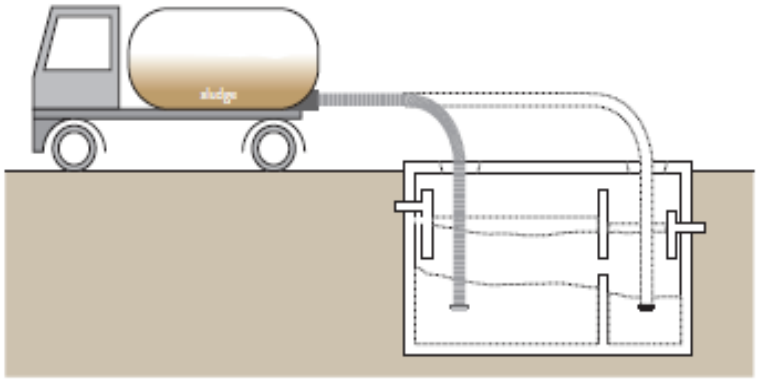

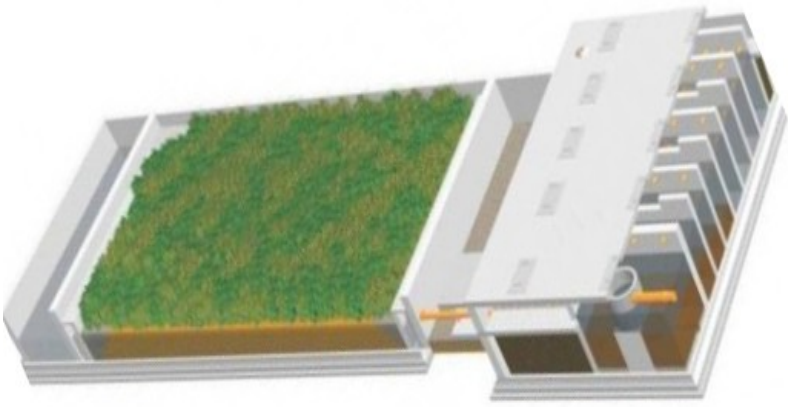

Module 3

SANITATION AND LIQUID WASTE MANAGEMENT

Training Module for Local Water and Sanitation Management

Maharashtra Jeevan Pradhikaran (MJP)
CEPT University

2012

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ABBREVIATIONS

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
DEWATS	Decentralised Wastewater Treatment System
HH	House Hold
MJP	Maharashtra Jeevan Pradhikaran
O&M	Operation and Maintenance
PVC	Poly Vinyl Chloride
RCC	Reinforced Cement Concrete

Conversion of basic units (with prefix)

1 meter (m)	100 centimeter (cm)
1 meter (m)	1000 millimeter (mm)
1 foot (ft/')	12 inches (")
1 inch (")	25.4 millimeter (mm)
1 meter (m)	3.28 feet (ft/')
1 cubic meter (cu.m)	35.31467 cubic foot (cu.ft.)
1 cubic meter (cu.m)	1000 litres
1 square meter (sq.m/m^2)	10.76391 square foot (sq.ft.)
1 Kilogram (Kg)	1000 Grams (g)

GLOSARRY OF TERMS

- Sanitation: Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces.
- Wastewater/liquid waste: Wastewater in this manual refers to domestic waste water generated from toilets, bathing, washing, cleaning, community stand post/hand pumps etc.
- Grey Water: Wastewater generated from bathing, washing, general cleaning, laundry, as well as from community stand post, well, hand pumps etc.
- Black Water: Wastewater generated from toilet/latrine containing faecal matter. Such water contain very high amount of pathogen compared to grey water.
- Yellow Water: Urine with or without flush water is termed as yellow water.
- Storm Water: Storm water indicates rainfall run off from roofs, roads and other surfaces.
- Sullage: Domestic dirty water not containing excreta. Sullage is also called grey water.
- Sludge: it is the settled solid matter in semi-solid condition. The term sewage sludge is generally used to describe residuals from wastewater treatment system, while the term Septage is used to describe the residuals from septic tanks.
- Effluent: Wastewater that flows out of a treatment system (septic tank in this module). It is partially treated.
- Faecal sludge: Faecal sludge is the solid or settled contents of pit latrines and septic tanks.
- Septage: Settled solid matter produced in septic tanks is termed as Septage.
- Scum: Impure matter like oil, hair, grease and other light material that float at the surface of the liquid in septic tank.
- Faeces: Faeces refers to (semi-solid) excrement without urine or water.
- Leachate: The liquid part of mixed wastewater that is separated through gravity or filtration from the solid component. It required further treatment prior to disposal
- Bio-solids: Sludge/septage that is partially treated/digested/stabilised and can be used or applied with reduced risk compared to raw sludge.
- Organic: Organic refers to bio-degradable material.
- Compost: Compost is a result of decomposition of organic material that can be used as manure in agriculture.
- Dry Toilets: Such toilets are mainly non-flushing toilets or waterless toilets with minimal or no use of water. They are also termed as compost toilets as they recycle/compost waste for its reuse.
- Pit Latrine: Latrine with a pit for collection and decomposition of excreta and from which liquid infiltrates into the surrounding soil.
- Flush Toilet: Toilet that depends for its operation on water for flushing faeces is termed as flush toilet. Such toilet is termed as pour flush if flushing is done manually, while it is termed as cistern flush toilet if flushing is done mechanically.
- Soakpit/Soakaway/leach pit: It is a covered porous walled chamber that allows liquid waste to infiltrate into surrounding ground.
- Septic Tank: An underground tank that treats wastewater by a combination of solids settling and anaerobic digestion. The effluents may be discharged into soak pits or small-bore sewers, and the solids have to be pumped out periodically.
- Sewer: It is an underground carriage system/network for transporting liquid waste from household level to disposal/treatment unit. The system carrying only waste water (black and/or grey water) is termed as sanitary sewer system, while that carrying storm water is termed as storm water sewer. There is a combined sewer, which carries combined waste.
- Ecological Sanitation: It is a form of sanitation which involves reuse of human faecal waste/ wastewater and its nutrient back into local environment, thus avoiding pollution of land, air and water resources.

INTRODUCTION

Domestic Waste is a serious threat to the public health in India. Absence to proper sanitation and unhygienic disposal of waste including domestic wastewater leads to pollution of natural resources and affects human health.

It is thus inevitable to develop proper waste management system in rural and urban areas. Moreover, waste has an economic value once treated and re-used. In country like India, where there is crunch of natural resources, reuse of treated domestic wastewater can lead to reduced depletion of fresh water sources and other natural resources.

This training module has been formulated in order to enhance capacity of community groups for development of sanitation systems in villages and towns and create larger awareness on better sanitation practices and domestic wastewater management amongst local communities.

The module provides insights on options and technologies for sanitation and liquid waste management as well as routine operation and maintenance of these systems.

MODULE A: BASICS ON SANITATION AND LIQUID WASTE MANAGEMENT

Training Objectives

To understand on what are the benefits, objective and options for appropriate sanitation systems and liquid waste management

Training tools: Slideshow, powerpoint/on board presentation, question answer, activity sheet

Approximate time:

Presentation: 15 minutes

Question answer: 15 minutes

Activity sheet: 15 minutes

TOTAL: 45 minutes

A1 Importance and Need for Better Sanitation Practices

Sanitation in general means safe managment and disposal of human excreta/domestic wastewater. The process invovles safe collection, safe storage/disposal and recyling/reuse of domestic wastewater.

The major objectives of sanitation are:

- Providing access to safe sanitation systems.
- To promote appropriate mangament and dispoal of domestic wastewater.
- To promote treatment and reuse of domestic wastewater.

Current santation practices in rural areas and small towns in India mainly involves drop and store (pit latrines etc.) and flush and discharge (pour flush toilets discharging wastes into septic tanks/sewer networks). However, the waste generated in majority of areas is disposed off without any treatment leading to pollution of water bodies, air and soil. Unsafe santiation practices have direct impact on human health. Moreover, conventional end of pipe technologies are expensive and require high operation and maintenance costs. Conventional technologies are not suitable for ceratin areas like coastal areas, areas with high water table, flood prone areas etc.

Moreover, such waste has an economical value if recycled and reused. Domestic wastewater/human excreta comrpises of certain nutrients, which can be turned into organic manure, bio gas, power/electricity (small scale) etc. Organic manure can be used in agriculture, while bio-gas can be used for cooking. Moreover, the wastewater can be treated and reused directly for irrigation, fishing/aquaculture as well as domestic flushing.

Hence, a pardigm shift is required in sanitition system promoting decentralised systems reducing huge infrastructure costs, promoting safe sanitaiton practices without polluting natural resources and considering waste as a resource through appropriate recyling and reuse.

A2 Classification of Toilets and Sanitation

Toilets can be classified into two major categories:

a. Dry Toilets: Such toilets are mainly non-flushing toilets or waterless toilets with minimal or no use of water. They are also termed compost toilets as they recycle/compost waste for its reuse.
b. Flush Toilet: Toilet which utilise water for flushing of waste. Flush toilets can be pour flush or cistern flush.

Sanitaiton facilities can be classified as on-site and off-site depending on disposal of waste.

a. On site sanitation: Such system aim to contain wastewater at the point of generation. Septic tank, pit and soak pit toilets and eco-san toilets which do not require sewer/transportation etc are types of on site sanitation systems. Septage in septic tank, however is transported through mechnical means at frequent intervals.
b. Off-site sanitation: Systems which require transportation of wastewater to another location for dispoal, treatment or reuse are termed as off-site sanitation systems. Normally, such systems require sewer system or mechnical transporation of waste. The off-site sanitation can be centralised (at single point in town/village) or decentalised (at communal level).

A3 About Liquid Waste/Domestic Wastewater

- Liquid waste is used and unwanted water which cannot be used for human consumption or other domestic purpose.
- There are two major categorisation of liquid waste/domestic wastewater:
    a. Grey Water: wastewater generated from bathing, washing, general cleaning, laundry, as well as from community stand post, well, hand pumps etc.
    b. Black Water: Wastewater generated from toilet containing faecal matter. Such water contain very high amount of pathogen compared to grey water.

    Grey and black water can be collected separately and treated/disposed separately, as grey water does not require very high treatment as black water. However, both can be collected and treated/disposed together.

    Liquid waste also comprise of Yellow Water (urine with or without flush water). It is separated in certain type of toilet units and reused as fertiliser.

- Once the waste is collected in pit, septic tank etc., it further disintegrates and can be termed as follow:
    a. Sludge: It is the settled solid matter in semi-solid condition in any collection/storage system. The term sewage sludge is generally used to describe residuals from centralised wastewater treatment, while the term septage is used to describe the residuals from septic tanks. Solids or settled content in pit latrines and septic tanks are also called faecal sludge.
    b. Scum: Impure matter like oil, hair, grease and other light material that float at the surface of the liquid in septic tank.
    c. Effluent: Wastewater that flows out of a treatment system (septic tank in this module). It is partially treated.
- Generally 80 percent of total water supplied is expected to be discharged as wastewater. In urban areas sewers are designed for minimum 100 litres/capita/day discharge (Source: CPHEEO). Thus, it can be assumed that a household (5-6 people) generate approximately 400-500 litres wastewater/day where there is adequate piped water supply.

A4 What is Ecological Sanitation

Ecological sanitation is a form of sanitation which involves reuse of human faecal waste/ wastewater and its nutrient back into local environment, thus avoiding pollution of land, air and water resources. The system involves treatment of human faecal waste and wastewater and reuse of the treated products. The system produces two types of products:

a. Manure for agricultural use.
b. Treated water that can be used in agriculture or gardening, flushing in toilets and aqua culture.

Activity Sheet

Section A Basics on Sanitation and Liquid Waste Management

1. What is sanitation and what are its broad objectives

2. What is difference between dry and flush toilets

3. What is difference between on-site and off-site sanitations systems? Give examples

4. What is liquid waste? Enlist two major types of liquid waste

5. What is meant by ecological sanitation

MODULE B: TECHNOLOGY OPTIONS FOR SANITATION AND LIQUID WASTE MANAGEMENT

Training Objectives

- To understand various technological options for toilet systems and liquid waste management including wastewater treatment

Training tools: Slideshow, powerpoint/on board presentation, question answer, activity sheet, movies/clippings

Approximate time:

Presentation: 1 hour

Question answer: 30 minutes,

Activity sheet: 30 minutes

Movies: 1 hour

TOTAL: 3 hours

Functional Grouping of Sanitation and Wastewater Management Options and Technologies

The sanitation and wastewater management options and technologies can be functionally divided into five groups based on its infrastructure, method and services. Any system can have single or multiple functions.

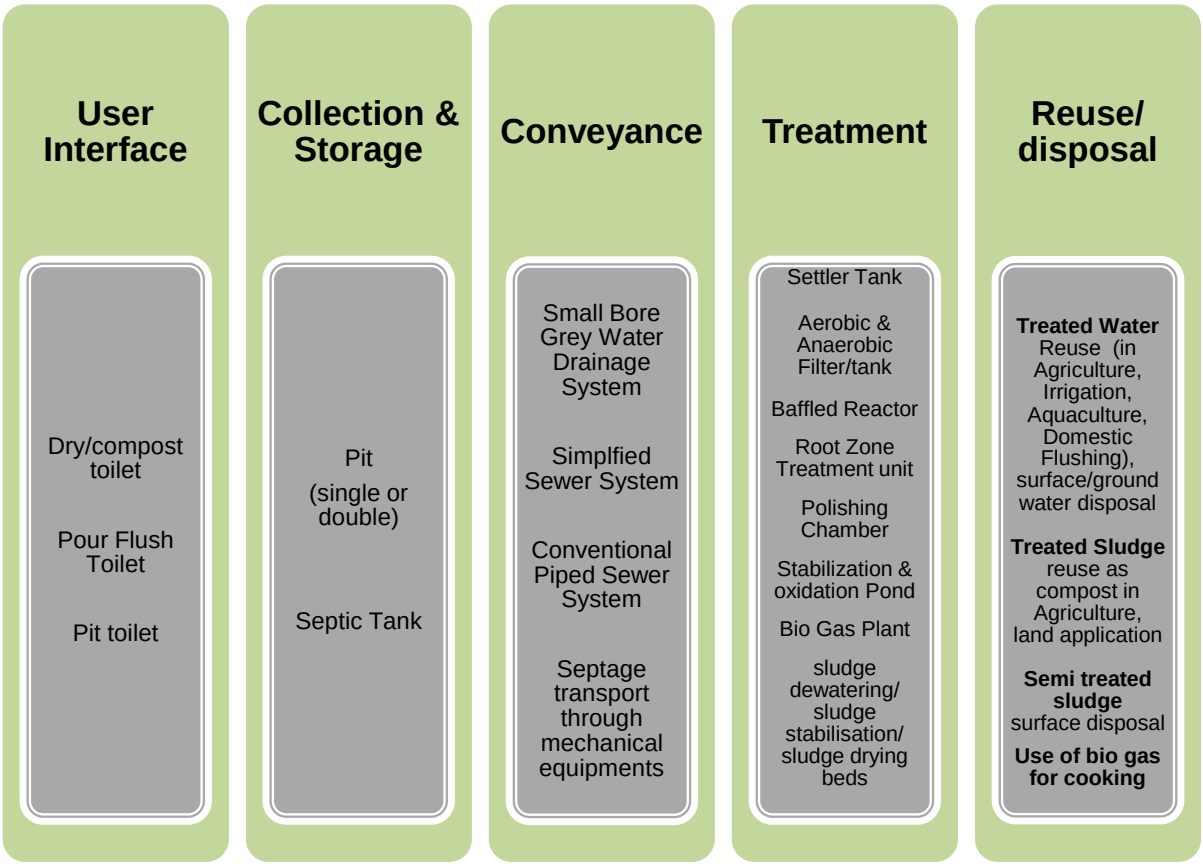
a. User Interface
   It describes the way that the user accesses the sanitation system. The access to sanitation will highly depend on water availability and land availability.

b. Collection and Storage
   It describes the system for collection and storage of wastewater.

c. Conveyance
   It describes the system/infrastructure for transport of wastewater/semi-solids collected from treatment units from source of generation to disposal/treatment point.

d. Treatment
   It describes the system/method for treatment of waste collected.

e. Reuse/disposal
   It describes the system for disposal or reuse of waste. Normally, the waste is treated upto desired level prior to its reuse or disposal.



