MUNICIPAL WASTE WATER ENGINEERING 18CV55- 2021

1 a. Explain the necessity of treating waste water

The use of conventional water and wastewater treatment processes becomes increasingly challenged with the identification of more and more contaminants, rapid growth of population and industrial activities, and diminishing availability of water resources because, the effluent from a typical secondary treatment plant still contains 20-40 mg/L BOD which may be objectionable in some streams. Suspended solids, in addition to contributing to BOD, may settle on the stream bed and inhibit certain forms of aquatic life. The BOD if discharged into a stream with low flow can cause damage to aquatic life by reducing the dissolved oxygen content. In addition, the secondary effluent contains significant amounts of plant nutrients and dissolved solids. If the waste water is of industrial origin, it may also contain traces of organic chemicals, heavy metals and other contaminants. Different methods are used in advanced waste treatment to satisfy any of the several specific goals, which include the removal of

(1) Suspended Solids
(2) BOD
(3) Plant Nutrients
(4) Dissolved Solids and
(5) Toxic Substances

The advanced wastewater treatment refers to methods and processes that remove more contaminants from the wastewater than remove more contaminants from the wastewater than are usually taken out by the usual conventional treatment and techniques.

1 b. Explain with neat sketch, construction and working of a manhole

Manholes: The manholes are R.C.C 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 be installed at every point 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 centre distance between manholes is less for sewers of smaller size while it may behave such a size that man can easily enter in the working chamber. The minimum size is 50cm diameter.

Classification of manhole

Shallow Manholes (Inspection Manholes) are the one which are about 0.75 to 0.9 m in depth. They are constructed at the start of a branch sewer.

Normal Manholes are those which are about 1.5 m in depth. They are constructed either in square (1 m * 1m) or rectangular (0.8 m * 1.2 m) in cross section.

DEEP MANHOLES: Are those which are deeper than 1.5 m. The size of such a manhole is larger at the bottom, which is reduced at the top to reduce the size of manhole cover.

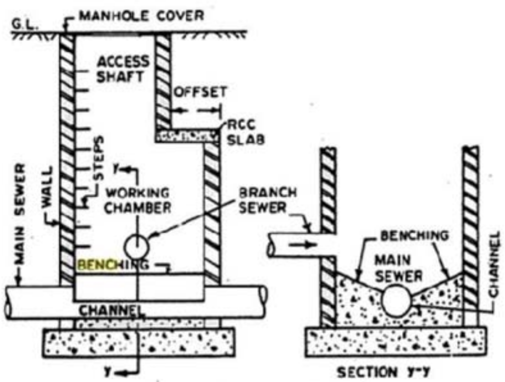


FIG. DEEP MANHOLE

Deep Manhole

Component parts of a manhole:

1. Access Shaft: The upper portion of a deep manhole is called access shaft. Minimum size of the rectangular manhole is about 0.75 x 0.6 m. and for a circular manhole, the minimum diameter is about 0.6 to 0.75m.

2. Working Chamber: The lower portion of the manhole is known as the working chamber, as it provides a working space for inspecting and cleaning-operations. Minimum size of rectangular manhole is about 1.2 x 0.9m and for a circular manhole, the minimum diameter is about 1.2m. The height of this chamber should generally be not less than 1.8m or so.

3. Benching: The bottom or invert portion of manhole. The bottom of portion of the manhole is constructed in cement concrete. A semicircular, or a U-shaped channel is generally constructed, and the sides are made to slope towards it. The concreting is known as benching, and facilitates the entry of sewage into the main sewer.

4. Side Wall: The side walls of the manhole are made of brick or stone masonry or RCC. The brick masonry walls are simple to construct and are commonly adopted. The approximate thickness may be calculated using, $t = 10 + 4d$, Where, t = thickness of wall, d = depth of excavation, m.

5. Steps or ladders: Steps are generally provided for descending into the manhole. The steps are made of cast iron, and are placed staggered at a horizontal distance of about 20cm and at a vertical centre distance of about 30cm. For deeper manholes, ladders are provided in place of steps.

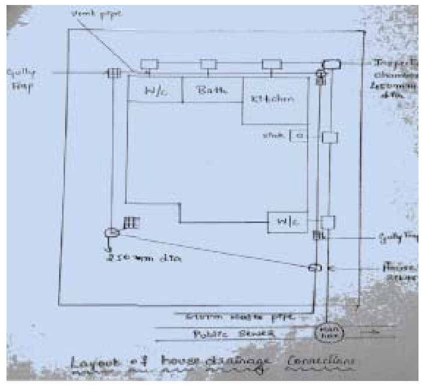
6. Cover and Frame: The manhole is provided with a cast iron cover and a cast iron frame at its top. The thickness of the frame is about 20 to 25cm, and its base is about 10cm wide. It is firmly embedded in the pavement, and the cover rests in the grove which is kept inside the frame.

1 c. Explain basic principles of house drainage

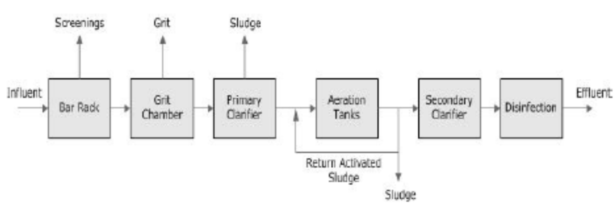
Basic principles of house drainage

1. Lay the sewers by the side of the building rather than below the building.
2. Drains should be laid straight between inspection chambers, avoiding sharp bends and junctions as far as possible
3. House drain should be connected to the public sewer only when public sewer is deeper than the house drain in order to avoid reverse flow.
4. Joints of sewer should be water tight and should be properly tested before putting the drainage line to use.

