F.No. S-18020//24/2015-SBM
Government of India
Ministry of Drinking Water & Sanitation
Swachh Bharat Mission (Gramin) Division

12th Floor, ParyavaranBhavan
CGO Complex, Lodi Road,
New Delhi–110 003, the 24th May, 2016
Ph: 011- 24363747, Fax: 24361062, Email: bala.g@nic.in

To,

The Principal Secretaries of all the States/ UTs in charge of Sanitation.

Sub: Comments on Draft Handbook on Technological Options on On-Site Sanitation in Rural Areas.

Sir,

The undersigned is directed to circulate the draft "Handbook on Technological Options on Onsite Sanitation in rural areas (copy enclosed) to all the States for their comments.

2. The States are requested to furnish their comments if any to shyni.stephen@nic.in on or before 30th May, 2016 positively.

Encl: As above.

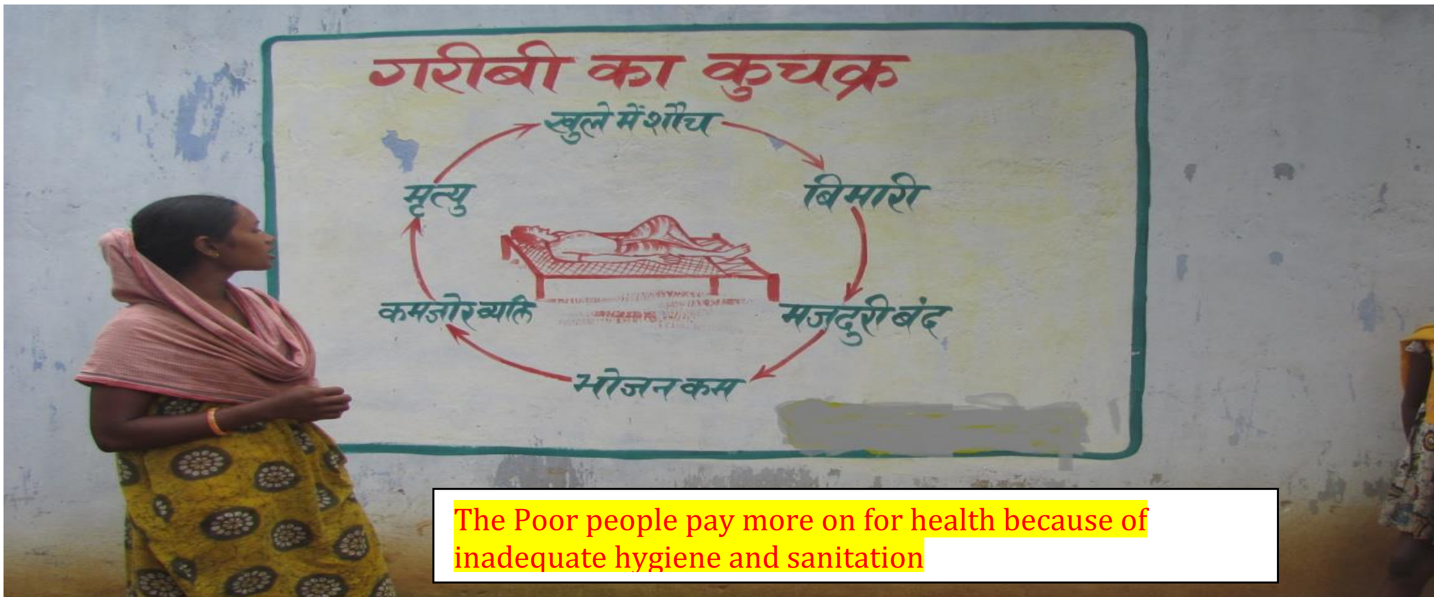
(G.Balasubramanian)
Deputy Adviser (SBM)

Copy to :

1. State Coordinators of all the States / UTs in charge of sanitation
2. Sr. PPS to Secy(DWS)/ PS to AS(SBM-G /
3. Director (NIC) – to upload in the Ministry's website.

Handbook on

Technological Options for On-site Sanitation in Rural Areas



The Poor people pay more on for health because of inadequate hygiene and sanitation

Cooking with biogas from a toilet-linked biogas plant

Ministry of Drinking Water & Sanitation

Government of India

June 2016

Handbook on
Technological Options for On-site Sanitation in Rural Areas

Contents

Chapters **Page No.**

Photo of Hon.
Minister
MDWS

MESSAGE

Our Government is committed to providing safe sanitation to everyone, everywhere. Swacch Bharat Mission is a nationwide movement involving participation and involvement of all. Providing adequate sanitation to every community has been a major challenge in India because of varying socio-cultural and economic conditions. The Ministry of Drinking Water and Sanitation (MDWS) is committed to helping every community in rural areas by improving sanitation through the national flagship scheme of Swachh Bharat Mission (SBM).

Proper awareness, collective behavior change, coupled with availability of sustainable technologies for construction and usage of toilets are important aspects of SBM. There are a wide range of hydro-geological conditions in different states of India. It is challenging to make one technology applicable in all areas. Selection of on-site sanitation technology has to be according to the hydro-geological condition of the targeted area, to avoid risk of ground-water pollution from on-site sanitation, and socio-cultural taboos in acceptability of the technology. Lack of information leads to many communities implementing the prototype household toilet technology even if unsuitable for the hydrological conditions of the area.

The objective of toilet technology providers, particularly in rural areas, should be to evaluate and help improve the situation. This Handbook tries to provide sustainable technological options for on-site sanitation for different hydro-geological conditions. Hardware by itself may not improve health much. What matters is the way in which it is used and promotes changes in hygiene related behaviors.

I am pleased to note that this Handbook has been prepared by a group of experts from MDWS and WaterAid India to fulfil needs of stakeholders in Swacch Bharat Mission. I am sure it will prove valuable for public health engineers, sanitarians in the field, different non-governmental organizations, civil society organizations, and communities involved in implementing Swacch Bharat Mission. It will also be useful for administrators, health personnel, planners and many others directly and indirectly concerned with improving sanitation among the deprived sections across rural India.

(Signature)

Photo

Hon. State
Minister, MDWS

MESSAGE

The Hand Book for On-site Sanitation in Rural India has been prepared and designed for use by sanitation practioners working for the Swacch Bharat Mission (SBM) (G).

The Ministry of Drinking Water and Sanitation (MDWS), Government of India had formerly released a Handbook on Technological Options for on-site sanitation in 2012. With revised guidelines of SBM and better financial support for different components under the programme, there was a need to update the Handbook to include other available technologies suitable for different hydro-geological conditions in rural areas for household on-site sanitation.

In previous sanitation programmes, taking appropriate low-cost technology to rural areas across India posed a major challenge. The MDWS in collaboration with WaterAid India decided to bring out this hand book to inform communities, Panchayats, state departments and other stakeholders involved in SBM on technologies that provide safe and sustainable on-site sanitation options and septage management. This handbook includes updated information on options such as Bio-toilets, hand-washing stations, and many more context specific technologies.

I am pleased to note that this handbook has been prepared by a group of experts from MDWS and WaterAid India to cater to the needs of stakeholders in the sanitation sector. It will be a valuable tool for non-governmental organizations, civil society organizations, sanitarians in the field, public health engineers, administrators, planners and everyone concerned with improving sanitation in rural India.

(Signature)

Photo
Secretary,
Ministry of Drinking Water and Sanitation ,
Government of India

It is with great pleasure and pride that I present this Handbook on technical options for on-site sanitation, prepared by the MDWS and WaterAid India for use by all professionals, and implementing and supporting organisations for Swacch Bharat Mission (SBM).

Technology plays an important role in SBM and its implementation. There is a need for sustainable low cost sanitation technologies for different hydro-geological areas in the country, and household sanitation technologies need to fulfil criteria defined by the ministry under the SBM guidelines

Since the inception of SBM in 2014, a need was felt by the ministry to update the previous handbook and make it more comprehensive, and explore more technological options for sanitation, as there was limited scope for on-site sanitation tech. Leach-pit toilets are being implemented widely across India, not taking into account the different types of soil in each area, or the possibility of ground water pollution in areas with high water tables. This handbook fulfils that gap with its suggestions. It also has an option of using common sub-structures of appropriate size for up to five homes, suitable for those with limited space, and also integrate low cost, hand-washing options such as tippy taps. The handbook is reviewed by the Mashelkar Committee on Technology working with MDWS.

I wish to acknowledge the efforts of Shri Saraswati Prasad for his efforts from the start of SBM; support from Shri Nipun Vinayak, Director (SBM), and Shri Bala G Subramaniam, Deputy Advisor, who helped make these guidelines a reality. Thanks are due to Dr. Shiny D.S., Team Leader, Sanitation, NRC and the members of Mashelkar Committee for useful suggestions and reviewing the handbook.

Lastly, I thank the team from WaterAid India, especially Dr Pawan Kumar Jha, Sri Neeraj Jain, Sri Arjen Naafs, Sri Puneet Srivastava, Sri Siddhartha Das, Sri Anil Cherukupalli, and Ms. Sharada Annamaraju for their immense contributions towards this handbook. I sincerely hope this publication provides guidance, and contributes to the Hon’ble Prime Minister’s vision to finally realise safe sanitation for *everyone, everywhere* by 2019.

(Signature)

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, and hygiene maintenance in food and housing. Sanitation and environmental sanitation converge in many aspects. Environmental sanitation 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)** present a rough guide on the relative importance of different aspects of sanitation as follows:

Excreta disposal — 25 points
Excreta treatment—15
Personal and domestic cleanliness—18
Water quality—11
Water availability—18
Drainage and sludge disposal—6
Food hygiene—17

A hygienic 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 on poverty alleviation and improvement of overall quality of life. Open defecation is still in practice in many rural areas resulting in serious social, health, economic and environmental problems. Openly lying human waste enables 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 the age of five are most prone to diarrhea and sometimes even lose their lives to an easily preventable disease. Loss of number of school days is another problem in times of illness. 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 and having to defecate in the open.

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

- Improves health

- Decreases morbidity and mortality
- Improves man-days
- Improves productivity
- Alleviates poverty
- Improves water quality
- Minimizes incidences of drop-outs in school; particularly among girl students

It is accepted and well known that the poor pay directly and indirectly more due to bad sanitation. Daily wage earners especially lose out from illnesses due to bad sanitation. Members looking after the ill, in turn lose daily earnings, or schooling (in case of children). In most rural areas, subsidised health facilities are rarely available forcing people to turn to private doctors, and quacks who charge exorbitant rates leading to higher economic loss.

Open defecation is 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. Even with advent of technology in rural India, a substantive proportion of the rural poor still prefer to purchase mobile phones than invest in toilets, as sanitation is neither a felt need nor is open defecation a socio-cultural taboo. The most important challenge for effective implementation of sanitation programmes in rural areas is the lack of awareness of overtly conscious of the linkage between sanitation and health. A second important barrier for sanitation is the lack of a concept of community health and hygiene in rural areas. Wherever there is awareness, it is limited only to personal sanitation and hygiene, but does not extend to the community. Effects of sanitation can be gauged only when facilities and practices are adopted at community scale. Individual toilets which can be maintained for home use and maintenance therefore become a collective solution. Every house with different financial restrictions can use different toilet technologies.

Key Provision of Swacch Bharat Mission (Gramin)

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

The Union Government of India restructured the programme, leading to the launch of the flagship Total Sanitation Campaign (TSC) in 1999 under the MDWS. 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 environments. The scheme was renamed Nirmal Bharat Abhiyan (NBA) in 2012 with increased financial incentives for household toilets for those below poverty line (BPL), all scheduled tribe (STs) and scheduled caste (SC) families.

The SBM was launched on 2 October 2014, the 150th birth anniversary of Mahatma Gandhi, by the Prime Minister of India to accelerate efforts to achieve universal sanitation coverage and place focus on sanitation. The Mission Coordinator is the Secretary, MDWS, with two sub-missions, the SBM-Gramin and SBM-Urban, which aims to achieve Swacch Bharat by 2019.

The main objectives of the SBM (G) are:

a. Bring an improvement in the general quality of life in rural areas by promoting cleanliness, hygiene and eliminating open defecation.
b. Accelerate sanitation coverage in rural areas to achieve the vision of Swachh Bharat by 2 October 2019.
c. Motivate communities and Panchayati Raj Institutions (PRIs) to adopt sustainable sanitation practices and facilities through creation of awareness and health education.
d. Encourage cost effective and appropriate technologies for ecologically safe and sustainable sanitation.
e. Develop where required, community managed sanitation systems focusing on scientific solid and liquid waste management systems for overall cleanliness in rural areas.

Providing safe disposal of human excreta is the backbone of the programme. The guidelines of the MDWS clearly state that a duly completed household sanitary latrine **shall comprise of a toilet unit including a sub-structure which is sanitary** (that safely confines human faeces and eliminates the need for handling by humans before it is fully decomposed), a super structure, **with water facilities and a hand-wash unit**. The mission aims to ensure that all rural families have access to toilets. There are various models of toilets available based on safe sanitation technologies like the Twin Pit, septic tank, and bio-toilets amongst others. The ministry encourages the development of other safe technologies, and states shall disseminate information about available technologies and their costs to the beneficiary to enable him to make an informed choice. States can also consider the construction of 'row' toilets and complexes for a group of families, mainly where it is not possible to construct Individual Household Latrines (IHHLs). It should be ensured that the toilets constructed for individual households meet the minimum design specifications to ensure sustainability. Care shall be taken to ensure that these toilets are not over-designed and over-constructed, for instance building unnecessarily extra-large pits. Affordability and contamination of drinking water is to be prevented. States have to ensure through effective communication that such tendencies are restricted. Appropriate information has to be provided to the beneficiary regarding the maintenance of the toilets provided. **The toilets must have a super structure acceptable to beneficiaries,** as poor quality of toilets has been one of the main complaints against earlier sanitation programmes. Various options for the superstructure should be explored and information about the options should be provided to the beneficiary to choose from.

The ministry is providing incentive to homes for construction and use of toilets. Incentive under the mission for the construction of IHHL shall be available for all BPL Households and Above Poverty Line (APL) Households restricted to SCs/STs, small and marginal farmers, landless labourers with homestead, physically handicapped, and women headed households.

The Incentive amount provided under SBM (G) to BPL, identified APLs households shall be up to Rs 12,000 for construction of one unit of IHHL and provide for water availability, including for storing for hand-washing and cleaning of the toilet.

The subsidy pattern has been revised in the financial year 2015—16 by the ministry keeping central share of Rs 7,200 (60%) and state share of Rs 4,800 (40%). For North-eastern states, and special category states, the subsidy pattern will remain the same, i.e., central share of Rs 10,800 (90%) and the state share of Rs.1, 200 (10%).

The beneficiary is to be encouraged to additionally contribute in construction of his IHHL to promote ownership. State governments have the flexibility to provide higher incentives for a household toilet, for higher unit costs from sources other than SBM (G). However this additional funding cannot be from the central share of any other Centrally Sponsored Scheme.

Special category states are declared by the GoI, with the objective to bring them at par with development levels of other states. North-eastern states including Sikkim, Uttarakhand, Jammu & Kashmir, and Himachal Pradesh are special category.

Definition of Open Defecation Free (ODF)

There has been lack of a uniform definition of ODF in past. Sometimes it is simply considered as physical elimination of defecation in open without taking into account quality of sanitation technology. Generally a sanitary toilet is defined as a toilet for safe containment of human excreta. The MDWS elaborates "safe confinement" in context of sustainable technology. Sustainability has been considered for environmental pollution, health and social aspects. A standard definition of ODF was also required to discourage implementation of technologies causing pollution to ground water, surface water or surface soil. Accordingly, the definition of ODF by the MDWS is:

ODF is the termination of faecal- oral transmission, defined by

a) No visible faeces found in the environment/ village.

b) Every household as well as public/ community institutions using safe technology for disposal of faeces. The safe technology options mean:

   i. No contamination of soil surface, ground water or surface water

   ii. Excreta inaccessible to flies or animals

iii. No handling of fresh excreta

iv. Freedom from odour and unsightly conditions

The key challenge in achieving total sanitation in villages is to provide affordable and sustainable technology in different geographical conditions. Their lack in the supply chain is a limiting factor. Another equally important challenge is to bring about a change in the knowledge, attitudes and age–old practices of the villagers towards open defecation and change behavior. To end this situation, providing easy access to a toilet and motivating people to use them is an enormous challenge.

This handbook details technology options for diverse areas with different hydrogeological conditions, economic statuses of communities, and enumerates the advantages, limitations, applicability against each technology. A final comparative list of technology vis-a-vis ground water pollution, operation, hygienic conditions, and costs also exists.

Chapter -2

Linkages between Sanitation, Health and Toilets

Sanitation has a direct impacts on health**.** Lack of awareness of the linkages between sanitation and health, and health and productivity makes it difficult to effectively implement most sanitation programmes in rural India. Often, they believe poor health and poor productivity is borne of factors other than sanitation. In many cases, social status/ dignity and privacy are few benefits of toilets. The SBM (G) programme highlights social and health benefits of sanitation leading to demand driven approach, making it successful in rural areas.

i. Human waste and disease transmission

Human excreta contains a full spectrum of pathogens that transfer from diseased to healthy individuals through several 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. Infections enters human body through fluids, fingers, flies, food, and fields (Fig. 1 and Fig. 2). Most transmission of infections can be avoided through proper sanitation and washing of hands before eating meals, and after defecation.

