in each. Since the effluent from the third chamber contain very few fecal solids, the long term infiltration rate of the effluent is much highter, approx 30L/M^2 day - 60L/M^2 day as opposed to 10L/M^2 day - 30 L/M^2 day for conventional septic tank. So the required absorption area is correspondingly smaller. From this study it is clear that when the toilet waste is mixed with sullage the organic loading is reduced which results better effluent. However, the extent of mixing of toilet waste, kitchen wastewater and bathroom wastes has not been studied earlier.

2.2.4 Size of the Septic Tank.

A septic tank should provide sufficient volume for sludge and scum storage and sedimentation. The tank should have a nominal liquid capacity to within 10% of that calculated in accordance with the following on the basis of the number of persons served. Manual of septic tank practice produced by the household waste treatment committee for the Ministry of Water Resources and Water Supply, Victoria Australia, suggests,household and other sources not exceeding 10 persons as:

W.C wastewater including kitchen wastes = Nominal capacity 2000 litres. (2.3)

All household wastes = Nominal capacity 3000 liters. (2.4)

Other classes of occupancy in accordance with the equation:

$$C = (2000 + P) \text{ liters.} \quad (2.5)$$

Where, C = the nominal liquid capacity of the tanks.

P = daily flow for design population as determined from Table 2.2 of daily flow rates for septic tank.

Table 2.2 Daily Flow Rates for Septic Tank System:

Contributing Source	Sewage Flow liters/person	No of Persons per unit
Houses		
W.C only	40	
W.C and kitchen wastes	60	5 per house
All waste water	200	
Flats and Units	150	2.5
Hospitals		
Nursing and geriatric	200	Per patient bed
Surgical and Medical	500	
Hotels, Motels and Residential homes	100	1.5 Per Room

(Source : Draft Manual of Septic tank Practice, Melbourne, Australia, undated)

The shape and dimensions of the tank are relatively unimportant to its operation provided that good settling characteristics and a minimum hydraulic scouring occurs. For tank in excess of 2000 liters capacity,it is subdivided into a larger first and a smaller second chamber at a ratio of 2 to 1. Multiple tanks or chambers provide an extra degree of sedimentation for removal of suspended solids. The ideal ratio of length to width for a single chamber tank is 3 to 1, but shall not be less than 1.5 to 1 (Draft Manual, Australia).

Cotteral (1969) describes size of the tank as one of the most important factors for septic tank performance. He suggests that since absorption system failure follows directly from the passage of solids through septic tank and into the drain field, with the resultant clogging of the infiltrative surface, tank must be sized to provide the best attainable removal of suspended solids. He assumes that all wastes (household) will be routed through septic tank. Approximately two thirds of the liquid volume of a septic tank be normally reserved for the storage of accumulated sludge and scum. Theoretical detention time recommended by USPHS for single compartment tank is 12 hours for a 1000 gallon tank to 21 hours for a 750 galon tank. A septic tank pilot study conducted by the Sanitary Engineering Research Laboratory of the University of California revealed that an added 28% suspended solids removal could be achieved by increasing the detention time from 20 hours to 35 hours which necessitates increasing the size of tank. Variations in tank shape and proportions within the normal ranges used do not appear to have much effect on performance so long as the detention time is same.

The volume provided in the bottom of a septic tank for accumulated sludge storage will depend on the size and shape of the tank and on the sludge clear space required to keep the sludge from entering the outlet. Weibel et al (1954) considered that the sludge clear space should be bigger as the tank surface area gets smaller. He intimated that the tank required cleaning when the sludge storage encroached on the sludge clear space, which must occur unless the tank is cleaned to remove accumulated digested sludge. Study of the hydraulics of flow into and out of a septic tank, however, suggest that a preferable minimum sludge clear space should be provided. Increasing the volume of a septic tank, therefore, should provide increased efficiency of suspended solids removal by increasing the volume of clear space provided.

Bashar (1990) made an attempt to standardize septic tanks for Bangladesh. In his study he proposed to lead toilet and kitchen sullage to septic tank. He also proposed to account for 40 gpc of wastewater flow in determining septic tank capacity. Minimum retention time considered was 24 hours and tanks max and min length/width ratio 2:1 and 6:1 respectively, the tank should be of two compartment and divided in the ratio of 2:1 with desludging interval of 3 years. In his design, width and depth of the tank are kept fixed while the length is varied directly with the number of users. Dimensions of septic tanks proposed by him are given in Table 2.3.

Table 2.3 Dimensions of Septic Tanks.

Number of Users P	Liquid Depth D	Width W	Length Lft	
			District Towns	Metro Cities
10 - 20	3' - 6"	2' - 6"	0.55P	0.66P
20 - 30	3' - 6"	3' - 6"	0.40P	0.52P
30 - 50	4' - 0"	4' - 0"	0.30P	0.40P
50 - 100	4' - 6"	4' - 6"	0.20P	0.26P
100 - 200	5' - 3"	5' - 3"	0.14P	0.18P

(Source : Basher, 1990)

In Bangladesh, septic tank systems are designed on the basis of per capita sewage production. Public Works Department calculate the capacity of tank on 22 gpcd sewage production and detention time is taken one day. Shahidullah & Associates Ltd determine the capacity of tank on the basis of 40 gpcd sewage production. Bangladesh Railways calculate the capacity on the basis of 50 gpcd sewage production. Whereas Military Engineer Services determine the septic tank capacity on 22 gpcd sewage production. Bangladesh National Building Code (1993) suggests, a septic tank should have a minimum liquid capacity of 2000 liters, minimum width 1m and minimum liquid depth 1m. The length of septic tank shall be at least twice ist width and in no case the length of the tank be more than four times its width. It also recommands to use two chamber septic tank when liquid capacity exceeds 3000L.

2.2.5 Inlet and outlet of Septic Tank

The wastewater flow into and out of a septic tank must not be such that the settleable solids are carried out of the tank. The inlet to a tank should be designed to dissipate the energy of the incoming water and to prevent short circuiting of the water in moving from the inlet to the outlet of the tank.

The inlet should preferably be either a sanitary tee, an elbow or a specially designed inlet device. The outlet may be protected by an outlet tee, by a baffle or by special outlets. In addition to protecting the effluent by reducing flow velocities and by providing gas deflection, large septic tanks are compartmented. Outlet protection using gas deflection baffles are an essential requirement for all septic tanks.

Bauman and Babbitt (1953) described tests with six septic tanks of various volumes and found that, gas deflection baffles only on the effluent compartment are effective in the prevention of tank unloading and in the reduction of normal carryover of settleable solids into the effluent. If an outlet baffle is used instead of an outlet tee, a gas deflection baffle can be installed across the tank to provide a larger protected volume. The protection of the water about to be discharged from the tank is important in keeping settleable solids in the tank.

2.2.6 Septic Tank Compartmentation

The University of Illinois(1946) studied five different tanks of 1080 gal (3.8 M^3) each. The tanks were dosed 4 times/day with a 360 gal/dose of city sewage. Comparison of single compartment, double compartment and triple compartment arrangements showed that the two compartment tank gave best results. The compartment segments of unequal detention time (72 hrs, 48 hrs,26 hrs) were compared and it was concluded that a more efficient tank could be a two compartment tank with a 72 hrs first compartment. The test also confirmed that *effluent from* the second compartment was better than that from the first compartment.

Studies in Australia (1970 s) shows that tanks with two equal compartment were found to be slightly more efficient than single compartment and double compartment tanks which had a large first compartment. Because the first compartment stored most of the solids. Single compartment tank effluent except for large capacity tanks, were observed more turbid as compared to the multi compartment tank effluent.

A second study was conducted by the University of Illinois in late 1940s using six different tanks; circular, cylindrical, rectangular, and two shallow imhoff type tanks. Two series of test were done using communal sewage, a variety of detention period from 6-48 hrs and a dosing apparatus. The tanks or effluent, or both,were measured for BOD, solids, turbidity and sludge accumulation, by a dye test and by a sand filter test. The first series of tests showed that the two multi-compartment tanks without inlet and outlet baffles were 10% - 20% less efficient than the four compartment tanks which are baffled. All tanks performed better at longer detention periods. The second series of tests using 27 hrs detention time showed that gas baffles are of paramount importance in eliminating unloading and improving the effluent qualify. The best consistent quality effluent was achieved using a multichamber tank with gas baffles. The outside shape of the tank, circular, cylinderical, or rectangular did not have any significant effect.

Additional studies (Laak, 1980) were carried out on multi-compartment tanks with periodic sludge additions to shorten test duration.All of the five test tanks unloaded sludge occasionally, the multicompartment tanks showed better quality effluent than a single compartment tank of equal capacity. A test showed that the minimum size of the first compartment is more important than the size of the second compartment.

Tests were conducted with three multicompartment tanks, having various surface area/depth ratios. It appeared that low surface area/depth ratios of 0.3 and 0.6 were less desirable than a ratio of 3. Current practice is a multicompartment tank with total capacity of the tank computed to equal a minimum detention time of 24 hrs or to equal the volume of maximum daily flow. The first compartment is usually calculated to be equal to two thirds the total tank capacity. Greater treatment efficiency is predicted if longer than minimum detention time are chosen.

In Bangladesh, septic tanks designed by PWD, S & A, BR and LGED have two compartment. Whereas MES design for single compartment tanks.

Theoretical evaluation of septic tank unit operations and unit processes showed that multicompartment tank effluent quality would be more stable. A mulicompartment tank has a greater potential for reducing effluent solids, short circuiting and turbulence.

2.3 Bacterial Modification of Septic System Effluents

Domestic wastewater contain bacteria, viruses, protozoa and helminths pathogenic to humans (Burge and Marsh, 1978). In addition, these infectious agents are widely distributed in many waste effluent and are commonly present in high numbers. Therefore, untreated domestic wastes embody a potential health hazard, and proper waste water purification and disposal is an important concern (Hoadly and Loyal, 1976). Septic tank soil absorption treatment systems serve as the principal disposer of waste effluent to the soil environment (Geraghty and Miller, 1978). Soil percolation of septic wastes is required for purification of drainfield effluent before it replenishes ground water utilized by individual and public water supply wells. However, many shallow ground water supplies have been polluted by contaminated recharge waters, and several investigators (Brooks and Cech, 1979 ;Hackett, 1965, Maynard, 1969 ; Rock, 1960, Sandhu et al, 1979 ; Wall and Weibel, 1970) have attributed such a decline in water quality to indiscriminate use of septic tank systems in soils unsuited for adequate domestic waste purification.

The septic tank is designed to slow the movement of raw sewage and promote the removal of solids either by settling or liquifaction. The organic load and fecal bacterial populations are reduced only to a limited extent. As an example of the minimum purification afforded by passage through septic tank ; Ziebell et al (1974) enumerated selected fecal bacterial populations in effluents from five systems and observed mean population densities of 3.4×10^{8} /100 ml for total coliform, 4.2×10^{6} /100 ml for fecal coliform 3.8×10^{6} /100 ml for fecal streptococci, and 1×10^{6} /100 ml for pseudomonas areuginosa. Also BOD_5 reductions of only

30-50%. were noted in all cases. Therefore, distribution of the septic tank effluents into unsaturated soil appears to be necessary to complete the treatment process. The soil must furnish the bulk of physical filtration, chemical reaction and biological transformations (Goldstein et al, 1972).

The most comprehensive study (Bauma et al,1972) on soil absorption of septic system effluent has been conducted by the small scale waste management project group at the University of Wisconsin. In the report of investigations on the purification efficiency of 19 subsurface soil disposal systems concluded that septic systems which exhibited proper hydraulic functioning also served to purify septic effluent. Bacterial filtration was determined by directing a drainfield and enumerating indicator organisms present in the soil at various distances below the drainfield trench. The large population of TC,FC and enterococci present in the effluent were reduced within 61 cm below percolation trench. Since this clogged layer, a few centimeters in thickness, was highly efficient in trapping and holding bacterial species present in the wastewater, it served as primary barrier to subsurface escape of fecal organisms.

However, if the developed mat was too thick or dense and restricted the hydraulic functioning of the system, then the effluent could not enter the soil and become pounded in the trench and subsequently spilled out into the surface.

Soil samples collected 30 cm lateral to and 8 cm below the trench produced coliform levels 100 fold less than the septic tank effluent, and samples collected 30 cm lateral to and 38 cm below yielded values 3,000 fold less than tank effluent. Therefore, in a properly functioning absorption field, the fecal indicator and potentially pathogenic bacteria were almost completely removed after a relatively short distance through unsaturated soil, Based on other reports, approximately 30-90 cm of soil beneath the base of the drainfield trench was adequate for complete bacterial removal of septic effluents. Therefore, US Public Health Service 1967, recommended for 120 to 150 cm of suitable soil as an adequate zone for the protection of ground water fall well.

2.4 On - Site Effluent Disposal System

Although the effluent from or septic tank undergoes some treatment in passing through the tank, further treatment is required before it can be considered safe. The appropriate method of treatment and disposal will vary considerably according to factors like site condition, economic considerations and environmental matters.Subsoil disposal of effluent has occasional malfunctions or breakdowns. The discharge of septic tank effluent below ground is by far the preferred option. The absorption systems may be soakage pits or absorption trenches. Whatever may be the type of absorption system it should be based on the ability of the soil to filter out pollutants within the effluent before it reaches the water table or a watercourse.

The most important factor to be determined when considering absorption systems is whether the soil is suitable for the absorption of the effluent. The soil factors which determine the rate of absorption are the infiltrative capacity of the liquid soil interface and the percolative capacity of the soil itself. Septic tank effluent is different in composition from clear water and therefore the long term infiltration rate will be less than the water percolation rate. The capacity of the soil to absorb the effluent is given by the long term infiltration which can be obtained by the soil percolation capacity test. Regarding effluent absorption the most common problem with a soil is that it is too impermeable, occasionally a very permeable soil such as sand may also be unsuitable. Such soils may not treat adequately and pollution of surface and groundwater may occur. It is recommended that absorption systems be limited to a maximum dosage rate of 50 $L/M^2/d$,irrespective of how permeable the soil might be. (Manual of Septic Tank Practice, Melbourne, Australia).

In location where the subsoil is unsuitable for the absorption of effluent or where it is not possible for absorption systems to be installed, considerations may be given to the disposal of effluent by the process of evapotranspiration. Evaporation from the ground surface and transpiration through grasses and shrubs growing on a specially prepared bed or trench enables the effluent to be disposed off without further treatment being necessary. In rocky areas where absorption systems are unsuitable or where the water table is high, the transpiration system can be constructed as a mound so as to reduce the amount of excavation required.

2.5 Soakage Pit

Although the effluent from a septic tank has undergone some treatment in passing through the tank,further treatment is required before it can be considered safe. So, the septic tank effluent is allowed to pass through a soak pit where inverted filters are provided at the bottom for further decomposition of organic substances present in the effluent. Final treatment is done by filter bed so that the effluent cannot pollute the ground water surface. Under favorable circumstances subsoil disposal of effluent has little immediate effect on the environment, major problem occurs due to occasional malfunctions or breakdowns.

The liquid capacity of soak wells shall be at least twice that of a septic tank (Bangladesh National Building code 1994). The size of the wells vary between 3 to 6 feet in diameter and 15-20 feet in depth. If the soil permits further depth is recommended upto 40 feet or sand layer. Soil percolation test is an important factor to determine the suitability of the site for soak well.The absorption capacity of sock well is determined from percolation tests results.Values from Table A31 can also be assumed Effective absorption area may be computed based on the discharge rate of effluent from the septic tank. The absorption capacity of soakage pit also depends on the effluent quality of septic tank. Turbid effluent will have different percolation rate than clear effluent. The inverted filters of soakage pits are made of crushed stone or brick bats.

Other methods of on-site disposal systems such as absorption trenches and transpiration beds require larger land area and isolated locality which gets direct sun light and air. On the other hand soakage pit requires minimum land area as the absorption bed is vertically down. It does not create any nuisence and no direct sunlight and ventilation is required. It may be constructed adjacent to septic tank. Construction cost of soakage pit is low. The disadvantage is if the ground water table is close, the pit is likely to be filled quickly and the soakage will be less.

In Bangladesh, soakage pits are the most suitable method of septic tank effluent disposal. Here the population density is more and the houses are not much dispersed. In urban areas, there is hardly any space left for the disposal of septic tank effluent. A soakage well hardly requires 25 sq feet area. If properly designed and maintained, a septic tank system shall function better with soak wells in Bangladesh. Basher (1990) standardized the soakage pits dimension, which are given in Table 2.4.

Table 2.4 Dimensions of Absorption Pits

Number of Users	District Towns		Metro Cities	
	Diameter	No of Wells	Diameter	No of Wells
20	3'-0"	01	3'-0"	01
30	3'-0"	01	3'-6"	01
50	3'-6"	01	5'-0"	01
100	5'-6"	01	5'-0"	02
200	5'-6"	02	6'-0"	02

(Source : Basher, 1990)

Note : Depth of pits 20ft minimum. Effluent loading rate is taken 3 gal/ft^2/d.

Public Works Department (PWD) of Bangladesh design soakage wells for effluent loading of 120L/m^2/d. Military Engineering Services (MES) and Shahidullah Associates (S&A) design soakage wells for a loading of 80L/m^2/d and 200L/m^2/d respectively. All these design parameters are applied without determining the field absorption capacities of soils.

2.6 Septic Tank Performance

The minimum performance expected from a septic tank include nearly complete removal of settleable solids. Babbitt and Baumann(1958) conducted tests on six small septic tanks dosed intermittently with municipal sewage to provide a retention time of about 30 hours, the tank efficiencies are listed in Table 2.5.

Table 2.5 Performance of Six Small Septic Tanks

Test	Units	Raw Sewage	Septic Tank Nos 1	2	3	4	5	6
Suspended Solids	mg/l	267	55	63	46	85	40	79
Settleable Solids	mg/l	8.05	0.45	0.07	0.08	0.83	0.09	1.79
BOD_5	mg/l	301	63	103	70	91	84	104

(Source : Baumann and Babbitt, 1953)

All tanks were dosed on a similar basis without major flow variations. Graphs were plotted for settleable solids over a period of four month. It was seen that the settleable solids in the effluents from the tank not equipped with baffles (Tank 1,4 and 6) are significantly greater than those tanks incorporating some form of gas baffles in their design (Tank 2,3 and 5). It also showed the removal of suspended solids by the six tanks,which might be expected to parallel the removal of settleable solids except for the anaerobic biological activity that takes place in the clear space. Such biological activity might increase the removal of suspended solids.

Septic tank systems are reasonably efficient systems only when the septic tank volume and effluent disposal method have been determined by the sewage loading from the building being served and is satisfactorily installed and maintained.

2.7 Causes of Septic Tank Failure

2.7.1 Soil Clogging

Improperly designed septic tanks produce a poor effluent which cloggs the seepage field and causes system failure. Low quality effluent is caused by the presence of excessive suspended solids, BOD and other nutrients. On the soil interface a biological mat forms. The mat is approximately 1 to 2 inch (2.45 - 5 cm)thick and filters discharge. The mat's permeability depends upon the delicate balance of load and natural unload. The load is caused by hydraulic head, nutrients and the solids applied. The mats unload results from biological degradation, liquification, demineralization, gravity and capillary flow in the mat and in the soil below the biological mat. A safe design would have an unload/load ratio of greater than one representing the safety factor against clogging failure.

Often the most cost effective technique to increase the safety factor against clogging failure is to increase the efficiency of the tank. In case of an existing clogged seepage bed, sufficiently increasing the septic tank treatment will reduce the degree of clogging and could eliminate the need to replace or expand the field (Laak, 1980).

Microbial growth at the soil water interface occurs within the first 2 inch of soil. This growth results in a slime layer which greatly reduces the soil permeability within the zone. The filtration of suspended solids adds to this reduction of the naturally occurring soil permeability. These processes occur on a time scale of weeks while another biological process, the reduction of sulfate to ferrous sulfide develops over months and years. This latter process can ultimately lead to highly impermeable conditions and to failure of the soil absorption system. Because of the reduction in the infiltration rate, the maximum percolative capacity of the soil is not maintained (Mara,1981).

Inadequate maintenance and design and improper construction are the three main causes of septic system failure. Causes of vast majority failures in septic system are associated with the problem in the disposal medium. The single most important failure mechanism is the formation of an impermeable clogged or crushed layer at or near the disposal bed soil water interface. Clogging results from three interdependent processes; growth of a microbially induced slime layer, physical entrapment of suspended solids from the septic tank effluent and reduction of sulfate to an impermeable ferrous sulfide due to development of anaerobic conditions in the slime layer (Noss ,1989). Anaerobic condition within the clogging zone will lead to further clogging through the growth of slimes and deposition of ferous sulfide in an even deeper zone of 2 inch to 3 inch beyond the surface (ASCE,1969).

Since anaerobic condition results in rapid clogging of the liquid soil interface, periodic reaeration of the soakage pit/drain field is important to the life of the system. For this reason continous inundation of the *absorption* pit must be avoided.

Restoration of aerobic conditions has the effect of restoring high rate aerobic decom position. The change of the deposited ferrous sulfide to soluble matter in the presence of oxygen in part accounts for the beneficial effects of restoring a absorption pit (ASCE,1969).

There should be sufficient absorption area for the effluent generated from the septic tank. Failure to provide minimum soil column length in an area with a high groundwater table will lead to continued inundation and failure.