5. Lateral sewers should be laid at proper gradient so that they cleansing velocity can develop self
6. Size of the drain should be sufficient so that they do not over flow at the time of maximum discharge.
7. Layout of the house drainage system should permit easy cleaning and removal of obstructions.
8. Entire system should be properly ventilated from the starting point to the final point of discharge
9. All the materials and fittings of the drainage system should be hard, strong and resistant to corrosion. They should be non-absorbent type.
10. The entire system should be so designed that the possibilities of formation of air locks
11. Rain water pipes should drain water directly into the street gutters from where it is carried to the storm water drain



2a. write a flow diagram employed to treat municipal waste water and indicating the importacnce of each units



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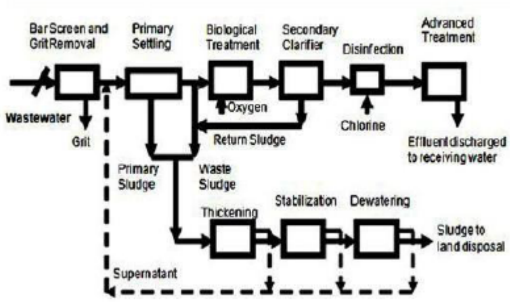


Flow diagram for municipal waste water

• 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 settle 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.

2.b Find the minimum velocity and gradient required to transport coarse sand through sewer od 60 cm diameter with sand particle of 1 mm diameter and specific gravity 2.66 . Assume в=0.06 and f = 0.02 . Assume the sewer to run half full. Take N=0.012

Sol^n: Minimum velocity / Self cleansing velocity

$$V_s = \sqrt{\frac{8\beta}{f}(G_s - 1) g d_s}$$

$\beta = 0.06$; $f = 0.02$; $G_s = 2.66$ and $d_s = 0.001 m$

$$V_s = \sqrt{\frac{8 \times 0.06}{0.02}(2.66 - 1) \times 9.81 \times 0.001}$$

$$V_s = 0.625 \ m\,sec^{-1}$$

"Sewer running half full"

$\frac{d}{D} = 0.5$; $\theta = 180°$

Area $a = \frac{\pi D^2}{4} \times \frac{1}{2} = \frac{\pi D^2}{8}$

Perimeter $p = \frac{\pi D \theta}{360°} = \pi D \times \frac{180}{360} = \frac{\pi D}{2}$

$$r = \frac{a}{p} = \frac{\pi D^2}{8} \times \frac{2}{\pi D} = \frac{D}{4} = \frac{0.6}{4} = 0.15 m$$

$$v = \frac{1}{n} r^{2/3} \sqrt{s}$$

$$v = \frac{1}{0.012} \times 0.15^{2/3} \sqrt{s}$$

Since $v = V_s = 0.625 \ m\,sec^{-1}$

$$\frac{0.625 \times 0.012}{0.15^{2/3}} = \sqrt{s}$$

$$\sqrt{s} = \frac{93}{3125} = 0.029 \simeq 0.03$$

$$\sqrt{s} = 0.03$$

$$s = \frac{9}{10000} = \frac{1}{\frac{10000}{9}} = \frac{1}{1111}$$

2c. what is sampling? Mention the types of sampling

Sampling:

The objective of sampling is to collect representative sample. Representative sample by means a sample in which relative proportions or concentration of all pertinent components will be the same as in the material being sampled. The objectives and significance must be clearly understood when environmental sampling is carried out. Field records and analysis data obtained using analytical instruments are required if we are to correctly evaluate the environmental situation, and such data must be representative of the environment.

Sampling Techniques
Two types of sampling techniques are used: grab and composite.

Grab samples:
Grab samples are single collected at a specific spot at a site over a short period of time (typically seconds or minutes). Thus, they represent a ―snapshot in both space and time of a sampling area.
Discrete grab samples are taken at a selected location, depth, and time. Depth-integrated grab samples are collected over a predetermined part of the entire depth of a water column, at a selected location and time in a given body of water.

Composite samples: Composite samples should provide a more representative sampling of heterogeneous matrices in which the concentration of the analyses of interest may vary over short periods of time and/or space. Composite samples can be obtained by combining portions of multiple grab samples or by using specially designed automatic sampling devices.

Integrated (discharge-weighted) samples: For certain purposes, the information needed is best provided by analyzing mixtures of grab samples collected from different points simultaneously, or as nearly so as possible, using discharge-weighted methods such as equal width increment (EWI) or equal discharge-increment (EDI) procedures and equipment.

3a. Discuss the importance of screening in waste water treatment operation and explain types of screens

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's, 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 consist 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.

Types of screens

Screens may classified as follows:
1) **According to size of openings** – coarse, medium and fine screens.

2) **According to shape of screens –** disc, band, drum, cage, wing and perforated plates.

3) **According to the condition of movement** – fixed and movable.

4) **According to the method of cleaning** – hand cleaned or mechanically.