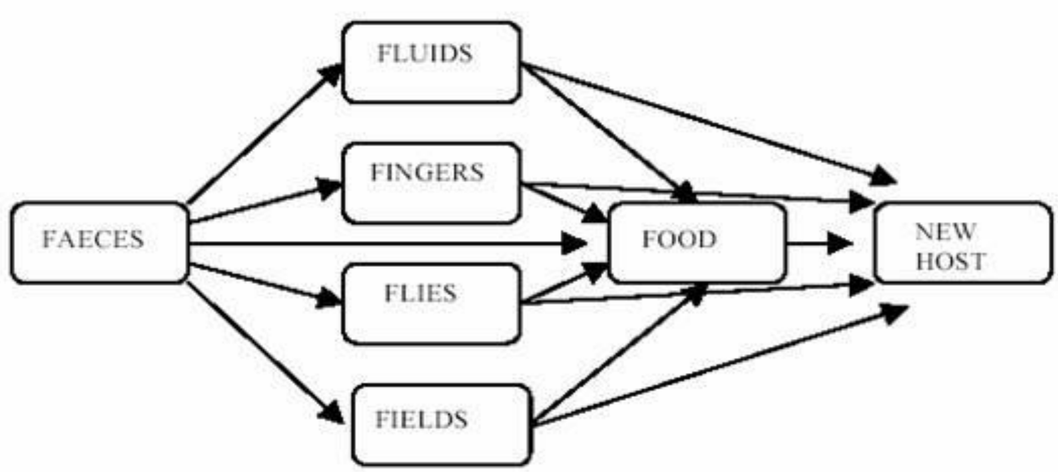


Figure 1. The F-diagram

Source: Wagner & Lanoix 1958

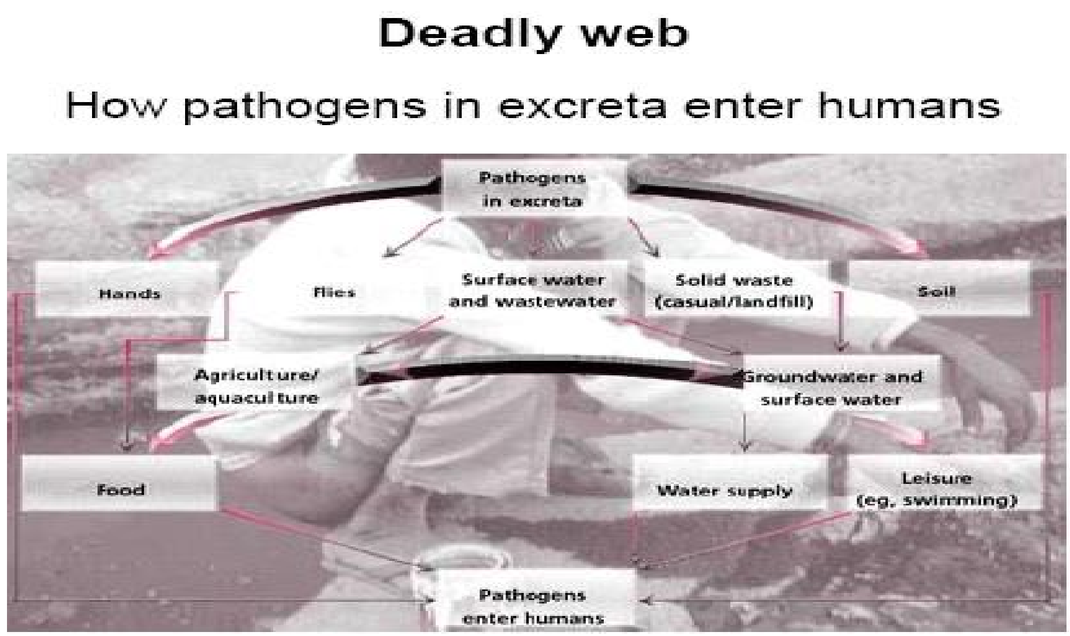


Figure 2. **Primary routes of transmission of infection through open defecation**

ii. Pathogens in human excreta

There are several bacterial pathogens in human waste. Some common bacterial and helminth pathogens are 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 vibrions	Diarrhoea	Human

Campylobactor fetus	Diarrhoea	Human, Animals
Yarsinia enterocolitica	Diarrhoea and septicimia	Human, Animals

Table 2: Helminth pathogens in human excreta

Helminths	**Common name**	**Diseases**	**Transmission**
Ancyclostoma 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-Pigs – Human
Trichuris trichura	Whipworm	Trichuriasis	Human–Soil-Human

Health aspects of sanitation require an understanding the diseases involved, their transmission, and the influence of sanitation hardware and hygiene promotion on them. 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 indicates that toilet provision is the most important aspect for controlling most infections.

Table 3: Sanitation related diseases and likely effects of interventions

Sl. No.	**Category**	**Examples**	**Prominent transmission**	**Likely effect of**	**Likely effect of**	**Major control of infections**

			mechanism	**sanitation hardware alone**	**hygiene promotion alone**	
1	Faecal–oral (non-bacterial)	Hepatitis A, Amoebic dysentery, Rotavirus giadiasis	Person-to-person contact, and domestic contamination	Negligible	Moderate	Domestic water supply, health education, Improved housing, and provision **of Toilets**.
2	Faecal -oral (bacterial)	Cholera, salmonellosis, Shigellosis	Person-to-person contact, domestic contamination, water contamination, and Crop contamination.	Slight to moderate	Moderate	Domestic water supply, health education, improved housing, p**rovision of toilets,** treatment of excreta prior to discharge or reuse
3	Soil Transmitted Helminths	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 (WHO) published 'Excreta Disposal for Rural Areas and Small Communities' by Wagner & Lanoix (1958). A second book published by WHO on 'A Guide to the Development of on-site Sanitation' by Franceys et al (1992) also 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 publications, 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 latrine.

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 foul odours or unsightly conditions.
vii. The method used should be simple, inexpensive in construction and operation.

The MDWS, under its definition of ODF also defines sanitary toilets as:

i. No contamination of soil surface, ground water or surface water
ii. Excreta inaccessible to flies or animals
iii. No handling of fresh excreta
iv. Freedom from odour and unsightly condition

II. WHO guidelines for the safe use of waste water, excreta and grey water

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 re-wet; 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 (Ancyclostoma / 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 wet material will prolong the time for absolute elimination

III. Sustainability of a sanitation technology

Sustainable sanitation is complementary to development. To make sustainability more specific, it should be adjudged according to:

- **Socio-cultural aspects** Social acceptance and adoption
- **Health and Economy** There should be no health risk with the system. Should be affordable to common people with least operation and maintenance costs.
- **Technical function** Ease of operation and maintenance in different climatic conditions.
- **Environmen**t Help restore environment rather than disturbing the ecosystem.

The importance of above aspects varies widely depending on socio-cultural and economic aspects of the community and also with the nature and magnitude of the development work.

Socio-cultural aspects: For implementing and making any sanitation related programme sustainable, social aspects are to be considered. Sanitation is mostly regarded as a socio-cultural issue rather than technical or economic. There are still many people in rural areas who due to lack of adequate knowledge, simply cannot correlate between sanitation and health. It is not uncommon for many to own personal vehicles, be able to afford to send their children to good schools, and quality house constructions, but have no toilets at home. However, many more simply cannot afford toilets and need financial support.

In India water is widely used for ablution. Therefore, pour-flush or water-borne toilet designs are socio-culturally acceptable. But water scarce areas need different options. Dry toilets or other designs with restricted use of water finds few takers.

Health and economy improving sanitation is directly related to improved health, and productivity. Waterborne diseases account for 80% sickness in rural areas, and sanitation is a sustainable, long term answer. Building a household toilet is a onetime cost, with nil recurring costs. However, people falling under BPL, and APL categories cannot afford toilets and here the economical aspect outdoes the social. Toilet design should also be suitable enough to handle waste to check infection outbreaks. To include health benefits accrued from safe hand-washing after defecation and economize the cost of Household Sanitary Toilet or IHHLs under SBM (G), the following points have been suggested:

1. To include an appropriate and low cost hand washing unit in the Household Sanitary Toilet design or IHHL.
2. To allow construction of a common substructure unit of technically appropriate size and design (such as leach pit, septic tank, Bio-toilets, ABR etc., for up to five families or 30 persons (whichever is fewer.)

   However, in this case of construction of common sub structure, it shall be mandatory that each of the household/ family has constructed an exclusive household toilet super structure (including platform, seat, hand washing unit, foot rest, water point etc.) to ensure appropriate hygiene standards and health benefits.

Technical function: Sustainability of any design of toilet depends on its technical function, ease of operation and maintenance. Any recurring expenditure on maintenance of toilet may not normally be feasible for majority of the rural population. Safe disposal or reuse of human excreta should be considered as sustainable sanitation.

Environment: Improved sanitation with well-planned solid and liquid waste management does not just lead to an improved quality of life but also complementary to the sustainable environment.

Chapter 4

Technology Options for On-site Sanitation

There are several technologies for disposal from household toilets. Most technologies are a refinement of already known and practiced methods, based on experience by different communities. It is somewhat difficult to find one universally sustainable technology because different climate, terrain, weather, socio economic conditions affect the choices. Technology options can be broadly grouped as under:

Every toilet has a (a) **Substructure and a (b) Superstructure.** Substructure is technically important as it provides safe disposal or reuse of human wastes. All technical options are meant for substructures only. The superstructure basically provides privacy. There may be a wide range of types of superstructures for the same type of sub structure, depending on the economic status of the beneficiaries. Both aspects have been described separately in the following paragraphs.

4.1 Twin Pit Pour Flush Water Seal Toilet

The Twin Pit Water Seal Toilet is an on-site sanitation measure for houses where the water table is sufficiently low to avoid ground water pollution. On one hand it fulfills all sanitary requirements; of a toilet and on the other 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.

Under the system, there are two pits which are used alternately (Fig 4.1). Both pits are connected with a junction chamber at one end. Pit walls have a honeycomb structure. The 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 three years. First pit, after it gets filled up in about three years, is blocked at the junction chamber and second pit is put in operation. The watery part of excreta percolates in soil through the honey comb structure. After two years of blockage 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

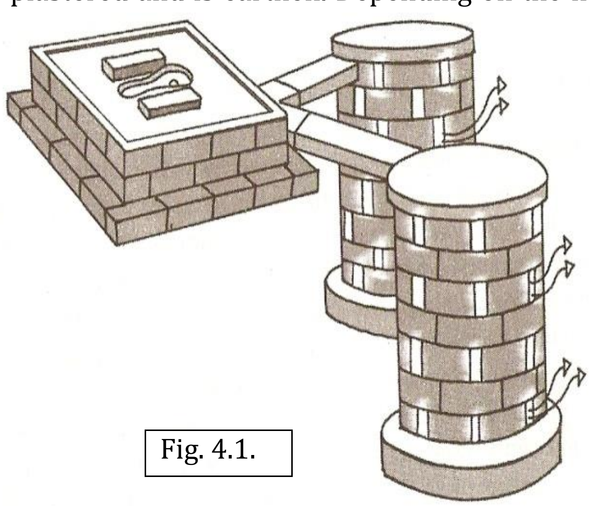


Fig. 4.1.

pits continues. A plan and section of the two pit toilet is in (Fig 4.2). Estimates of a twin pit toilet are in Annexure i and estimates of a toilet with bath is in Annexure ii.

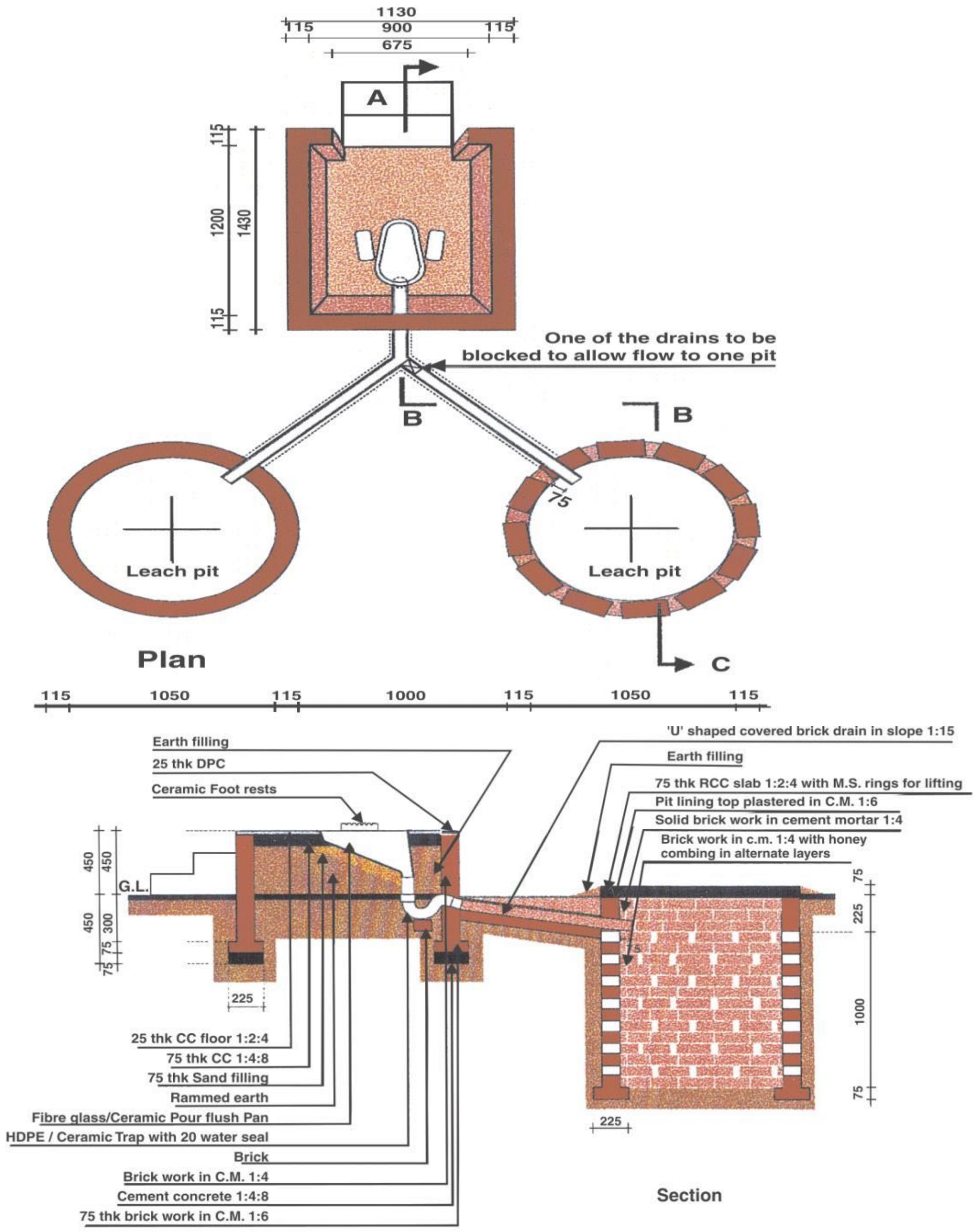


Fig 4.2

Fig 4.3

Pan and trap / water seal:

The pan used in the pit toilet has a steep slope of 25^0-29^0. It may be made of ceramic, mosaic or fiber. People normally do not accept mosaic pan as the surface of such pan is not smooth and makes it difficult to clean it and requires more water. The fiber pan is cheaper, lighter and easy in handling. However it is also not acceptable to many beneficiaries due to its colour. After some years of operation, it develops yellowish colour which is not aesthetically appealing.

Ceramic pan is used in most of the cases where it is available (Fig 4.3). These pans are easily available in the markets. It is aesthetically acceptable and requires less quantity of water (1.5 to 2 liters). 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

Water seal in pans should be of 20 mm only. The trap should be approximately seven centimeters in diameter. Such a trap / trap with pan with a steep slope, as mentioned above, require only 1.5–2 liters of water to flush out excreta. Water seal more than 20 mm should be avoided as it requires more water. Due to high need for water, the life of leach pits gets reduced. A pan with a 20 mm water seal makes it suitable even for water scarce areas. Such water seals can made be of ceramics, mosaic or made of fiber. A drawing and photograph of different water seals are given below (Fig 4.4, 4.5, 4.6). A water seal of 50 mm is also shown in Fig 4.7.

Fig. 4.4 A fiber water seal of 20 mm

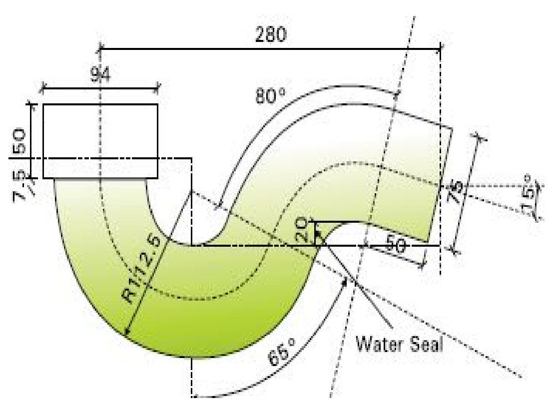


Fig 4.5 Drawing of a water seal

Fig 4.6 Ceramic water seal of 20 mm with flat bottom   Fig 4.7 Ceramic water seal of 50 mm with flat bottom

Foot Rests

These can be of ceramic, cement concrete, cement mosaics or brick plastered. The top of the footrest should be about 20 mm above floor level and inclined slightly outwards in the front.

Pit Lining

The pits should be lined to avoid collapse. Bricks joined in a 1:6 cement mortar ratio are most commonly used for lining. Locally manufactured bricks should be used wherever available. Stones or laterite bricks and cement concrete rings could be used depending upon their availability and cost. However, for ease of construction, using concrete rings will be advantageous where subsoil water level is above the pit bottom.

The lining in brick work should be 115 mm thick (half brick) with honey combing up to the invert level of incoming pipe or drain; the size of holes should be about 50 mm wide up to the height of the brick course. For ease of construction, holes should be provided in alternate brick courses. In case the soil is sandy and a sand envelope is provided, the width of openings should be reduced to 12 –15 mm. Where foundation of building is close to the pit, no holes should be provided in the portion of lining facing the foundation and in rest of the lining 12–15 mm wide holes should be provided. The lining above the invert level of pipe or drain up to the bottom of pit's cover should be in solid brick work, i.e., with no openings.

Pit Bottom

Except where precautions are to be taken to prevent pollution of water sources, the pit bottom should be left in a natural condition.

Pit Cover

Usually RCC slabs are used for covering the pits, but depending upon the availability and cost, flag stones can also be used. The RCC Slab may be centrally cast in pieces for convenience of handling.

An indicative bill of quantity for a two pit toilet is in Annexure I.

Location of Pits

The ideal position for locating the pits is that the pits are placed symmetrically at the backside of pan. The pits may be located within the premises, under footpath or narrow lanes or under the road. The minimum space between two pits should be equivalent to at least the effective depth (distance between the bottom of the pit and invert level of pipe or drain. Spacing can be reduced by providing an impervious barrier like cut off screen or puddle wall.

The safe distance of the leach pits from the foundations of existing building depends upon the soil characteristics, depth as well as type of foundation of the structure, depth of the leaching pits etc., and varies from 0.2 to 1.3 m.

However, in cases where the leach pits are quite close to the existing building foundation, the opening in the brick work lining of the leach pit may be reduced to 12 to 15 mm.

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 30l/^{2} m /day for a three years sludge storage volume works out as described in Table 5:

Table 5

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

The above depths should be increased by 300 mm to provide a free board depth of pit from invert level of pipe or drain to bottom of pit cover.

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 previous table. Circular and square pits (separated completely) are better than the linear or rectangular pits (when separated by a dividing wall only), as in the former case space for leaching out effluent is more than in the latter case. A graphical presentation of different shapes of pits is described (Fig 4.8).