The technologies and sanitation options are listed ahead based on:

B1. Types of toilets including their system of storage, treatment and reuse.
B2. Conveyance system – Types of sewer systems for off-site sanitation.
B3. Treatment Technologies for waste water and its possible reuse.

B1. Toilet Options

Various types of options are available for toilet system based on end disposal/reuse of waste materials. Common types of toilet systems are:

1. Toilet units with single pit system.
2. Toilet units with twin pit system.
3. Flush Toilet units with septic tanks.
4. Dry toilets (compost toilets).

1. Toilet units with Single Pit system

Conventional pit latrine is a non-water dependent latrine, which does not require water for functioning, though a small amount of water can be used to for cleaning. This type of latrine is suitable in water scarce areas. This system is particularly applicable for those communities who have open defecation practice and need better hygiene.

Such system comprises following components

a. Pit (lined with stone/brick work or unlined). Normally, lining prevents the pit from collapsing and support the superstructure. Where superstructure is not built or it a temporary or semi-permanent cover, unlined pits are also in practice.
b. Squat plate with hole and foot rest.
c. Superstructure with masonry wall and roof or any other locally available covering.
d. Ventilation pipe in case of Ventilated Improved Pit (VIP) toilet.

In case, the water table level is high, the pit bottom can be sealed with sand envelope. In case the bottom is not sealed, the distance between pit bottom and ground water table should be atleast 2 m. The lateral distance between the pit and drinking water source should be 3 m for unsaturated soils and 10 m for saturated/wet soils. (Source: IS 12314 (1987, Reaffirmed 2007): Code of Practice for Sanitation with Leaching Pits for Rural Communities.

The pit latrine should be upgraded to a ventilated improved pit latrine having a vent pipe with a fly-screen fitted outside the superstructure to trap flies and reduce odour nuisance. If suitable and continuous source of soil, ash, or organic matter (leaves, grass rice husks etc.) is available, it can be put on excreta after each use. This will prevent odour and flies as well as accelerate decomposition of matter and increase storage period of waste.

The pit when filled, is abandoned and new pit is constructed and the toilet unit is shifted. The pit is covered with soil and the waste is allowed to decompose and can be utilised as manure after a year. Alternatively, The pit can be emptied with equipments.

Such systems though easy and cheap to construct, require higher maintenance once the pits get filled. Hence, where ground water table is low, the pit may be

constructed deep. Such pits may last for two to five years or even more depending on the depth of the pit and users.

Advantages

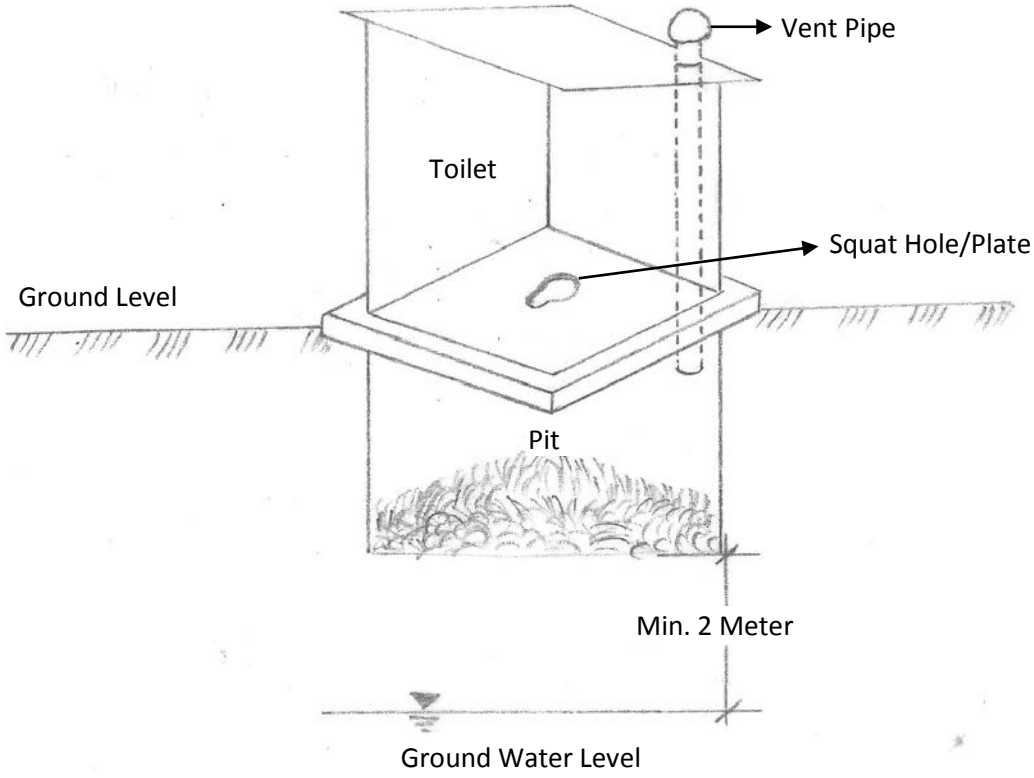
- It does not require any water for flushing.
- It is easy to construct, operate, and maintain.
- Low costs of construction, operation, and maintenance.

Disadvantages

- Odour problems may occur during the night and early morning in toilets relying more on solar radiation than on wind speed for air flow in the vent pipe.
- Such system cannot be considered fully hygienic for use.
- In areas with soils with a low infiltration capacity, the use of water for cleansing should be limited or avoided.
- When the pit is emptied, the pit sludge contains pathogens and must be handled carefully.

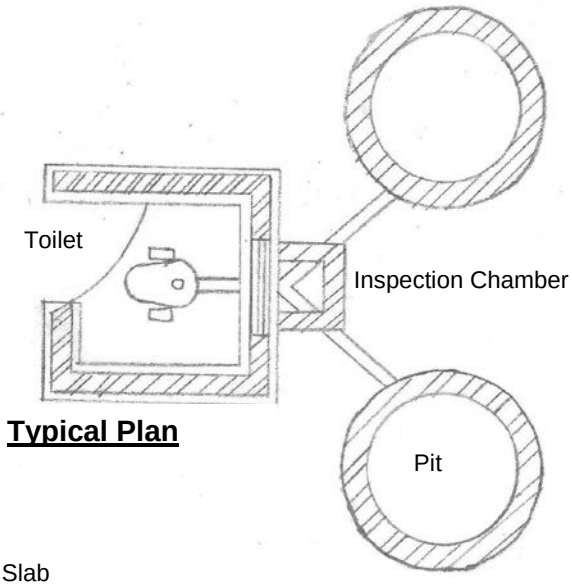
O&M

- Operation consists of regular water cleansing of the slab and squatting pan, etc. The door should be kept closed so that the superstructure remains dark inside. The drop hole should never be closed as this blocks airflow.
- When the single pits are filled completely, they should be closed and covered with soil upto 2 feet. New pit should be constructed when existing pit gets filled In case the pit is to be reused, they need to be emptied with equipments. If the filled pit is closed and allowed to decompose for 12-18 months, the waste gets converted into manure and this manure can be emptied.
- Maintenance consists of monthly inspections to check for cracks in the floor slab and damage to the vent pipe and fly screen, and digging out of part of the faeces at the end of the dry season. As these faeces may not have been fully decomposed, it should be handled with care and buried in a pit covered with soil. After at least a year, when the contents of the pit have decomposed into harmless humus, the humus can be can be used as fertiliser.

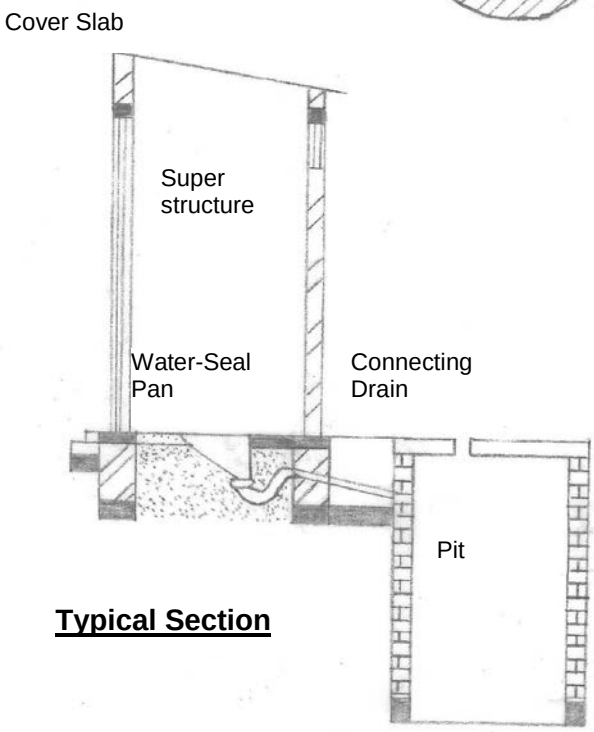


2. Toilet Units with twin pit system

- Such systems are most common and widely used in rural or peri-urban areas where there is small amount of waste.
- Such toilets require water for flushing.
- Such system consists of water seal which remains at bottom of the pan after its use. This removes odour.
- System consists of two alternating pits connected to toilet unit
- The advantage with double pit is that it allows continuous operation of system while one pit gets filled.
- The pits are constructed at an offset with and not below the toilet unlike normal pit toilet.
- Flushing in the system can be manual/pour flush or by mechanical/cistern means. Pour flush requires about 1-2 litres for flushing, while mechanical/cistern flushing consumes higher amount of water.
- Wastewater gets absorbed in the soil and excreta collected in pit gets decomposed after certain time period in such system. If the pit after filling is allowed to decompose to 12-18 months, the waste gets converted into organic manure.
- Such systems are useful in soils which are permeable.



Typical Plan

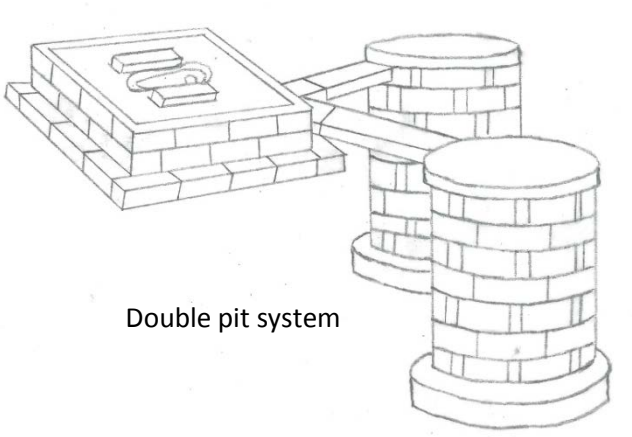


Typical Section

Components of the system

The system consists of following main components

a. Sub structure:
   - ✓ Such structure is below the ground and is always honey comb/ perforated wall.
   - ✓ Can be constructed with brick/stone masonry, ferro cement, hollow blocks etc.
   - ✓ Can be constructed at household level or even at community level and sized based on usage.
   - ✓ The pit cover can be done with stone/ RCC/ferro cement /wood etc. The pit is normally made of diameter of about 3-4 feet. Depth of pit can be 4.5-12 feet or more depending on number of users, soil absorption characteristics, ground water table and de-sludging intervals.
   - ✓ The pit and pan is connected with pipe (normally 2-3 inches diameter) with appropriate slope.
   - ✓ Junction/inspection Chamber (only for twin pit): The junction chamber has one inlet (connected to the P-trap) and two outlets (connected to the soak pits) which are for alternate use. The chamber is usually of size 1 feet x 1 feet).

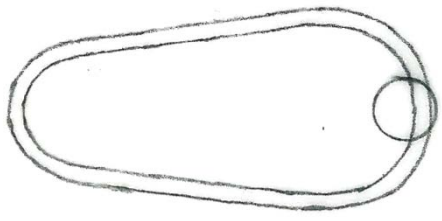


Double pit system

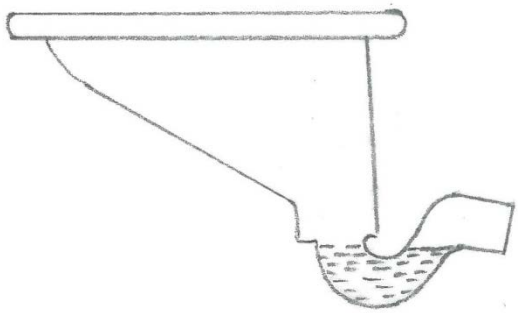
   - ✓ Vent pipe is placed on the top of pit.
   - ✓ The minimum space between the two pits should be equivalent to at least the effective depth of the pit. The spacing between the two pits can be reduced by providing a barrier like cut-off screen or puddle wall. (Source: IS 12314 (1987, Reaffirmed 2007): Code of Practice for Sanitation with Leaching Pits for Rural Communities).
   - ✓ The ideal position of locating the pits is that the pits are placed symmetrically at the back side of the latrine pan. However, if site conditions do not permit this layout, the pits may be placed on the sides or even in front of the pan. (Source: IS 12314 (1987, Reaffirmed 2007): Code of Practice for Sanitation with Leaching Pits for Rural Communities).

b. Super Structure:
   - ✓ Toilet walls: Can be permanent/semi-permanent/kutcha structure with available material and needs of the community. Commonly done with brick/stone masonry walls and stone/metal sheet/RCC roof.
   - ✓ Squatting Platform - The squatting platform is a raised pucca floor constructed with appropriate plinth and foundation.
   - ✓ The toilet floor can be done with tiled flooring or cement concrete.

c. Water Seal Pan/bowl:
   - ✓ The pan has a steep bottom slope, which allows easy flushing of excreta with lower use of water. Normally, pans with slope of 25-40 degrees are suitable for low water usage.



- ✓ Can be of plain cement/plastic/mosa/ ceramic etc.
- ✓ The bowl should be fixed into either a squatting platform aligned from toilet floor for offset pit. Proper finishing needs to be done of the floor.
- ✓ The outlet of the pan is connected with a P-trap.



Advantages

- System required low land area.
- Requires no energy for functioning.
- Can be built and repaired with locally available materials.
- Odour free.
- Better health and hygiene practice.
- Prevents insects due to water seal.
- Cheap and easy construction and maintenance.