According to size of openings:
Coarse Screen: These types of screens are also called as **Racks or Bar screens.** They have relatively larger openings ranging from 5cm to 10cm. They serve more as protecting devices in contrast to fine screens with function as treatment devices. Bar screens are usually hand cleaned.
Medium Screens: These types of screens have openings of 2cm to 5cm. These are mechanically raked units, and used before all pumps or treatment units such as stabilization ponds.
Fine Screens: These types of screens are mechanically cleaned devices using perforated plates or very closely spaced bars with clear openings of less than 2cm and they need continuous cleaning to prevent clogging.

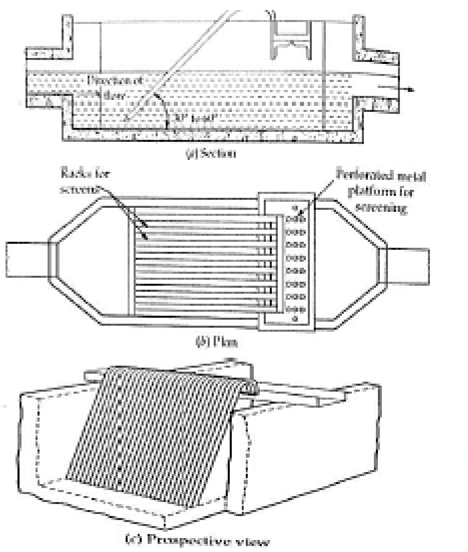


Fig 3.2 Fixed Bar type hand cleaned coarse or medium screen or rack

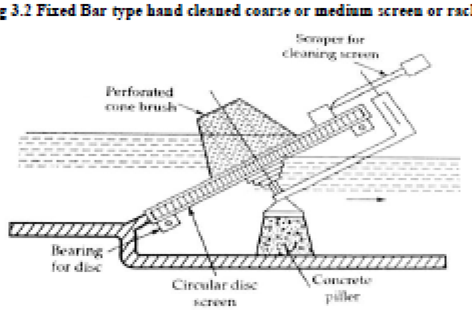


Fig 3.3 Reinsch-Wurl Screen (disc type fine screen)

3b. what do you understand by self-purification of natural water bodies? Explain the factors affecting self-purification

When sewage is discharged into a natural body of water, the receiving water gets polluted due to waste products, present in sewage effluents. But the conditions do not remain so forever, because the natural forces of purification, such as dilution, sedimentation, oxidation-reduction in sunlight, etc., go on acting upon the pollution elements, and bring back the water into its original condition. This automatic purification of polluted water, in due course, is called self-purification phenomenon. The various natural forces of purification which help in effecting self-purification process are summarized below:

1. Physical forces
(i) Dilution and Dispersion
(ii) Sedimentation
(iii) Sunlight

2. Chemical forces
(iv) Oxidation (Bio)
(v) Reduction

(i) Dilution and Dispersion
When the putrescible organic matter is discharged into a large volume of water contained in the river-stream, it gets rapidly dispersed and diluted. When sewage of concentration CS flows at a rate QS in to river stream with concentration CR flowing at a rate QR, the concentration C of the resulting mixture is given by

CS QS + CR QR = C (QS + QR)

C = CS QS+CR QRQS+ QR

This equation is applicable separately to concentrations of different impurities, such as oxygen content, BOD, suspended sediments, and other characteristic content of sewage.

(ii) Sedimentation
The settleable solids, if present in sewage effluent, will settle down into the bed of the river, near the outfall of sewage, thus, helping in the self-purification process.

(iii) Sunlight
The sunlight has a bleaching and stabilizing effect of bacteria. It also helps certain micro-organisms to derive energy from it, and convert themselves into food for other forms of life, thus absorbing carbon dioxide and releasing oxygen by a process known as photosynthesis. The evolution of oxygen in river water due to sunlight will help in achieving self-purification through oxidation.

(iv) Oxidation
The oxidation of the organic matter present in sewage effluent, will start as soon as the sewage outfalls into the river water containing dissolved oxygen. The deficiency of oxygen so created, will be filled up by the atmospheric oxygen. The process of oxidation will continue till the organic matter has been completely oxidized. This is the most important action responsible for affecting self-purification of rivers.

(v) Reduction

Reduction occurs due to hydrolysis of organic matter settled at bottom either chemically or biologically. Anaerobic bacteria will help in splitting the complex organic constituent of sewage into liquids and gases, and thus paving the way for their ultimate stabilization by oxidation.

The various factors on which these natural forces of purification depend are
(a) Temperature
(b) Turbulence
(c) Hydrography
(d) Available dissolved oxygen
(e) Rate of aeration

Temperature: The quantity of DO available in stream water is more in cold temperature than in hot temperature. Also, as the activity of microorganisms is more at the higher temperature, hence, the self-purification will take less time at hot temperature than in winter.

Turbulence: Turbulence in the body of water helps in breaking the surface of the stream or lake, and helps in rapid re-aeration from the atmosphere. Wind and undercurrents in lakes and oceans cause turbulences which affect their self-purification.

Hydrography: Affects the velocity and surface expanse of the river stream. High velocities cause turbulence and rapid reaeration, while large surface expanse will also have the same effects.

Dissolved Oxygen: Larger the amount of dissolved oxygen present in water, the better and earlier the self-purification will occur.

