CBCS SCHEME

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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)**

* * * * *

Module - 1

1

a Explain the different types of Sewarage Systems with their advantages, disadvantages and Suitability.

The Sewerage System are classified as follows.

(a) Combined Systems
(b) Seperate System
(c) Partially Seperate System.

(a) Combined System

This System is best Suited in areas having Small rainfall, Which is distributed, throughout the area, because at Such places Self-cleaning Velocity will be available in every Season. As only one Sewer is laid in this System. it is best Suited for Crowded area because of traffic problems. the Combined System can also be used in area having less Sewage, to obtain the Self-cleaning Velocity.

Merits →

① There is no need of flushing because Self-cleaning Velocity is available at every place due to more quantity of Sewage.

② The Sewage Can be treated Easily and economically because rainwater dilutes the Sewage

③ House plumbing Can be done Easily only one set of pipe Will be required.

Demerits →

① The initial Cost is high as compared to Seperate System

② It is not Suitable for areas having rainfall for Smaller periods of one year result in silting of Sewers due to Self-Velocity is not available.

(b) Seperate System

When domestic and industrial Sewage are taken in onset of Sewers. Where as Storm water are taken in another Set of Sewer. it is Called Seperate System.

Merits →

① Since the Sewage flows in Seperate Sewer, the quantity to be treated is Small which results in economical design of treatment works.

② Seperate System is cheaper than combined System, because only Sanitary Sewege flows in closed Sewer and Storm water which is unfoul in nature can be taken through open channel or drains, Where as both types of Sewege is to be carried in closed Sewer in combined System.

③ During disposal if the Sewage is to be pumped. the Seperate System is cheaper

④ There is no fear of stream pollution.

Demerits →

① Flushing is required at Various points because self-cleaning Velocity is not available due to less quantity of Sewage.

② There is always risk that the storm water may enter the Sanitary Sewage Sewer and cause the overflow of Sewer and heavy load on treatment plant.

③ Mentainance cost is more because of two Sewers.

④ In busy lanes laying of two Sewers is difficult Which also Causes inconvenience to the traffic during repairs.

(c) Partially Seperate System.

In the Seperate System, if a portion of Storm water is allowed to enter in the Sewers Carrying Sewage and the remaining storm water flows in Seperate Set of Sewers, it is Called partially Seperate System.

Merit →

① It is economical and reasonable size sewers are required because as it is an improvement over Seperate System.

② The work of house-plumbing is reduced because the rain water from roof, Sullage from and Kitchen, Can be taken in the Same pipe Carrying the discharge from the water closets. the Water from all other places Can be taken in Seperate Sewer

③ No flushing is required because Small portion of storm water is allowed to enter in Sanitory Sewage.

Demerit →

① Cost of pumping is more than Seperate System when pumping is required because portion of storm water is mixed.

② There are possibilities of over-flow.

③ In dry wheather, the Self-cleaning Velocity may not develops.

Suitable conditions for Seperate Sewerage System →

* Where rainfall is uneven
* Where Sanitory Sewage is to be pumped.
* The drainage area is steep, allowing to runoff quickly.
* Sewers are to be constructed in rocky strata.

Suitable conditions for Combined System →

* Rainfall in even throughout the year
* Both Sanitory Sewage and the storm water to be pumped.
* Effective or quicker flows have to be provided.

b) Explain Dry Wheather Flow (DWF) and explain the factors on which DWF depends.

Dry wheather Flow →

Domestic Sewage and industrial Sewage collectively Called as dry wheather flow (DWF). It does not contains Storm water. It indicates the normal flow during dry Season of the year.

The dry wheather flow or quantity of Sanitary Sewage depends upon the following factors.

* Rate of water Supply
* population growth
* Type of area Served
* Infiltration of ground water.

Rate of water Supply →

The rate of water Supply to a City or town is expressed So many litres/capita/day. The quantity of waste water entering the Sewers Would be less than the total quantity of water Supplied. This is because of the fact that water is lost in domestic Consumption, evaporation, lawn spinkling, fire fighting, industrial consumption. However, private Source of water supply (i.e Water from domestic Wells etc) and infiltrations of Sub-soil Water in the Sewers increase the waste water flow rate

This extra water that enters the Sewers can be assumed to approximately equal to the water lost in consumption etc. due to this reason, waste water flow rate may be assumed equal to the rate of water Supply by muncipal authorities.

Population growth →

The quantity of Sanitory Sewage directly depends on the population. As the population increases the quantity of Sanitary Sewage also increases. the quantity of water supply is equal to the rate of supply multiplied of population. The Sewage quantity which will be produced in the town due to future developments of the town and population should be taken into account and as far as possible accurate results should be obtained.

Type of Area Served →

The quantity of Sanitory Sewage also depends on the type of area to be served, wheather it is residential, industrial or commercial. The quantity of sewage produced in residential areas diretly depends on the quantity of water supply to the area. The quantity is obtained by multiplying the population with this factor. the quantity of sewage produced by various industries depends on their various industrial processes. and it is different for each industry. This quantity can be determined by doing a survey of that area collecting the data.

Infiltration of ground water →

Ground water or sub-soil water may infiltrate into sewers through the leaky joints. Ex-filtration is the reverse process which indicated the flow of waste water from sewer into ground. While due to infiltration the quantity of flow through sewer increases, ex-filtration results in decrease in the flow and consequent increase in the pollation of ground water. both infiltration as well as ex-filtration are undesirable and take place due to Imperfect Joints. (5)

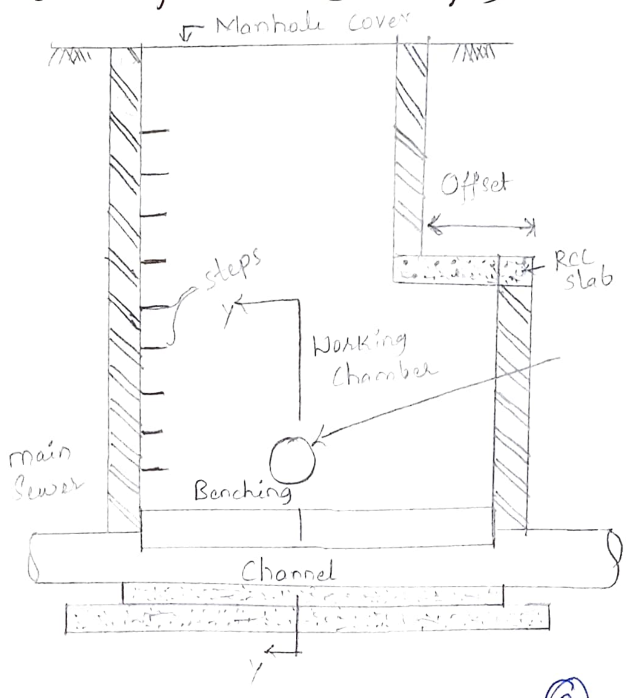
2

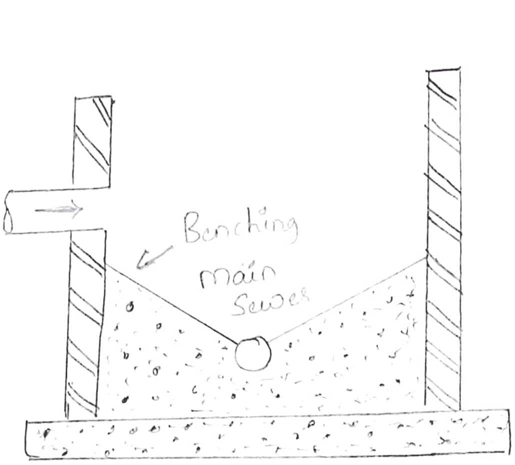
a) Define Sewer appurtenances. Explain with neat sketch, Construction and working of manhole.

The Sewage flowing in the sewer line contains a large number of impurities in the form of silt, fats, oils, rags etc. under the normal flows they are not likely to settle and chock the sewers. but during small flows self-cleaning velocity is not likely to develop and the chances of choking of the sewers are increased. choking have to be removed time to time and facilities should be provided on the sewer lines for this purpose. Therefore, for proper functioning and to facilitate maintenance of the Sewage system, various additional structures have to be Constructed on the sewer lines. these structures are known as Sewer appurtenances.