Disadvantages

- Manual removal of humus is required
- Possible contamination of groundwater

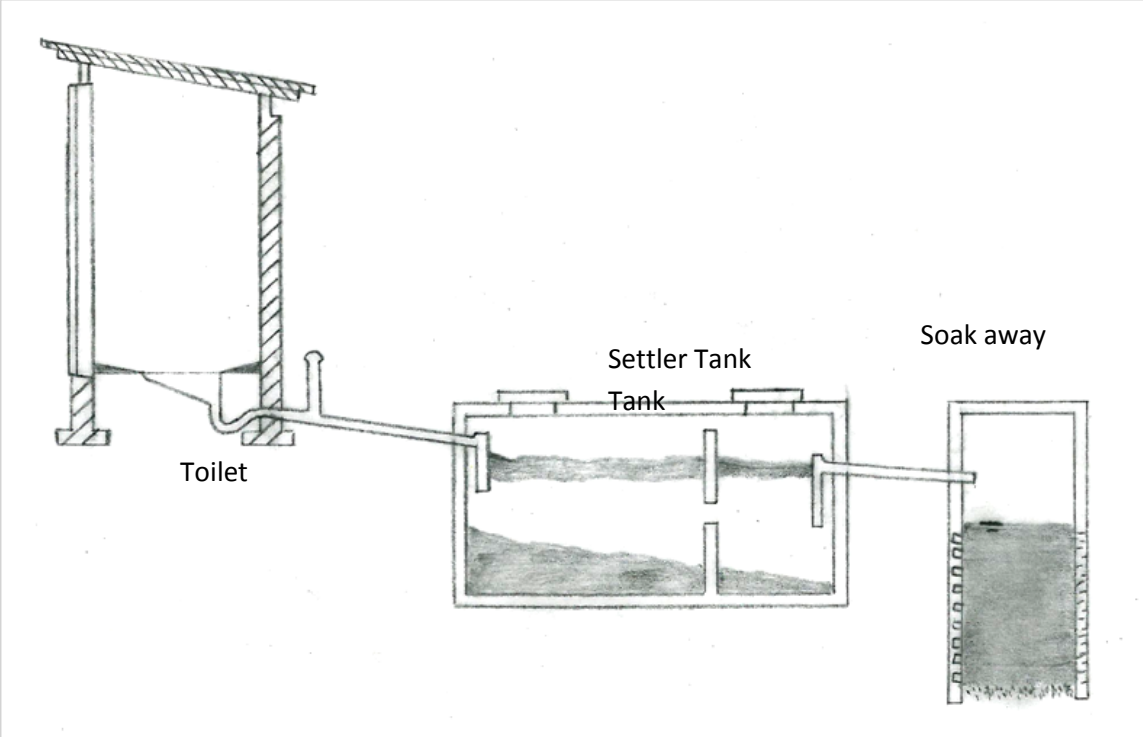
Operation and Maintenance

- Such system normally does not require any major operation/maintenance, except routing cleaning of toilet system.
- For double pits, if one pit gets filled completely, pipe leading to the full pit should be sealed and the flow be diverted into the second pit. Filled pit can be closed and sealed with soil and the waste be allowed to decompose into manure for 12-18 months.

3. Flush Toilet Units with Septic Tank

- Septic tanks are underground structures for disposal of excreta, where sewer system is not available.

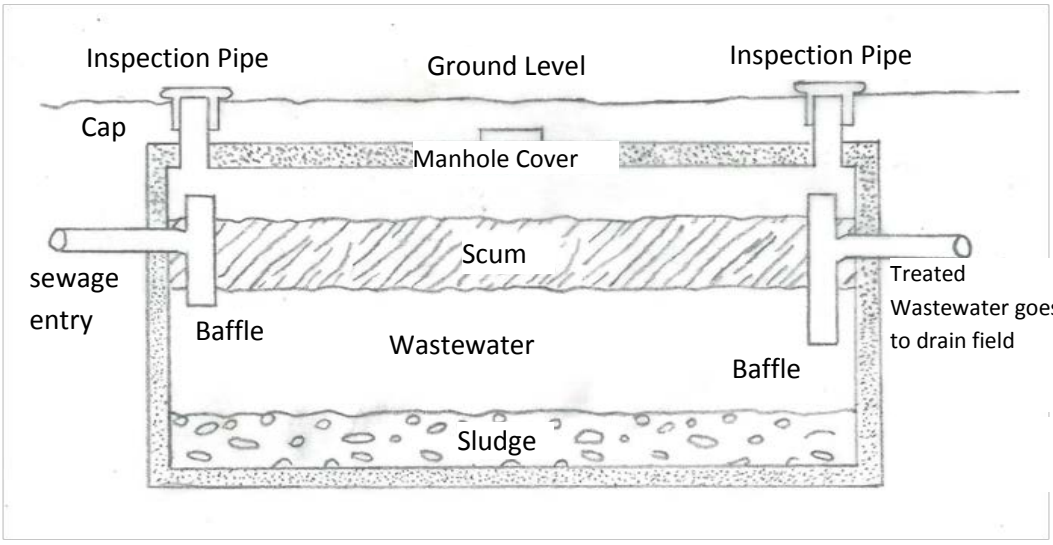
- Septic tanks do not dispose waste, but separate solid from liquid.



- Septic tanks can be constructed at household level or even at cluster level.
- The system consists of settler chambers with two to three compartments. The inlet of settler chamber is connected to toilet with a pipe and U-trap, while the outlet of the tank is connected to a small bore/soak pit. In case of high water table area, the settler tank may be connected to drainage field system.

Settler Tank

- The settler tank can be constructed with cement concrete/RCC, pre-cast concrete or plastered masonry structure or even from polyethylene and fibre glass. Polyethylene and fibre glass provide advantage of ensuring water tight compartment. Steel structure is not constructed as there are chances of high corrosion.



- Some of the solids float on the surface, which is called scum, while other solids settle at bottom of tank and they are broken down by bacteria into sludge. The liquid

waste (effluent) flowing out of the chamber is disposed into soak pit/small bore sewers.

- The tank must have vent pipe to allow hazardous gases like methane to escape as they are highly inflammable if confined to the tank.
- The accumulated sludge needs to be removed regularly, depending on size of tank. Normally, it needs to be removed once every one to five years.
- In case the soil is not permeable or the water table is high, all the waste needs to be collected in tank and the capacity of tank needs to be made bigger. Alternatively, the tank can be connected to sewer system if available.
- The septage/sludge and scum removed should be disposed off hygienically or treated. It can be treated with existing sewage treatment plant or can be used for composting with solid organic waste. In any case, such waste should not be disposed into water bodies or left open.

Size of Septic Tank

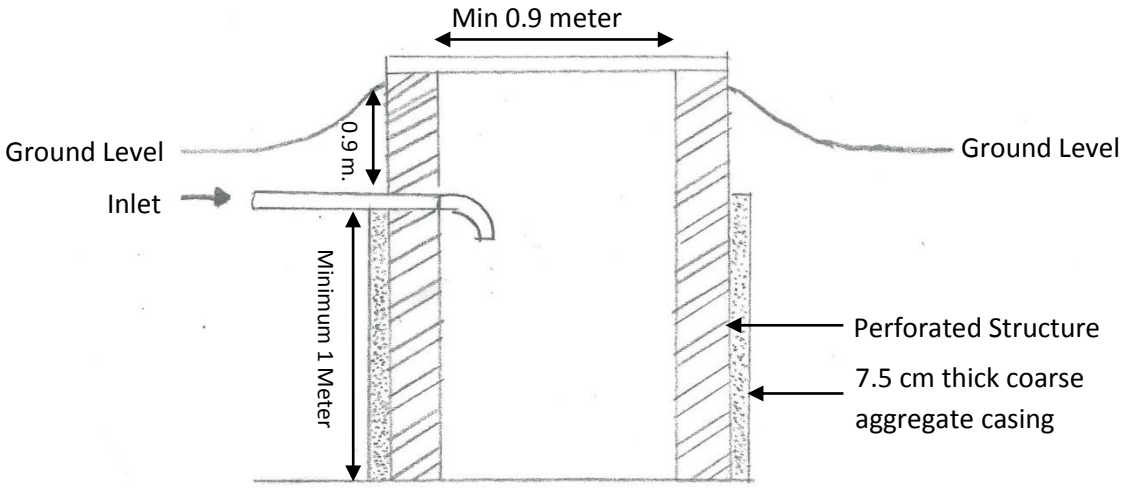
Following points shall be considered for estimating size of septic tank:

- The depth of tank shall be minimum 3 feet below waste water level.
- Minimum liquid capacity of tank should be 1000 litres.
- For rectangular tanks, length of tank shall be 2-4 times the width. The width shall be minimum 2'10".
- For circular tank, the diameter shall not be less than 4.5 feet.
- Table below recommends normal size of tanks based on its use in residential areas

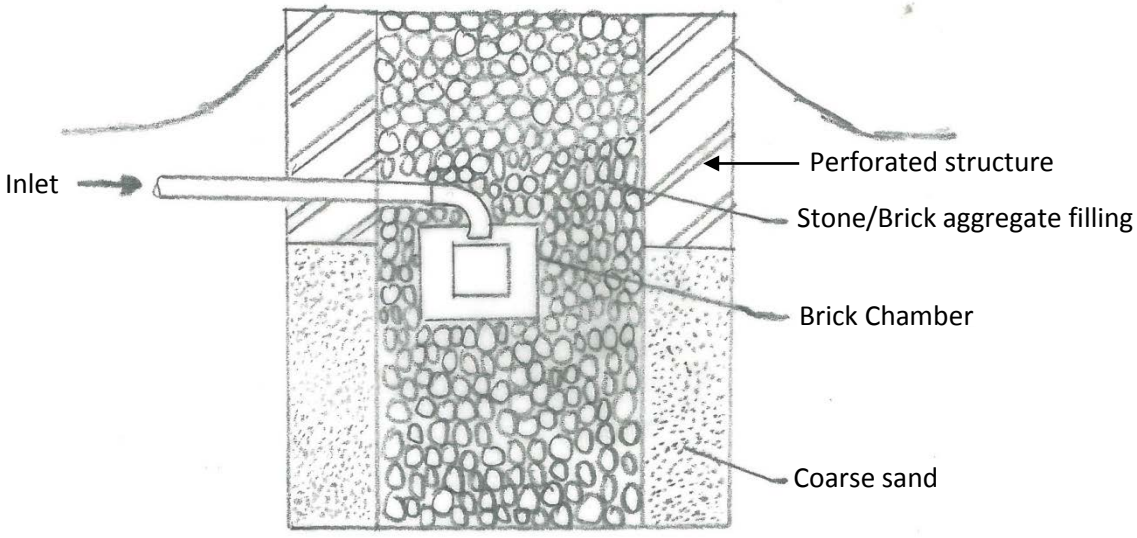
Person using system	Length	Breadth	Liquid Depth		Notes
			Cleaning interval 1 year	Cleaning interval 2 years	
	meters	meters	meters	meters	Assuming discharge only from WC/toilet
5	1.5	0.75	1.0	1.05	
10	2.0	0.9	1.0	1.4	
15	2.0	0.9	1.3	2.0	
20	2.3	1.1	1.3	1.8	
50	5.0	2.0	1.0	1.24	
100	7.5	2.65	1.0	1.24	
Based on Bureau of Indian Standard (Code of Practice For Installation of Septic Tank, IS 2470:1986, re-affirmed 1996). These standards are for on-site construction of septic tanks. There are pre-cast tanks available in market. The IS 9872:1981 is followed for pre-cast concrete tanks.					

Soak/seepage pit for disposal of effluent

- The soak pit/ seepage pit can be constructed of perforated masonry structure or RCC. The perforations should be till the bottom of inlet pipe. Above the inlet pipe, the pit can be lined with cement concrete. The pit should be covered with stone/RCC cover. If the pit is not lined with pucca structure, the pit should be filled with stones/ brick aggregates. The structure above the inlet pipe should however be lined with masonry structure. The inlet pipe can be placed about 3 feet deep from ground level to avoid mosquitoes.
- The seepage pit should have cross-sectional dimension of at least 0.90 m and not less than 1.0 m in depth below the inlet pipe



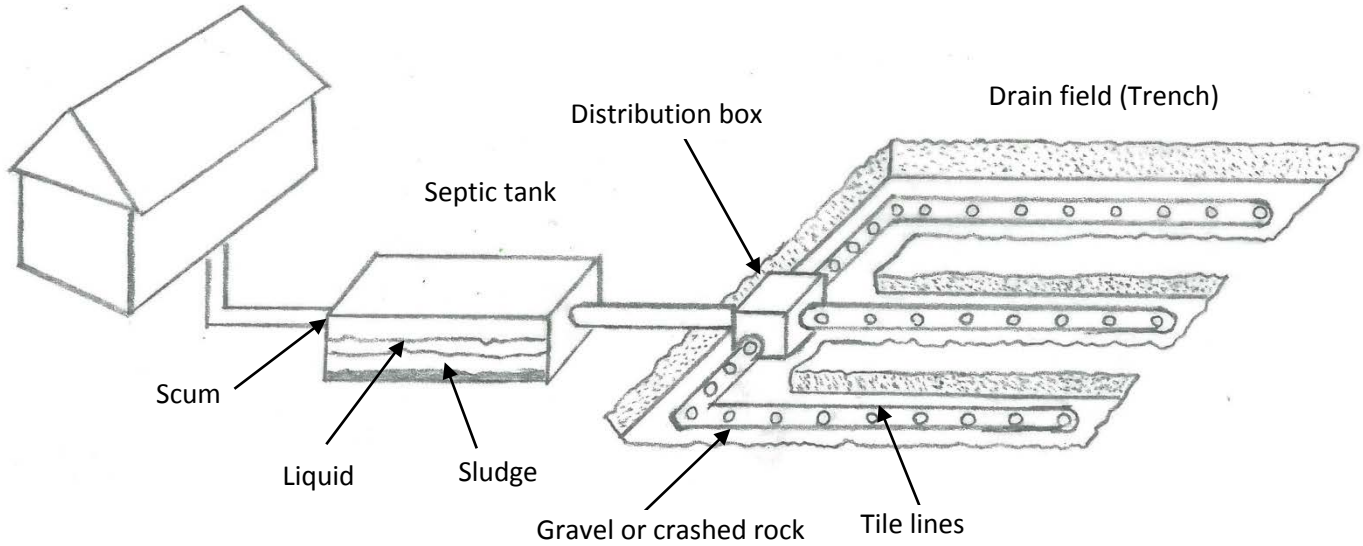
Pit with lining



Pit without lining

Drainage field/dispersion trench system (for disposal of effluent) for areas with high water table

- In case the water table is within 6 feet from ground level, wastewater cannot be disposed into ground through soak pit/small bore.
- Instead drainage field/dispersion trench system can be connected to the settler tank. A distribution box can be placed between septic tank and trenches.
- Dispersion trenches shall be 0.5 to 1.0 m deep and 0.3 to 1.0 m wide. Minor slope should be given. The trenches shall be filled with washed stone or crushed gravel. Each trench should not be longer than 30 meters. There should be a gap of atleast 2 m between two trenches.



- Perforated pipes should be placed in trenches. The pipes shall be earthen ware or concrete and with minimum internal diameter of 75-100 mm.
- The pipes should be covered with aggregates (12-15 mm) upto 0.15 m. The trench may be covered with about 0.3 m of ordinary soil.