Rate of Aeration: The rate at which the D O deficiency is replenished, will considerably govern the self-purification. The greater is this rate, the quicker will be the self-purification, and there will be no chances of development of anaerobic conditions

3c. Explain sewage farming. Mention the various methods of sewage farming

When the wastewater, either raw or partly treated, is applied or spread on the surface of land, the method is called disposal by land treatment. Some part of the wastewater evaporates while other part percolates into the ground leaving behind suspended solids which are partly acted upon by the bacteria and partly oxidized by exposure to atmospheric actions of air, heat and light. The sewage adds to the fertilizing value of the land, and crops can be profitably raised on such land. Due to this, the disposal by land treatment is also known as sewage farming.

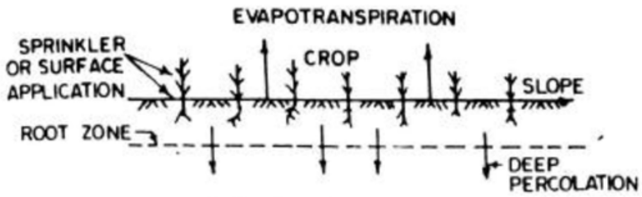
The three-principal process of land treatment of wastewater are:

1. Broad irrigation or sewage farming

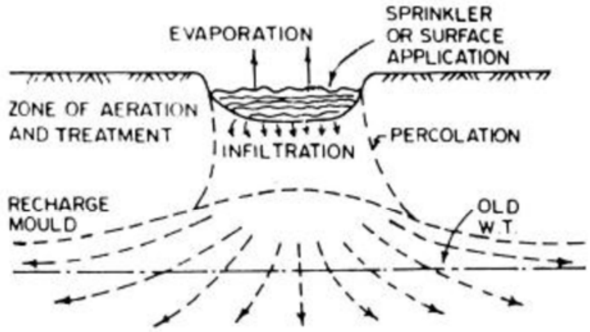
2. Rapid infiltration

3. Overland runoff

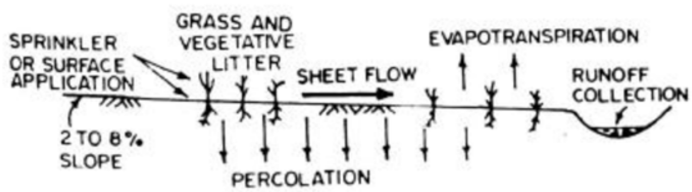
The first two processes depend upon the moving or percolating the water downward through the soil and thus are limited by infiltration and percolating capacity of the land. While the percolating capacity is a function of soil characteristics, the infiltration depends upon the degree of clogging at the soil surface. If the waste is sufficiently pretreated, clogging will be minimized and percolation will limit the rate at which liquid can be applied. For percolation of 6 to 25mm/min - rapid infiltration is practicable, for 2 to 6mm/min – broad irrigation is suited and below 2mm/min overland runoff should be adopted



(a) IRRIGATION



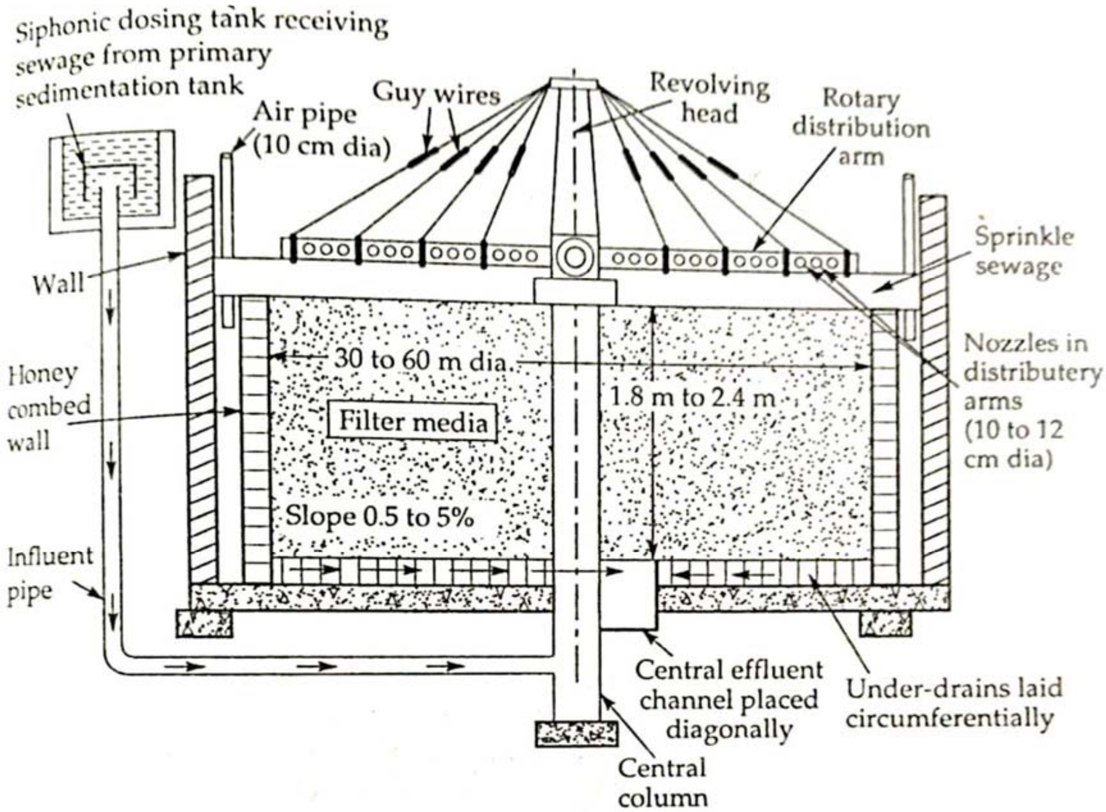
(b) RAPID INFILTRATION



(c) OVERLAND RUNOFF

4a. Explain with neat sketch the working of trickling filter. What is the principle on which it working?