Soil with effective size ranging from 0.1 mm to 1 mm or greater have long term infiltration rates. If the soil particle size is too small, bacterial removal will be excellent but infiltration and percolation rates will be unacceptable. But for coarse size particle it is otherwise.

Soil clogging can be delayed or altogether mitigated by reducing the applied mass loading rates of total BOD and total suspended solids either through lower hydraulic loading rated or reduced effluent concentration (Siegrist et al, 1987).

Investigation reveals that soil clogging development accelerates at higher hydraulic loading rates or with more concentrated effluent (Jones and Taylor, 1965 Laak, 1970; Hargettet) concentrated near the infiltrate surface were effective in blocking and filling soil pores, thereby reducing natural soil infiltration rates.

2.7.2 Role of Wastewater Quality

Siegrist (1986) observed that silty clay loam soils intermittently dosed with tapwater (1.3 to 5.2 cm/d) experienced no clogging during 70 months, of loading. Soils continuously flooded with tapwater resulted in soil clogging (Allusion, 1947). Tapwater amended with organic matter and nutrients appeared to stimulate soil clogging (Macula, 1950). Siegrist demonstrated that soil clogging development in a silty clay loam soil was highly co-related with the cumulative loading of total BOD (ultimate carbonaceous and nitrogenous) plus TSS.

Domestic septic tank effluent (STE) clogged more rapidly than aerobically treated STE (with a TOC and TSS content approximately 4 to 5 times lower than in the untreated STE). At high loading rates, the untreated STE induced a clogging rate about 3 times as fast as that of aerobically treated STE.

Clogged infiltrative surface zone have been consistently characterized by elevated water contents and organic matter accumulations at the soil infiltrative surface and disposed within the first 10mm of the soil matrix (Siegrist, 1987). The organic carbon contents in clogged infiltrative surface zone have always been less than 0.074 kg/kg (7.4% by weight). While low, these concentrations of organic materials have been effective in blocking and filling soil pores and thereby dramatically reducing natural soil infiltration rates.

Research by Weibel, and others showed that the higher the BODs in the septic tank effluents of the same TSS, the faster the soils clogged. A study by Winneberger (1960), showed that septic tank effluent and extended aeration plant effluent clogged soil at the same rate when their BODs's were about the same and the TSS concentration was 150 percent higher in the aerobic system. Measurements on BOD and TSS removals in the soils showed that the aerobically prepared liquid loses more TSS in the soil than the anaerobically prepared liquid.

Increasing the pretreatment of domestic wastewater prior to soil application increases the service time of the soil surface. The service time of the soil surface is directly related to the sum of total SS and the BOD.

2.7.3 Hydraulic Loading Rates and Insufficient Absorption Area

Hydraulic loading rate is an important factor for the failure of septic system. As long as loading rates are sufficiently low that soil moisture content don't approach saturation and cause anoxic soil conditions, soil clogging development will be roughly equivalent at equivalent mass loading rates. By this approach, wastewater effluents possess concentrations of the BOD and TSS lower than typical domestic septic tank effluent . When the loading rates are more than absorption rate, failure of the system occurs.

Similarly loading rates should correspond to the infiltrative capacity of the area and sufficient absorption area is available. But if the volume of effluent generated is more than the available absorption capacity the system will fail.

2.8 Effluent Quality Standard

The pollution control programme all over the world envisage that need for a stringent effluent quality standard in the face of increasing waste volume with industrialization and rapid growth of population. The Royal Commission (RC)of UK adopted two basic effluent quality parameters, BOD and SS and proposed that normal treated effluent should have a quality of 20mg/L of BOD and 30 mg/L of SS or better. The RC 20/30 standard has been widely adopted although sometimes a stringent standard may be required for streams receiving effluent with dilution factor less than 8 (Ahmed,1985). The tolerance limits suggested by Indian Standard Institution (Ahmed 1985) for industrial effluents discharged into inland water are 30 mg/L of hexavalent chromium and 5.5 to 9.0 for PH. Standard values of industrial effluent proposed by Department of Environment (DOE) Bangladesh is given in Table A.33 in Annexure A. Water quality standards in Bangladesh issued by DOE is also given in the same annexure. However there is no set standard for effluents to be discharged to soak pits. But it should be such not to pollute ground water or nearby surface water.

CHAPTER - 3
EXPERIMENTAL PROGRAMME

3.1 Introduction

This chapter describes the various parts of field survey, data collection, description of the experimental conditions, laboratory test programme and field test programme under-taken in this study. The purposes, equipments used and the experimental procedure of each parameters are described and presented in some detail. The present study aims at looking into the effluent quality of septic tanks, designed for different purposes e.g. water closet only septic tanks, all purpose septic tanks and septic tanks receiving toilet and kitchen wastewater only. The study would also look into the matter of soil absorption capacity for effluents of different quality. With this aim, septic tank effluents were collected from different locations of family quarters of Dhaka Cantonment area from different sizes of septic tanks and different loading rates of tanks. Field percolation testing were done using septic tank effluents of different composition in the close vicinity of soakage pits to determine the absorption capacity of soakage wells. The test procedures are analyzed and described in this chapter.

3.2 Field Survey and Data Collection

Dhaka Cantonment, originally known as Kurmitola Cantonment was established during World War II. Gradually the area expanded and a large number of unit lines,headquarters and family accomodations came up over the last 35 years. The Cantonment was not expanded in a planned manner as such no sewerage system was developed. Individual offices and accomodations have its own septic tank and soakage wells constructed time to time as per MES type design.

The size of soakage pits are same irrespective of soil absorption capacities. Most of the septic tanks and soak wells overflow, which require continuous cleaning.

In order to assess the reasons for septic tank overflowing in Dhaka Cantonment area, a field survey was undertaken in different residential colonies. Data on septic tanks sizes and numbers were collected from different areas. Also the overflow rate and frequency of septic tank cleaning was noted. From these data suitable sites were selected for sampling points for the study. Field visits were made during September,1994 to August,1995 to collect the data. In order to collect information regarding water consumption, a questionnaire was prepared and a door to door survey was conducted.

3.3 Description of Test Sites

Three test sites have been selected in Dhaka Cantonment area, located 7 miles north of Dhaka city. These are typical of the areas comprising multistoried buildings and the sanitation system based on individual septic tanks and soak pits. The tanks are of different sizes serving different number of users. The areas are Kafrul officers quarters, Golf club officers quarters and E in Cs complex staff quarters. The map in Fig 3.1 - 3.3 shows the test sites, details of which are described below.

3.3.1 Test Site 1

It is located in Kafrul area.there are 16 numbers of 4 storied buildings and each building has 8 family flats in the area. An average of 6 members live in each flat and in total 48 persons live in each building. For each building domestic wastewater is treated in a septic tank and discharged to a soakage pit. Waste-water is generated in each flat through standard water using fixtures comprising 4 water closet toilet, 4 hand wash basin, 4 showers, 1 kitchen sink & 2 laundary wash point.

Deep tube well water is supplied to all water points. Field survey estimates that the mean daily water use was 120 liters per person, which generates approximately 5760 liters of wastewater per day. There are three plumbing lines in each building ; one for carrying toilet wastes, one for carrying kitchen sullage and the
third one for bathroom and washwaters.In the original setup of the building only the toilet wastewater line is connected to the septic tank. From the field survey it appears that approximately 36 lpcd wastewater is generated from toilets, so a total of 1724 lpd of toilet wastes are discharged to the septic tank.

The liquid volume of the septic tank is 9120 liters. The minmum retention volume is 1/3 liquid depth which is 3040 liters. So the average detention time is 67 hours prior to discharge of effluent to the soakage pit, when the tank is 1/2 filled with sludge.

The site is on original ground and are not inundated during monsoon. The soil is sandy clay. The septic tank system of this building faces frequent soakage overflow.

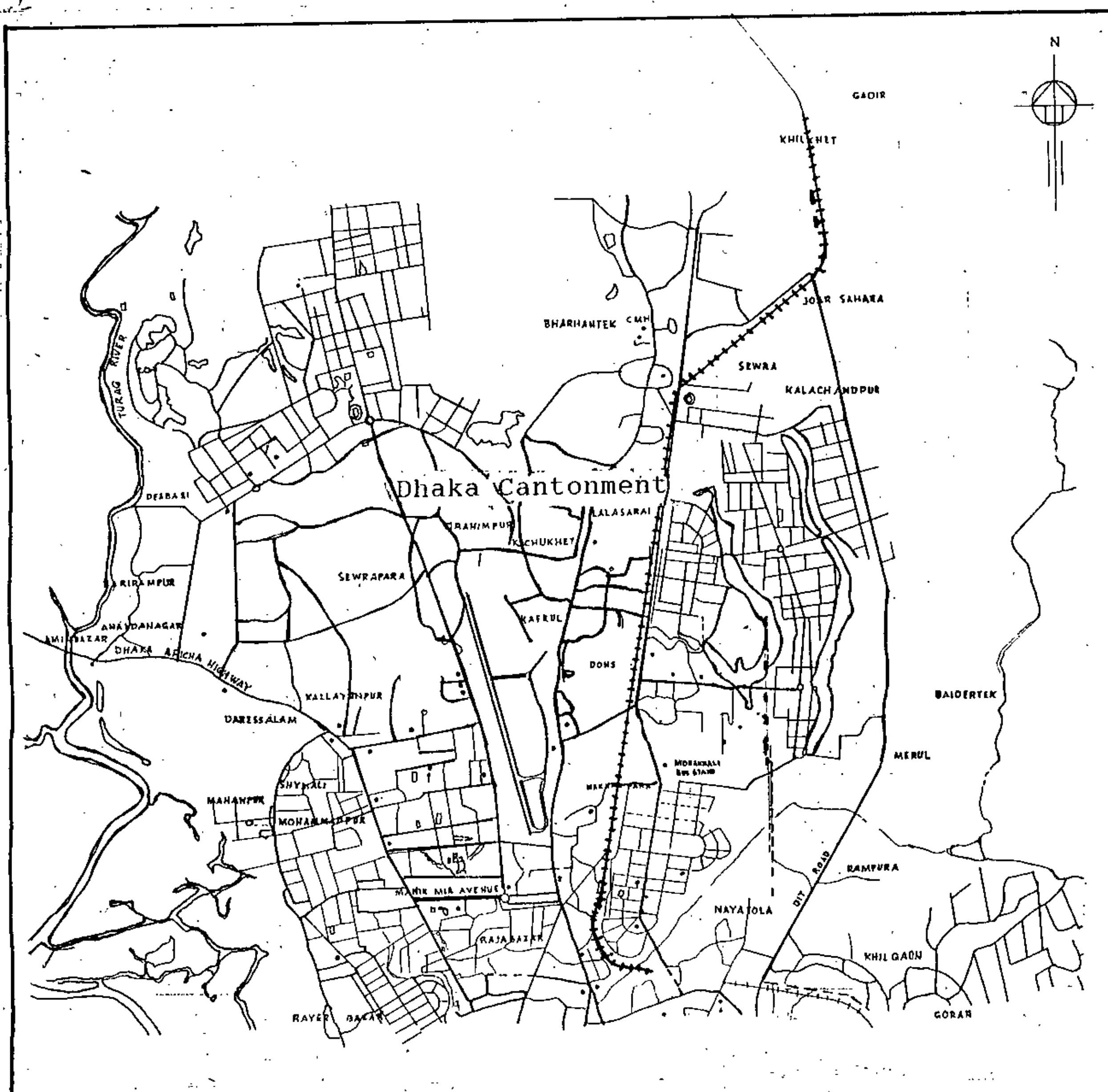


Figure 3.1 Map Showing Location of Dhaka Cantonment

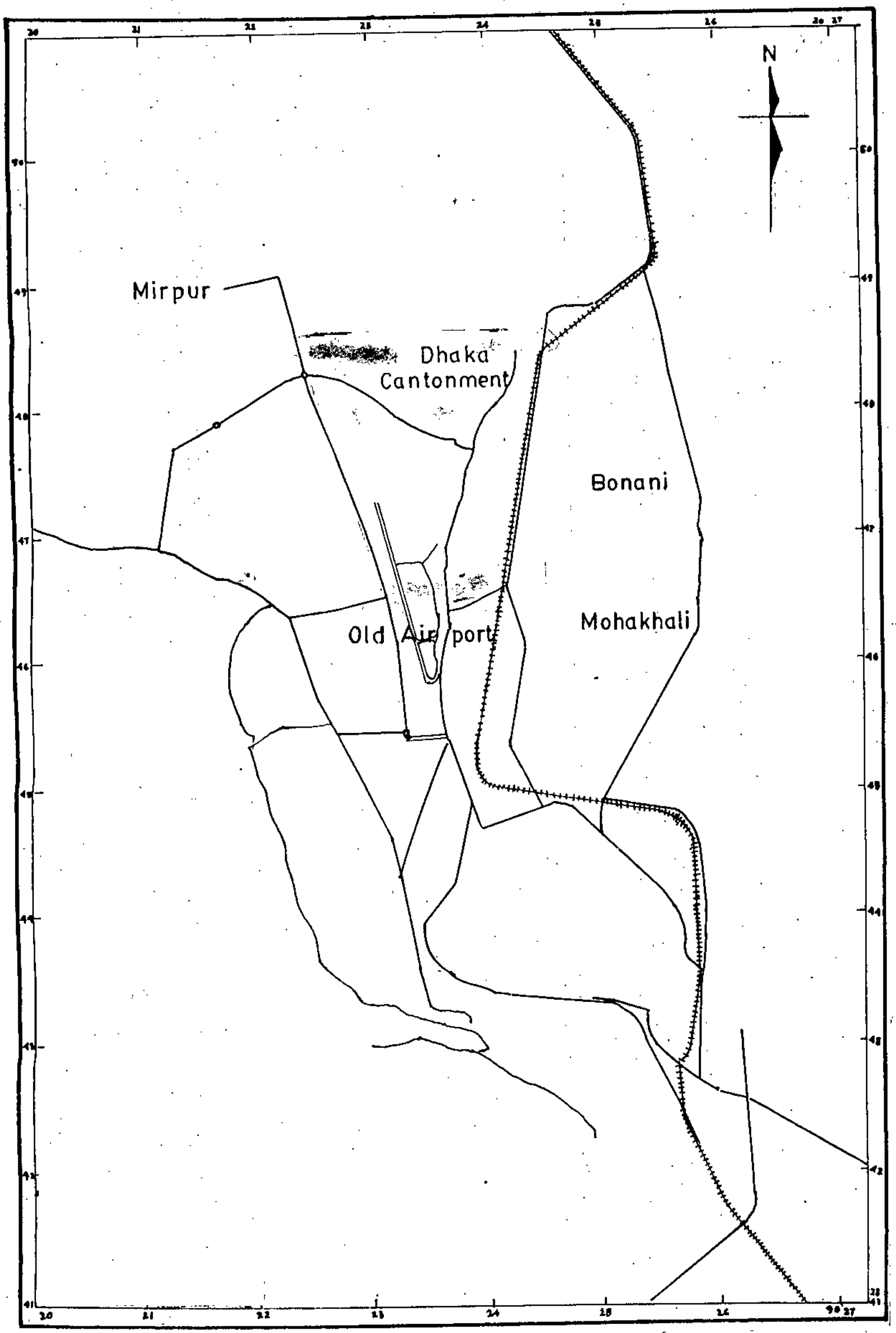


Figure 3.2 Enlargement Showing Dhaka Cantonment

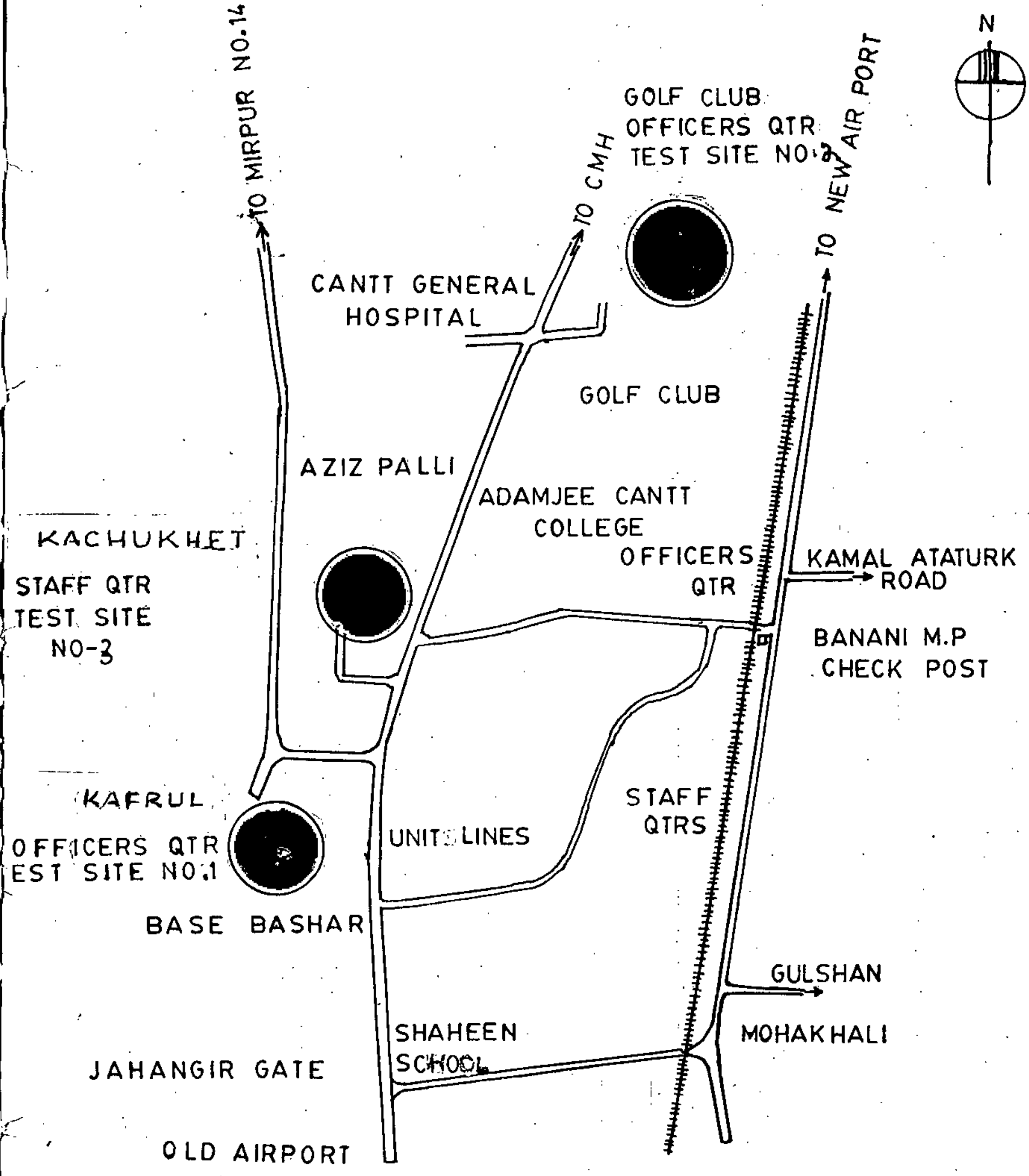


Figure 3.3 Sketch of Dhaka Cantonment (South) Showing Test Sites

3.3.2 Test Site 2

It is located near Kurmitola golf club area. There are six buildings, two of which are five storied and the remainings are three storied. A five story building (No.513) is taken as test site. It has ten flats. Average occupants per flat is 5. So a total of 50 persons live in this building . For each building domestic wastewater is treated in a septic tank and discharged to a soakage pit. Wastewater is generated in each flat through standard water using fixtures comprising 4 water closet toilet, 4 hand wash basins, 4 bath/shower point, one kitchen sink and one laundry wash point. Deep tubewell water is supplied to all water points.

Field survey estimates the mean daily water use as 120 liters per person, which generates approximately 6000 liters of wastewater per day. Like test site 1 only toilet waste line is connected to septic tank. From the field survey estimating , 36 lpcd of the total wastewater is generated from toilets. So a total of 1800 lpd of toilet wastes are discharged to the septic tank.

The liquid volume of the septic tank is 9120 liters. The minimum retention volume is 1/3 liquid depth which is 3040 liters. So the average detention time is 64 hours prior to discharge of effluent to the soakage pit, when the tank is 1/2 filled with sludge.

The site is on original ground which is not inundated during monsoon. The soil is sandy clay. The septic tank is having the problem of over flowing.

3.3.3 Test site 3

It is located in Katchukhet area. There are 13 four storied building in the area. The test site area comprise two four storied building connected to a septic tank and soakage pit. The building has 16 flats and an average of 6 persons live in each flat. The total population was 96. Wastewater generated through standard water using fixtures which include 1 asiatic pan, 1 hand wash basin, 2 bath/shower point, 1 kitchen sink and a laundry wash point. Deep tube-well water is supplied to all water fixtures. Field survey estimates the mean daily water use as 100 liters per person which generates approximately 9600 liters of wastewater per day. Similar to test site 1 and 2, only toilet wastewater line is connected to the septic tank. From the field survey estimate,36 lpd of the total wastewater is generated from toilets. So a total of 3450 liters of toilet wastes are daily discharged to septic tank.

The liquid volume detention capacity of the septic tank is 27900 liters. The minimum retention volume is 1/3 of liquid depth which is 3900 liters. So the average detention time when the tank is 1/2 depth filled with sludge is 114 hours.

