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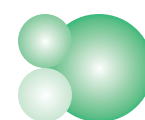
Handbook on Technical Options for On-Site Sanitation



Government of India
Ministry of Drinking Water and Sanitation

Handbook on Technical options for on-site Sanitation

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Chapter- 1

INTRODUCTION

Sanitation is a broad term which includes safe disposal of human waste, waste water management, solid waste management, water supply, control of vectors of diseases, domestic and personal hygiene, food, housing, etc. Sanitation includes environmental sanitation which is largely viewed as “the control of all those factors in man’s physical environment which exercise a deleterious effect on his physical environment, health, alleviating poverty, enhancing quality of life and raising productivity- all of which are essential for sustainable development” (WHO 1992).

Feachem et al. (1983) gave a rough guide to the relative importance of different aspects of sanitation as follows: Excreta disposal- 25; Excreta treatment- 15; Personal and domestic cleanliness-18; Water quality- 11; Water availability-18; Drainage and silage disposal-6 and Food hygiene- 17 points.

Sanitary household toilet is the most important aspect of sanitation. Besides, restoration of dignity, privacy, safety and social status, sanitation has strong bearings on child mortality, maternal health, water quality, primary education, gender equity, reduction of hunger and food security, environmental sustainability, global partnerships and ultimately poverty alleviation & improvement of overall quality of life. Open defecation is still in practice in many rural areas resulting in serious social, economic and environmental problems. Openly left human waste helps in breeding and transmission of pathogens, which carry diseases and infections. The problem is most acute for children, women and young girls. Children, especially those under 5 are most prone to diarrhoea and sometimes even lose their lives. In case of women, lack of sanitation facilities often forces them to restrict themselves by reducing and controlling their diet, which leads to nutritional and health impacts. Women, especially adolescent girls, face higher risks of sexual assault due to lack of household toilets.

Impacts of good sanitation: Good sanitation has the following impacts on individuals and on community:

- Improves health
- Decrease in morbidity and mortality
- Improves productivity

- Poverty alleviation
- Improves water quality
- Minimizes incidence of drop-out in school particularly girl students

It is an accepted fact that the poor pay directly and indirectly more due to bad sanitation. Most of them who earn on daily wages basis lose out in case of illness due to bad sanitation. In most of the rural areas health facility is rarely available forcing people to take the advice of private doctor or quacks who charge very high leading to more economic loss.

Open defecation has been a deep-rooted age old socially inherited behaviour in rural India. Provision of adequate sanitation coverage in rural India has been a major challenge due to its heterogeneous socio-economic conditions. Hence, even with advent of technology in rural India, substantive proportion of the rural poor still prefer to purchase a “mobile phone”, rather than on investing for sanitary toilets, since sanitation is neither a felt need nor open defecation is a socio-cultural taboo. The most important challenge for effective implementation of sanitation programme in rural areas is that the rural population are poorly informed or not overtly conscious of the linkage between sanitation and health. Due to inadequate knowledge and lack of awareness they mostly believe that status of health has no linkage to poor sanitation. Another important barrier for sanitation is that there is no concept of community health and hygiene in rural areas. Wherever, there is awareness, it is limited only to personal sanitation and hygiene but not at community level. Impact of sanitation can be gauged only when the toilet facility is used and the sanitation practices are adopted at community level.

Best option for improved sanitation is by construction and proper use of a latrine by the household, which is owned and maintained for its own use and benefit. Such individual toilets can be built through various technological options to suit the household’s affordability.

Total Sanitation Campaign and its Key Provisions

In 1986, the Rural Development Department initiated India’s first national programme on rural sanitation, the Central Rural Sanitation Programme (CRSP). The CRSP interpreted sanitation as construction of household toilets, and focused on the promotion of pour-flush toilets through hardware subsidies to generate demand. The key issue of motivating behaviour change to end open defecation and use of toilets was not addressed in the programme. As a result the

programme was implemented in the supply driven mode & had limited intervention in improving rural sanitation coverage. As a result there was nearly just 1 percent annual increase in sanitation coverage throughout the 1990s.

In light of the relatively limited intervention of the CRSP in improving the rural sanitation coverage, the Government of India restructured the programme, leading to the launch of the Total Sanitation Campaign (TSC) in the year 1999. Total Sanitation Campaign (TSC) is a flagship scheme of the Government of India administered by the Ministry of Drinking Water and Sanitation. TSC supports village communities to end open defecation in their areas and achieve total sanitation, to improve social dignity, privacy and ensure hygienic and healthy living environment. Creation of demand for sanitation from people through Behavior Change Communication (BCC) and supporting them with information on a menu of technological options to construct and use safe sanitation facilities is the key objective of TSC.

Under the TSC, financial support in the form of an incentive is given to households living Below the Poverty Line (BPL) for construction and use of toilets. However, the main focus of the programme is to create sustainable awareness and behavior change among the people through capacity building and motivation to build individual household latrines (IHHLs) thereby creating a sense of ownership among the beneficiaries.

The key challenge in achieving total sanitation in villages is to provide sustainable & affordable sanitation technology even for poor families in different geographical conditions and also bring about a change in the knowledge, attitudes and age-old practices of the villagers towards open defecation. To address this challenge, it is important to provide easy access, to a toilet and motivating people to use it.

Chapter -2

LINKAGE OF SANITATION & HEALTH

Sanitation has a direct linkage with health of any community. The most important challenge for effective implementation of any sanitation programme in rural areas is that most of the rural population is unaware of the linkage between sanitation and health; and health and productivity. Due to inadequate knowledge and awareness, they believe that good or bad health and poor productivity is due to reasons other than sanitation. Most communities demand toilets due to reasons of social status, dignity & privacy. The TSC programme aims to highlight such social benefits of sanitation leading to demand driven approach, making the programme successful in rural areas. There is scientific evidence to show that there is direct linkage between health and sanitation.

I. Human waste and disease transmission

Human excreta contains a full spectrum of pathogens that transmit from diseased persons to healthy ones through various direct and indirect routes, causing infections and superimposed infections. In rural areas it is estimated that about 80% diseases are water borne diseases-directly or indirectly linked with human waste. Different infections from human waste enter into human body through fluids, fingers, flies, food and fields. Such transmissions from different sources can be depicted through the following diagram (Fig. 1 and Fig 2). It is obvious that most of the transmission of infections can be avoided through use of toilet and hand washing before eating and after defecation.

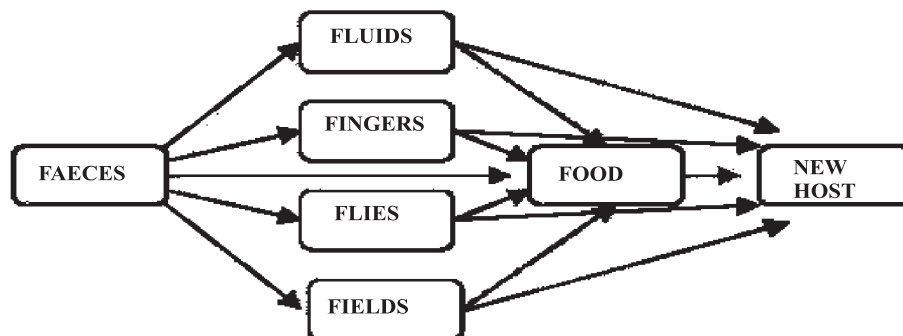


Figure 1. The F-diagram

Source: Wagner & Lanoix 1958

Primary prevention and routes of possible transmission of diseases from faeces

Deadly web

How pathogens in excreta enter humans?

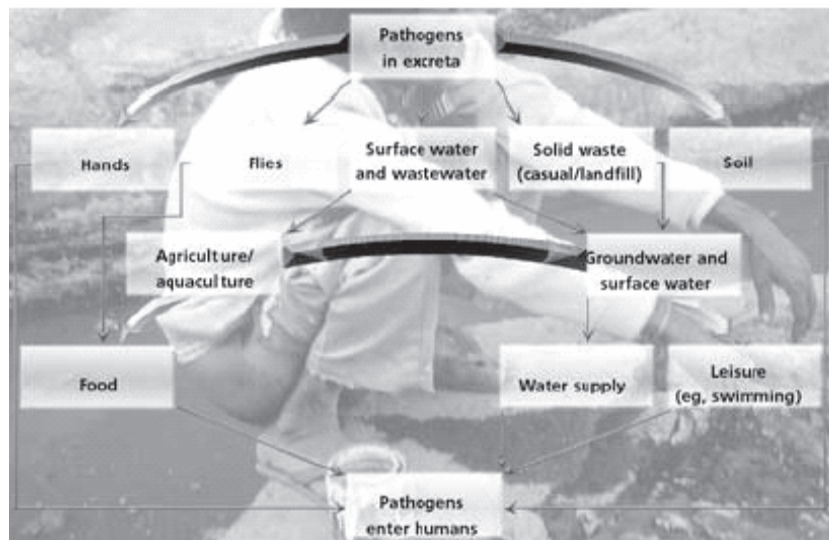


Fig 2

II. Pathogens in human waste

There are several bacterial pathogens in human waste causing diseases. Some of the commonly found bacterial and helminthic pathogens are as described below (Table 1 and 2).

Table 1 : Bacterial Pathogens in Human Excreta

Bacteria	Diseases	Reservoir
Escherichia coli	Diarrhoea	Human
Salmonella typhii	Typhoid fever	Human
S. paratyphii	Paratyphoid fever	Human
Other salmonellae	Food poisoning and other salmoellioses	Human
Shigella spp	Bacilliary dysentry	Human
Vibrio cholera	Cholera	Human
Other vibriions	Diarrhoea	Human
Campylobactor fetus	Diarrhoea	Human , Animals
Yarsinia enterocolitica	Diarrhoea and septicimia	Human, Animals

Table 2 : Helminthic Pathogens in human excreta with mode of transmission

Helminthis	Common name	Diseases	Transmission
Ancylostoma duodenale	Hookworm	Hookworm	Human-soil-human
Ascaris lumbricoides	Roundworm	Ascariasis	Human-Human-soil
Taenia saginata	Beef worm	Taeniasis	Human-Cow-Human
T. solium	Pork Tapeworm	Taeniasis	Human-Pig -Human
Trichuris trichura	Whiworm	Trichuriasis	Human –Soil-Human

To understand linkage between health & sanitation it is essential that knowledge of the types of diseases that are caused due to poor sanitation & hygiene are understood by the community. The classification of different infections and likely effects of interventions and control measures as suggested by Faechem (1983) and Cairn Cross & Faechem (1993) is presented below (Table 3) which clearly indicates that provision of toilet is the most important aspect of control of most of the infections.

Table 3 : Sanitation related diseases and the likely effects of interventions

	Category	Examples	Prominent transmission mechanism	Likely effect of sanitation hardware alone	Likely effect of hygiene promotion alone	Major control of infections
1	Faecal–oral (non-bacterial)	Hepatitis A, Amoebic dysentery, Rotavirus giardiasis	Person to person contact, Domestic contamination	Negligible	Moderate	Domestic water supply, health education, Improved housing, Provision of toilets
2	Faecal oral (bacterial)	Cholera, salmonellosis, Shigellosis	Person to person contact, domestic contamination, water contamination, crop contamination.	Slight to moderate	Moderate	Domestic water supply, health education, Improved housing, Provision of toilets , treatment of excreta prior to discharge or reuse

3	Soil Transmitted Helminthes	Hookworm Roundworm Whipworm	Path/ compound contamination, Communal defecation areas Crop contamination	Great	Negligible	Provision of toilets, treatment of excreta prior to discharge or reuse
4	Tapeworms	Beef Tapeworm, Pork tapeworm	Path / Compound contamination Fodder contamination Field contamination	Great	Negligible	Provision of toilets, treatment of excreta prior to discharge or reuse
5	Water based helminths	Schistosomiasis	Water Contamination	Moderate	Negligible	Provision of toilets, treatment of excreta prior to discharge or reuse
6	Excreta Related insect vectors	Filariasis, some faecal- oral diseases	Insects breed in sites of poor sanitation	Slight to moderate	Negligible	Provision of toilets, treatment of excreta prior to discharge or reuse

Chapter -3

Criteria for a sanitary toilet and sustainability of sanitation

I. Criteria for a sanitary toilet

There was a major breakthrough in the field of on-site sanitation when World Health Organisation, Geneva, published the book “Excreta Disposal for Rural Areas and Small Communities” by E.G. Wagner & J.N. Lanoix, in 1958. Another book of WHO on “A Guide to the Development of on-site Sanitation by Franceys, R. Pickford j. & Reed, R, published in 1992 provided useful information on on-site sanitation. The books gave details of different technological options for sanitation suitable for rural and small communities. Some technologies, like pit toilets, as mentioned in these books, are being implemented in rural as well as urban areas in different countries. The book describes simple technologies from pit latrines to chemical toilets. Wagner & Lanoix (1958) recommended the following seven basic criteria for a sanitary latrines :

- i. The surface soil should not be contaminated.
- ii. There should be no contamination of ground water
- iii. There should be no contamination of surface water.
- iv. Excreta should not be accessible to flies or animals.
- v. There should be no handling of fresh excreta
- vi. There should be freedom from odours or unsightly conditions.
- vii. The method used should be simple, inexpensive in construction and operation.