Trickling filters are adopted for giving secondary treatment to sewage. It consists of tanks of coarser filtering medium, over which the sewage is allowed to sprinkle or trickled down by means of spray nozzles or rotary distributors. The percolating sewage is collected at the bottom of the tank through a well-designed under drainage system. The purification of the sewage is brought about mainly by the aerobic bacteria, which form a bacterial film around the particles of the filtering medium. The action due to the mechanical straining of the filter bed is much less. In order to ensure the large-scale growth of the aerobic bacteria, sufficient quantity of oxygen is supplied by providing suitable ventilation facilities in the body of the filter and also to some extent by the intermittent functioning of the filter.
The effluent obtained from the filter must be taken to the secondary clarifier for the settling out the organic matter, oxidized while passing down the filter.



Construction and operation:

• Trickling filter tanks are generally constructed above the ground. They may either be rectangular or more generally circular.

• Rectangular filters are provided with a network of pipes having fixed nozzles, which spray the incoming sewage into the air, which then falls over the bed of the filter under the action of gravity.

• Circular filter tanks are provided with rotary distributors having a number of distributing arms (generally 4 no's). These distributors rotate around a central support either by an electric motor or more generally by the force of reaction on the sprays. Such self- propelled reaction type of distributors is now-a-days preferred and used. The rate of revolutions varies from 2 RPM for small distributors to < ½ RPM for large distributors. Two arms are used for taking low flows and all 4 arms are used in case of high flows. The distributing arms should remain about 15 to 20cm above the top surface of the filtering medium in the tank.

• The application of the sewage to the filter is practically continuous with a rotary distributor, whereas with spray nozzles, the filter is dosed for 3 to 5min and then rested for 5 to 10min before the next application. The dosing tanks are used in case of spray nozzles method.

• The filtering medium consists of coarser materials like cubically broken stones or slag free from dust or small pieces of stones. The size varies from 25 to 75mm. The filtering material should be washed before it is placed in position and it should be unaffected by acidic action of sewage and should be sufficiently hard. Usually strong form rocks of granite or limestone may be used. The depth of filtering medium may vary from 2 to 3m. The walls of the filter tank should be provided with openings for the circulation of air through.

• The under-drainage system below the filter bed provides drainage and also ventilation of the sewage. These systems are made of vitrified clay blocks which are placed on a concrete thickness of 10 to 15cm thick and which is sloped gently at about 1 in 300 towards the main effluent rectangular channel. The main effluent channel may be provided adjoining the central column of the distributor. The depth and width of this central channel should be such that, maximum flow is carried below the level of the under drains.

4b. Explain the different stages involved in the sludge digestion process

Sludge Digestion Process

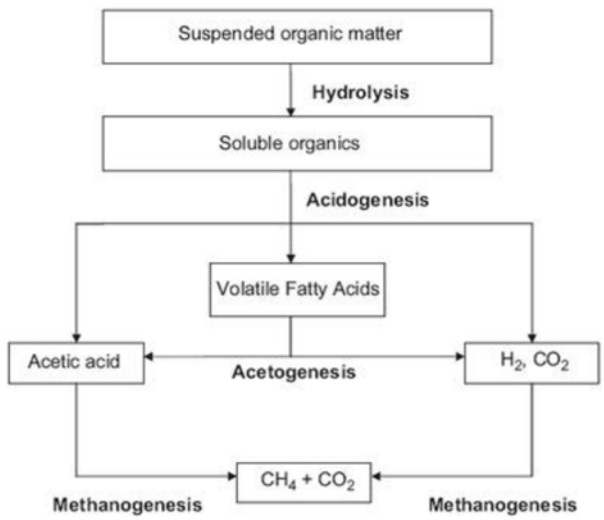
Sludge digestion involves the treatment of highly concentrated organic wastes in the absence of oxygen by anaerobic bacteria. The stabilization of sludge by decomposing the organic matter under controlled anaerobic conditions is called as _sludge digestion'. During this process of sludge digestion, sludge gets broken into three forms- 1) digested sludge 2) supernatant liquid 3) gases of decomposition. The digested sludge is also called as humus and it is black in colour and has less moisture and thus less volume. It will be free from pathogenic bacteria but may contain cysts and eggs of protozoa and helminths.

The supernatant liquor will have liquefied and finely divided solid matter with a high rate of BOD. Many odourous gases like methane, carbon dioxide, hydrogen sulphide are emitted from the process of sludge digestion. The anaerobic treatment of organic wastes resulting in the production of carbon dioxide and methane, involves three distinct stages. In the first stage, referred to as "acid fermentation", complex waste components, including fats, proteins, and polysaccharides are first hydrolyzed by a heterogeneous group of facultative and anaerobic bacteria. This action of bacteria starts fermentation and the end products of this process will be acid carbonates and volatile organic acids and gases like methane, carbon dioxide and hydrogen sulphide. The pH value falls down less than 6. The second stage or the Acid Regression Stage is an intermediate stage where the volatile organic acids and the nitrogenous compounds of the first stage are attacked by the bacteria to form acid carbonates and ammonia compounds. The decomposed sludge emits offensive odour and its pH value rises to 6.8. The main feature of this stage is that the decomposed sludge and the entrapped gases of decomposition becomes foamy and rises to the surface of the digester forming scum. This stage continues for about 3 months or so and the amount of BOD will be very high. However in the third stage, referred to as "Alkaline fermentation", proteins and organic acids are decomposed by anaerobic bacteria into simple substances like ammonia, organic acids and gases.

