UNIT – 3
RURAL SANITATION Conservancy, Public Latrine, Concept of Eco-sanitation, Trenching and Composting methods, Two pit latrines, Aqua Privy, W.C., Septic Tank and Soak Pit.

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RURAL SANITATION

The main objectives of Rural sanitation in villages can be dealt under the following heads:

1) Provision of safe and potable water for domestic purposes
2) Collection and disposal of dry refuse
3) Collection and disposal of waste water
4) Disposal of excretal waste

1) To provide Safe and Clear water for Domestic use: Village water sources are mainly rivers, lakes, ponds and wells. A river can be accepted as source of water if it has not been polluted upstream. Lakes and ponds can be sources of water also. Provided the catchment area of these lakes and ponds are not contaminated by daily defecation by people or animals.

Wells are the best source of water for rural areas. Well water used for domestic purposes should be regularly disinfected.

2) Disposal of Dry Refuse: Dry refuse consists of all sorts of dry wastes except excretal waste from latrines. It includes house sweepings, vegetable wastes, rags, glass pieces, paper, etc. They do not give any foul smell nor create any nuisance. They can be disposed of by any of the following methods.

1. Dumping in low-level areas for land reclamation
2. If dry refuse is of organic nature, it may-be disposed of by incineration
3. The organic dry refuse, specially animal dung, can be disposed of by the method of composting, and the byproduct may prove to be a very good manure

3) Collection and Disposal of Waste Water: Waste water consists of water used for domestic purposes, it includes water from bathrooms, kitchens, house washings, washing of clothes, etc. It does not contain any excretal refuse, therefore, is, not very dangerous. It can be disposed of by any of the following methods:

1. May be used for watering the trees or kitchen gardens in the house.
2. If the waste water available is more in quantity, it can be utilized for farm work in broad irrigation
3. It may be lead to the composing pit to help easy decomposition of compost material
4. May be carried outside the village by open drains and admitted into natural watercourse

4) Disposal of Excretal Waste: The excretal waste from houses is collected and disposed of suitably. This system is called conservancy system of disposal, which includes night soil and urine from latrines.

Methods of Disposal of Sewage :

There are two methods of disposing wastes of a locality :

- Conservancy System ; and
- Water Carriage System.

Conservancy System:

The system includes disposal of the different types of refuses separately in the following manner ;

1. The night soil or faecal matter is collected in pans or buckets from residences and then carried away by carts or trucks to a suitable site. Here it is buried in trenches and covered with alternate layers of dry earth. The night soil is used as manure later.
2. The refuse, garbage, etc., are collected from streets in pans or baskets and conveyed to a suitable place in carts or trucks. The organic refuse is burnt and the rest buried in low-lying areas.
3. The sullage water and storm water are collected in open drains and led away to a nearby stream.

Disadvantages of Conservancy System :

- The night soil is removed only once in the day and decomposition takes place causing insanitary conditions. It attracts flies which spread diseases like cholera, dysentery, etc.
- The system depends on labour and in the event of a strike or any stoppage of work, the locality is polluted.
- Plenty of suitable land is required for disposing of night soil.
- Improper disposal of sewage would result in outbreaks of epidemics e.g. Cholera.
- Night soil carts pass through densely inhabited areas and cause nuisance.
- The sullage and storm water is carried in open drains which breed mosquitoes and cause insanitary conditions.
- The liquid waste from latrines is likely to soak into ground and pollute underground water supply.

Water Carriage System :

In this system, water is used to convey the sewage for disposal. The sewage consisting of solid faecal matter and liquid waste is conveyed underground in suitably designed sewers.

The advantages of this system over the conservancy system are :

- More hygienic as sewage is carried in closed sewers. Hence no risk of epidemics.
- The area of land required for treatment works, etc., is less.
- Modern methods of treating sewage can be adopted before disposing it off.
- Water closets could be located within the residential establishment s conveniently.

Trench Composting :

Trench composting, or trenching, is a way of composting by burying food scraps directly in the garden. This method of composting is good for composting materials that attract rodents such as meat, dairy, breads, and processed foods. It is also a safe and effective way of composting pet waste. Trenching is a great a way of depositing nutrients into your soil at the exact place where plants need it – at their root zones.

Trenching is the act of burying the organic waste directly into the garden soil. The advantage of this method over conventional composting is that it enables you to compost meat, grains, dairy, and cooked left over foods that contain oil in addition to other kitchen scraps. Because these items attract rodents and flies, it is recommend to don't put them into the regula

compost. By burying them in a trench one can avoid these problems, since neither rodents nor flies will be able to access the material if it is 45 cm (18") underground. And all is needed is a shovel!

Trenching is also a safe method for composting pet waste. Because the waste is buried in the ground, the risk of pathogen spread is very unlikely. However, pet waste should not be trenched near edible food crops.

Trenching is an excellent method to use in combination with growing annual plants, especially heavy feeding plants like cabbage, corn, and squash. It also encourages the development of deep, water conserving root systems. Trenching utilizes anaerobic (without oxygen) decomposition to create an underground band of nutrient-rich humus for the plants. This is a slower composting process than that which occurs in a well-managed backyard bin, but the trenched materials will retain more nitrogen during the process.

Procedure for trenching :

1. Dig a hole or trench in your garden 45-60cm (18-24") deep and as wide and long as is practical – a shovel's width is usually fine. Pile the soil up beside your trench.
2. Fill the bottom 15 cm (6") of your trench with your nutrient-rich food waste and organic materials, and fill in the hole with the excavated soil. Make sure the materials are quite moist before you bury them.
3. Top with a layer of organic mulch material (i.e. leaves or straw). Alternatively, you can also sow a cover crop to protect the soil from the elements and suppress weeds in the time it takes for the trenched materials to decompose.
4. You can trench compost at any time of the year. Trenching in late fall ensures that your soil is ready for your heavy feeding spring and summer plants. Summer trenches are also effective, building up the soil's nutrient and organic matter content.+

Trench composting offers some great advantages:

- It virtually eliminates all smell and rodent problems if materials are buried at least 45cm (18") deep and well covered with garden soil.
- The anaerobic process will retain more nutrients than hot composting which loses much of its nitrogen in the decomposition process.
- It requires no investment in containers or materials, all you need is a shovel.

COMPOSTING METHODS :

Composting of refuse is a biological method of decomposing solid wastes. This decomposition can be affected either under aerobic conditions, or under anaerobic conditions, or both. The final and product, is manure, called the compost or humus, which is in great demand in European countries as fertilizer for farms.

Basically, composting is considered to be an aerobic process, because it involves pilling up of refuse and its regular turning, either manually or by mechanical devices, so as to ensure sufficient supply of air and oxygen during its decomposition by bacteria, fungi and other microorganisms, like antinomycetes. Initially, the process starts with the mesophilic bacteria, which oxidise the organic matter (in the refuse) to carbon dioxide and liberate heat. The temperature rises to about 45% C, and at this point, the thermophilic bacteria take over and continue the decomposition. During this phase, the temperature further rises to about 60^0 C, which has to be maintained for at least 3 days in order to destroy pathogenic bacteria. Optimal decomposition occurs between 55 and 60^0C, but if the temperature exceeds 60^0C, decompositio slows down. In about 4 to 5 weeks, along with progress in decomposition temperature of th compost mass starts falling. Complete stabilisation occurs after the compost is allowed to cure fo

another 2 to 8 weeks. During the active early decomposition phase, the thermophilic bacteria act as the principal decomposers, while fungi are more active during the curing stage. The entire composting, thus, gets completed in about 3-4 months time. The finally produced compost usually, has earthy smell and a dark brown colour.

Moisture content of the compost mass should, however, be controlled to ensure optimum aerobic decomposition, because excessive moisture will make it difficult to maintain aerobic conditions, while deficient moisture inhibits biological life. Moisture content of about 55% should be established, so that aerobic biological activity may proceed at an optimum rate. It may, therefore, become necessary to add water to the compost mass during its turning, for maintaining satisfactory moisture content.

Methods of Composting :

In India, the composting is practiced in rural areas on the mixture of night soil and refuse. Two methods, which are generally adopted here, are :
(i) Indore Process : and (ii) Bangalore Process.

INDORE PROCESS (Windrow process or Aerobic process) :

This process uses manual turning of piled up mass (refuse + night soil), for its decomposition under aerobic conditions. In this method, layers of vegetable wastes and night soil are alternatively piled in depths of about 7.5 to 10 cm each, to a total depth of about 1.5 m in a trench, or above the ground to form a mound called a Windrow.