Following are the important appurtenances

① Manholes ② Inlets ③ Flushing devices ④ Catch basins ⑤ Regulators ⑥ Inverted Siphons ⑦ Grease and oil traps ⑧ Lamp holes. ⑨ Leaping weirs ⑩ Junction chambers.





Section Y-Y

The manholes are RCC or masonry chambers constructed on the Sewer line to facilitate a man to enter the Sewer line and make the necessary inspection and repairs. these are fitted with Suitable cast iron covers. the manholes should installed at every points where there is a change in direction, change in pipe size or considerable change in gradient. As far as possible Sewer line between two Subsequent man holes should be straight. The Center distance between manhole is less for Sewers of Smaller size while it may behave Such a size that man easily enter in the working chamber. the minimum size of 50cm diameter.

The construction of manholes →

① Excavation

① The excavation for manhole shall be as per the dimensions and levels specified in the plan

② The excavation width shall includes the necessary working space for accessibility for mason to work freely below the ground.

② Bed Concrete

① A bed concrete of 1:4:8 shall be laid over which the manholes shall be constructed.

② The minimum thickness of bed concrete shall be 20cm & 30cm for manholes of depth 4.25m & above 4.25m

③ In case of loose soil, special foundation shall be constructed to support the manholes.

③ Brick masonry →

① The standard quality of bricks used in the construction of manholes shall be of class 7.5N with Cement 1:4 ratio.

② For arched type & Circular manholes, the Cement-mortar ratio 1:3

③ The finishing of the brick masonry in the external face shall be finished smooth

④ plaster and pointing →

① The inside of the brick masonry of manholes shall be plastered with a 12mm thick 1:3 cement mortar.

② Generally, the outer side of the manhole isn't plastered, but in case of saturated soil, external surface of the manholes shall be plastered with a 12mm thick.

③ The inside plastered surface shall be waterproofed with a agents.

⑤ Channel and Benching →

Benching in manhole refers to the path made out of cement mortar to directing waste water in certain direction and stop splashing of waste, which turns damages manhole.

① The channels and benching in a manholes shall be constructed using cement ratio 1:2:4.

② The depth of channels and benching shall be neatly finished.

⑥ Footrests →

The Footrests in the manholes are provided for easy accessibility in case of cleaning and maintainance.

① Footrests are provided in the manholes if the depth of manholes exceeds more than 0.8m.

② The Footrest shall be of PVC or mild steel

③ The Footrest shall be placed 450mm below manholes cover

⑦ Manhole covers and frames.

① The manholes cover shall be gas-tight and water tight

② The manholes covers and frames shall be of the light duty, medium duty, Heavy duty

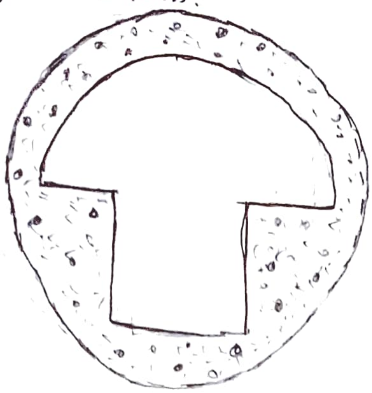
③ After completion of the construction of the manhole, the covers shall be sealed employing thick grease.

b) Explain any five different Shapes of Sewers With neat sketches.

Following are the non-circular shapes of Sewers used for

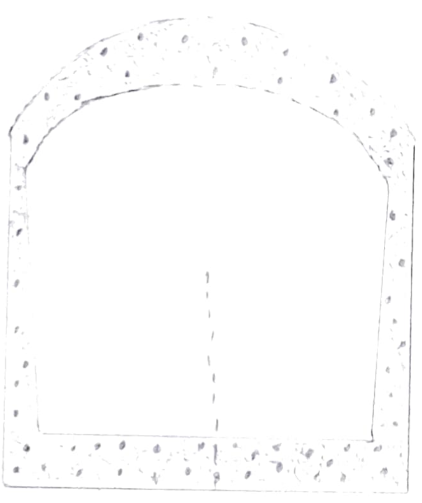
(1) Basket handle Sewer

The Shape of this Sewer resembles the Shape of a basket handle. Small discharge flow through the bottom narrower portion. during rainy days, the combined Sewage flows in the full Section.



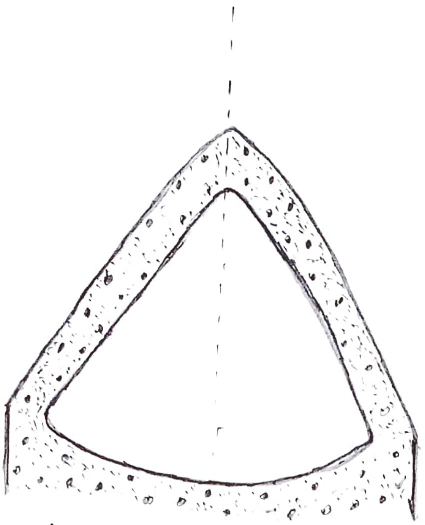
(2) Horse-Shoe Sewers

This is as shown in below figure, usually Semicircular With Sides inclined or vertical. the bottom may be flat, Circular or parabolic. Its height is more than Width. It is mostly used for Sewers in tunnel. It is used for construction of large Sewers With heavy discharged Such as trunk Sewers. This Shape gives increased head room.



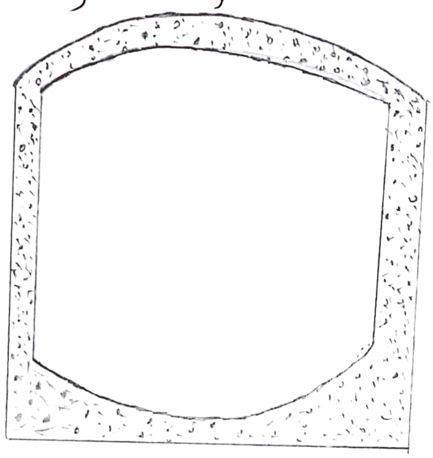
(3) Parabolic Sewers

In this form of Sewers, the upper arch takes the shape of parabola as shown in figure below. The invert of the Sewer may be flat, parabolic or elliptical. they are used for disposal of relatively Small Sewage.



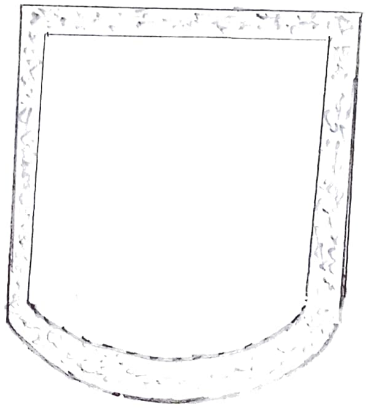
④ Semi - Circular Sewers.

The Semi-circular sewer gives a wider case at the bottom and hence, it becomes suitable for constructing large sewers with less available headroom. Now a day they are replaced by rectangular sewers.



⑤ U shaped Sewers.

Two Sections of U-shaped sewers are shown in below Trench provided at the bottom is called cunnette. These are easy to construct. their invert may be flat or Semi-Circular. The sides are generally vertical and up top may be flat or arched.



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.

→

Population = 50,000

N = 0.012

Per capita Water Supply = 150 lit/day.

Average water Supply = 150 × 50000

= 7,500,000

Average water Supplied = $\frac{50,000 \times 150}{1000 \times 24 \times 60 \times 60}$ = 0.00868 cumecs

Average Sewage discharge = 80% of water Supplied.

= 0.8 × 0.00868

= 0.006944 cumecs

DWF = 0.006944 Cumecs

Maximum discharge for which Sewer should be designed full.