II. WHO Guidelines for the safe use of waste water, excreta and grey water (2006)

The use of excreta and grey water in agriculture is increasingly being considered a method combining water and nutrient recycling, increased household food security and improved nutrition for poor households. Recent interest in excreta and grey water use in agriculture has been driven by water scarcity, lack of availability of nutrients and concerns about health and environmental effects. The guidelines are based on the scientific evidence concerning pathogens, chemicals and other factors, including changes in population characteristics, changes in sanitation practices, better methods for evaluating risk, social/equity issues and socio-cultural

practices. Recommendations of WHO for treatment, storage and use of human wastes is presented in table 4.

Table 4 : Recommendations for storage, treatment of dry excreta and faecal sludge before use at the household and municipal levels.

Treatment	Criteria	Comment
Storage; ambient temperature 2-20°C	1.5-2 years	Will eliminate bacterial pathogens; regrowth of E.coli and Salmonella may need to be considered if rewetted; will reduce viruses and parasitic protozoa below risk levels. Some soil – borne ova may persist in low numbers
Storage ; ambient temperature > 20 -35°C	>1 year	Substantial to total inactivation of viruses, bacteria and protozoa; inactivation of schistosome eggs (< 1 month); inactivation of nematode (roundworm) eggs, e.g., hookworm (Ancylostoma / Necator) and whipworm (Trichuris); survival of a certain percentage (10- 30%) of Ascaris eggs (≥ 4 months), whereas a more or less complete inactivation of Ascaris eggs will occur within 1 year.
Alkaline treatment	pH >9 during > 6 months	If temperature is > 35°C and moisture < 25%, lower pH and / or wetter material will prolong the time for absolute elimination

III. Sustainability of a sanitation technology

The primary objective of sustainable development is to reduce the absolute poverty through providing lasting and secured livelihoods that minimize resource depletion and environmental degradation. In absolute term it is quite difficult to find out sustainable technology/ methodology for any development process, however, sustainability of sanitation can easily be viewed in absolute term – without any conflict with the development process. In fact it is always complementary to the development processes. To make the sustainability more specific, it should be adjudged in the following terms:

- **Socio-cultural aspects** - Social acceptance and adoption
- **Health and Economy**- There should be minimal health risk. Further it should be affordable to common people with least operation and maintenance costs.

- **Technical function** – Ease to operate and maintain the system, in different climatic conditions.
- **Environment** - Help restore environment rather than disturbing the ecosystem.

The degree of importance of the above aspects varies widely depending on socio-cultural and economic aspects of the community.

- **Socio-cultural aspects:** For implementing any programme related to sanitation, social aspect is one of the most important issues to make it sustainable. Sanitation is mostly regarded as a socio-cultural issue rather than techno-economic. There are still many people in rural areas who due to lack of adequate knowledge, simply cannot correlate between sanitation and health. This is evident also from the observation that there are many people having own vehicles, good houses and children enrolled in good public schools but without household toilets. This is simply due to lack of awareness on health and sanitation. However, there are other groups of people who really cannot afford to construct a toilet due to lack of required fund. Such families need financial support from other agencies to have their own household toilets.

In India most of the people use water for ablution. Therefore, pour flush or water borne toilet designs are socio-culturally more acceptable. However, there should be minimum requirement of water to flush human waste to make it sustainable even in water scarce areas. Dry toilet or any other design of toilet where use of water is prohibited, is difficult to be adopted by many people. Such toilets are not sustainable in many rural areas.

- **Health and economy:** Since sanitation is directly linked with the preventive measures to all the water borne diseases that account for over 80% sickness in rural areas, it is a sustainable means to improve health and consequently productivity of a family or community. So far as the sanitation in terms of household toilet is concerned; it is always a onetime expenditure with almost nil recurring cost. However, there are several people under Below Poverty Line (BPL) category who really can't afford to pay for the construction of toilets. Similar may be the case with some people of category who are Above Poverty

Line (APL), who are unable to bear the cost of a toilet. For them economical aspect is more important than social aspect. Design of toilets should also be adequately suitable to check any handling of waste resulting in possible infections.

- **Technical function:** Sustainability of any design of toilet depends on its technical function, operation and maintenance. Any recurring expenditure on the maintenance of toilet is normally not acceptable for majority of the rural population. A technology which promotes safe disposal or reuse of human excreta may be considered as sustainable sanitation.
- **Environment:** Improved sanitation with well planned solid and liquid waste management leads to a better environment & quality of life. In fact good sanitation is complementary to creating a sustainable environment.

Chapter-4

TECHNOLOGY OPTIONS FOR ON-SITE SANITATION

There are several technologies for human waste disposal. Most of the technologies are a refinement of already known and practiced methods, based on experience by different communities. It is too difficult to find any technology which is universally sustainable. Selection of technology should be based on socio-cultural and economical aspects of beneficiaries and hydro- geological conditions and soil type of the intended area. Based on the hydro-geological conditions of the areas and socio-cultural behavior of people, the technology options can be broadly grouped for the following two situations:

- I. **For normal soil with low water table**
- II. **For high water table areas and /rocky soil**

Every toilet has two major parts- (a) **Substructure** and (b) **Superstructure**. Substructure is technically important as it provides safe disposal or reuse of human wastes. All the technical options are meant for substructures only. Superstructure is basically meant to provide privacy of the toilet and major technical inputs are not required for this component. There may be a wide range of types of superstructures for the same type of sub structure, depending on the affordability of the beneficiaries. Both the aspects have been described separately in the following paragraphs

- I. **For normal soil with low water table**

In most of the areas in India, people use water for ablution and type of soil is normal. Under such conditions on-site sanitation, through pit toilet is most suited option. Some of the pit toilet technologies used in India are as below:

A. Twin Pit Water Seal Toilet

The Twin Pit Water Seal Toilet is a complete on-site sanitation measure at household level which, on one hand fulfills all the sanitary requirements of a toilet and on the other hand, provides continuous use with minimal maintenance. The main components of such a toilet are the two pits used alternately, a pan, water seal / trap, squatting platform, junction chamber and a superstructure.

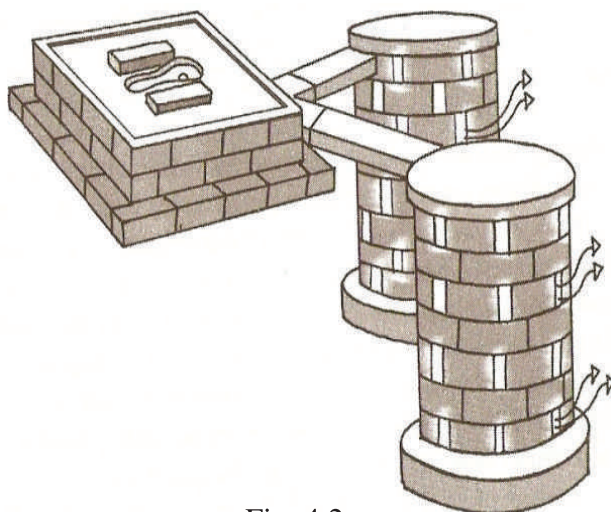


Fig. 4.2

Under the system, there are two pits which are used alternately (Fig 4.2) . Both the pits are connected with a junction chamber at one end. Pit walls have honeycombed structure. Bottom of the pit is not plastered and is earthen. Depending on the number of users of toilet, size of the pit varies. Capacity of each pit is normally kept for 3 years. First pit, after it gets filled up in about 3 years is blocked at the

junction chamber and second pit is put in operation. Water part of excreta percolates in soil through honey combs. After 2 years of blocking of the first pit, its contents degrade completely and turn to solid, odourless, pathogen free manure. It is dug out by beneficiaries and used for agriculture and horticulture purposes. After the second pit is filled, it is similarly blocked and the first pit is put in use again. Thus, alternate use of both the pits continues. A plan and section of two pit toilet is as below (fig 4.3). Estimates of a twin pit toilet is annexed (Annexure -1A) and estimates of a toilet with bath is annexed (Annexure -IB).

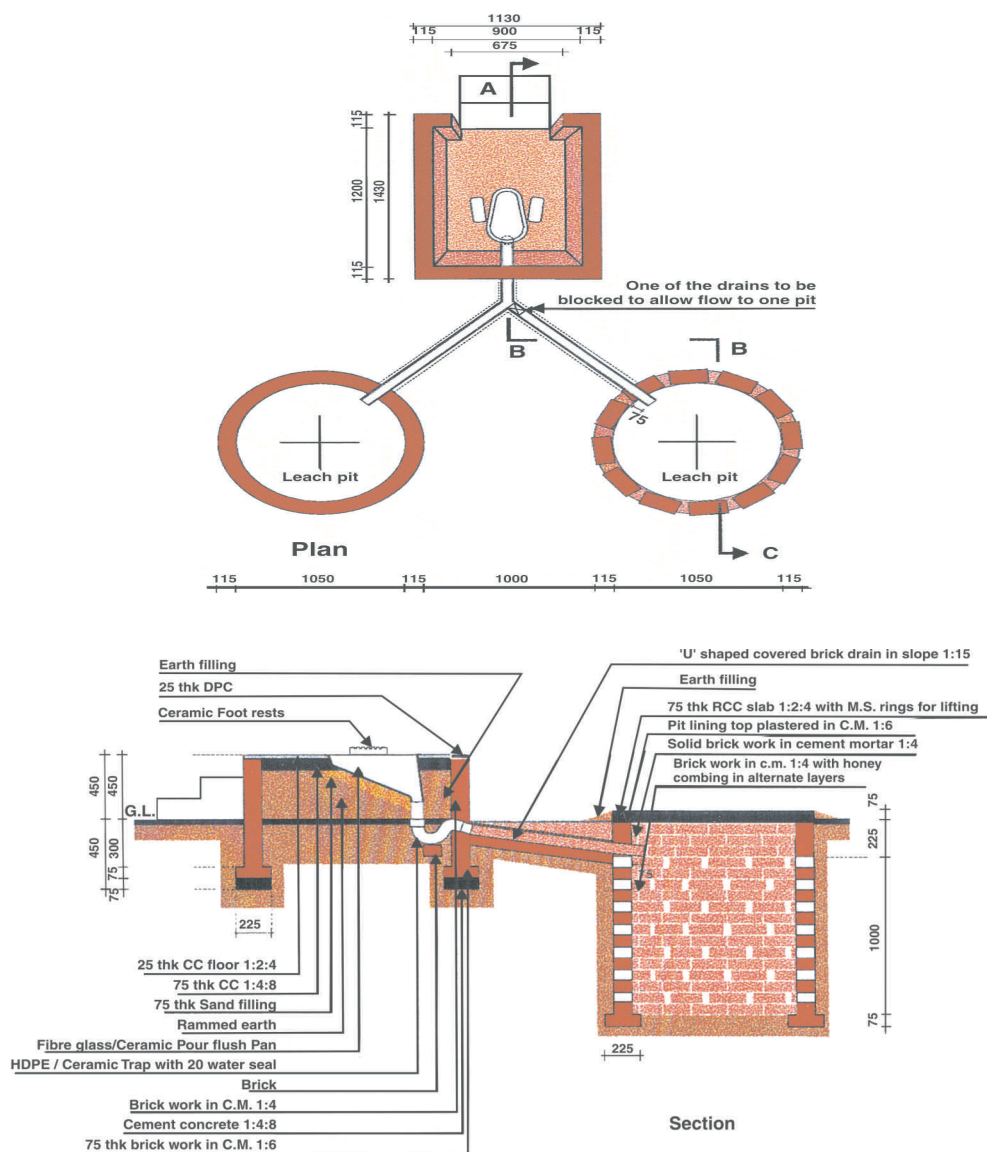


Fig. 4.3

Pan and trap / water seal:

The pan used in the pit toilet has steep slope of 28°-29°. It may be of ceramic, mosaic or fibre. People normally do not accept mosaic pan as the surface of such pan is not smooth on which the excreta sticks. Therefore, it requires more water for cleansing. Fiber pan is cheaper, lighter and easy in handling. However it is not acceptable to many beneficiaries due to its colour. After some years of operation, it develops yellowish colour which is not aesthetically appealing to most of the beneficiaries.