A windrow is a long mound or stack of the organic MSW (mixed with cattle dung and human excreta if needing disposal) dumped on land in a height of about 1.5 m to 2m, usually about 2.5 m to 3 m wide at the base. Most windrows are conical in cross-section and about 50 m in length. The composting waste is aerated by periodically turning with a pitchfork can be adopted at smaller installations. While at larger plants, mechanical devices like self-propelled overcab loaders, rotary ploughs, etc. may be used to turn the refuse once or twice per week, which serves to introduce oxygen and to control the temperature. Buildozers and Pocklain machines are used for reshaping the stacks and for forming new ones. The moisture content of the turning mass is maintained at about 55% for getting optimal decomposition of the waste mass. This process of turning is continued for about 4 to 5 weeks, during which time, the readily biodegradable organics are consumed. The waste compost mass is finally allowed to cure for another 2 to 8 weeks without any turning. The entire composting process, thus takes about 3-4 months time to complete, after which the compost becomes ready for being taken out for use or for sale.

BANGALORE PROCESS (Pit process or Anaerobic process) :

This involves anaerobic decomposition of wastes, and does not involve any turning or handling of the mass, and is, hence, cleaner than the Indore method. This method is, therefore, widely adopted by Municipal authorities throughout India. The refuse and night soil, in this method, are, therefore, piled up in layers in an underground earthen trench (about 10m x 1.5 m x 1.5 m). This mass is covered at its top by layer of earth of about 15 cm depth, and is finally left over for decomposition.

Within 2 to 3 days of burial, intensive biological action starts taking place, and organic matter begins to be destroyed. Considerable heat gets evolved in the process, which raises the temperature of the decomposing mass to about 75^0C. This heat prevents the breeding of flies by destroying the larvae. After about 4 to 5 months (depending upon the season), the refuse gets fully stabilised and changes into brown coloured odourless innocuous powdery mass, called "humus". This humus is removed from the trenches, sieved on 12.5 mm sieves to remove stones,

broken glass, brick bats, etc., and then sold out in the market as manure. The empty trenches can again be used for receiving further batches of refuse.

The initial **C-N ratio** and moisture content of the compost heap are the two important controlling factors in the success of anaerobic digestion, which finally produces a compost free from pathogens and contains 1% N, 1.1% P (as P_2O_5), and 1.5% K (as K_2O) on dry basis, thus proving to be valuable nutrient for the soils, along with producing biogas as a by-product.

VERMI – COMPOSTING :

Vermi-composting uses the natural composting of decomposition of biodegradable organic matter by the soil bacteria – as in ordinary composting techniques described earlier, but takes the assistance of cultured earth worms, that are now produced commercially. These earth worms do help in quicker decomposition of the organic matter. The method helps in adopting the composting technique in individual bungalows and institutions, to dispose of the domestic waste, and more particularly for disposing of the yard and garden wastes, particularly the leaves and grass clippings, which cannot be thrown away with MSW in countries like USA. The various steps involved in applying the vermi-composting technique at individual domestic level are summerised below;

(i) Dig a small pit-about 0.5 m square and 1 m deep.
(ii) Line the pit with straw or dried leaves and grass.
(iii) Organize the disposal of organic domestic waste (such as vegetable wastes) into the pit as and when generated.
(iv) Introduce a culture of worms that is now produced commercially.
(v) Cover the pit contents daily, by sprinkling of dried leaves and soil every day.
(vi) Water the pit once or twice a week to keep it moist.
(vii) Turn over the contents of the pit every 15 days.
(viii) In about 45 days, the waste will be decomposed by the action of the microorganisms.
(ix) The produced humus (soil) in the pit is fertile and rich in soil nutrients. It can, hence, be used in the garden.

SANITARY LATRINES

The following types of latrines are commonly adopted. The type to be adopted depends on the soil conditions, level of water table and economy.

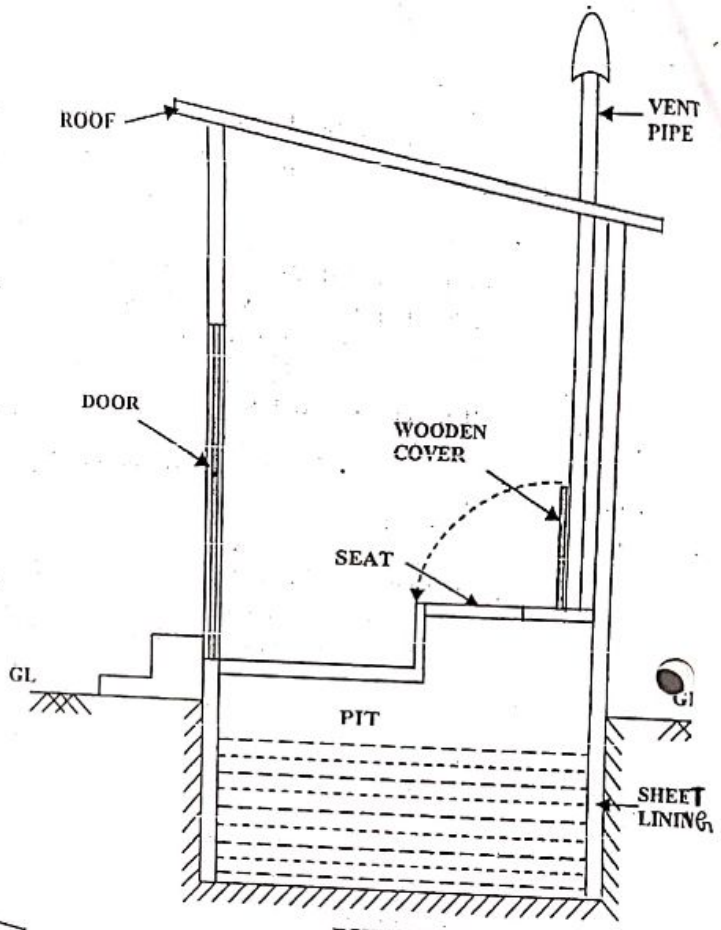
1) Pit privy
2) Pail privy
3) Cesspool
4) Aqua privy
5) Bore- hole latrines
6) Sanitary latrines
7) Concrete vault privy

1) Pit privy: The pit privy consists of a pit of 1m square and 1.3m deep. The sides are sometimes lined with wooden planks or GI sheets. But the bottom is not lined. The pit is covered by the squatting seat. The seat is provided with a wooden cover with a hinge, which can be kept closed, when not in use. A vent pipes are provided to allow foul gases to escape. A temporary shed is constructed above the seat. Lime should be sprinkled periodically to reduce odours.

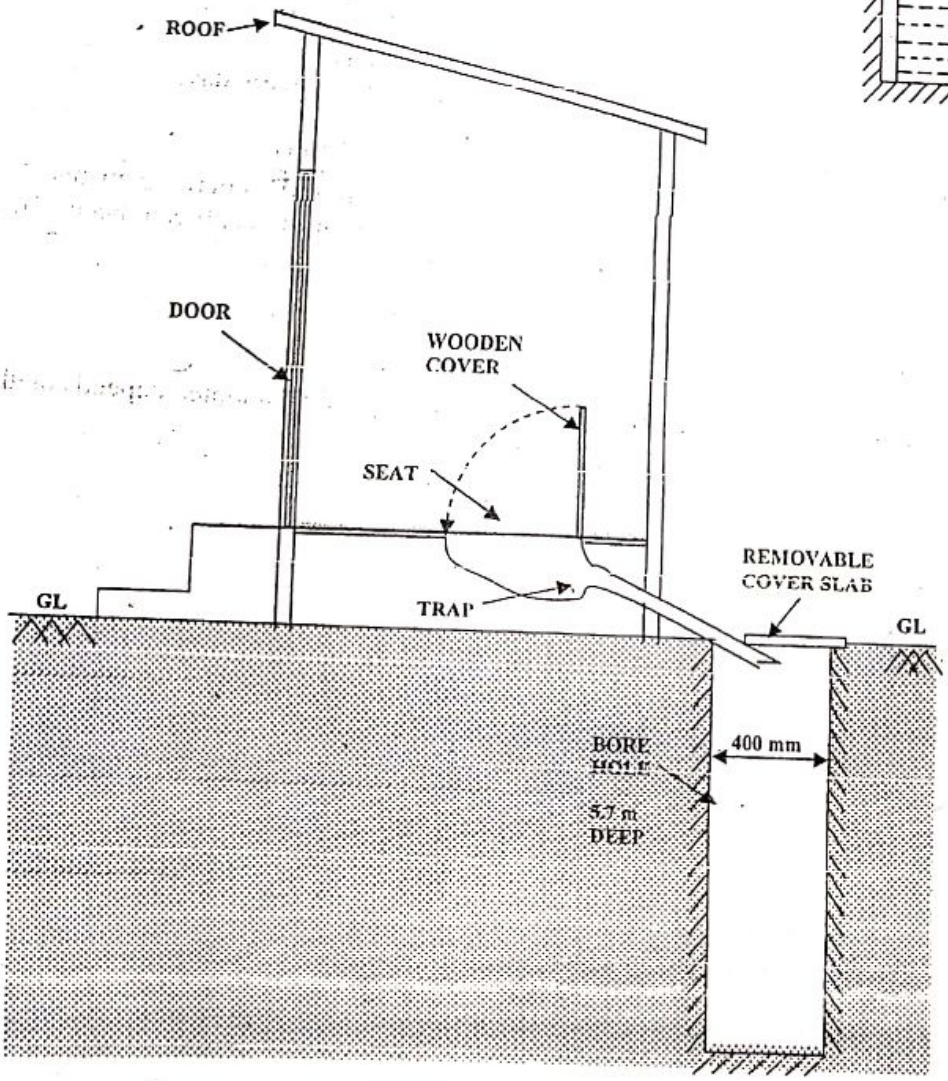
When the pit is filled, it is covered with earth of 0.6m thickness and abandoned. The compartment and seat are shifted to another site.