$Q = 4 \times 0.006944$ = 0.0278 cumecs

Now, using Manning's formula

$$Q = \frac{1}{N} \cdot A R^{2/3} \sqrt{S}$$

[Capital letter for running full]

$$0.0278 = \frac{1}{0.012} \times \left(\frac{\pi}{4} \times D^2\right)\left(\frac{D}{4}\right)^{2/3} \cdot \frac{1}{\sqrt{500}}$$

$$D^{8/3} = \frac{0.18 \times 0.012 \times 4 \times 2.52 \times 25}{\pi}$$

$$D^{8/3} = 0.173$$

$$D = 0.1$$

$$D^{8/3} = \frac{0.0278 \times 0.012 \times 4 \times 2.52}{\pi}$$

$$D^{8/3} = 0.0107$$

$$D = (0.0107)^{3/8} = 0.183\,m$$

6 Explain Self cleaning Velocity and non-Scouring Velocity. What are different types of Sampling? Explain.

Self cleaning velocity – It is necessary to mentain a minimum Velocity in a Sewer line to ensure that Suspended Solids do not deposit and cause choking troubles. Such minimum velocity is called as Self cleansing velocity.

The Self-cleansing velocity can be found by formula

$$V = \sqrt{\left[\left(\frac{8K}{f}\right)\left(\frac{S_s - S}{S}\right) g d\right]}$$

f = Darcy's co-efficient of friction 0.03
K = Characteristics of Solid particles. = 0.06
S_s = Specific gravity of particle
S = Specific gravity of Sewage (1.0)
g = acceleration due to gravity
D = diameter of particles.

Non-Scouring Velocity →

The interior Surface of the Sewer pipe gets Scored due to Continuous abrasion Caused by Suspended Solids present in Sewage. The Scouring is pronounced at higher velocity than What can be tolerated by the pipe materials. This wear and tear of the pipe will reduce the life span of the pipe and their Carrying Capacity. In order to avoid this, it is necessary to limit maximum velocity that will be produced in Sewer pipe at any time.

There are 2 types of Sampling techniques ① Grab ② Composite

ⓐ Grab Sampling –

Grab Sampling are Single Collected at a Specific Spot at a Site over a short period of time thus they represent a "Snapshot" in both space and time of a Sampling area. Descrete grab Samples are taken at a Selected location, depth and time of a Sampling area. depth-integrated grab Samples are Collected over a predetermined part of entire depth of a water Column, at a Selected location and time given water body.

Grab Sample consisting of either a single discrete sample or individual samples collected over a period of time not to exceed 15 minutes. the grab samples should be representative of the waste water conditions at the time of sample collection. Sample volume depends upon type and numbers of analyse to be performed.

Composite Samples →

Composite samples should provide a more representative sampling of heterogenous matrices in which the concentration of the analytes of interests may vary over short periods of time and space. Composite samples can be obtained by combining portions of multiple grab samples or by using specially designed automatic sampling devices. Sequential composite samples are collected by using continuous, constant sample pumping or by mixing equal water volumes collected at a regular time intervals. Flow proportional composites are collected by continuous pumping at a rate proportional to flow. by mixing equal volumes of water collected at time intervals that are inversely proportional to the volume of flow or by mixing volumes of water proportional to the collected during or at regular time intervals.

— Advantages of composite samples includes reduced costs of analyzing a large number of samples, more representative samples of heterogeneous material, matrices, & large samples size when amounts of test samples are limited.

Disadvantages of composite samples includes loss of analyte relationships in individual samples. potential dilution of analytes below detection levels. increased potential analytical interferences, and increased possibility of analyte interactions. In addition potential dilution of analyte below detection levels. increased analytical interferences, and composite sample may reduce the number of samples analyzed below the statistical need for specified data quality objectives or project-specific.

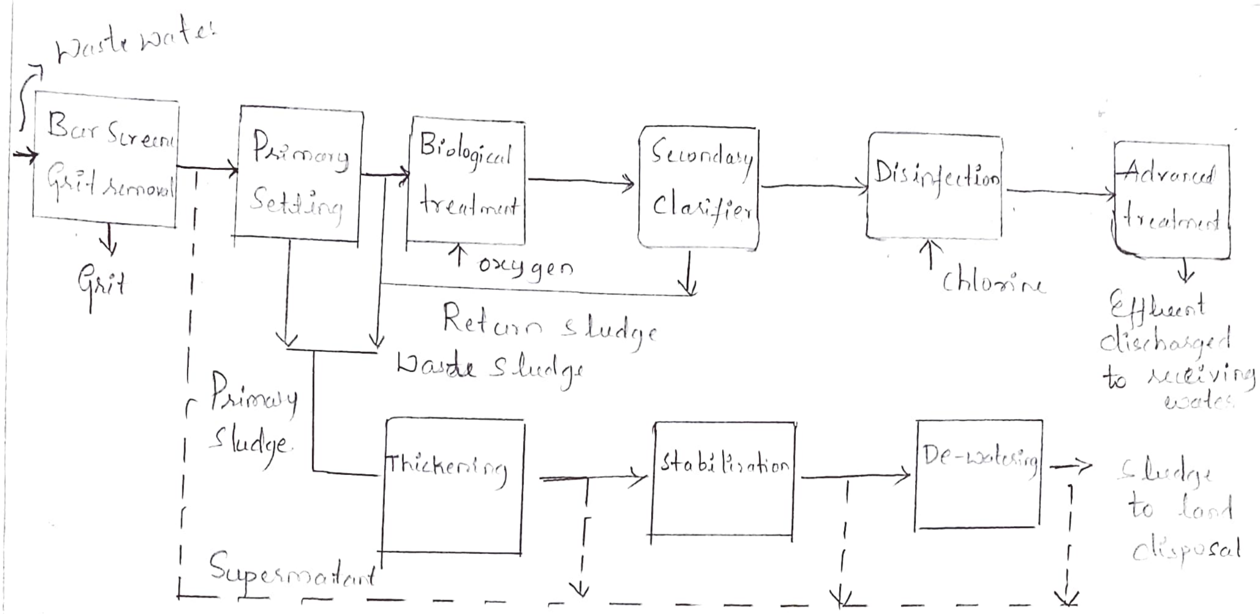
4
a

Draw a neat flow diagram employed for a muncipal Wastewater treatment plant. Indicate the importance of each unit indicated in the flow diagram.

→ The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. Irrigation with waste water is both disposal and utilization and indeed is an effective form of waste water disposal. However, Some degree of treatment must normally be provided to raw muncipal wastewater before it can be used for agricultural or landscapes irrigation or for aquaculture. the quality of treated effluent used in agriculture has a great influence on the operation and performance of the wastewater - soil - plant or aquaculture System. In the case of irrigation, the required quality of effluent used in agriculture has a great influence on the operation and performance of the waste water - soil - plant or aquaculture System. through Crop restriction and Selection of irrigation System which minimize health risk, the degree of pre-application waste water treatment can be reduced. A similar approach is not feasible in aquaculture System and more reliance will have to be placed on control Waste water treatment

The wastewater treatment plant has following parts

① Screening
② Primary treatment
③ Secondary treatment
③ Advanced treatment



① Bar Screens → The function of bar screen is to remove sand & grit from ~~the~~ entering the treatment plant.

② Primary Settling → The primary settling are used to settle sand in the primary treatment process. it is also having the detention period of the 2-3 hours.

③ Biological treatment → The biological treatment can be used for the removal of macro and micro-organisms.

④ Secondary clarifier → The clarifier are used to remove some dissolved and suspended solids in the Clarifloculator

⑤ Disinfection → The removal of unwanted bacteria and virus present in the waste water by adding chlorine.

⑥ Advanced treatment → The advanced treatment are used for waste water treatment such as Caustic Soda, lime etc.

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

→

$$K_{D(20°C)} = 0.1/day$$

$$K_{D(30°C)} = K_{D(20°C)} [1.047]^{(T-20°)}$$

$$= 0.1 \times (1.047)^{10} = 0.158/day$$

$$Y_{5(30°C)} = L[1-10^{-K_D(30°C)t}]$$

$$L = \frac{110}{[1-10^{-0.158 \times 5}]} = 131.3 \ mg/l$$

$$Y_{5(20°C)} = L[1-10^{-K_D(20°C)t}]$$

$$= 131.3 \times [1-10^{-0.1 \times 5}] = 89.8 \ mg/l$$

C

Explain the term BOD and their importance in waste water

BOD is defined as the oxygen required for the micro organisms to carry out biological decomposition of dissolved solid or organic matter in the waste water under aerobic condition at standard temperature.