The digested sludge, which is alkaline in nature (with a pH of 7.5), is formed in this stage and it gets separated out from the liquid. Large quantity of methane gas which has high calorific value is emitted from this stage. The sludge is also called as ripened sludge. BOD comes sown and this process takes almost one month to get over.

Stages of anaerobic sludge digestion

In anaerobic digestion soft wet types of biomass are converted into biogas and digested state. It is a complicated process, requiring many types of bacteria to cooperate in series. The products of one type of bacteria are used as feedstock by the bacteria performing the next step in the chain. To envisage the process, the series of conversions is divided into four stages: hydrolysis, acidogenesis, acetogenesis and methanogenesis. The stages of anaerobic digestion process is depicted in figure.



Stages/steps in the anaerobic digestion process

Hydrolysis

The hydrolysis process transforms suspended organic matter into soluble organics. During the hydrolysis step, polymeric compounds are broken down by extra cellular enzymes into monomeric or dimeric compounds. The optimal pH for the hydrolysis step is 6, and the hydrolysis step usually is the rate limiting factor in anaerobic digestion. A larger surface area enables enzymes to work faster because more enzymes are able to _attack. the organic material at the same time. Therefore a method to increase the rate of the hydrolysis is to increase the surface area of the substrate by previous grinding, boiling etc. Research is directed to apply this in practice. Also (bio)chemical pre-treatment of the organic material is being investigated, leading to more accessible polymers and hence to a higher rate and a higher degree of hydrolysis .

Also a two stage digester is used in practice, enabling the hydrolysis step to proceed under optimal conditions

Acidogenesis

In the acidogenesis process the soluble organics that were produced by the hydrolysis are transformed into volatile fatty acids, mostly C2-C4 acids. In essence, glucose (sugar) is transformed into acids. While hydrolysis is the slowest process, acidogenesis is the quickest process.

The production of volatile fatty acids lowers the pH in the digester. When the pH drops below 4, the production of acids stops. It is therefore necessary that the following steps, the acetogenesis and methanogenesis take place at a sufficient rate. Otherwise the whole process stops, if the digester has turned acidic.

Acetogenesis

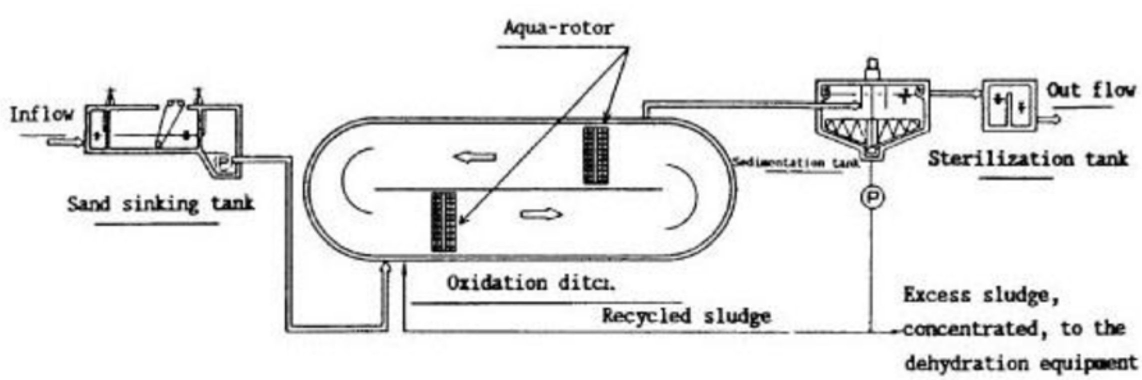
In the acetogenesis process, the volatile fatty acids, (mostly) propionic acid, butyric acid and also ethanol are combined with water and are transformed into acetic acid, CO2 and H2.

Methanogenesis

In this step the acetic acid, CO2 and H2 are converted into methane. In a stable digestion process around 70% of the methanogenesis converts acetic acid into CH4 and CO2, and this process is known as aceticlastic methanogenesis. This is the most efficient converstion from an energetic standpoint, as it produces the least amount of heat. The remaining 30% of the biogas is produced in the hydrogenotrophic methanogenesis, and this is the least effective energetic conversion. H_2 and CO_2 are converted into methane and water.