This method is useful when:

1) The water table is low
2) No surface drainage is admitted into pit
3) No well is located with in 30m



PIT PRIVY



2) Bore-hole Latrine This is similar to pit privy except that instead of a pit, a hole of 400mm diameter is drilled. The depth of the bore should be 1m above the ground water table to prevent the ground water being polluted.

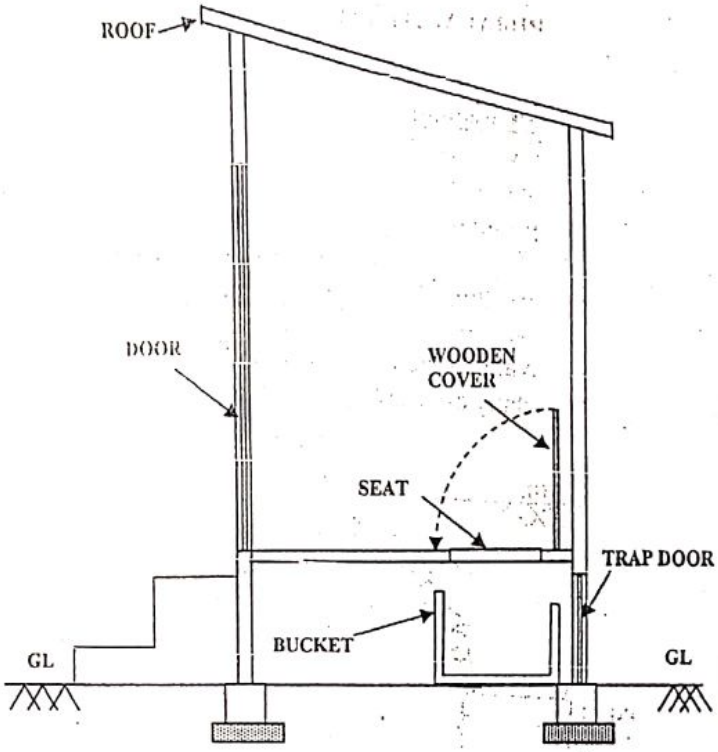
An improved bore- hole privy is shown in Fig. A hole is drilled outside the compartment. A trap is provided which reduces fly nuisance and odours. The conditions for which this type of latrine is suitable are the same as pit privy.

When the hole is filled, it is covered with a thick layer of earth and another hole is dug nearby. After two or three years, the contents could be used as manure.

BORE HOLE LATRINE

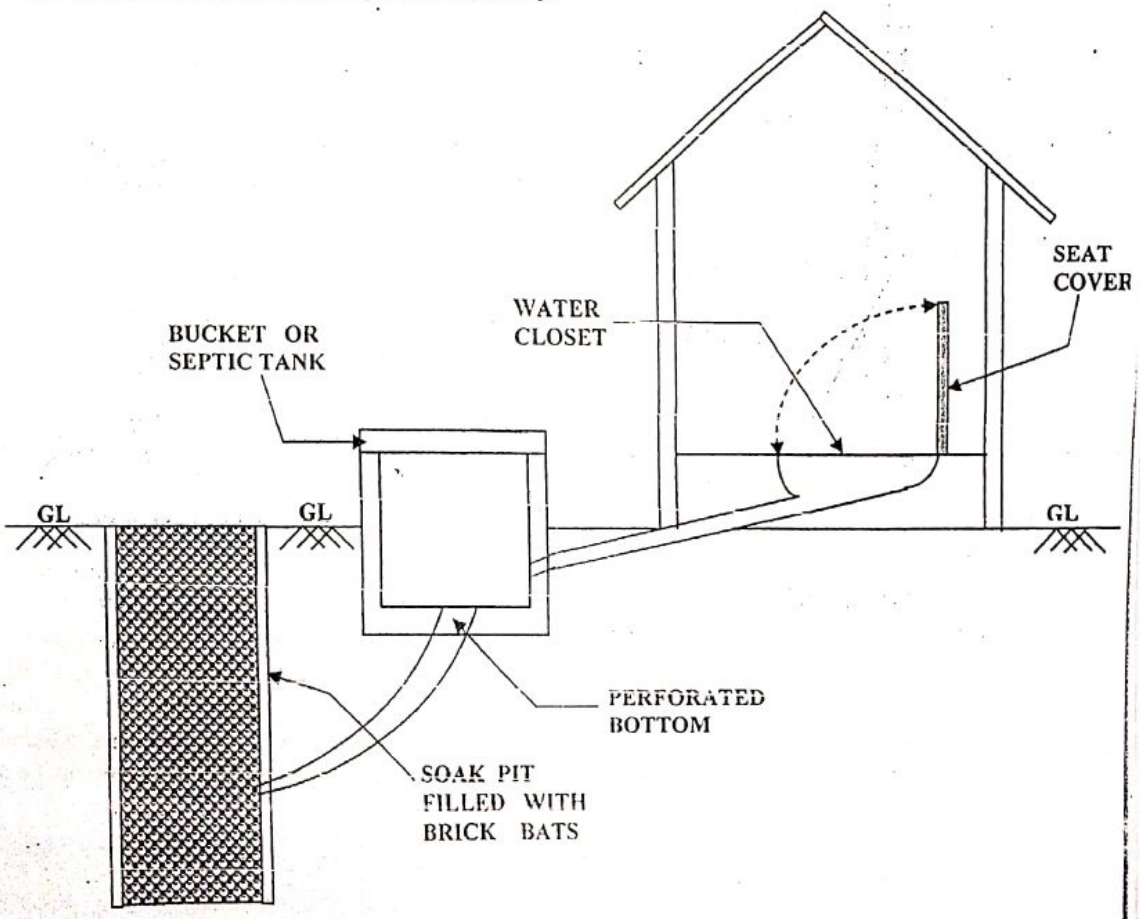
3) Pail Privy or Tub Privy: In this type, buckets or boxes are placed bellow the seat. An enclosure is provided around the squatting seat. The bucket or box has holes under earth to allow the ablution water to escape. This water is collected in a pit near by. The night- soil is removed by sweepers. A trap provided near the ground. The night-soil is then collected in trucks and disposed of far away.

Note: In all the preceding methods, wherever a squatting plate is used, a trap can be fixed to the bottom of the plate below the hole so that foul gases may not come out as the water in the trap prevents the same.