The importance of BOD in waste water treatment

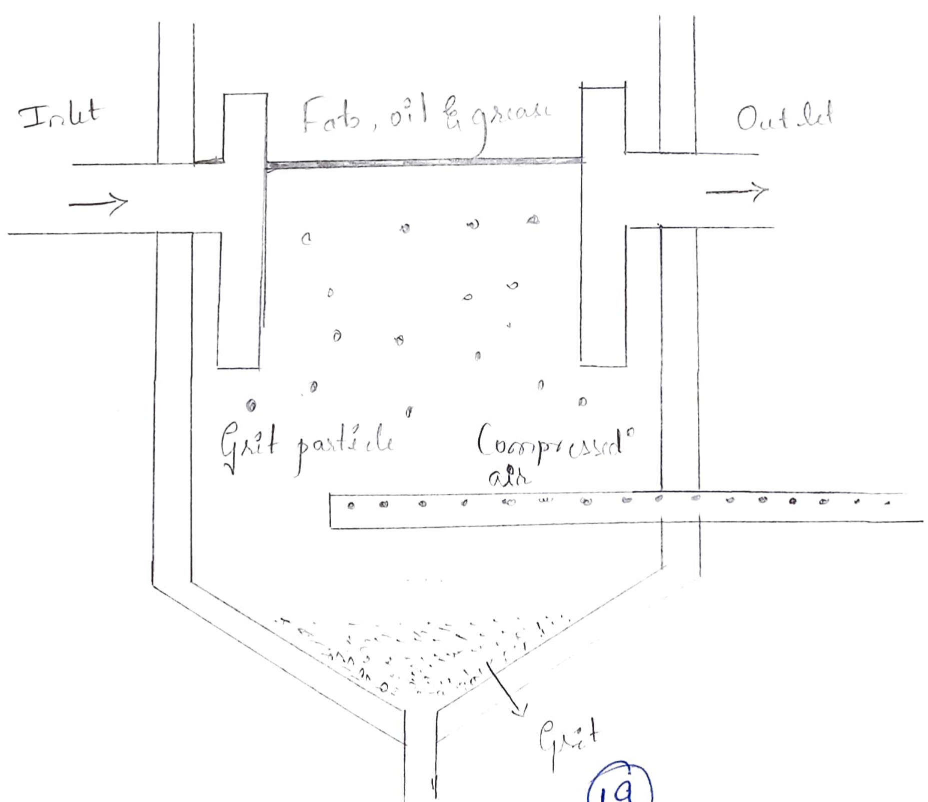
1. Determination of approximate quantity of oxygen required for the biological stabilization of organic matter.
2. It is important in determining size of waste water treatment
3. It is help in measurement of efficiency of some treatment process.
4. It helps in determination of strength of sewage
5. It helps in finding amount of water required for the efficient disposal of waste water by dilution.

5

a Explain the working of a "Grit chamber" and "oil and grease" removal tank with figures

Grit chamber –

◉ A 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 bottom. The heavier grit particles with their higher settling velocities drop down to the floor, where as lighter organic particles with their higher settling velocities drop down to floor. Where as lighter organic particles will remains in suspension and carried with the roll of spiral motion due to diffused air and eventually carried out of the tank.

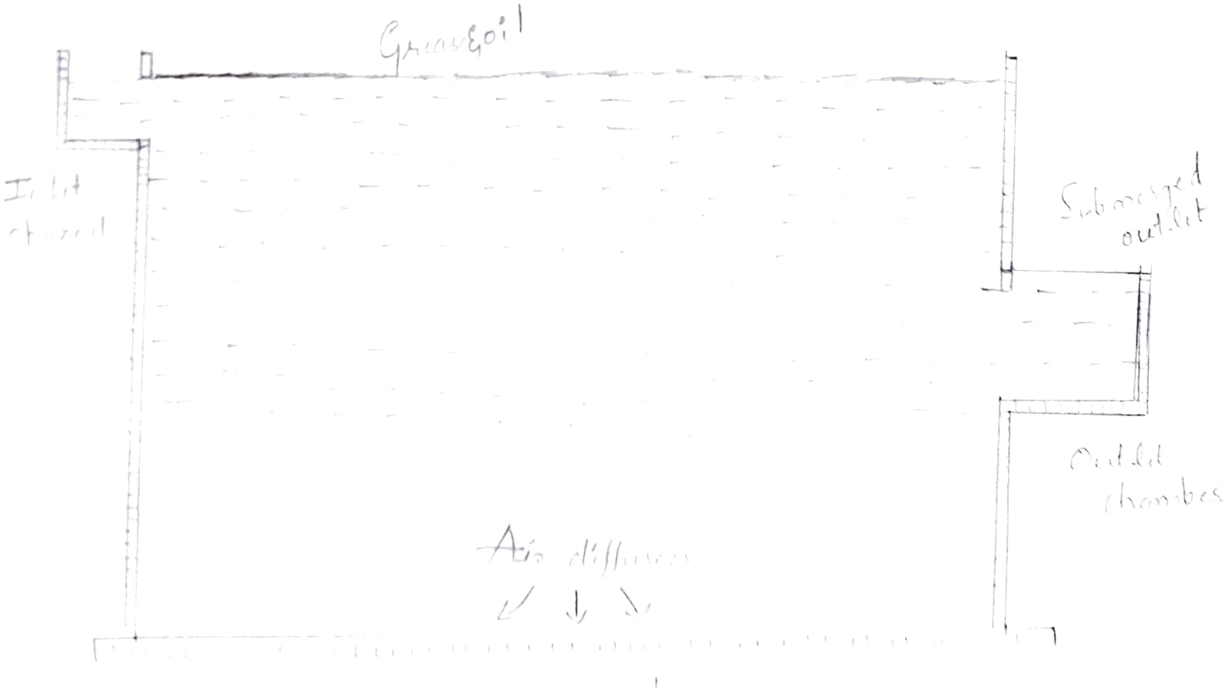


Oil and Grease removal tank →

The oil and grease may be removed by floatation or Settling as scum or sludge. formation of scum is promoted by diffusing air through the Sewage is called skimming tanks.

Skimming tanks →

Skimming tanks are narrow rectangular tanks having atleast two longitudinal baffle walls interconnected, they are used to remove grease and fatty oils from the Sewage. Air diffusers are provided at the bottom of the tank. Compressed air applied at rate Varying from 300 to 6000 m^3/million litres of Sewage agitates the Sewage. which prevents settling of solids. Air tends to change the oil and grease to a soapy mixture. This mixture is carried to the Surface by the air bubbles. Some of which are entrained in it and may be skimmed off.



Skimming tank

b) Write short notes on (1) Screens (2) Settling tank.

(1) Screens

Screening is the first and essential step in the treatment of Sewage. It consist of passing Sewage through different sized Screens to trap and remove comparatively large size of floating matters. Such floating matters are not removed they may damage pumps & equipments.

Screens are to be situated before the grit chambers & they are housed in a chamber called Screen chamber. the Screens are always set in an inclined position with an angle 30° to 60° with vertical.

Types of Screens →

Screens are classified into following →

(1) According to size of openings.

Coarse Screen →

These type of Screens are also called as Racks or Bar Screens. they have relatively larger openings ranging from 5cm - 10cm. They serve more as protecting devices. in contrast to fine Screens.

Medium Screens →

These type of Screens have openings of 2cm – 5cm. these are mechanically racked units, and used before all pumps.

Fine Screens →

These type of Screens are mechanically cleaned devices using perforated plates or very closely spaced bars with clear openings of less than 2cm & needs continuous cleanings.