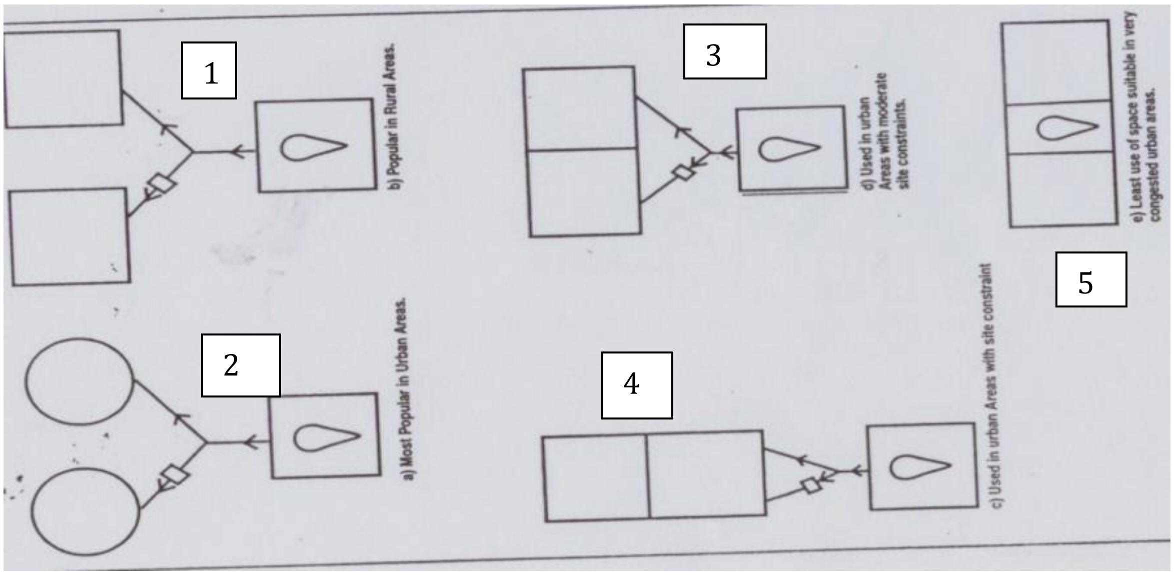


Fig 4.8. Sourced from Pickford & Reed (1992)

Circular and square pits (Nos 1 and 2) are more effective as in these cases there is space available between the pits. It increases leaching rate. These should be opted when space is available. Model 3 can be implemented when sufficient space is not available. Model 4 is more suitable for a narrow lane where other models can't be adjusted. Model 5 requires least space. In this case the toilet seat is fixed on dividing wall of the pits. This is suitable when space is a major constraint.

In case of combined pits and the partition wall should not have holes. The partition wall should go 225 mm deeper than the pit lining and plastered on both sides with cement mortar.

Requirement of vent pipe:

A pit toilet does not require a vent pipe. Gases produced in the pit are diffused in soil through honey comb structures. The gases are mainly Carbon dioxide and Methane. The system also helps in reducing air pollution, from such Green House Gases.

Material and other details for latrine unit

Materials and size of squatting pan, trap, foot rest and connecting drains are summarized in the table 6 below.

Table 6

No.	Squatting Pan	Trap	Footrests	Connecting Drain
1	Horizontal length of pan should be at least 425 mm and longitudinal bottom slop 25- 28^0	It should be 70 to 75 mm with 20 mm water seal.	It should be 250x125mm with 15 to 20 mm height.	May be non-pressure pipe of PVC minimum 75 mm diameter.
2	Material: Ceramic, FRP, PP, HDPE, PVC, Cement mosaic or cement concrete	Fibre Glass, Ceramic, HDPE or CC traps.	Ceramic or concrete with mosaic finish brick or stone	Bricks or stone semi-circular bottom
3	Should conform to IS: 2556 (Pt.III), IS: 11246, DRP Sq. Pan	Should conform to IS: 2556 (Pt. XIII)	Should conform to IS: 2556 (Pt, X)	Slope should be 1 in 5 to 1 in 15 as per site conditions
4	**(A)**			**(B)**

(A) Ceramic, FRP, and PP are smooth and require less water for flushing. FRP is cheaper, lighter and easier to transport than other materials.
(B) The inlet pipe should project 100 mm in to the leach pit. A junction chamber of 250×250 mm should be provided in case of pipe.

(Source: CPHEEO, 1993)

4.1.1 Common pit for two or more individual toilets:

In some areas it has been found that some households do not have sufficient space for individual leach pit or septic tanks, or bio digesters. In such cases combined leach pit/ soak pit or other substructure can be constructed with required volume, number of users of these toilets in a day. Space required for combined substructure is always lower than the total individual substructures.

Fig 4.9. A combined septic tank with a common soak pit for two toilets.

4.1.2 Design of pits under different soil conditions

In high subsoil water level: Where the subsoil water level rises to less than 300 mm below ground level, the top of the pits should be raised by 300 mm above the likely subsoil water level and earth should be filled all-round the pits and latrine floor raised as stated above. A typical pour flush latrine with leach pits in high subsoil water level is shown in Figure 4.10

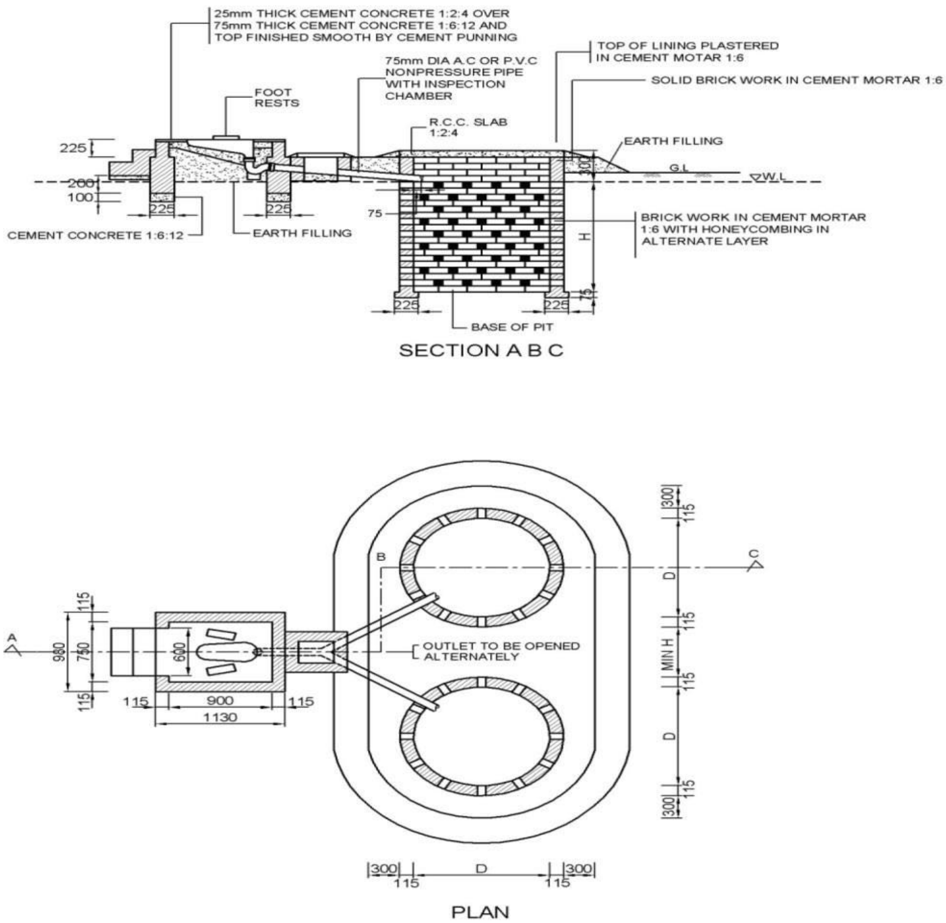


Fig 4.10 Pour flush latrine in high water table areas (Source CPHEEO, 1993)

In water logged area the pit top should be raised by 300 mm above the likely level of water over ground level if there is water logging. Earth should then be filled well- compacted around the pits up to 1.0 m distance from the pit and up to its top. The raising of the pit will necessitate raising of latrine floor also. A typical pour flush latrine in water logged areas is depicted in Figure 4.11

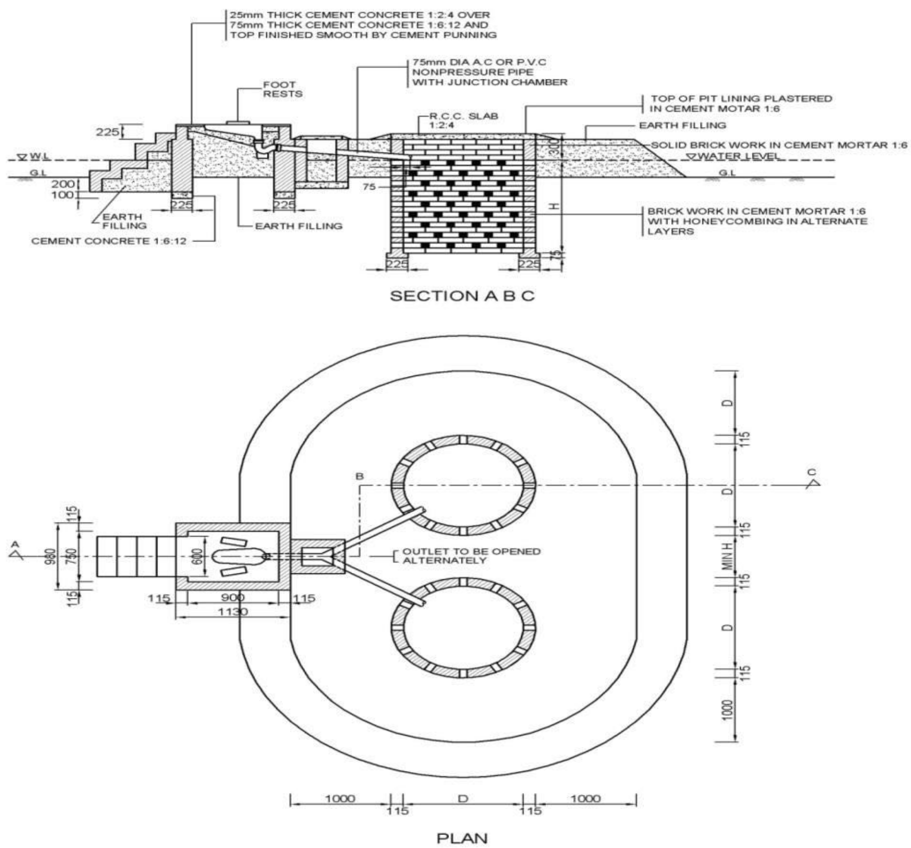


Figure 4.11 Pour flush latrine in water logged areas (Source CPHEEO, 1993)

In Black Cotton soil: Pits in black cotton soil should be designed taking infiltrative rate of 10 l/m2/d. However a vertical fill (envelope) 300 mm in width with sand, gravel or ballast of small sizes should be provided all-round the pit outside the pit lining.

Where the bottom of the pit is below the maximum ground water level:

i. The top of the pits should be raised above the ground level, if necessary, so that the pipe into the pit is at least 0.75 m above the maximum ground water level.
ii. The sand envelope is taken up to 0.3 m above the top of the inlet pipe and confined suitably to exclude any surface drainage including rain water directly entering the sand envelope (Fig. 4.11 B)

In mound type latrines, 1 m high earth filling should be provided at least 0.25 m beyond the sand envelope, with the edges chambered to lead away rain or surface water. The honeycomb brick work for the pit lining should be substituted by brick work in cement mortar 1:6 with open vertical joints, i.e. without mortar. Where sand is not available economically, local soil of effective size of 0.2 mm can also be used.

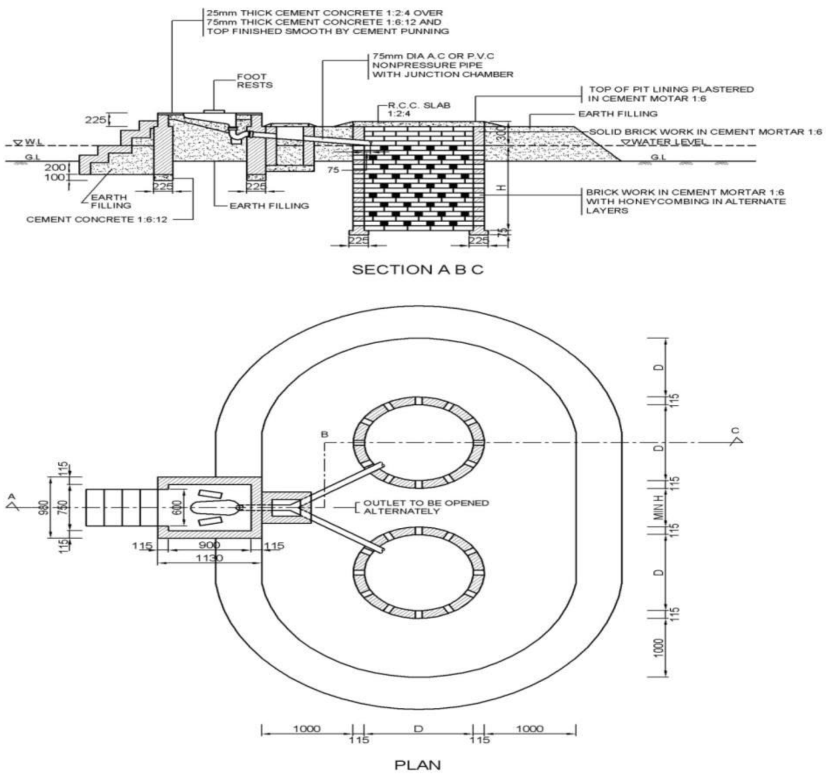


Fig. 4.11 B

4.1.3 Twin pit toilet with reinforced cement concrete rings:

Two pit toilets are generally constructed through brisk cement structure. It is slightly costlier due to increasing costs of materials and labour. Construction of pits using concrete rings is a better option to reduce the cost (Fig 4.12). However, diameter and depth of the pit must be maintained by using required number of ring channels. Number of ring channels may depend on thickness. Its life is as good as brick, or a cement structure. Provision of honey combs in the concrete ring channel should be as mentioned before. However, it has been observed that such honey combs are avoided by the manufacturers of the rings to save labour and costs.

Fig 4.12 Ring channels for construction of pits.

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 liters of water per use of toilet

iii. Digested human wastes, when taken out of the pit after two years is semi solid, free from odour and pathogens, that can be easily dug out by 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 whenever such facility is available in future.
vii. Its maintenance is easy.

Limitations of two-pit pour flush toilet

a) Leach Pit toilet 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 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 to beneficiaries. Moreover, even after the pit is emptied, it is quite difficult to dispose the sludge safely.

Applicability: Twin leach pit toilet is applicable in any areas except high ground water and rocky areas.

4.1.4 Ground water Pollution Safeguards

In order to reduce the pollution risk of ground water and water sources, the following safeguards should be taken while locating the pits. There are various reports on ground water pollution from leach pit toilets. Such pollutants are mainly due to microbiological and nitrate present in human excreta. All the available reports indicate ground water pollution from leach pit toilets. However, magnitude of pollution and travel distance of pollutants vary in different reports. It is mainly due to soil type, climatic condition and hydraulic load in the leach pit. Detail of the information available from reports published at national and international reports will be presented in relevant section in the book.

Below is the precautionary measure as mentioned under the CPHEEO Manual (2013), for minimum distance of leach pit toilet from drinking water sources.

Safe Distance from Drinking Water Sources

A. In dry pits or unsaturated soil conditions, i.e. where the height between the bottom of the pit and the maximum ground water level throughout the year is 2 m and more.

i. The pits can be located at a minimum distance of 3 m from the water sources such as tube wells and dug wells if the effective size (ES) of the soil is 0.2 mm or less, and

ii. For coarser soils (with ES greater than 0.2 mm) the same distance can be maintained if the bottom of the pit is sealed off by an impervious material such as puddle clay or plastic sheet and 500 mm thick envelope of fine sand of 0.2 mm effective size is provided around the pit.

B. In wet pit saturated soil conditions, i.e. where the distance between the bottom of the pit and the maximum ground water level during any part of the year is less than 2 m,

i. The pits can be located at a minimum distance of 10 m from the water sources such as tube wells and dug wells if the ES of the soil is 0.2 mm or less, and

ii. For coarser soils (with ES more than 0.2 mm), minimum distance of 10 m can be maintained if the pit is sealed off by an impervious material such as puddle clay or plastic sheet with 500 mm thick envelope of fine sand of 0.2 mm, effective size provided all-round the pit.

A. A study is reported by National Institute of Technology, Calicut, Kerala, India, in respect of safe distance in laterite type of soils (Biju.et.al.2011)

The study area had houses with either the septic tank-soak pit system or pit latrines, the latter being more common with open wells as the source of water at 1.2 m to 2.4 m below ground in laterite soil. The horizontal distance between well and the soak pit / pit latrines varied from 5 m to 31 m. The MPN of total coliform from nearly 35 wells was studied and it was found that the number of total coliform correlated with the length of a specific parabolic curve connecting the soak pit / pit latrine and the well. This relationship was used to calculate the safe distance between the soak pit / pit latrine and open well so that the total coliform was not exceeding the MoEF classification of class "A" water in the well water and which is "Drinking water source without conventional treatment but after disinfection" at total coliform of not exceeding 50/100 ml. The distance evaluated was 21 m, where the water table rises to the level of soak-pit / pit latrine and the well (CPHEEO 2013).

4.2 Shankar Balram Model

This model is more suitable for areas where people use water for ablution. It is basically combination of latrine and specifically designed septic tank.

The latrine consists of a water closet seat (WC seat) made of concrete along with water-seal trap. The toilet consists of two-cement concrete Hume pipes of different diameter and length. Larger Hume pipe is of 250 cm length and diameter depending on the number of the proposed users. The smaller Hume pipe serves as the subsidiary tank. It is 125 cm long and its diameter also changes with the number of proposed users. Bottom of both the tanks is sealed with PCC (plane cement concrete).

The two hume pipes are interconnected by using a smaller diameter pipe at a preconceived point to allow the flow of effluent from bigger hume pipe (main tank) to the smaller hume pipe (subsidiary tank). This interconnection is so designed and fixed that this outlet pipe does not allow the flow of raw night soil from main tank to the subsidiary tank unless it is absolutely liquefied. A smaller diameter pipe is also fixed between these two Hume pipes at point above the water level to allow the flow of gas from main tank to the subsidiary tank and vice-versa. The gases so produced are allowed to escape through the vent pipes.

In this system, the human excreta entering the main tank initially floats over the surface of water and gradually settles down to the bottom of the tank and starts decomposing. In this way the previous night soil is covered by a fresh intake of night soil. Human excreta in the first tank biodegrade due to bacterial action.