Advantages of Septic Tank System

- Can be built and repaired with locally available materials.
- Well managed septic tank can remove 50-60 percent of biological load in wastewater.
- Do not require centralised infrastructure and can be used where there is no sewer network.
- The system has long shelf life.
- Requires no energy for functioning.

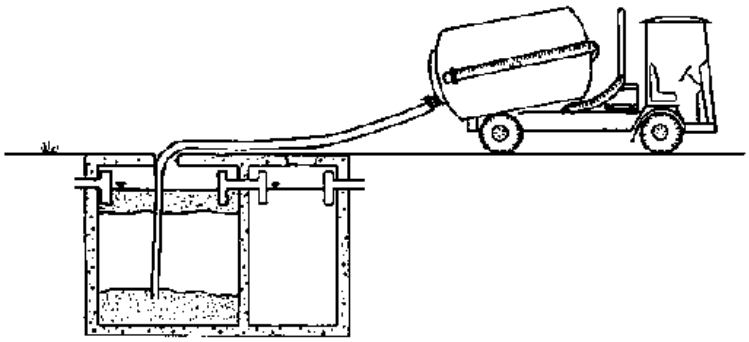
Disadvantages of Septic Tank System

- The system is not suitable in regions with water scarcity, with areas not having enough space to construct the system, areas with very high water table and non-permeable soil.
- The system is expensive in comparison to normal soak pit system.

- The system requires regular emptying of the tank and needs trained professional to remove it.
- The system provides treatment upto primary level only. The waste in the septic tank if disposed into ground or water bodies without treatment, creates high amount of pollution.
- Manual cleaning of the settler tank is highly hazardous, while mechanical cleaning (vacuum trucks) requires sophisticated instruments and involves skilled human resource.

Operation and Maintenance of Septic Tank

- Small amount of water should be poured down the drop pipe daily to maintain the water seal, and to clear scum from the bottom of the drop pipe, in which flies may breed.
- Adding some sludge to a new tank will ensure the presence of micro-organisms and enhance the anaerobic digestion of the excreta.



- Routine inspection is needed to check whether de-sludging is needed and to ensure that there are no blockages at the inlet or outlet.
- The tank should be emptied when solids (scum + sludge) occupy between one-half and two-thirds of the total depth between the water level and the bottom of the tank.
- Tanks should be emptied half year or yearly or atleast once in two years and scum/sludge should be removed. However, frequent de-sludging inhibits the anaerobic action in the tank. While longer duration of de-sludging result in hardening of sludge making it difficult to remove. Hence, normally the tank is designed to remove sludge in between one to two years.
- Septic tank can be de-sludged using mechanical means like vacuum tanker. Manual cleaning should be prevented as it poses high health risk to humans.

4. Dry Toilets (Compost Toilets)

Dry toilets are sanitation systems with minimal/no use of water. Such toilets help in processing of waste hygienically without destroying the nutrients of waste, thus promoting recycling/composting of waste and its reuse (ecological sanitation). Such toilets are also called compost toilets.

Two main methodologies are used for design of such toilets:

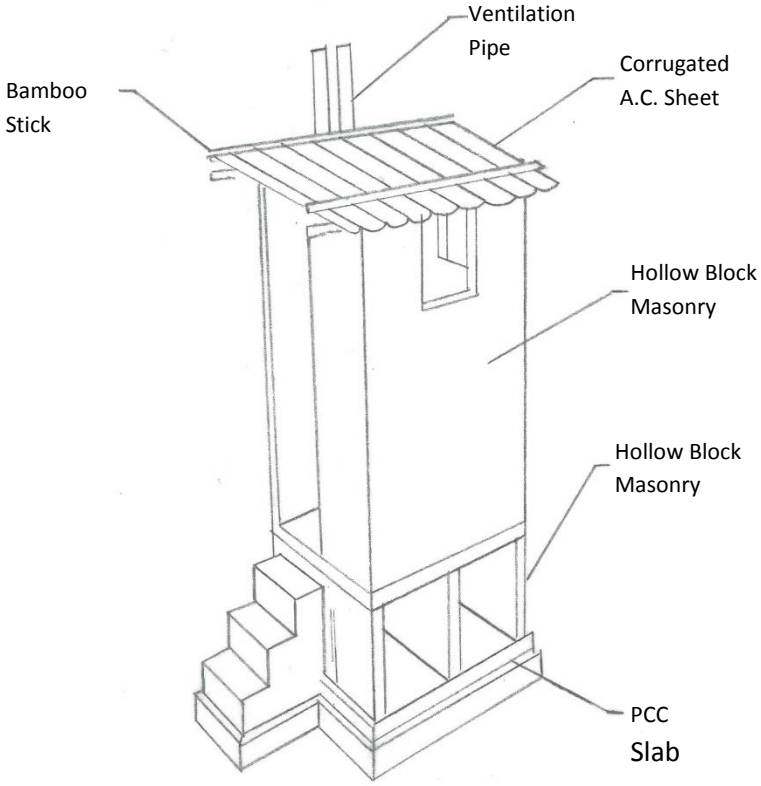
- Dehydrating Toilets: They are used to collect, store and dry/dehydrate faeces. In such toilets liquids like urine, hand and anal cleansing are collected separately and faeces are collected separately. Separation of collection of hand wash, urine and faecal matter is done through built-in separators in toilet units or special toilet pans. The urine/liquid is diluted and directly used for watering of certain types of plants, while the faecal matter is allowed to decompose into organic manure which can be used as compost.

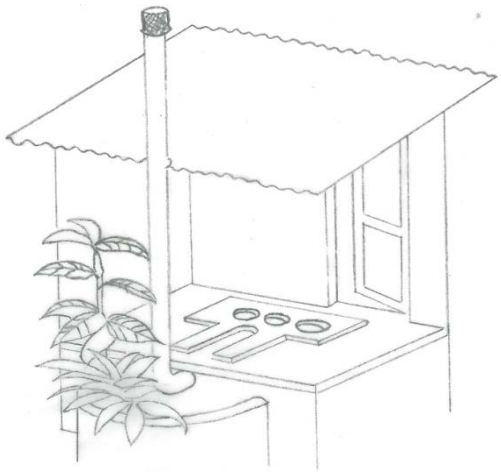
- Composting Toilet: Such toilets utilise process by which biodegradable components are biologically decomposed under aerobic conditions by micro- organisms. In such toilets, urine may not be diverted separately. Hence, saw dust or other organic matter is used to cover and soak up liquid after use. Earth worms are introduced in some toilets for facilitating vermi-composting of faceal matter.

Such systems can be installed at household/community/institutional level.

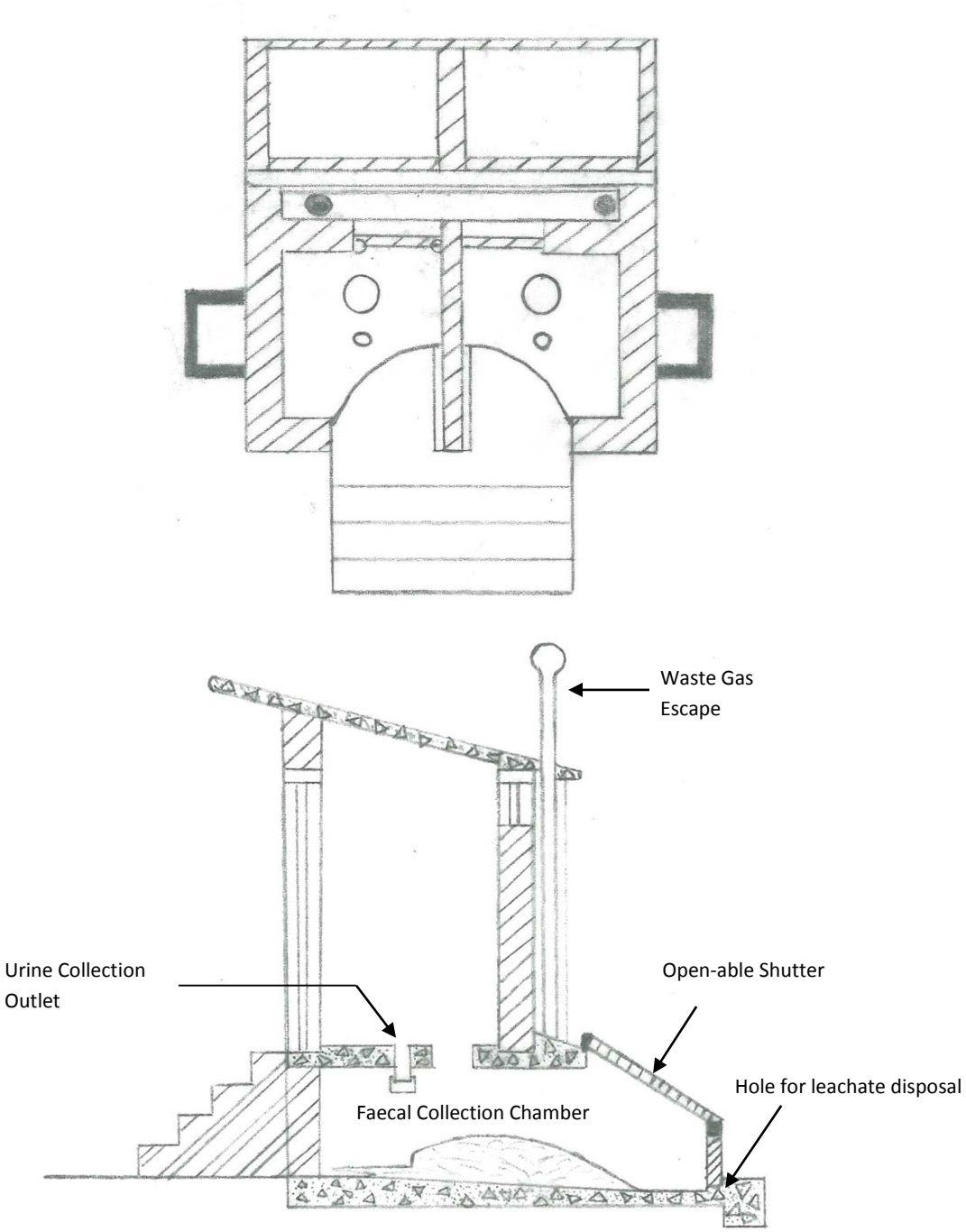
Such system comprise of two compartment/units, which can be alternatively used for every 6-12 months in order to allow decomposition of the faecal matter.

The systems are mainly laid over the ground with suitable foundation to manage wastes. The collection tank of the system is done with plastered masonry or RCC. While enclosure walls can be made as per local requirements. Special toilet pans separating liquids and faecal matter can be installed or precast/in situ RCC slab with holes can also be installed instead. The bottom floor of collection tank is made with PCC for easy collection of waste.





Typical Dehydrating Toilet



Typical Composting Toilet

Advantages

- Low/minimal requirement of water and highly suitable where water availability is scarce.
- Highly useful in saline and flood prone areas with issues of decomposition of waste into soil as well as high water table areas where conventional waste disposal is a major problem.
- Hygienic recycling and reuse of waste.

- Decentralised and require no additional system for waste disposal thus saving on land, infrastructure and cost.

Disadvantages

- Strict control on water use and separation of liquid and solid waste.
- Requires regular operation and maintenance emptying of the manure generated and urine/liquid collected.
- Possibility of odour if not operated properly.
- Low acceptance currently due to lack of awareness about eco-sanitation, higher operation and maintenance and lack of demonstration models.

Operation and Maintenance

- Such systems require collection of urine, hand wash and faecal matter separately.
- The hand wash wastewater can directly be diverted into plantations near by.
- The urine collected in separate tank in dehydrating unit needs to emptied regularly and used as fertilisers with required dilution for certain type of plantation.
- Faecal matter require to be covered each time after use of toilet with dry leaves, saw dust, dried soil, plant ash, lime etc for facilitating drying of the matter and speeding of its composting process, control on odour and flies etc.
- For cleaning of toilet floor, lid is placed on the pan/holes in the slab and the water is diverted into hand cleaning hole/spate holes for disposal of washing water.

B2 Types of Sewer Systems for Wastewater Conveyance

Sewerage consists of a network of underground pipes that convey wastewater from a house to the point of disposal. Sewers remove both excreta and sullage from the household and thereby, do not require on-site servicing making it highly convenient for users. Normally, flush toilets are connected to sewer systems as they consume higher amount of water.

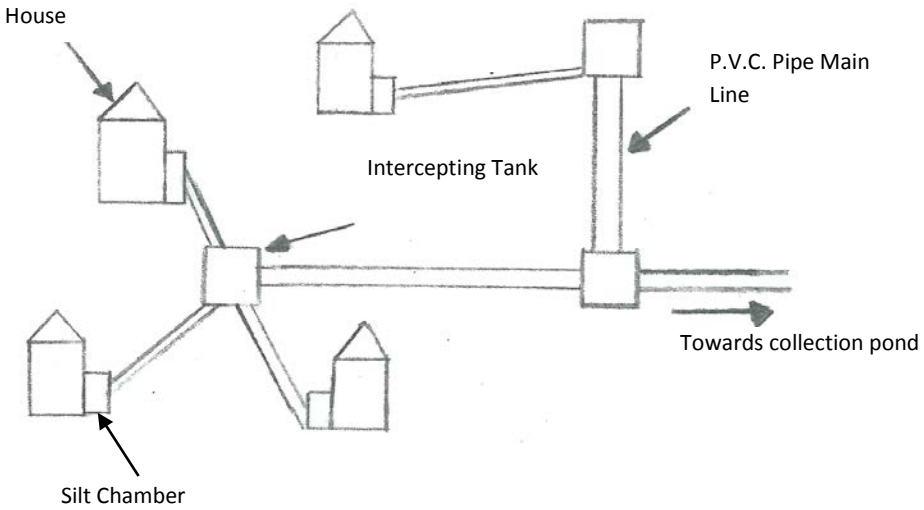
Following are common types of sewer systems:

1. **Open Drains:** Open drain surface sewers are used in rural/peri-urban areas mainly for diverting grey water. They can also carry effluent discharged from septic tanks. But such drains does not provide hygienic disposal. Partial cover to the surface drains with flag stones or RCC slab pieces is not advisable as it may not be cleaned properly.

2. **Small Bore Sewer System**

   Small bore sewer system consists of pipeline networks with intercepting tanks, mainly used for grey water and/or septic tank effluent drainage. The system is laid at shallow depth close to soil surface. The system involves use of smaller diameter pipes. The system provides ease in operation and maintenance.

The system consists of following components:



a. Main Pipeline

Normally, pipeline of diameter 100-150 mm (4”-6”) is preferred depending on peak flow of waste and pipe material. PVC pipes are widely used to prevent silt accumulation, easy joining and comparatively lower cost compared to metal/RCC pipes.

b. Intercepting/inspection tank

Intercepting tanks are laid for catching and cleaning silt instead of man holes in conventional system. The inlet of tanks is connected to one or more household. The tanks provide out let connecting the main pipeline. Plastered masonry tanks with stone/RCC covers are constructed normally of size of 2’-4’ and depth of about 3’-4’. The inlets and outlets of the tank are fitted with “T” fittings to prevent silt from staying in the main pipeline.

c. Household pipelines connected to intercepting tanks:
Normally, PVC pipelines of a diameter 75-100 mm are connected from household level to the intercepting tank.
d. Silt chambers outside individual houses:
Silt chamber is constructed outside house to prevent silt accumulation. Outlet of the chamber is connected to household level pipeline, which is in turn connected to intercepting tanks.