PAIL PRIVY

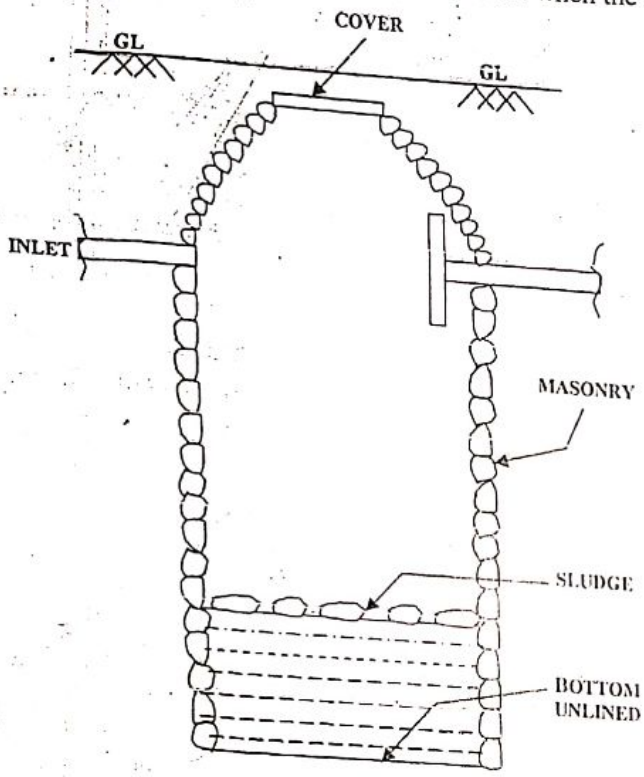
4) Sanitary Latrines: In this type, a septic rank or a bucket is provided for collecting the night-soil. The effluent is discharged in to a soak pit. The soak pit is filled with clinker or brickbats. The water closet is flushed or water poured manually.



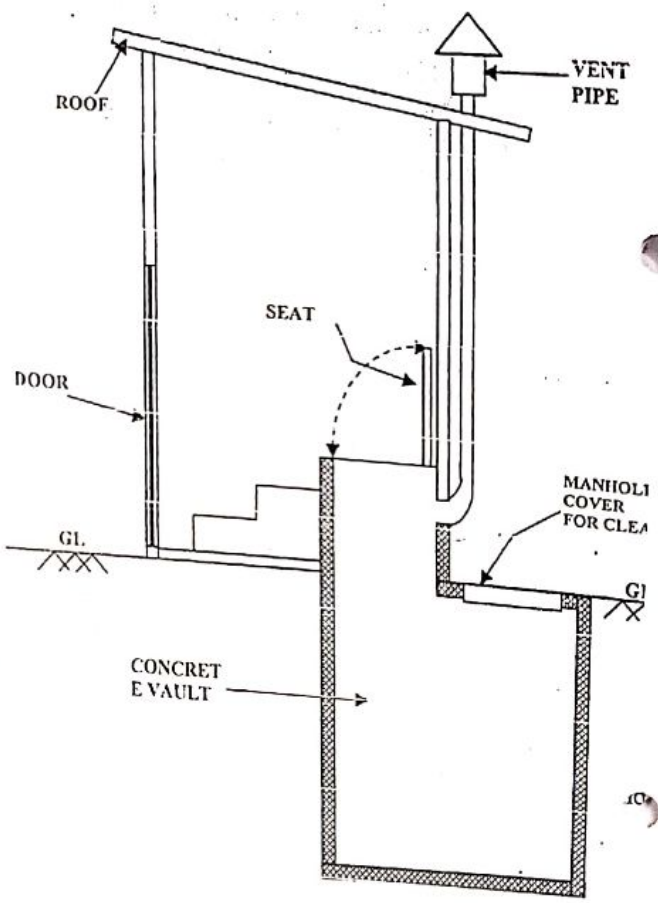
SANITARY LATRINE

5)Cesspool: This consists of a masonry chamber into which the faecal matter is discharged from the water closet. The sludge collects at the bottom and when the cesspool is filled up, it is emptied and materials disposed of suitably. It is cleaned once in 2-3 years. This may serve one house or a group of houses.

6)Concrete Vault Privy: In this type, a concrete vault or chamber is provided under ground. The squatting seat with the compartment is placed over the chamber so that water will not enter the vault. When the chamber is filled, it is emptied and cleaned. To prevent foul smell earth is thrown daily after use. This type is useful when the water table is high and soils are pervious.

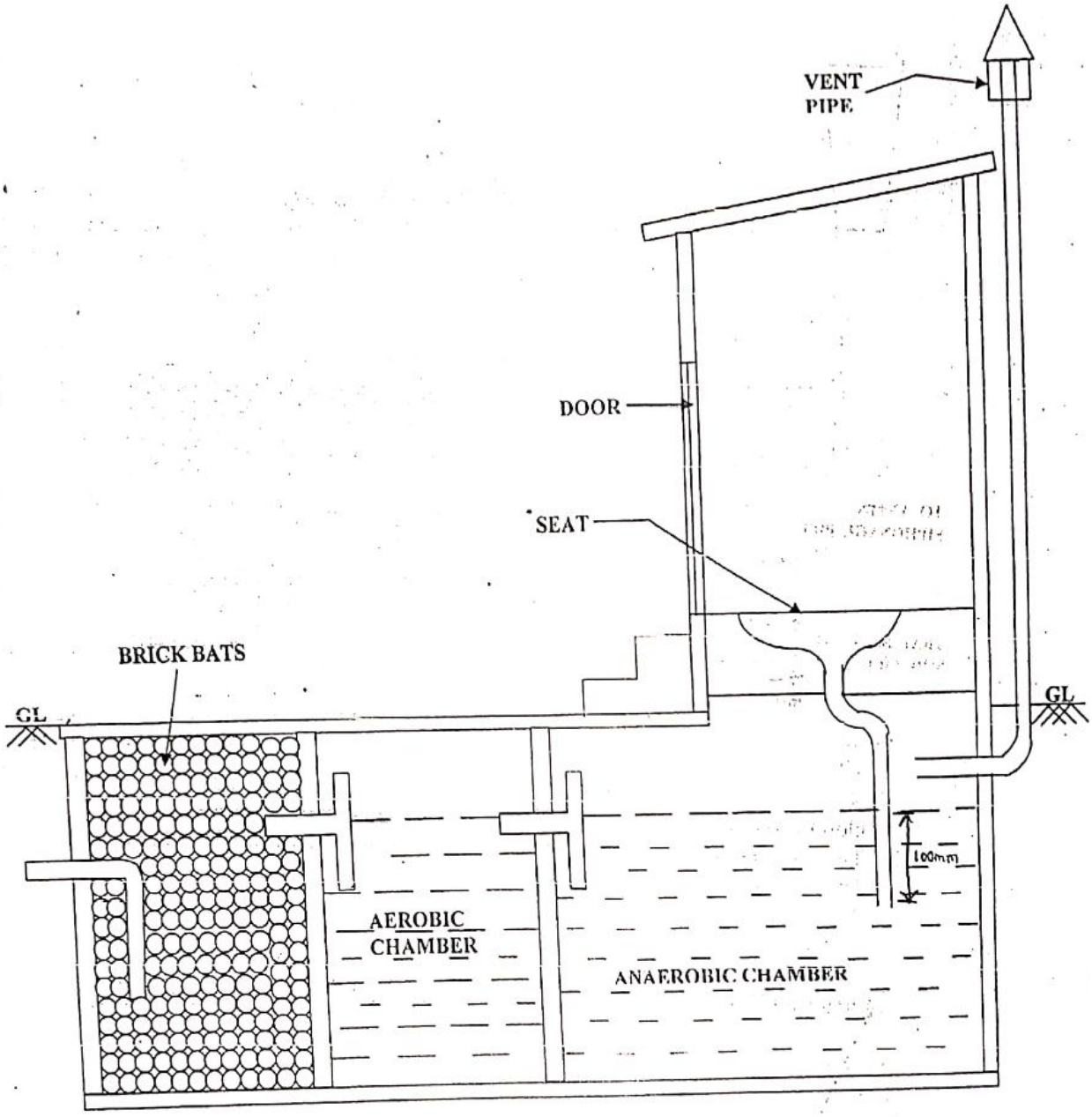


CESS POOL



CONCRETE VAULT

7)Aqua Privy : This type consists of three underground masonry chambers, the first two filled with water (aqua means water). Latrine pans enclosed in compartments are fixed on top of the masonry tank. The water-closet pipe is extended to 100mm below the water level to maintain water-seal. The organic matter in the first chamber is decomposed by anaerobic bacteria. The gases produced escape through the vent pipe. In second chamber, the organic matter is decomposed by aerobic bacteria. The sludge collects at the bottom and is cleared once in two years. The effluent is discharged into the third chamber, which is filled with clinker by means of a long bent pipe. As the effluent rises, it is purified. The water collected can be led to a nearby watercourse or used for gardening.