Effluent coming out of the subsidiary tank is quite clean with very low turbidity and foul smell. The decomposed night soil also flows with the effluent in the form of small particles. High quality of effluent is mainly due to high retention time of human wastes due to much larger size of the chambers/ Hume pipes. Sizes of hum pipes for different users of toilets are as mentioned in Table 7.

Table 7
Sizes of Hume pipes / tanks for different number of users of toilets

No. of users	Diameter of main & subsidiary Tanks	Length of main & subsidiary Tanks	Water cu.m
20 per day	0.06 m & 0.45 m	2.50 m & 1.25 m	0.663
35 per day	0.76 m & 0.45m	2.50 m & 1.25 m	1.034
50 per day	0.91 m & 0.45 m	2.50 m & 1.25 m	1.5
75 per day	1.06 m & 0.60 m	2.50 m & 1.25 m	2.051
100 per day	1.21 m & 1.06 m	2.50 m & 1.25 m	2.668

Source: shankerseptictanks.com, CPHEEO 2003

Applicability:

The Shankar Balram Model is suitable for normal soil, high ground water table areas and rocky areas. It can be implemented even in water logged areas with some modification. Such modification can be made by raising the lengths of both the Hume pipes suitably above the maximum water logged point. Accordingly toilet seat should be raised.

Limitations:

i. Drainage system is required for effluent. In the absence of drainage system, soak is the only option. Since as per design around 25 liters of water per person per day is required for optimal function of the system, volume of effluent would be the same. Thus size of soak pit needed would be too large.

ii. In the absence of readymade Hume pipes, construction of tanks with cement concrete will be costly, due to larger capacity of the tanks. The designs are for 20 or more number of users, i.e., group of families. Based on the design, a toilet for individual houses can be implemented. However, it can be constructed with ring channels also with suitable modification to bring cost lower.

Individual household toilet based on Shankar Balram Model:

Individual household toilet based on Balram Model with RCC (Reinforce cement concrete) structure can be made easily. The Toilet seat and pan and trap are the same as discussed above and earlier section. Only the sizes of the tanks are smaller as mentioned below in the drawing (Fig 4.13). Its cost estimate is annexed (Annexure iii).

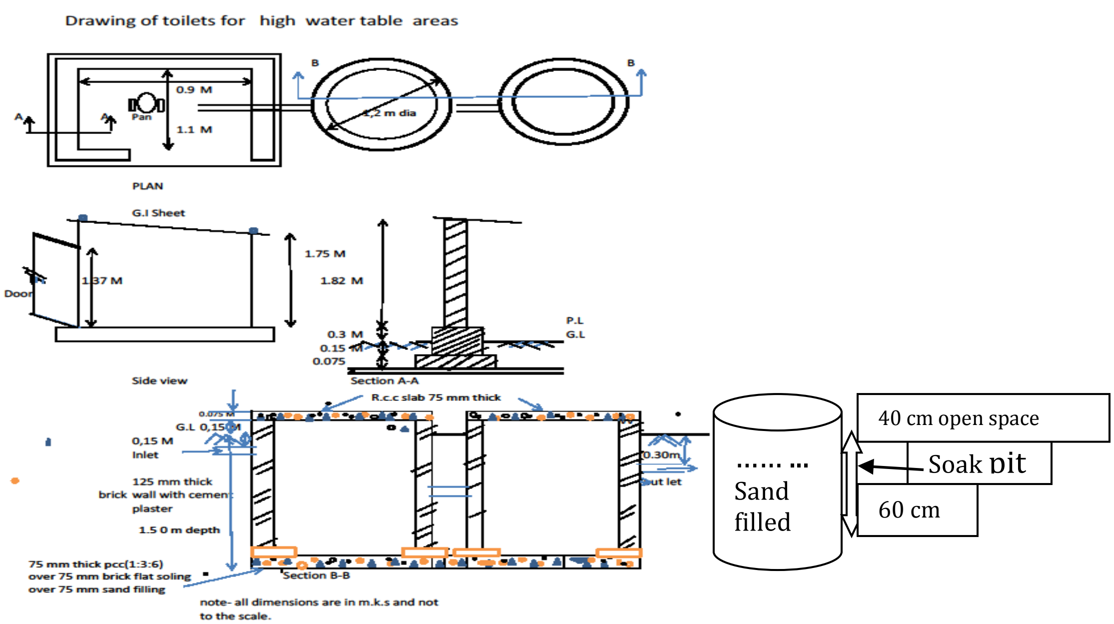


Fig 4.13

Shankar Balram Model using ring channels:

Ring channels are being manufactured by several entrepreneurs in different states. It is easy to manufacture such rings of suitable sizes. Five ring channels each of 0.90 m dia and 0.30 m height can be used for one tank by putting one ring above the other and joining with cement. Two such tanks can be prepared and connected in above the middle by a 100 mm∅ pipe. Bottom of both the tanks should be sealed with PCC. Human wastes from toilet seat enter into 1st chamber. From 150 mm of top level of 2nd tank a 100 mm∅ pipe is connected to the covered drain for flow of treated effluent. Human waste settles and degrades in the 1st tank, liquid part flows in the 2nd tank where it is further degraded and finally through outlet pipe from this tank liquid passes out in a drain. Such treated effluent can be used for agriculture purpose.

4.2.1 Modification for high water table:

In case of water logged area or flood affected area, 0.90 meter of the tank (i.e.3 channels) is kept below the ground level and rest 0.60 m (2 channels) above the ground. It makes suitable to work even in water logged condition of up to 0.60 m water level, without any problem. Height of the tank above the ground can be increased suitably taking into account the maximum water level in case of flood. Accordingly toilet seat should be raised (Fig 4.14)

Fig 4.14

In case of high water table, a soak pit of 1m depth should be constructed. It should be filled with sand up to 0.40 m from the outlet pipe from the 2nd tank. It will increase sand column of 0.60 m for filtration of effluent and thus its quality would be much better with much less chance of ground water pollution.

4.3 Ecosan Toilet

The objective of Ecosan is not to promote any particular technology, but to bring forward a new philosophy of dealing with recovery of plant nutrients from human wastes for agricultural purposes and move away from a linear to a circular /close-loop flow of such nutrients. There are several technologies like dry toilets, UDDT, biogas from human wastes etc., fulfilling the objectives of Ecosan. Under the section only Dry toilet and UDDT will be discussed, Biogas will be described in other section.

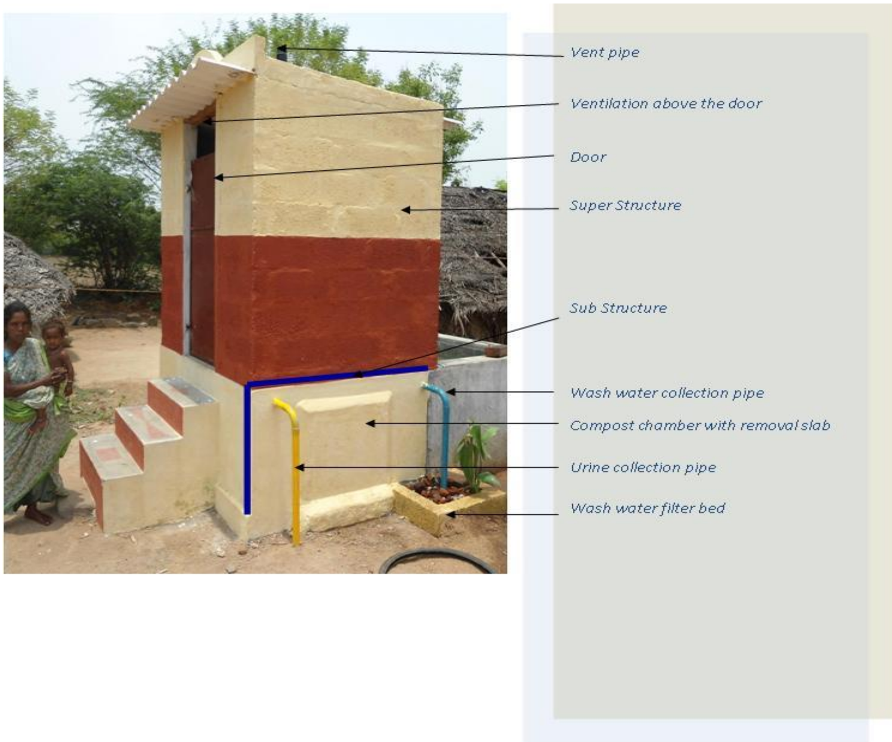
i. Dry Toilet:

A dry toilet is a toilet that operates without flush water. The dry toilet may be a raised pedestal on which the user can sit, or a squat pan over which the user squats. In both cases, excreta (both urine and faeces) fall through a drop hole (EAWAG 2014).

The dry toilet is usually placed over a pit; if two pits are used, the pedestal or slab should be designed in such a way that it can be lifted and moved from one pit to another. Hole is covered with lid to prevent rodents entering into the chamber. After each use of toilet ash is put over faeces.

The system is suitable for reuse of nutrients human excreta for agricultural purposes. There is no chance of ground water pollution at all. However, in areas where people use water for ablution, the system is difficult to be socially accepted. Further, due to lack of water seal, odour problem can’t be avoided. This also makes people hesitant in adopting the technology.

ii. **A Urine-Diverting Dry Toilet (UDDT)** is built such that urine is collected and drained from the front area of the toilet, while faeces fall through a large chute (hole) in the back. Depending on the collection and storage / treatment technology that follows drying material such as lime, ash or earth should be added into the same hole after defecating (Eawag 2014). There are also 3-hole separating toilets that allow anal cleansing water to go into a third, dedicated basin separate from the urine drain and faeces collection (Fig 4.15).



Degraded human waste is directly used for agriculture purposes. Materials required for an UDDT is annexed (Annexure IV)

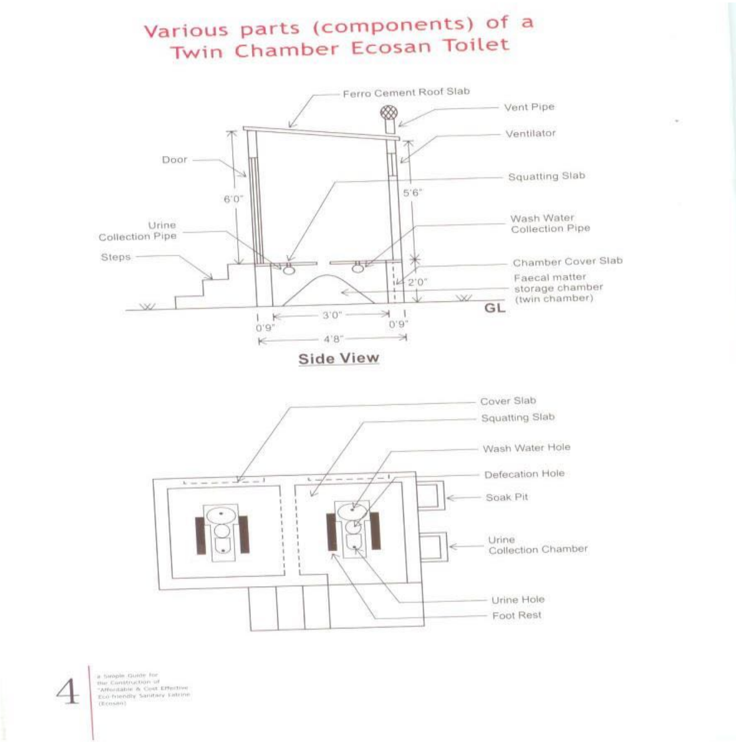


Fig 4.15

A UDDT is slightly more difficult to keep clean compared to other toilets because of both the lack of water and the need to separate the solid faeces and liquid urine. No design will work for everyone and, therefore, some users may have difficulty separating both streams perfectly, which may result in extra cleaning and maintenance. Faeces can be accidentally deposited in the urine section, causing blockages and cleaning problems (EAWAG (2014).

Advantages of Ecosan toilet

i. It saves water
ii. Protects ground and surface water from contamination
iii. Recycles valuable nutrients
iv. Creates no waste
v. Provides no place for mosquitoes to breed
vi. Self-contained and can be totally managed by the family.
vii. The system is also suitable for high water table areas, flood prone and rocky areas, where conventional pit toilets are not suitable.

Advantages and 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 of 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.

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, Ecosan toilet system can be made a productive sanitation system.

4.4 Conventional Septic Tank

Septic tanks are watertight, multi-chambered receptacles that receive black and/or grey water and separate the liquid from the solid waste, which it stores and partially digests. Many on-site sanitation (OSS) are mistakenly called septic tanks, even when they are inadequately sized or designed, have only one chamber, or have open bottoms, and therefore do not perform primary wastewater treatment.

A septic tank is a combined sedimentation and digestion tank where the retention time of sewage is one to two days. During this period, settleable solids settle down to the bottom. This is accompanied by anaerobic digestion of settled solids (sludge) and liquid, resulting in reasonable reduction in the volume of sludge, reduction in biodegradable organic matter and release of gases like carbon dioxide, methane and hydrogen sulphide. The effluent although clarified to a large extent, will still contain appreciable amount of dissolved and suspended putrescible organic solids and pathogens, as the efficiency is only 30-50 % for BOD and 60-70 % for TSS removal. Several experiments and performance evaluation studies have established that only about 30% of the settled solids are anaerobically digested in a septic tank. When a septic tank is not desludged for a longer period, i.e., more than the design period, substantial portion of solids escape with the effluent.

The septic tanks are normally rectangular in shape and generally a double tank. In case of double tank, first compartment is usually twice the size of the second. The liquid depth is 1-2 m and the length to breadth ratio is 2-3 to 1.

Size of compartments of septic tank for different number of daily users of toilets

Table 8

No. of users	Length (m)	Breadth (m)	Liquid depth (m) (Cleaning interval of)	
			2 years	3 years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

Source: CPHEEO, 1993

Baffles are generally provided at both inlet and outlet and should dip 25 cm to 30 cm into and project 15 cm above the liquid. The baffles should be placed at a distance of one-fifth of the tank length from the mouth of the straight inlet pipe. The invert of the outlet pipe should be placed at a level 5 to 7 cm below the invert level of inlet pipe. Drawing of a septic tank is as mentioned below (Fig. 4.16)

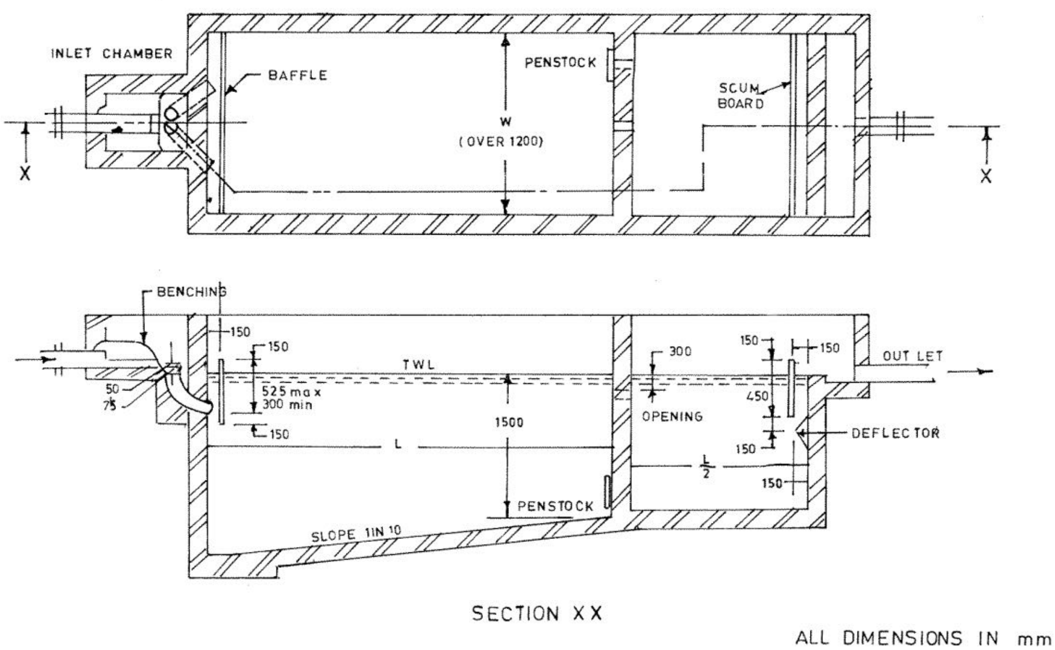


Fig. 4.16. Drawing of a septic tank, (**Source:** CPHEEO, 1993)

Applicability

The conventional septic tank system is particularly applicable for:

i. Primary treatment of wastewater from individual houses.
ii. It is suitable even for high water table areas where drainage facility for effluent discharge is available.
iii. Septage/Sludge collection and treatment facility is available nearby.

Disadvantages of septic tank

i. Safe removal of septage from septic tank is a problem. Due to lack of any such policy septage is disposed of in open space, low land areas or drains causing health and environmental pollution.
ii. Lower treatment efficiency (30-60 % BOD and SS Removal) and associated cost and space requirements for the construction of soakage pit is comparatively higher.
iii. Septic tank is incapability to handle hydraulic shock loads, as peak flow disturbs the settling zone and causes high suspended solids in the effluent.

4.5 Toilet Linked Biogas Plant

Generation and utilization of biogas from human wastes through bio digester has multiple benefits- it improves sanitation, gives bio energy at low cost and provides better quality of manure for agriculture purposes. The technology is an Ecosan as there is complete reuse of nutrients in human wastes and nothing is left to pollute environment.

Biogas can be generated from any biodegradable wastes through anaerobic digestion. Design of bio digester depends on quality and quantity of such wastes. Design of bio digester based on human wastes needs special consideration. The design should be free from manual handling of human wastes, it should not be visible at any stage and there should not be any odour.

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 2 hours 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

Household biogas plant solely based on human waste for a family is not economically viable as the biogas produced per family is not adequate to meet the daily requirement of cooking fuel. 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 alone 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. It has been observed that human excreta have additive effects on production of biogas when mixed with cow dung in biogas plant. For one cum of biogas production 25 kg of cow dung is required. Whereas, when plant is linked with toilet, only 18-20 kg of cow dung is required for the same quantity of biogas, depending on number of users of toilets in a family.