Fig 4.4 A ceramic pan

Ceramic pan is used in most of the cases where it is available (Fig 4.4). Such rural pans are also easily available in the markets. It is aesthetically acceptable and requires less quantity of water (1.5 to 2lts). There are only few manufacturers of Ceramic pans in India, resulting into higher cost in comparison to other pans due to high transportation cost.

Trap / Water seal in rural pans is of 20 mm only. Therefore, such pans require only about 1.5- 2 lts of water to flush out excreta with 20mm water seal. Thus, the system is also suitable for water scarce areas. Such water seal may be of ceramics, mosaic or made of fibre (Fig 4.5). A drawing of water seal as given below (Fig 4.6). An indicative Bill of Quantity for a two pit toilet is at Annexure-I.



Fig. 4.5 A fiber water seal

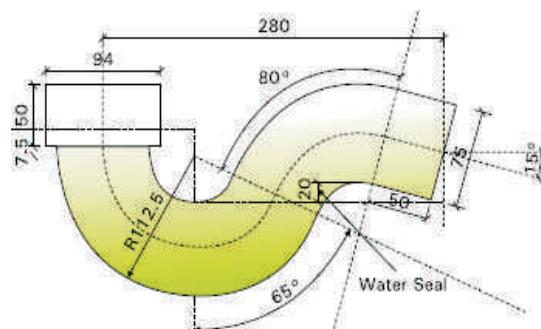


Fig 4.6 Drawing of a Water seal

Vent pipe not required:

A pit toilet does not require vent pipe. Gases produced in the pit are diffused in soil through honey combs. Such gases are mainly Carbon dioxide and Methane. Thus the system also helps in reducing air pollution, arising out of such Green House Gases.

Size of the pit

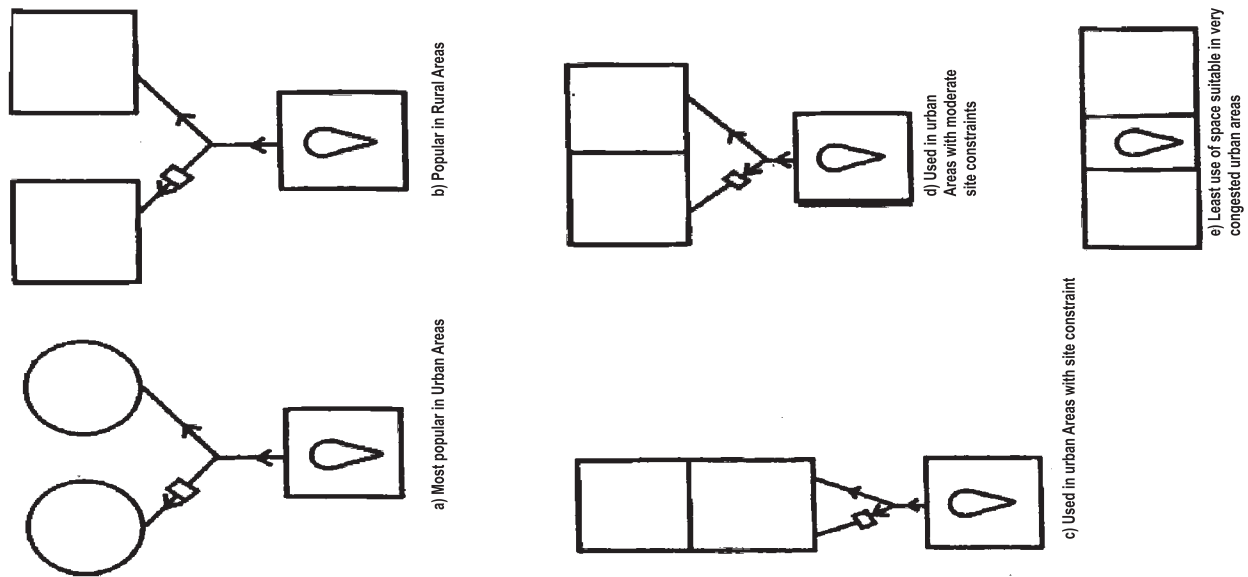
The sizes of pits where ground water level is always below the bottom of the pit and infiltration rate of soil is 30 l /m²/day for a 3 years sludge storage volume works out as described in Table 4.1:

Table 4.1

No. of daily users of toilet	Circular pit		Combined rectangular pit divided by partition wall in two equal compartments. Size of each pit		
	Diameter mm	Depth mm	Length mm	Breadth mm	Depth mm
5	1050	1000	1000	1000	800
10	1200	1500	1250	1250	1050
15	1400	1630	1400	1400	1200

Shape of the pit

A pit may be circular, square, rectangular or linear in shape depending on the availability of space for household toilets. However, effective volume of each pit should be as per the above table. Circular and square pits (separated completely) are better than the linear or rectangular pits (when separated by dividing wall only), as in the former case space for leaching out effluent is more than in the later case. A graphical presentation of different shapes of pits is described (Fig 4.7).



Source- (Pickford & Reed,1992)

Fig 4.7

Advantages of two pit pour flush toilets

- i. It is a permanent solution for on- site household human waste disposal
- ii. It requires only 1.5 to 2 lits of water per use of toilet
- iii. Digested human wastes, when taken out of the pit after 2 years, is semi solid, free from odour and pathogens, that can be easily dug out by the beneficiaries.
- iv. Degraded sludge has good percentage of plant nutrients and can be used for agriculture and horticulture purposes.
- v. It does not require scavenger to clean the pits.
- vi. It can be easily upgraded and connected to sewer when ever such facility is available in future
- vii. Its maintenance is easy

Limitations of two- pit pour flush toilet

- a) Pit toilet (single or double pit) is not suitable for high water table and rocky areas. In high water table areas, there is chance of ground water contamination. In coastal areas also these toilets are not suitable at all. Further, due to high water

table, adjoining soil of the pit becomes saturated and further percolation from pit reduces significantly causing frequent filling of the pits.

- b) In case of rocky areas, there is no chance of percolation of water from pits. Consequently, pit gets filled in frequently. Due to unavailability of mechanical devices to clean the pits, it is not acceptable by the beneficiaries. Moreover, even after the pit is emptied, it is quite difficult to dispose the sludge safely.

II. Toilet for high water table and /rocky areas.

For coastal and other areas having high water table and also for rocky areas the following technologies are appropriate.

- A. Model for high water table
- B. Ecosan toilet
- C. Biogas toilet
- D. Septic Tank

A. Model for high water table.

This model is more suitable for areas where people use water for ablution. The system consists of 2nos. of chambers connected at the middle. It may be a brick-cement or ferro-cement structure. Cost of a ferro-cement structure is cheaper than the brick- cement structure. Bottom of both the chambers are sealed with P.C.C. (Plane Cement Concrete). During the use of the toilets human waste comes into first chamber and after settlement, it flows to the second chamber. From this second chamber, it flows through the covered drain to its outlet. Toilet seat with pan and trap in the design remains the same as discussed under two pit pour flush toilet.

This model of toilet is useful also in low water table and coastal areas. This is also useful in rocky areas where water of leaching pit may not be absorbed by the ground. The detention period of the soak will increase to a great extent and for a family of 5 members, the detention period will be about 20-25 days and so the B.O.D (Biochemical Oxygen Demand) of the effluent will also be less, permissible to be discharged in drain or use for agriculture purpose..

A typical drawing of the model for high water table is described in Fig 4.8. Cost estimates is annexed (Annexure-II)

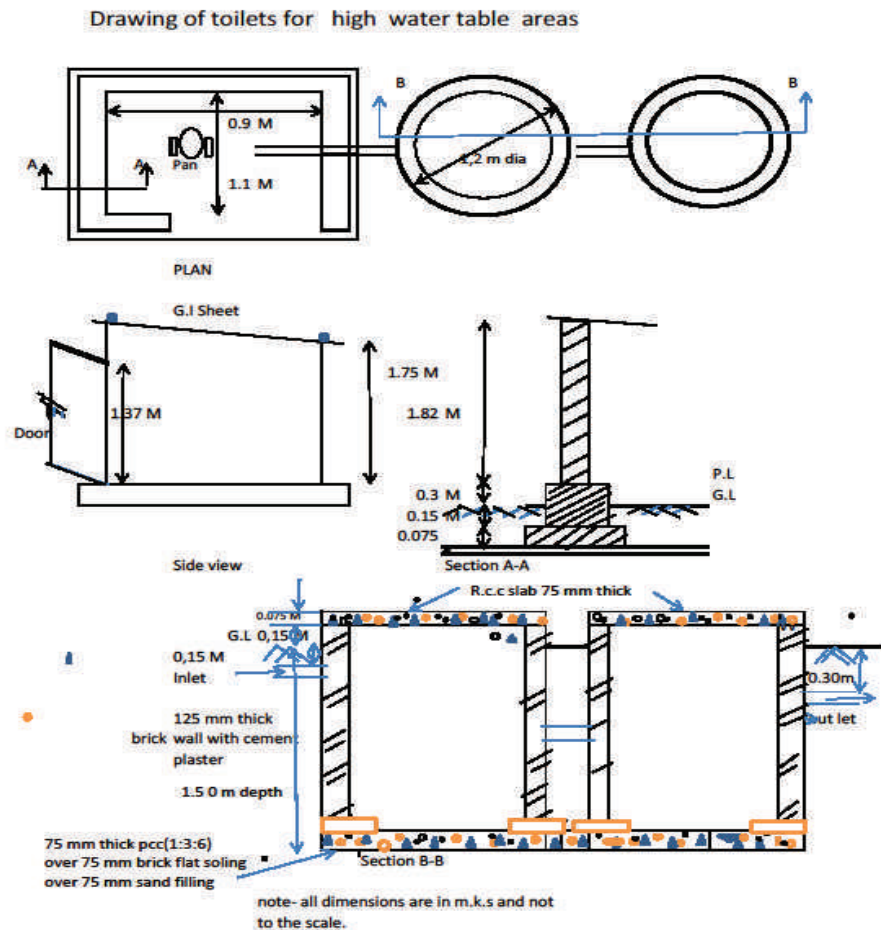


Fig 4.8

Following provisions are made in this type of toilet design:

- a) Internal size 0.9mx1.10 m
- b) Height of wall is 1.82 m from front and 1.75 m at back
- c) Roof cover is of G.I Sheet/Asbestos sheet
- d) Two nos. of leaching pits of internal size 1.20 m and 1.50 m depth up to ground level.
- e) Doors of size 0.76x1.37 m size ,20 gauge G.I framed with M.S angle
- f) Thickness of cover slab in each leaching pit -75 mm thick
- g) Materials required for construction of a Balram Toilet as annexed (Annexure II)

Advantages

- i. It is suitable even for high water table without any chance of ground water pollution, as the bottom of human waste collecting chamber is kept sealed.
- ii. There is no chance of odour with this toilet
- iii. In rocky areas also this type of toilet is suitable

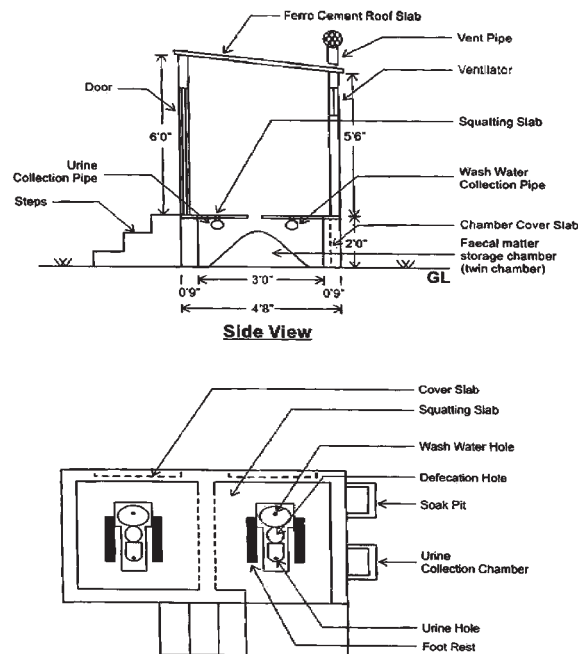
Limitations

- i. Cost of this toilet is higher than leach pit toilet
- ii. Cleaning of chambers is cumbersome when they are filled. Chambers are to be emptied only through mechanical devices. In rural areas such device is not easily available.