4a. Briefly explain RBC

The Oxidation Ditch (OD) is a modified form of the activated sludge system. Oxidation ditches are mechanical secondary treatment systems which are tolerant of variations in hydraulic and organic loads. Treatment of wastewater using an oxidation ditch is relatively similar to wastewater treatment in a packaged plant. But the oxidation ditch replaces the aeration basin and provides better sludge treatment. The ODs can be easily adjusted to meet most combinations of incoming sewage and effluent standards. This system achieves both high BOD reduction and some nutrient removal. The only pretreatment typically used in an oxidation ditch system is the bar screen. After passing through the bar screen, wastewater flows directly into the oxidation ditch. The OD consists of a "ring or oval shaped channel" equipped with mechanical aeration devices.
Activated sludge is added to the oxidation ditch so that the microorganisms will digest the B.O.D. in the water. This mixture of raw wastewater and returned sludge is known as mixed liquor. Screened wastewater, which enters the ditch is aerated and circulated. ODs typically have long detention times and are capable of removing between 75% and 95% of the Biological Oxygen Demand (BOD) Oxygen is added to the mixed liquor in the oxidation ditch using rotating biological contactors (RBC's.) RBC's are more efficient than the aerators used in packaged plants. In addition to increasing the water's dissolved oxygen, RBC's also increase surface area and create waves and movement within the ditches Once the B.O.D. has been removed from the wastewater, the mixed liquor flows out of the oxidation ditch. Sludge is removed in the clarifier. This sludge is pumped to an aerobic digester where the sludge is thickened with the help of aerator pumps. This method greatly reduces the amount of sludge produced. Some of the sludge is returned to the oxidation ditch while the rest of the sludge is sent to waste.
The proprietary "Orbal System" uses three channels or ditches concentrically placed. Each channel is independently aerated and can be configured to act in parallel or series with the other channels, depending upon the degree of treatment required.
After screening and grit removal, sewage enters the outer channel where most of the biological reaction takes place. The second channel is held at a slightly higher dissolved oxygen content for further BOD and nutrient reduction. The innermost channel is used for polishing the effluent before it passes to a clarifier.
Typical figures for ODs are as follows:



Biological Nitrification:

5a. Discuss in brief the Nitrification and denitrification process in advance waste water treatment

Nitrification is the process in which Nitrosomonas bacteria oxidize ammonia to nitrite and Nitrobacter bacteria oxidize nitrite to nitrate. In is the process in which ammonia is first converted into nitrate form, thereby eliminating problem of toxicity to fish and reducing the nitrogen oxygen demand. The oxidation of ammonia to nitrate is a two-step process.
First step, ammonia is oxidized to nitrite by Nitrosonomas a genus of strict aerobic autotrophic bacteria.

Nitrosonomas

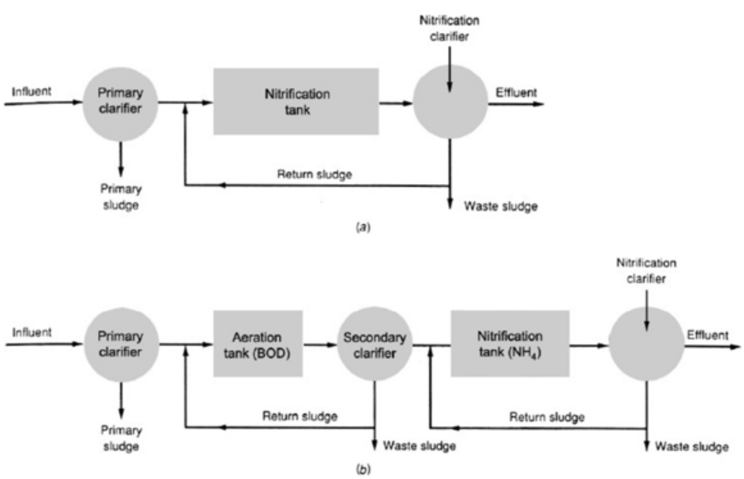
$$NH_4 + 1.5\ O_2 \xrightarrow{\text{Nitrosonomas}} NO_2^- + H^+ + H_2O + \text{Energy}$$

Second step, the conversion of nitrite to nitrate, is accomplished by Nitrobacter, which is a genus of autotrophic bacteria.

Nitrobacter

$$NO_2^- + 0.5\ O_2 \xrightarrow{\text{Nitrobacter}} NO_3^-$$

The biological processes used for nitrification are identified as aerobic suspended growth and aerobic attached growth. This process results in the overall conversion of ammonia to nitrate. These microorganisms are autotrophic, which means they derive their carbon source from inorganic carbon, such as carbon dioxide and bicarbonate. Most other types of organisms in activated sludge are heterotrophic, which means they derive their carbon source from the organic matter in the wastewater. Environmental conditions of pH, alkalinity, temperature, dissolved oxygen concentration and organic loading affect the nitrification process in activated sludge plants.



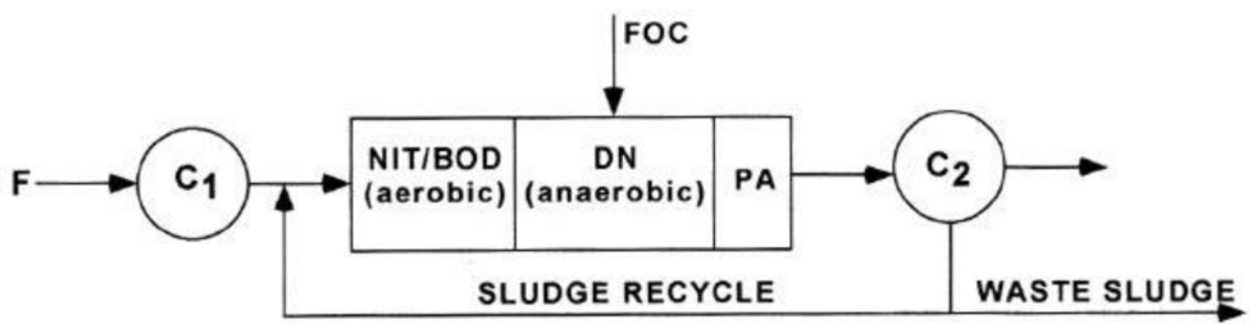
Biological Denitrification

Denitrification is the process in which microorganisms reduce nitrate to nitrite and nitrite to nitrogen gas. In the denitrification process, a balanced amount of substrate is supplied to reduce the nitrate in the process of stabilization of the supplied substrate under anaerobic conditions.
Heterotrophic bacteria normally present in activated sludge perform this conversion when there is no molecular oxygen or dissolved oxygen, and there is sufficient organic matter. The bacteria derive their oxygen from the oxygen contained in the nitrate. Methanol (CH3OH) has been used as a carbon source in denitrification. The nitrogen gas produced is in the form of nitric oxide (NO), nitrous oxide (N2O) or nitrogen gas (N2).