The test site is on original ground with sandy soil and not inundated during monsoon,. The Septic tank frequently overflows.

3.3.4 Details of Septic Tank Design

Typical plan of septic tanks and soaks wells of Chief Engineer(Army)is followed in all the three sites. Detail dimensions are given below:

Table 3.1 Septic Tank Dimensions at Test Sites

Site No	No of Flats	Septic Tank						Soakage pit	
		Leng th mm	Width mm	Liquid depth mm	Liquid volume m^3	Liquid volume liter	Length width Ratio	Diameter mm	Depth mm
1	8	6600	1000	1370	9.0	9120	6.6:1	1200	6500
2	10	6600	1000	1370	9.0	9120	6.6:1	1200	6500
3	16	7800	2600	1370	27.8	27900	3:1	1200	6500

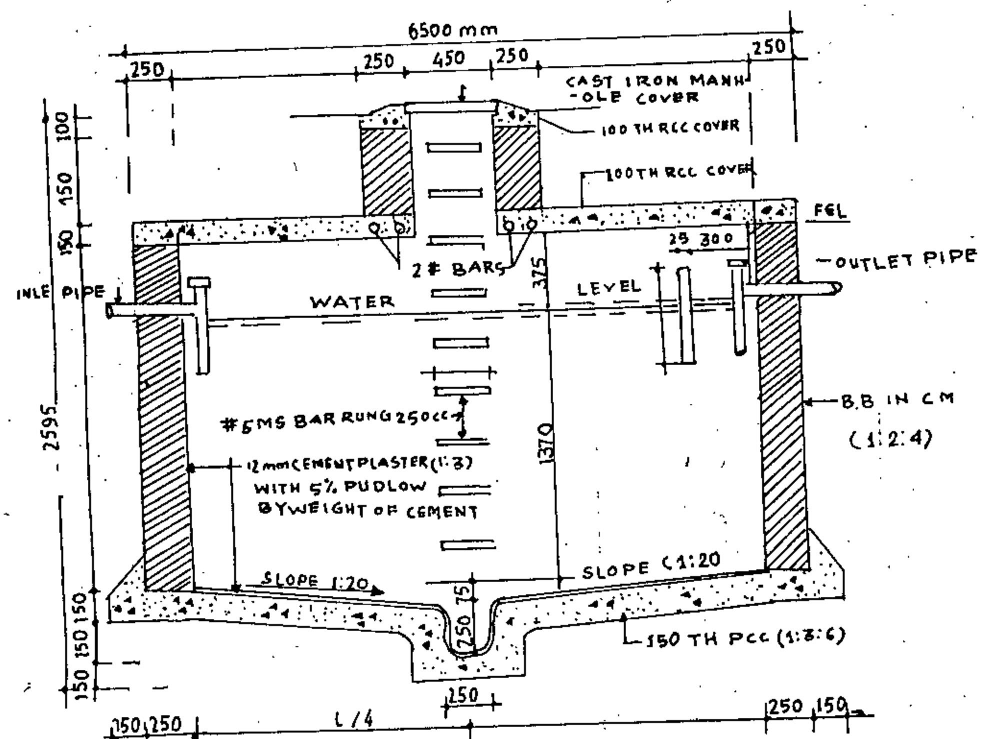
(Source : DW & CE Army)

The tanks are of different sizes and the flow rates are different. Detail sketch of the septic tanks and soakage pit is shown in Fig 3.4 - 3.6.

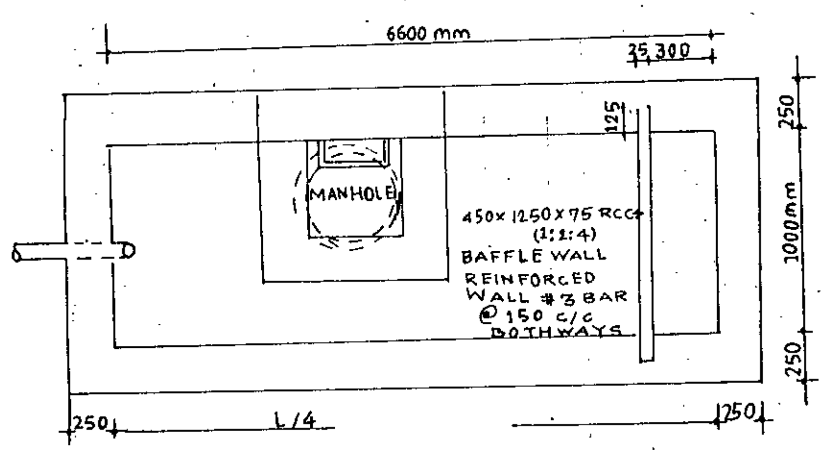
All the three septic tanks are single compartmented. Inlet and outlet pipes are 'T' shaped and are of diameter 4" (100 mm). They are placed at the same level i.e 375 mm from the top of tank. There is a baffle wall constructed 300 mm from the outlet end.

The bed of the tank is sloped (1:20) inwards toward the center of the tank to facilitate deposition of sludge and cleaning. A manhole is placed L/4 distance from the inlet end for inspection and cleaning. The tank is made of brick walls with concrete floor and RCC top.

Soakage wells are 1200 mm in dia and 6500 mm depth. The sides of the wells are brick walled upto 2400 mm depth. The top of the pit is covered with concrete slab without any opening. The well is back filled with brick bats.



LONG SEC OF SEPTIC TANK



TYPICAL PLAN OF SEPTIC TANK

Figure 3.4 Details of Septic Tank in Test Site 1 and Test Site 2

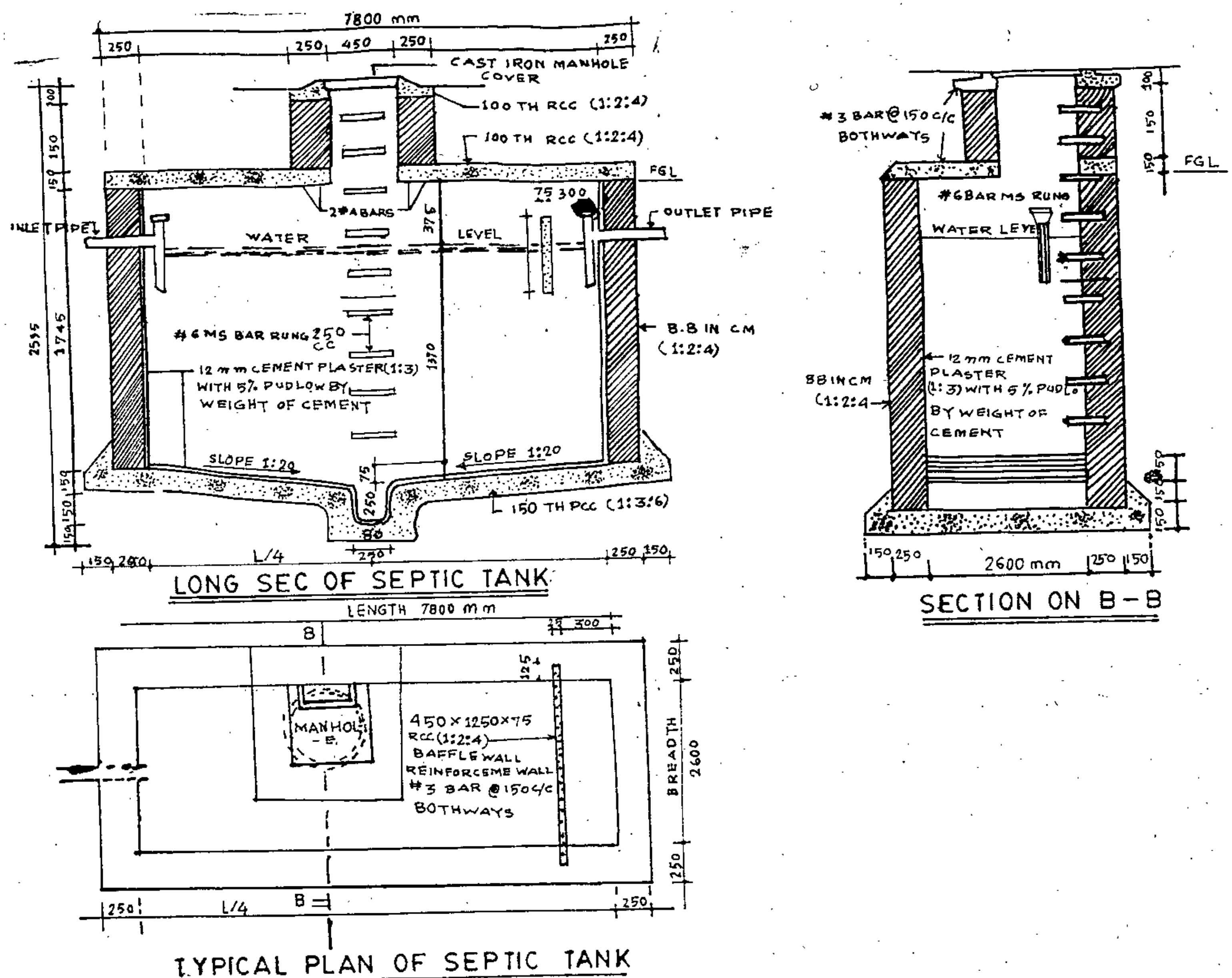
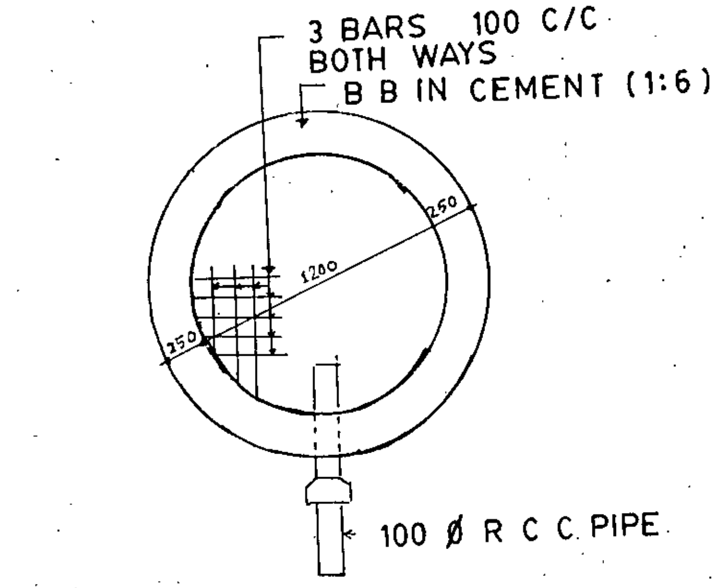
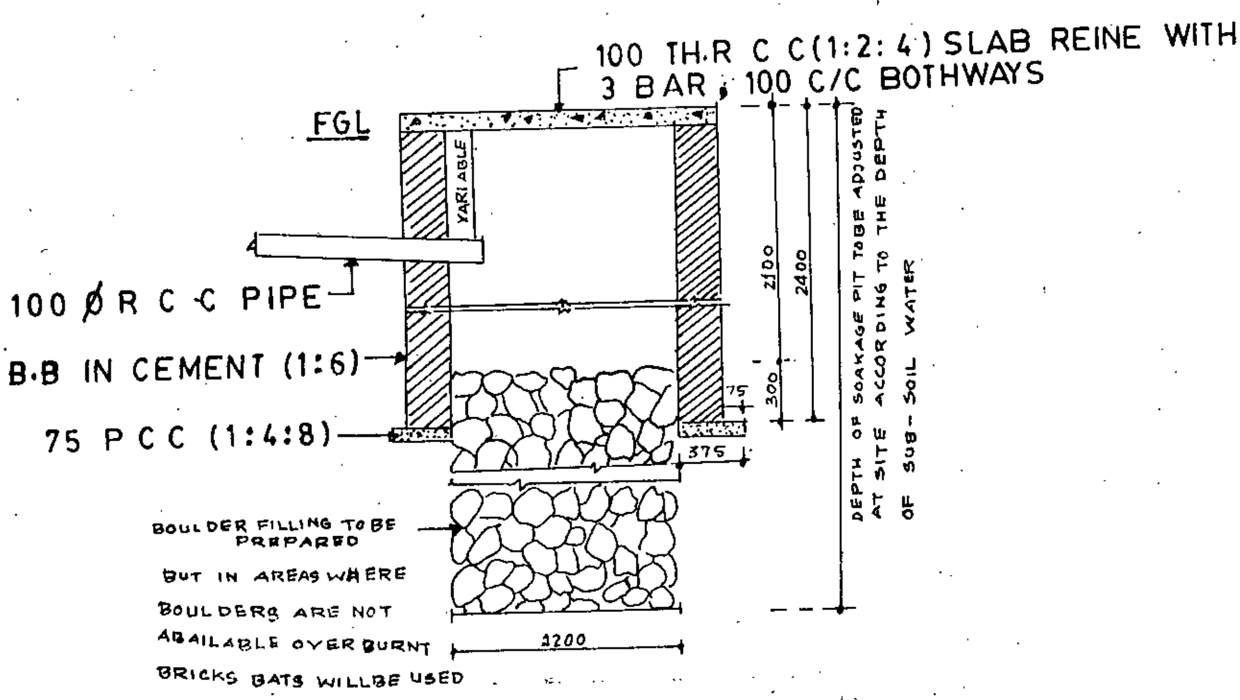


Figure 3.5 Details of Septic Tank in Test Site 3



PLAN OF SOAKAGE PIT



CROSS SEC OF SOAKAGE PIT

Figure 3.6 Details of Soakage Pit at All Test Sites

3.4 Description of Experimental Conditions

The septic tank effluent has been tested for physical, chemical and bacteriological parameters, considering different sources of domestic wastewater. For this study three septic tanks and soakage wells were selected from three different areas. The tanks are of different sizes and the hydraulic as well as organic loadings are different for each tank. Septic tank effluents were collected from these different arrangements and composition of domestic wastewater as described below. The effluents were collected at the inlet point of soakage pit. To ascertain the septic tank efficiency, raw sewage was also collected at the inlet end of septic tank, which consists of toilet wastes,toilet and kitchen waste, toilet kitchen and bathroom wastes. In addition kitchen and bathroom wastes were collected seperately. Arrangements of the septic tanks for test conditions are:

Arrangement - 1 (A1). Only toilet wastewater is discharged to septic tank.

Arrangement - 2 (A2). Toiletwastes and kitchen wastewaters are discharged to septic tanks.

Arrangement - 3 (A3). All purpose wastewater i,e toilet, kitchen and bathroom wastewater discharged to septic tanks.

Photographs of different arrangement are shown in Annexure.'B' In original setup of the buildings, all toilet wastewater lines are connected to one plumbing main pipe, sullage to another pipe and bathroom water to another pipe. So there are three sets of vertical wastewater pipe on both the eastern side and western side flats separately. The toilet waste pipes of all the flats are connected to septic tank. Other wash water pipes discharges to surface drain which finally falls to low laying areas. A1 facility is already existing. For A2 arrangement kitchen wastewater lines are connected to septic tanks. Similarly for A3 arrangement bathroom wastwater lines are connected to septic tank in addition to A1 and A2 arrangement. Soil absorption capacity of effluents under arrangements A1,A2 and A3 are measured by percolation tests for the same type of soil.

3.5 Laboratory Test Programme

The whole operation of laboratory testing programme may be broadly classified into three categories :

(1) Constructing connection arrangements of different septic tanks for different test condition (2) Collection of samples (3) Detail analysis of samples in the laboratory to evaluate the effluent quality.

3.5.1 Connections to Septic Tanks

The tests were performed in three arrangements of the wastwater inflow to the septic tank. Before the start of the test program all the three septic tanks were cleaned. The test under first arrangement starts after three weeks from the cleaning. In A1 arrangement,only the toilet wastewater was discharged into the tank.

In A2 arrangement kitchen wastewater line was connected to septic tanks and allowed to remain in this condition of operation for three weeks. The efflument was then collected and tested for desired parameters. In arrangement A3, bathroom lines were also connected to septic tank and allowed to remain in operation for another three weeks before testing. PVC pipes were used for making connection to septic tanks. Plates in Annexure B shows the connections. In this way three sets of septic tanks in three different testing sites were prepared for carrying out series of tests.

3.5.2. Collection of Samples

The frequency of sampling depends on the objective of the measurement programme and on the type of the parameters to be measured. Since this study is for the purpose of comparison of tested data of septic tank effluents, samples were collected under different combination of wastewaters. Wastewater samples must be collected in a proper manner so that these are representative. There are three main methods of sampling viz, single sampling, composite sampling and continous monitoring samples. However, sampling for ordinary chemical analysis requires no special method and precaution other than collecting the sample in a clear glass container with glass stopper. Samples for bacteriological analysis were collected in a sterile bottle with stopper. Samples of effluents collected from different sources fairly represented the body of wastewater from which these were collected. All the samples were collected at the inlet point of soakage pits in plastic container.

3.5.3. Detail Analysis of Samples

To assess septic tank effluent quality for different combinations of domestic wastewater, various parameters were considered. The parameters selected for the present study are :

Suspended solids (SS)

Temperature

Total organic carbon (TOC)

Biochemical oxygen demand (BOD)

Chemical oxygen demand (COD)

Nitrate (NO_3)

Phosphate (PO_4)

pH

Total Coliform (TC)

Facel Coliform (FC)

3.6.4.Experimental Procedure

The physical, chemical, and bacteriological qualities of the wastewater are assessed through laboratory analysis. The different tests performed were suspended solids, temperature for ascertaining physical qualities ;pH, COD,TOC,NO_3 and PO_4 for chemical qualities, BOD for biological quality and TC and FC for bacteriological quality. The experimental procedure for determining each parameters are described in brief in this section.

3.6.1. Temperature

Temperature measurements are made with a good mercury filled Celsius thermometer. The thermometer has a scale marked for every O.1^{0} C on capillary glass.Each sample was taken in a beaker and the thermometer was dipped in it. The reading was noted in degree C.

3.6.2. pH

It is determined by using automatic pH meter. pH meter is first put in a buffer solution for calibration. Then the pH meter is put in the sample solution. The pH reading, after appropriate correction, was noted. Plate of automatic pH meter is shown in Annexure 'B'.

3.6.3. Solids Content

Solids may be classified as total solids(TS), dissolved solids (DS) and suspended solids(SS). Total solids refer to the matter that remains as residue upon evaporation at a temperature of 103^0-105^0c in oven (ASTM 1988). The particles having size less than or equal to 0.0001 micrometer, when present in the waste, are known as dissolved solids. Total solids and dissolved solids were determined by standard method (APHA, AWWA,WPCF, 1985). Then Suspended Solids was determined from the equation:

$$SS = (TS - DS) \text{ mg/l} \qquad (3.1)$$

3.6.4. Dissolved Oxygen (DO)

Dissolved oxygen is measured by HACH standard method (APHA,AWWA,APCE 1985) using titration method.

3.6.5. Biochemical Oxygen Demand (BOD)

The BOD determination is an empirical test in which standard laboratory procedures are used to determine the relative oxygen requirements of wastewater effluent. The method consists of placing sample in a full, airtight bottle and incubating the bottle under specified conditions for a specific time. Dissolved oxygen is measured initially and after incubation. The BOD is computed from the difference between initial and final DO. Standard reagents i,e. phosphate, buffer solution, magnesium sulfate solution, calcium chloride solutions, ferric chloride solution, sodium sulfide solution (0.025 N) are used.

Since the wastewater contain high BOD, dilution of the sample is made of the order of 10,50, and 100 times as per standard procedure before conducting test. Dilution water blank is also prepared. The initial DO of the samples are determined.

The remaining samples are then incubated at 20^0 C ± 1^0C in BOD bottle for 5 days. After 5 days of incubation DO is determined. The BOD_5 is then calculated by the equation.

$$BOD_5\ mg/l = \frac{(D1 - D2) - (B1 - B2)f}{P} \qquad (3.2)$$

Where, D1 = DO of diluted sample immediately after prepared mg/l.

D2 = " " " " after 5 day incubation at 20^0 C, mg/l

B1 = DO of seed control before incubation, mg/l

B2 = " " " " after " "

f = Ratio of seed in sample to seed in control.

P = Decimal volummetric fraction of sample used.

3.6.6. Chemical Oxygen Demand (COD)

In determination of COD,equal volumes (10 ml) of diluted sulfuric acid and potassium permanganate are added to 100 ml of sample and heat in a water bath for 30 minute.After heating, 10 ml of standard ammonium oxylate was added to the boiled sample.

permanent pink color is obtained the ml of standard potassium permenganate added to the sample. Calculate the COD by formula :

$$\text{COD (mg/l)} = \frac{\text{(Ml of } KMnO_4 \text{ Used in last step x 100)}}{\text{Ml of sample Used}} \qquad (3.3)$$

3.6.7. Nitrate (NO_3)

Nitrate content of the wastewater is determined using DR EL/4 (HACH,1984)spectrophotometer Nitraver 5 pillows were used and the spectrometer wavelength was adjusted to 500 nm. Nitrate content was measured by HACH standard method using spectrophotometer.

3.6.8 Phosphate (PO_4)

Phosphate content was determined using DR-EL/4 spectrophotometer (HACH, 1984). Phospha ver 3 pillows were used and spectrophotometer wavelength was adjusted to 700 nm. Phosphate content was measured by HACH standard method using spectrophotometer DR EL/4.