B. Ecosan Toilet

Ecological Sanitation or Ecosan toilet is based on the principle of minimizing the loss of nutrients in human wastes and using such wastes, including urine for agriculture purposes. It is a closed- loop system, which treats human excreta as a resource. In this system, excreta is processed on site until it is free of pathogenic organisms. In the system, faeces and urine are collected separately in containers (Fig 4.9). Urine is used in agriculture land directly, whereas faeces are stored for 6 months or so, to degrade it and its use in agriculture. In this system, water is not used for cleaning purpose. To prevent foul smell, dry ash is put after each use of toilet, in the container. Degraded human waste is directly used for agriculture purposes. Materials required for an Ecosan Toilet is annexed (Annexure V).

Various parts (components) of a Twin Chamber Ecosan Toilet



4
A Simple Guide for
 the Construction of
 Affordable & Cost Effective
 Eco-friendly Sanitary Latrine
 (Ecosan)

Fig 4.9

If ecological sanitation could be adopted on a large scale, it would protect our groundwater, streams, lakes and seas from faecal contamination at the same time less water would be consumed. Farmers would also require less chemical fertilizers, most of which is washed out of the soil into water, thereby contributing to environmental degradation. Since in rural areas, more agricultural land is available, therefore, Ecosan toilet system can be made a productive sanitation system for such areas. The system is also suitable for high water table areas, and also for, flood prone and rocky areas, where conventional pit toilets are not suitable.

Advantages of Ecosan toilet

- i. It saves water
- ii. Protects ground and surface water from contamination
- iii. Recycles valuable nutrients
- iv. Contains and sanitizes excreta

- v. Creates no waste
- vi. Does not smell
- vii. Provides no place for mosquitoes to breed
- viii. Self-contained and can be totally managed by the family.

Limitations:

Ecosan toilet is more suitable where people don't use water for cleaning and instead, papers, napkins etc. are used for such purpose. In Indian conditions, cultural aspect does not appear suitable for such Ecosan system in most for the communities. Moreover, cost of the Ecosan toilet is much higher than the pit toilets. More awareness and motivation is required to make Ecosan toilet acceptable at community level in rural areas.

C. Biogas toilet

Generation and utilization of biogas from human excreta and other wastes has three major advantages- it improves sanitation, gives bio energy at low cost and provides better quality of manure for agriculture purposes. It is suitable for all hydro geological conditions and in areas where people use water for ablution.

However, household biogas plants solely based on human waste for a family is not economically viable as the biogas produced per family is not adequate for any useful purpose. In a family having 5 users of toilet, only around 5 cubic feet (cft) of biogas would be produced per day and minimum requirement of biogas is about 40 cft for cooking for 2 meals in a day for a small family. Therefore, biogas can't meet cooking requirement of a small family, if produced from human waste of a family. However, it can be made viable, when mixed with cattle dung along with human wastes. Biogas from dung of at least 2 nos. of cattle when mixed with human wastes can cater to the need of cooking for a small family.

Design of biogas plant

For a household level biogas plant there are basically two designs (1) Floating drum type popularly known as KVIC model and (2) Fixed dome type, popularly known as Deenbandhu Model.

In the KVIC model gas holder is made up of iron sheet (mild steel). During winter season when temperature falls down to about 10°C or so, this model ceases to function as the iron sheet gas holder acts as good conductor of heat and inner temperature of the digester also attains the same temperature. Secondly, this gas holder requires regular care and maintenance to prevent from getting worn out because of corrosion and has short working life. Manufacturing of gas holder requires sophisticated workshop facility which is rarely found in rural areas. Therefore, in rural areas, success rate of this model of biogas plant is far below the level of satisfaction. Below is the description of materials required for Deenbandhu Model of biogas plant :

Quantity of biogas production from different feed materials

- i. From animal dung, around 10 kg dung is available per animal per day. Biogas production rate from dung is about 1.5 cft per kg, i.e., per animal per day 15 cft of biogas is produced
- ii. From human waste, per person per day, 0.35 kg of waste is produced and gas production from per kg of human wastes is 3.6 cft. Per day per person only one cft biogas is produced.
- iii. A total amount of biogas of one cum can be produced per day from a family having 5 members and 2 cattle heads.

Utilizations of biogas

One cum of biogas per day can be utilized in a family as follows:

- i. Cooking of 5 family members for two times a day
- ii. Mantle lamps (2nos.) can be used for 6 hours per night. Such mantle lamps give illumination equivalent to 40 Watt bulb at 220 volts of electricity.
- iii. Can run an engine of one Horse Power for 2 hours

Manure value of sludge from biogas plant

Besides biogas, the manure of the plant has good plant nutrient value. It is directly used for agriculture purpose. The following is the comparative value of plant nutrients (N,P,K, value) from biogas manure and other compost (Table 4.2).

Table 4.2

Sl.No.	Name of constituent	Compost Manure (%)	Biogas slurry (%)
1.	Nitrogen	0.50-0.75	1.30-1.50
2.	Phosphorus	0.70-0.80	0.85-0.92
3.	Potash	1.20-1.50	1.50-1.65

Deenbandhu model. — This model is predominately found in India. It is an underground fixed dome digester made up of complete brick or RCC structure (Fig. 4.10). It is a permanent structure having almost nil operation and maintenance costs. There is no separate gas holder, biogas is stored inside plant through liquid displacement chamber. This design is suitable also for generation of biogas from human wastes along with cow dung and kitchen wastes. There is almost no effect of atmospheric variation of temperature on biogas generation during winter season. It has several advantages over the KVIC design. The following section describes different aspects of Deenbandhu biogas plant..

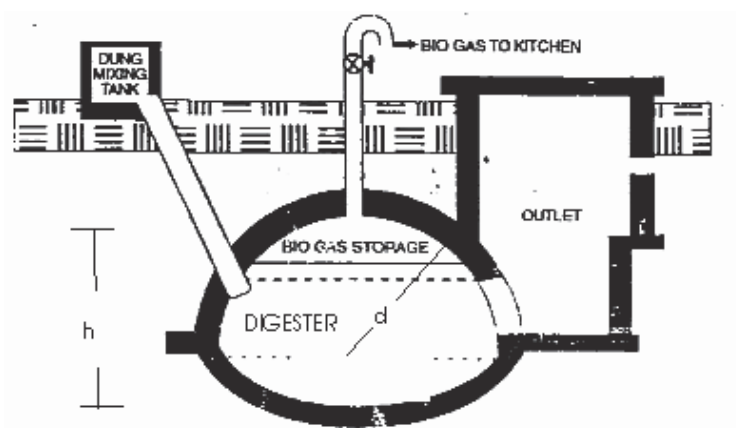


Fig. 4.10

Selection of site

Site of biogas plant should be selected properly, it should not be water logged and soil should be hard (high bearing capacity). It should not be constructed in a shaded area. Sunlight helps increase digester temperature therefore, production of biogas. Biogas plant should be as near to its use points- cooking and mantle lamps lighting. Longer the distance between biogas plant and its use points would reduce gas pressure in gas pipe and hence will create problem.

Selecting a biogas plant size:

A biogas plant of specific capacity can be selected based on the daily availability of cattle dung, users of toilet (in case of toilet linked) and water requirements.

Materials required for biogas plant

The biogas plant can be set up with Bricks, Cement, Stone chips of 1/2" Coarse Sand, G.I. pipe 3/4" dia. sockets, 30 cm., A.C./ PVC pipe 6" dia, Iron bars (6mm dia) for outlet tank cover, Paint (gas leak proof dibhapoxy), labour for digging pit, labour for construction, skilled masons, BG Stove, 10 m pipe line, lamp, accessories.

Components of a biogas plant:

Foundation

The foundation of the plant is bowl shaped with a collar around the circumference. The construction of the digester dome is based on this collar. Dome is divided in 2 parts, Digester & Gas storage. Digester: The bottom part is called the digester, where the mixture of dung and water passes through inlet chamber and anaerobic digestion by the help of different bacterial groups takes place producing biogas. Retention time of digester is kept normally as 40 days.

Gas storage

Gas produced by the bacterial activity is stored in the upper part of the digester dome called gas storage. Capacity of the gas storage is designed for 50 % of the daily gas production capacity of the plant. However, as per requirement, gas storage capacity can be increased, depending on use of biogas.

Gas outlet pipe

A nipple is fitted on the top of the dome, which is connected to a GI pipe of 1/2 inch. The gas reaches the kitchen through this pipe.

Inlet chamber

Inlet is the point where cow dung is mixed with water before it passes to biogas plant through inlet pipe connected with chamber.

Outlet chamber

Outlet chamber or liquid displacement chamber has two functions- it allows passage of effluent from the biogas plant and it determines the storage capacity of biogas plant.

Factors affecting biogas generation

Temperature

For optimum biogas production, a temperature of 35- 37°C is optimum. At lower temperatures gas production rate decreases. In winter season when temperature falls to 10°C or so, gas production almost ceases. However, in case of underground fixed dome digester like that of Deenbandhu model, there is least affect on biogas production due to atmospheric temperature difference. This is due to the fact that digester dome is covered with soil that acts as insulator. It has least impact on inside temperature.

pH

The pH range suitable for biogas production is rather narrow i.e. between 6.6 to 7.5. A pH value below 6.2 (acidic slurry) and above 8.0 (alkaline slurry) becomes toxic to the bacteria.

Total solid concentration in feed material

Total solids in feed material is an important aspect. Around 8% TS is optimum for biogas production. In case of cow dung, this concentration is achieved after mixing cow dung with water in the ratio of 1:1, i.e., 10 kg of cow dung is mixed with 10 lit. of water.

Testing the digester;

The digester of the Deenbandhu plant on completion is tested before commissioning through smoke test for detecting gas leakages. Smoke producing material is burnt inside the digester and thereafter all vents of the digester are closed and checked for leakage. Any section of the dome emitting smoke is identified and can be sealed.

Hydraulic testing for water leakages is done by filling half of the digester with water and marking the level. Thereafter, after a period of 6 to 7 days, the water level is rechecked. In case of leakages the water level will go down.

Starting a digester with feed material;

Initial digestion process with cattle dung feed should start within few weeks depending upon the temperature. If available, effluent (5-10%) from a running biogas plant should be added to new biogas plant once at the start as an inoculum. Cow dung itself contains a lot of methanogenic bacteria, therefore, in case of unavailability of working biogas plant and its effluent, biogas production will continue.



Uses of biogas

Common uses of biogas are for cooking and lighting through mantle lamps. Biogas cooking burners are available in markets (Fig. 4.11). A cooking burner consumes 8-24 cft of biogas per hour depending on its size. Biogas burns in blue flame without any shoot or odour like LPG.

Fig. 4.11 .