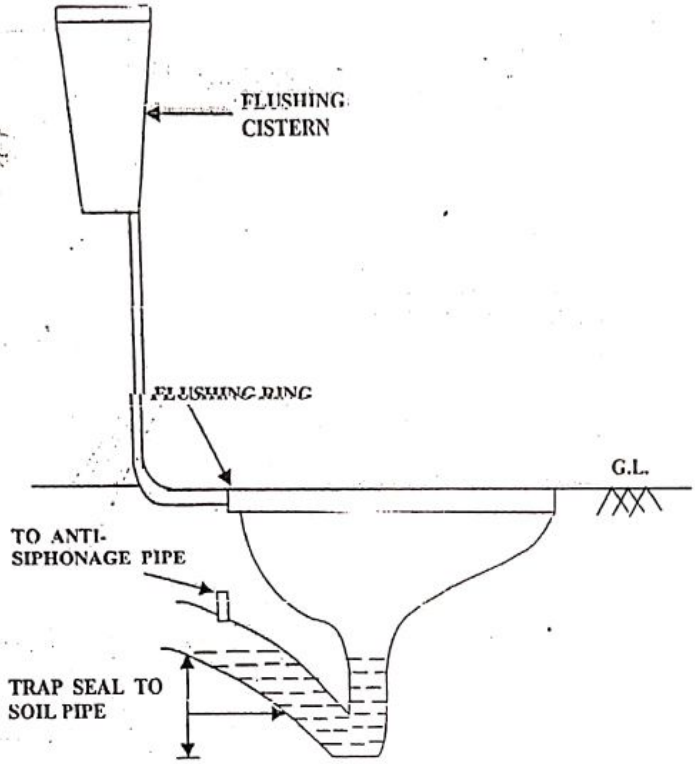
AQUA PRIVY

This method is both economical and hygienic. This is the best method of disposing of night-soil in places not provided with piped water-supply. Suitable for factories, villages, hill stations, etc.

Water Closet : (W.C.)

A water closet is a sanitary fitting used to receive the human excreta directly from the user. (The room or compartment in which the water closet is installed is also called a water closet). There are two types of water closets.

1. Indian Water Closet and
2. Wester / European Water Closet.



1.Indian Water Closet : The Indian water closet consists of a pan designed such taht it can be used in a squatting position. A trap is provided at the bottom, which is supplied in a seperate piece and fitted to the pan. An opening in the trap is provided to connect it to the anti siphonage pipe. The water closets are available in the market.

One disadvantage in this type is that the excreta does not fall directly into the trap and hence it is likely to become foul. Thus it requires plenty of water for flushing. The pan has an opening to connect it to the flushing cistern. When overhead water tank is not available, then flushing is done manually.

When Indian water closet is provided, the following points need consideration :

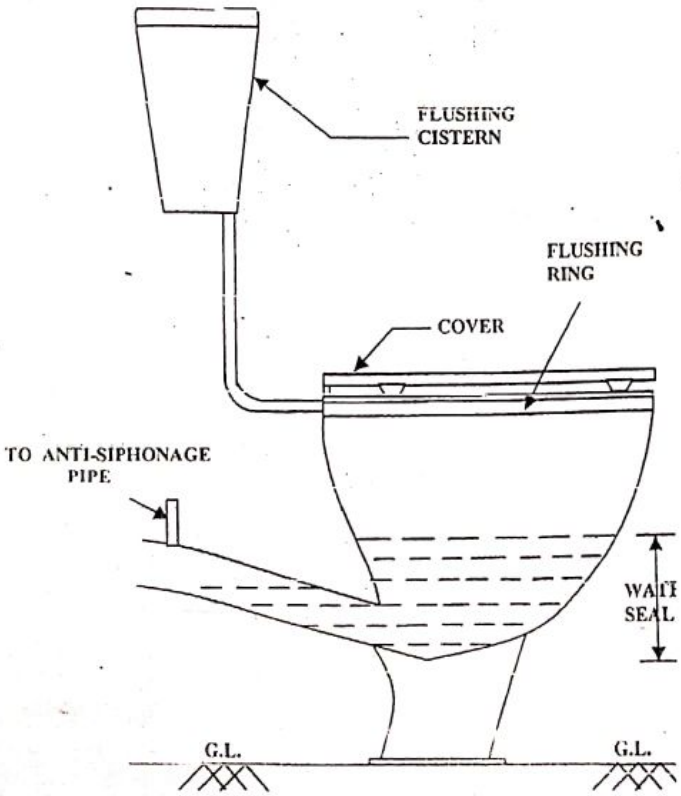
1. The floor slab in the water closet may be preferably depressed or made lower than the general floor level to accommodate the water closet. Alternatively, the height of the portion of water closet is raised to accommodate the height of water closet.
2. The floor should be suitably sloped so that the waste water is drained into the pan.
3. Tap may be provided at a height of 200-300 mm above floor level.
4. A pair of foot-rests may be provided if desired.

2. European Water Closet :

The European water closet consists of a pan made of white glazed ceramic ware which can be used in the sitting position. It is provided with an elastic seat and cover. A trap is provided at the bottom.

Excreta falls directly into the trap and hence it can be kept more clean. The flushing is done by a low-level flushing cistern. The following fittings have to be provided with the European water closet.

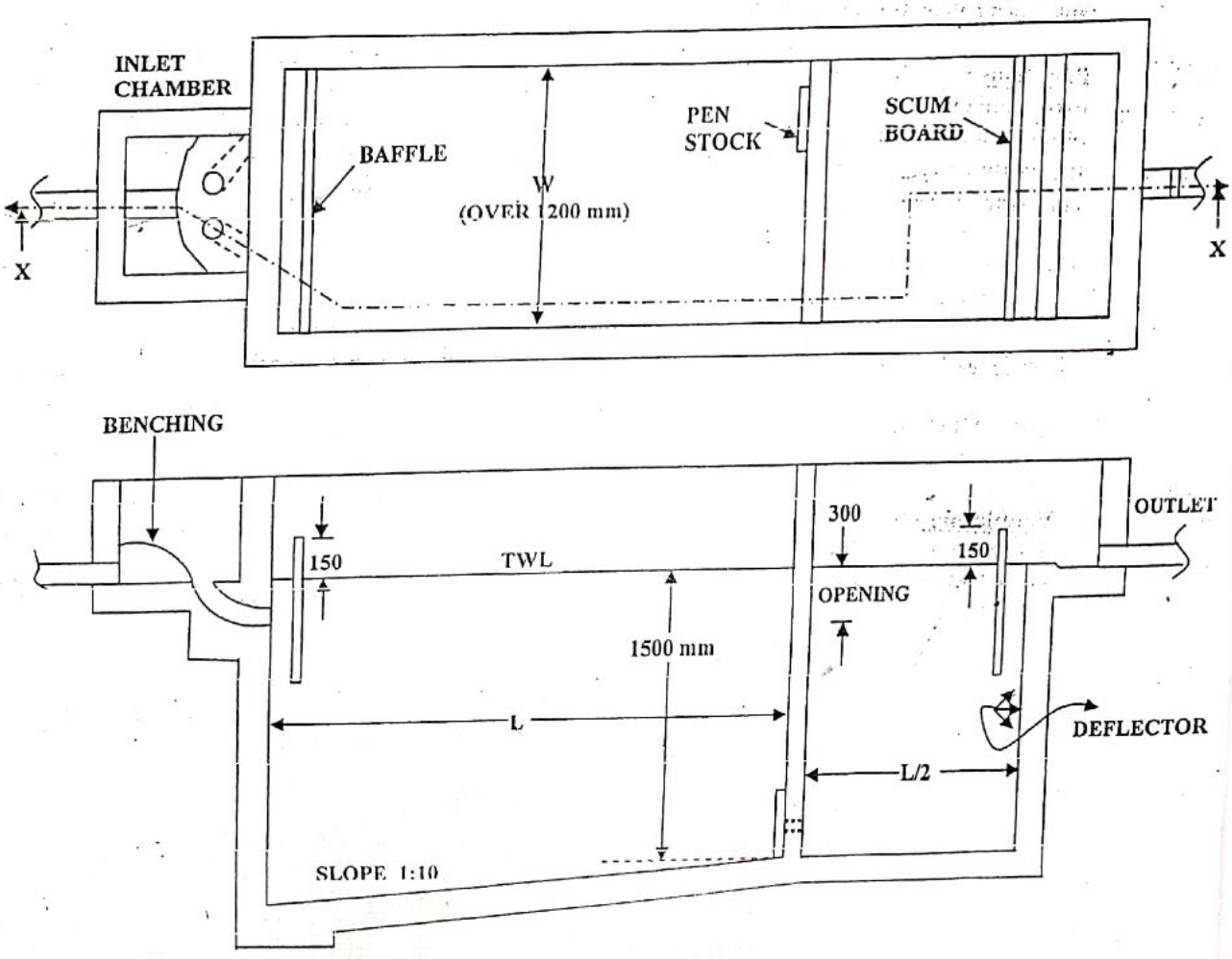
- A floor trap.
- A toilet-paper holder
- An ablution tap in public buildings.