The human excreta can be anaerobically digested either alone or in combination with cattle dung. It is rich in nitrogen and phosphorus in comparison to cow dung. The characteristics of human excreta are different from the cow dung and are mentioned in the table 9 below:

Table -9

Characteristics of human excreta and cow-dung

No.	Characteristics	Night soil	Cow dung
1	Moisture content,%	85-90	74-82
2	Volatile solids as % of total solid	80-88%	70-80
3	Total Nitrogen as N,% on dry basis	3-5	1.4-1.8

4	Total Phosphorus as P_2O_5, % on dry basis	2.5-4.4	1.1-2.0
5	Potassium as K_2O,% on dry basis	0.7-1.9	0.8-1.2

Source: CPHEEO, 1993

Design of biogas plant

There are several models of biogas digester. The Deenbandhu model of biogas plant is approved by the Ministry of New Renewable Energy (MNRE), Government of India under its programme of Central Financial Assistance (CFA). The design does not require manual handling of human wastes at any stage and neither it is visible. Plant is underground where flow is under gravity. There is slight modification in the plant to suit inflow for two feeds- cow dung and human wastes.

Design Criteria

The design criteria for night soil digester are listed in table below:

Table 10

No	Items	Magnitude
1	Volumetric organic loading, Kg VS/m^3 d	1.6
2	Hydraulic residence time , d	25-30
3	Solid concentration of slurry fed to digester , %	5
4	Volatile solids destroyed during digestion,%	45-55
5	Gas yield, m^3 kg of VS added in m^3 / capita/d	0.5
6	m^3 / capita/d	0.034

Source: CPHEEO, 1993

Design of Deenbandhu plant:

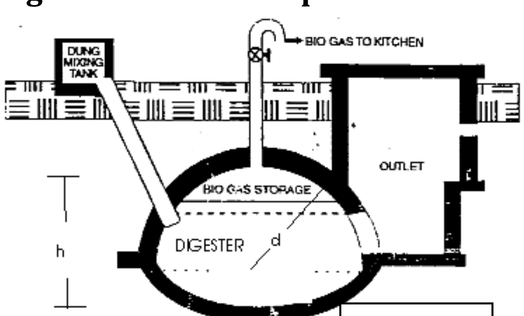


Fig 4.17

This model is predominately found in India. It is an underground fixed dome digester made up of complete brick or RCC structure (Fig. 4.17). 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. There is almost no effect of atmospheric variation of temperature on biogas gene g winter season. The following section describes different aspects of Deenbandhu biogas plant.

Design modification for toilet linked biogas plant:

In a toilet linked biogas plant there is minor modification in the design. The inlet pipe from cow dung mixing tank to biogas plant has one Y junction. Another arm of Y is connected with the incoming pipe from toilet. Since the connection from toilet pipe is underground, there is no visibility of human excreta (Fig 4.18). Estimates of biogas plant of 2 cum capacity is annexed (Annexure V)

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 will reduce gas pressure in gas pipe and hence will create problem.

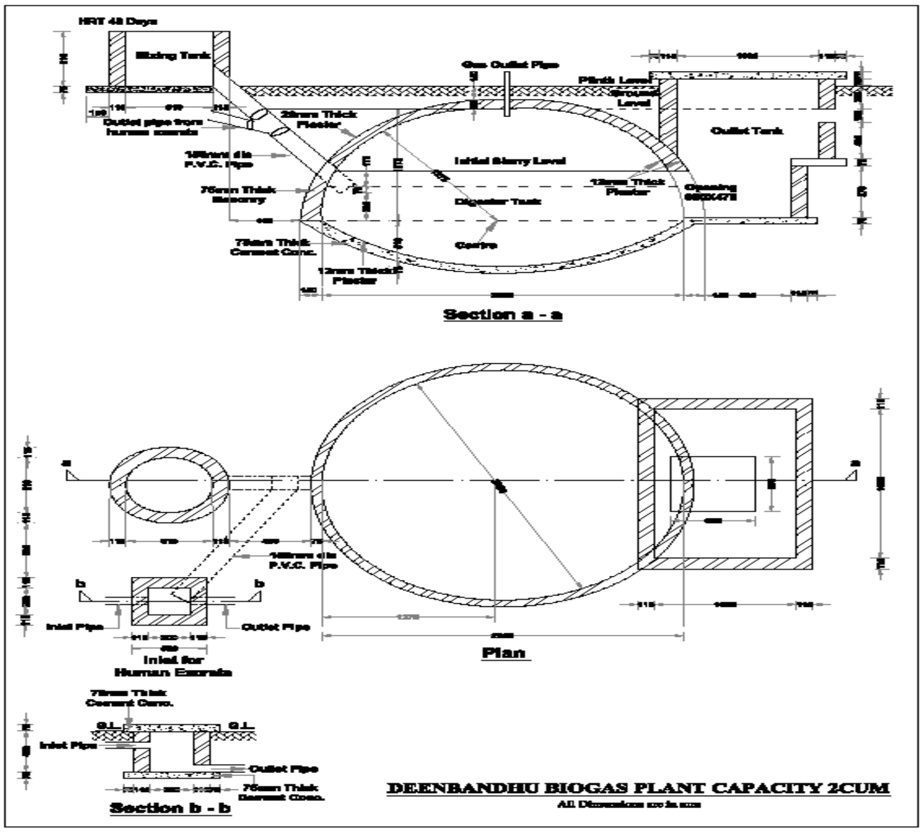


Fig 4.18 A section and plan of family size biogas plant of 2 cum capacity

Selecting a biogas plant size:

A biogas plant of specific capacity should be selected based on the daily availability of cattle dung, users of toilet and water requirements.

Materials required for biogas plant

The biogas plant can be set up with RCC or 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. Construction of plant with RCC should be preferred to avoid any chance of leakage.

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. 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 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 ½ 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.

Mold of Mild Steel (MS):

During construction of biogas plant, it has been seen that design was not strictly followed by the mason concerned. Construction of dome is also a bit difficult. To avoid such problem a mold of mild steel is very helpful. One time cost of construction is slightly higher but it save labour/ mason cost. Further there is no chance of deviation from the design, as the mold is strictly based on the design. One such mold is below (Figs. 4.19, 4.20)

Fig. 4.19, A mild steel mold (Photo: PK Jha 2014)

Fig 4.20 A plant under construction (Photo: PK Jha)

Starting a digester with feed material:

Initial digestion process with cattle dung feed should start within few weeks depending upon the temperature.

Cow dung mixed with water in the ration of 1:1 should be filled at the level of outlet chamber. If available, effluent (5-10%) from a running biogas plant should be added to new biogas plant once at the start, as inoculums. 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. Connection with toilet should be done simultaneously. However, if toilet is not ready, it can be connected later. Production of biogas starts within a few days. However, initially there is more percentage of carbon dioxide than methane, therefore it does not burn. Normally burnable biogas is achieved after 20^{th} day. Thereafter it continues. Feeding of biogas plant with required quantity of cow dung should be made daily.

Total solid concentration in feed material

Total solid 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 liter 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. However, in case of RCC structure there is no chance of leakage and thus such testing can be avoided.

Composition of biogas:

Biogas constitutes mainly methane and carbon dioxide and trace amounts of hydrogen, nitrogen and ammonia. Methane is only burnable constituent. Percentage of methane varies in biogas plants based on cow dung alone and linked with toilet. It has been analysed that percentage of methane in toilet linked biogas plant is higher over without toilet linked and based on cow dung only (Table 11)

Table-11

Sl. No.	Source	Methane %	Carbon Dioxide %	Hydrogen sulphide (ppm)
1	With toilet linked biogas plant	63.8	31.4	55.37
2	Without toilet linked biogas plant	60.4	33.9	72.82

Source: Analysis conducted through a NABL accredited laboratory (PK Jha 2014)

Uses of biogas:

Common uses of biogas are for cooking and lighting through mantle lamps. Biogas cooking burners are available in markets (Fig. 4.21). A standard cooking burner for family consumes half cum of biogas per hour. Biogas burns in blue flame without any shoot or odour like LPG. 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 faulty connection of pipe. In rural areas where people are mostly dependent on fire wood or dung cake for cooking .purpose, biogas is a boon in improving health, environment and is economical.

Fig 4.21 Use of biogas for cooking purpose

Lighting through mantle lamp is another common use of biogas (Fig 4.22). 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 student 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

Fig. 4.22 Biogas being used as lighting through mantle lamp

Factors affecting biogas generation Temperature

For optimum biogas production, a temperature of 35- 37^{0}C is optimum. At lower temperatures gas production rate decreases. In winter season when temperature falls to 10^0 C or so, gas production almost ceases. However, in case of underground fixed dome digester like that of Deenbandhu model, there is least effect 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.

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-12).

(Table-12)

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

Do's and Don'ts to operate biogas plant

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 as far as possible.
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't

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 utilization 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. Avoid using chemicals / detergents in cleaning toilet pans as it lowers activity of bacteria responsible for production of biogas. Added this point

xi. 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.

4.6 Anaerobic Baffled Reactor

An anaerobic baffled reactor (ABR) is an improved septic tank, which, after a primary settling chamber, uses a series of baffles to force all kind of wastewater to flow under and over the baffles as it passes from the inlet to the outlet (Figures 4.23, 4.24, 4.25). The wastewater is introduced into the chamber at the bottom, leading to an enhanced contact with the active biomass which results in an increased retention and anaerobic degradation of suspended and dissolved organic pollutants. ABRs are robust and can treat a wide range of wastewater, but both remaining sludge and effluents still need further treatment in order to be reused or discharged properly (Tilley et al., 2008).

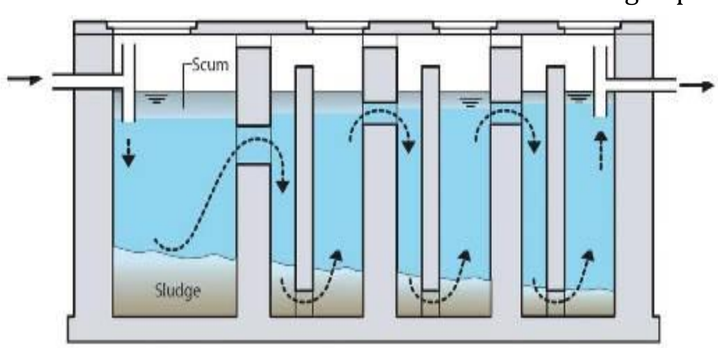


Fig. 4.23 Anaerobic Baffled Reactor; Source: Morel & Diener 2006

Fig. 4.24: An ABR under construction
Source. DEWATS guidelines

Fig 4.25 An ABR after completion

Through ABR, BOD is removed by 90%. Removal of organic matters is much better than conventional septic tank. The design is suitable for flow ranging from 2 m^3 to 200 m^3 per day. Hydraulic retention time is designed for 2 to 3 days only. Number of chambers depends on inflow. However it ranges from 3 to 6. Connection between the chambers is generally through vertical pipes of 100mm. Such pipe from near top of the previous chamber comes to near the bottom of the next chamber. It helps spiral flow of waste water inside chamber and thus increases retention time. There is no chance of dead space due to such circulation. Biogas is produced through ABR. But due to much lower retention time produced gas is too low for any economical use. For the exit of gases vent pipe is used.

Applicability

i. ABR technology is suitable for individual household or group of households or community level.
ii. It is suitable for any soil condition.

Advantages

i. Required space is much less
ii. Quality of effluent is much better with higher reduction of BOD than septic tank system.
iii. No electrical energy is required
iv. It is suitable for high water table and water logged areas also
v. Resistant to organic and hydraulic shock loads
vi. Low operating costs
vii. Low sludge production than septic tank
viii. Moderate area requirement (can be built underground)

Limitations

i. Requires expert design and construction
ii. Low reduction of pathogens and nutrients
iii.

4.6.1 ABR technology for water logged areas:

The ABR technology with up flow system is being implemented for individual rural households at larger scale in normal as well as water logged areas by the Department of Sanitation Water Supply, Government of Punjab in different districts. For water logged areas there is slight modification. Toilet seat as well as RCC cover of the chambers is suitably raised to avoid entering of flood water into the toilet seat or chambers. Design, drawing and photograph of such implemented toilet are as follows (Figs 4.26, 4.27, 4.28 and 4.29). Bill of quantity of such toilet is annexed (Annexure--VI)

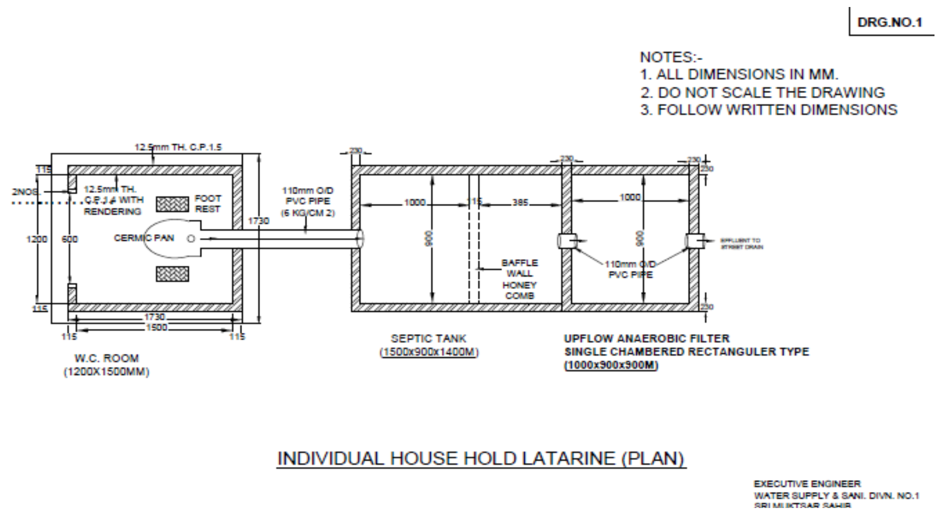


Fig 4.26

Fig 4.27

Source; An ABR for household toilet, Department of water and sanitation, Government of Punjab, site photo

Fig.4.28, Toilet with ABR technology for water logged area   Fig. 4.29 Toilet with ABR technology for water logged area

(Source: Department of Water Supply and Sanitation, Government of Punjab)

4.7 **Bio Toilet System**

The Bio tank system is developed by DRDO for the treatment of toilet wastewater is based on ABR technology. It is made of FRP / bricks or any other suitable material and consists of different chambers for the primary treatment of wastewater (Fig 4.30). Functioning of the system is as per a typical ABR system. As per information provided by DRDO the technology consists of consortium of microbes that grow in a wide range of temperature and degrade organic matters rapidly, resulting in low residue of sludge in the chambers.

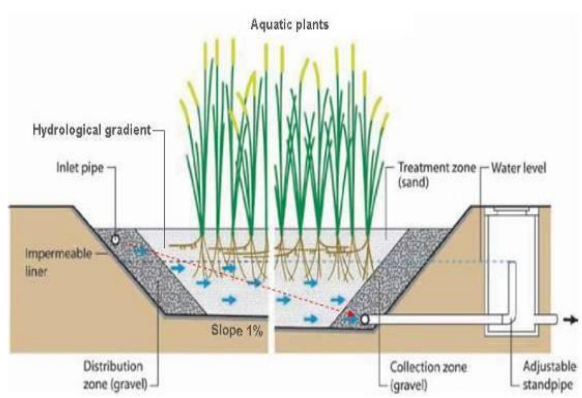


Fig. 4.30 A DRDO Bio tanks showing different chambers Fig 4.31.F ig: Constructed wet land: Tilley et al. (2008)

Normally for a household toilet, these bio tanks are filled up up to 1/3rd of its volume by inoculum once while commissioning the Bio Toilet. The effluent from Bio Toilet can be connected to a soakage pit in case of household Bio toilet.

However, for larger capacity of Bio Tanks with treatment capacity of multiple households it is recommended that effluent from the bio tank, is released into reed bed or constructed wet land (Fig 4.31. A reed bed system performs secondary treatment of the wastewater coming out of the bio tank. The reed bed system comprises of bed of sand and pebbles along with reed plants capable of natural amelioration of the wastewater coming out of the bio tank. It eliminates smell, suspended particulates, pathogenic and other microorganisms.

Natural reed plants-microbial consortium work efficiently at wide range of temperature and effluent is very safe to discharge into environment and may be used for irrigation purposes.

The effluent from the reed bed may be stored to a tank for further use or may be released directly to the agro fields for irrigation when available or in a drain.

Applicability

i. The system can be implemented in any soil condition. It is suitable for high ground water table areas.
ii. Due to requirement of lesser area, it is suitable for areas where space is a major concern
iii. Recurring cost is almost nil
iv. Effluent is suitable for reuse in agriculture purpose.

Limitations:

i. Trained manpower is required to implement the system
ii. As it is prefabricated, its availability in rural areas is difficult and transportation cost will add the cost.
iii. Reed bed system is useful to treat any domestic waste water. However, its cost and space requirement is the limiting factor for acceptance at household level.

4.8 Anaerobic Filter

The Anaerobic Filter is an improved design over ABR. In case of ABR, bacterial mass is flush out with effluent, resulting in less degradation of organic matters. In case of Anaerobic Filter, suitable media are provided in chambers for the growth and to retain microbes in chambers (Fig 4.32). This results in high population density of bacterial mass, resulting in higher degradation of organic matters and thus lowering BOD of final effluent.

In India, the technology is commonly known as BORDA Model of DEWATS (Decentralized Wastewater Treatment Solutions) as it was first developed and implemented in India by BORDA (Bremen Overseas Research and Development Association), during 1995-'99**.**

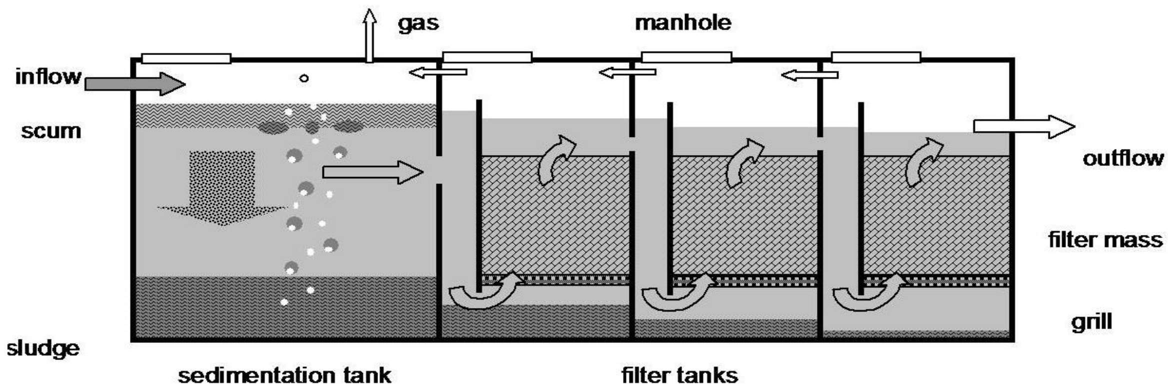


Fig. 4.32 A scematic diagram of Anaeroibic filter **, Source DEWATS**

The majority of settle able solids are removed in a sedimentation chambers before passing into the anaerobic filter. In subsequent chambers suspended and dissolved organic matters are reduced by bacterial degradation. Bacterial growth media help increase bacterial population in the system. For growth media material should be selected having rough and porous surface area. Cinders, rough stones, pumice are some suitable media. Sizes for the growth / filter media should be 12 to 55 mm in diameter. The surface area ensures increased contact between the organic matter and the attached biomass that effectively degrades it. Ideally, the material should provide between 90 to 300 m2 of surface area per m3 of occupied reactor volume (Ulrich, A, et. el. 2009).