It contains around 1 % hydrogen sulphide that has pungent odour, but for cooking during burning there is no such odour at all such odour is useful to detect any leakage of biogas due to loose connection of pipe etc. In rural areas where people are mostly dependant on fire



wood or dung cake for cooking purpose, biogas is a boon in improving health, environment and is economical. Lighting through mantle lamp is another common use of biogas (Fig 4.12). Such mantle lamps are available in markets. A Mantle lamp consumes 2-3 cft of biogas per hour. It gives illumination equivalent to 40 watt bulb at 220 volt of electricity. In rural areas in most of the families

students can't study in night due to unavailability of electric supply and high cost of kerosene oil, biogas is a sustainable option and boon for such communities. A drawing and estimates of a 2 cum biogas plant linked with toilet is annexed (Annexure- III and IV).

Do's and Don'ts

Do's

- i. Select the size of the biogas plant depending on the quantity of dung available with the beneficiaries.
- ii. Install the biogas plant at a place near the kitchen as well as the cattle shed preferably.
- iii. Ensure that the outer side of the plant is firmly compacted with soil.
- iv. Ensure that the plant is installed in an open space, and gets plenty of sunlight for the whole day, all round the year.
- v. Feed the biogas plant with cattle dung and water mixture in the right proportion-add 1 part of cattle dung to 1 part of water by weight to make a homogeneous mixture.
- vi. Ensure that the slurry (mixture of dung and water) is free from soil, straw, etc.
- vii. For efficient cooking, use good quality and approved burners and gas lamps.
- viii. Open the gas regulator cock only at the time of its actual use.
- ix. Adjust the flame by turning the air regulator till a blue flame is obtained, this will give maximum heat.
- x. Light the match first before opening the gas cock.
- xi. Cover the top of the inlet and outlet tank opening with wooden, stone or RCC cover, to avoid accidental falling of cattle and children.

Don'ts

- i. Don't install a bigger size of biogas plant if sufficient cattle dung or any other feed-stock to be used for biogas production is not available.
- ii. Don't install the gas plant at a long distance from the point of gas utilisation to save the cost of pipeline and loss of biogas.
- iii. Don't install the plant under a tree, inside the house or under shade.
- iv. Don't add more than required quantity of either dung or water-doing so might affect the efficient production of gas.
- v. Don't leave the gas regulator (valve) open when the gas is not in use.

- vi. Don't inhale the biogas as it may be hazardous.
- vii. Don't allow soil or sand to enter into the digester.
- viii. Don't use the gas if the flame is yellow. Adjust the flame by the air regulator till it is blue in colour.
- ix. Don't use the gas after initial loading of slurry, as it may take 15- 25 days for gas production in freshly loaded plants. No foreign material should be added.
- x. Don't let any water accumulate in the gas pipeline; otherwise the required pressure of gas will not be maintained and the flame will not be proper.

D. Septic Tank toilet

Septic tank offers a preliminary treatment of sewage prior to final disposal. It is an underground structure made up of bricks, cement or concrete. It has 3 or more chambers separated by baffle wall. In different chambers wastes are settled and degraded anaerobically and the final effluent is discharged through outlet pipe of Septic Tank. Sewage is held in these tanks for some prescribed period during which time the suspended solids present in the storage settle down. The settled sludge and the supernatant liquor undergoes anaerobic digestion. The digestion results in appreciable reduction in the volume of sludge and reduction in organic matter in the liquid. Total retention time is maintained for 24-48 hours only.

Septic tank has minimum width of 750 mm, minimum depth of one metre below water level and a minimum liquid capacity of 1000 litres. For rectangular septic tanks, the length of the tank is 2 to 4 times the width. For circular tanks the minimum diameter should not be less than 1-35 m and operating depth should not be less than 1 m.

Inlet - The design of septic tank inlets is such as to introduce the crude sewage with the least possible disturbance of the settled sludge or the surface scum. For tanks not more than 1200 mm wide, T-shaped dip-pipe not less than the nominal bore of incoming drain may be provided. The pipe is fixed inside the tank, with top limb rising above scum level and the bottom limb extending about 300 mm below the top water level. For tanks in excess of 1200 mm in width, two or more submerged inlets are preferable. One method of providing such inlets is by the use of submerged bends of the same nominal bore (not less than 100 mm) set as closely together as practical in a shallow sump formed within a small benched chamber.

Outlet - The final outlet for tanks which are less than 1200 mm wide should be by 100 mm nominal bore dip-pipe fixed inside the tank with a top limb rising above scum level and the bottom limb extending to about 1/3 of the liquid depth below top water level. The invert of the outlet pipe shall be 50 mm below the invert of the inlet pipe. Final effluent is discharged through outlet that passes through drain to a suitable discharge point. A typical drawing of a septic tank attached to Individual Household Latrine (IHHL) is annexed (Annexure-VI). The cost of such septic tank (five to seven users) may vary from Rs. 16000 – 20000 depending upon the soil condition, terrain and specific design considerations.

Advantages.

Septic system provides sanitary method of disposal of human wastes. There is no foul smell with the system, no chance of breeding of mosquitoes occur with a suitable design septic tank.

Disadvantages

- i. It costs higher
- ii. Cleaning of chambers is a cumbersome process. In rural areas mechanical device to clean septic tank chambers is normally not available. Under such condition, only manual cleaning is the option. Cleaning manually is an unhygienic and unsocial. Even if it is cleaned mechanically, it's quite difficult to dispose it of safely, as it has bad odour and containing lot of pathogens.
- iii. Lot of water is required to flush human wastes. Therefore, in water scarcity areas, this system is difficult to implement.

III. Toilet for physically handicapped and old age people

For physically challenged persons, squatting toilet is not suitable. It needs a suitably modified commode toilet to suit their needs. Such toilet is also useful to elderly people or people having knee / joint pain. For physically challenged people using wheel chair, they need a proper space to move with such wheel chair inside the toilet. A grab bar is needed to provide support to such persons while using the toilet. Taking all these factors in consideration following should be the elements of a toilet for disabled persons:

- i. One special W.C. should be provided for the use of handicapped persons with essential provision of wash basin near the entrance.
- ii. A normal toilet has an average height of around 32-40 cms while for handicapped persons toilets have an average height of about 42-48cms. Many people who have no disabilities also find this toilet more comfortable, while it is a necessity for people with back and leg problems.
- iii. The minimum size of toilet cubicle should be 1500mm x 1750 mm
- iv. Minimum clear opening of the door shall be 900 mm. and the door shall swing out.
- v. Suitable arrangement of vertical/horizontal handrails with 50 mm. clearance from wall shall be made in the toilet.
- vi. Toilet floor shall have a non-slippery surface.
- vii. Guiding block near the entry should have a textural difference,
- viii. Light-weight PVC door shutter should be provided as a sliding door
- ix. Provision of vertical and horizontal rail as 40 mm steel pipe
- x. The rear wall grab bar shall be 36 inches long minimum and shall extend from the center-line of the toilet 12 inches minimum on one side and 24 inches minimum on the other side.
- xi. Additional options for toilets for handicapped persons include adding a handicap bidet to wash the backside. Some people are unable to reach that area with toilet paper or have trouble in wiping.

A typical inside photo of a disabled toilet is placed at Fig 4.13 and drawings at Fig 4.14 and 4.15

A Typical Toilet for handicapped person



Fig 4.13

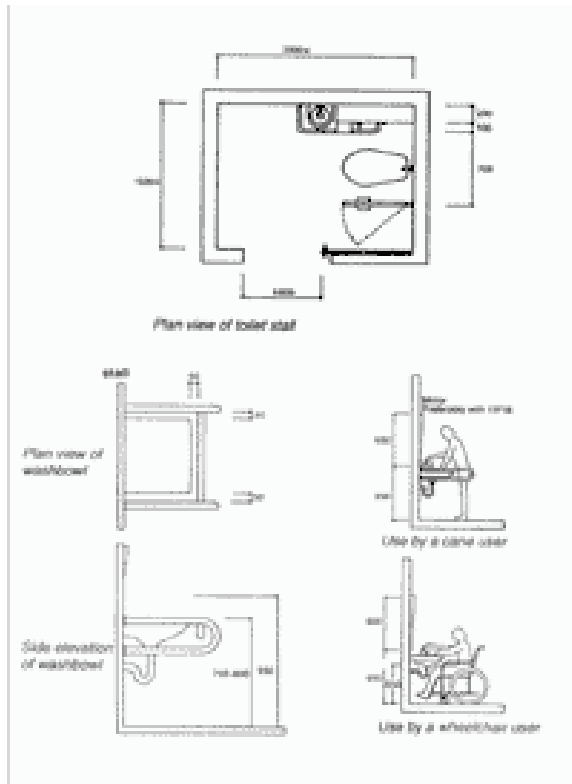


Fig 4.14

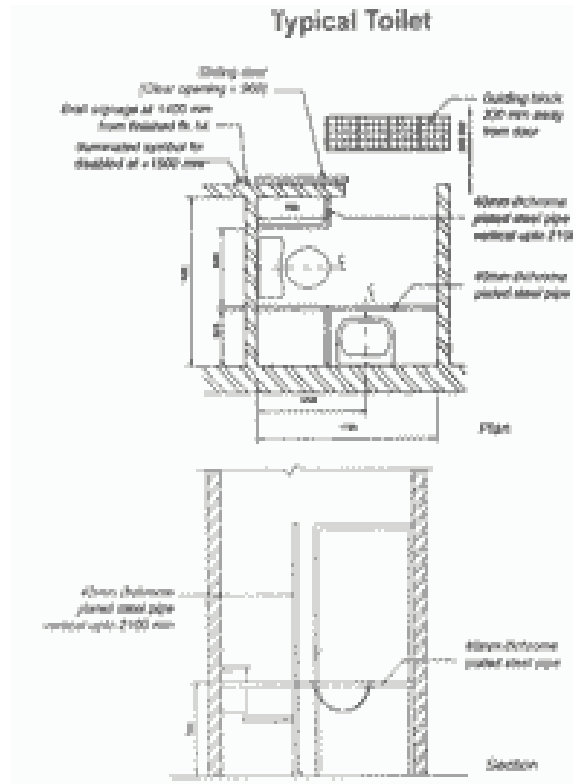


Fig 4.15 An inside view of toilet for handicapped

IV. Different types of superstructures for household toilets affordable for different economic groups of people



Superstructure with brick, cement and RCC roof and wooden door



Superstructure with stone wall, RCC roof and iron door



Superstructure with thatch



Superstructure with G.I. sheet



Supersaturate with thatch, and roof of G.I. sheet



Ecosan toilet superstructure with brick, cement, and RCC roof and iron door



Ecosan toilet superstructure with brick, cement, and red stone roof and Tin door

V. Assessment of some widely used technologies for household toilets in rural areas.

Sl.No	1	2	3	4	5	6	7	8	9	10	11
	Type of Technology	Important Features	Requirement of Land	Degree of skilled labor	Suitable for soil conditions	Requirement of Water	Ease of O&M	Meeting Hygiene	Overall Cost of Technology	Safe reuse or disposal of human wastes	Socio-cultural Acceptability
1	Simple Pit Toilet	Squat plate with a hole, a lid (or cover), Foot rests near squat hole. A pit below the squat hole	Low	Low	Permeable/ not suitable for high water table or rocky soil	Little water	Easy	Low	Low	No. It needs manual scavenging or mechanical device to empty pit	Acceptable with health risk
2	Single pit pour flush	Squatting pan with water seal having single offsite leach pit	Low	Medium	Permeable/ not suitable for high water table or rocky soil	Medium- 2 lts per use	Easy	Low	Low-Medium	No. It needs manual scavenging or mechanical device to empty pit	Acceptable with health risk
3	PourFlush Toiletwith Twin Pit	Pour Flush Squat platform two pits with honey combs	Medium	High	Permeable/ not suitable for high water table or rocky soil	Medium (2 lts per use)	Fairly Easy	High	Medium	Yes, safe reuse of human wastes, manure for agriculture purpose	Acceptable without health risk
4	Eco-san Toilet	Separate collection of faeces and urine in water-tight chambers	High medium	Very High	Suitable for any soil including rocky and high water table	No Water	Difficult	High	High	Yes, safe reuse of human wastes and urine as manure.	Acceptable where people don't use water for cleaning
5	Septic Tank toilet	Squatting or commode with cistern, 2 to 4 tanks in series for settling of wastes	High	High	Stable soil, but not suitable for rocky soil	High	Difficult	High, However, problems continue with safe disposal of sludge of septic tank.	High	Disposal of sludge and effluent is a problem	Acceptable
6	Biogas plant linked with toilet	Squatting pan, pour flush, instead of pits underground biogas plant is required	High	High	In all soil types	Medium	Needs training	High	High	Safe reuse of effluent. Biogas is used for beneficial purposes	Acceptable when properly demonstrated.