3.6.9 Total Organic Carbon (TOC)

TOC was determined using Yanco TOC analyzer model TOC -8L. It measures TOC by 2 channel method based on JIS (Japan Industrial standard) method having two combustion ovens, high temperature oven (TC oven) and low temperature oven (IC oven).

The high temp oven is controlled at 900^{o} C. When a sample is subjected to combustion at such temperature,all carbon in it is oxidized into CO_2.The low temperature oven is controlled at 150^{o} C to 160^{o} C. When a sample is subjected to combustion at such temperature, only organic carbon in it is changed into CO_2. The concentration of CO_2 generated in each oven is measured by the infrared analyzer to determine TC and IC. Difference between TC and IC corresponds to TOC.

First of all span calibration is done using standard solutions for TC and IC. On the basis of this value the concentration of an actual sample can be obtained. If the sample contains no SS and no salts, the sample can be injected without any processing. If sample contains SS the sample Should be filtered prior to injection. The test of the sample was performed by injecting actual sample. Each test reading is converted with span value of standard sample to obtain TC and IC value. Plate of Yanco - TOC analyzer is shown in Annxure B.

3.6.10 Coliform Analysis

Millipore corporation membrane filters (MF) procedure for coliform analysis is used for determining TC and FC. MF technique have much greater precision than MPN method. In determing TC,after proper sampling and filtration, the bacterial retentive membrane filter is placed on the top of MF - Endo media. The standard volume to be filtered is 100 ml. As the wastewater contains enough coliform, the samples were diluted 10^6 time before filtering. The membrane filter is then incubated for 24 hours at 35^0 C ± 0.5C. The media defuses through the pores in the filter, supplying nutrients to the multiplying bacteria. Many kinds of bacteria from the water sample can grow and form colonies under these conditions, but only the coliform will ferment lactose. Thus the coliform can be identified as dark yellow colonies and can be identified even with naked eye.

In determining fecal coliform the filtration step is similar to that of TC. The same media is used. The filter membrane is incubated for 24 hours at 44.5^0 C ± 0.2C allowing only coliform of fecal origin to grow into visible colonies. The non fecal coliform due to heat shock will not grow. As the FC grow they ferment lactose and when viewed will exhibit a dark yellow big colony. In both the cases the colonies are counted as under :

Total coliform colonies / 100 ml

$$= \frac{\text{Coliform Colonies Counted}}{\text{Ml sample filtered}} \times 100 \quad (3.4)$$

3.7 Field Test Programme

Field test programme consists of conducting soil percolation Capacity tests to determine absorption rate of the effluent under different arrangement of wastermater in the septic tank. Standard percolation tests are performed by making absorption pits and measuring the percolation of effluents from septic tanks designed for different purpose under arrangement A1,A2 and A3.For each test six numbers of 100 mm diameter and 500 mm deep holes were drilled in the soil. Holes are uniformly spaced over disposal area, but not closer than 2m apart. The sides of the holes are roughened and 5 mm coarse sand and fine gravel were placed in the holes.

Testing procedure consists of filling the holes with water and topped up with more water to keep the level at least 150 mm above the bottom. The holes were soaked for overnight (24 hours). Then the water level is adjusted to a depth of 150 mm above the bottom. The drop in water level is measured at 10 minute intervals until the drop was uniform. Water is added at the end of each test interval as required to maintain a depth of 150±10 mm. The percolation rate was calculated by taking the uniform 10 minute rate of fall in each hole to determine the rate per hour. The arithmetic mean of the holes are used as the percolation rate for the area. Then the absorption capacity of the seepage pit can be found consulting Table A.31 (Bangladesh National Building Code, 1993). The percolation tests were conduced at test site 1 and 3 with effluents collected under A1, A2 and A3 arrangement. Annuxere A shows the percolation test results in detail.

3.8 Limitations of the Experimental Programme

In this test programme existing septic tank systems were utilized, where inflow and outflow of sewage & effluent from the septic tank could not be controlled. So detention time of wastewater in the septic tank could not be kept same for different composition of waste waters. During BOD testing in the laboratory titration method was used to determine dissolved oxyzen content.

Absorption tests were performed by standard percolation method using bore holes instead of conducting the test in the soakage pits. Actually due to prolonged use of the soaks pits their absorption capacity would be different. More so the absorption capacity was measured during fairly dry season, which would be different in monsoon.

CHAPTER - 4

PRESENTATION OF RESULTS AND DISCUSSIONS

4.1 Introduction

In order to assess the quality of septic tank effluent for different loading combinations of domestic wastewaters and to determine the absorption rate of effluent in the soakage pits, effluent samples were collected from soakage pits at the inlet from three different test sites of Dhaka Cantonment area. Laboratory investigation on the quality of untreated wastewater and septic tank effluent as well as field test on soil absorption capacity for different wastewater combination were performed. The results of these investigations are presented and discussed in this chapter. A complete set of results for the entire experimental programme can be found in Annexure A.

4.2 Household Water Usage Pattern

Household water usage pattern was determined by conducting field questionnaire survey to all the households using the septic tanks which were considered for the present study. Water used by residential houses consists of water for washing,bathing, culinary purposes,and waste removal. Questionnaire survey carried out in residential areas at test sites led to the estimation of per capita wastewater flowrates. For the purpose of determining residential interior water usage pattern, households are classified as category A and B. Category-A households are officers quarters and category B households are troops quarters. In category A houses the number of toilets and water fixtures are more compared to category-B houses. However, the family members of each category house were more or less the same. Table 4.1 shows the average domestic wastewater flow rate pattern of the houses at test sites. The average flowrate per capita is based on an average occupancy of about six residents per home.

Table 4.1 Domestic Wastewater Flowrates Pattern.

Use	Catagory A		Catagory B	
	Flowrates in lpcd	% of total	Flowrates in lpcd	% of total
Toilets	36	30	36	36
Kitchens	16	13	12	12
Baths	36	30	28	28
Laundry and washings	29	24	20	20
Leakage	3	3	4	4
Total	120	100	100	100

On average every person uses toilet twice a day which generates 36 liters of wastewater. Kitchen water consumption was 12-16 lpcd. The wastewater from kitchen included fats, oils, washings of vegetables, fishes, meat and cleanings of utensils. Cleaning detergents were used for toilet cleaning. Soaps and detergent powders were mostly used for laundry purposes in bathrooms. The washings and moppings of the rooms were discharged through bathrooms.

During field survey it was seen that the general condition of the septic tanks were satisfactory. But most of the tanks were filled. Overflowing soakage pits were connected to the surface drains for discharge of effluents. The wastewater in the septic tanks were blackish and turbid with scums and bubbles. Plate in Annexure B shows the soak pit effluent condition. In course of conversation with inhabitants it was understood that the septic tanks overflow frequently. They reported that the overflowing septic tanks were cleaned by MES only on reporting. Garrison Engineers Maintenance were consulted about the malfunctioning of the septic tank system. They informed that a substantial amount of money is spent every year for cleaning of overflowing septic tanks. The frequency of cleanings were high.The situation worsen during monsoon when ground water table rises up.

4.3 Effluent Quality Under Different Composition of sewage

To assess the impact of different composition of domestic wastewater on their effluent quality,samples were collected from septic tanks and soakwells with different organic and hydraulic loading over a period of ten months. Laboratory tests were performed for each sample collected from selected septic tanks at test sites for determining individual constituents. In addition to testing of effluents in A1,A2 and A3 loading conditions (discussed in chapter 3), untreated toilet, kitchen and bathroom wastewaters were also tested. The characterestics of untreated sewage and effluent vary in constituents and concentrations with the hour of the day, the day of the week, the month of the year and other local conditions. So every time the samples were collected in the morning around 9.30 A.M to get a uniformity of sewge constituents. Details of test results are discussed below.

4.3.1. Quality of Untreated Wastewater

Seperate tests were performed for assessing the quality and composition of untreated domestic wastewater and their combination at three test sites. The combination wastewaters were mixed in the proportion assessed in A1,A2, and A3 loading conditions at test sites. The test samples were collected from the pipe outlet points of toilets,kitchen and bathrooms.Samples were analyzed for BOD_5 COD,TOC,SS,NO_3 and PO_4. Table 4.2 shows the constituent of untreated wastewater at different loading conditions.

The Table 4.2 shows that BOD and COD of toilet wastewaters are more than those of sullage. However, while the sullage has slightly higher value,the SS content of the sullage is much higher than the toilet wastes only. Depending on the concentration of these constituents,wastewaters were classified according to Metcalf(1991),Table A-35 as weak sewage at ST1 and ST2 and medium sewage at ST3, which are typical of domestic sewage. Analysis of the results show that BOD and COD of untreated wastewater were reduced by 10% when toilet and kitchen wastewaters were mixed. When toilet, kithen and bathroom wastewaters were all mixed this quality improvement was 40%. On the other hand, the SS content was increased by about 9% when toilet and kitchen wastewaters were mixed. In case of all wastewater mixed together the SS content was reduced by about 20%. The pH of the wastwater remained between 6.2 to 6.9. So there was not much change in it.It can be seen therefore, that the quality of raw wastewater containing toilet, kitchen and bathroom wastes when mixed together improves significantly.

Table 4.2 Constituents of Untreated Wastewaters Under Different Condition :

Test sites	Samples	BOD_5 mg/L	COD mg/L	TOC mg/L	SS mg/L	PO_4 mg/L	NO_3 mg/ L
Septic Tank 1 (ST 1)	Toilet (T)	160	290	102	58	25	30
	Kitchen (K)	130	240	110	105	15	15
	Toilet(T)+Kitchen(K)	140	260	105	65	15	25
	Toilet(T)+Kitchen(K) + Bathroom (B)	110	200	58	44	30	30
	Quality improvement of sewage (T+K) in relation to T only	12%	10%	-3%	-12%	-20%	17%
	Quality improvement of sewage (T+K+B) in relation to T only	31%	31%	56%	24%	-20%	0
Septic Tank 2 (ST 2)	T	190	340	106	65	20	13
	K	140	290	130	129	40	20
	T+K	160	300	96	70	40	20
	T+K+B	110	190	85	78	25	20
	Quality improvement of sewage (T+K) in relation to T	16%	12%	10%	-8%	50%	-53%
	Quality improvement of sewage (T+K+B) in relation to T .	42%	44%	20%	20%	-25%	-53%
Septic Tank 3 (ST3)	T	200	340	160	40	15	13
	K	160	380	212	84	50	24
	T+K	180	300	180	43	20	13
	T+K+B	110	210	102	15	35	15
	Quality improvement of sewage (T+K)in relation to T	10%	11%	-12%	-7.5	-33%	0
	Quality improvement of sewage (T+K+B) in relation to T	45%	39%	36%	37%	130%	-2%

4.3.2 Effluent Quality of Toilet Wastewater Only (A1 condition)

Samples of septic tank effluent were collected from septic tank outlets during the month of sep 94 to Aug95 in every three weeks. The samples were collected under A1 condition from three septic tanks at three test sites.As mentioned earlier (chapter 3) samples were analyzed for wastewater constituents pH, temperature, BOD_5,COD, TOC, SS, NO_3,PO_3,TC and FC. The efficiency of the septic tank system were evaluated with respect to removal rates of the constituents. Table 4.3 shows the efficiencies of septic tanks containing toilet wastes only.

Table 4.3 Efficiencies of Septic Tank System for Toilet Wastewater Only (A1 condition)

Test sites	Samples	BOD_5 mg/L	COD mg/L	TOC mg/L	SS mg/L	PO_4 mg/L	No_3 mg/L	FC 10^6/ 100ml
ST 1	Raw sewage	230	370	180	86	4	12	15
	Septic Tank Effluent	110	170	91	59	2	5	5
	Removal Efficiency %	52	54	50	31	50	58	66
ST 2	Raw sewage	250	380	171	94	7	13	20
	Septic Tank Effluent	120	180	92	66	4	7	10
	Removal Efficiency %	52	53	46	30	57	46	50
ST 3	Raw sewage	100	200	56	93	20	13	6
	Septic Tank Effluent	42	80	38	56	7	6	3
	Removal Efficiency %	58	60	32	40	65	46	50

The constituents of untreated wastewater indicated that the sewage was of medium strength in ST1 and ST2 and weak strength in ST3. In A1 condition the average theoretical detention time of sewage in septic tanks were 67 hours in ST1,64 hours in ST2 and 114 hours in

ST3. The BOD and COD removal efficiencies were around 50% in ST1 and ST2, and in ST3 it was slightly higher. Similarly the TOC removal rate were about 45% in ST1 and ST2 with slightly lower value in ST3. The SS removal rate were similar in ST1 and ST2, whereas it was more in ST3. The nitrate and phosphate reduction rate followed the same trend which were around 45% in all cases. These two constituents of the wastewater were little in amount. So a small variation in the measurement may alter the removal efficiency to a significant extent. Therefore, the degree of uncertanity was enhanced in measuring these values. The FC removal rate were about 50% for all the cases of septic tanks. The results reflect that the removal efficiencies for all constituents were more for bigger tanks like ST1 and ST3 having longer detention time compared to ST2.

Organic contaminent and flow rates were more in ST2 compared to ST1 resulting less detention time in ST2. This resulted less removal efficiency in ST2 compared to ST1. On the other hand,sewage detention time at ST3 was much more and hence removal efficiencies were more.

4.3.3 Effluent Quality of Toilet and Kitchen Wastewater (A2 condition)

Samples of septic tank effluents were collected for A2 condition from all three test sites. Samples were analyzed for the constituents similar to the previous condition.Removal efficiencies of BOD_5, COD, TOC, SS, NO_3, PO_4 and FC were calculated with respect to influent quality. Table 4.4 shows the efficiencies of the same septic tanks treating toilet and kitchen wastewaters.

Table 4.4 Efficiencies of Septic Tank System for Toilet and Kitchen wastewaters (A2 condition)

Test sites	Samples	BOD_5 mg/L	COD mg/L	TOC mg/L	SS mg/L	PO_4 mg/L	NO_3 mg/L	FC 10^5/ 100ml
ST 1	Raw sewage	140	250	87	70	45	50	250
	Septic Tank Effluent	60	100	38	45	30	40	150
	Removal Efficiency%	58	60	56	36	33	20	40
ST 2	Raw sewage	160	300	96	71	35	50	15
	Septic Tank Effluent	70	120	49	46	21	30	10
	Removal Efficiency%	56	60	49	35	40	40	33
ST 3	Raw sewage	180	300	82	80	45	35	9
	Septic Tank Effluent	60	110	33	40	25	18	5
	Removal Efficiency%	66	63	60	50	45	48	45

Constituents of untreated sewage indicated that the concentration of sewage in all the three septic tanks were of weak strength. This indicate improvement of effluent quality in A2 condition compared to A1 condition. In A2 condition the avarage detention time of wastewaters in septic tanks were 46 hours in ST 1, 44 hours in ST 2 and 83 hours in ST3.

The table shows that the removal effiiencies of BOD and COD were around 56% in ST1 and ST2 with more removal in ST3. The TOC reduction followed the same trend of BOD removal. Higher SS removal was obtained in ST3 compared to ST1 and ST2. The phosphate and nitrate reduction were more in ST3 compared to ST2. In A2 condition PO_4 and NO_3 values increased significantly in untreated wastewater compared to A1 condition. The FC removal rate were around 40% in A2 condition, whereas it was around 50% in A1 condition. This lower removal rate is attributed to lower detention time of wastewater in the septic tanks and inclusion of kitchen wastewaters in A2 condition.

In all the test sites, hydraulic loadings were increased which consequently reduces the detention time of sewage by 21 hours in ST1, 20 hours in ST2 and 31 hours in ST3. Kitchen wastewater added to toilet wastes had less values of BOD and COD. So the overall quality of wastewater were better compared to A1 loading condition and consequestly effluent quality was better even when the detention time was reduced. The removal efficiencies of NO_3,PO_4 and FC were however, less due to reduction of detention time and their higher initial content.

4.3.4. Effluent Quality for All Wastewaters(A3 condition)

Samples of septic tank effluents were collected at A3 condition which contained toilet, kitchen and bathroom wastewater, from all three test sites in a process described earlier. Samples were analyzed for constituents mentioned in earlier cases. Removal efficienies were calculated with respect to raw sewage. Table 4.5 shows the efficiencies of the same septic tanks containing all wastes.

Table 4.5 Efficiencies of Septic Tank System for All Wastewater (A3 condition)

Test sites	Samples	BOD_5 mg/L	COD mg/L	TOC mg/L	SS mg/L	PO_4 mg/L	NO_3 mg/L	FC 10^6/ 100ml
ST 1	Raw sewage	110	200	121	80	6	40	13
	Septic tank Effluent	40	60	55	38	4	38	9
	Removal Efficiency%	63	70	46	50	30	16	30
ST 2	Raw sewage	110	190	85	78	25	55	12
	Septic Tank Effluent	45	50	47	40	20	10	24
	Removal Efficienccy%	60	64	45	40	20	10	24
ST 3	Raw sewage	110	210	102	86	45	30	8
	Septic tank Effluent	35	60	60	35	30	19	5
	Removal Efficciency	68	72	58	70	33	35	40

The constituents of raw sewage indicate that at all test sites the concentrations were weak and hence of improved quality even in untreated state. These effluent quality were the best of all three conditions. In A3 condition the average detention time of sewage in septic tanks were 20 hours in ST1, 19 hours in ST2 and 73 hours in ST3.

It may be seen from the table that the BOD and COD removal efficiencies were 60% in ST1 and ST2. A further removal of 68% was obtained in ST3. The TOC removal was much higher in ST3 compared to ST1 and ST2. The SS removal efficiency in ST3 was above 70%, which were 50% in other two cases. This higher SS removal results due to addition of domestic detergent which caused increased sedimentation.

The phosphate and nitrate reduction were around 30% in A3 loading condition. These values were lower in this condition than in A1 and A2 which is due to the presence of detergents in bathroom wastewater and anaerobic activity in the tank. Similarly,the FC removal rates were decreased in A3 condition. The lower removal rate of FC, NO_3 and PO_4 is attributed to lower detention time of wastewater in the tanks and their higher initial content.

In A3 condition the flow rates were increased over 200 percent in all septic tanks. Addition of bathroom wastewaters diluted the sewage which reduced BOD,COD and SS of the effluent. This mixing improved the quality of raw sewage very significantly. Although the detention time was reduced, the removal efficiencies were found to be fairly high compared to A1 and A2 conditions. This is due to dilution of the sewage which helped settling and thereby BOD removal is enhanced. Though the content of NO_3,PO_4 and FC were reduced, the overall removal efficiencies of these constituents were less. The result also shows that, even with one day detention time, the removal efficiencies were 60% for BOD, 45% for TOC and 40% for SS. From the test results, it appears that the all purpose septic tank produces much better quality effluent.

4.3.5 Percolation Test

Soil absorption capacities of septic tank effluent were determined by standard percolation test described in chapter 3. Percolation tests were performed at the same test sites where septic tank 1 and 3 are located for all the three types of sewage e.g, toilets only, toilet and kitchen wastewater and all wastewaters.A summary of the absorption capacities of seepage pits at different sites are given in Table 4.6. Details of the percolation test programme are given in Annexure-A. At test site 1 the type os soil is sandy day and at test site 3 the soil is fine sand.

Table 4.6 Absorption Capacities of Soakage Pits

Test Sites	Types of Effluent	Percola-tion rate for 25 mm fall	Absor-ption rate in $L/m^2/d$	Seepage area required in m^2	Seepage area availa-ble in m^2
Test site 1	Toilets only	27 min	51	25	17
	Toilets and kitchens	26 min	53	24	-
	All wastewaters	25 min	56	23	-
Test site 3	Toilets only	16	78	19	17
	Toilets and Kitchen	14	79	19	-
	All wastewaters	13	83	18	-

These test results indicate that percolation rate slightly increases with toilet and kitchen wastewater for the same type of soil and the rate is highest when all types of wastewater are discharged to septic tanks. The percolation test result confirms the previous studies by Siegrist (1987), that increasing the pretreatment of domestic wastewater prior to soil application, increases the soil absorption capacity. Test results show that absorption rates were more for effluents with lower BOD_5 and SS.

As the TOC content decreased in A2 and A3 conditions, the chances of soil clogging of soak pits would be less. The Table 4.6 also shows insufficient soil capacity to absorbe a higher quantity of wastewater which resulted in functional failure of soak pits at test sites. In addition, the infiltrative surface had been clogged due to continous inundation of soak pits with effluents from septic tanks treating toilet wastewaters as indicated by Laak (1987).

4.3.6 Comparison of Effluent Quality under Different Composition of Wastewater

As indicated earlier, studies were carried out with untreated sewage containing toilet, kitchen and bathroom wastewaters seperately and in combination, and effluents from septic tanks of different sizes with different organic and hydraulic loadings. Results show that the toilet wastewater contain high BOD compared to kitchen wastewater,whereas kitchen wastewater contain high TOC,NO_3 and SS. On the otherhand bathroom wastewater contain insignificant amount of BOD,COD,TOC,NO_3 and SS. But it contains higher PO_4.

When toilet and kitchen wastewaters were mixed together, the constituents BOD,COD and TOC were reduced compared to toilets only, but the SS content slightly increased. When all the wasteswaters were mixed together,the resultant constituents reduced significantly.