The wastewater collected is then disposed to wastewater stabilisation pond or can be treated through appropriate treatment system.

Advantages

- Flexible design with lower cost and ease in O&M.
- Can be built and repaired with locally available materials.
- Can be extended.
- Useful in very narrow lanes areas with high water table, rocky ground etc.

Disadvantages

- The interceptor tanks can overflow when they have not been desludged in time.
- The system can become blocked because of illegal connections that by-pass the interceptor tank.

Maintenance

- Minimum maintenance includes cleaning, flushing, repairs and supervision of connections and removal of clogging/silt from the inspection chambers.

3. Shallow Depth Sewer System/Simplified Sewer system

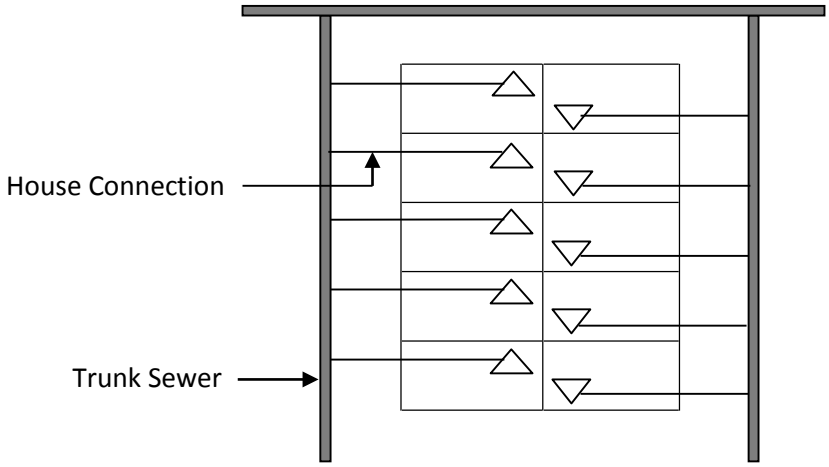
Simplified sewers system for both, grey and black water disposal is constructed using smaller diameter pipes laid at a shallower depth and at a flatter gradient than conventional sewers. It provides flexible design with lower cost and higher number of household connections. Because the sewers are more communal, they are often referred to as condominial sewers

This system consists of house connections, inspection chambers, laterals, street collector sewer which finally disposes waste water into disposal/treatment point. In this system, the manholes (in conventional sewer system) are replaced with simple inspection chambers. Vertical ventilation is provided on house connection. The lateral pipes are of small diameter, minimum 100 mm and minimum depth of pipe invert is 0.4 m. Lateral pipe normally have straight alignment between inspection chambers and are aligned around existing buildings and normally laid in back yards, side-walks etc. Inspection chambers are provided along the street collector sewers and along the length of lateral at intervals not above 40 m. Usually, one chamber is provided in each house. Two or more houses can also share one inspection chamber. The inspection chamber must have RCC air tight cover. The street collector sewer pipe is normally of 100- 150 mm diameter. (Source: Manual of Sewer & Sewerage System, CPHEEO, MoUD, 1993).

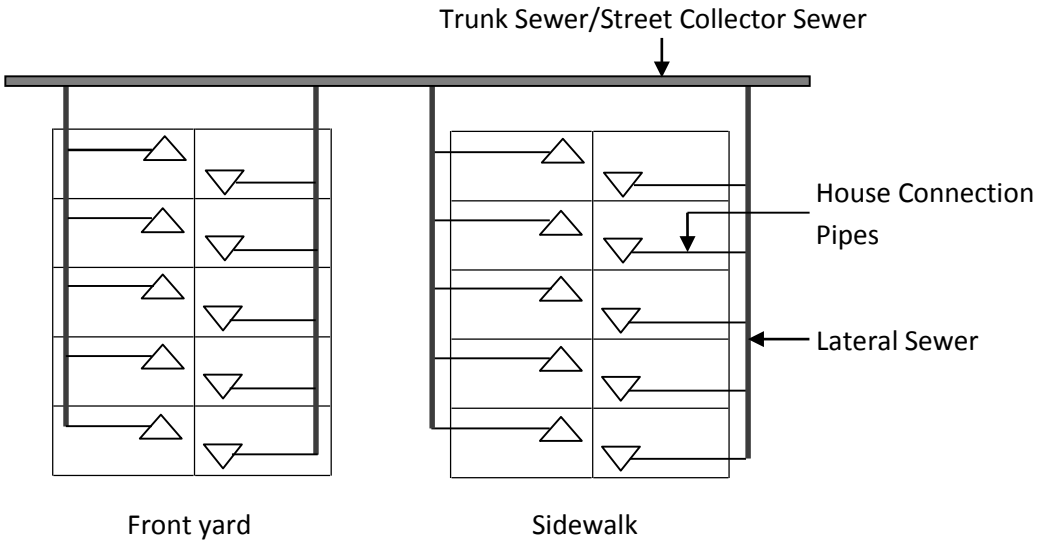
The pipelines are laid normally in gradient of 1 in 200 m. A 100 mm diameter sewer laid at a gradient of 1 m in 200 m (0.5 percent) will serve around 200 households of 5 people 1000 users) with a wastewater flow of 80 L/person/day. (Source: Compendium of Sanitation Systems and Technologies, Water Supply and Sanitation Collaborative Council)

Depth of simplified system is normally 0.65 m below walkways, 0.95-1.5 m below residential street. In case of system laid below heavy traffic roads, it should be laid below 2.5 m. (Source: Simplified Sewerage: Design Guidelines, UNDP, World Bank's Water and Sanitation Program).

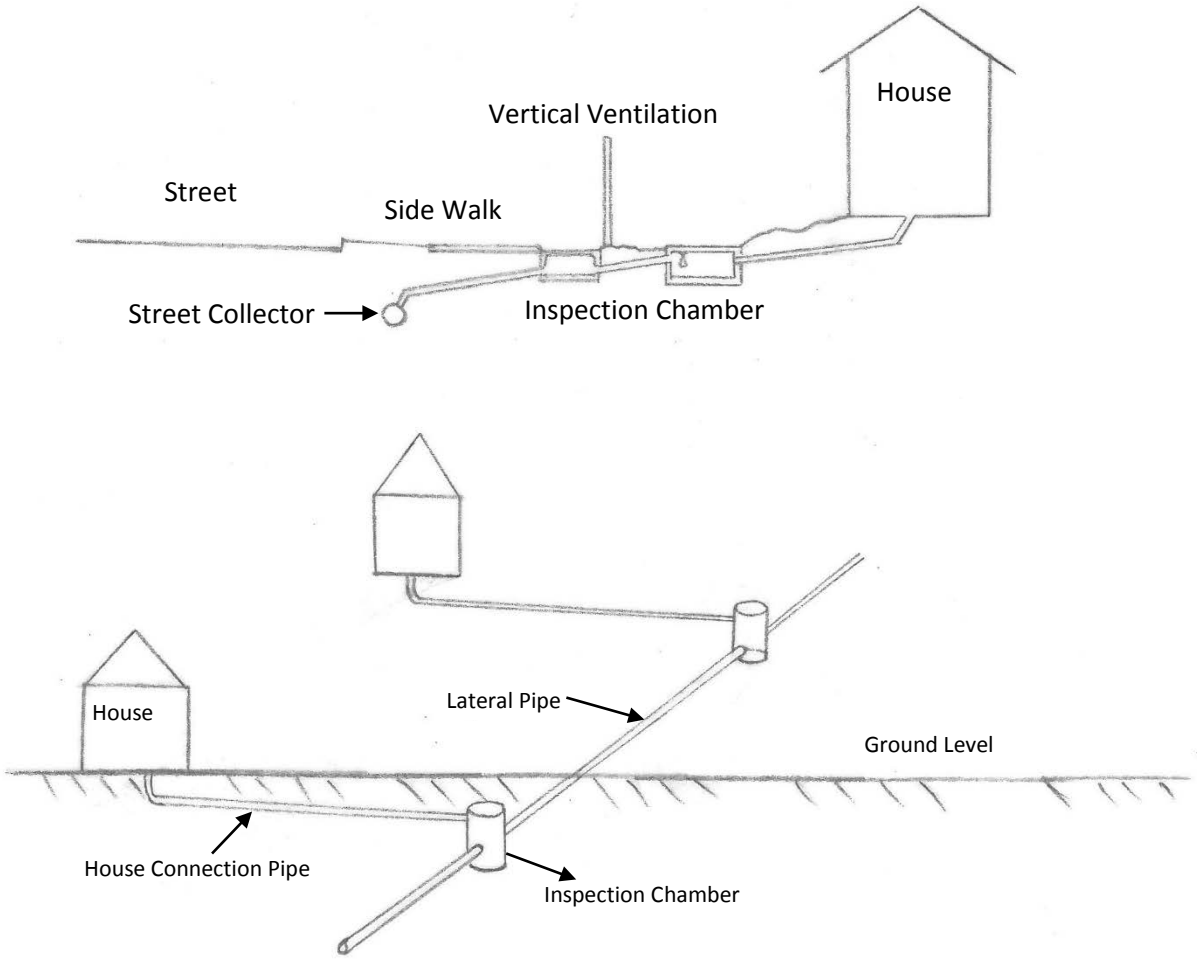
In conventional sewers, trunk pipelines/ street collector pipelines are constructed in streets around the housing units to allow individual connections from each unit. However, in simplified system, wastewater from households in same blocks can be collected through small diameter pipes (lateral pipes) and then delivered to trunk pipelines (refer figure ahead).



Conventional Sewer System



Simplified Sewer System



Typical Simplified Sewer System Section

Advantages

- Lower capital cost than conventional sewer system (normally 50 percent lower cost).
- Can be built and repaired with locally available materials.
- Can be extended.
- Useful in very narrow lanes, areas with high ground water table, rocky areas.

Disadvantages

- The interceptor tanks can overflow when they have not been desludged in time.
- The system can become blocked because of illegal connections that by-pass the interceptor tank.
- This system is more suitable where adequate ground slope is available. In flat gradients, clogging may occur at times.

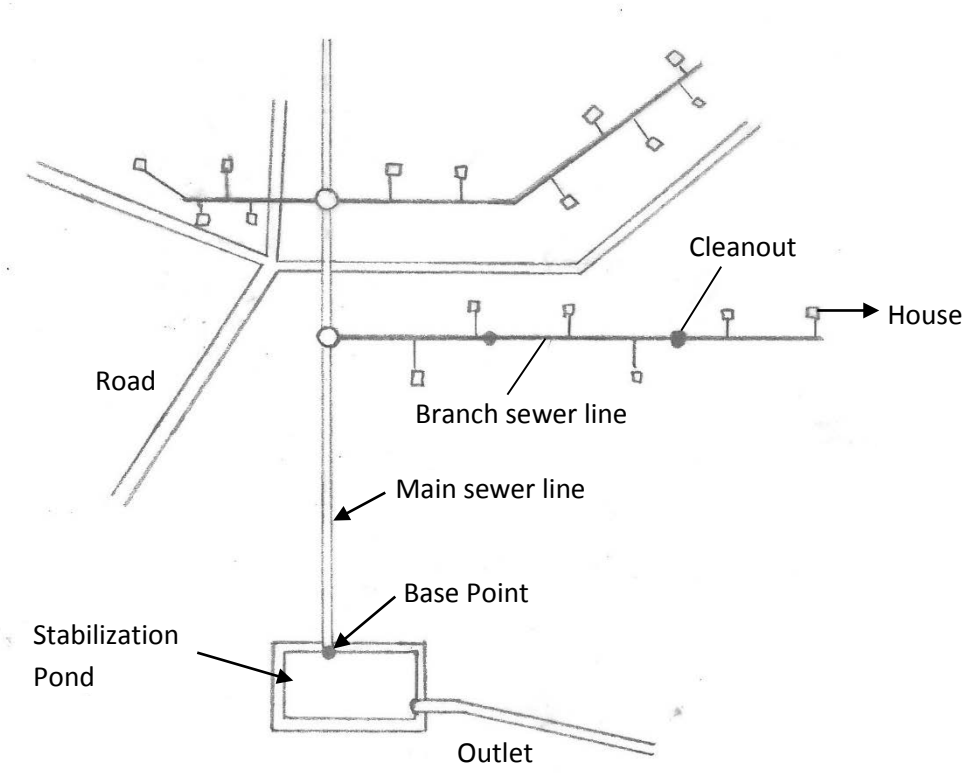
Maintenance

- Minimum maintenance include cleaning, flushing, repairs and supervision of connections and removal of clogging/silt from the inspection chambers.
- Effluent and sludge (from inspection chamber) requires secondary treatment and/or appropriate discharge.

4. Conventional Piped/Gravity Sewers:

They are large networks of underground pipes that convey black water and grey water from individual household units to a centralised disposal/treatment facility using gravity (and pumps where necessary). The Conventional Gravity Sewer system is designed with many branches. Typically, the network is subdivided into primary (main sewer lines along main roads), secondary, and tertiary networks (network at the neighbourhood and household level). The system consists of appurtenances like manholes and junctions etc for effective operation, cleaning/inspection and prevent deposits. Design period for such systems is 30 years. Minimum pipe diameter for such system is 150 mm (Source: CPHEEO). They are laid normally at depth 1.5-3 m. Such systems are highly expensive and require expert planning, construction, operation and maintenance. Pipeline material for such sewer system mainly consist of RCC, high alumina cement concrete, stoneware, asbestos cement, cast iron, ductile iron, rigid PVC and HDPE.

When storm water is combined with this system, it is termed as combined sewer. However, such system is not preferred as storm water increases unnecessary loading to sanitary sewer. Moreover, the storm water does not contain organic load and does not require treatment and can be used for recharging of ground water separately. Hence, separate storm water sewers can be laid. Local/de-centralised recharging can also be taken up where space permits.



B.3 Technology options for Wastewater Recycling and its Disposal/Reuse

The objective of wastewater treatment is to remove harmful pathogens and other waste to certain level so that they can either be disposed off hygienically without polluting natural resources or it could be reutilised for irrigation, gardening and certain domestic uses.

Wastewater treatment involve mainly two processes:

- Primary (mechanical treatment) which separate solid and suspended solids. It can be done in settler tank, septic tanks, sedimentation tank etc.
- Secondary (biological) which breakdown dissolved organic constituent by micro-organisms. It is done through aerobic or anaerobic ponds, baffled septic tank and passing through special type of plantations etc.

Once the wastewater is treated upto certain standards, they can be disposed off into drains or can be reused. Central Pollution Control Board (CPCB) has specified norms in India for discharge of water into inland surface water, public sewers, land for irrigation and marine coastal area.