Chapter 5

Design criteria for pit and chamber for a household toilet

Design criteria of latrines depend on several factors that vary considerably in different geological conditions. The basic dimensions for most common designs of toilets adopted in rural areas are being given below.

Design criteria for two -pit pour flush latrine

To design a pit latrine (single pit or double pit) the following must be taken into account:

- Volume of pit should be sufficient enough to store sludge for the intended period – minimum of 2 years
- There should be sufficient pit wall areas available for leaching of liquid from pit to soil. It can be determined through the infiltration rate of the soil.

Sludge accumulation rate and its storage volume

Not much information is available regarding rate of accumulation of sludge in pit latrines. It varies widely depending on water table, geological conditions of area, quantity of water use for cleaning etc. Degradation of human wastes under water is much higher than in dry condition. In India people generally use water for ablution. Under such conditions, in West Bengal, Wagner & Lanoix, (1958) reported a sludge accumulation rate of 25 litres per person per year. However, later Baskaran (1962) reported it to be 34 litres in the same area. In case of degradable cleaning materials, Wagner & Lanoix (1958) reported sludge accumulation rate to be much higher- 60 lit per person per year.

Storage volume of a pit can be calculated as follows:

$$V = N \times P \times R$$

V = effective volume of the pit (m³)

N = Cleaning interval of the pit (normally it is 3 years)

P = Average users of toilet per day

R = Sludge accumulation rate –per person per year (m³)

Depth of sludge in the pit: For calculation of depth of sludge in a pit, plan area of the pit is determined. Depth of sludge is calculated as follows:

$$\text{Sludge depth} = \text{Total sludge volume (V)} / \text{Plan area}$$

Infiltration rate and Leaching Area of the pit wall: Rate of infiltration from pits varies and depends on soil type. Clay soil in wet condition has least infiltration rate, it becomes almost impermeable. Sand and silt have more permeability and high infiltration rates due to large soil porosity. The rate of infiltration also depends on ground water table. In case of unsaturated soil, infiltration is induced by gravity and presence of air and water in the soil pores. In the saturated soil all pores are filled with water and infiltration depends on the size of the pores. However, pore size of surrounding soil of a leach pit is never constant. Soil pores get clogged during operation of leach pits due to organic matters in the effluent of pit, it causes reduction of infiltration rate. Therefore, it is quite difficult to determine infiltration rate of any soil in course of operation of a leach pit toilet.

Infiltration rate of different soil types has been studied by many experts and they vary widely. The recommended infiltration rate of different soil types as recommended by the US Environmental Protection Agency (1980) is as follows:

Soil type	Infiltration capacity, settle sewage (Its. per m ² per day)
Coarse or medium soil	50
Fine sand loamy sand	33
Sandy loam, loam	25
Porous silty clay and porous silty clay loam	20
Compact silty loam, compact silty clay loam and non-expansive clay	10
Expansive clay	<10

In India sandy loam, loam, silty clay and silty clay loam soils are found in most of the areas. On a safer side, a filtration rate of 20 lit. per m² per day is adopted for a general design of household leach pit toilet. However, for site specific soil conditions, a separate calculation for design should be done, taking into account the actual infiltration rate.

Design calculation for a two pit pour flush toilet used daily by 5 users, for 3 years capacity

Sludge volume = N x P x L

$$= \frac{3 \times 5 \times 34}{1000}$$

$$= 0.5 \text{ cum}$$

Sludge depth = sludge volume / plan area

Assuming the diameter of the pit to be 1m, the sludge depth would be

$$0.5 \times 4 / 3.14 = \mathbf{0.6 \text{ m}}$$

Liquid depth : Total volume of water for flushing of the toilet, per day by all the 5 users of toilet is taken as 25 litres. However, for a rural pan with 20 mm water seal it requires only 2 lit per use of toilet. The volume is taken on higher side for safety as some may require more water for cleaning and flushing.

For 25 litres water, area required for leaching would be $20 / 30 = 0.66 \text{ m}^2$ (infiltration rate 30l / m^2 per day is taken on a safer side)

Infiltration depth = Area required / circumference of pit

$$= 0.66 / 3.14 = \mathbf{0.21 \text{ m}}$$

Depth of each pit =

Sludge depth =	0.6 m
Liquid depth =	0.21 m
Depth to bottom of inlet pipe/ drain * =	0.20 m.

Total depth =	1.01 m

*It is the depth of bottom of incoming pipe from the junction chamber, this part does not have honeycombs and thus can't be considered for leaching area

Thus, total depth of a pit for 5 users and 3 years capacity should be 1.01 m.

Design calculation of chambers for Ecosan toilet

In case of ECOSAN toilet, people use papers for cleaning and cleaning water is separated in a chamber. Ash is put over the waste after each use of toilet. Under such conditions, depending on usage pattern, an ultimate volume of desiccated faeces with additive mixture of 0.25 to 0.40 litres per person per day can be considered (Ecological sanitation Practitioner's book, 2011).

Calculation for a storage chamber for an Ecosan toilet, daily used by 5 users and one year capacity is as follows: People use desiccating materials after each use of toilet.

Volume of storage chamber = $N \times P \times R$

= $1 \times 5 \times 146$ liters = 0.7 cum (per day 0.4 litres per person 365 x 0.4 l per year is considers)

Sludge depth = Sludge volume / plan area

Taking length and breadth of chamber are 1m each then depth would be -

$0.7 / 1 = 0.7$ m.

In case of Ecosan toilet there is no chance of infiltration of liquid, as the bottom of the chamber is plastered, infiltration area is not considered.

Soil seal depth: it is assumed to be 0.5 m

Total designed depth of the chamber is $0.7+0.5 = 1.2$ m.

Thus for an Ecosan toilet used by 5 users per day having one year of decomposition time the designed dimension of each chamber should be 1 x 1 x 1.2 m, i.e. volume of 1.2 cum.

Chapter 6

**KEY TECHNOLOGICAL ISSUES IN IMPLEMENTING
HOUSEHOLD TOILETS****I. Technical issues**

In rural areas, pit toilets are most appropriate option in most of the cases. It is acceptable also due to its simple design, low cost, and easy to construct. Untrained masons normally modify the design at site without knowing the importance of each component of the toilet. Sometimes such modification is also due to perceived social status. The common problems faced with the implementation of household toilets are follows:

- i. **Use of Vent pipe:** In case of pit latrines (single or double pit) vent pipe is not required. Gases produced during decomposition of wastes are diffused in surrounding soil through honeycombs of the walls of pit. Further, if the height of vent pipe is lower- 4-5 feet (that has been observed in most of the cases), there is sometimes foul smell in the surrounding, resulting in avoidance of construction of a toilet. Villagers are normally unaware of the function of vent pipe, they simply take it as status symbol.
- ii. **Insufficient honey combs:** In case of pit toilets constructed with bricks, honey combs are normally provided. It has been observed that honey combs are not provided in the ring channel toilets. Some part of the water leaches out through joints of the channel and through bottom of the pit. Most of the water remains in pit resulting in frequent filling of the pit. Under such condition taking out manure from the pit is quite difficult as the content of the pit remains wet for longer time. In sandy areas, large size of honey combs is not required. In such case, sand falls in the pit through honeycombs. In such cases honeycomb of 1” is sufficient for leaching of water.
- iii. **Size of the pits:** Size of each pit of toilet is normally 3 ft in diameter and 4 ft in height for 5 users and 3 years capacity .It has been observed that some people construct large size of pits with the idea that such pit will require 10-20 years for

emptying. Such unnecessary digging of large pits has unfavorable consequences. High depth of pit may cause ground water pollution; in case of loose soil, more depth may result into collapse of pit wall when sufficient strength is not provided to the brick walls.

- iv. **Improper pan and Trap:** Pit latrine is suitable for low consumption of water for flushing of wastes. For low flush of water, pan should be of higher slope (28°-30°) and water seal / trap of 20 mm only. It requires only 2 lit of water to flush human wastes per use of toilet. Such pan and trap are made up of fiber, china clay, mosaic etc. Fiber pan and trap are cheaper and easy to transport due to its light weight. However, it has been observed that in many cases people do not use such pan and the 20 mm trap. Instead, they use ceramic pan with a trap of 60 mm or even higher, that requires more water to flush out excreta. Higher quantity of water to flush the excreta, causes frequent filling of pits, in addition to loss of water which is generally the drinking water, through the pits. Absorbance capacity of any soil is finite. High hydraulic load causes accumulation of water in pit which gets filled up frequently. The reason of using such pans in rural areas could be either that the people are not well aware of the 20 mm water seal and/ ceramic pan or they consider using such pan as a status symbol. However, rural ceramic pan with 20 mm water seal is available in the markets. Villagers should use such pan and water seal.
- v. **Improper junction chamber/inspection chamber/ Y chamber:** In case of double pit toilet proper junction chamber is essential. It is required to change over pit when one pit is filled. Junction chamber should be suitable enough to block the pit after it is filled. Such blocking is done normally by putting a piece of brick at the opening of the pipe connecting to the pit. In some cases it has been observed that junction chamber/ Y chamber is not properly designed to block human wastes completely. It results in flow of wastes in both the pits. In such case, contents of the pit remains wet and becomes difficult to remove. In case of single pit toilet also there should be proper junction chamber. It will be required when second pit will be constructed.

- vi. **Ground water contamination:** One of the limitations with pit toilet is that there should be a safe distance of 10 meters or 15 meters from drinking water source to the toilet pit. However, not much attention is given by the beneficiaries to this aspect. Due to lack of adequate awareness, people sometimes construct toilet very close to hand pump/well. The community may face severe water borne diseases due to contamination of ground water, if safe distance of toilet with drinking water source is not maintained properly.
- vii. **Height of the pit above ground level:** Pit should be at least 3-4” above the ground level, to avoid rain water entering into pit. However, it is been observed that in some cases pit cover is made at the level of ground. In such cases during rainfall water flows in to the pit causing inconvenience in use of toilet.
- viii. **Problems with rodents:** It has been observed that in some cases rodents in unused pit cause damages and due to several holes in pit caused by rodents, pit collapses. Beneficiary should find out suitable solution to avoid such problem. However, there is a simple solution to avoid such occurrence in case of rectangular pits, separated by a partition wall. At the upper portion of the partition wall, a small hole should be made. Through this hole, gases formed in the pit in use will pass into other pit. Such gases contain methane, carbon dioxide and hydrogen sulphide, therefore, rodents do not come to that pit. However, it is difficult to apply this method for the pits which are completely separated.
- ix. **Superstructure:** For a toilet, superstructure is important to maintain privacy, without proper superstructure, no one would like to use toilet. It has been observed that in many cases half superstructure without proper door is constructed. As per the report of TARU/UNICEF (2008) such poor and unfinished structure of toilets accounts for significant number of toilets not being used. Such practice of making incomplete superstructure should be avoided.

II. Operation and maintenance of a household toilet

For proper operation and maintenance of a household toilets the following do's and don'ts should be observed :

Do's and don'ts to maintain a toilet

Do's--

- i. Level of slab on the pit should be 3-4 inches above the ground level, otherwise, rainwater may enter into the pit. Therefore, do not make pit with cover slab below the ground level.
- ii. Both the pits should be used alternately.
- iii. Keep two liters of bucket with water ready in the toilet for flushing.
- iv. Pour little quantity of water on the pan before it is used. It helps excreta to slide down the trap and pit easily
- v. Use only 20 mm water seal/ pit trap as it requires only 1.5 -2 lits. of water to flush out excreta.
- vi. Toilet should be regularly cleaned.
- vii. Desludging of pit should be done after 2 years, digested human waste in the pit becomes odourless and pathogen free by that time.
- viii. Manure from the pit should not be thrown, rather used in agriculture as it contains good percentage of plant nutrients.
- ix. Such digested human waste should be handled with care and direct hand contact should be avoided/minimized.

