CBCS SCHEME

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18CV55

Fifth Semester B.E. Degree Examination, Feb./Mar. 2022
Municipal Wastewater Engineering

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Explain the different types of sewerage systems with their advantages, disadvantages and suitability. **(10 Marks)**

b. Explain Dry Weather Flow (DWF) and explain the factors on which DWF depends. **(10 Marks)**

OR

2 a. Define sewer appurtenances. Explain with neat sketch, construction and working of manhole. **(10 Marks)**

b. Explain any five different shapes of sewers with neat sketches. **(10 Marks)**

Module-2

3 a. Design a sewer for a population of 50,000 with per capita water supply of 150 lit/day. The slope available is 1 in 500 and 80% of the water supplied emerges as sewage. The sewer is to be designed to carry 4 times the DWF when running full. Assume N = 0.012 and compute the velocity of flow when running full. **(10 Marks)**

b. Explain self cleaning velocity and non-scouring velocity. What are different types of sampling? Explain. **(10 Marks)**

OR

4 a. Draw a neat flow diagram employed for a municipal wastewater treatment plant. Indicate the importance of each unit indicated in the flow diagram. **(10 Marks)**

b. The 5 day 30°C BOD of sewage sample is 110 mg/*l*. Calculate its 5 days 20°C BOD. Assume the deoxygenation constant at 20°C, K_{20} as 0.1. **(06 Marks)**

c. Explain the term BOD and their importance in wastewater treatment. **(04 Marks)**

Module-3

5 a. Explain the working of a "Grit Chamber" and "Oil and Grease" removal tank with figures. **(10 Marks)**

b. Write short notes on: (i) Screens (ii) Settling tank **(10 Marks)**

OR

6 a. Discuss in detail the process of de-oxygenation and re-oxygenation with respect to self-purification of natural water with a neat sketch. **(10 Marks)**

b. A city discharges 100 cumecs of sewage into a river which is fully saturated with oxygen and flowing at the rate of 1500 cumecs during its lean days with a velocity of 0.1 m/sec. The 5-days BOD of sewage at the given temperature is 280 mg/*l*. Find when and where the critical D.O. deficit will occur in the downstream portion of the river, and what is its amount. Assume coefficient of purification of the steam (f) as 4.0 and coefficient of de-oxygenation (K_D) as 0.1. (Take saturated D.O. = 9.2 mg/*l*). **(10 Marks)**

Module-4

7 a. Explain the five modifications of activated sludge processes. **(10 Marks)**

b. The sewage is flowing at 4.5 million litres per day from a primary clarifier to a standard rate trickling filter. The 5-day BOD of the influent is 160 mg/*l*. The value of the adopted organic loading is to 160 gm/m^3/day, and surface loading 2000 *l*/m^2/day. Determine the volume of the filter and its depth. Also calculate the efficiency of this filter unit. **(10 Marks)**

OR

8 a. Explain briefly with neat sketches, the working of :

(i) Sludge digester's

(ii) Sludge drying beds **(10 Marks)**

b. Calculate the dimensions of an oxidation pond for treating sewage from a residential colony with a population of 5000 persons. Assume the rate of sewage flow 120 *l*pcd and 5 day BOD of sewage as 300 mg/*l*. Take organic loading as 300 kg/ha/day and length of the tank as twice of its width and depth of pond as 1.2 m. Apply check for detention time. **(10 Marks)**

Module-5

9 a. Write about the need for advanced wastewater treatment? Explain the biological phosphorus removal process. **(10 Marks)**

b. What is the necessity for the removal of nitrogen? Discuss the nitrification and denitrification process for removal of nitrogen. **(10 Marks)**

OR

10 a. Explain the septic tank with neat sketch. Also write the design considerations required for septic tank. **(10 Marks)**

b. Write brief note on with sketch:

(i) Two-pit latrines

(ii) Soak pits **(10 Marks)**

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18CV55-MWWE VTU 2022 SOLUTION

1.

A. Conservancy System

This method is also called as "Dry System". This system is in practice from very ancient times.

In this system, the waste products of society had been collected, carried and disposed off manually to a safe point of disposal by the sweepers. Various types of refuse and storm water are collected, conveyed and disposed off separately.