② Settling tank →

Every efficient System of Sewage disposal makes use of a collecting tank in which the raw Sewage is recieved

A collecting is not filled and then emptied before it recieves more Sewage, but the Sewage flows through it continuously. It is made of Sufficient size to hold at least the quantity of Sewage that is produced during twelve or twenty four hours. The Sewage therefore remains in the tank for from twelve to twenty-four hours. and during that time it undergoes 2 processes

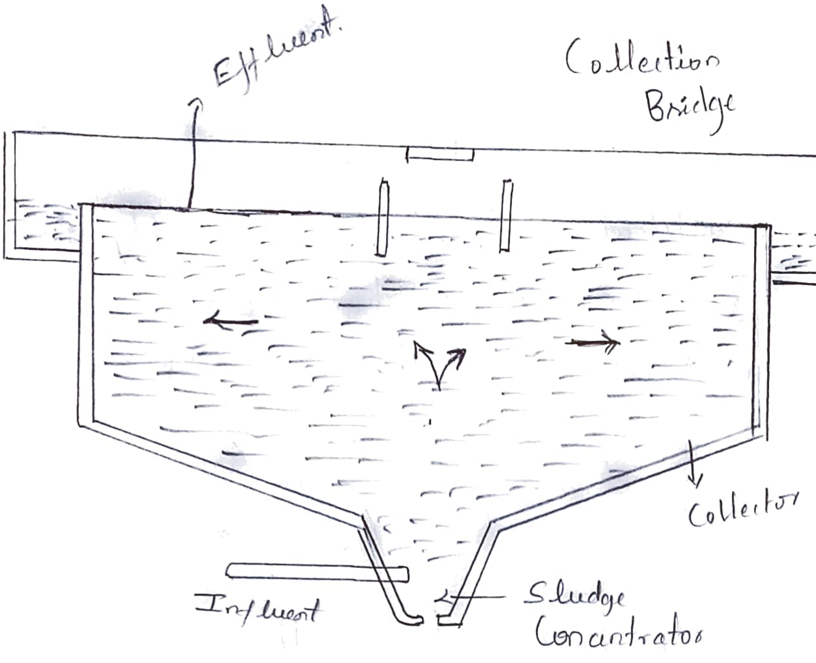
① Sedimentation

② Putrefaction

While Sewage is flowing slowely through a collection tank the heavily particles of solid matter sinks to the bottom and lighter one float on the Surface. For this reason, collecting tank is also called settling tank. An efficient tank will usually remove Somewhat less than one-half of the Solid matters in Sewage.

An active bacterial action also takes place in a collecting tank. The action is one of putrefaction, and for this reason the receptacle is often called a Septic tank. the result of putrefaction is to liquefy Some of Solid bits of matter that floats in Sewage, and to decompose Some of the Substances that are dissolved in it. the action is rapid during first few hours that a particular mass of Sewage remains in the tank, but after that period of time the action is slow. there is no advantage in retaining the liquid part Sewage in a Septic tank for a longer time than a day. A Septic tank will remove about half of the decomposable Substances which are contained in Sewage and effluent will undergo decomposition unless Subjected to Purification.

Settling tank



6.

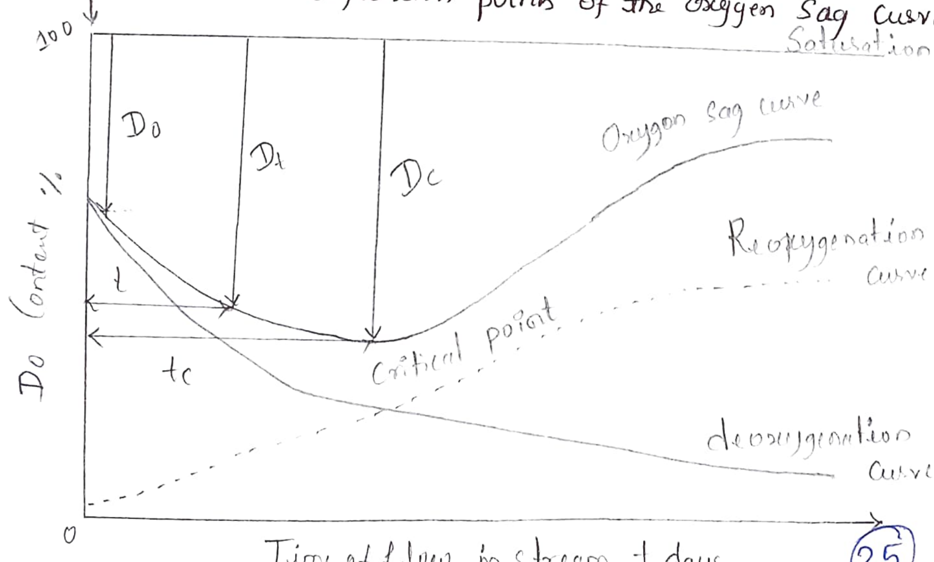
a) Discuss in detail the process of de-oxygenation and re-oxygenation with respect to self-purification of natural water with sketch.

The oxygen sag or oxygen deficit in the stream at any point of time during self purification process is the difference between the saturation DO content and actual DO content at that time. the amount of resultant oxygen deflect can be obtained by algebraically adding the de-oxygenation and re-oxygenation curves. the resultant curves so obtained is called oxygen sag curve.

Oxygen deficit D = Saturation DO − Actual DO

The saturation DO value for fresh water depends upon the temperature and total dissolved salts present in it. & its value varies from 14.62 mg/l at 0°c to 7.63 mg/l at 30°c, and lower DO at higher temperatures.

The DO in the stream may not be at saturation level and may be initial oxygen deficiet 'Do' At this stage, when the effluent with initial BOD load Lo. is discharged in to stream, the DO content of the stream starts depleting and the oxygen deficit (D) increases. the variation of oxygen deficit (D) with the distance along the stream and hence with time of flow from the point of minimum DO. i.e maximum deficit. the maximum or critical dificit (DC) occurs at the inflexion point of the oxygen sag curve.



Deoxygenation & Re-oxygenation Curves.

De-oxygenation – the curve which represents (or) showing the depletion of D.O with time at the given temperature.

Re-oxygenation – In order to counter balance the consumption of D.O due to the de-oxygenation, atmosphere supplies oxygen to the water and the process is called the re-oxygenation.

When waste water is discharged into the stream, the DO level in stream goes on depleting. this depletion of DO content is known as deoxygenation. the rate of deoxygenation depends upon the amount of organic matter remaining (L_t) to be oxidized at any time t, as well as temperature (T) at which reaction occurs. the variation of depletion of DO content of the stream with time is depicted by the deoxygenation curve in the absence of aeration. the ordinates below the deoxygenation curve indicates the oxygen remaining in the natural stream after satisfying the bio-chemical demand of oxygen. when the DO content of the stream is gradually consumed due to BOD load, atmosphere supplies oxygen continuously to the water, through the process of re-aeration or reoxygenation

The rate of reoxygenation depends upon →

① Depth of water in the stream: more for shallow depth

② Velocity of flow in the stream: less of stagnent water.

③ oxygen deficit below saturation DO: since solubility rate depends on difference between saturation concentration & existing concentration of DO

④ Temperature of water: Solubility is lower at higher temperature and also saturation concentration is less at higher temperature.

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 co-efficient of purification of the stream (f) as 4.0 and Co-efficient of de-oxygenation (K_D) as 0.1 (Take Saturated D.O = 9.2 mg/l)

→ The initial D.O of river.

= Saturation D.O at the given temp
= 9.2 mg/l

DO of mix at t=0 is at start

$$= \frac{9.2 \times 1500 + 0 \times 100}{1500 + 100}$$ (assume D.O of Sewage nil)

= 8.62 mg/l

Initial D.O deficit of the stream

= D.O = 9.2 − 8.62 = 0.58 mg/l

Also, 5-day BOD of the mixture of Sewage and stream is given by.

$$C = \frac{C_s Q_s + Q_R C_R}{Q_s + Q_R} = \frac{280 \times 100 + 1500 \times 0}{100 + 1500}$$

= 17.5 mg/l.