Don'ts-

- i. Don't use supply water pipe inside the toilet. It results in more use of water for flushing, causing decrease in efficiency of pit and high hydraulic load may cause ground water pollution
- ii. Don't use both the pits simultaneously.
- iii. Don't use any chemicals and detergent to clean the pan. It causes killing of microbes also, resulting in less degradation of wastes.
- iv. Don't allow kitchen water or bathing water to enter into toilet.
- v. Any solid material like plastic or small ball etc. should not be put into the pan, it blocks the pit trap making toilet non-functional.
- vi. In case of blockage of pan due to such objects, it should be taken out manually from the pan; it may cause more problems, if stuck in the trap.
- vii. Don't throw lighted cigarette butts into the pan
- viii. Don't desludge the pit before 2 years, after it is filled up and put out of use.

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Annexure-I A

Estimates of a toilet varies significantly depending up on size of the pits and materials used for superstructure. There are several options for superstructure specially materials for doors and roof. The estimates as provided by different states are presented on the table below :

ABSTRACT OF COST FOR CONSTRUCTION OF TOILET													
Sl	Item	Quantity	Unit	ODISHA		KARNATAKA		TAMILNADU		GUJARAT		HARYANA	
				Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount
A	TOILET												
1	Earth work excavation in foundation	1.39	m3	52.48	72.89	73.22	101.70	69.50	96.54	78.00	108.34	59.04	82.01
2	Brick work in Foundation	0.67	m3	631.00	422.77	680.00	455.6	691.10	463.04	1050.00	703.50	450.00	301.50
3	Earth Filling in plinth	0.21	m3	34.98	7.35	20.00	4.2	12.20	2.56	38.00	7.98	34.48	7.24
4	Brick work in Plinth level	0.44	m3	1501.00	660.44	880.00	387.20	895.00	393.80	1250.00	550.00	450.00	198.00
				2219.46	1163.45	1653.22	948.70	1667.80	955.93	2416.00	1369.82	993.52	588.75
5	Brick Masonry in cement mortar (1:6)	0.91	m3	2401.00	2184.91	2506.00	2280.46	2423.00	2204.93	2719.00	2474.29	2901.35	2640.23
6	Non-Asbestos (GI sheet) for Roof covering	5.48	m2	170.00	931.60	150.00	300.00	140.00	767.20	160.00	876.80	145.80	798.98
7	12 mm thick Cement plaster in C.M. 1:6	9.22	m2	54.00	497.88	75.00	691.50	74.00	682.28	62.00	571.64	63.95	589.62
8	12 mm thick Cement plaster in C.M. 1:6	13.05	m2	54.00	704.70	75.00	978.75	74.00	965.70	62.00	809.10	63.95	834.55
9	10 cm thick dry brick khoa	0.96	m2	84.00	80.64	96.00	92.16	96.00	92.16	367.00	352.32	34.72	33.33
10	2.5 cm thick A.S. flooring with punning	1.50	m3	134.00	201.00	150.00	225	150.00	225	105.00	157.50	150.00	225.00
11	White washing	22.27	m2	6.00	133.62	8.50	189.295	8.70	193.75	4.70	104.67	4.12	91.75
12	Ferro cement Door	1	Nos	500.00	500.00	500.00	500.00	500.00	500.00	450.00	450.00	400.00	400.00

Annexure - IB

ABSTRACT OF COST FOR CONSTRUCTION OF TOILET AND BATHING ROOM

SI	Item	Quantit	Unit	ODISHA		KARNATAKA		TAMILNADU		GUJARAT		HARYANA	
				Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount	Rate	Amount
A TOILET AND BATHING ROOM													
1	Earth work excavation in foundation	1.39	m3	52.48	72.89	73.22	101.70	69.50	96.54	78.00	108.34	59.04	82.01
2	Brick work in Foundation	1.39	m3	631.00	876.46	680.00	944.52	691.10	959.94	1050.00	1458.45	450.00	625.05
3	Earth Filling in plinth	0.49	m3	34.98	17.25	20.00	9.86	12.20	6.01	38.00	18.73	34.48	17.00
4	Brick work in Plinth level	0.93	m3	1501.00	1400.43	880.00	821.04	895.00	835.04	1250.00	1166.25	450.00	419.85
5	Brick Masonry in cement mortar (1:6)	2.37	m3	2401.00	5695.17	2506.00	5944.23	2423.00	5747.36	2719.00	6449.47	2901.35	6882.00
6	Non-Asbestos (GI sheet) for Roof covering	6.39	m2	170.00	1085.79	150.00	300.00	140.00	894.18	160.00	1021.92	145.80	931.22
7	Brickwork for parapet wall over Asbestose roof with (1:6) CM	0.05	m3	1701.39	79.99	2506.00	117.81	2423.00	113.91	2719.00	127.83	2901.35	136.40
8	12 mm thick Cement plaster in C.M. 1:6	19.80	m2	54.00	1069.20	75.00	1485.00	74.00	1465.20	62.00	1227.60	63.95	1266.21
9	12 mm thick Cement plaster in C.M. 1:6	20.97	m2	54.00	1132.38	75.00	1572.75	74.00	1551.78	62.00	1300.14	63.95	1341.03
10	10 cm thick dry brick khoa	2.27	m2	84.00	190.68	96.00	217.92	96.00	217.92	367.00	833.09	34.72	78.81
12	2.5 cm thick A.S. flooring with punning	2.27	m3	134.00	304.18	150.00	340.5	150.00	340.5	105.00	238.35	150.00	340.50
13	White washing	40.78	m2	6.00	244.68	8.50	346.63	8.70	354.79	4.70	191.67	4.12	168.01
14	Ferro cement Door	2	Nos	500.00	1000.00	500.00	1000.00	500.00	1000.00	450.00	900.00	400.00	800.00
15	Pan & Piping	LS	LS	750.00	750.00	LS	750.00	LS	750.00	LS	750.00	LS	750.00
B INSPECTION CHAMBER													
16	Earth work excavation in ordinary soil	0.06	m3	52.48	2.89	73.22	4.03	69.50	3.82	61.00	3.36	59.04	3.25
17	Sand filling at base	0.02	m3	43.73	0.70	42.00	0.67	31.26	0.50	41.80	0.67	87.50	1.40
18	P.C.C for Base of inspection chamber(1:3:6) using 40mm metals	0.02	m3	2673.00	42.38	2868.00	45.47	2347.40	37.22	2649.00	42.00	2838.21	45.00
19	Brick masonry in cm 1:6	0.09	m3	1701.39	151.42	2506.00	223.03	2423.00	215.65	2719.00	241.99	2078.65	185.00
20	12 mm thick Cement plaster in C.M. 1:6	0.88	m2	54.00	47.52	75.00	66.00	74.00	65.12	62.00	54.56	63.95	56.28
21	R C C cover plate for inspection chamber	0.02	m3	3986.00	75.61	3710.00	70.38	3455.00	65.54	4400.00	83.47	5482.51	104.00
22	Reinforcement 0.60qntl / cum.	0.011	Qntl	4696.00	51.66	4900.00	53.90	4800.00	52.80	4500.00	49.50	5504.50	60.55
C SOAK PIT													
23	Earth work excavation in ordinary soil	5.21	m3	52.48	273.51	73.22	381.62	69.50	362.23	61.00	317.93	59.04	307.72
24	Honeycomb Brick Work	7.79	m2	72.50	564.56	78.20	608.94	79.50	619.07	120.75	940.28	55.86	434.98
25	R.C.C. 1:2:4 in Cover plate	0.033	m3	3986.00	131.54	3710.00	122.43	3455.00	114.02	4400.00	145.20	5482.51	180.92
26	Reinforcement for cover slab	0.111	Qntl	4696.00	521.26	4900.00	543.90	4800.00	532.80	4500.00	499.50	5504.50	611.00
TOTAL					15782.14		16072.35		16401.92		18170.29		15828.19
TOTAL ESTIMATE					15800.00		16100.00		16400.00		18200.00		15800.00

Annexure-II

Estimate for construction of a model for High Water Tank

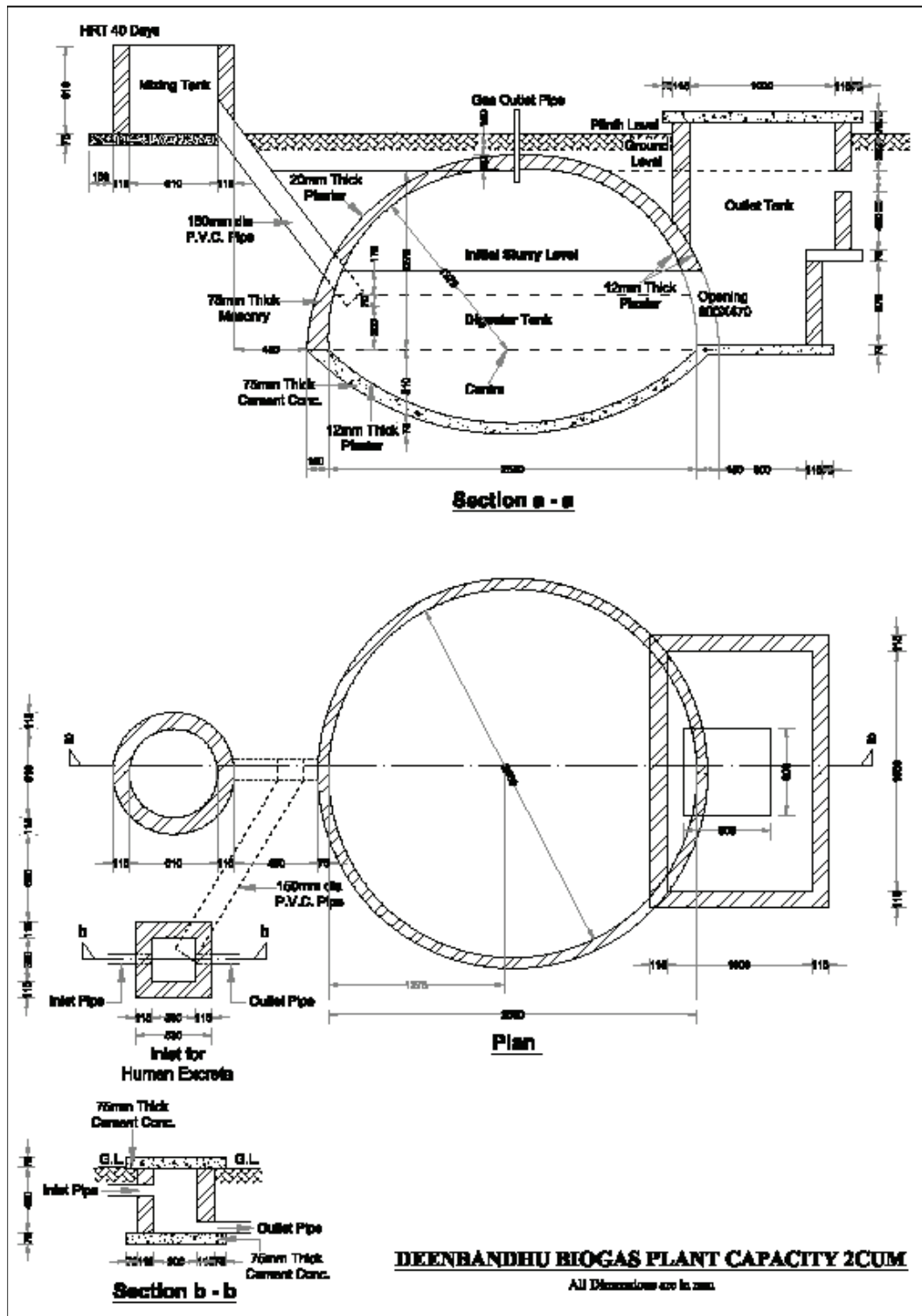
S.No	Particulars	Quantity	Unit	Rate	Amount(Rs)
1	2	3	4	5	6
1 5.1.1 5.1.2	Earth work in excavation in foundation trenches is soil item B etc. all complete Room c/c distance 4.5 mtr. Pit dia - 1.2 M x 1.5 M deep - two No. $4.50 \times 0.380 \times 0.380 = 0.65$ $0.785 \times (3.35)^2 \times 1.75 = 15.41$				
	total = 16.06	16.06	M ³	64.93	1042.78
2 5.1.10	Providing coarse , clean sand filling in foundation & plinth etc. $0.785 \times 3.35^2 \times 0.075 = 0.66$ $4.5 \times 0.380 \times 0.075 = 0.128$ Total = 0.788 M3	1.448	M ³	145.78	211.09
3 5.2.6	Providing designation 75 B brick work in c.m 1:3 in foundation plinth e.t.c Room- $4.5 \times 0.380 \times 0.250 = 0.43$ Leaching pit - $2 \times 3.14 \times 1.325 \times 0.125 \times 1.50 = 1.71$ $2 \times 3.14 \times 1.325 \times 1.50 \times 0.250 = .312$ total = 2.452	2.452	M ³	2697.14	6613.39
4 5.2.10	Providing designation 75 B brick work in cement (1:6) in super structure Room $4.50 \times 0.125 \times 1.82 = 1.82 \text{ M}^3$ Over the roof $4.50 \times 0.125 \times 0.25 = 0.14 \text{ M}^3$ Total = 1.164 M^3 Less opening for door $0.76 \times 1.60 \times 0.125 = 0.152 \text{ M}^3$ Less opening for back Ventilation $0.380 \times 0.380 \times 0.125 = 0.018 \text{ M}^3$ Net volume = 0.993 M^3	0.993	M ³	2398.02	2381.23