Studies on septic tank effluent with toilets only and toilet and kitchen wastewater indicated that for a detention time of 2 days (ST 1 in A2 condition), the removal efficiency of effluent constituent in later case were lower than that of same composition of sewage with 3 days detention (ST 3 in A2 condition). This improvement in effluent quality was higher in case of BOD,TOC and SS. However, the SS quality improvement was less. This is because of kitchen wastewater contain higher amount of SS and lower detention time. In A2 condition, the septic tank volume is to be increased by 40% compared to tanks with discharges from toilets only. So, the daily effluent flow rate remains low which need less absorption area.

Again, when all the wastewaters are discharged to septic tank, it resulted in the best quality of effluent. For a detention time of 3 days, the removal efficiency obtained were 68% in BOD and TOC (ST3 in A3 condition). In this option the size of septic tank will be huge involving high initial cost. However, incase of a shorter detention time (1 day) of sewage (ST 1 and ST 3 in A3 condition) these removal efficiencies were about 60% which is lower than that of 3 days detention time. In this case the volume of septic tank need to be increased by 230% compared to tanks receiving toilets only. Moreover, the daily effluent discharge rate will be much higher which would require larger absorption area.

Another option would be toilet wastewaters only septic tank with 5 days detention time. This reduces BOD by 58%. But SS and TOC removal were 40% and 32% only. This 5 day detention time will increase the size of tanks.

With respect to septic tank volume, septic tanks only with toilet and kitchen wastewaters with 3 days detention would be better compared to other options discussed.

Table 4.7 shows removal efficiencies of BOD, TOC and SS in three composition of domestic wastewater at three test septic tanks. From the study of the table it is clear that in A2 condition septic tank size is required to be increased by 40% and corresponding BOD removal increases by 6% compared to A1 condition. Whereas, in A3 condition, septic tank size need to be increased by 230%, while the corresponding BOD removal increases only by 11% compared to A1 condition. Therefore,it is apparent that optimal removal rates from economic point of view is achieved in A2 condition as the size of the tank is smaller. However maximum removal would be in A3 condition.

From the environmental sanitation point of view kitchen wastewater should not be discharged untreated as it contain high BOD, TOC, SS, Coliforms and other nutrients. Therefore, it should be treated in the septic tank before final desposal.

Table 4.7 Septic Tank Efficiencies for Various Composition of Wastewaters

Test sites	Sewage volume lpd		Detention time in hours	Absorption rate in L/m^2/d	Removal rate %		
					BOD	TOC	SS
ST 1	A 1	1720	67	51	52	50	31
	A 2	2570	46	53	58	56	36
	A 3	6240	20	56	63	46	50
ST 2	A 2	1870	64		52	46	30
	A 2	2800	44	-	56	49	35
	A 3	7020	19		60	45	40
ST 3	A 1	3000	114	78	58	32	40
	A 2	4480	83	79	66	60	50
	A 3	8580	73	83	68	58	70

A set of graphs (Figure 4.1 - 4.9) are drawn as Removal efficiency Vs Detention time and Sewage volume for all three test sites. As mentioned earlier, the sizes of the tanks were not varied at test sites, but the detention time in the tank varied due to increase in flow rates to the tanks. So,it can be seen from these figures that eventhough the detention time of sewage were less the removal efficiencies improved due to different combination of wastewaters. When kitchen wastewater., containing lower BOD, were mixed with toilet wastewater the overall concentration of BOD in the mix reduced. Furthermore, when bathroom wastewater containing insignificant amount of BOD,TOC and SS were mixed with toilet and kitchen wastewater, the overall concentration of these constituents in the mix reduced significantly. This enhanced BOD reduction is attributed to increased settling resulting due to dilution by mixing.

The Removal efficiency Vs Volume of sewage curve in Figure 4.4 to 4.6 indicate improvement of effluent quality caused by dilution and increased sedimentation as a result of increased flow volume. The SS curves also demonstrate that the behaviour of SS removal are similar to that of BOD. But the removal rate is higher due to the presence of detergent in it. As the sewage volume increses, the removal efficiencies increase.

From the BOD kinetics it is known that when pH is greater than 6 BOD reduction in anaerobic pond is a function of temperature and BOD loading. The higher the loading, the greater the reduction, optimum time being 5 days. Less than that will result smaller BOD removal and poorer quality of effluent (Mara 1976). In this study it is found that BOD removal is enhanced when organic loading is decreased. This is because of bathroom and wastewater mining with the sewage resulting dilution which helped increased settling and BOD removal.

The FC cound of the wastewater is maximum when kitchen wastewater is added loilet wastewater. But when bathroom wastewater is added, the FC count is decreased. From the treatment efficiencies of septic tanks it is seen that FC removal rate is lower in A2 and A3 condition ccompared to A1 condition. This lower removal results due to lower detention time and it higher initial content.

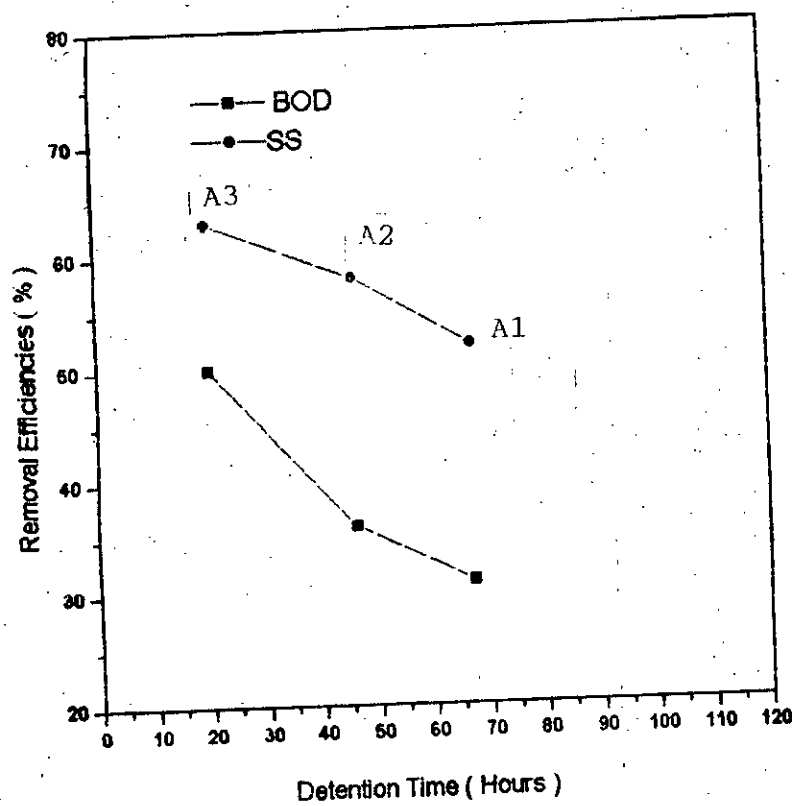


Figure 4.1 BOD & SS Removal in Septic Tank 1.

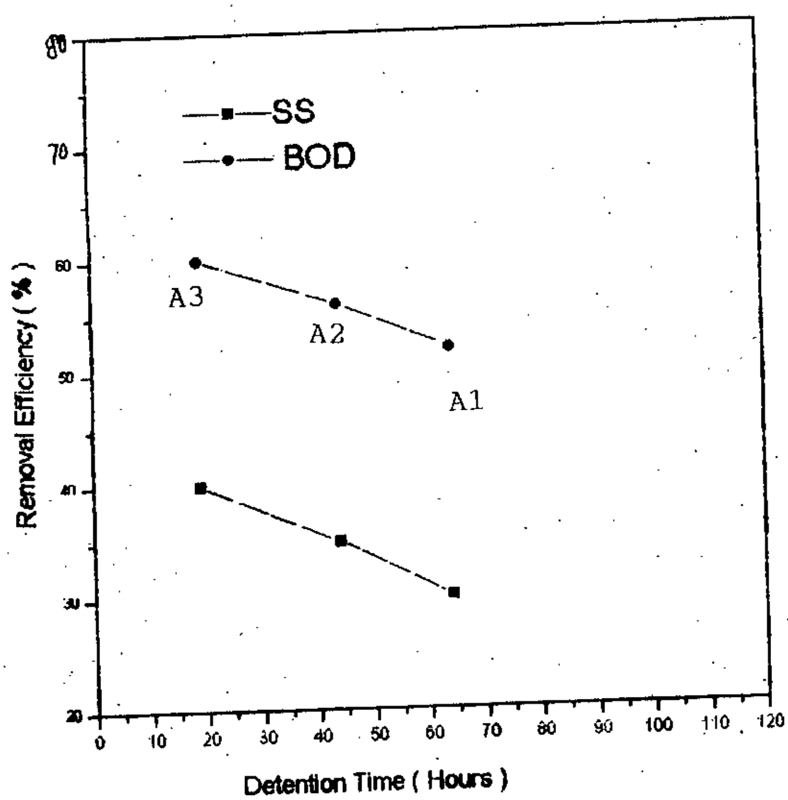


Figure 4.2 BOD & SS Removal in Septic Tank 2.

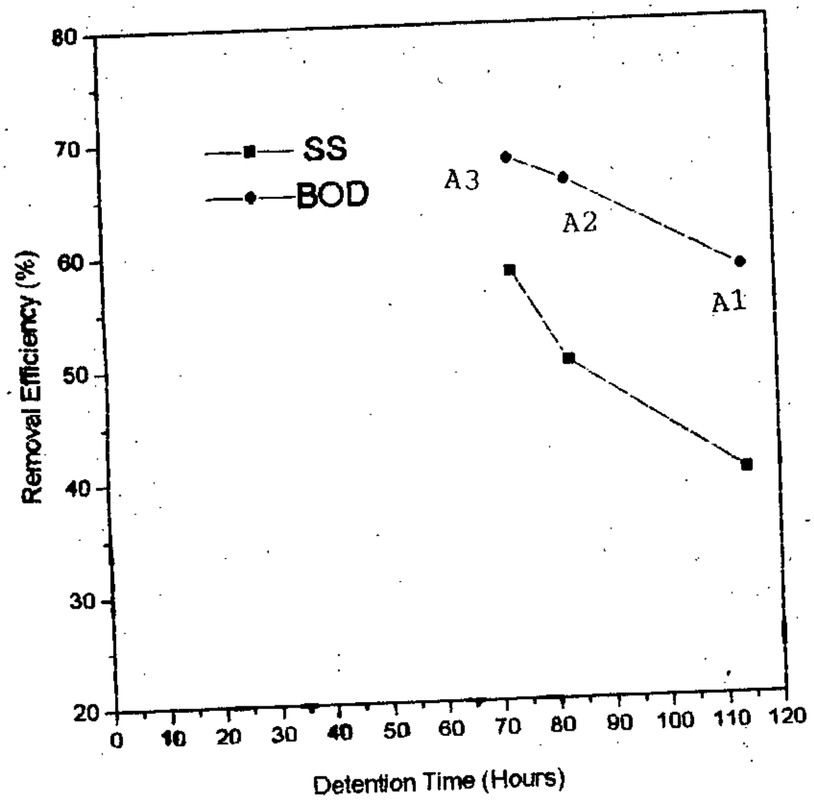


Figure 4 . 3BOD & SS Removal in Septic Tank 3.

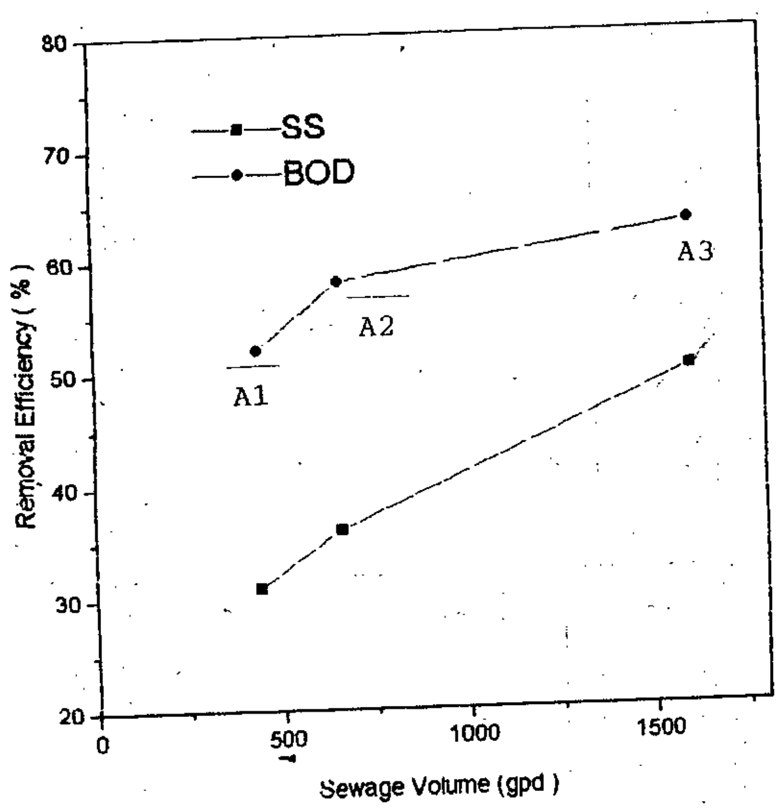


Figure 4 . 4BOD & SS Removal in Septic Tank 1.

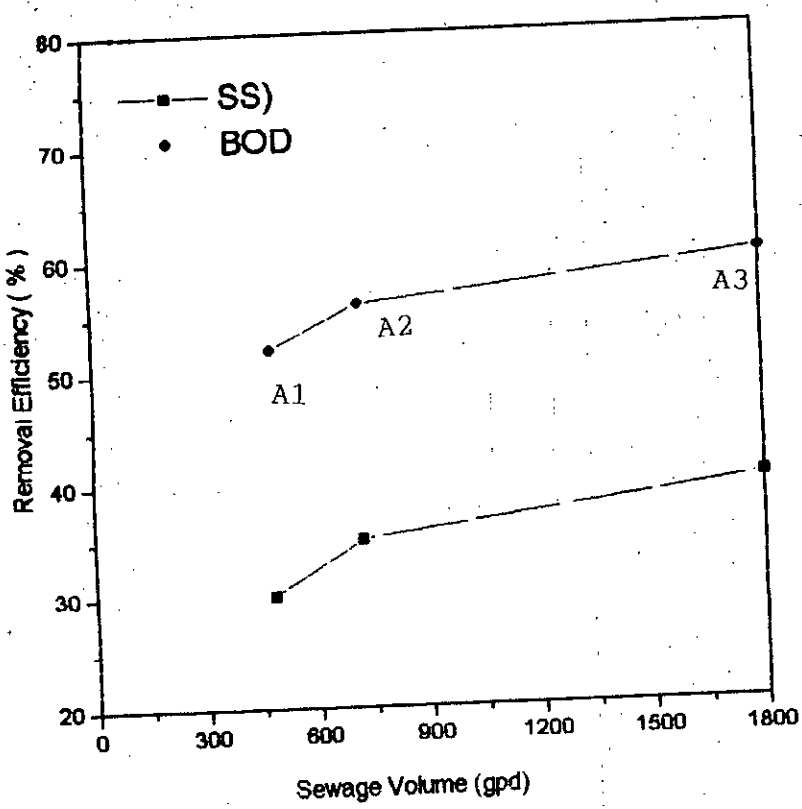


Figure 4.5 BOD & SS Removal in Septic Tank 2

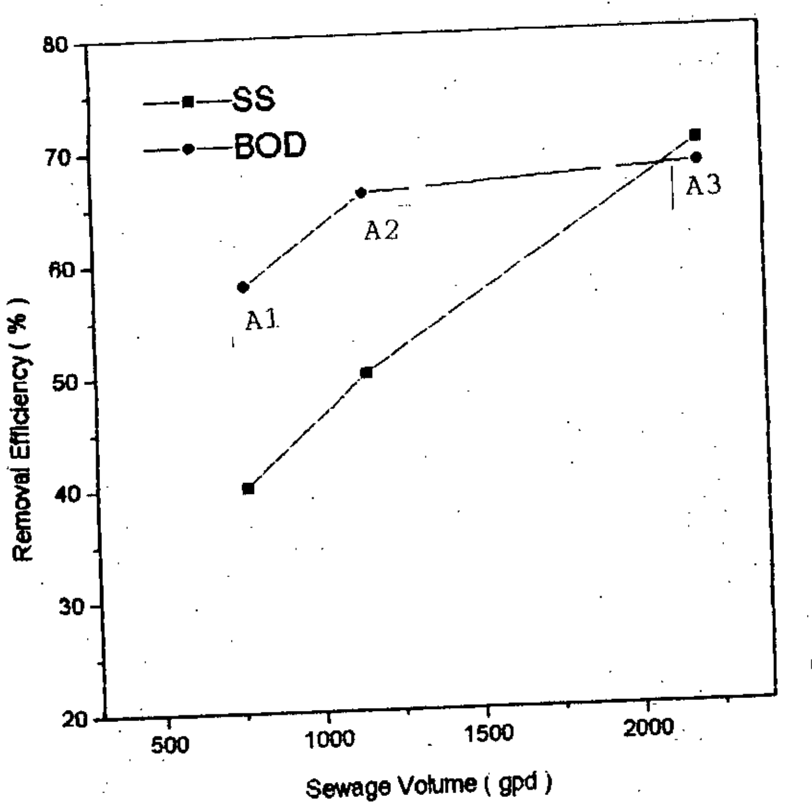


Figure 4.6 BOD & SS Removal in Septic Tank 3.

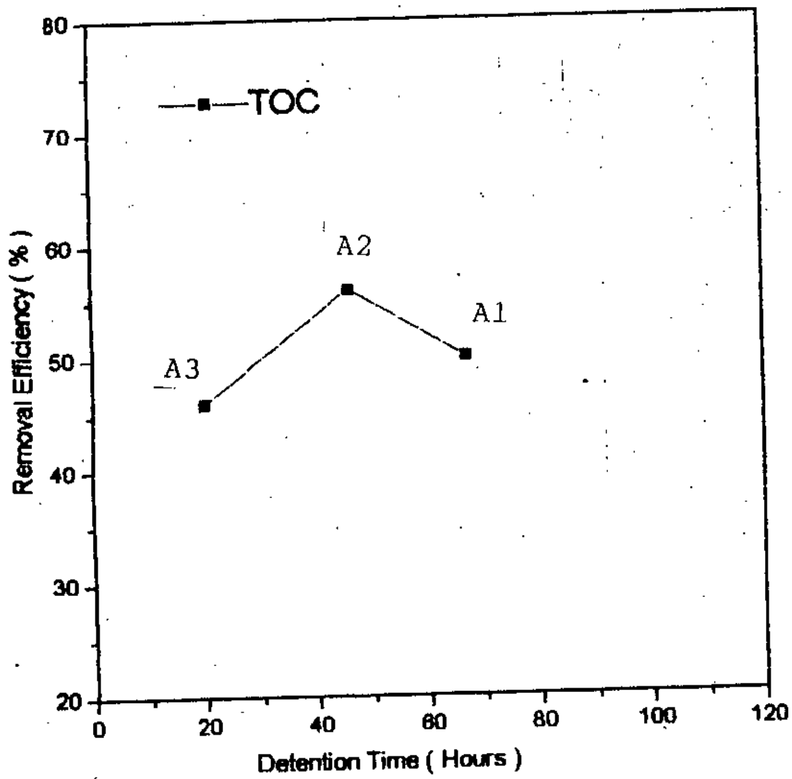


Figure 4 . 7TOC Removal in Septic Tank 1 .

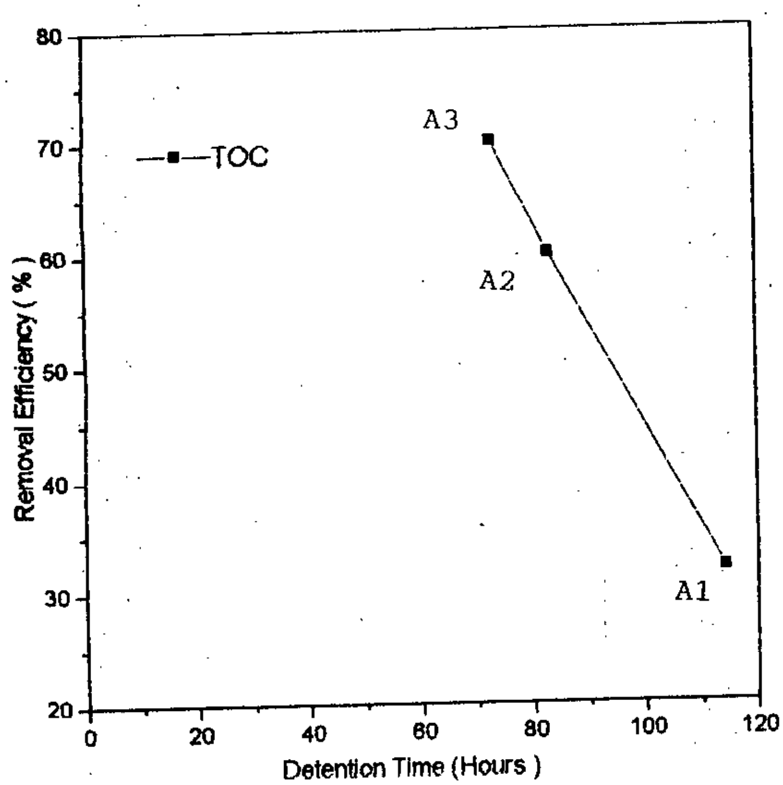


Figure 4 . 8 TOC Removal in Septic Tank 3 .