SEPTIC TANK :

It is a device built underground to deal with the sewage coming from water closets. It is a watertight single storeyed tank in which sewage is retained for the sufficiently long to permit sedimentation of suspended solids and partial digestion of settled sludge by an aerobic bacterial action. The effluent of septic tanks may be discharged into perennial streams or used for gardening or irrigation. If it is not possible, then the effluent is discharged into soak pits. IS: 2470 (Part-I)-1985 covers the design and construction of septic tanks.

Dimensions : The septic tank may be rectangular or circular. The tank should have a minimum width of 750 mm, minimum depth of 1 m below water level, a minimum liquid capacity of 1000 litres. For a rectangular tank, the length is two to four times the width. For circular tanks, the minimum dia and depth are 1.35 m and 1.0 m respectively. The walls of the tank may be constructed with brick masonry and the thickness should not be less than 200 mm. The floor should be water tight and may be constructed with cement concrete of grade M:15. A slope of 1: 10 towards the sludge outlet should be given to facilitate desludging.



SECTION XX

Following table gives the recommended sizes of septic tanks for 20 users:

No of Users	Length	Breadth	Liquid Depth (Cleaning interval of)	
			1 year	2 years
(1)	(2)	(3)	(4)	(5)
	M	m	M	m
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

Note : 1. The capacities are recommended on the assumption that discharge from only WC will be treated in the septic tank.

2. A provision of 300 mm should be made for free board.

3. The sizes of septic tank are based on certain assumptions while choosing the sizes of septic tank exact calculations shall be made.

Partitions : When the capacity of the tank exceeds 2000 litres, the tank may be divided into two chambers by means of a fixed partition. The partition should be located such that the capacity of the first chamber is twice that of the second chamber. Suitable openings should be provided in the partitions at approximately 300 mm below the water level. Typical sketch of two-compartment septic tank for populations of over 50 is as shown in figure.

For population over 100, two tanks should be provided and operated parallel. It should be so arranged that while one tank is being desludged, the other will permit the entire flow to pass into it.

Free Board : A minimum free board of 300 mm should be provided.

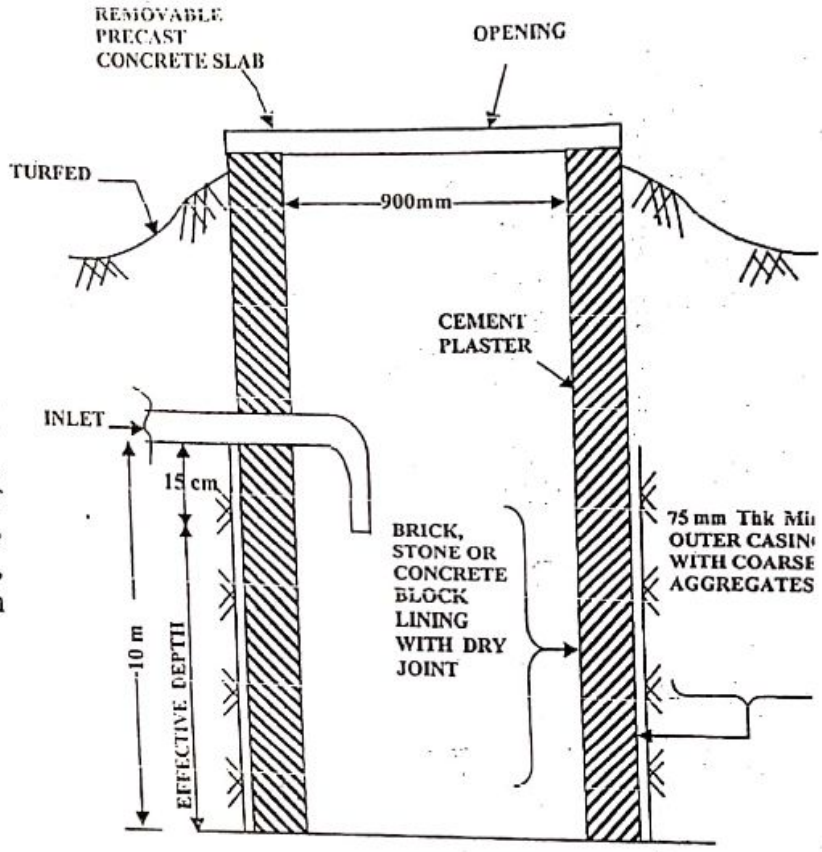
Access Openings : Each compartment of a septic tank should be provided with rectangular or circular openings for access into it. The cover may be of R.C.C. or C.I.

Ventilating Pipe : Every septic tank should be provided with a ventilating pipe of minimum dia 50 mm. The top of the pipe should be provided with mosquito proof mesh and should be taken to a height which would not cause smell nuisance.

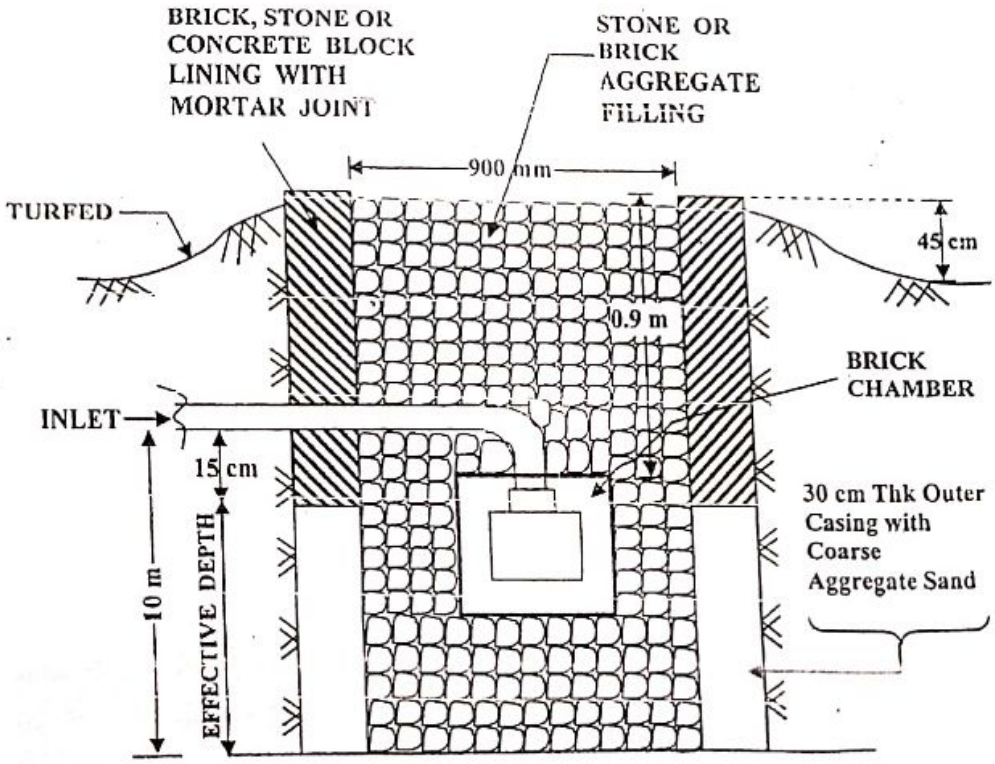
SOAK PITS :

The covered pit through which effluent from septic tank is allowed to be soaked or absorbed into the surrounding soils is called soak pit. In this system, the effluent is discharged into a pit of any suitable shape with least dimension of 0.9 m and height not less than 1.0 m in depth below the invert level of the pipe. The pit may be lined with stone, brick or concrete blocks with dry open joints which should be backed with at least 75 mm of clean coarse aggregate. Where no lining is used, specially near trees, the entire pit should be filled with loose stones.

The soak pits are of two types:
a) Empty soak pit; and
b) Filled soak pit.



EMPTY PIT WITH LINING



EMPTY PIT WITH LINING

UNIT - 4
DRAINAGE SYSTEMS: Storm water and sullage disposal, Rain water harvesting and uses.

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Collection and Disposal of Storm water and Sullage:

Sullage is merely the wastewater from bathrooms, kitchens, house washings, washing of clothes etc. it does not contain any excretal refuse, and hence it is neither very dirty nor create bad smell. It is collected and disposed off by the following methods:
(i) The wastewater may be led to pits in which animal dung and dry refuse is also dumped. Wastewater will help easy decomposition of waste refuse and convert it into manure by composting.
(ii) Wastewater may be carried outside the village in open drains and admitted into a nallah or a natural watercourse.
(iii) Wastewater may be used for watering trees or kitchen gardens in the house. If the quantity is more, it can be utilized for farm work in board irrigation.