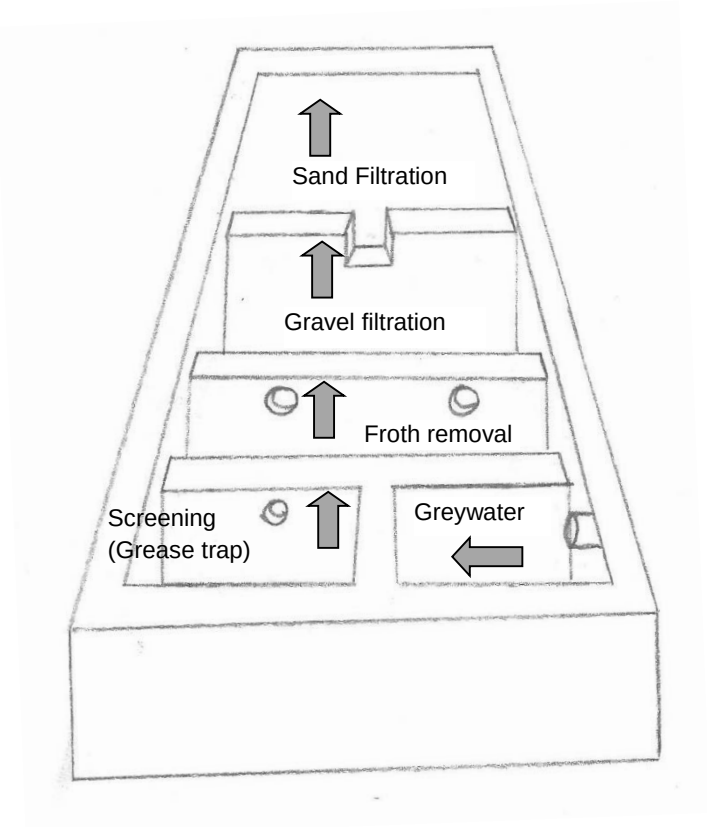
Wastewater recycling can be done at individual, cluster or village/town level. Following are common types of wastewater recycling options:

1. Grey Water Treatment and reuse at household level.
2. Wastewater stabilisation ponds for centralised water treatment.
3. Decentralised Physical and Biological Treatment System.
4. Bio-gas Plant linked with toilet.
5. Sludge/septage treatment.

1. Grey Water Treatment and Reuse at Household Level

This system involves treatment of mainly grey water only. Process involves screening (grease and silt removal), soap froth removal, equalisation and filtration. The system involves three stage filtration at household level with following components in sequence:

a. Inlet Pipe: PVC pipe of about 2" connected from the wastewater source to the inlet chamber of treatment system.
b. Inlet chamber: Size of about 1'x1' size and 4" depth. Sponge is kept in this tank to absorb debris from the wastewater.
c. Gravel chamber: About 1' x 2' size with 1' depth. This tank is filled with gravels.
d. Sand chamber: about 1'3"x 2' size with 1' depth. The tank is filled with fine sand.



e. Storage tank for treated water: As per requirement and use.
f. Outlet pipe: 2" PVC pipe.

The tanks are built of cement plastered masonry structure and removable RCC/stone covers. The base of the tanks is made with cement concrete. The system is laid in manner, which allows flow of water from various tank by natural gradient. Small outlet pipes/holes are placed in gravel and sand chambers to allow water pass to adjacent chambers.

Operation and Maintenance

- Such system requires minimal maintenance.
- The sponge in the inlet chamber require regular washing (once a week or as needed), and changing when needed. The inlet chamber needs cleaning once a month.
- The gravel and sand require regular washing, once in three months or replacement when needed.

Use of treated Water

- Can be done for gardening/kitchen garden etc.
- Such system can also be adopted at community or cluster level and designed according to the quantum and quality of water. Grey water from bathing/washing ghat, wastewater from hand pump/stand post etc. can also be connected to such treatment system.

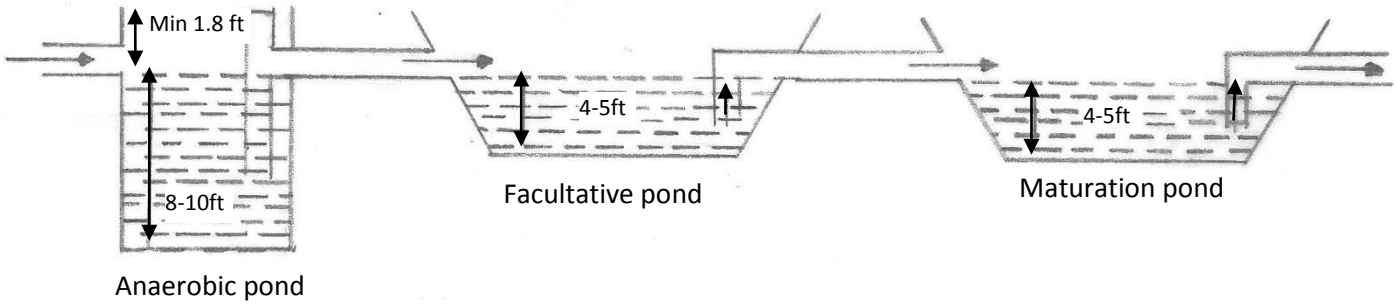
2. Wastewater Stabilsation Ponds for Centralised Treatment

- This system is used to treat waste water collected through sewer system/drains.
- They are also called oxidation ponds/lagoons.
- The wastewater is stabilised by natural processes involving algae, bacteria and natural oxidation processes. The treated water from this system can be used for irrigation.
- These ponds are aerobic in upper layers and anaerobic in lower layers.
- The system consists of various ponds, which are excavated in soil and sides and bottom are densely compacted so that they do not collapse and limits permeability of waste water into soils. Brick lining or plastic sheeting topped with soil can also be done in case soils are highly permeable.
- The treated water from the system can be used for agriculture and aquaculture.
- Hot climate, availability of solar radiations and light are essential for effective functioning of the process.
- Parameters like temperature, rainfall, altitude, groundwater table, soil percolation. Provision of expansion etc should be taken care for design of the system.
- IS 5611 (1987, reaffirmed 2007): Code of Practice for Construction of Waste Stabilisation Ponds (Facultative Type) is followed for design, operation and maintenance.

- Shape
  The shape of the ponds is normally rectangular/polygon. The ponds are rounded at corners in order to avoid waste accumulation. Normally, length: breadth ratio of 3:1 or 2:1 is maintained for better water retention (as per IS 5611).

- Location (as per IS 5611)
  The system is contracted as far away from habitation as possible, preferably atleast 200 m from the habitation also considering the future habitation development.
  Trees should be removed within 30 m from pond edge.
  In homogenous soils, wells should be atleast 15 m from the ponds.

- Components of system in sequence:



a. Anaerobic Pond
   - ✓ In this pond, the solids from incoming waste water settle at the bottom where they are digested aerobically.
   - ✓ Pond has depth of about 8-10 feet.
   - ✓ The hydraulic retention time in the pond is 1-2 days.
   - ✓ The size of pond is design based on approximately 4 m^2/m^3 daily flow (SASSE 1998).

b. Facultative Pond
   - ✓ Partially clarified water from anaerobic pond is discharged into facultative pond.
   - ✓ Three types of processes take place in the pond: aeration from air through the surface, oxidation due to photosynthetic activity of algae, bacterial metabolism and sun light.
   - ✓ The depth of this pond is normally 4-5 feet and hydraulic retention time is three to five days. The length of the pond should normally be three times the width.
   - ✓ Minimum top width of embankment is 4.5 feet and 9 feet in case of vehicle movements.
   - ✓ The embankment slop should not be steeper than 2-2.5 horizontal to one vertical for unprotected embankment and 1.5 horizontal to one vertical for pitched or lined embankment. For sandy/unstable soils, flat slopes should be used.
   - ✓ Dimensions of all the ponds are calculated based on volumetric organic load and retention time.
   - ✓ The size of pond is design based on approximately 25 m^2/m^3 daily flow (SASSE 1998).

c. Maturation Pond
   - ✓ The stabilised water from facultative pond is then treated in maturation pond.
   - ✓ Maturation pond allows destruction of pathogen through aerobic process.
   - ✓ Depth of this pond is normally 4-5 feet and hydraulic retention time is three to five days.
   - ✓ The size of pond is design based on approximately 4 m^2/m^3 daily flow (SASSE 1998).
   - ✓ In case of land constraint, multiple ponds of smaller sizes can also be constructed.

O&M

- Minimal O&M is required.
- Regular cutting of grass on embankments.
- Removal of floating scum from pond surface.
- Mosquito control spraying needed especially in monsoon.
- Removal of sludge at regular intervals.

Advantages

- The system involves natural process.
- Capital cost is low as it mainly requires excavation and soil compaction for construction of ponds.
- O&M cost is low and easy.
- No technical energy required for O&M.

Disadvantages

- Requires adequate open land.
- System functioning is disturbed in monsoon.

3. Decentralised Wastewater Treatment System

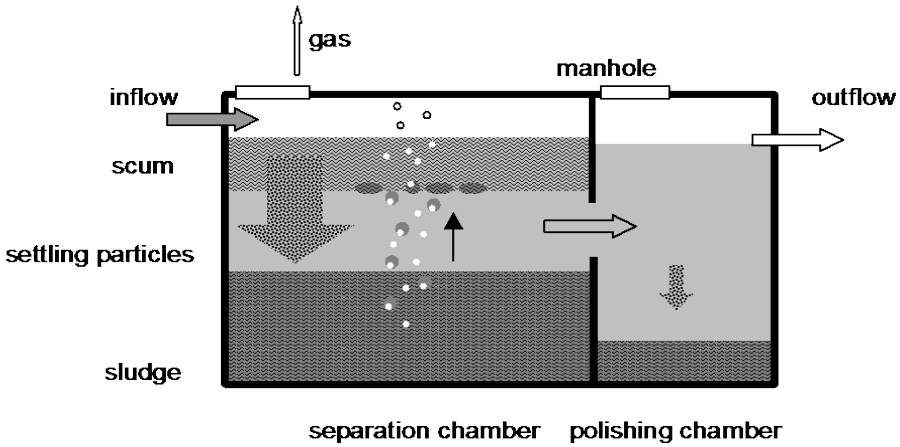
- This system involves decentralised low maintenance sewer water treatment system involving physical and biological treatment.
- This system is widely known as Decentralised Wastewater Treatment System (DEWATS) in India which was developed by Bremen Overseas Research and Development Association (BORDA), Germany.
- The system can be adopted for treatment of 1000 liters (household level) to 500,000 liters/day (rural or town level). However, its major advantage is in adoption of the system at household/apartment/cluster level/housing colonies as well as school/institutional level to minimise the cost on sewer/piping systems.
- This system is simple and flexible without use of any technical energy and use of gravity for functioning as far as possible.
- The system has minimal operation and maintenance cost and can be managed by semiskilled person.
- The treated water can be used for gardening, irrigation, building construction, ground water recharge, aquaculture and even domestic use like flushing. Side product like bio-gas in low quantity can also be trapped from the system.
- Majority of the system can be underground, except planted filter and thus system occupies minimal ground space practically.

<u>System Components</u>

The complete system can be constructed underground except the planted filter and polishing pond. The system can be constructed from cement plastered masonry structure with RCC airtight roof, ferro cement. Prefabricated system especially for household level made of PVC/ ferro cement are also available in market.

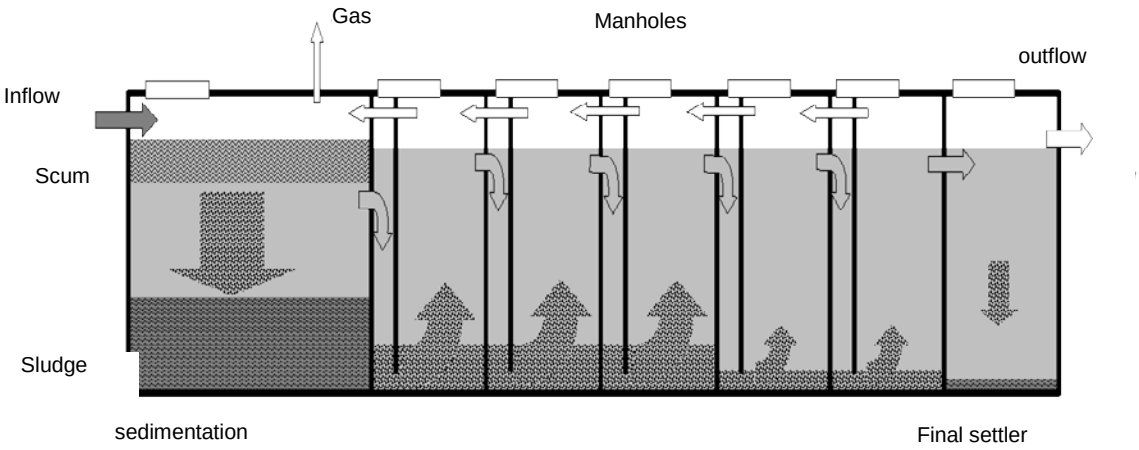
1. Septic Tank

- A sedimentation tank stabilising settled sludge by anaerobic digestion.
- Removes suspended solids to upto 55%. Removal of organic waste 15-25 percent.
- Such tank requires 0.5 sq. m space for 1000 litre of wastewater treatment (Source: DEWATS, Decentralised Wastewater Treatment in Developing Countries, BORDA, Germany)



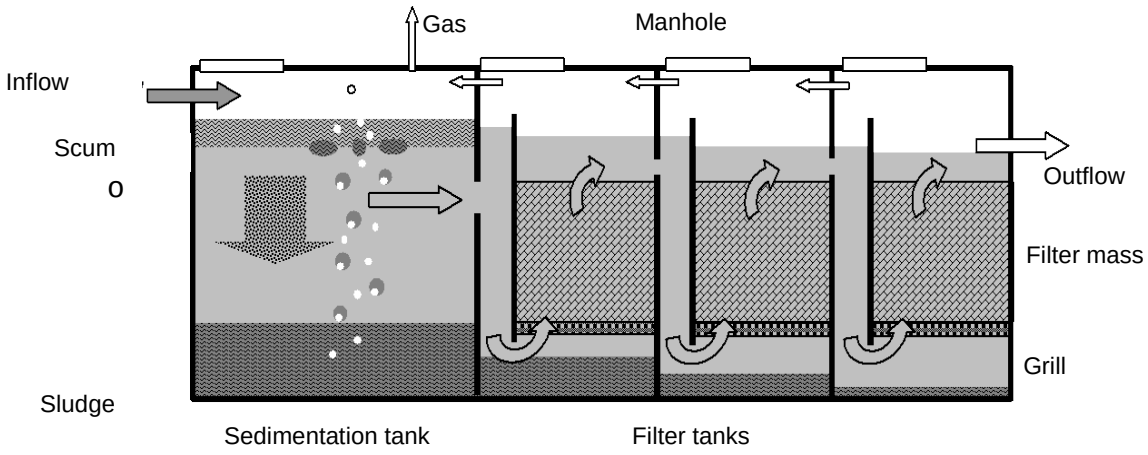
2. Horizontal Baffler Reactor

- Allows anaerobic degradation of suspended and dissolved solids.
- Consists of two to five chambers depending of treatment required.
- Removal of suspended solid upto 15 percent.
- Removal of organic load from 25-35 percent.
- Such tank requires 1 sq. m. space for 1000 litre of wastewater treatment (Source: DEWATS, Decentralised Wastewater Treatment in Developing Countries, BORDA, Germany)



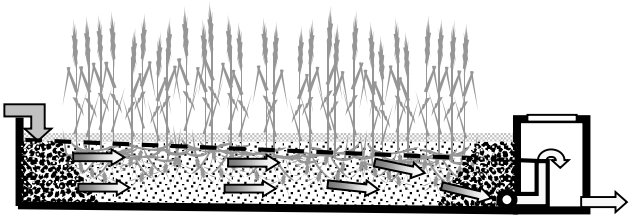
3. Anaerobic Filter

- Consists of sedimentation tank and filter mass like hollow blocks, in-situ/precast RCC jail etc. allowing bacteria to grow.
- This unit enhances digestion of organic matter.
- Removes organic matter from 15-25 percent and suspended solids from 15-20 percent.
- Such filter requires 4 sq. m. space for 1000 litre of wastewater treatment (Source: DEWATS, Decentralised Wastewater Treatment in Developing Countries, BORDA, Germany).



