Internal Assesment Test -IV–Jan-2022

Sub:	Municipal Waste Water Engineering					Sub Code:	18CV55	Branch:	CIVIL	
Date:	27/12 / 2021	Duration:	90 min's	Max Marks:	50	Sem/Sec:	V		OBE	

	Answer All Questions	MARKS	CO	RBT
1	What are sewer appurtenances? Explain with a neat sketch the drop manhole.	[10]	CO1	L2
2	Draw and explain briefly the flow Diagram of Municipal waste water treatment plant with their operation units	[10]	CO2	L2
3	Explain the different stages involved in the sludge digestion process	[10]	CO4	L2
4	Explain in brief Nitrification and denitrification process in advanced waste water treatment	[10]	CO5	L2
5	Explain the Electro coagulation, Soak pits, Eco toilets	[10]	CO5	L2

1. What are sewer appurtenances? Explain with neat sketch, construction and working of a drop manhole

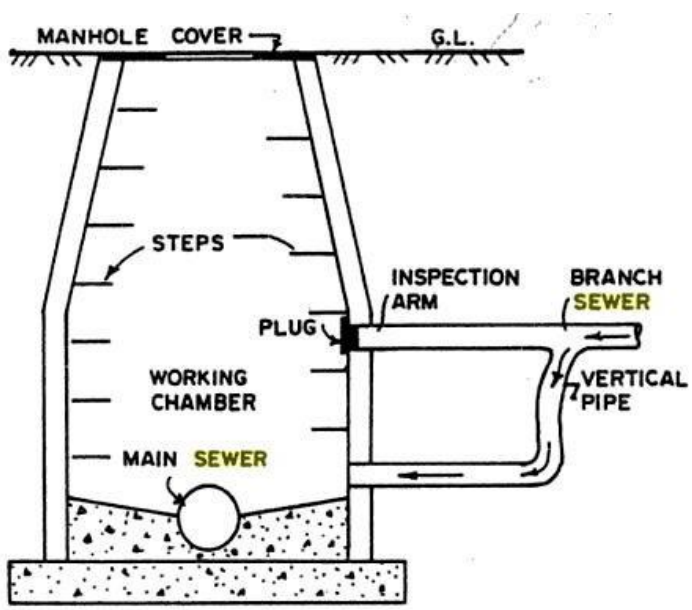
   Sewage flowing in the sewer line contains a large number of impurities in the form of silt, fats, oils, rags etc. Under normal flows they are not likely to settle and choke the sewers, but during small flows self-cleansing velocity is not likely to develop and the chances of choking of the sewers are 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. Catch basins 4. Flushing devices 5. Regulators 6. Inverted siphons 7. Grease and oil traps 8. Lamp holes 9.Leaping weirs 10. Junction chambers

Drop Manhole: It is a measure of connecting high level branch sewer to low level main sewer. They are connected through a vertical pipe. The installation of a drop manhole becomes necessary when there is difference in levels is more than 60cm between branch sewer and the main sewer, which can be avoided by increasing the sewer grade.

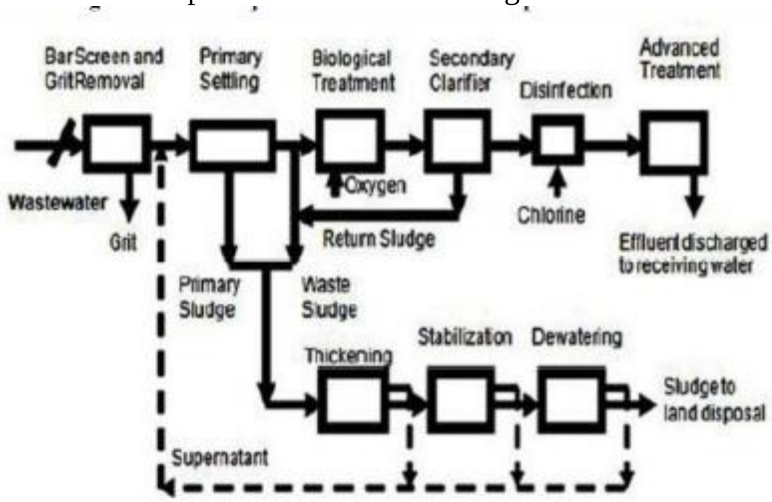
Components parts of a Deep Manhole are:

i) Access shaft ii) Working chamber iii) Bottom or Invert iv) Side walls v) Steps or ladder vi) Top cover



2. Flow diagram of Municipal wastewater treatment plant

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



Dewatering process. The dry form of sludge is used as manure for improving the fertility of soil. The effluent which comes out of secondary clarifier is fed into disinfection tank where chlorine is added to the wastewater to kill germs and pathogenic bacteria's present in the water. Then water which comes out of disinfection tank containing germs are removed out in final or advanced or tertiary treatment process after that, the water can be directly discharged to nearby water courses.