Garbage is collected in dustbins placed along the roads from where it is conveyed by trucks ones or twice a day to the point of disposal. All the noncombustible portion of garbage such as sand dust clay etc are used for filling the low level areas to reclaim land for the future development of the town. The combustible portion of the garbage is burnt. Human excreta or night soil are collected separately in conservancy latrines. The liquid and semi liquid wastes are collected separately. After removal of night soil, it is taken outside the town in trucks and buried in trenches. After 2-3 years the buried night soil is converted into excellent manure.

In conservancy system, the sullage and storm water are carried separately in closed drains to the point of disposal where they are allowed to mix with river water without treatment.

Merits

1. It is cheaper in initial cost because storm water can pass in open drains and conservancy latrines are much economical.
2. The quantity of sewage reaching disposal point is less.
3. The storm water goes in open drains; the sewer section will be small.
4. Night soil which is buried can be used as fertilizers after 2 to 3 years.

Demerits

1. For burying human excreta more space of land is required.
2. Building can't be designed as one compact unit because; latrines are to be provided away from the living room due to foul smell.
3. There is every possibility the liquid refuse may yet get an access in the sub-soil and pollute the ground water.
4. In the presence of conservancy system, the aesthetic appearance of the city cannot be increased.
5. Decomposition of sewage causes insanitary conditions which are dangerous to public health.
6. This system depends on the mercy of sweepers every time.

B. Water Carriage System

In this system, waste products are mixed up with sufficient quantity of water and are taken out of the city by properly designed sewer system where they are disposed off after necessary treatment in sanitary manners. The treated sewage effluents may be disposed off either in a running body of

water such as streams or may be used for irrigating crops. The sewage so formed in water carriage system consists of 99.9% of water and remaining 0.1% of solid matter.

Merits

1. It is a hygienic method because all the excremental matters are collected and conveyed by water only and no human agency is employed for it.
2. In this system, the sewage is carried through underground pipes and these pipes do not occupy floor area on road sides or impair the beauty of the surroundings.
3. In multi storied Buildings where the water closets one above the other can be easily constructed and connected to a single vertical pipe.
4. Land required for disposal work is less as compared with conservancy system.
5. The usual water supply is sufficient and no additional water is required in water carriage system.
6. The system does not depend on manual labour at every time except when sewers are clogged.
7. Sewage after treatment can be used for various purposes.

Demerits

1. The system is very costly in initial stages.
2. The maintenance of this system is very costly.
3. During monsoon, large volume of sewage is to be treated, where as very small quantity is to be treated in the remaining period of year.

2

DRY WEATHER FLOW (DWF):

It is that quantity of wastewater that flows through as sewer in dry weather when no storm water is in the sewer. The dry weather flow is also sometimes called as 'sanitary sewage', and is obtained from the following sources:

Factors Affecting sanitary sewage

1) Population
2) Rate of water supply.
3) Type of area served (Industrial, Commercial, Etc…)
4) Ground water infiltration and exfiltration

1.Population: The quantity of sanitary sewage or DWF directly depends on the population at the end of the design period. As the population increases, the quantity of sanitary sewage also increases. The quantity of water supply is equal to the rate of water supply multiplied by the population. There are several methods used for forecasting the population of a community.

2.Rate of water supply: The quantity of wastewater discharged into a sewer system is less than the amount of water supplied to the community. This is because of losses due to leakage from pipes, lawn sprinkling and manufacturing process etc. hence the rate of consumption of both public as well as private supplies must be taken into account. In estimation of quantity of sewage, the anticipated rate of water consumption at the end of the design period must also be studied

3.Type of area to be served: Quantity of sanitary sewage depends upon the type of area such as Residential, industrial or Commercial. The quantity of sewage produced in residential area directly depends on the quantity of water supply to that area. This type of sewage is generally expressed as litres per capita per day.

Quantity of sewage produced by an industrial area varies from industry to industry depending upon their various industrial processes. Quantity of sewage from public and commercial places can be determined by studying the development of such area. The rate of flow of sewage in such areas is expressed in liters per day per sq. meter of area

4. Groundwater infiltration and exfiltration:

i. Infiltration: In case of sewers which are laid below ground water table and in water clogged areas, an allowance should be made for the water entering the sewers through leaky joints. Infiltration represents a slow response process resulting in increased flows mainly due to seasonally-elevated groundwater entering the drainage system, and primarily occurring through defects in the pipe network. The quantity of ground water infiltration depends upon the following factors such as the nature of soil,, materials of sewers, number and conditions of sewer joints, depth of the sewer below ground water table etc