In the system Hydraulic Retention Time (HRT) is designed for 12 to 36 hours only. Due to, lower HRT the system requires lesser space than ABR and septic tank system. In fact this is the lowest HRT under anaerobic condition of waste water treatment. Final effluent is suitable for use in agriculture purposes. However, it needs to be handled with due precaution as it contains pathogens.

Applicability

i. It is suitable in any type of soil.
ii. There is no chance of ground water pollution from the system

Advantages

i. No electricity is required
ii. There is minimum operation and maintenance costs
iii. High reduction of organic loads and consequently of BOD
iv. Very low accumulation of sludge
v. Area required is lower than ABR and septic tank

Limitations

i. Effluent needs further treatment for elimination of pathogens for its safe reuse of discharge
ii. Sludge needs further treatment for its safe reuse
iii. Expert professional required for designing and construction of the system
iv. Removing and cleaning of clogged filter media is a cumbersome process.

4.9 Package Type Anaerobic Filter System

This type of package on-site treatment system can be prefabricated of LLDPE (Low Linear Density Polyethylene) or FRP (Fiber Reinforced Plastic) and can be installed easily in a very short time. It consists of two chambers, i.e., settling and anaerobic filter. The first chamber works as a septic tank, where settleable solids are settled down and further degraded anaerobically at the bottom zone. The second chamber consists of up flow anaerobic filter where further removal of organic matter takes place. Anaerobic filters are made up of synthetic plastic media with high specific surface area (Figs. 4.33, 4.34). The high specific surface area not only prevents clogging but also provides intensive contact between the wastewater and the fixed film anaerobic bacteria for the fast degradation of organic matter. The treatment performance ranges 50-70 % for BOD and SS removal.

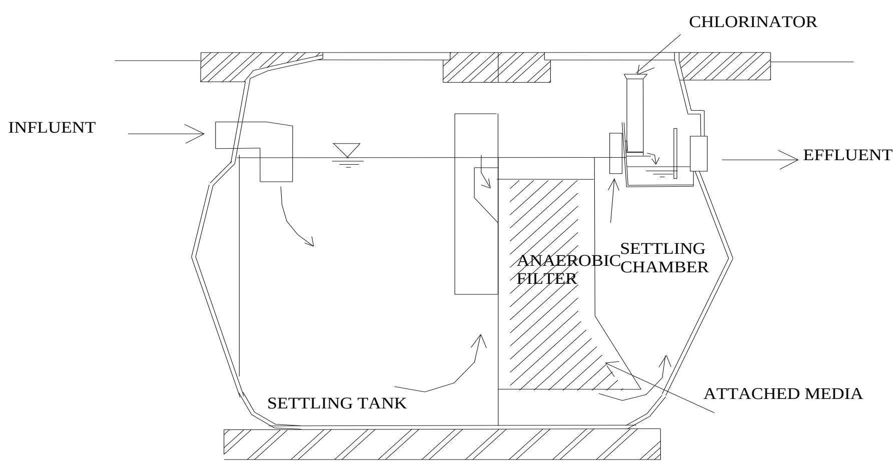


Fig.4.33 Typical cross-sectional drawings of a prefabricated septic-tank anaerobic filter type systems (Kazmi A. A. 2003)

A prefabricated package Anaerobic Filter Type advanced septic tank system was installed for the treatment of black water at Navodaya Vidyalala in Shikarpur Gram Panchayat, near Roorkee City. The project was sponsored by the Ministry of Drinking Water & sanitation. The installation of the system is provided in Figure 4.34. Although, at the initial start-up stage, packaged type septic tank-anaerobic filter system only removes BOD and TSS around 40-50 % respectively, but gradually, after formation of biofilm on the media, the BOD and TSS

Fig 4.34

removal was as high as 60-70 % without any requirement of power.

4.10 A Settling –Contact Aeration System – LDDPE type. A simplified method for settling - contact aeration system has been developed and tested. The system can be connected with a single toilet or a group of toilets for school toilets. The present photograph show a toilet block having 3 nos. of WCs and one bath used by over 20 persons per day. The system has two Linear Low Density Polyethylene (LLDPE) tanks of different sizes. They are connected in series with inlet chamber of waste water. Smaller tank (1st tank) has retention time of 12 hrs whereas larger (2nd tank) has of two days. 1st tank works as anaerobic settling chamber and 2nd as aerobic & treatment chamber (Fig 4.35, 4.36). In the 2nd chamber, air is provided through air pump having flow of 60-80 lpm. It is desirable to provide air for 24 hrs. However, due to limited electric supply it is not feasible always. At reduced air supply level of BOD and other parameters of waste water will increase.

Fig. 4.35 LDDPE made settling –contact aeration system Fig. 4.36 Coirs used as growth medium

Fig. 4.37 Schematic diagram of settling –contact aeration system (Source Jha PK, 2010)

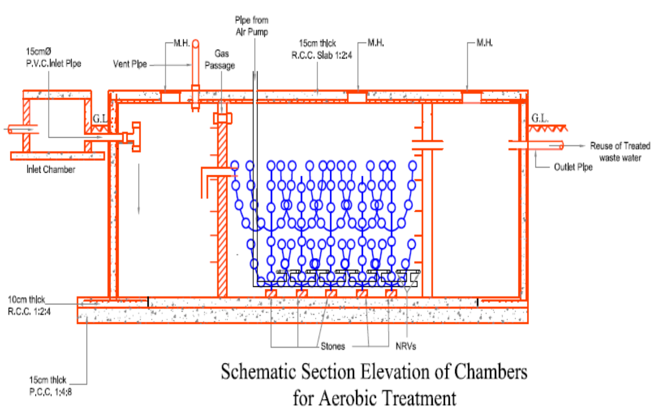


Table-13

Parameters	Value (mg/l) except pH, of effluent	
	Aerobic condition	Anaerobic condition
BOD	7	65
COD	19	125
TKN	3.4	35
Phosphorus	2.2	10
TSS	25	52
pH	7.5	7.4

Air pump operates on 50 watt electricity. Air diffuser is provided at the bottom of the tank through non-return valves fitted in ½”- ¼’’ inter connecting G.I. pipes at multiple points. For the bacteria growth media, coir rope which is having huge rough surface area can be used (Jha, P.K, 2010). Such growth medium is easily available in most of rural areas and much cheaper than other plastic media. Required length of 5-10 coir ropes can be tied at one end and with a brick/ stone and put in aeration chamber. In this way coirs remain submerged and float in waste water (Fig. 4.36). Removal of coir is much easier as they are tied and pulled out of chamber easily. A schematic diagram of the system is depicted (Fig 4.37) Treated waste water is stored in a storage tank from where it is reused for agriculture purposes. Results of different parameters of effluent under aerobic and under anaerobic conditions from different plants using same design and methods are presented in Table-13. Effluent is chlorinated to make bacteria free, whenever required. Such effluent, under aerobic condition, is free from any odour and colour making suitable for use in agriculture and other non- potable purposes. Effluent from anaerobic condition can be used for agriculture purpose.

Advantages:

i. It is suitable for normal soil, high water table and water logged and rocky areas
ii. Waste water can be reused for agricultural purposes
iii. In case of non-availability of electricity the system can be operated under anaerobic condition, however, quality of effluent would be reduced in such condition.
iv. Space requirement is very low in comparison to other technologies
v. More suitable for group of toilets like community toilets, school toilets etc.

Limitation:

i. Availability of electricity is a major concern for such technology
ii. Trained manpower is required to install the system.

4.11 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 cm while handicap toilets have an average height of about 42-48 cms. 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 handicap toilets 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 drawing and photograph of a toilet for disabled is at Figs 4.39 and 4.40

A Typical Toilet for handicapped person

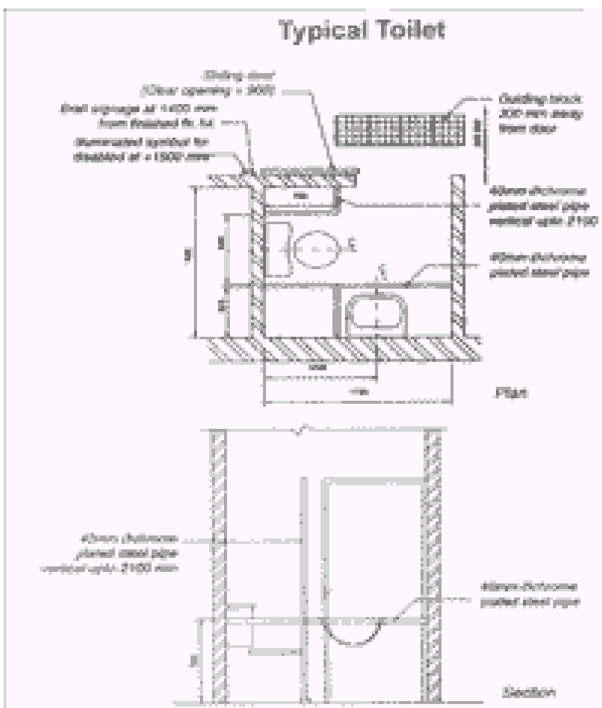


Fig 4.39. A drawing of a toilet for handicapped

Fig 4.40.Inside view of a handicapped toilet

Ministry of Drinking Water and Sanitation in collaboration with WaterAid India has developed a separate hand book on toilet technologies for the people with special needs which could be referred for more information on different types and designs of toilets for people with different types of special needs.

4.13 Assessment of Some Technologies for Household Toilets in rural areas.

	1	2	3	4	5	6	7	8	9	10
S. No	**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**	**Safe reuse or disposal of human wastes**	**Socio-cultural Acceptability**
1	Pour Flush Toilet with Twin Pit	Pour Flush Squat platform two pits with honey combs	Medium	High	Permeable / not suitable for high water table or rocky soil/ water logger areas	Medium (2 lts per use)	Fairly Easy	Good	Yes, safe reuse of human wastes, manure for agriculture purpose	Acceptable without health risk
2	UDDT 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	Easy	Good, Odour problem is an issue	Yes, reuse of human wastes and urine as manure. However, pathogens in manure is a concerned.	Acceptable where people don't use water for cleaning. Odour problem is there
3	Septic Tank toilet	Squatting or commode with cistern, 1 to 3 tanks in series for settling of wastes	High	High	Stable soil, but not suitable for rocky soil	High	Easy. Cleaning of tank is difficult and costly	High, However, problems continue with safe disposal of sludge of septic tank.	Disposal of sludge and effluent is a problem.	Acceptable
4	Biogas plant linked with toilet	Squatting pan, pour flush, instead of pits underground biogas plant is required	High	High	In all soil types	Medium	Easy, Needs training	High	Reuse of effluent with proper care. Biogas is used for beneficial purposes.	Acceptable when properly demonstrated.

5	ABR technology	Squatting or commode with cistern, 2 to 4 chambers in series with baffle wall for settling of wastes	Low to high	High	Suitable for any soil- low/ high water table. Black soil. May be designed for water logged area also	High	Easy, Needs training	High,	Very less generation of sludge. Effluent can be used for agriculture purpose.	Acceptable
6	Shankar Balram Model	Squatting pan or commode with 2 hume pipes connected in series	Medium	Medium	Normal soil, high water table, with some modification suitable for water logged and rocky areas also	Medium/ High	Easy	High	Effluent can be reused for agriculture. There is very less quantity of generation of sludge	Acceptable
7	Anaerobic filter	Squatting pan or commode with multiple chambers with bacterial growth media	High	High	Suitable for any soil. Can be suitably modified for water logged areas also.	Medium / High	Needs training	High	Effluent can be reused for agriculture purposes. After disinfection it can be used for other non-potable purposes	Acceptable
8	Package type pre-fabricated septic tank	Squatting pan or commode with multiple chambers with bacterial growth media	High	High	Suitable for any soil except water logger area	High	Needs training	High	Effluent can be reused for agriculture purposes.	Acceptable
9	DRDO Bio Toilet	Squatting pan or commode with multiple chambers with bacterial growth	Low	High	Suitable for normal and high water table and rocky areas, but not for waterlogg	High	Needs training	High	Effluent can be reused for agriculture purposes	Acceptable

		media, made of FRP			ed areas					
10	Contact Aerobic Settling with masonry works	Squatting pan or commode with 1-2 chambers	Low	High	Suitable for any soil type	Medium/ High	Needs training. Electrical energy is required for aeration	High	Effluent is of much better quality and can be used for agriculture and for non-potable use	Acceptable

4.14. Different Types of Superstructures for Household Toilets

There are several models for superstructures for household toilets being implemented in different states in India. Materials of superstructure are used as per the economic condition of households and their availability.

The SBM guidelines clearly mentions that the toilets must have a superstructure acceptable to the beneficiaries, as the poor quality of toilets constructed has been one of the main complaints against earlier sanitation programmes. Superstructure should be sufficiently durable to avoid any dysfunctionality of toilet due to lack of proper privacy.

Some of the superstructures made from different materials are as follows.

Fig1.Superstructure with bamboos.

The part of bamboo below soil has not much life as termites destroy it. Therefore, care needs to be taken to overcome the problem

Fig 2 Superstructure with thatch.

Its durability is almost same as bamboos

.

Fig 3 Superstructure with brick, cement and RCC roof and iron sheet door

Fig 4 Superstructure with stone wall, RCC roof and iron sheet door

Fig 5 Superstructure with G.I. sheet

Fig 6. An Ecosan toilet superstructure with brick, cement, and RCC roof and iron door

Fig. 7 Superstructure with precast ferro- cement slabs and wooden door used in Junagadh area in Gujarat

Fig 8 Superstructure with precast ferro- cement slabs

Fig 9 Superstructure of Textile Reinforced Concrete (TRC) with water storage tank found in some parts in Orissa state

Fig 10. Superstructure with laterite and iron sheet gate

Fig 11. A superstructure with brick cement and RCC roof and plastic door

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 liters per person per year. However, later Baskaran (1962) reported it to be 34 liters 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 x P x R

V = effective volume of the pit (m^3)

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 (m^3)

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:

Sludge depth = Total sludge volume (V) / 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(lts. 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 m^2 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 cum

Sludge depth = sludge volume / plan area

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

0.5 x 4 / 3.14 = **0.6 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 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 **= 0.21 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. Water used for anal cleaning is separated in a chamber. There is no flushing water for ECOSAN toilets. 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). The book issued by the Ministry of Drinking Water and Sanitation, Govt. of India and UNICEF, Delhi, gives details of the design, operation and maintenance of Ecosan toilets.

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.

N = No. of year of storage capacity of a chamber

P= No. of person using toilet daily

R. = Accumulation of sludge in a year per person use of toilet daily

Volume of storage chamber = N x P x R

= 1x 5 x 0.4 x 365 litres

= 1 x 5 x 146 liters = 0.7 cum

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 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 people are not well aware of the 20 mm water seal and/ ceramic pan might be taken 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 f 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 take out. 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 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. A 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. Issues Related to Operation and Maintenance of a Household Toilet

For proper operation and maintenance of a household toilets the following do and don't should be observed.

Do and Don'ts to maintain a toilet

Dos--

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 odour less 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- hand contact should be avoided/ minimized.

Don’ts-

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

i. Don’t use both the pits simultaneously.
ii. Don’t use any chemicals and detergent to clean the pan. It causes killing of microbes also, resulting in less degradation of wastes.
iii. Don’t allow kitchen water or bathing water to enter into toilet.
iv. 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.
v. 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.
vi. Don’t throw lighted cigarette butts into the pan
vii. Don’t de sludge the pit before 2 years, after it is filled up and put out of use.

Chapter 7
Septage Management

As per the 2011 Census, in rural areas, septic tank constitutes highest percentage of sanitation coverage with toilets. In rural areas 14.7 % households use septic tanks, 8.2% households have pit toilets with slabs, and another 2.3 % without slabs, 2.2 % have a piped sewer system available and 1.9 % use public toilets. In 0.2% households night soil is cleaned by people, in another 0.2% night soil is cleaned by animals, 2.5% have other system of toilets and rest 67.3% households go for defecation in open. In the coming years, percentage of septic tanks in rural areas is expected to further increase as the financial support from the MDWS for implementation of IHHLs has increased covering more socio-economic groups of households and septic tanks are included under the guidelines along with other innovative toilet technologies.

Septage is the combination of scum, sludge, and liquid that accumulates in septic tanks. Safe disposal of septage from septic tank is rarely taken into consideration either by households or local bodies due to lack of any policy in practice for such disposal. Such effluents are normally discharged in open fields or low land areas, or ditches, causing ground water pollution, severe environmental and health problems.

In rural areas it appears quite challenging to adopt the proper process of septage management. There is almost complete lack of awareness to community, lack of infrastructure for emptying and transportation of septage from septic tank, lack of required fund to local government/ body to take the issue at Gram Panchayat level. Moreover, there is no financial support at present to take up the management of septage at household or Gram Panchayat level. However, some Gram Panchayat having such infrastructure and capable to manage septage may be encourage to include the issue under SBM programme.

Emptying of septic tanks and transportation of septage: A septic tank should be emptied every 2–3 years depending on the size of tanks. However, in practice it has been observed that households empty it only after the tanks are completely filled and there is sign of blockage of passing human wastes into the tanks. In such case there is no treatment of waste water in septic tank. It acts just like a storage tank.

In rural areas for emptying of septic tanks, sludge pump/ vacuum pump fitted on tractor mounted sludge tank is rarely available. In most of the cases septic tank is cleaned manually by households themselves or employing manual labourers. Manual emptying of septic tank is health hazards if proper safety is not followed. For employing manual cleaning of septic tank, the Prohibition of Employment as Manual Scavenger and their Rehabilitation Act 2013 should be followed.

Mechanical device for cleaning septic tank in rural areas, can be arranged from nearby city. In such case, households in group can hire one device for a day for cleaning 4-5 septic tanks in a day. In case of higher demand the owner of the tractor may find it a good business and take up cleaning and transportation process.

Selection of site for septage management: Availability of suitable site for septage management in rural areas is a major challenge. In Gram Panchayats where Panchayat / Government land is available, the problem can be solved. However, in most of the Panchayats such land is not available. Gram Panchayat should approach to local land lords to donate required land for the purpose. Such land should be selected near the land for SLWM activities for the Gram Panchayat.