$$NO_3^- + \frac{5}{6}CH_3OH \rightarrow \frac{1}{2}N2 + \frac{5}{6}CO_2 + \frac{7}{6}H_2O + OH^-$$

The net removal of nitrogen is accomplished by stripping the nitrogen gas formed during denitrification out of the wastewater in a subsequent aeration process.

Post-Denitrification Systems

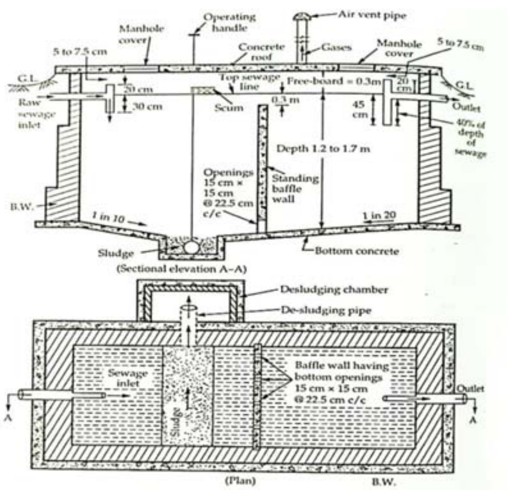


Post-Denitrification

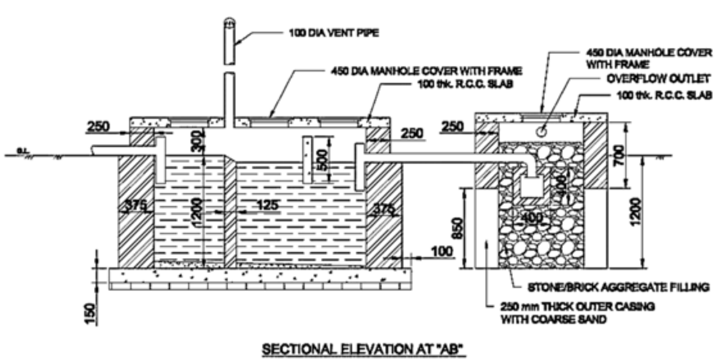
♦ In post-denitrification systems, as seen in the middle diagram in the previous figure, BOD and nitrification occur first in an aerobic environment, followed by denitrification in an anoxic environment.
♦ Aerobic and anoxic conditions are controlled by the placement of aeration devices. For example, in a plug flow reactor, diffused aerators would be placed along the aerobic zone and no aerators would be placed in the anoxic zone.
♦ Post-denitrification systems have a post-aeration zone following the anoxic zone to strip the nitrogen gas from the wastewater.
♦ Since most of the carbon source is consumed in the BOD/nitrification stage, a supplemental carbon source, typically methanol is added to the denitrification zone to support denitrifying bacteria. Denitrifying bacteria require a methanol-to-nitrogen ratio of about 3:1.

5b. Draw a neat sketch of septic tank. Write the design criteria required for 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.



Septic tank without soak pit



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.

5c. Write a short note on advance oxidation process

Advanced chemical oxidation processes make use of (chemical) oxidants to reduce COD/BOD levels, and to remove both organic and oxidisable inorganic components. The processes can completely oxidise organic materials to carbon dioxide and water, although it is often not necessary to operate the processes to this level of treatment.

Theory of Advanced Oxidation:

Advanced oxidation processes typically involve the generation and use of the hydroxyl free radical as a strong oxidizing agent to destroy the compounds that cannot be oxidized by conventional oxidants such as oxygen, ozone and chlorine. The hydroxyl radical reacts with the dissolved constituents, initiating a series of oxidation reactions until the constituents are completely mineralized. Nonselective in their mode of attack and able to operate at normal temperature and pressures, hydroxyl radicals are capable of oxidizing almost all reduced materials present without restriction to specific classes or groups of compounds, as compared to other oxidants.

A wide variety of advanced oxidation processes are available:

• Chemical oxidation processes using hydrogen peroxide, ozone, combined ozone & peroxide, hypochlorite, Fenton's reagent etc.

• Ultra-violet enhanced oxidation such as UV/ozone, UV/hydrogen peroxide, UV/air

• Wet air oxidation and catalytic wet air oxidation (where air is used as the oxidant)

Advanced oxidation processes are particularly appropriate for effluents containing refractory, toxic or non-biodegradable materials. The processes offer several advantages over biological or physical processes, including:

- Process operability
- Unattended operation
- The absence of secondary wastes
- The ability to handle fluctuating flow rates and compositions

However, advanced oxidation processes often have higher capital and operating costs compared with biological treatment. The most suitable variant for each application is chosen on the basis of the chemical properties of the effluent.