However the storm water and sullage can be disposed of safely and scientifically by any of the following methods :
a) Open Drain System, and
b) Closed Conduit or Sewerage System.

a) Open Drain System :

This system is practiced under Conservancy method of disposal of sewage. In this system storm water and sullage are carried in open drains provided along the sides of the roads and disposed into the nearby stream without any treatment. Trenches or channels of 1 ½ to 2 feet wide and 1 feet depth are dug along both sides of the roads, pathways and sufficient slope is also provided. Linings done using stone slabs, precast concrete slabs etc., and are joined by the cement mortar. Strom water from the roofs of the houses and unpaved/paved surface of the roads are directly led into these open drains. Where as the sullage from the kitchens may be diverted to the back yards where it can be applied on the land for growing flowery plants, vegetables, fruit bearing trees etc. If not these sullage can be made to join the open drains where it mix up with the storm water and led away to a nearby water body. Though this system is very simple in construction and operation, it has following disadvantages which makes it to think before adopting the same ;

Disadvantages of Open Drainage System :

1. Open drains often are very good breeding sites for the insects. Hence cause out breaks of diseases.
2. Overflow of drains occur if there is any blockages due to litters likes tree leaves. Thereby create unhygienic environment.
3. Proper maintenance of drains such as clearing of drains before the rainy seasons is needed. This raises the labour cost in turn making operating cost high.
4. If the down streamside of the river is a source of drinking water for another village, then disposal may create problem.

Closed Conduits System or Sewerage System :

In this system both the storm water and sullage are collected along with sewage and disposed through a closed conduits known as sewers, which are laid under ground below the water pipe lines. This system is adopted in Water carriage system of disposal of sewage. Sewers may be laid to carry storm water and sullage or sewage separately or combinely or partially. Depending upon this layout of sewer network this system is classified as follows :

a) Separate system
b) Combined System
c) Partially separate System.

a) Separate System :

The separate system provides two separate systems of sewers – the one intended for the conveyance of foul sewage only, such as, faecal matter, domestic wastewaters, sullage and the other for the rain water, including the surface washing from certain streets, overflow from public baths etc. The sewage from the first system of sewers can be led to the treatment works, while the flow from the second system of sewers can be discharged directly to natural streams etc. without any treatment.

Advantages :

1. The cost of installation is low. The storm water can be disposed off through the open channels along the road sides. Old sewers may also be suitably converted to carry rain water. Thus, the actual sewers carrying foul sewage will be of smaller size.
2. The load on the treatment units will be lowered, since only the foul sewage carried by the separate sewers need be treated.
3. If there is necessity of lifting the sewage mechanically, the system will prove to be economical both from the point of view of running costs.
4. the sewages in the separate system will be of uniform character, and so will lend itself more easily to putrification.
5. There is no necessity of providing automatic flushing tanks, for use in dry weather, because the flow in a sewer of smaller section is much more efficient.
6. Sewers of smaller section can be easily ventilated than those of larger section.
7. The night flow will be comparatively small this may facilitates operations at the outfall works.
8. Rain water can be discharged into streams or rivers without any treatment.

Disadvantages :

1. Since the sewers are of small size, it is difficult to clean them
2. They are likely to get chocked.
3. Two sets of sewers may ultimately prove to be costly.
4. There is likelihood of connections being wrongly made through a confusion of the systems.
5. Storm water sewers or drains comes in use only during the rainy season. During other part of the year, these may serve as dumping place for grabage, and may get chocked.
6. Because of lesser air contact in small size sewers, foul smell may be there due to the sewage gas formed.

b) Combined System :

The combined system provides only one sewer to carry both the foul sewage /sullage as well as the rain water. The sewage and rain water are carried to the sewage treatment plant, before its final disposal. The combined system is advocated on the ground that the street surface washings are as impure as the sewage itself, and should therefore be suitably treated before being allowed to enter the natural stream.

Advantages :

1. The system requires only one set of sewers. Hence the maintenance costs are reduced.
2. The sewers are of larger sizes, and therefore the chances of their choking are rare. Also, it is easy to clean them.
3. The strength of sewage is reduced by dilution.
4. there is more air in the larger sewers than in smaller ones of the separate system. Hence the sewer gas that may be formed gets diluted. Thus the chances of foul smell are reduced.

Disadvantages :

1. The cost of construction is very high because of large dimensions of the sewers to be constructed at sufficient depth to receive the sewage from the basement.
2. Because of larger size of sewers, their handling and transportation is difficult.
3. Due to the inclusion of the storm water, the load on the treatment plant increases.
4. The system is uneconomical in the circumstances when pumping is required for lifting of sewage.
5. During heavy rains, the sewers may overflow, and may thus create unhygienic conditions and cause pollution problems.
6. Storm water is unnecessarily polluted.
7. The large sewers get easily silted if not properly designed. They may become foul in dry weather, when rain water, is not available.
8. Large sewers are more difficult to be ventilated than the smaller ones.

c) Partially Combined System :

In this system, only one set of underground sewers is laid. These sewers admit the foul sewage as well as the early washings by rains. As soon as the quantity of storm water exceeds a certain limit, the storm water overflows, and is thus collected and conveyed in open drains to the natural streams. The foul sewage, however, continues to flow in the sewers.

Advantages :

1. The sewers are of reasonable size. Their cleaning is therefore not very difficult.
2. it combines the advantages of both the separate as well as the combined systems.
3. the storm water permitted in the sewers eliminates its chances of choking. The sewers are completely cleaned during rainy season.
4. the problem of disposing off storm water from homes is simplified.

Disadvantages :

1. During the dry weather, when there is no rain water, the velocity of flow will be low. Thus self cleansing velocity may not be achieved.
2. The storm water increases the load on treatment units.
3. The storm water also increases the cost of pumping.

RAIN WATER HARVESTING :

Rainwater harvesting is a technique of increasing the recharge of groundwater by capturing and storing rainwater. This is done by constructing special water-harvesting structures like dug wells, percolation pits, lagoons, check dams etc. Rainwater, wherever it falls, is captured and pollution of this water is prevented. Rainwater harvesting is not only proving useful for poor and scanty rainfall regions but also for the rich ones.

The annual average rainfall in India is 1200 mm, however, in most places it is concentrated over the rainy season, from June to September. It is an astonishing fact that Cherapunji, the place receiving the second highest annual rainfall as 11000mm still suffers from water scarity. The water flows with run off and there is little vegetation to check the run off and allow infiltration. Till now there is hardly any rain-water harvesting being done in this region, there by losing all the water that comes through rainfall.

Rain water harvesting has the following objectives:

1) To reduce run off loss
2) To avoid flooding of roads
3) To meet the increasing demands of water
4) To raise the water table by recharging ground water
5) To reduce ground water contamination
6) To supplement groundwater supplies during learn season.

Rainwater can be mainly harvested by any one of the following methods:

1) By storing in tanks or reservoirs above or below ground.
2) By constructing pits, dug-wells, lagoons, trench or check-dams on small rivulets
3) By recharging the ground water.

Before adopting a rain-water harvesting system, the soil characteristics, topography, rainfall pattern and climatic conditions should be understood.

Traditional Rain Water Harvesting:

In India, it is an old practice in high rainfall areas to collect rainwater from rooftops into storage tanks. In foot hills, water flowing from springs is collected by embankment type water storage. In Himalayan foot- hills people use the hollow bamboos as pipelines to transport the water of natural springs. Rajas-than is known for its 'tanks, (underground tanks) and khadins (embankments) for harvesting rainwater. In our ancient times we had adequate Talaabs, Baawaris, Johars, Hauz etc. in every city, village and capital cities of our kings and lords, which were used to collect rain-water and ensured adequate water supply in dry periods.

Modern Techniques of Rain Water Harvesting:

The following measures may be adopted for rain water harvesting to recharge the underground reservoir :

(1) On channel storage of Rain water : In this method, rain water is impounded in a long and large storm water drain, as to promote its infiltration to the under-ground reservoir. The stored water is also lifted sometimes through pumps and used for irrigation or for other purposes.

(2) Development and Deepening of Old Village Ponds : In this method, the old existing village ponds are deepened and restored by removing encroachments and stopping the inflow of domestic sewage. This method, not only recharges the ground water, but also provides an aesthetic environment to the entire village.

(3) Creation of New Water Bodies : In this method, abandoned courses of drains or escape channels are used to develop new water bodies, which are filled up by diverting the storm runoff.