The recommended quantity of ground water infiltration in case of sewers below ground water table is as follows

a) 250-500 L/day/man-hole

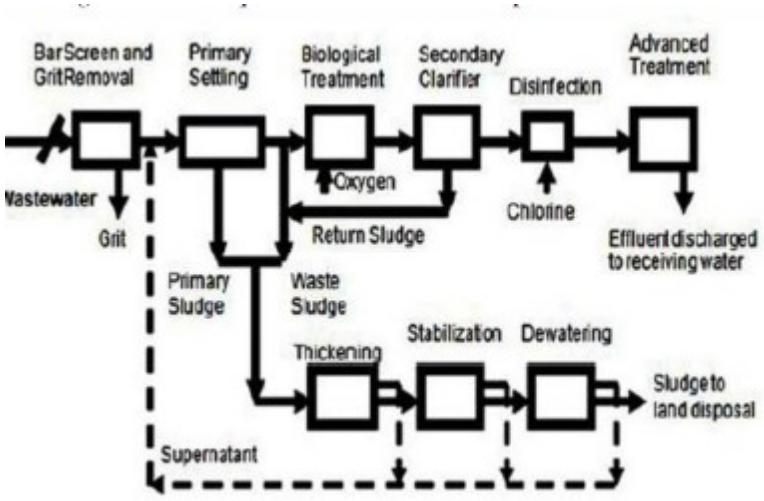
b) 500-50,000 L/day/hectare of drainage area

c) 500-5000 L/day/km length of sewer/cm diameter of sewer

ii. Exfiltration: represents losses from the sewer pipe, resulting in reduced conveyance flows and is due to leaks from defects in the sewer pipe walls as well as overflow discharge into manholes, chambers and connecting surface water pipes. The physical defects are due to a combination of factors including poor construction and pipe joint fittings, root penetration, illicit connections, biochemical corrosion, soil conditions and traffic loadings as well as aggressive groundwater.

Exfiltration losses are much less obvious and modest than infiltration gains, and are therefore much more difficult to identify and quantify. However, being dispersed in terms of their spatial distribution in the sewer pipe, exfiltration losses can have potentially significant risks for groundwater quality.

3.



The influent or wastewater collected from residences or industries are first subjected to Screening process to remove the floating matters present in the sewage. The water which comes out of screening
tanks is passed through the Grit chambers or Detritus tanks to remove the grits or sand particles. Then effluent which comes out of grit chamber is subjected to Primary Sedimentation tanks in order to remove the large suspended organic solids which is achieved by settling process where water is allowed to flow in slower rate, then heavy denser particles settles down at the bottom of the tank. The
settled organic particles at the bottom of the primary sedimentation tanks is called primary sludge. The effluent which comes out of the primary settling tank is subjected to Biological treatment or Secondary treatment where, decomposition of organic matter takes place by aerobic bacteria with the supply of oxygen. Then stabilized organic particles along with the water is passed through the Secondary clarifier where the stabilized organic particles settles at the bottom of the tank. The sludge
which is settled at the bottom of the tank is again recirculated back and mixed with effluent which comes of primary sedimentation tank which is part of Activated Sludge Process and remaining sludge
is mixed with primary sludge and then subjected to Sludge digestion process. In sludge digestion process, wastewater is first subjected to Thickening, where number of solid sludge particles are increased by separating from liquid. The liquid which rests over the solid sludge particles are removed
out is called as supernatant. The solid sludge which consists of moisture content is removed out in Dewatering process. The dry form of sludge is used as manure for improving the fertility of soil. The
effluent which comes out of secondary clarifier is fed into disinfection tank where chlorine is added

to the wastewater to kill germs and pathogenic bacteria's present in the water. Then water which comes

out of disinfection tank containing germs are removed out in final or advanced or tertiary treatment process after that, the water can be directly discharged to nearby water courses.

8.7. BIOCHEMICAL OXYGEN DEMAND (BOD)

The biochemical oxygen demand (BOD) is a measure of the oxygen required to oxidize the organic matter present in a sample, through the action of micro-organisms contained in a sample of wastewater. It is the most widely used parameter of organic pollution applied to both wastewater as well as surface water. *The BOD may be defined as the oxygen required for the micro-organisms to carry out biological decomposition of dissolved solids or organic matter in the waterwater under aerobic conditions at standard temperature.* The BOD test results are used for the following purposes :

(*i*) Determination of approximate quantity of oxygen required for the biological stabilization of organic matter present in the wastewater

(*ii*) Determination of size of wastewater treatment facilities.