5	Providing C.A Sheet for Roof (6 mm thick) size as per availability $1.06 \times 1.20 = 1.27 \text{ M}^2$	1.27	M^2	212.53	269.9131
6	Providing labour for fixing C.A sheet 1 No. Angale below C.Asheet	1.27 1 No.	M^2 each	27.52 70.00	34.95 70.00
7 5.7.3	Providing 12 mm thick plaster 1:6 with clean coarse sand out side $2 \times 1.32 \times 1.82 = 4.80$ $1 \times 1.17 \times 1.75 = 2.05$				
	Inside $2 \times 1.06 \times 1.82 = 3.85$ $1 \times 1.01 \times 1.75 = 1.76 \text{ M}^2$ Total = 12.47 M^2	12.47	M^2	74.51	929.1397
8 5.5.29	Providing fitting and fixing 20 gauge c.r sheet for door framed with M.S angle $0.76 \times 1.37 = 1.04 \text{ M}^2$	1.04	M^2	1898.15	1974.076
9 5.3.5A	Providing precast R.C.C 1:2:4 slab cover for leaching pit $2 \times 0.785 \times 0.075 \times (1.45)^2$	0.248	M^3	3858.2	956.8336
10 5.5.5	Providing reinforcement T.M.T steel bar for cover slab 0.248 M^3 80 Kg/ M^3	20	Kg	50.5	1010
11	Supplying fitting and fixing low cost pan with foot rest , pvc pipe and Jointing all complete. With vent pipe ,inlet & outlet ,making chamber e.t.c	1 item	L.s	1200.00	1200.00
12 5.6.10	Providing 12 mm cement plaster (1:6) with clean coarse with punning of neat cement $0.90 \times 1.10 = 0.99 \text{ m}^2$ 12 mm cement plaster (1:3) with 1.5 punning with water proofing mat. $2 \times 3.14 \times 1.2 \times 1.65 = 12.44$	0.99 12.44	M^2 M^2	74.51 124.37	73.7649 1547.1628
13 5.8.24	Providing punning snowcem white washing two coats over new surface same as item no same as plaster Area.	12.47	M^2	46.67	581.9749

14 5.8.28	Providing two coats of synthetic enamel paint over steel surface 2x1.27 =2.54 m2	2.54	M2	89.28	226.7712
15	Carriage of materials	1 item	each	1000	1000.00
	Total				20123.07
Total					20324.30
ESTIMATED COST					20400.00

Annexure – III

A Drawing of 2 cum Biogas Plant linked with Toilet



Annexure – IV

**ABSTRACT COST FOR DEENBANDHU BIOGAS PLANT
2 CUM CAPACITY (RATE BASED ON DSR 2007)**

Sl. No.	Item	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	2	3	4	5	6
1.	Earth work in excavation by mechanical means (Hydraulic excavator) / manual means in foundation trenches or drains (not exceeding 1.5 m in width or 10 sqm on plan) including dressing of sides and ramming of bottoms, lift upto 1.5 m, including getting out the excavated soil and disposal of surplus excavated soil as directed, within a lead of 50 m. All kinds of soil	cum	12.12	103.40	1,253.21
2.	Providing and laying in position cement concrete of specified grade excluding the cost of centering and shuttering - All work up to plinth level: 1:2:4 (1 cement: 2 coarse sand : 4 graded stone aggregate 20 mm nominal size)	cum	0.29	3,257.45	944.66
3.	Brick work 7 cm thick with F.P.S. brick of class designation 75 in cement mortar 1:3 (1 cement: 3 coarse sand) in superstructure.	sqm	11.45	214.85	2,460.03
4.	Half brick masonry with F.P.S. brick of class designation 75 in foundations and plinth in Cement mortar 1:3 {1 cement: 3 coarse sand)	sqm	11.12	289.60	3,220.35
5.	Centering and shuttering including strutting, propping etc. and removal of form for Arches, domes, vaults up to 6 m span	sqm	13.01	514.70	6,696.25
6.	Reinforced cement concrete work in walls (any thickness), including attached pilasters, buttresses, plinth and string courses, fillets, columns, pillars, piers, abutments, posts and struts etc. up to floor five level excluding cost of centering, shuttering, finishing and reinforcement 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	cum	0.21	3,720.00	781.20

7.	Reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete Mild steel and Medium Tensile steel bars.	Kg.	16.50	41.50	684.75
8.	20 mm cement plaster of mix : 1:4 (1 cement: 4 coarse sand)	sqm	11.45	118.25	1,353.96
9.	12 mm cement plaster 1:3 (1 cement: 3 coarse sand) finished with a floating coat of neat cement.	sqm	31.62	112.80	3,566.74
10.	12 mm cement plaster of mix : 1:4 (1 cement: 4 coarse sand)	sqm	12.61	82.55	1,040.96
11.	Providing and fixing 150 mm dia PVC pipe	Rmt	6.00	160.00	960.00
12.	Providing and fixing single equal plain invert branch of required degree:150x150x150 mm	Each	1.00	60.00	60.00
13.	Providing and fixing gas outlet fitting	Each	1.00	150.00	150.00
14.	Finishing with Epoxy paint (two or more coats) at all locations prepared and applied as per manufacturer's specifications including appropriate priming coat, preparation of surface, etc. complete On concrete work	sqm	11.28	77.75	877.02
	ESTIMATED COST Rs.				24,049.12

Annexure - V

List of construction materials required for one Ecosan toilet:

Bill of quantity varies significantly depending up on size of the chambers and materials used for superstructure. There are several options for superstructure specially materials for doors and roof. The following Bill of quantity can be taken as indicative. It is as provided by the NGO (SCOPE) Trichy.

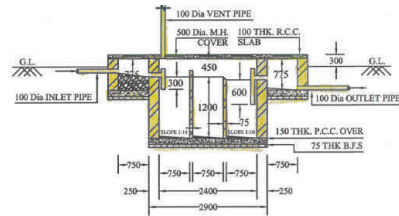
List of construction materials and its cost for one Ecosan toilet:

S.No	Items	Qty	Amount per unit in Rs.	Total in Rs.
1	Foundation Stones	50 Basket	12/-	600.00
2	Cement	6 bags	310/-	1860.00
3	Baby chips	20 Basket	25/-	500.00
4	6 mm Rod	25 kg	40/-	1000.00
5	Binding wire	250 gram	25/-	100.00
6	Sand	1 Tyre Cart	500/-	500.00
7	Red bricks	1300 Nos.	5/-	6500.00
8	4" PVC pipe	10 feet	18/-	180.00
9	4" PVC 'L'	1 No.	45/-	45.00
10	4" PVC Cowl	1 No.	25/-	25.00
11	4" Steel Clamb	2 Nos.	10/-	20.00
12	3" Nail	4 Nos.	L.S	20.00
13	1 ¼" PVC Pipe	17 Feet	17/-	120.00
14	1 ¼" PVC 'T'	2 Nos.	17/-	34.00
15	1 ¼" PVC	4 Nos.	13/-	52.00
16	PVC Solvent	50 ML	12/-	12.00
17	Mosquitoes Net	2 Sq.feet	18/-	36.00
18	Red Oxide	500 gram	50/-	50.00
19	White Cement	10 Kg	8/-	80.00
20	Bucket with Cover	2 Nos.	45/-	90.00
21	Mug	1 no.	10/-	20.00

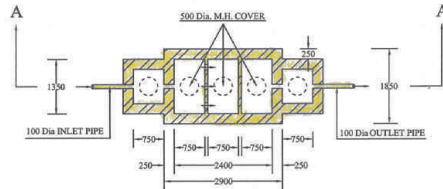
22	Colour washing-Green Stainer	100 ml	35/-	35.00
23	Blue Paint	50 ml	15/-	15.00
24	Yellow Paint	50 ml	15/-	15.00
25	Black Paint	50 ml	18/-	18.00
26	2" Brush	1 No.	18/-	18.00
27	4" Brush	1 No.	40/-	40.00
28	5' X 2' Steel Door	1 No.	750/-	750.00
29.	Cement Jally	1' X 1'	50/-	50.00
30.	Mud Pot	1 No.	20/-	20.00
31.	Transportation charges	L.S	500/-	500.00
32.	Mason Skilled Labour	4	400/-	1600.00
33.	Unskilled Labour	4	300/-	1200.00
	ESTIMATED COST			16165.00

(Rupees Sixteen thousand one hundred and sixty five only)

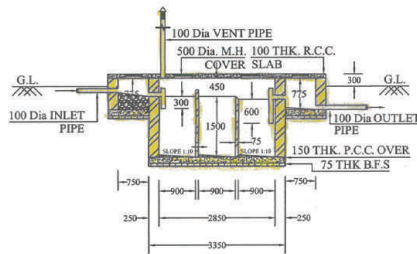
Annexure - VI



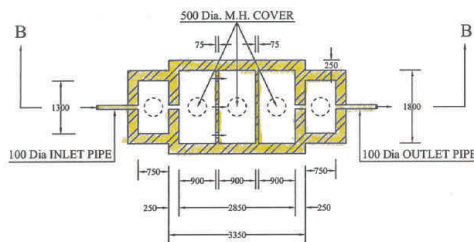
SECTION A - A



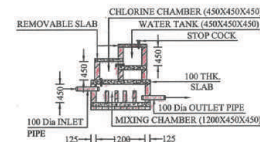
PLAN OF EXISTING SEPTIC TANK No. 1
(50 USERS)
(SCALE - 1:50)



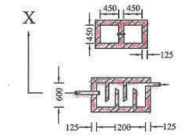
SECTION B - B



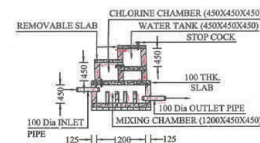
PLAN OF EXISTING SEPTIC TANK No. 2
(100 USERS)
(SCALE - 1:50)



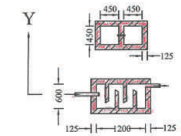
SECTION X - X



PLAN OF PROPOSED CHLORINE UNIT No. 1
(SCALE - 1:50)



SECTION Y - Y



PLAN OF PROPOSED CHLORINE UNIT No. 2
(SCALE - 1:50)

SCHEDULE OF EXISTING SEPTIC TANKS WITH PROPOSED CHLORINE UNITS :-

SEPTIC TANKS				VOL. OF S.T.	CAPACITY OF USERS	SECONDARY TRE
ST No.	LENGTH	WIDTH	DEPTH			
1	2250	1350	1200	3.645 CU. M	50 USERS	CHLORINE U
2	2700	1800	1500	7.290 CU. M	100 USERS	CHLORINE U