4. Planted Filter

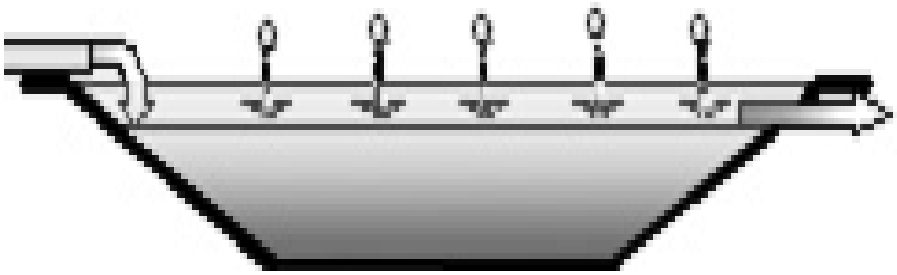
- Open shallow basic filled with gravel/pebbles to support growth of plants/reed with shallow roots.
- Mainly reduces organic content, foul smell and colour and acts as filter mechanism.
- Removes organic contents from 15-25 percent, suspended solids from 5-10 percent.



- Such filter requires upto 30 sq. m. space for 1000 litre of wastewater treatment (Source: DEWATS, Decentralised Wastewater Treatment in Developing Countries, BORDA, Germany).

5. Polishing Pond

- Polishing pond is the last step of treatment. The process involves removal of stabilised or otherwise inactive suspended substances in order to clarify the water physically (for example reducing turbidity).
- It helps in final pathogen removal; water storage until further use; odour removal; and additional removal of BOD; solids; and nutrient.
- This system is optional.
- Such filter requires 4 sq. m. space for 1000 litre of wastewater treatment (Source: DEWATS, Decentralised Wastewater Treatment in Developing Countries, BORDA, Germany).



Advantages

- Decentralised system – useful in areas with space constraint.
- Low operation and maintenance cost.
- Does not require skilled human resources for operation.
- Reuse of treated water.
- Low/Nil post installation management burden.
- Highly useful in saline areas as well as high water table areas where wastewater disposal is major problem.

Disadvantages

- The system is highly useful for treating organic load. However, it cannot treat heavy oils, grease, heavy metals, dissolved salts, and arsenic etc. Hence, it is advisable not to mix small scale industrial wastes with domestic sewer waste.
- Such system is not useful where there is acute shortage of space.
- System design detailed design based on quality and quantity of water to be treated through trained professional.

Operation and Maintenance

- Daily operation includes opening and closing and regulating of inlet and outlet valves as per requirement.
- It is also essential to undertake water quality test of the treated water after 1.5 months of system initiation before it is reused or disposed. Water testing should also be done every six month.
- Following Maintenance Schedule needs to be adopted for such systems.

Element	Maintenance Period	Checklist
Control Valve	Every month	Blockage due to salt and chemicals in water Marking of opening, Breakage
Manholes	Every month	Breakage, Air tight. Corrosion
Conveyance pipes	Every month	Breakage, Sagging/ Distress, Blockage
Settler tank	Every three months	Clean up of sludge/scum Clean up brackishness on walls and pipes due to salt and chemicals in water Leakage from pipes or holes Blockage in pipes
Baffled Reactors	Every six months	Clean up of sludge/scum Clean up brackishness on walls and pipes due to salt and chemicals in water Leakage from pipes or holes Blockage in pipes
Anaerobic Filter	Every six months	Clean up of filter medium Clean up brackishness on walls and pipes due to salt and chemicals in water Leakage from pipes or holes Blockage in pipes
Plantation Bed	Every month	Weeding out grass and shrubs around plantations Cutting plants if required (too dense)
Pipes in plantation bed	Every six months	Blockage in inlet pipes (holes) Blockage in outlet pipes (strains)

4. Bio-gas plant linked with toilet

- Generation of bio-gas from cattle dung has been widely used in India since long. Gas contain large amount of methane, which is inflammable and is used for cooking. The gas can also be used for small lightning.
- Human excreta can also be added to bio-gas plant as feed. Bio-gas of about 2 cubic m is generally sufficient for cooking of 4 persons daily. However, generation of 1 cu. m of gas require excreta of about 25-30 persons per day. Hence, cattle/animal dung is also mixed in appropriate proportion to avail adequate amount of gas.

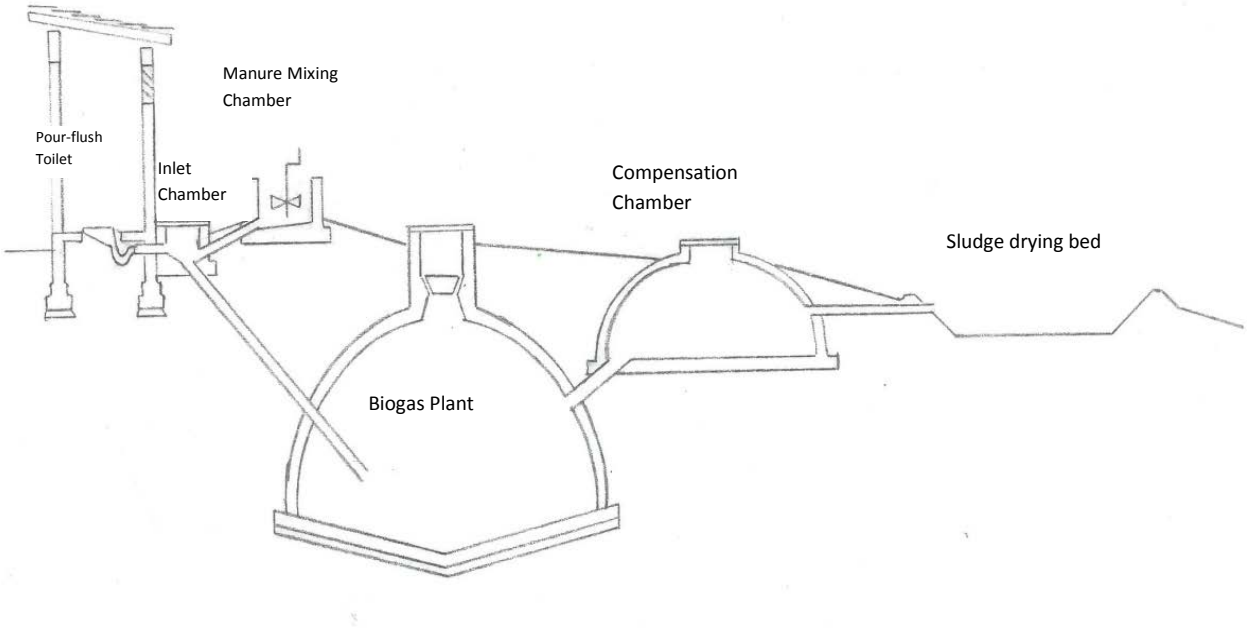
Human excreta yield of gas	0.04 cu. m. gas/person/day
Buffalo dung yield of gas	0.27 cu. m. /no./day
Gas required for lamp -100 candle lamp (60 W)	0.13 cu. m. /hour

Source:
Solid & Liquid Waste Management in Rural Areas, DDWS, MoRD, India
Training Material on bio-gas sanitation, Ecosan Services Foundation, India
Ministry of New and Renewable Energy, GoI. (http://www.mnre.gov.in/schemes/decentralized-systems/schems-2/)

- The centre part of a sanitary biogas unit is the bio-digester (i.e. either a floating-drum or fixed-dome type biogas plant) that receives the animal manure and toilet water from pour-flush toilets and degrades the organics (animal manure, excreta, etc.) an-

aerobically, thus, producing biogas and a slurry (collected in compensation tank). The bio-gas can be used for cooking, while the slurry can be treated in sludge drying beds and used as manure. The fixed dome type of system is widely used at household level and is less expensive than the floating drum. However, floating drum type provides gas with constant gas pressure. Floating drums are highly effective for institutional level system.

- Use of water is toilet should be minimal for effective production of bio-gas as specific proportion of solid content needs to be maintained. Toilet pan which require low water flushing may be installed in such toilets.
- Normal retention time of such plants is about 60 days, after which it starts generating gas.
- The bio-gas plant is made of cement plaster masonry structure, ferro cement, pre-fabricated fibre glass or RCC etc. The digester is normally below the ground level.



Operation and Maintenance

- Daily feed of cattle dung mixed with appropriate amount of water.
- Sludge from the digester needs to be removed atleast once in five years and further treated prior to reuse/disposal.
- The slurry should be disposed off regularly or treated for manure.
- The treatment of slurry/sludge can be done in sludge drying beds.

Advantage

- Provides ecological sanitation through scientific disposal/treatment of wastewater.
- Provides clean fuel/energy and organic manure.
- Low operation and maintenance cost.

Disadvantage

- Low social acceptance of gas generated for cooking.
- Requirement of cattle dung on regular basis as feed.
- Requires trained mason for construction of plant.
- Requires appropriate operation, maintenance and servicing for effective running.
- Production of gas is not very feasible in regions with cold climates (below 15^{o} C).

5. Sludge/Septage Treatment and Disposal

- The sludge/septage collected in septic tanks, wastewater treatment systems and stabilisation ponds, bio-gas plant etc. should be removed are treated prior to its disposal/reuse.
- It is odorous and can create health hazards, if disposed directly into water bodies or soil, mainly due to presence of pathogens. It also has adverse impact on aquatic animals if disposed into water bodies directly.
- Its treatment can be done is various ways. The treatment type is selected based on land availability, infrastructure for transportation, technical expertise, and local conditions etc.
- As per IS 2470-1985 part 1, volume of digested sludge/septage is 0.00021 m^3 per capita per day.

5.1 Sludge/Septage Treatment System and its Reuse

5.1.a Sludge Dewatering

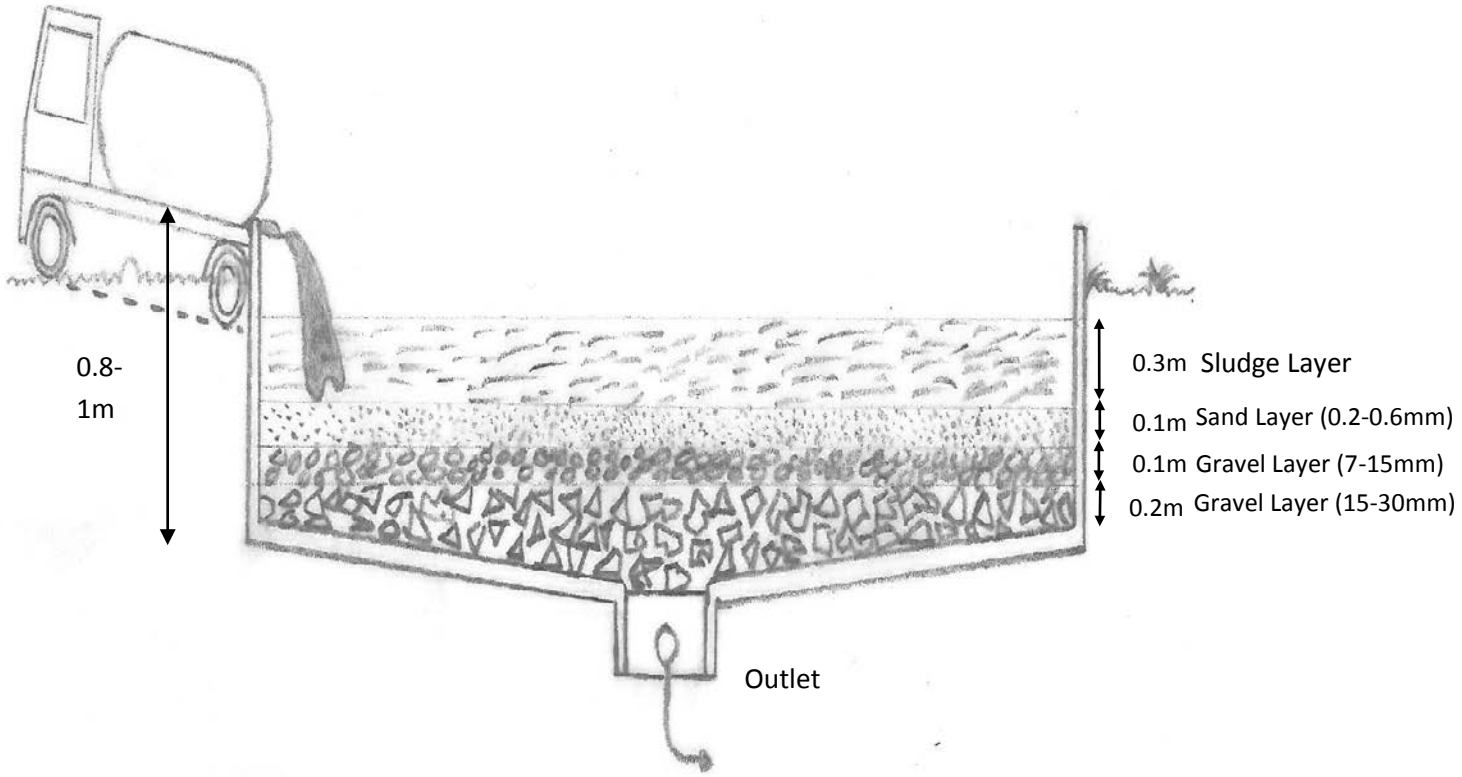
Dewatering removes water from sludge making it easier to handle and less expensive to transport for further treatment system/landfill site. Dewatering can be done through mechanical means, or processing in drying beds. Mechanical dewatering often require use of chemicals (coagulants and flocculants like lime etc.) to enhance the process. Mechanical dewatering is expensive compared to drying beds and is used for large amount of waste and where land availability is constraint.

The filtrate from dewatering unit is further required to be treated in waste stabilisation pond, anaerobic baffled reactor, constructed wetlands, or aerobic treatment systems etc. before discharging into environment. While the dewatered sludge can be used as organic fertiliser after composting or can be treated in common sewage treatment plants if any.