(*iii*) Measurement of efficiency of some treatment processes.

(*iv*) Determination of strength of sewage

(*v*) Determination of amount of clear water required for the efficient disposal of wastewater by dilution.

The organic matter present in wastewater may belong to two groups : (*i*) Carbonaceous matter and (*ii*) Nitrogenous matter.

The *ultimate carbonaceous* BOD of a liquid waste is the amount of oxygen necessary for the micro-organisms in the sample to decompose the carbonaceous materials that are subject of microbial decomposition. This is the first stage of oxidation and the corresponding BOD is also sometimes called the *first stage demand.* In the second stage, the nitrogenous matter is oxidised, and the corresponding BOD is known as *second stage* BOD or *nitrification demand*. In fact, pollution – waters will continue to absorb oxygen for a long time. Biochemical oxidation is a slow process and theoretically takes an infinite time to go to completion, though the ultimate first stage BOD of a given wastewater is equal to the initial oxygen equivalent of the organic matter present. Generally, a 5 day period is chosen for standard BOD test, during which oxidation is about 60 to 70 percent complete, while within 20 days period, the oxidation is about 95 to 99 percent complete. A constant temperation of 20°C is maintained during the incubation. The BOD value of 5-day incubation period is commonly written as BOD_5 or 5-day BOD.

BOD test can be performed by two methods:

4.

Grit chambers: Grit includes sand and other heavy matters which are inert inorganic such as metal fragments, rags etc. If not removed in preliminary treatments, grit in primary settling tank can cause abnormal abrasive wear and tear on mechanical equipment and sludge pumps, can clog by deposition and can accumulate in sludge holding tanks and digesters. Therefore grit removal is necessary to protect the moving mechanical equipment and pump elements from abrasion. Grit removal devices depends upon the differences in specific gravity between organic and inorganic solids to affect their separation.

Types of Grit chambers:

Grit chambers are of two types, mechanically cleaned and manually cleaned. Mechanically cleaned grit chambers are provided with mechanical equipment for collection and washing of grit chambers, which are operated either on a continuous or intermittent basis. Manually operated grit chambers should have sufficient capacity for storage of grits between the intervals of cleaning.

Aerated Grit chambers: An aerated grit chamber is a special form of grit chamber consisting of a standard spiral flow aeration tank provided with air diffusion tubes placed at one end of the tank at about 0.6 to 1m from the bottom. The heavier grit particles with their higher settling velocities drop down to the floor, where as lighter organic particles will remain in suspension and carried with the roll of spiral motion due to the diffused air and eventually carried out of the tank.

Oil and Grease removal: Oil and grease, if not removed, may create the following difficulties.

1) If sewage is being discharged into the water bodies for disposal, unsightly scum will be formed at the surface and foul odor is prevalent around the natural water bodies. The scum retards re-oxygenation and thus causes anaerobic conditions.

2) They do not digest easily and therefore create problems in sludge digestion tanks.

3) They promote clogging of filter material of the trickling filters.

4) They affect the biological activities of the organisms and thus affect their smooth working.

The oil and grease particles may be removed by floatation or settling as scum or sludge.

Formation of scum is promoted by diffusing air through the sewage. The tank in which scum Formation is promoted by air diffusion through the sewage is called Skimming tanks.

Primary and secondary settling tanks

Solid liquid separation process in which a suspension is separated into two phases –

- Clarified supernatant leaving the top of the sedimentation tank (overflow).
- Concentrated sludge leaving the bottom of the sedimentation tank (underflow).

Purpose of Settling

- To remove coarse dispersed phase.
- To remove coagulated and flocculated impurities.
- To remove precipitated impurities after chemical treatment.
- To settle the sludge (biomass) after activated sludge process / tricking filters.

Principle of Settling

- Suspended solids present in water having specific gravity greater than that of water tend to

settle down by gravity as soon as the turbulence is retarded by offering storage.
 Basin in which the flow is retarded is called settling tank.
 Theoretical average time for which the water is detained in the settling tank is called the detention period.

Types of Settling

Type I: *Discrete particle settling* - Particles settle individually without interaction with neighboring particles.

Type II: *Flocculent Particles* – Flocculation causes the particles to increase in mass and settle at a faster rate.