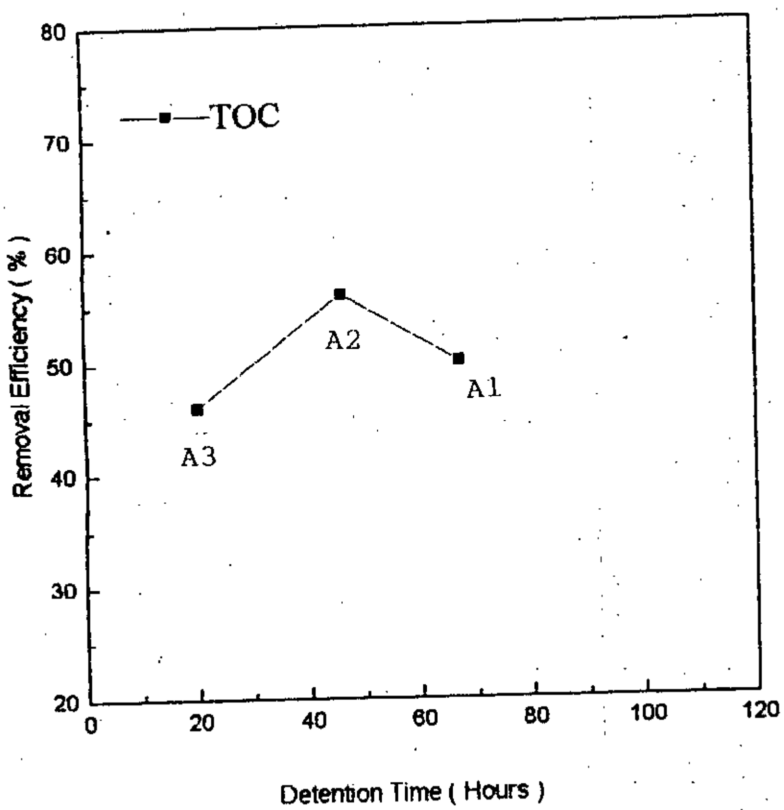


Figure 4.9 TOC Removal in Septic Tank 2.

The percolation test results show that the absorption capacities of soak pits depend on wastewater quality. Table 4.7 relates absorption rate with wastewater quality for the same type of soil . With toilet and kitchen wastewater the absorption rate was more than wastewaters from toilets only. The absorption rate was best when all the wastewaters were discharged to septic tanks. The result confirmed that better quality effluents with low BOD,COD,TOC and SS reduce the chances of soil clogging and hence increase the service life of soak pits which coroborates the study by Seigrist(1987).

4.4 Concluding Remarks

From the present study it appears that the septic tank effluent quality varies significantly under different composition of domestic wastewater. For domestic sewage with toilets only, effluent quality was poor. With the addition of kitchen wastewater the effluent quality improved significantly. For all purpose septic tanks receiving toilets, kitchen and bathroom wastewater, the effluent quality is much better. However, increased wastewater volume increases septic tank size increasing initial cost. The kitchen wastewater contains higher BOD, TOC, SS, FC and other nutrients, whereas the bathroom wastewater contain insignigicant amount of these constituents.

From the soil percolation test it appeared that the absorption rate of septic tank effluent increased with the improvement of effluent quality as suggested in literature (Siegrist,1987). However long term effect could not be determined within the scope of present study.

It became clear from the study that at test sites the septic tanks are improperly designed and soak wells have insufficient absorption area. Basing on the study results Four design option could be evolved.

Option 1. Toilet and kitchen wastewaters septic tank with 3 days detention time. Wastewater effluent constituent removal is BOD-60%,SS-50% and TOC-66%.

Option 2. All purpose septic tank with 1 day detention time. Wastewater effluent constituent removal is BOD-60%, SS-50% and TOC-46%.

Option 3. All purpose septic tank with 3 days detention tiem. Wastewater effluent constituent removal is BOD 68%, SS-70% and TOC-58%.

Option 4. Toilet wastewaters only septic tank with 5 days detention time. Wastewater effluent constituent removal is BOD-58%, SS-40% and TOC-32%.

Table 4.8 Comperative Efficiencies in Options

Consti-tuents	Treatment Efficiencies %			
	Option 1 A2 condition	Option 2 A3 condition	Option 3 A3 condition	Option 4 A1 condition
BOD_5	60	60	68	58
TOC	66	46	58	32
SS	50	50	70	40
PO_4	45	30	33	65
No_3	48	16	35	46
FC	45	30	40	50

From the comperative treatment efficiencies of four design options given in Table 4.8, option 3 is the best one and option 1 is second best.

CHAPTER - 5

DEVELOPMENT OF A NEW DESIGN APPROACH

5.1 Traditional Design Concept

In Bangladesh septic tank systems are designed on the basis of per capita sewage production. As the number of persons served increases, the length and width of the tank size also increase. Analysis of design drawings of some leading organisations are summerized here. However, the details were discussed in literature review. In PWD, capacity of septic tank is calculated on 86 lpcd with a detention time of one day. BR calculated the volume of septic tank on 200 lpcd, whereas MES design tanks on the basis of 88 lpccd S & A, a leading consultant in the country base their septic tank design on 150 lpcd.Similarly, there is a great variation in the design of soak wells. Effluent loadings to soak wells are considered as 120 $L/m^2/d$ by PWD,80 $L/m^2/d$ by MES and 200 $L/m^2/d$ by S & A. Basher(1990) suggested that for designing septic tanks in cities, kitchen wastewater should also be taken and a total wastewater contribution be 60 lpcd. He considered detention time to be one day.

5.2 Some International Design Concepts

International design concept on septic tank system is also based on volume of sewage generated per day. According to British code practice CP 302, the general equation for design of septic tank is, V=(2000+180xP) litres, where V is the volume of tank and P is the number of users contributing to the tank. Australian Household Waste treatment committee suggested the septic tank volume as, C=(200+P) litres, where C is the nominal liquid capacity of tank and P is the daily flow for design population. It also suggests that absorption system be limited to a maximum dosage of 50 L/m^2 d, irrespective of how permeable the soil might be.

Mara (1976) suggests, septic tank volume be calculated based on volume of sewage generated and retention time three days. Design followed by UNDP is based on the Brazilian septic tank code as; Minimum mean hydraulic retention time(t_h)= 1.5-0.3 log(PQ),where t is in days, P in numbers and Q is in Lcd. The total effective depth of tank= sludge depth+clear space depth+maximum submerged scum depth. Sludge depth (V_s)= 70x10 PN, where P is contributing Population, Q is wastewater flow and N is desludging interval.

5.3 Discussion on Traditional Design Concepts

Septic tank design practice discussed above are all based on daily flow rates for design population and with a detention time of one day. None of the above design practice consider effluent quality as one of factors of design. Septic tank failure is a common seen in Bangladesh. The main reasons for failure are attributed to the poor quality of effluents from septic tanks and under designed soak wells. Effluents containing high BOD, TOC and SS cloggs the infiltrative surfaces of soak wells and thereby reduce the absorption rate.

From the present study it is clear that the effluent quality of septic tank play a vital role in determiming the size of septic tank and soak pit. Percolation test results also reveal that better quality effluent result in better absorption. The study also indicates that optimal removal rate is achieved with toilet and kitchen wastewater receiving septic tanks. However, maximum removal was obtained with a septic tank receiving all the wastewaters. Four design options mentioned in article 4.4 may be evaluated for a hypothetical situation. The datas for design are:

- A household of 50 persons
- Wastewater flowrates in Lpcd:
    - Toilets - 36L
    - Kitchen - 16L
    - Bath, Laundry etc. - 68L
- Assume absorption rate of soil 51 $L/m^2/d$

Detail analysis are tabulated below:

Table 5.1 shows the economic analysis of four design options of septic tank system. From the environmental sanitation point of view, kitchen wastewater should not be discharged untreated to surface drainage as it contain substantial amount of BOD, TOC, SS,coliforms and other nutrients, which would pollute environment. Basing on these test results and cost analysis a new approach could be developed incorporating septic tank effluent quality and soil absorption rate in design criteria. The proposed design concept is based on toilet and kitchen wastewater septic tank with sewage detention time of 3 days(option 1). From the economic point of view also(Table 5.1)this system would be better compared to other options discussed in article 4.4.

Table 5.1. Cost Analysis of Septic Tank Systems

Design Options	Removal Efficiencies (%)		Volume of septic tank required (m^3)	Construction cost (Tk)	Daily discharge to soak well (L)	No of well	Construction cost of well (Tk)
	BOD_5	SS					
1	66	50	7.8	20,147 (491$ US)	2,600	2	40,000 (976$US)
2	60	50	6	15,500 (378$ US)	6,000	4	80,000 (1952$US
3	68	70	18	46,500 (1134$S)	6,000	4	80,000 (952$US)
4	58	40	9	23,247 (567$ US)	1,800	2	40,000 (976$US)

Note: Costing is done basing on MES rate of schedules.
Soak well size is assumed 2.4m diameter and 4.1m effective depth.

5.4 Design Steps in New Approach

A new criteria has been proposed here for the design of septic tank system. In this approach it is suggested to discharge toilet and kitchen wastewater to septic tanks. The raw sewage is detained in the tank for minimum 3 days before the effluent is discharged to soak pit. The size and number of soak pit is determined by conducting field percolation test. The design steps are given below:

Step.1. Determine volume of wastewater generated per day by equation:

$$\text{Wastewater volume (litres)} = PQT \quad (5.1)$$

where T as 3 days, Q as toilet + kitchen wastewater in litres and P as number of users.

Step.2. Calculate sludge accumulation volume by equation:

$$\text{Sludge volume (litres)} = PSD \quad (5.2)$$

where D is 3 years and S is 40 L per capita per year.

Step.3. Compute volume of septic tank by equation:

$$\text{Septic tannk volume } (m^3) = PQT+PSD+G \quad (5.3)$$

where G is freeboard which is 0.3m above liquid level (Duggal,1983)

Step.4. Determine absorption capacity($L/m^2/day$) of soil(R) by percolation test. Then calculate the absorption area required for soakwell using equation:

$$\text{Absorption area } (m^2) = \frac{PQ}{R} \quad (5.4)$$

If the absorption capacity of the soil is less than 30 $L/m^2/d$, use other disposal option.

Step.5. Calculate diameter of soak well using ; A/L.

A flow chart showing new approach of septic tank design is shown in Figure 5.1. Notations for flow chart are :

V= Total volume of tank
G= Freeboard
P= Number of users contributing to the tank
Q= Percapita flowrate to the tank
T= Hydraulic detention time
S= Per capita sludge accumulation yearly
D= Disludging interval in years

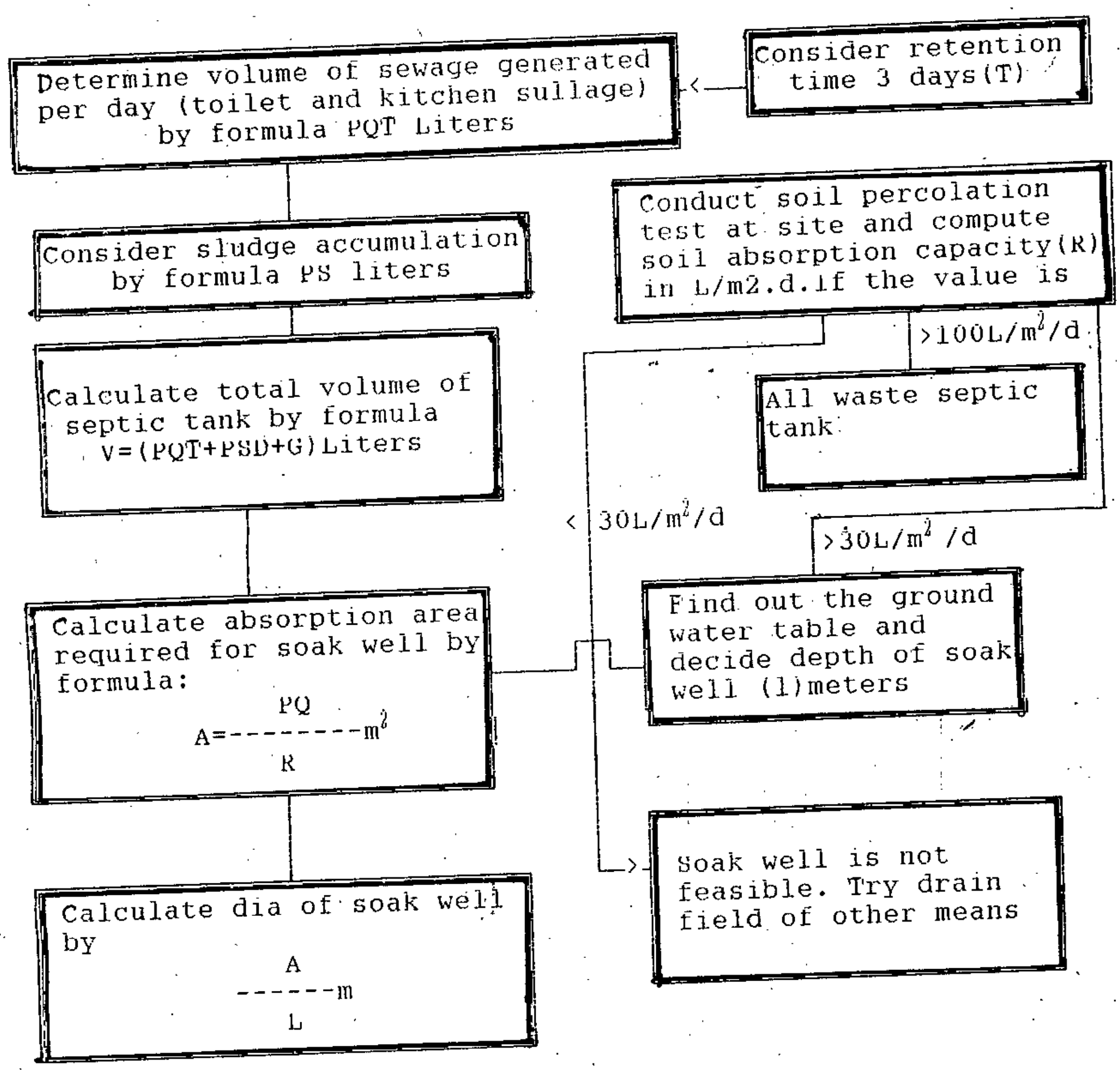


Figure 5.1 Flow Chart Showing New Approach of Septic Tank Design

5.5 Design Example

Following sections involve designing a septic tank system for a hypothetical situation using the new approach developed in this study and the UNDP and other design methods. The data for design are:

* A household of 56 persons
* 34 lpcd of toilet and kitchen watewater
* Disludging interval 3 years
* Soil absorption rate 51 $l/m^2/d$

5.5.1 New Approach

Step.1 Calculate volume of sewage by equation(5.1):

Volume of Sewage = PQT

= 56x34x3 = 5712 liters.

Step.2 Calculate volume of sludge by equation(5.2):

Sludge accumulation Volume=PSD

=56x40x3=6720 liters.

Step.3 Calculate volume of septic tank by equation(5.3):

Total Volume of Septic Tank

= PQT+PSD+G

= (5712+6720)+G

= (12.4+G) m3,take G as 0.3m (free board)

= 16 m^3.

Step.4 Calculate absorption area required for soakage pit by equation (5.4):

$$A = \frac{56 \times 34}{51} = 37 \text{ m}^2$$

Step.5 Determine size of soak well

Use one soak well of 2.4 m dia and 5 m deep.

5.5.2 Design Proposed by Basher (1990)

Basher (1990) attempted standardization of septic tanks for Bangladesh. Following his recommanded approach for septic tank this example is solved as follows.

Step.1 From Table 2.3 dimensions of the septic tank is :

Liquid depth = 4'-6" + 1 = 5'-6"

Width = 4'-6"

Length = 0.26P = 0.26x56 = 14'-7"

Volume of tank = 5.5'x4.5'x14.56'=360.36 ft3

$= 10.2 \text{ m}^3$

Step.2 From Table 2.4 dimensions of absorption pit is

Diameter = 5' = 1.5 m

Depth = 20' = 6m

No of well = 1

5.5.3 UNDP Approach

This approach is based on Brazilian code discussed in article 5.2.

Step.1 Minimum mean hydraulic retention time.

t_h = 1.5 - .3 log (pq).

= 1.5 - .3 log (56x34)

= 1.5 - .984 = 0.516 day.

Step.2 Volume required for sedimentation.

v_h = 10-3 (pq) t_h

= 10-3 (56x34)(0.516) = 0.98 m^3

Step.3 Volume required for sedimentation storage

Vs = 70 x 10-3 PN

= 70 x 10-3 x (56x3) = 11.8 m^3.

Step.4 Assume a cross - sectional area (A) of $6m^2$

(i) Max depth of sludge = $\frac{VS}{A} = \frac{11.8}{6}$ = 1.96m

(ii) Min submerged scum depth dss=$\frac{0.7}{6}$ =0.117m

(iii) Min sludge clear space=(0.82-(.26x6)=-0.74m

this is less than 0.3m .

(iv) Total clear space depth is =

0.075+.3=0.375m ; this is greater than Vn/A = 98=0.163m. So, the total clear space is the controlling factor in design.

Step.5 Total effective depth= 1.96+0.375+0.117 =2.45m

Step.6 The suitable overall internal dimensions of the tank would be 1.5m x 4m x 2.45m = 14.7 m3.

Step.7 Absorption area required for this septic tank effluent having 24 hrs detention time would be more since BOD, TOC and SS in the effluent will be more.

5.5.3. Comparison of Design

A design example has been solved using new approach, design proposed by Basher and conventional Brazilian code. The salient features which came up in the design are compared and tabulated below:

New Approach	**Conventional Approach**
Detention time 3 days	Detention time 1 day
Liquid volume of septic tank required is 16 m^3 which is 9% more volume than UNDP approach and 57% more volume than Basher.	Liquid volume of septic tank required is 14.7 m^3 as per UNDP and 10.2 as per Basher.
Septic tank effluent quality will be reduced to 40% of BOD	Effluent quality will be bad and there is no check and

and 50% of SS.	balance. There will be significant quantity of BOD, TOC and SS in the effluent which will clog infiltrative surfaces.
Septic tank effluent absorption be better and service life of septic tank and soak well would be increased.	More chances of clogging and would failure of soak wells. Service life of septic tank and soak well would be decreased.
Design is more comprehensive and scientific	Design based on empirical formula.

CHAPTER - 6

CONCLUSIONS AND RECOMMENDATIONS

6.1. Summary

In Bangladesh, the sanitation programmes are largely limited to onsite options. The primary onsite option include septic tank disposal system. The design principles commonly in practice are based on per capita sewage generation rate. Some organization design septic tanks for toilet wastewaters only, whereas others design for all type of wastewaters. In none of the design practice sewage quality is taken into consideration. Septic tank failure is a common sceen in Bangladesh. The main reasons for failure are improperly designed septic tanks and soak wells.

For the purpose of carrying out studies on septic tank effluent and its effect on soakage Dhaka Cantonment family accomodations were selected as test sites. Accordingly, three septic tanks at three test sites have been selected where the number of family accomodations are more and where the septic tank failure are common. In Dhaka Cantonment septic tanks are designed for receiving toilet wastes only. This study deals with the quality of effluent for various composition of domestic wastewater which include toilet wastes only, toilet and kitchen wastewater and toilet kitchen and bathroom wastewater. For the purpose of study three different composition of wastewaters were made for the existing septic tanks by connecting kitchen and bathroom wastewaters pipelines to the septic tanks in successive arrangement. Keeping the size of the septic tanks fixed the variations were made in organic and hydraulic loading, which brought variations in sewage characterestics. Also,the absorption capacities of soak wells were determined by standard percolation test.

The result shows that septic tank effluent generated from toilet wastes contain high concentration of BOD,TOC,SS and coliforms. Effluents generated from toilet and kitchen wastewater results better than toilets only. Effluents generated from all wastes septic tanks produced best effluents among the three cases. The detention time also played an important role in the quality of effluent generated. Soil percolation tests showed that all wastes effluent absorption rate is better than toilet and kitchen wastewater, and toilet wastes only.

The failure of the existing septic tanks occured due to poor quality of septic tanks effluents receiving toilet wastewater only. The high loading rates and continous inundation of soak pits enhanced clogging of absorption bed.

6.2 Major Findings of the Study

Major findings of the study with septic tank effluent and its soakage are listed below.

* septic tank effluent generated from toilets only is of poor quality.It contains high concentration of BOD, TOC, SS and coliform bacteria.

* Septic tank effluent generated from the combination of toilet and kitchen wastewater, is of better quality than toilets only.

* Septic tank effluents generated from all type wastewaters containing toilets, kitchen and bathroom is of much better quality than other two cases.

* Kitchen wastewater contain significant amount of BOD, TOC, SS, coliforms and other nutrients and should not be discharged untreated.

* Bathroom wastewater contain insignificant amount of BOD, TOC, SS and other constituents and may be discharged to surface drains untreated.

* In this study it is found that BOD removal is enhanced when organic loading is decreased. This is because of bathroom and washwater mixing with sewage resulting dilution which helped increased settling and BOD remoal.