5-day BOD of mix at the given temp

Y_5 = 17.5 mg/l

The ultimate BOD of the mix is L

$$= \frac{17.5}{0.684} = 25.58 \text{ mg/l}$$

Now $$\left[\frac{L}{D_c \cdot f}\right]^{f-1} = f\left[1 - (f-1)\frac{D_o}{L}\right]$$

$$\left[\frac{25.58}{D_c \times 4}\right]^3 = 4\left[1 - (4-1) \times \frac{0.58}{25.58}\right] = 4.12 \text{ mg/l}$$

Now

$$t_c = \frac{1}{K_D(f-1)} \log_{10}\left[f\left\{1-(f-1)\frac{D_o}{L}\right\}\right]$$

$$t_c = \frac{1}{0.1\,(4-1)} \log_{10}\left[4 \times 1 - \frac{3 \times 0.58}{25.58}\right]$$

$$= \frac{1}{0.3} \times 0.571 = 1.905 \text{ days.}$$

Now distance = Velocity of river × Travel time

$= 0.1\ m/s \times (1.905 \times 24 \times 60 \times 60)$

$= 16.460\ m = 16.46\ km$

7

a) Explain the five modifications of activated sludge processes.

Activated sludge process modifications.

Many activated sludge process modification 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 manner in which the microorganisms are mixed with incoming wastewater.

Major modifications of ASP are

① Conventional

This configuration requires primary treatment, has the influent and returned sludge enter the tank at the head end of the basin, mixing is accomplished by the aeration system, and provides excellent treatment. on the downside, this modification requires large aeration tank capacity, higher construction costs, high initial oxygen demand, & is very sensitive to operation problems, such as bulking.

② Tapered Aeration

The tapered aeration system is similar to the conventional ASP. The major difference is in the arrangement of the diffusers. The diffusers are close together at the influent end where more oxygen is needed. towards the other end of the aeration basin.

③ Step Aeration

In step aeration, the returned sludge is applied at several points in the aeration basin. Generally the tank is subdivided into 3 or more parallel channels with around the end baffles & the sludge is applied at separate channels or steps.

④ Complete mixe Aeration

In complete mix aeration the influent and the returned sludge are mixed and applied at several point along the length and width of the basin. the contents are mixed, and the mixed liquor suspended solids (MLSS) flows across the tank to the effluent channel.

⑤ Contact stabilization

In contact stabilisation, primary treatment is not required. The activated sludge is mixed with influent in the contact tank where the organic are absorbed by microorganisms. The MLSS is settled in the clarifier. the returned sludge is aerated in the reaeration basin to stabilize the organics. the process requires approximately 50% less tank volume and then can be prefabricated as a package plant for flows of 0.05 – 1 MGD. on downside. this system is more complicated to control because many common control calculations not work.

E. The Sewage is flowing at 4.5 million litres/day from a primary Clarifier to a Standard rate trickling filter. the 5-day BOD of the influent is 160mg/l. the value of the adopted organic loading is to 160mg/m³/day. and Surface loading 2000l/m²/day Determine the volume of the filter and its depth. Also Calculate the efficiency of this filter unit.

→

Total 5-day BOD present in Sewage

$$= \frac{160 \times 4.5 \times 10^6}{10^3} \times m/day = 7,20,000 \text{ ml/day}$$

Volume of the filter required

$$= \frac{\text{Total BOD}}{\text{Organic loading}} = \frac{7,20,000}{160} = 4500 \text{ m}^3$$

Surface Area required for the filter

$$= \frac{\text{Total flow}}{\text{Hydraulic loading}} = \frac{4.5 \times 10^6}{2000} = 2.25 \times 10^3 \text{ m}^2$$

$$= 2250 \text{ m}^2$$

$$\text{depth of the bed required} = \frac{4500}{2250} = 2m$$

Efficiency of the filter is given by

$$y = \frac{100}{1 + 0.0044\sqrt{u}}$$

u = organic loading in kg/ha-m/day

$$y = \frac{100}{1 + 0.0044\sqrt{1600}} = \frac{100}{1 + 0.176}$$

$$= 85.03\%$$

8 a

Explain briefly with neat sketches, the working of
① Sludge digesters
② Sludge drying beds.

① Sludge digesters –

The anaerobic digesters are of two types. Standard and high rate. In standard type consisting of usually unheated or unmixed. The digestion period may varies from 30 to 60 d. In high rate contains heated & completely mixed. the detention period is 10 – 20 days.

Construction and working of sludge digester.

① It is usually circular RCC tank. with hoppered bottom and having fixed or floating type of roof.

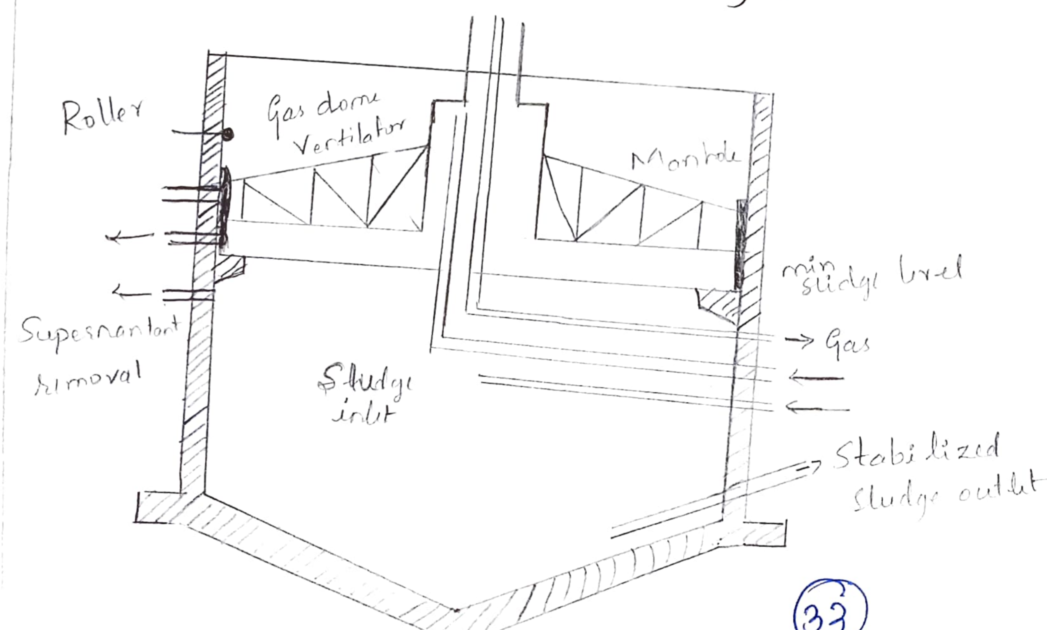
② The raw sludge is pumped into the digester and it is seeded with digested sludge from another tank.

③ power driven mechanical devices or a screw pump is used to stir the sludge

④ In cold countries digestors are provided with heating facility to maintain the optimum temperature

⑤ The gases produced after decomposition is collected seperately or in a gas dome in the same tank.

⑥ Digested sludge gets settled in a bottom of the tank is removed periodically and the supernatant liquor is removed using pipe kept at various heights.



② Sludge drying beds.

① The digested sludge contains lot of moisture content which should be eliminated before disposing of it. It is usually achieved using sludge beds. The method consists of applying the sludge on specially prepared open beds of land.

② Open beds of land 45 – 60cm deep.

③ 30 – 45cm thick graded layers of gravel or crushed stone in size varying from 15cm at bottom to 1.25cm at top.