Type III: *Hindered or Zone settling* –The mass of particles tends to settle as a unit with individual particles remaining in fixed positions with respect to each other.

Type IV: *Compression* – The concentration of particles is so high that sedimentation can only occur through compaction of the structure

Screening: Screening is the first and essential step in the treatment of sewage. It consists of passing sewage through different sized screens to trap and remove comparatively large size of floating matters. If such floating matters are not removed they may damage pumps and mechanical equipment, and it will interfere with the satisfactory operation of the treatment units. Screen is device with openings generally of uniform size for removing bigger suspended or floating matters in sewage. The screening element may consists of parallel bars, gratings or wire meshes or perforated plates and the openings may be of any shape, although generally they are circular or rectangular.

Screen should be situated preferably just before grit chambers, and they are housed in a chamber called screen chamber. These screens are always set in an inclined position with an angle of about 30º to 60º with vertical. This increases the effective screening surface by 40 to 100% and helps in preventing the excessive loss of head due to clogging.

4.

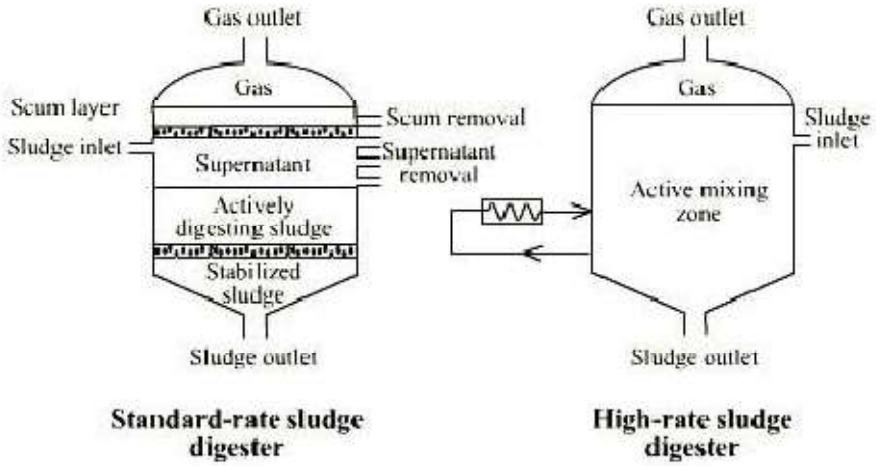
The anaerobic digesters are of two types: standard rate and high rate. In the standard rate digestion process, the digester contents are usually unheated and unmixed. The digestion period may vary from 30 to 60 d. In a high rate digestion process, the digester contents are heated and completely mixed. The required detention period is 10 to 20 d.

Often a combination of standard and high rate digestion is achieved in two-stage digestion. The second stage digester mainly separates the digested solids from the supernatant liquor: although additional digestion and gas recovery may also be achieved.

Modifications of ASP

Many activated sludge process modifications exist. Each modification is designed to address specific conditions or problems. Such modifications are characterized by differences in mixing and flow patterns in the aeration basin, and in the manner in which the microorganisms are

mixed with the incoming wastewater.
The major process modifications of the activated sludge process are:
1. conventional
2. tapered aeration
3. complete mix
4. step aeration
5. contact stabilization
6. extended aeration
7. pure oxygen systems



Sludge Drying Beds

The digested sludge contains lot of moisture content which should be eliminated before disposing it. It is usually achieved using sludge drying beds. The method consists of applying the sludge on specially prepared open beds of land. It consists of Open beds of land 45 to 60 cm deep.

30- 45cm thick graded layers of gravel or crushed stone in size varying from 15cm at bottom to 1.25 cm at top 10-25 cm thick coarse sand layer over the graded gravel layer Open jointed under-drain pipes of 15 cm in dia @ 5-7m c/c lay below the gravel layers at a slope of 1 in 100.

15 x 30 m in plan and are surrounded by brick walls rising about 1m above the sand surface.

Top of the bed can be covered with glass to protect it from rains

New sludge is spread only when the previous one has been removed.

The sludge is spread on the top of the bed and a part of the moisture gets drain through the bed and some gets evaporated in the atmosphere. It takes 2 weeks to 2 months for complete drying. Usually sludge will be removed after 7-10 days, as within this period about 30% of the moisture gets away.