* The FC count of the wastewater is maximum when kitchen wastewater is added to toilet wastewater. FC removal rate is lower in A2 and A3 condition compared to A1 condition. This lower removal rate results due to lower detention time and its higher initial content.

* For the same type of soil, absorption rate of effluents in soakage well for all purpose septic tanks is better than effluents from toilets only and toilet and kitchen. Effluent with lower BOD, TOC and SS enhance absorption and delay soil clogging.

* The removal of SS in single chambered septic tanks was less, which resulted in reduced removal efficiency compared to double chambered septic tanks.

* None of the conventional design practices consider effluent quality in design approach.

* Four options derived for the design of septic tanks from this study are:

Option 1. Toilet and kitchen wastewater septic tanks with 3 days detention time.

Option 2. All purpose septic tank with 1 day detention time.

Option 3. All purpose septic tank with 3 days detention time.

Option 4. Toilets only septic tank with 5 days detention time.

From the functional efficiency, option 3 would be preferable if the soil percolation capacity is sufficient to absorb effluent generated daily and the cost is within acceptable limit. Otherwiseoption 1 would be better.

6.3 Recommendations

The present study can not be considered as a comprehensive one covering all aspects of septic tank configuration and long term effects on absorption capacity of soak wells. However, within its scope and limitations , the study provided a guidance for improving design concepts of septic tank and soakage.

The following recommendations are made from the present study:

(a) Septic tanks may be designed based on receiving toilet and kitchen wastewater with 3 days detention time. The bathroom wastewater may be discharged to surface drains.

(b) The findings of this study is by no means a omprehensive one. The effectiveness of proposed design may again be tested with more field testing before put to practice.

(c) To have a comprehensive study on the subject, followings are recommanded:

  (i) Study with septic tank of different sizes with inflow and outflow measuring device.

  (ii) Post treatement of effluent with sand filter for direct discharge to surface drains where soil absorption capacity is very low.

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ANNEXURE A

Data Tables give the results of Septic Tank Effluent quality, Raw sewage characteristics, Effluent percolation test results and Absorption capacities of soakage pits.

Table A.1. Raw Sewage Characteristics Data and Test Results.

1.	Sample Used	:	Actual and Diluted sewage from septic tank.
2.	Composition of sewage	:	Untreated toilet wastewater
3.	Date of Collection	:	09-10-94.
4.	Test Site	:	Kafrul Officers Quarter (ST 1)
5.	Weather	:	Sunny day.
6.	Test Results	:	Shown below.

Parameters	Values
Temp, oC	29.5
pH,	6.9
TOC,mg/l	180
BOD_5, mg/l	230
COD,mg/l	370
SS,mg/l	86
NO_3,mg/l	12
PO_4,mg/l	4
TC, nos/100 ml	2.5×10^7
FC, nos/100 ml	1.5×10^7

Table A.2 Raw Sewage Characteristics Data and Test Results.

1. Sample Used : Actual and diluted samples from septic tank.

2. Composition of sewage : Untreated toilet wastewater

3. Date of Collection : 09-10-94.

4. Test Site : Kurmitola Golf Club officers club(ST 2).

5. Weather : Sunny day.

6. Test Results : Shown below.

Parameters	Values
pH	7.0
Temp, oC	29.5
TOC, mg/l	170.8
BOD_5,mg/l	250
COD, mg/l	380
SS,mg/l	94
No_3,mg/l	13
PO_4,mg/l	7
TC,nos/100 ml	40×10^6
FC nos/100 ml	20×10^6

Table A.3 Raw Sewage Characteristics Data and Test Results.

1. Sample Used : Actual and diluted samples from septic tank.

2. Composition of sewage : Untreated toilet wastewater

3. Date of collection : 09-10-94.

4. Test Site : Katchukhet Staff Quarters(ST 3).

5. Weather : Sunny day.

6. Test Results : Shown below.

Parameters	Values
pH	7.2
Temp, oC	29.5
TOC,mg/l	55.71
BOD_5, mg/l	100
COD,mg/l	200
SS,mg/l	93
No_3,mg/l	13
PO_4,mg/l	20
TC, nos/100 ml	10×10^6
FC,nos/100 ml	6×10^6

Table A.4 Raw Sewage Constituents

1. Sample used : Actual and diluted samples
2. Composition of Sewage : Untreated toilet and kitchen wastewater
3. Date of collection : 01-11-94
4. Test of site : ST 2
5. Weather : Dry
6. Test Result : Shown below

Parameters	Values
PH	6.9
Temp, ^0C	28
TOC,mg/l	96
BOD_5,mg/l	160
COD, mg/l	300
SS, mg/l	71
No_3, mg/l	50
PO_4,mg/l	35
TC,nos/100 ml	15×10^7
FC,nos/100 ml	15×10^6

Table A.5 Raw Sewage Constituents

1.	Sample Used	:	Actual and diluted samples
2.	Composition of sewage	:	Untreated toilet and kitchen wastewater
3.	Date of collection	:	01-11-94
4.	Test site	:	ST 3
5.	Weather	:	Dry
6.	Test Result	:	Shown below

Parameters	Values
PH	6.9
Temp, oC	28
TOC, mg/l	82
BOD_5, mg/l	180
COD, mg/l	300
SS, mg/l	80
No_3, mg/l	50
PO_4, mg/l	45
TC, Nos/100 ml	35×10^7
FC, nos/100 ml	25×10^7

Table A.6 Raw Sewage Constituents

1. Sample Used : Atual and diluted samples

2. Compostion of sewage : Untreated toilet,kitchen and bathroom wastewater

3. Date of collection : 25-11-94

4. Test site : ST 1

5. Weather : Dry

6. Test Result : Shown below

Parameters	Values
PH	6.8
Temp, OC	22
TOC, mg/l	121
BOD_5, mg/l	110
COD, mg/l	200
SS, mg/l	80
No_3, mg/l	40
PO_4, mg/l	6
TC, nos/100 ml	15×10^7
FC, nos/100 ml	13×10^6

Table A.7 Raw Sewage Constituents

1.	Samples Used	:	Actual and diluted samples
2.	Composition of sewage	:	Untreated toilet, kitchen and bathroom wastewater
3.	Date of collection	:	25-11-94
4.	Test site	:	ST 2
5.	Weather	:	Dry
6.	Test Result	:	Shown below

Parameters	Values
pH	6.8
Temp, oC	22
TOC, mg/l	85
BOD_5, mg/l	110
COD, mg/l	190
SS, mg/l	78
NO_3, mg/l	55
PO_4, mg/l	25
TC, nos/100 ml	17×10^7
FC, nos/100 ml	12×10^6

Table A.8 Raw Sewage Constituents

1.	Sample Used	:	Actual and diluted samples.
2.	Composition of sewage	:	Untreated toilet, kitchen and bathroom wastewater
3.	Date of collection	:	25-11-94
4.	Test site	:	ST 3
5.	Weather	:	Dry
6.	Test Result	:	Shown below

Parameters	Values
pH	6.8
Temp, ^{O}C	22
TOC, mg/l	102
BOD_5, mg/l	110
COD, mg/l	210
SS, mg/l	86
No_3, mg/l	30
PO_4, mg/l	45
TC, nos/100 ml	15×10^7
FC, nos/100 ml	8×10^6

Table A.9 Raw Sewage Characterstics Test Result

1. Sample Used : Actual and diluted Samples
2. Composition of sewage : Raw Toilet wastewaters
3. Date of collecttion : 16-8-94
4. Test site : Kafrul (ST1),Kurmitola Golf Club (ST 2),Katchukhet (ST 3)
5. Weather : Cloudy
6. Test Result : Shown below

Parameters	Values		
	ST 1	ST 2	ST 3
pH	6.3	6.3	6.3
Temp, ^{O}C	31	31	31
TOC, mg.l	76	106	160
BOD_5, mg/l	160	290	200
COD,mg/l	290	340	340
SS, mg/l	58	65	40
No_3, mg/l	30	13	13
PO_4, mg/l	25	20	15

Table A.10 Raw Sewage Characterstics Test Result

1.	Sample Used	:	Actual and diluted samples
2.	Composition of sewage	:	Raw kitchen wastewaters
3.	Date of collection	:	16-8-95
4.	Test site	:	ST1, ST2, ST3
5.	Weather	:	Cloudy
6.	Test Result	:	Shown below

Parameters	Values		
	ST1	ST2	ST3
pH	6.2	6.3	6.3
Temp, ^{O}C	31	31	31
TOC, mg/l	123	130	160
BOD_5, mg/l	150	140	160
COD, mg/l	240	290	380
SS, mg/l	105	129	84
No_3, mg/l	15	20	24
PO_4, mg/l	15	40	50

Table A.11 Raw Sewage Characterstics Test Result

1. Sample Used : Actual and diluted samples
2. Composition of sewage : Raw Bathroom wastewater
3. Date of collection : 16-8-95
4. Test site : ST 1, ST 2, ST 3
5. Weather : Monsoon
6. Test Result : Shown below

Parameters	Values		
	ST 1	ST 2	ST 3
pH	6.3	6.3	6.3
Temp, ^{O}C	31	31	31
TOC, mg/l	36	30	100
BOD_5, mg/l	6	7	10
COD, mg/l	20	22	25
SS, mg/l	9	6	4
No_3, mg/l	30	20	34
PO_4, mg/l	30	15	25

Table A.12 Raw Sewage Characterstics Test Result

1. Sample Used : Actual and diluted samples

2. Composition of sewage : Raw toilet wastewater and kitchen wastewater mixed in proportion 2:1 for ST1 and ST2 and 2.34:1 for TS3

3. Date of collection : 16-8-95

4. Test site : ST 1, ST 2, and ST 3

5. Weather : Dry

6. Test Result : Shown below

Parameters	Values		
	ST1	ST2	ST3
pH	6.3	6.3	6.3
Temp, ^{o}C	31	31	31
TOC, mg/l	87	96	180
BOD_5, mg/l	140	160	180
COD, mg/l	260	300	300
SS, mg/l	44	70	34
No_3, mg/l	25	20	13
PO_4, mg/l	15	40	20

Table A.13 Raw Sewage Characterstics Test Result

1. Sample Used : Actual and diluted samples
2. Composition of sewage : Raw toilet, kitchen and bath room wastewater mixed in proportin (2): (1): (3.7) for TS1 and TS2 and(2.26):(1): (3.33) for TS3
3. Date of collection : 16-8-95
4. Test site : ST 1, ST 2 and ST 3
5. Weather : Cloudy
6. Test Result : Shown below

Parameters	Values		
	ST 1	ST 2	ST 3
pH	6.3	6.3	6.3
Temp, ^{o}C	31	31	31
TOC, mg/l	38	85	102
BOD_5, mg/l	110	110	110
COD, mg/l	200	190	210
SS, mg/l	44	78	15
No_3, mg/l	30	20	15
PO_4, mg/l	30	25	35

Table A.14 Raw Sewage Constituents

1.	Sample Used	:	Actual and diluted samples.
2.	Composition of sewage	:	Untreated toilet and kitchen wastewater
3.	Date of collection	:	01-11-94
4.	Test site	:	ST 1
5.	Weather	:	Dry
6.	Test Result	:	Shown below

Parameters	**Values**
pH	6.9
Temp, ^{O}C	28
TOC, mg/l	87
BOD_5, mg/l	140
COD, mg/l	250
SS, mg/l	70
No_3, mg/l	50
PO_4, mg/l	45
TC, nos/100 ml	60×10^7
FC, nos/100 ml	25×10^6

Table A.15 Septic Tank Effluent Characteristic Data and Test Results.

1. Sample Used : Actual and diluted samples collected from the effluents of septic tank in soakage pit.
2. Composition of Sewage : Toilet Wastes only(A1).
3. Date of collection : 25-10-94.
4. Test Site : Kafrul Officer quarters(ST 1).
5. Weather : Sunny day.
6. Test Result : Shown below.

Parameters	Values
pH	7.0
Temp, oC	28
TOC,mg/l	90.5
BOD_5,mg/l	
At Dilution 1/10	109
At Dilution 1/50	108
At dilution 1/100	110
COD,mg/l	170
SS,mg/l	59
NO_3,mg/l	5
PO_4,mg/l	2
TC, nos/100 ml	2.5×10^7
FC, nos/100 ml	5×10^6

Table A.16 Septic Tank Effluent Characteristic Data and Test Results.

1.	Sample Used	:	Actual and diluted sample collected from the effluents of septic tank in soakage pit.
2.	Composition of sewage	:	Toilet wastes only (A1).
3.	Date of collection	:	25-10-94.
4.	Test Site	:	Kurmitoal Golf club officers quarters(ST 2).
5.	Weather	:	Sunny day.
6.	Test Result	:	Shown below :

Parameters	Values
pH	7.3
Temp, oC	28
TOC,mg/l	92
BOD_5, mg/l	
At Dilution 1/10	117
At Dilution 1/50	118
At Dilution 1/100	120
COD, mg/l	180
SS, mg/l	66
NO_3, mg/l	7
PO_4, mg/l	4
TC, nos/100 ml	3×10^7
FC, nos/100 ml	1×10^7

Table A.17. Septic Tank Effluent Characteristics Data and Test Results.

1. Sample Used : Actual and diluted samples collected from the effluents of septic tank in soakage pit.

2. Composition of sewage : Toilet wastes only (A1).

3. Date of collection : 25-10-94.

4. Test Site : Katchukhet Staff quarters(ST 3).

5. Weather : Sunny day.

6. Test Results : Shown below.:

Parameters	Values
pH.	7.1
Temp, ^0C	28
TOC,mg/l	38
BOD_5, mg/l	
At Dilution 1/10	44
At Dilution 1/50	40
At Dilution 1/100	40
COD,mg/l	80
SS, mg/l	56
NO_3, mg/l	6
PO_4,mg/l	7
TC,nos/100 ml	$8x10^6$
FC, nos/100 ml	$3x10^6$

Table A.18. Septic Tank effluent Characteristics Data and Test Results.

1.	Sample Used	:	Actual and diluted samples collected from the effluents of septic tank in soakage pit.
2.	Composition of sewage	:	Toilet wastes and kitchen sullage (A2).
3.	Date of collection	:	22-11-94.
4.	Test Site	:	Kafrul Officers Quarters(ST1).
5.	Weather	:	Fair Weather.
6.	Test Results	:	Shown below :

Parameters	Value
pH	6.9
Temp, ^0C	27
TOC,mg/l	38
BOD_5,mg/l	
At Dilution 1/10	55
At Dilution 1/50	55
At Dilution 1/100	60
COD, mg/l	100
SS,mg/l	45
NO_3, mg/l	40
PO_4,mg/l	30
TC,nos/100 ml	20×10^7
FC,nos/100 ml	15×10^7

Table A.19. Septic Tank Effluent Characteristic Data and Test Results.

1.	Sample Used	:	Actual and diluted samples collected from the effluent of septic tank in soakage pit.
2.	Composition of sewage	:	Toilet wastes and kitchen sullage only (A2).
3.	Date of collection	:	22-11-94.
4.	Test Site	:	Kurmitola Golf club Officers quarters(ST 2).
5.	Weather	:	Fair.
6.	Test Results	:	Tabulated below :

Parameters	Values
pH	6.9
Temp, °C	27
TOC,mg/l	48.6
BOD_5,mg/l	
At Dilution 1/10	65
At Dilution 1/50	60
At Dilution 1/100	70
COD,mg/l	120
SS mg/l	46
NO_3,mg/l	30
PO_4,mg/l	21
TC, nos/100 ml	14×10^6
FC, nos/100 ml	10×10^6

Table A.20. Septic Tank Effluent Characteristics Data and Test Results.

1. Sample Used : Actual and diluted samples collected from the effluent of septic tank in soakage pit.

2. Composition of sewage : Toilet wastes and kitchen sullage only (A2).

3. Date of collection : 22-11-94.

4. Test site : Katchukhet staff quarters(ST 2).

5. Weather : Fair.

6. Test Results : Tabulated below :

Parameters	Values
pH	6.9
Temp, °C	27
TOC, mg/l	32.7
BOD_5, mg/l	
At Dilution 1/10	-
At Dilution 1/50	35
At Dilution 1/100	40
COD , mg/l	80
SS, mg/l	40
NO_3, mg/l	18
PO_4,mg/l	25
TC, nos/100 ml	7×10^6
FC, nos/100 ml	5×10^6

Table A.21. Septic Tank Effluent Characteristics Data and Test Results.

1. Sample Used : Actual and diluted samples collected from the effluent of septic tank.

2. Composition of sewage : Toilet wastes,kitchen sullage and bathroom wastewater (A3).

3. Date of Collection : 18-12-94.

4. Test Site : Kafrul Officer quarters(ST1).

5. Weather : Moderate.

6. Test Results : Tabulated below :

Parameters	Values
pH	6.7
Temp, ^0C	21.5
TOC,mg/l	55
BOD_5, mg/l	35
At Dilution 1/10	40
At Dilution 1/50	50
COD, mg/l	38
SS,mg/l	30
NO_3, mg/l	4
PO_4,mg/l	40
TC, nos/100 ml	$13x\ 10^6$
FC, nos/100 ml	9×10^6

Table A.22. Septic Tank Effluent Characteristic Data and Test Results.

1.	Sample Used	:	Actual and diluted samples collected from the effluent of septic tank in soakage pit.
2.	Composition of Sewage	:	Toilet, Kitchen and bathroom wastewater (A3).
3.	Date of collection	:	18-12-94.
4.	Test Site	:	Kurmitola Golf Club Officers quarters(ST 2).
5.	Weather	:	Moderate
6.	Test Results	:	Tabulated below :

Parameters	Values
pH	7
Temp, ^0C	21.5
TOC, mg/l	47
BOD_5, mg/l	
At Dilution 1/10	40
At Dilution 1/50	40
COD, mg/l	50
SS, mg/l	36
NO_3, mg/l	50
PO_4, mg/l	20
TC, nos/100 ml	11×10^6
FC, nos/100 ml	9×10^6

Table A.23. Septic Tank Effluent Characteristics Data and test Results.

1.	Sample Used	:	Actual diluted sample collected from the effluent of septic tank in soakage pit.
2.	Composition of Sewage	:	Toilet, kitchen and bathroom wastewaters (A3).
3.	Date of collection	:	18-12-94.
4.	Test Site	:	Katchukhet staff quarters(ST 3).
5.	Weather	:	Moderately cool.
6.	Test Result	:	Tabulated below :

Parameters	Values
pH	6.7
Temp ^0C	21.5
TOC, mg/l	60
BOD_5, mg/l	
At Dilution 1/10	35
At Dilution 1/50	40
COD, mg/l	60
SS, mg/l	35
NO_3 mg/l	19
PO_4 mg/l	30
TC,nos/100 ml	7×10^6
FC, nos/100 ml	5×10^6

Table A.24 Characteristics of Raw Kitchen Wastewater

1.	Sample Used	:	Actual and diluted samples from kitchen wastewater line.
2.	Date of collection	:	23-7-95
3.	Test Site	:	Kurmitola Golf Club officers quarters(ST 3)
4.	Weather	:	Summer, rainy
5.	Composition of sewage	:	Kitchen wastewaters only.
6.	Test Result	:	Shown below :

Parameters	Values
pH	6.8
Temp, ^0C	30
TOC, mg/l	148
BOD_5, mg/l	190
COD, mg/l	270
SS, mg/l	70
NO_3, mg/l	30
PO_4,mg/l	2.5
TC, nos/100 ml	-
FC, nos/100 ml	-

Table A.25. Effluent Percolation Test Result.

1.	Sample Used	:	Actual effluent collected from soakage pit.
2.	Composition of sewage	:	Toilet wastes only (A1).
3.	Date of Testing	:	08 Jan 95
4.	Test Site	:	Kafrul Officer quarters(ST1).
5.	Weather	:	Fairly Cold.
6.	Preparation of Holes	:	Diameter. 100 mm Depth. 500 mm Spacing of holes. Not closer then 2 m. Over night soaking of holes.
7.	Test Result	:	Tabulated below :

Table A.25(continued)

Tex t NO	Reading s	Test Hole 1		Test Hole 2		Test Hole 3		Mean Drop in water level cm
		Level cm	Drop in water level	Level cm	Drop in water level	Level cm	Drop in water level	
1	Initial 10 min later	15 11.5	3.5	16 13	3	15 12	3	
2.	Initial 10 min later	15.5 12	3.5	15 12.5	2.5	15 12.5	2.5	
3.	Initial 10 min later	15 12	3	15 13	2	15 13	2	
4.	Initial 10 min later	15 13	2	15 13.5	1.5	15 13.5	1.5	
5.	Initial 10 min later	15.5 14	1.5	15 14	1	15 13.5	1.5	0.92 cm/ 10 min / 35 mm in 27 min
6.	Initial 10 min later	15 14	1	15 14	1	15.5 14.5	1	
7.	Initial 10 min later	15 14.25	.75	15 14	1	15 14	1	
8.	Initial 10 min later	15 14.25	.75	-	-	-	-	
	Uniform Drop in water level	.75		1		1		

Table A.26. Effluent Percolation Test Results.