Sludge Drying Beds are mainly two types: Planted drying beds and Unplanted drying bed.

a.1 Unplanted Sludge Drying Bed

- It is a simple, permeable bed that allows separation of leachate/liquid part of sludge from its solids. It further allows the leachate collection at bottom separately and allows the solid sludge to dry by evaporation reducing pathogens in it.
- The bed frame is lined with concrete or plastic sheeting and given appropriate slope for collection of leachate. The bottom of the drying bed is lined with perforated pipes that drain away the leachate. Sand and gravel layers are placed on pipes (see details in figure ahead) for better infiltration of liquids. The bed can be covered with roof in monsoon in order to prevent rain water enter the beds.
- The sludge is placed in the bed in layers not more than 20-30 cm, as the sludge will not dry effectively. After about 10-20 days, depending on weather, the sludge will get dried and can be removed for further treatment. About 50-80 percent of sludge/septage volume drains off as liquid. New sludge can be applied to the beds only after the dried sludge from prior batch is removed. Where there is more sludge production, more than one drying beds can be constructed which can work simultaneously.
- Normally land requirement for such system is 0,05 m^2 per capita for a 10 days cycle. On an annual basis, about 100-200 kg total solid/m^2/year can be applied to drying bed. (Source: www.sswm.info). The total depth of the unit may be 0.8-1 meter.
- The leachate is further treated in stabilisation pond or any other treatment system. While the solid sludge is further treated for composting or treated in common sewage treatment plants if any.

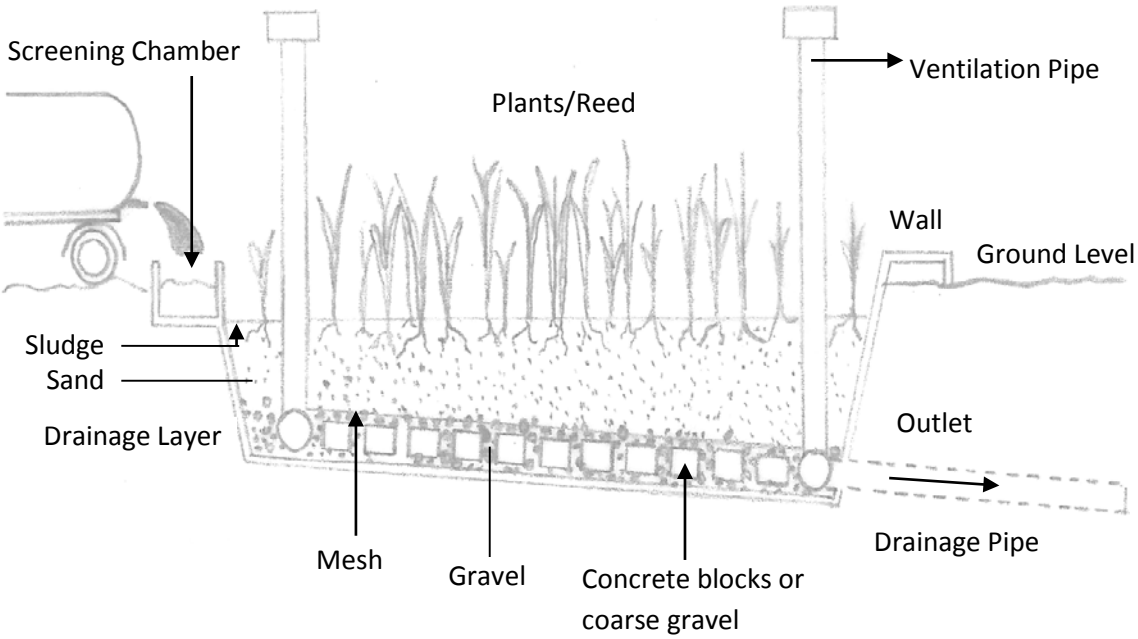


a.2 Planted Sludge Drying Bed

- A Planted Drying Bed is similar to an Unplanted Drying Bed, but provides higher transpiration and does not require de-sludging after each feed/drying cycle.
- Fresh sludge can be applied directly onto the previous layer; it is the plants and their root systems that maintain the porosity of the filter.
- This technology provides benefit of dewatering as well as sludge stabilisation.
- The bed frame is lined with concrete of plastic sheet and slope provided in such a manner to separate leachate/liquids.
- The layer in the bed can be designed in following manner from bottom:
    1. 250 mm of coarse gravel (grain diameter of 20 mm)
    2. 250 mm of fine gravel (grain diameter of 5 mm)
    3. 100–150 mm of sand.
    4. Free space of 1 m above sand for accumulation of sludge for 3-5 years.

- When the bed is constructed, the plants/reeds should be planted evenly and allowed to establish themselves before the sludge is applied. Plantations should be selected based on climate and availability.
- Sludge should be applied in layers between 75 to 100 mm and should be reapplied every three to seven days depending on the sludge characteristics, the environment and operating constraints. Sludge application rates of up to 250 kg total solid/m^2/year can be done.
- The sludge can be removed after three to four years depending on climate and drying. However, prior to removal it is advised to stop applying new sludge for about one to two years. In such way, the treated sludge solid is nearly pathogen free and can be re-used directly as bio-solid/manure in agriculture or applied into land fill.
- The leachate has passed from the plants and is relatively treated, but requires further treatment in polishing plant etc prior to its disposal/reuse.

As the sludge drying beds may have some odour, it is advisable that such beds are constructed as far away from the habitations for hygiene purpose. However, odour is reduced in planted drying beds.



Operation and Maintenance of Drying Beds

- Sludge feeding on regular basis as per requirement.
- Sludge removal upon drying (10-15 days in unplanted bed, every three to four years in planted bed depending on climate).
- Drainage pipe verification and cleaning when needed for better percolation of leachate.
- Refill/replacement/cleaning of sand /gravel layer – once in six months.
- Cutting of plants/weeds as per requirement.

Advantage of drying beds

- Economical compared to mechanical dryers.
- Can handle high amount of sludge loadings.
- Lower operation costs compared to mechanical dryers.
- No electrical energy required.
- The planted drying beds provide benefit of continuous feeding and longer duration for removal of treated sludge. Moreover, it provides relatively pathogen free solids, which can directly be used for agriculture and does not required further treatment.

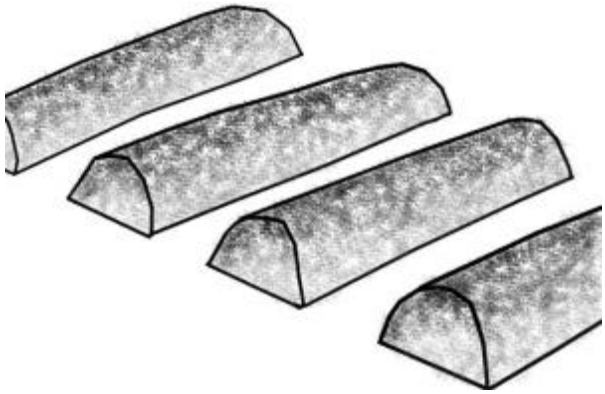
Disadvantage of drying beds

- Requires large land area.
- Odour and flies menace is associated with system.
- Labour intensive removal of the treated material.
- Provides partial treatment and the treated solids (only in case of unplanted drying beds) and leachate (from planted/unplanted drying beds) require further processing.

5.1.b Co-Composting

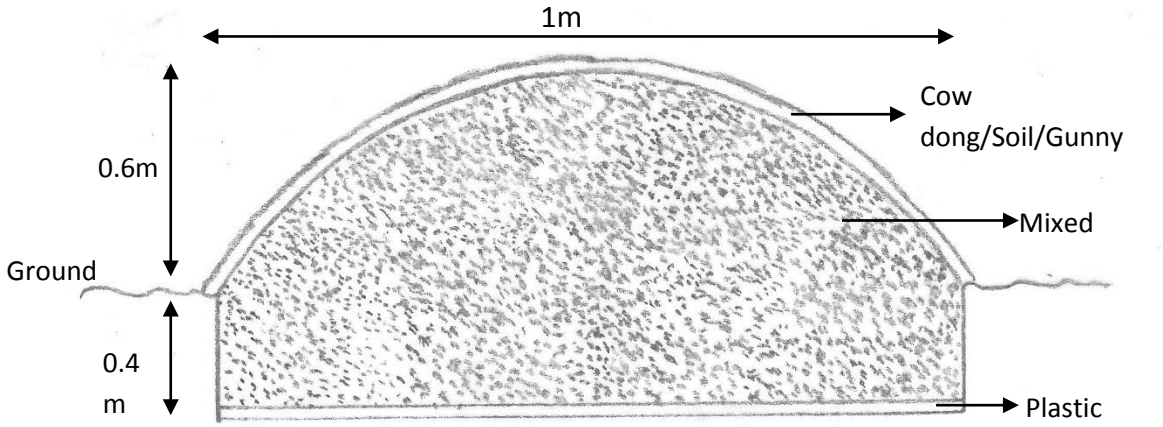
- Co-composting indicates treatment of sludge/septage also with bio-degradable municipal solid waste. The sludge/septage has high moisture and nitrogen content, while biodegradable waste have high organic carbon and good bulking properties. Combining both can optimise composting process and better final product in form of manure.
- This system can treat liquid as well as dewatered sludge/septage.
- The ratio of dewatered sludge: solid waste is normally 1:2 to 1:3. However, ratio of liquid sludge: solid waste is normally 1:5 to 1:10.
- The compost treatment can be done in open land or in vessel. However, in vessel, composting requires controlled moisture and air supply as well as mechanical mixing, which makes it unsuitable and less economical for decentralised and small wastes. Hence, open treatment is mostly preferred in rural and per-urban areas. Earth worms can also be introduced while composting for better quality manure.
- Normally, in aerobic compost treatment, the weight of output (compost/treated waste) is 50-60 percent of total input (sludge + solid waste).

Open Composting Procedure



- The mix (sludge and solid waste) is piled into long heaps/rows called windrows on ground or they can be treated in long pits/trenches partially underground.
- The total land area required for a 3 tonne per day compost plant is about 810 m^2. (Source: www.sswm.info)
- The piles are normally 3.5 m in length and 1 m in width. Piles are atleast 1 m high and are covered with soil/cow dung for providing heat in the pile and speed up composting process. In case of pits/trenches, the waste heaps are placed such that they are about 0.6 m above ground. For about 5000 kg compost output/ 8000 kg input, 16-20 heaps/rows are preferred (based on local practices in India).
- The system may require cover/roof to prevent rain water percolation in the heaps and to prevent excessive drying of the mix. The cover may be made from net tied on metal/bamboo poles for economy.
- The piles are turned periodically (twice a week for first two weeks and later, once in every 10 day) to provide oxygen and equal treatment of the material.
- The temperature of the pile should increase to about 65º C in the first week and then go down to 40º C over the next few weeks. After about 21 to 60 days, the material is matured and the pile should be left without turning for some weeks depending on the local conditions. Normally, the compost is ready within 25-40 days in hot climates.
- In vermi-compost technology, waste is placed in trench/pits only for treatment. Moreover, bottom is covered with plastic sheets for maintaining moisture. Earthworms as available in local market are introduced on top layer of heaps. In such system, temperature and moisture needs to be maintained to ensure survival of worms. Hence, as per need water is sprinkled on the heaps. The heaps can be covered with gunny bags/jute bags for retaining temperature and moisture.

The produced compost can directly be used for agriculture as manure



Typical Cross Section of Vermin Compost

Advantage of co-composting

- Easy set up.
- Lower infrastructure and O&M cost.
- Can also be managed by local community based groups.
- Output material does not require any further treatment and can be directly reused.
- Can be done at decentralised and even centralised level.

Disadvantage of composting

- Requires large land area.
- Requires proper moisture and temperature maintenance for better quality compost preparation and earthworm survival.

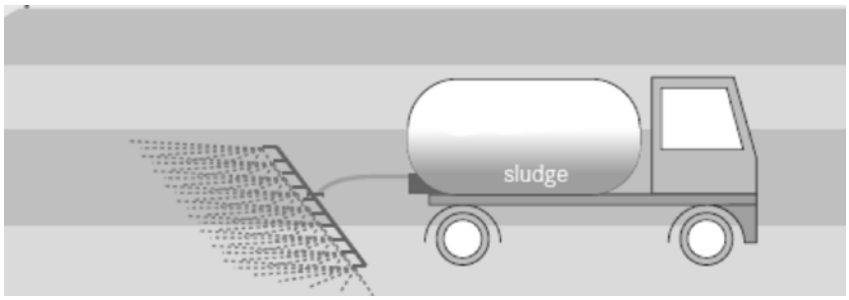
5.1.c Co-treatment of Septage in Sewage Treatment Plants.

- Co-treatment of septage/sludge along with domestic sewage at a sewage treatment plant (STP), if available, is also one of the options for its treatment. However, STPs are not very economical and has very high O&M costs. Moreover, the sewage treatment plants should have adequate capacity to accept the septage without hampering the functioning of the sewage treatment plant.

5.2 Sludge/Septage Bio-solids Disposal

5.2.a Land Application of Bio-solids

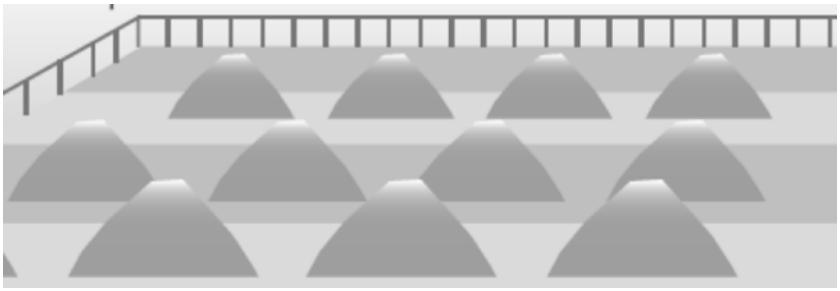
- Digested/stabilised sludge/septage also referred as bio-solids can be applied to land for agriculture. Normally, the stablised sludge from the drying beds can be applied to land.



- However, if ground water table is very high, such system should be avoided as it may percolate ground water and contaminate.
- Bio-solids are spread on the ground surface using manure spreaders, tank trucks or specially designed vehicles. Application rate should be designed based on soil and bio-solid characteristics.
- Use of bio-solids into land can increase its water retention capacity and reduce soil erosion.

5.2.a Surface Disposal of Bio-solids

- Surface disposal refers to stockpiling of bio-solids or application underground in landfills. This is done when bio-solids cannot be reused.



- In case of land fill under the ground, bio-solids should not be mixed with municipal solid waste in the landfill. Separate places can be allocated for it.
- The disposal site should be away from water courses and habitations. Such system should be avoided where ground water table is very high or in that case, plastic lining on the ground should be done.
- The waste should be covered with soil to maintain hygiene and prevent flies and stray animal menace.
- This method should be used only when bio-solids cannot be further treated or reused as this system occupies space and there are not benefits out of it.

Activity Sheet

Section B Technology Options for Sanitation and Liquid Waste Management

1. What is current sanitation scenario and liquid waste management in your village/town?

2. What are the advantages or issues with current sanitation and liquid waste management scenario in your village/town?

3. Suggest and outline of sanitation system and liquid waste management system that can be adopted/modified in your village/town.

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Source for photos on cover page:

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- www.eepco-tz.org

The Performance Assessment System (PAS) Project

The Performance Assessment System (PAS) Project aims to develop appropriate methods and tools to measure, monitor and improve delivery of water and sanitation in cities and towns in India. The PAS Project includes three major components of performance measurement, performance monitoring and performance improvement. It covers all the 400+ urban local governments in Gujarat and Maharashtra.

CEPT University has received a grant from the Bill and Melinda Gates Foundation for the PAS Project. It is being implemented by CEPT University with support of Urban Management Centre (UMC) in Gujarat and All India Institute of Local Self-Government (AIILSG) in Maharashtra.

PAS Project

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