Technology for treatment of Septage: Septage has very high contents of Total solids, Suspended solids, Biochemical oxygen demand, Chemical Oxygen Demand, Nitrogen, Phosphorus and pathogens. However, heavy metals and toxic elements are almost nil. Septage has good contents of plant nutrients. It can be completely recycled and reused for agriculture purposes after proper treatment/ management. It can be proved as a resource recovery rather than a problem for disposal. In rural areas there is very good option for reuse of septage in agriculture purposes.

Septage has both water bond and water free solids i.e, both hydrophobic and hydrophilic in nature.

- Free water is removed through filtration and bound water through evaporation and evapo-transpiration through macrophytes.
- The drying process is based on two principles.

(i) Percolation of the leachate through sand and gravels. This process is significant with sludge that contains large volumes of free water and is relatively fast, ranging from hours to days.

(ii) Evaporation, removes bound water fraction and this process typically takes place over a period of days to weeks.

Two types of filter beds Planted and Unplanted bed are used for the removal of water from septage.

Unplanted sludge drying bed

Unplanted sludge drying beds are shallow filters filled with sand and gravel with an under-drain at the bottom to collect leachate. The sludge is discharged on the surface of bed for dewatering of free water. Unplanted sludge drying beds, allow more removal of free water through percolation as compared to other options. There is loss of bound water through evaporation from the surface of the sludge to the air. It requires more space than planted filter beds. However, there are no recurring expenses with almost nil operational cost.

A schematic diagram is as follows;

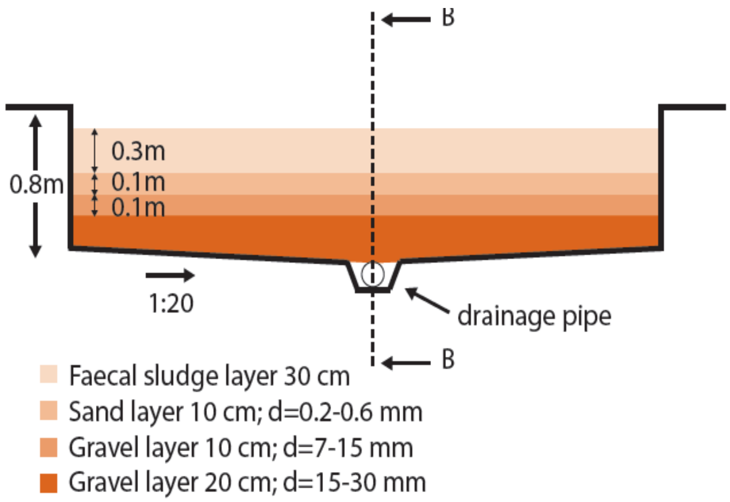


Fig. Schematic diagram of a filter bed

Designing a filter bed

For designing a filter bed, designing criteria includes:

i. Quantity of septage per day
ii. Removal of grits and floating materials from septage,
iii. BOD of septage
iv. Total Solids of septage,
v. Loading rate of septage in beds,
vi. Drying intervals of beds
vii. Number of beds.

Planted Drying Bed (PDB): Through planted drying beds loss of water from septage is through percolation as well as evapo-transpiration through macrophytes. Planted Drying Beds (PDBs), are planted with emergent macrophytes.

Although a variety of macrophytes exist in nature, there are a limited number of emergent macrophytes that grow well under PDB conditions. These plants have rhizomes that help grow even in water stress and aquatic conditions.

Some internationally known such plants are:

i. Reeds (*Phragmites sp.*)

ii. Cattails (*Typha sp.*)

iii. Antelope grass (*Echinochloa sp.*)

iv. Papyrus (*Cyperus papyrus*).

Role of Macrophytes

Macrophytes play essential roles in

i. Increasing moisture loss (through evapo-transpiration, in contrast to only evaporation in unplanted drying beds);

ii. Stabilising the beds to prevent media erosion and clogging, and improving the drainage;

iii. Providing a surface area for microbial growth within the sludge layer; Transferring oxygen to the sludge layer (i.e. within the rhizosphere); and

iv. Absorbing heavy metals and nutrients.

Characteristics of Macrophytes

Macrophytes are characterized by the following features

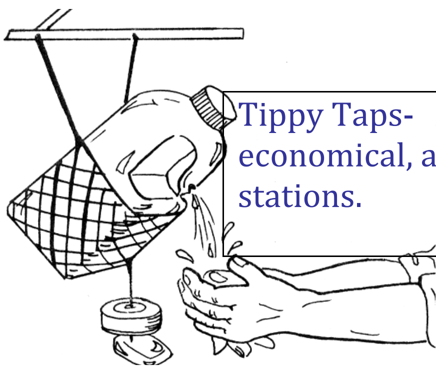
- They grow fast under diverse conditions
- They have high transpiration capacity
- They are tolerant to different water levels and drought conditions
- They are tolerant to high levels of pH and salinity
- They have deep growing rhizome and root system
- Ability to build new roots on the nodes when they become encased in sludge
- Readily available, indigenous and non-invasive

<u>*Motha (Cyprus rotundus)*</u> Lesser Cattail, Elephant grass (*Typha angustifolia*)

After filtration, effluent from filter beds can be treated through any suitable technology depending on quantity of effluent, and requirement of treatment quality for different purposes. Several technologies have been mentioned in the book Technological Options for Solid and Liquid Waste Management, released by the MDWS in April 2015. For rural areas, WSP (Waste Stabilization Pond) Technology is appropriate.

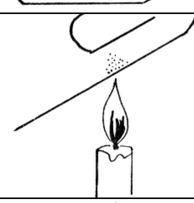
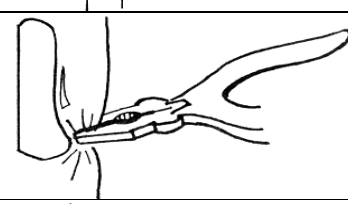
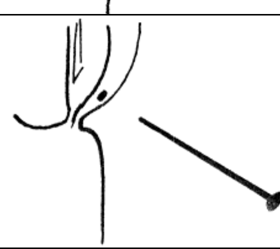
Chapter 8
Hygiene for effective use of Sanitary Toilet

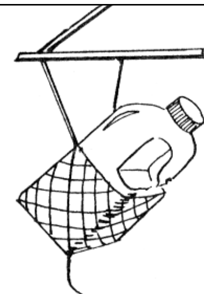
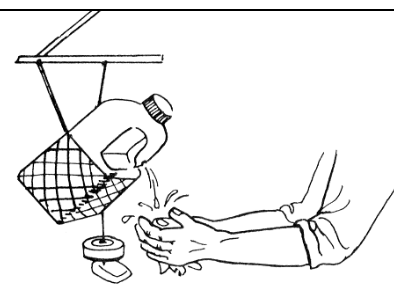
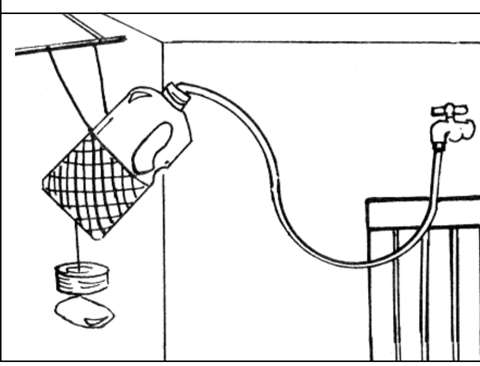
Tippy Tap Hand Washing stations



Tippy Taps- A design for simple, economical, and effective handwashing stations.

“Tippy Taps” are simple and economical hand-washing stations, made with commonly available materials and not dependent on a piped water supply.

	1. First, select a plastic container of approximately 5 litres, or 1.5 gallons, with a handle.	
	2. Then, warm the base of the handle with a candle until the plastic is soft.	
	3. When the base is soft, pinch the base closed with a pair of pliers and let it cool. Make sure that no water can flow through the pinch – closed base.	
	4. With a hot nail, make a 2 millimeter hole just above the pinch-closed base of the handle. .	

	5. With a plastic net suspend the bottle from a metal support. Let one piece of plastic hang down to suspend the Soap from. If a net is not available, two holes can be made in the back of the bottle, and the Tippy Tap can be suspended by connecting a string through those holes to the support	
	6. Make a hole in the centre of a bar of soap. From the hanging piece of plastic, suspend with a string the soap and a plastic or metal cover (Such as a tin can) to protect it from sun and rain.	
	To Install and Use a Tippy Tap	
	Hang the Tippy Tap near a latrine, kitchen, or school. Use the handle to tip the container and allow water to flow out of the hole onto your hands. Use soap every time you wash your hands!	
	Recommendations for Tippy Tap Maintenance	
	If there is a water tap present, a hose can be used to fill the Tippy Tap.	

	Clean the outside of the Tippy Tap with a brush and soap daily, and clean the inside of the Tippy Tap once a week with clean water and disinfectant.	

Source: If you have any questions on Tippy Taps, or about safe water and sanitation in the developing world, Please contact the Centres for Disease Control and Prevention, Foodborne and Diarrheal Disease Branch, at safewater@cdc.gov or visit http://www.cdc.gov/safewater. We would like to thank CIDEPTA and PAHO for the figures and source material.

	'Tippy Tap' is an initiative taken by Dr. Sudam Khade, District Collector, Sehore, Madhya Pradesh. It resulted in development of an exemplary model for large scale replication with 'zero cost' hand-washing stations throughout the district. The innovative Tippy Tap approach provides opportunity to anganwadi workers and the community to design their own taps using local resources readily available in the village without any financial investment. "Tippy Tap hand-wash and water saving technology" has been adjudged amongst the Top 200 Smart Technologies Projects in India for the year 2015. Collector Sehore Dr Sudam Khade received the award at the 42 Skoch Summit held in New Delhi in December 2015.

Bibliography

i. Bhaskaran, T.R. (1962). A decade of research in environmental sanitation. New Delhi, Indian Council of Medical Research (Special Report Series No. 40)

ii. Cairn Cross, S., Feachem. R (1993), *Environmental Health Engineering in the Tropic: An Introduction Text,* 2nd edition, John Wiley, London, 231 -290,

iii. CPHEEO, (1993,2003 2013) Manual on sewerage and sewage treatment, Ministry of Urban Development , Government of India,

iv. Ecological Sanitation Practitioner's book, (2011) Ministry of Drinking Water and Sanitation,

v. EAWAG (2014): Compendium of Sanitation Systems and Technologies, 2nd edition

vi. Faechem, R G, et al (1983). Sanitation and disease: health aspects of human excreta and waste water management. Cichester, Wiley

vii. Franceys, R. Pickford j. & Reed, R. (1992) A guide to the development of on-site sanitation, World Health Organization, (WHO), Geneva.

viii. Jha, P.K. (2003), Health and Social Benefits from Improved Hygiene and Sanitation. International Journal of Environmental Research, April 2003.

ix. Jha. P.K. (2010) Presented a paper on "Sustainable technical options for effective decentralized waste water treatment system", at the International Conference on Decentralized Wastewater Treatment Solution in Developing Countries, organized by BORDA and IWA at Surabaya, Indonesia

x. Kazmi A.A (2003), On site wastewater treatment in Japan-An overview. Journal of Institution of Engineers, (India). Vol. 83, March 2003, pp.41-45.

xi. Mara, D.D. (1985b). The design of pour flush latrines. Washington, D.C, World Bank (TAG Technical Note No. 15)

xii. Mara D.D. & Cairn Cross, S. (1989) Guidelines for the safe use of waste water and excreta in agriculture and aquaculture. Geneva, World Health Organisation.

xiii. Morel, A. and Diener, S. (2006). *Greywater Management in Low- and Middle-Income Countries. Review of Different Treatment Systems for Households or Neighbourhoods.* Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, CH. Available free for download at:
www.sandec.ch

xiv. Pickford & Reeds (1992); A Guide to Development of on-site Sanitation, WHO

xv. Roy, A.K. et al. (1984) Manual on the design, construction and maintenance of low cost pour flush water seal latrines in India. Washington, D.C, World Bank (TAG note no. 10)

xvi. Swachh Bharat Mission Guidelines of Ministry of Drinking Water and Sanitation, Government of India (2015)

xvii. Tilley, E.; Luethi, C, Morel, A, Zurbruegg, C, Schertenleib, R (2008): Compendium of Sanitation Systems and Technologies. Duebendorf and Geneva: Swiss Federal Institute of Aquatic Science and Technology (EAWAG). URL [Accessed: 15.02.2010]. PDF

xviii. Ulrich, A. (Ed.), Reuter, S. (Ed.), Gutterer, B. (Ed.), Sasse, L., Panzerbieter, T. and Reckerzügel, T. (2009). *Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries. A Practical Guide.* WEDC, Loughborough University, Leicestershire, UK.

xix. Wagner, e.g. & Lanoix, J.N. (1958) Excreta disposal in rural areas and small communities. Geneva, World Health Organization (WHO Monograph Series No. 39).

xx. WHO Guidelines for the Safe Use of Waste Water, Excreta and Grey Water (2006), ISBN 92 4- 1546876 WHO Press, World Health Organization, Geneva, Switzerland.

Annexure-I

Cost estimates of a twin pit toilet

Estimates of a toilet varies significantly depending on size of the pits and materials used for superstructure. The following indicative estimates provided by different states are presented but may vary as per geographic locations and time to time.

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.	1.50	m3	134.00	201.00	150.00	225	150.00	225	105.00	157.50	150.00	225.00

	flooring with punning												
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
13	Pan & Piping	LS		750.00	750.00	LS	750.00	LS	750.00	LS	750.00	LS	750.00
B	**INSPECTION CHAMBER**				8311.25		7904.57		8292.89		9285.96		7540.96
14	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
15	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
16	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
17	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
18	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
19	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
20	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**				372.18		463.48		440.65		475.54		455.47
21	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
22	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
23	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
24	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
					1490.		1656.90		1628.1		1902.9		1534.6

					86				2		1		2
Say					**9000.00**		**9100.00**		**9400.00**		**10300.00**		**9000.00**

Annexure II

ABSTRACT OF COST FOR CONSTRUCTION OF TOILET AND BATHING ROOM

Sl	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		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**
Say					**15800.00**		**16100.00**		**16400.00**		**18200.00**		**15800.00**

Note: The above rates are indicative and may vary based on geographical locations, market availability and time .

Annexure-III

Estimate for construction of a Balram model for High Water Table

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. 4.50x0.380x0.380 = 0.65 0.785 x $(3,35)^2$x1.75 = 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. 0.785x3.35^2 x.075 =0.66 4.5x0.380x0.075 =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-4.5x0.380x0.250 = 0.43 Leaching pit - 2x3.14x1.325x0.125x1.50 = 1.71 2x3.14x1.325x.150x.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 4.50x0.125x1.82 =1.82 M^3 Over the roof 4.50x0.125x0.25=0.14 M3 Total =1.164 M^3 Less opening for door 0.76x1.60x0.125 = 0.152 M3 Less opening for back Ventilation 0.380x0.380x0.125= 0.018 M3				

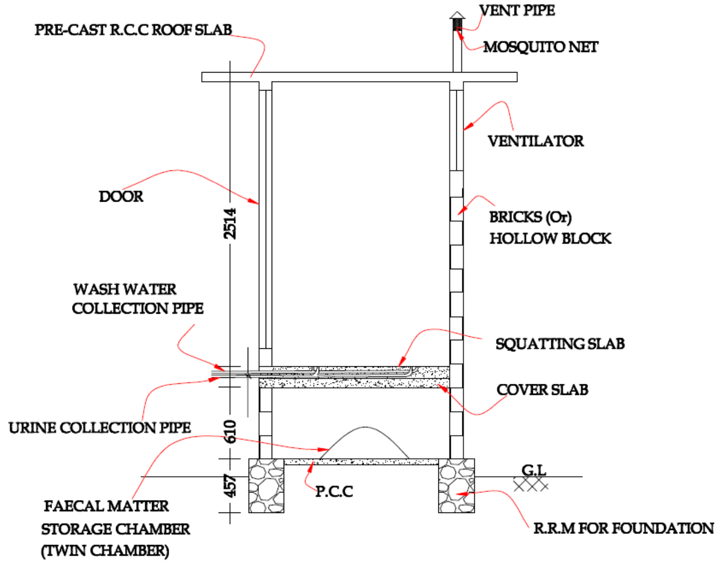
	Net volume =0.993 M^3	0.993	M^3	2398.02	2381.23
5	Providing C.A Sheet for Roof (6 mm thick) size as per availability 1.06x1.20 =1.27 M^2	1.27	M^2	212.53	269.9131
6	Providing labour for fixing C.A sheet 1 No. Angale below C.Asheet	1.27 1 No.	M2 each	27.52 70.00	34.95 70.00
7 5.7.3	Providing 12 mm thick plaster 1:6 with clean coarse sand out side 2x1.32x1.82= 4.80 1x1.17x1.75 =2.05				
	Inside 2x1.06x1.82=3.85 1x1.01x1.75 =1.76 M^2 Total =12.47 M^2	12.47	M2	74.51	929.1397
8 5.5.29	Providing fitting and fixing 20 gauge c.r sheet for door framed with M.S angle 0.76x1.37= 1.04 M^2	1.04	M2	1898.15	1974.076
9 5.3.5 A	Providing precast R.C.C 1:2:4 slab cover for leaching pit $2x0.785x0.075x(1.45)^2$	0.248	M^3	3858.2	956.8336
10 5.5.5	Providing reinforcement T.M.T steel bar for cover slab 0.248 M3 80 Kg/M3	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 & out let ,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 clea n coarse with punning of neat cement 0.90 x1.10=0.99m2	0.99	M2	74.51	73.7649
	12 mm cement plaster (1:3) with 1.5 punning with water proofing mat. 2x3.14x1.2x1.65 =12.44	12.44	M2	124.37	1547.1628

13 5.8.24	Providing punning snowcem white washing two coats over new surface same as item not same as plaster area.	12.47	M2	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	eac h	1000	1000.00
	Total				20123.07
				Total	20324.30
				Say Rs.	**20400.00**

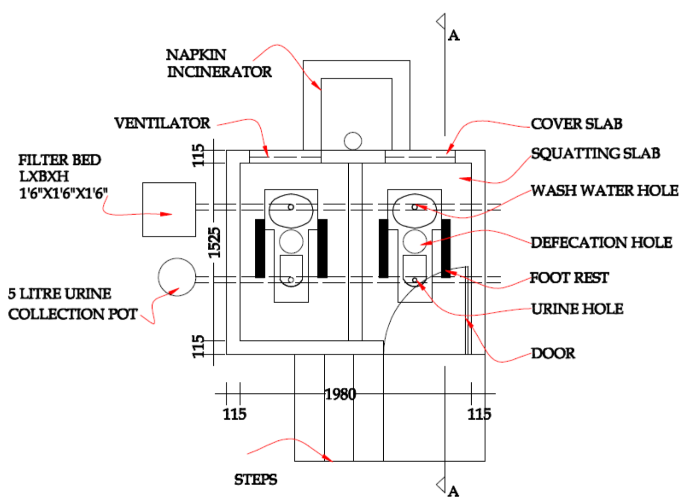
Note: The above rates are indicative and may vary based on geographical locations, market availability and time.