1.	Sample Used	:	Actual effluent collected from the soak pit.
2.	Composition of sewage	:	Toilet wastes, Kitchen wastewater and bathroom wast water(A3).
3.	Date of Testing	:	08-1-95.
4.	Test Site	:	Katchukhet Staff quarters(ST 3).
5.	Weather	:	Fairly cold.
6.	Test Holes	:	Diameter 100 mm Depth 500 mm Spacing Not closer than 2 m Overnight Soaking
7.	Test Result	:	Tabulated below :

Table A.26(continued)

Tex t No.	Reading	Test Hole 1		Text Hole 2		Text Hole 3		Mean Drop mm
		Level cm	Drop in level cm	Level cm	Drop in level cm	Level cm	Drop in level cm	-
1.	Initial	16	4.5	15	4	16	4	
	10 min later	11.5		11		12		
2.	Initial	15	4	15	3.5	15.5	3.5	
	10 min later	11		11.5		12		
3.	Initial	15.5	3.5	15.5	3	15.5	3.5	
	10 min later	12		12.5		12		18.3 mm/
4.	Initial	15	3.5	15	2.5	15	3.5	10 min
	10 min later	11.5		12.5		12		or
5.	Initial	15	3	15	2	15	3	13 min
	10 min later	12		13		12.5		for 25
6.	Initial	15	2.5	15	1.75	15	2.5	mm fall
	10 min later	12.5		13.25		13		
7.	Initial	15	2	15	1.75	15	2	
	10 min later	13		13.25		13.25		
8.	Initial	15	2			15	1.75	
	10 min later	13				13.25		
							1.75	
Uniform Drop in water level		2		1.75		1.75		-

Table A.27. Effluent Percolation Test Result.

1.	Sample Used	:	Actual effluent collected from the soakage pit.
2.	Composition of Sewage	:	Toilet,kitchen and bathroom wastewaters (A3).
3.	Date of Testing	:	10 Feb 95
4.	Test Site	:	Kafrul officers quarters(ST1).
5.	Weather	:	Fairly Cold.
6.	Test Holes	:	Diameter 100 mm Depth 500 mm Spacing Not closer than 2 m Overnight soaking
7.	Test Result	:	Tabulated below:

Table A.27(continued).

Tex t No.	Reading	Test Hole 1		Text Hole 2		Text Hole 3		Mean Drop mm
		Level cm	Drop in, level cm	Level cm	Drop in level cm	Level cm level cm	Drop in level cm	
1.	Initial	13.5	2	13	2.00	15	2.5	
	10 min	11.5		11		12.5		
2.	later	16	1.5	16	1.75	15	2	
	Initial	14.5		14.25		13		10 mm/
3.	10 min	17	1	16	1.5	15	1.5	10 min
	later	16		14.25		13.5		or
4.	Initial	17	1	16	1	15	1.25	25 mm
	10 min	16		15		13.75		in
5.	later	16	.75	16	1	15	1.25	25 min
	Initial	15.26		15		13.75		
6.	10 min	15	.75	16	1	-	-	
	later	14.25		15		-		
	Initial							
	10 min							
	later							
	Initial							
	10 min							
	later							
Uniform Drop in water level		.75		1		1.25		

Table A.28. Effluent Percolation Test Result.

1.	Sample Used	:	Actual effluent collected from soak pit.
2.	Composition of sewage	:	Toilet wastes only (A1).
3.	Date of Testing	:	10 Feb 95
4.	Test Site	:	Katchukhet staff quarters(ST 3).
5.	Weather	:	Fairly Cold.
6.	Test Holes	:	Diameter 100 mm Depth 500 mm Spacing not closer than 2 m Overnight Soaking.
7.	Test Result	:	Tabulated below :

Table. A.28 (continued).

Tex t No	Reading	Test Hole 1		Test Hole 2		Test Hole 3		Mean Drop cm
		Leve l cm	Drop in leve l	Leve l cm	Drop in level cm	Leve l cm	Drop in leve l	
1.	Initial	15	4	16	3.5	15	3	
	10 min later	11		12.5		12		
2.	Initial	15	3.5	15	3	15	2.5	
	10 min later	11.5		12		12.5		
3.	Initial	15	3	16	2.5	16	2	
	10 min later	12		13.5		13		
4.	Initial	15	2.5	15	2	15	2	
	10 min later	12.5		13		13		15.8 mm
5.	Initial	15	2	15	1.75	15	1.75	in 10 min
	10 min later	13		13.2 5		13.2 5		
6.	Initial	16	1.5	15	1.5	15	1.75	or
	10 min later	14.5		13.5		13.2 5		
7.	Initial	-	1.5	15	1.5	-	-	25 mm in
	10 min later	13.5		13.5		-		16 min
Uniform Drop in water level		1.5		1.5		1.75		-

Table. A.29. Effluent Percolation Test Result.

1.	Sample Used	:	Actual sample collected from the soakage pit.
2.	Composition of Sewage	:	Toilet wastes and kitchen wastewater (A2).
3.	Date of Testing	:	10 Feb 95
4.	Test Site	:	Kafrul officers quarters(ST1).
5.	Weather	:	Fairly Cold.
6.	Test Holes	:	Diameter 100 mm Depth 500 mm Spacing Not closer than 2 m Overnight Soaking.
7.	Test Result	:	Tabulated below :

Table A.29 (continued).

Text No.	Reading	Test Hole 1		Test Hole 2		Test Hole 3		Mean Drop mm mm
		Leve l cm	Drop in leve l cm	Level cm	Drop in in level cm	Level cm	Drop in level cm	
1.	Initial	15	2	15		15		
	10min later	13		13.1	1.9	13	2	
2.	Initial	15		15		15		
	10 min later	13.6	1.4	13.5	1.5	13.3	1.8	
3.	Initial	15		15		15		0.96 cm/
	10 min later	13.8	1.2	13.7	1.3	13.5	1.5	10 min.
4.	Initial	14.5		15.5		15		25 min in
	10 min later	13.6	0.9	14.5	1	14	1	26 min
5.	Initial	15		15		15.5		
	10 min later	14.1	0.9	14	1	- 14.5	1	
Uniform Drop in water level		0.9		1		1		

Table A.30. Absorption Capacity of Disposal Field and Seepage pit.

Percolation Test Rate in limited for water to fall 25 mm	Effluent Allowance Rate of Seepage unit inlitres per M2 per day	
	Disposal Field Trenches(Bottom)	Seepage pit (Wall area)
2 or less	128	172
5	96	128
10	68	92
30	32	44
60 (Not recommended)	16	24
Over 60 (Not suitable)	-	-

(Source : Bangladesh National Building Code (Final Draft 1994)

Table .A.31 Absorption Capacities of Soils

Relative absorption	Soil Type	Effluent Loadings l/m2/d	gal/ft2/d
Rapid	Coarse sand, gravd	140	3.0
Medium	Fine sand, sandy loam	70	1.5
Slow	Sandy clay,silt	30	0.6
Semi impervious	Dense clay	20	0.4
Impervious	Rock	-	-

(Source : Khanna, P.N 1982. Indian Practical Civil Engineers Handbood.)

Data Tables give Water Quality Standards in Bangladesh.

Table A.32 Std Value for water use.

Parameters	Drinking Water	Recreati onal water	Fishing water	Industrial water	Irrigat ion water	Livestock water
pH	6.5 -8.5	6.0 -9.5	6.5-8.5	6.0-9.5	6.0 -9.5	5.5 -9.0
DO mg/l	6	4-5	4-6	5	5	4-6
BODs,mg/l	0.2	3	6	10	10	-
COD, mg/l	4	4	-	3-10	-	-
Chloride, mg/l	150-600	600	600	-	600	2000
EC, mohs/cm	-	500	800-1000	-	750	-
Turrhidit y JTU	10	10	-	50	-	-
Ammonia, mg/l	0.5	2.0	0.075	-	3	-
Chromium (hexavale nt as cr 6)mg/l	.05	.05	-	0.5	-	-
Total coliform nos/100 ml	2	200	500	-	1000	100
TDS, mg/l	1000	-	-	1500	2000	5000
SS,mg/l	10	20	25	75	-	-

(Source : DOE, July 1991)

Table A.33. Std Values for Industrial Effluent.

Parameters	Discharged into inland & surface water	Discharged into public sewer	Discharged on land (irrigable/non irrigable)
pH	6.0-9.0	6.0-9.0	6.0-9.0
DO, mg/l	4.5 - 8.0	4.5 - 8.0	4.5 -8.0
BOD5, mg/l	50	250	500
COD,mg/l	200	400	400
Chloride, mg/l	600	600	600
EC.micro,mehs / cm	1200	1200	1200
Arnmonia(Nlt z) ,mg/l	5	5	15
Chromimuni(hex avalant as cr 6) mg/l	0.1	1.0	1.0
Total coliform nos/100 ml	10000	10000	10000
TDS mg/l	2100	2100	2100
SS mg/l	150	500	200

(Source : DOE Jul 1991)

Table A.34 : The Water Quality Std for Water Use.

Parameter	For Recreation (Pond,fount ain)	For Laundry	For Bathing	For Survival of Aquaticlife
Temp Of	-	-	-	85
pH	5.8 - 8.6	5.8 - 8.6	5.8 - 8.6	6.0 -9.0
Color, mg/l	<30 - <50	<10 - <15	<5 -<15	-
E.C mic mohs/cm	-	-	-	500 - 1000
Chloride mg/l	> 300	> 200	> 200	250
Turbidity PPM	< 5 - <20	< 10 - < 15	< 5 - < 10	25
T.S mg/l	< 10	< 500	< 500	-
T.D.S mg/l	< 1000	-	-	-
SS, mg/l	< 10	Very Small	Very Small	80
DO,mg/l	-	-	-	> or = 4
BOD5,mg/l	< 8 - < 10	-	-	< or = 5
COD, mg/l	< 20	-	-	-
Chromium mg/l	< 1.4	< 1.5	< 0.5	.03 -.05
Ammonia,mg/l	< 10 - < 20	< 10	< 0.5	0.5

(Source JICA (1987) and Azad (1976))

Table A.35 Typical Composition of Untreated Domestic Wastewater

Contaminent	Unit	Concentration		
		Weak	Medium	Strong
Solids (TS)	mg/l	350	720	1200
Suspended solids (SS)	mg/l	100	220	350
BOD_5 at 20^0c	mg/l	110	220	440
TOC	mg/l	80	160	290
COD	mg/l	250	500	1000
Nitrates	mg/l	0	0	0
Phosphorus(Total as P)	mg/l	4	8	15
Organic	mg/l	1	3	5
Inorganic	mg/l	3	5	10
chlorides	mg/l	30	50	100
Sulfate	mg/l	20	30	50
TC	nos/100 ml	10^6-10^7	10^7-10^8	10^7-10^9

(Source : Table 3-16, Metcalf and Eddy 1991)

ANNEXURE B

e Pit

Plate B-2 : Blue pipes showing kitchen and bathroom wastewater connection to septic tank.

Plate B-3: Hach pH Tester Digital.

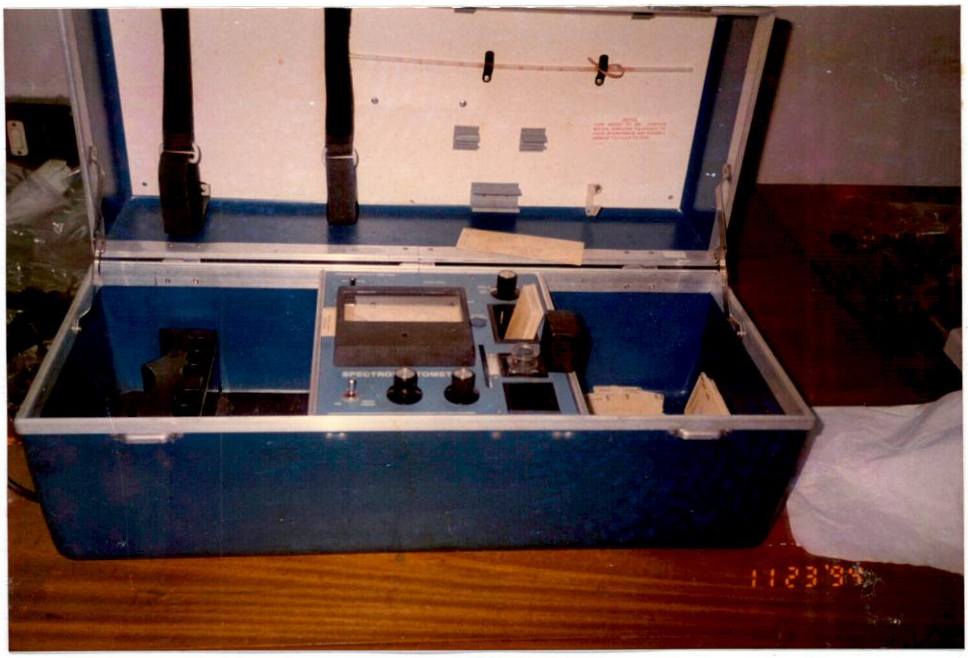

Plate B-4: Spectrophotometer DR-EL/4(HACH)

Plate B-5: Ynco - TOC Analyzer 8L.

Plate B-6: Laboratory Incubator.

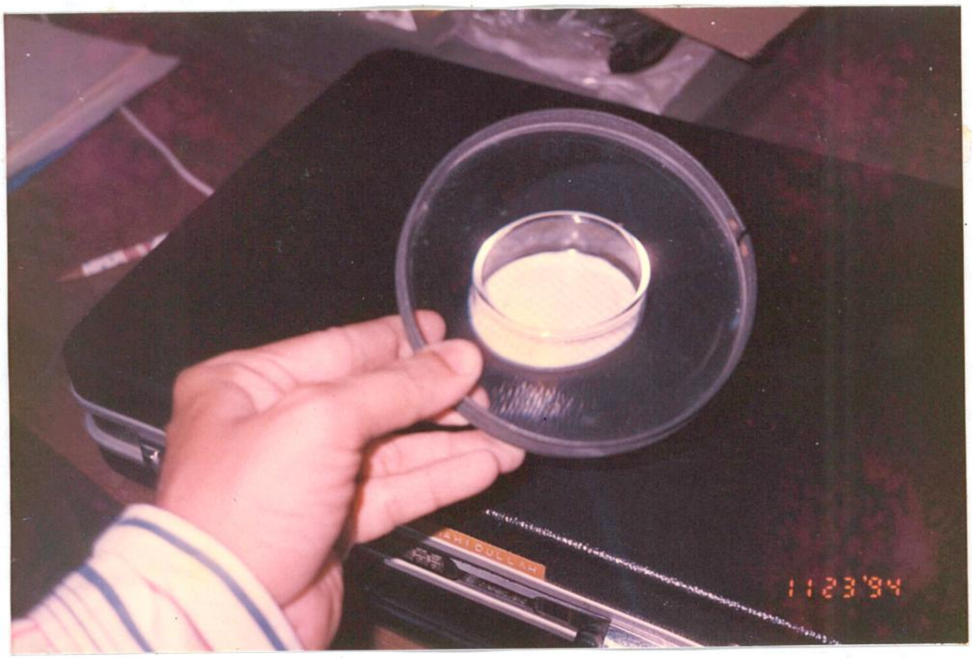

Plate B-7 : Membrane Filter (MF) Before Placing in Incubator.

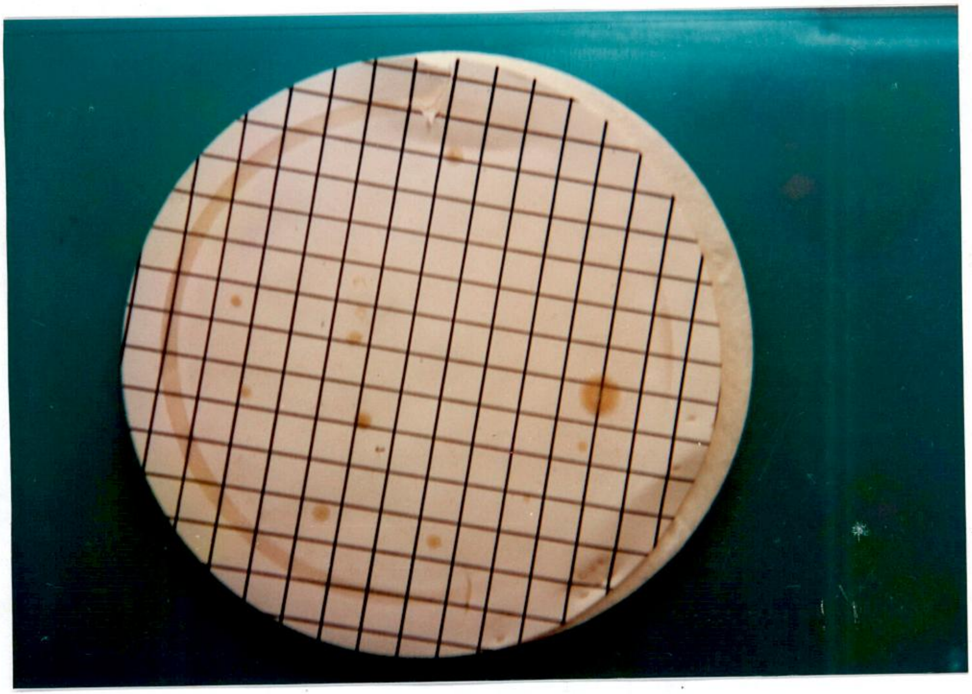

Plate B-8 : Shows Colonies of Fecal Coliform After Incubation.

Plate B-9 : A Percolation Test Hole Showing Depth.

Plate B-10 : Septic Tank Effluent Being Poured in one of the Test Holes.

ANNEXURE C

Questionnaire.

A survey on Domestic Water Consumption and Sewage Generation within Dhaka Cantonment Residential Quarters for the Thesis on

"Studies on Septic Tank Effluent Quality and Soakage"

1. Holding number of the Building : ________

2. Number of Flats in the Building : _______

3. Name of the occupant :________

4. Name of the interviewee : ________

5. Number of family member :

   Each Flat : _________
   Each Building : ______

6. Number of toilets in each Flat : _______

7. Number of pan/comode in each Flat : _______

8. Flushing systern capacity:_____________
9. Number of water points in each Flat :
   Shower point _____
   Kitchen sink _____
   Hand basins ______
   Bath tap _________

10. Average consumption of water per person :______

11. What type of detergents used for laundry : ________

* Soap ______ * Detergent powder _________

12. What type of cleaners used for washing utensils :

* Soap______ * Washing Powder ______ * Other thing______

13. What type of cleaners used for cleaning bathroom wares :

* Harpic ______ * Bleaching Powder____ * Other things____.

14. What type of disinfectant used in the commode :

* Phenol_____ * Acid _______ * Other thing _________

15. Is there any problem in present sewage disposal system :

_____ Yes _______ No

16. Is there any odour in the toilet from the sewer line :

__________ Yes __________ No

17. What waste is thrown in the sink line ______

18. Mention the date of cleaning septic tanks in the last two years : ________

19. Date of construction of the Building: ________

20. Any other information : ________

ANNEXURE D

List of Family Quarters in Dhaka Cantonment Area having Septic Tank disposal system as on Nov 94.

Table : D-1 Garrison Engineer Maintenance (South)

Name of Area	No of Quarte rs	No of family living	-	Size of Septic tank(m)	No of Septic tank	Size of soakage pit(m)
Cantt Market Area	15	24		2.8x1x 1.73	15	1.2 x 6
Moinul Road				6.6x1x 1.37	1	"
	8	64		6.15x2 .84x	8	"
				2. 43		
	5	50		4.87x1 .83x	5	"
				2. 4		
	12	12		3.6x1. 8x18	12	"
	4	4		5.5x7x 1.8	4	"
	19	19		3.7x7x 1.84	19	"
	7	28		4.3x1x 1.3	3	"
				x1.8		
Aziz Paalli	26	26		4.3x7x 1.8	26	1.2 x 6
Kachukhet	2	16		7.8x2. 6x	2	"
Staff quarters	9	72		1.37	9	"
Kafrul	1.4	156		5.1x1x 1.73	14	"
Officers quarters				6.6x1x		
Badiuzzman Road	15	32		1.375	15	"
				4.26x. 71 x		
Yousuf Roa	44	317		1.375	38	"
				6.7x1x		
				1.375	4	"
				5.48x1 x		
				1.375	2	"
				3x1x1. 375		

(Source : On ground survey)

Table: D-2 Garrison Engineer Maintanance(North)

Name of Area	No of Quarte rs	No of Family living	-	Size of septic tank (m)	No of septic tank	Size of Soak pit (m)
Shaheed Basher Road	27	184		12.7x1.8x1	4	1.2 x 6
				6.6x1x1.37 5	17	"
				3 x 1.8 x 1	8	"
Mannan line	28	213		3.5 x 1.8 x 1	7	"
				6.5 x 1.8 x 1	8	"
				3 x 1.8 x 1	1	"
				6.4 x 1.8 x 1	7	"
				4.7 x 1.8 x 1	3	"
Mostafa Kamal line	43	424		12 x 2.2 x 1.8	2	1.8 x 6
				8 x 2.2 x 1.8	4	"
				6 x 2.2 x 1.8	11	"
				5.5 x 1 x 1.8	19	1.5 x 6
Zia Coloney	702	3510		4.9 x 2.3 x 1.5	7	1.2 x 6
				6.7 x 1 x 1.5	8	"
				5.8 x 1 x 1.5	10	"
				4.3 x 1 1.5	5	"
				5.5 x 1.825 x 1	2	"
				5.2 x 2.8 x 1	3	"
				4 x 1 x 1.83	13	"

(Source : On ground survey)