5. SEPTIC TANK

♦ A septic tank may be defined as primary sedimentation tank with a longer detention period (12 to 36hrs, against a period of 2hrs in an ordinary sedimentation tank), and with extra provision for digestion of the settled sludge.

♦ The digestion of the settled sludge is carried out by anaerobic decomposition process; the septic tank unit is generally classified under the units which work on the principle of anaerobic decomposition.

♦ The septic tank is a horizontal continuous flow type of a sedimentation tank, directly admitting raw sewage, and removing about 60% to 70% of the dissolved matter from it.

♦ The sludge settled at the bottom of the tank, and all the oils and greasy matter rising to the top surface of the sewage as scum, are allowed to remain in the tank for a period of several months, during which they are decomposed by the anaerobic bacteria to form gases and liquids by the process of sludge digestion.

♦ Septic tanks are generally provided in areas where sewers have nit been laid and for catering to the sanitary disposal of sewage produced from isolated communities, schools, hospitals, hotels, other public institutions, etc.

♦ Suspended solids removal is 50 to 70 percent; five-day BOD removal is about 60 percent.

Fig. 5.9 Septic tank without soak pit

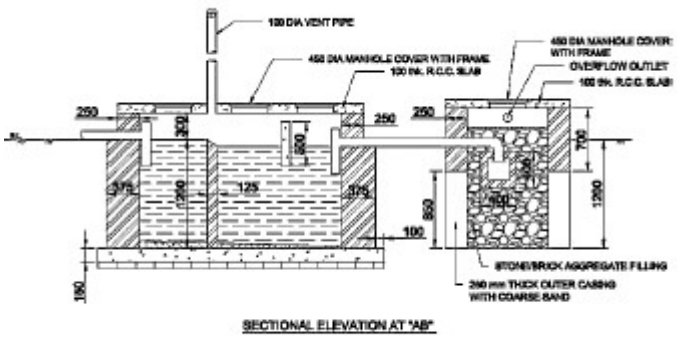


Fig. 5.10 Septic tank with soak pit

Working Principle: A septic tank is a watertight tank designed to slow down the movement of raw sewage and wastes passing through so that solids can separate or settle out and be broken down by liquefaction and anaerobic bacteria action. It does not purify the sewage, eliminate odors, or destroy all solid matter. The septic tank simply conditions the sewage so that it can be disposed of normally to a subsurface absorption system without prematurely clogging the system.

Design Consideration:

(1) Capacity of the Septic tank:

♦ The volume of liquid which a septic tank can accommodate is called its capacity.

♦ Capable of storing the sewage flow during the detention period. An additional volume sludge for 6 months to 3 years.

♦ Only water closets connected – 40 to 70 liters/capita/day.

♦ When Sullage is also discharged – 90 to 150 liters/capita/day.

♦ The rate of sludge accumulation – 30 liters/person/year.

♦ Minimum capacity of septic tank for about 8 to 10 persons may be 2,250 and 1,400 Liters.

(2) Inlet and Outlet baffles:

Baffles extended up to top level of the scum (about 20-22cm above the top sewage line), but must stop a little below the bottom of the covering slab (by atleast 7.5cm or so). Inlet should to penetrate by about 30cm below the top sewage line, and the outlet should penetrate to about 40% of the depth of the sewage. The outlet invert level should be kept 5 to 7.5cm below the inlet invert level.

(3) Detention Period:

The detention period for a septic tank generally varies between 12 to 36hrs, but commonly adopted as 24hrs.

(4) Length to Width Ratio:

Septic tanks are usually rectangular with their length at about 2 to 3 times the width. The width should not be less than 90cm. The depth of the tank generally ranges between 1.2 to 1.8m.

TWO-PIT LATRINES

This technology consists of two alternating pits connected to a pour flush toilet. The blackwater (and in some cases greywater) is collected in the pits and allowed to slowly infiltrate into the surrounding soil. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel and reused on-site, much like compost, to improve soil fertility and fertilize crops. Although most pathogens are filtered during soil infiltration or die-off with time and distance, there remains a risk of groundwater pollution, particularly in densely populated areas or in areas with a high groundwater table.