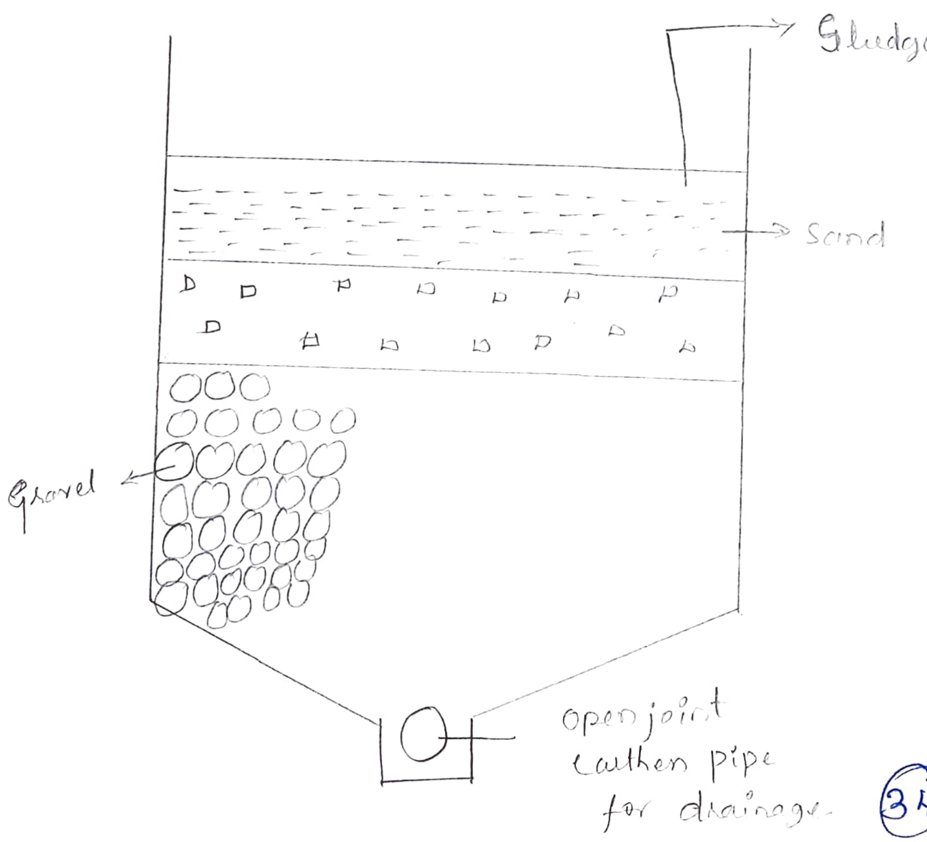
④ 10 – 25cm thick coarse sand layer over the graded gravel layer

⑤ Open jointed under-drain pipes of 15cm in dia @ 5-7m c/c below the gravel layers at a slope of 1 in 200.

⑥ 15×30m in plan and are surrounded by brick walls rising about 1m above the sand surface.

⑦ Top of the bed can be covered with glass to protect it from rains

⑧ Now 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 moisture gets away.



8

b

Calculate the dimension of an oxidation pond for treating sewage from a residential colony with a population of 5000 persons. Assume the rate of sewage flow 120 lpcd 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.

→ The quantity of sewage to be treated per day

$= 5000 \times 120 = 6,00,000$ litres

$= 0.6$ M litres $= 600\ m^3$

The BOD content per day

$= 0.6\ Ml \times 300\ mg/l$

$= 180$ Kg

Now, assuming the organic loading in the pond as say 300 kg/ha/day,

The surface area required

$= \frac{180\ Kg/d}{300\ Kg/ha/d} = \frac{180}{300} = 6000\ m^2$

Assume length of tank (L) as twice of its width (B)

$2B^2 = 6000 \Rightarrow B^2 = \frac{6000}{2} = 3000$

$B = \sqrt{3000}$

$\approx 54.7\ m$: Say $\underline{\underline{55\ m}}$

$L = \frac{6000}{55} = 110\ m$

Using a tank with effective depth as 1.2 m

The provided capacity $= 110 \times 55 \times 1.2 = 7260\ m^3$

Capacity = Sewage flow per day × detention time

$$\text{Detention time} = \frac{\text{Capacity in } m^3}{\text{Sewage flow per day}}$$

$$= \frac{7260}{600} = 12.1 \text{ days} \quad \text{Say } \underline{12 \text{ days}}$$

Hence use an oxidation pond with length = 110m

width = 55m

depth = (1.2+1) = 2.2m

Design inlet pipe. Assuming average velocity of sewage as 0.9 m/sec & flow 8 hours only.

$$\text{discharge} = \frac{600}{8 \times 60 \times 60} \text{ cumecs.}$$

$$\text{Area required} = \frac{\text{discharge}}{\text{Velocity}} = \left(\frac{600}{8 \times 60 \times 60}\right) \times \frac{1}{0.9} \; m^2$$

$$= \frac{1}{7.2 \times 6} m^2 = \frac{1}{43.2} m^2$$

$$= 232 \, cm^2$$

$$\text{Dia of inlet pipe} = \sqrt{\frac{4 \times 232}{\pi}}$$

$$= \underline{17.2 cm} \simeq \underline{18 cm}$$

Dia of outlet pipe may be taken as 1.5 times inlet

Say 27 cm

9] a)

Module - 5

Write about the need for advanced wastewater treatment? Explain the biological phosphorous removal process.

Need for Advanced waste water treatment.

① Advanced treatments solutions have become an area of global interests as individuals, industrial essentials.

② It is also necessary as Society mitigates the impacts of increased population, urbanization, depletion of portable water.

③ It is very much needed. as the waste water treatment generates the concerns including odour. issue & health Issues.

④ It is also helpfull to supply water from waste water treatment plant to irrigation field.

⑤ To protect humans and the ecosystem from toxic elements in waste water.

The Biological phosphorous removal process.

The principal advantages of biological phosphorous removal are reduced chemical costs and less sludge production as compared to chemical precipitation.

In the biological removal of phosphorous, the phosphorous in the influent waste water is incorporated into cell biomass, which is subsequently removed from the process as a result of sludge wasting. the reactor configuration provides the P accumulating organisms (PAO) with a competitive advantage over other bacteria. So PAO are encouraged to grow and consume phosphorous. the reactor configuration is comprised of an anaerobic tank and activated sludge in the anaerobic tank is about 0.50 - 1.00 hours. & its content are mixed to provide contact with the return activated sludge and influent waste water.

In Anaerobic Zone —

Under anaerobic conditions, PAO assimilate fermentation product into Storage products within the cells within concomitant release of phosphorous from stored polyphosphate Acetate is produced by fermentation of COD, which is dissolved degradable organic material that can be easily assimilated by the biomass. Using energy available from Stored polyphosphates, the PAO assimilate acetate and produce intracellular poly hydroxy butryte (PHB) storage products. magnesium, potassium, Calcium. Cations.

In the aerobic Zone →

The energy produced by the oxidation of Storage products and polyphosphate storage within the Cell increases. Stored PHB is metabolized, Providing energy from oxidation and Carbon for new Cell growth. Some glycogen is produced from PHB metabolism. the energy released from PHB oxidation is used to form polyphosphate bonds in cell Storage. the Soluble orthophosphate is removed from Solution and incorporated into polyphosphates within the bacterial Cell. PHB utilization also enhances cell growth and this new biomass with high polyphosphate storage accounts for phosphorous removal. As a portion of biomass is removed from the biotreatment reactor for ultimate disposal with waste sludge.

The phosphorous removed by biological storage can be estimed from amount of COD that is available in waste water influent.

9]

b) What is the necessity for the removal of nitrogen? Discuss the nitrification and denitrification process for removal of nitrogen

The removal of nitrogen from waste water has become an emerging worldwide concern because these compounds cause Eutrophication in natural water. moreover, nitrate is a risk to human health, especially as a possible cause of infant methaemoglobinaemia

Nitrification →

Nitrification is a microbial process by which ammonia is Sequentially oxidized to nitrate and then to nitrate. The nitrification process is accomplished primarily by two group of autotrophs nitrifying bacteria that can build organic molecules by using energy obtained from inorganic Sources - in this case, ammonia or nitrate.

In the first step of nitrification, ammonia-oxidizing bacteria oxidize ammonia to nitrate according to below equation

$$NH_3 + O_2 \rightarrow NO_2 + 3H^+ + 2e^-$$

Nitrosomonas is the most frequently identified genus associated with this step, although other genera, including Nitrosococcus & Nitrosospira may be involved. The Subgenera Nitrosolobus and Nitrosovibrio Can also autrophically oxidize ammonia.

In Second step of the process, nitrate-oxidizing bacteria oxidize nitrate to nitrate according to below equation

$$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$$

Nitrobacter is the genus most frequently associated with this Second step, although other genera, Such as Nitrospina, Nitrococcus and Nitrospira, Can also autotrophically oxidize nitrate.

10.

a) Explain the Septic tank with neat sketch. Also write the design consideration required for Septic tank.

A Septic tank is similar to an aquaprivy, except that a Septic tank can be located outside the house. the toilet used with a Septic tank also has a U-trap water seal. As with the aquaprivies, Septic tanks can be used to dispose of greywater and must be periodically emptied of sludge. they also require the use of a soak field for Secondary treatment of effluent. Septic tanks may have two chambers to Seperate and promote further settlement of liquid and Solid excreta.