(4) Construction of Bunds and Check Dams : In this method bunds are constructed across small streams to conserve stream flows, with practically no submergence above the normal water levels of the stream during rainy season. The bunds are the structures constructed across the stream by placing locally available boulders (stones) in a mesh of steel wires (called wire crates), which is anchored to the stream banks. The height of such a structure is around 0.5m and is normally used in the streams having width less than about 10m. The excess water overflows this structure, storing some water to act as a source of recharge.

Check dams are the walls erected across the streams or drains to store water upstream. Their height, however, is more and they are pucca masonry structures like weirs or dams of small height. The height of check dams is usually not kept more than 2m, so that the water stored upstream is confined to the normal stream section. The excess water coming in the stream may be allowed to flow over the wall. To harness maximum runoff of the stream, a series of check dams can be constructed to have sufficient recharge of ground water all along the stream, as to cover a larger area.

(5) Construction of Recharge Trenches and Recharge Shafts : This is the most efficient and cost effective method to recharge an unconfined aquifer overlain by an impervious or poorly permeable strata. Recharge shaft may be dug manually if the stratum is of non-caving nature: or may be drilled through hand augers, etc. The diameter of the recharge shaft may be kept between 0.5 to 3 m in diameter. The depth of the shaft will depend upon the availability of the first aquifer below the top impervious soil strata.

~~(6)~~ Roof Top Rainwater Harvesting : Collection of rain water from the paved roofs or G.I corrugated roofs, and paved court yards of houses, either in storage tanks, or in the ground water reservoir is known as *roof top rain water harvesting*. The collected water serves as a good source of water in water scarce areas. This technique is highly promising even for urban areas and places where the rain fall occurs only for a few months in a year, and where other sources of water are scarce and ground water levels have gone down, such as in Gujarat, Delhi, Madhya Pradesh, etc.

In its simplest form, the roof top water harvesting involves taking down a PVC or M.S. pipe of 90-120 mm dia from the roof's outlet to the ground floor, which can be connected to a water tank (placed either above ground level or below the ground level) or to the underground water-table. The rain water before collection should, however, generally be passed through simple sand or charcoal filters for removal of suspended particles and micro-organisms from the rain run-off being collected. The roofs or court yards should also kept as clean as possible at the time of rains.

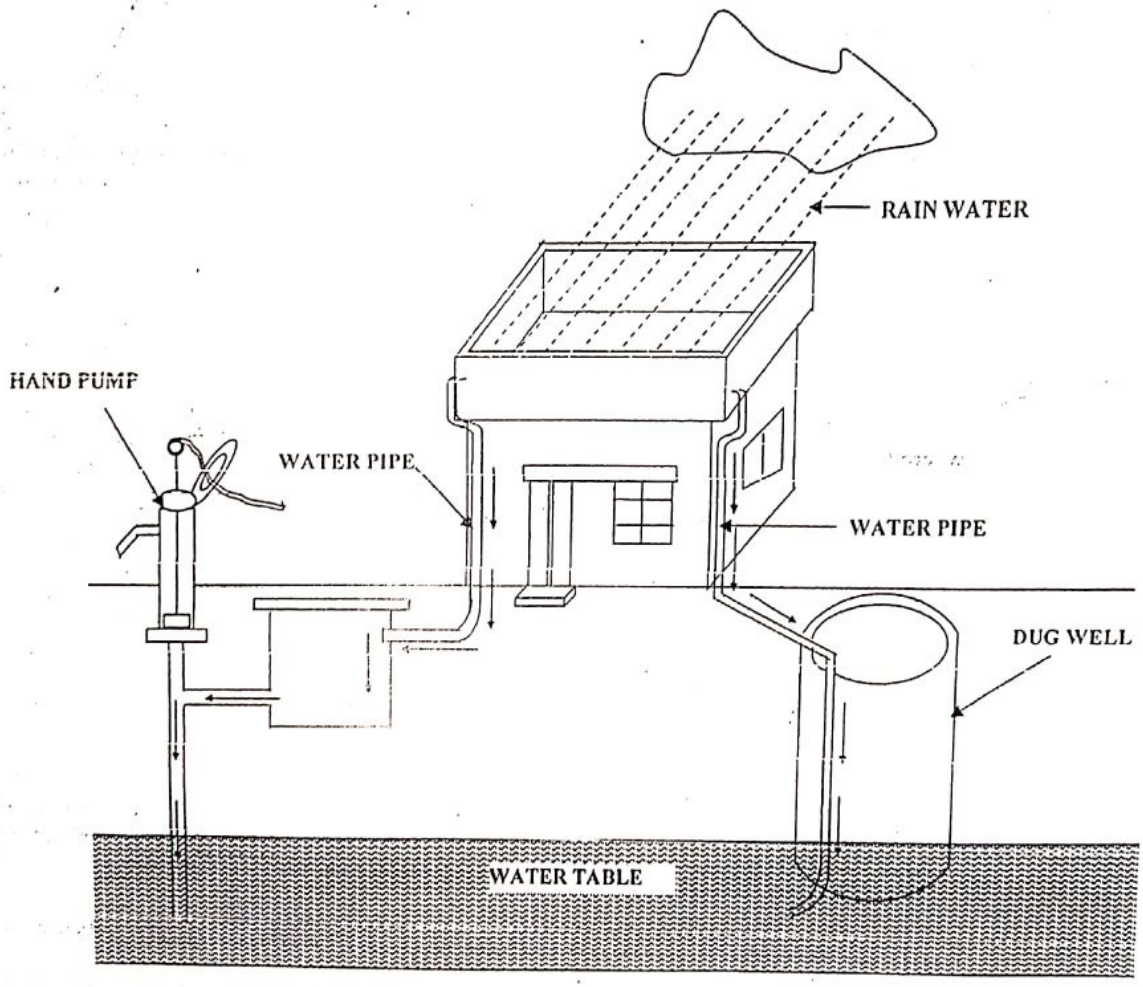
(7) Rain water collection for direct use: The rain water collection for direct use can be practiced by collecting the water coming down from the roof into a storage tank of plastic, R.C.C or masonry. The tank can be placed either above the ground or below the ground depending on the availability of space and cost considerations. Cleaning and disinfecting the tank at regular intervals and ranking of filters is a must.

In a campus, where sufficient space is available, the water can be stored in an open excavated pond, which also acts as a settling pond for impurities.

(8) Rain water collection for ground water recharge: When rain water collection for direct use is difficult or costly or impracticable, then ground water recharge option can be easily practiced to supplement the falling ground water table of the area. The ground water recharging can be practiced by directing the rain water to infiltrate into ground to join the water-table either through a *Recharge Pit* or through a *Recharge Well* or through a *Recharge well with a Pressure Filter*, depending upon the available circumstances, as discussed below;

(i) Recharge Through a Recharge Pit :

This method is suitable in areas having shallow ground water-table/aquifer and for smaller buildings with roof area of 100-150 sqm. A pit of 1-2 m deep is excavated at a suitable location in the plot, and the run-off water from the catchment area (roof, etc.) is diverted into this recharge pit. The pit is filled with water crushed gravel and coarse sand to filter out the rain water, before it infiltrates through the aquifer to join the water-table.



ROOF-TOP RAIN WATER HARVESTING BY RECHARGING :
(i) Through Hand Pump or (ii) Through abandoned dug well.

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(ii) Recharge Through a Recharge Well:

This method is suitable in areas having low ground water-tables. In this method, a bore hole is dug or drilled up to or near to the ground water level, or up to the porous strata or rock fracture for effective recharge.

The diameter of the bore hole may vary from 0.2 to 0.3 m depending upon the porosity of the receiving strata. Slotted pipes are then installed into this bore hole to enable discharge of water from the sides of the drilled bore. The slots should, however, be located to coincide with favorable pervious strata only. Such a recharge well should preferably be constructed 10-15 m away from the built area.

(iii) Recharge Through a Recharge well with Pressure Filter :

This method is suitable for areas with low ground water-tables, when ground profiles involve large depths of impervious strata, making ground water infiltration difficult under simple force of gravity, at the rate of rainfall.

In this method, the rain water is first of all collected into an underground tank, from where it is lifted up by a pump (through a filter) and pressured down into recharge well. The shaft or well is drilled up to the ground water level or just above the normal tube well withdrawal level, and may be made by lowering G.I. tube well type pipe into a bore hole of 0.15 to 0.3 m dia. (depending upon the porosity of the receiving strata)..The pipe to be lowered in the bore must be slotted in the lower part of the shaft to enable permeability in the ground water-table. The slots in the upper length may also be located to coincide with favorable permeable strata, if any.

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