Two-Pit Latrine system

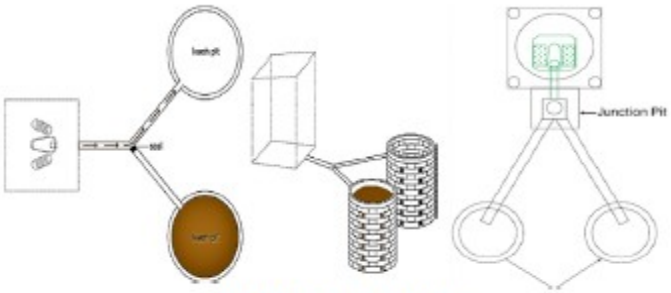
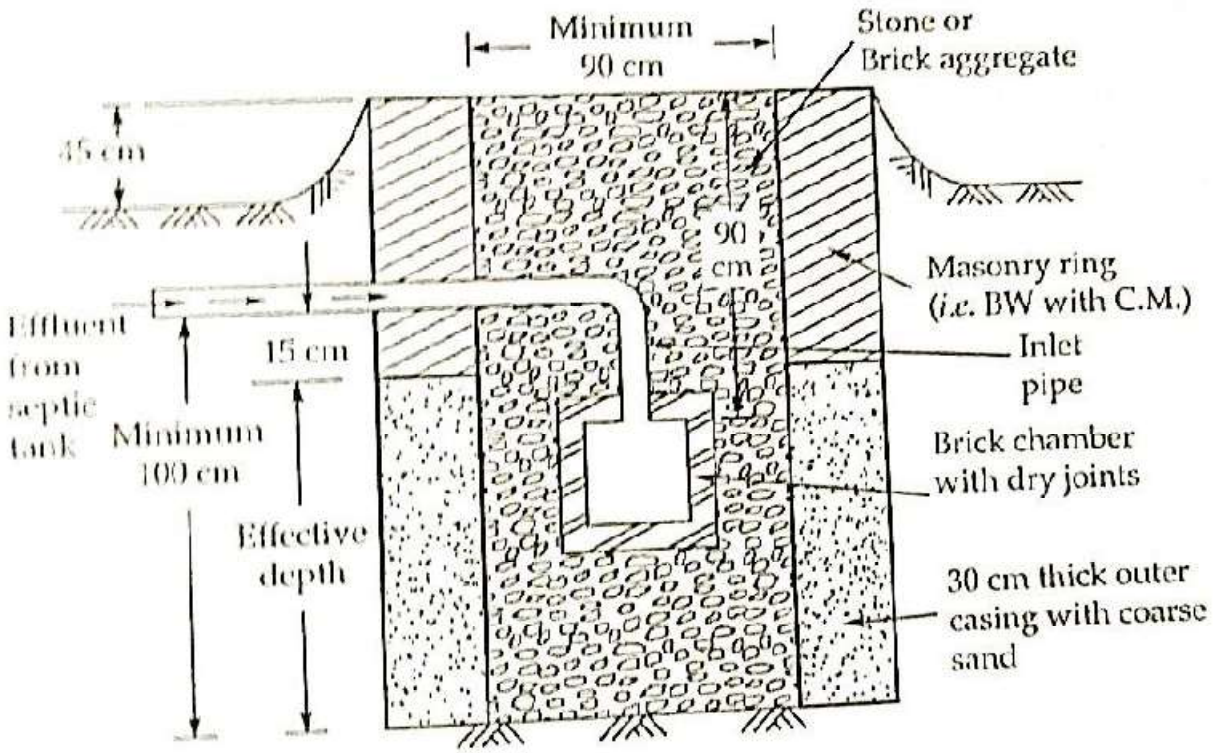


Fig. 5.11 Two-Pit Latrine system

SOAK PITS

A soak pit is a circular covered pit, through which the effluent is allowed to be soaked or absorbed into the surrounding soil. The soak pit may either be filled with stone aggregate or may be kept empty. When the soak pit is empty, the pit is lined with brick, stone or concrete blocks with dry open joints.



above the groundwater table.

♦ It should be located at a safe distance from a drinking water source (ideally more than 30 m).

♦ The soak pit should be kept away from high-traffic areas so that the soil above and around it is not compacted. It can be left empty and lined with a porous material to provide support and prevent collapse, or left unlined and filled with coarse rocks and gravel.

♦ The rocks and gravel will prevent the walls from collapsing, but will still provide adequate space for the wastewater. In both cases, a layer of sand and fine gravel should be spread across the bottom to help disperse the flow.

♦ To allow for future access, a removable (preferably concrete) lid should be used to seal the pit until it needs to be maintained.