Annexure IV A

Drawing of a UDDT toilet



SECTION AB



PLAN

HOUSE HOLD ECOSAN TOILET PLAN

All dimensions in mm

Annexure IV B

Bill of quantity of a UDDT toilet

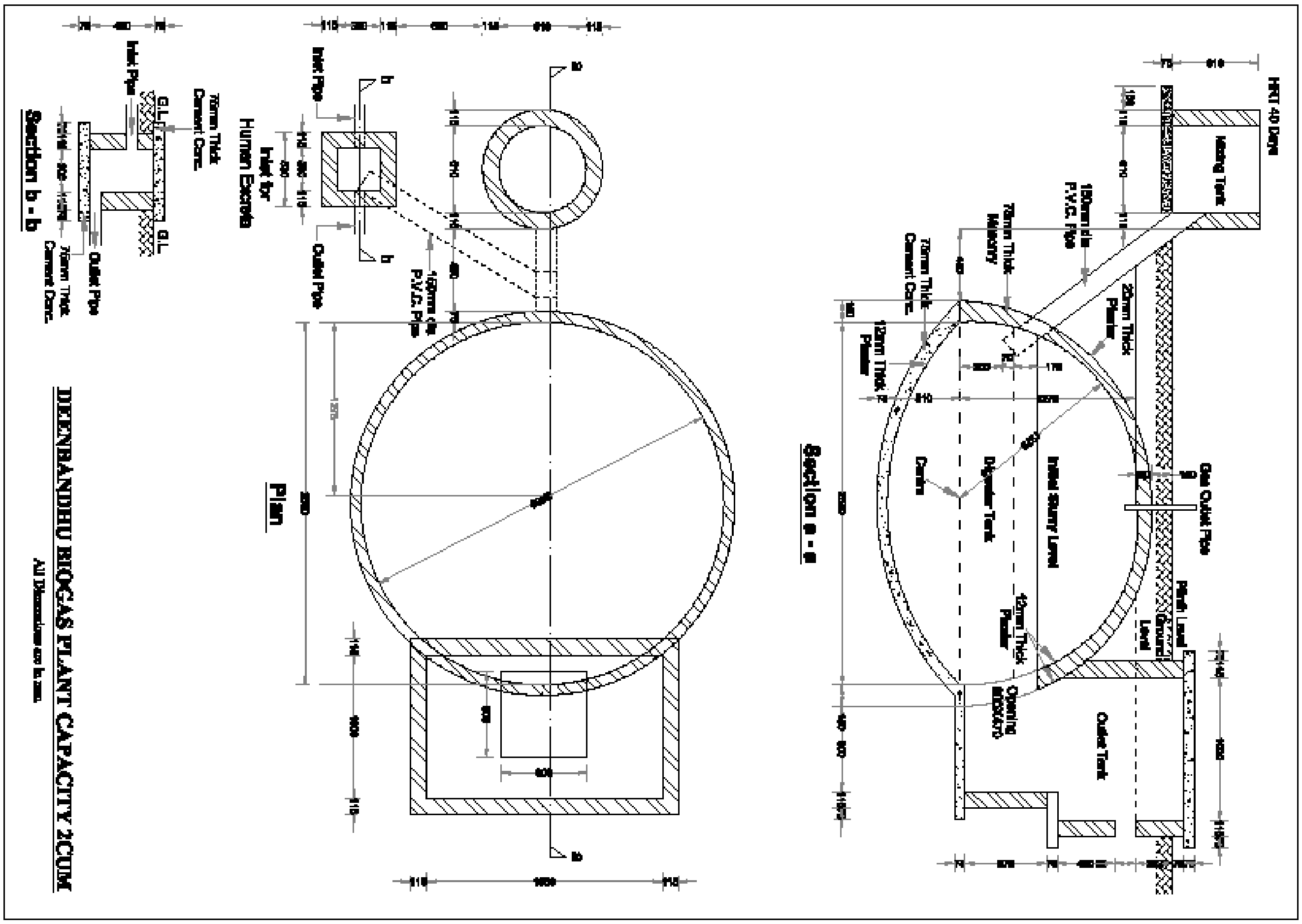
S.No.	Details	Quantity	Cost	Amount
1.	Earthwork, Foundation using R.R rough stones	L.S	600	600
2.	a)4" Cement Hallow Block (size:16"X4"X8") (or) b)Bricks (size: 9" x 4" x 3")	200 Nos. (or) 1300 Nos.	22 (or) 5	4400 (or) 6500
3.	Cement (53 Grade)	6 bags	370	2220
4.	Sand	1 unit	750	750
5.	6mm Rod (4'x10" – 7 nos.), (2'x10" – 11 nos.) for one slab, for two slabs – 7nos.x2 slabs = 14 nos., 11 nos.x 2 slabs = 22 nos.	20kg	44	880
6.	20 mm Blue metal or baby chips	25 basket	50	1250
7.	Binding Wire	250grams	100	100
8.	Steel Door Size (5' X 2') with hinges steel clamb	1 No.	1500	1500
9.	4'' PVC Pipe	10 feet	35	350
10.	4'' PVC 'L' bend	1no.	60	60
11.	4'' PVC Cowl	1 no.	40	40
12.	4'' Steel Clamb (2 nos)	1 No.	25	50
13.	2'' nail	4 Nos.	5	20
14.	1 ¼ " PVC Pipe	16 feet	225	225
15.	1 ¼ PVC 'T'	2 no.	60	120
16.	1 ¼ PVC 'L'	4 nos.	50	200
17.	PVC Paste	100ML	30	30
18.	Red Oxide	250 gram	50	50
19.	Metal galvanized sheet 1 m width x 2m length (6 hooks with bolt)	2 nos.	700	1400
20.	GI pipe 1 ¼ "	12 feet		300
21.	White cement & coloring	10kg	20	200
22.	Blue Paint	100ml	50	50
23.	Yellow Paint	100ml	50	50
24.	Black Paint	100ml	50	50
25.	2'' Brush	1no.	35	35
26.	5 Litre capacity Plastic Bucket with lid & Mug	3nos.	80	140
27.	5 litre capacity mud pot & Jerry can	1no.	100	100
28.	20 mm blue metal (chips)	2 basket	25	50
29.	Charcoal	2 basket	25	50
30.	Mosquitoes Net	1sq.f	20	20
31.	FRP Pan Three in One	2nos.	1500	3000
32.	Cement jally	2 nos.	40	80
33.	Labour- skilled	7days	600	4200
34.	Unskilled labour (female 5, Male 1) Female=1500 Male=500	-	2000	2000

35.	Labour charges for white & colour washing	L.S	600	600
36.	Transportation Charges	L.S		670
	Total Cost (hallow blocks)			25840
	Total Cost (bricks)			27940

Note: The above rates are indicative and may vary based on geographical locations, market availability and time.

Annexure V A

A Drawing of 2 cum Biogas Plant linked with Toilet



Annexure VB

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				

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
	Total Rs.				**24,049.12**

Note: The above rates are indicative and may vary based on geographical locations, market availability and time.

Annexure VI A

Detail Indicative Cost for Toilet Room Size 1.50 X 1.20 Mtrs.

Sr. No.	Description	NO	L	B	D	Quantity	Unit	Rate	Amount	Premium	Am	
1/6.6	Earth work in excavation in foundation, trenches etc. in all kinds of soil where pick jumper work is not involved and not exceeding 2.0 metres depth in cluding dressing of bottom and sides of trenches, stacking the excavated soil clear from the edge of excavation											
	Long Walls	2	1.960	0.225	0.225	0.198	Cum					
	Short Walls	2	0.970	0.225	0.225	0.098	Cum					
					Total	**0.297**	**Cum**	52.77	16.00	80%	Rs.	
2/10.6	Cement Concrete 1:8:16 with brick ballast 40mm gauge.											
	Long Walls	2	1.960	0.225	0.075	0.066	Cum					
	Short Walls	2	0.970	0.225	0.075	0.033	Cum					
	Under Floor	1	1.200	1.500	0.100	0.180	Cum					
					Total	**0.279**	**Cum**	1570.22	438.00	35%	Rs.	
3/10.29	Damp proof course 4 cm thick of cement concrete 1:2:4 with water proofing compound as per manufacturer guide lines.		2	1.730	0.115	0.398	Sqm					
			2	1.200	0.115	0.276	Sqm					
					Total	**0.674**	**Sqm**					
	Deduct Door		1	0.600	0.115	0.069	Sqm					
					Net Total	**0.605**	**Sqm**	146.28	88.00	35%	Rs.	
4/11.35	115mm thick brick wall laid in cement sand mortar 1:4 without reinforcement in foundation and plinth.		2	1.730	0.275	0.952	Sqm					
			2	1.200	0.275	0.660	Sqm					
	First Step				**Total**	**1.612**	**Sqm**	323.08	521.00	54%	Rs.	
5/11.36	115mm thick brick wall laid in cement sand mortar 1:4 without reinforcement in super structure.											
	Long Walls		2	1.730	2.00	6.920	Cum					
	Short Walls		2	1.200	2.00	4.800	Cum					
					Total	**11.720**	**Cum**					
	Deduct Door		1	0.600	1.650	0.990	Sqm					
					Net Total	**10.730**	**Sqm**	334.32	3587.00	54%	Rs.	

6/10.21	RCC M-15 mechanicaly batch mixed using batch type concrete mixer as per IS : 1791 and vibrated by needle vibrator but excluding steel reinforcement centring and shuttering in foundation and plinth.	1	1.930	1.630	0.005	0.016	Cum	3217.97	51.00	28%	
7/9.8	Centering & Shuttering for flat surface such as suspended floors, Roofs, Landing, Chhaijas, Shelves etc.	0.016	@ 8.25 Sqm/Cum			0.13	Sqm	151.12	20.00	35%	Rs.
8/ 18.17	Cold twisted deformed (ribbed/ for steel) bars Fe 415 grade as per IS 1786-1985 for RCC works where not included in the complete rate of RCC including bending, binding and placing in position complete. Quantity as per Sr. No. 6		0.016	@ 80 Kg/Cum		1.26	Kg	49.83	63.00	16%	Rs.
9/15.9	12.5 mm thick C Plaster in 1:4 inside toilet.										
	Long Walls		2	1.500	2.00	6.000	Cum				
	Short Walls		2	1.200	2.00	4.800	Cum				
					Total	**10.800**	**Cum**				
	Deduct Door		1	0.600	1.650	0.990	Sqm				
				Net Total		**9.810**	**Sqm**	84.10	825.00	40%	Rs.
Sr. No.	**Description**	**NO**	**L**	**B**	**D**	**Quantity**	**Unit**	**Rate**	**Amount**	**Premium**	**Am**
10/ 15.48	Cement rendering on plaster 1mm thick										
	Long Walls		2	1.500	0.30	0.900	Cum				
	Short Walls		2	1.200	0.30	0.720	Cum				
					Total	**1.620**	**Cum**				
	Deduct Door		1	0.600	0.300	0.180	Sqm				
				Net Total		**1.440**	**Sqm**	29.13	42.00	40%	Rs.
11/ 15.10	12.5 mm thick C Plaster in 1:5 outside toilet.										
	Long Walls		2	1.730	2.15	7.439	Cum				
	Short Walls		2	1.430	2.15	6.149	Cum				

				Total	**13.588**	**Cum**					
	Deduct Door	1	0.600	1.650	0.990	Sqm					
			Net Total		**12.598**	**Sqm**	76.18	960.00	40%	Rs.	
12/14.5	Conglomerate floor 25mm thick cement concrete rate 1:2:4 Toilet Floor	1	1.50	1.20	1.80	Sqm	94.59	170.00	33%	Rs.	
13/14.4	Floating coat of 1.5 mm sqm thick neat cement laid in one operation to the topping	1	1.50	1.20	1.80	Sqm	18.43	33.00	30%	Rs.	
14/ NS	Supply and Fixing Ceramic Rural WC Pan including Chinaware P-trap and pair of footrest				1.00	No.	250.00	250.00	-	Rs.	
15/ 28.13 + 28.1	Providing, Stringing out, P.V.C Pipes as per IS-4985 casting along the Trenches and laying the same in Trenches to correct alignment and gradients, cutting jointing and testing including cost of specials as per specifications including earth work in excavation & back filling complete in all resepct. 110mm o/d pipe 4kgf./sqcm				4.00	Mtrs	189.50	758.00	0%	Rs.	
16/ NS	Providing and Fixing 1.60 X 0.60 m size MS Door made from 25X3mm thick MS Flat and MS Sheet of 20 gauge including Cost of tower bold, hinges, nuts and bolts including wooden fatti size 600 x 250mm painting and slogan writing complete in all respects				1.00	No.	1200.00	1200.00	-	Rs.	
18/ 5.2	Carriage of Fine aggregate (Sand) , Coarse aggregate (Bajri) , Jalallabad Sand , Bricks & other Material As required at Site.										
	Carriage of Fine Sand and Course Aggregate. (Total Lead = 320 KM)										
	(a) Up To 60 KM				0.39	Cum	288.25	112.00	25%	Rs.	
	(b) 61 KM To 150 KM=90 KM @ Rs 1.70/Km				0.39	Cum	153.00	60.00	20%	Rs.	
	(c) 151 KM To 320 KM=170 KM @ Rs 1.10/Km				0.39	Cum	187.00	73.00	15%	Rs.	
	Carriage of Jallalabad Sand (Total Lead = 85 KM)										
	(a) Up To 60 KM				0.70	Cum	288.25	202.00	25%	Rs.	
	(b) 61 KM To 85 KM=25 KM @ Rs 1.70/Km				0.70	Cum	42.50	30.00	25%	Rs.	
							TOTAL			Rs.	**12**
	Less 10% Contractor Profit on CSR items as IHHL will Constructed by Beneficiaries i.e.						Rs.	11402.00		Rs.	
							TOTAL			Rs.	**11**

Annexure VI B

DETAIL OF ABR OF SIZE 1.50 X 0.90 X 1.00 MTRS. AND UPFLOW ANAEROBIC FILTER

Sr. No.	Description	NO	L	B	D	Quantity	Unit	Rate	Amount	Premium	Amount	
1/29.2 (a)	Earth work in excavation in foundation and trenches etc. for S&S tank, High Level tank, Filter Bed, Clear water tank etc. including Disposal of surplus spoils as Directed within a lead of 30 mtrs.	1.00	3.25	1.76	0.65	3.72	Cum	47.16	175.00	0%	Rs.	175.00
2/10.7 (b)	C.C. 1:6:12 with stone ballast 40mm gauge	1.00	3.25	1.76	0.075	0.43	Cum	1592.96	683.00	35%	Rs.	922.00
3/10.12	Cement concrete 1:2:4 with Stone Ballast a) Bed	1.00	3.05	1.56	0.075	0.36	Cum					
	b) Slope Bed	1.00	1.00	0.90	0.050	0.05	Cum					
					Total	**0.41**	**Cum**	2799.75	1148.00	28%	Rs.	1469.00
4/10.15	Reinforced cement concrete M-20 with Mechanically batch mixed using batch type concrete mixer as per IS. 1791 & vibrated by needle vibrater but excluding steel reinforcement	1.00	2.85	1.36	0.08	0.29	Cum	3274.96	952.00	28%	Rs.	1219.00

	centring and shuttering in foundation&plinth a) Top Slab										
5/11.5	First class burnt brick work laid in cement sand mortar 1:5 in foundation and plinth.										
	Long Walls	2.00	2.85	0.23	1.40	1.84	Cum				
	Short Walls	2.00	0.90	0.23	1.40	0.58	Cum				
					Total	**2.42**	**Cum**	2485.48	6002.00	54%	Rs.	9243.00
6/15.7 + 15.48	12.5mm thick cement plaster 1:2 with rendering.										
	Inside Tank	1.00	0.90		1.40	1.26	Sqm				
	Inside Tank	1.00	1.50		1.40	2.10	Sqm				
	Anaerobic Filter	2.00	0.90		1.40	2.52	Sqm				
	Anaerobic Filter	1.00	1.00		1.40	1.40	Sqm				
					Total	**7.28**	**Cum**	136.31	992.00	40%	Rs.	1389.00
7/9.8	Centring and shuttering for flat surfaces such as suspended floors, roofs, landings, chajjas, shelves etc. Qty. same as per Sr. No. 4 @ 8.25 per sqm/cum	0.29	@ 8.25 Sqm/Cum			2.40	Sqm	151.12	362.00	35%	Rs.	489.00

28.51 (d)	Providing and placing in horizontal layers filtering media screened, washed and cleaned as described below:- Fourth Layer:- Bajri screened cleaned and washed and graded from 20mm to 25mm (from Pathankot or approved equivalent quarry)	1.00	1.00	0.90	0.90	0.81	Cum	901.00	730.00	0%	Rs.	730.00
8/ 18.17	Cold twisted deformed (ribbed/ for steel) bars Fe 415 grade as per IS 1786-1985 for RCC works where not included in the complete rate of RCC including bending, binding and placing in position complete. Quantity as per Sr. No. 4		0.29	@ 60 Kg/Cum		0.17	Qtl	4983.14	847.00	16%	Rs.	983.00
Sr. No.	**Description**	**NO**	**L**	**B**	**D**	**Quantity**	**Unit**	**Rate**	**Amount**	**Premium**	**Amount**	
9/ 29.36	Providing & Fixing RCC MH cover & frame 560mm i/d (c) (d) Light duty					2.00	No.	992.26	1985.00	0%	Rs.	1985.00
10/ 5.2 (i)	Jallalabad sand Lead upto 85 km											
	Lead 6 km to 60 km					0.92	cum	288.25	265.00	25%	Rs.	331.00
	61 km to 85 km					0.92	cum	42.50	39.00	20%	Rs.	47.00
11/ 5.2 (i)	Pathankot sand & Bajri Lead upto 320 km											

	Lead 6 km to 60 km					1.81	cum	288.25	522.00	25%	Rs.	653.00
	61 km to 150 km					1.81	cum	153.00	277.00	20%	Rs.	332.00
	151 km to 320 km					1.81	cum	187.00	338.00	15%	Rs.	389.00
								TOTAL			Rs.	**20356.00**
	Less 10% Contractor Profit on CSR items as IHHL will be constructed by Beneficiaries i.e.							Rs.	20356.00		Rs.	2,036.00
								TOTAL			Rs.	**18320.00**

Note: The above rates are indicative and may vary based on geographical locations, market availability and time.