Septic tanks are more costly than aquaprivies. given the higher initial investment required, plus the recurring costs of emptying the tanks, this method is not generally recommended for poor rural communities. For pre-urban areas, the ability to Connect the household to a Sewage System at a later date is a major benefit. the disadvantages include faulty or leakage Septic tanks, water requirements, higher costs and the use of a Soak field. If the Septic tank is faulty, flooding can cause hydraulic overloading.

A Septic tank is a water tight single storied, Underground horizontal continuous flow Sedimentation tank in which Sewage is retained sufficiently long to permit 60-70% of Suspended Solids to Settle in the form of Sludge at the bottom of the tank. Some of the lighter Solids including grease and fat rise to the Surface of the sewage to form Scum. the Scum and Sludge so formed are then retained with the Sewage in the tank for a Several months during which they decomposed by the process called Sludge digestion. Consequently, there is a reduction in volume of the Sludge to be disposed off.

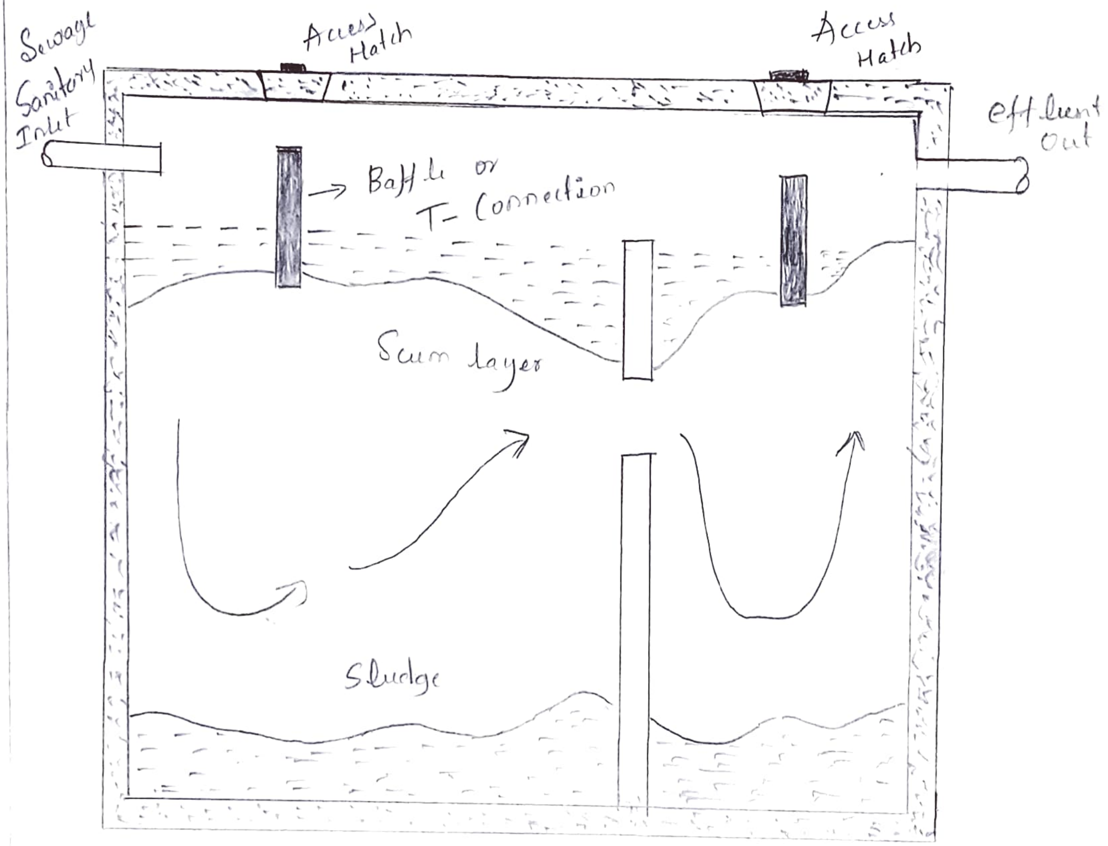
The design consideration required for Septic tank.

ⓐ Space for Sewage retention to allow Sedimentation

ⓑ Space for digestion of Settled Sludge;

ⓒ Space for storage of digested sludge and scum accumulating in between successive cleanings or sludge withdrawals at intervals varying from 6 months or 2 years.

Septic tank



1a

·b

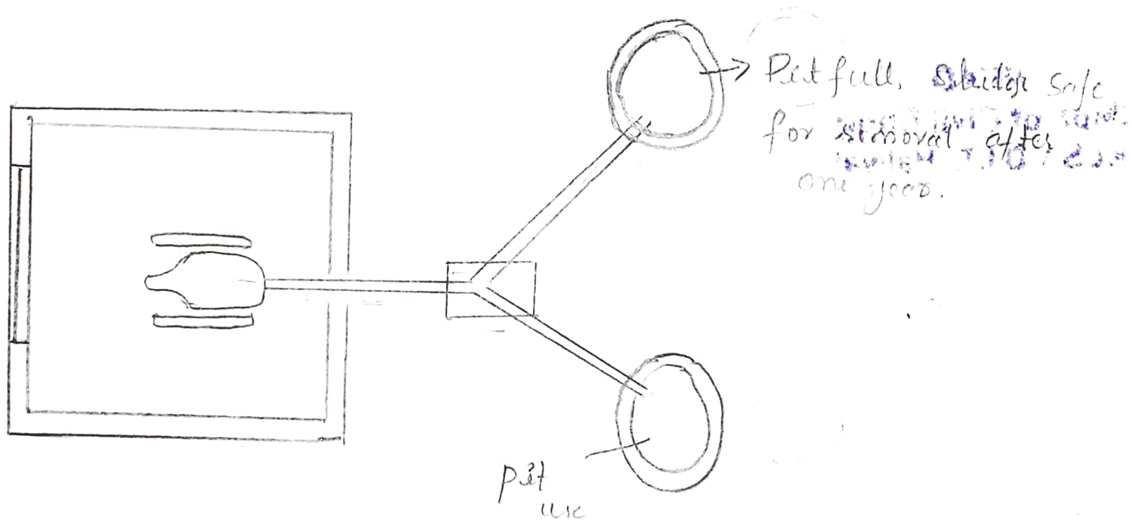
Write brief note on with sketch

① Two-pit latrines

② Soak pits.

① Two-pit latrines. →

Two-pit latrines or ventilated pit latrines are in improvement over traditional latrines in two important respects: they mitigate the noxious odour and reduce the number of flies and other insects that plague users of traditional latrines. In a VIP latrines, a vent pipe flows allows to enter fresh air through latrine, reduce odour the vent also allows light into the latrines. attracting insects into the pipe. where they are trapped by the fly Screen at top of pipe. the Screen also keep out insects & locking out insects to pipe from outside. the dry decomposition options utilizing anaerobic breakdown have been developed to allow excreta to be reused for agricultural purposes. If VIP latrines are Constructed with two pits, instead of moving the latrines when the pit is full, users switch to the other pit. After the waste in the full its pit composts, it Can be used as fertilizers. the amount of time before the compost Can be used as fertilizers depends on climate.



(7) Soak pit →

The Soak pit which is also called the Soakway is a closed rectangular or circular, Covered-up construction with porous or perforated walls, which is connected to primary treatment unit or directly connected to the washroom and even Some types of toilet

It allows water to slowely penetrate into the ground. Soak pit, which is lined with porous materials that provide foundational Support to prevent the collapse of the underground chamber, may also be used for Seperate treatment of greywater.

It is one of the most Commonly used techniques to discharge industrial and domestic wastewater safely into ground and even helps with the recharge of groundwater. If there is no intention or no need to reuse wastewater, collected Stormwater or greywater, Soak pit can offer a cost-efficient opportunity for a partial treatment of waste or greywater from primary treatment and provide a relatively Safe way of discharging it into the environment and therefore also recharging groundwater.

(Staff Incharge)

25-03-22

Dean, Academics