Treatment process as a whole classified into 4 types

1) Priliminary treatment process
2) Primary treatment process
3) Secondary or Biological treatment process

4) Tertiary or final or advanced treatment process

Preliminary treatment process:

This treatment process consists of separating the floating materials like dead animals, tree branches, papers, pieces of rags or wood etc., present in the sewage and also to remove heavy settable inorganic solids. This process also helps in removing oil and grease particles present in the sewage. This process reduces the BOD of wastewater by about 15 to 30%.

The units used in preliminary process are

a) **Screening** - For removal of floating matters like papers, rags, pieces of clothes etc.

b) **Grit chambers or Detritus tank** – For removal of grits and sand particles.

c) **Skimming tanks –** For removal of oil and grease particles present in the sewage.

Primary treatment process: This treatment process consists of removing large suspended organic solids. This is usually achieved by **sedimentation process**. The liquid effluent from primary treatment process consists of large amount of suspended organic matters having BOD of 60% of original. The organic solids which are separated out in the sedimentation tank are often stabilized by anaerobic decomposition in a digestion tank. This residue is used for landfills or soil conditioners.

Secondary treatment process: This treatment process further treats the effluent which is coming out from primary sedimentation tanks. This treatment process is achieved by biological decomposition of organic matter which can be carried out either under aerobic or anaerobic condition.

Treatment process in which organic matter is decomposed by aerobic bacteria is called aerobic decomposition. Units which are used in this treatment process are

Filters – Interment sand filters as well as trickling filters. Intermittent sand filters are used for treatment of wastewater by attaching microorganisms to the filter medium and treated water is collected in the underdrains at the bottom of sand filter and is transported to a line for further treatment or disposal. Trickling filters are used to remove organic matter from wastewater. Trickling filter is an aerobic treatment system that utilizes microorganisms attached to the medium to remove organic matter from wastewater.

Aeration tanks – Wastewater is is mixed with microbes in the aeration tank and oxygen is supplied. Microbes consume that supplied oxygen and decomposes the organic matter present in the wastewater and thus water is cleaned.

Oxidation ponds – Oxidation ponds are also known as stabilization ponds or lagoons. Within an oxidation pond heterotropic bacteria degrade organic matter in the sewage which results in production of cellular material and minerals. The production of these supports the growth of algae in the oxidation pond.

Aerated lagoons: Aerated lagoons or aerated basins is a holding and treatment pond provided with artificial aeration to promote the biological decomposition of wastewater. Treatment process in which organic matter is decomposed anaerobic bacteria is called **anaerobic decomposition**. Units which are used in this treatment process are,

a) **Anaerobic lagoons**: These are also called as manure lagoon which are manmade earthen basins filled with animal waste that undergoes anaerobic decomposition and it will be converted into excellent manures.

b) **Septic tanks**: These are water-tight box made of concrete or fiber glass to separate solids and liquids by settling process. Tanks are used for reception and processing of sewage which is achieved by sedimentation along with anaerobic sludge digestion. The effluent from the secondary biological treatment will usually contain a little BOD of 5 to 10% of original

Final or Advanced or Tertiary treatment process: This process removes remaining organic load after secondary treatment and to kill pathogenic bacteria present in the sewage and this achieved by chlorination

Tertiary Treatment

Tertiary treatment or advanced waste water treatment includes operation and process used to remove organic load left after the secondary treatment and in particular to kill the pathogenic bacteria. It is normally carried out by chlorination.

Tertiary treatment may be aimed at the reuse of wastewater. The common processes that are used in this treatment are:

i. Removal of refractory organisms through adsorption.

ii. Removal of dissolved inorganic substances through chemical precipitation, ion recharge, reverses osmosis, electro dialysis, membrane filtration process and distillation, nutrient removal such as nitrogen and phosphorus etc

3. **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.

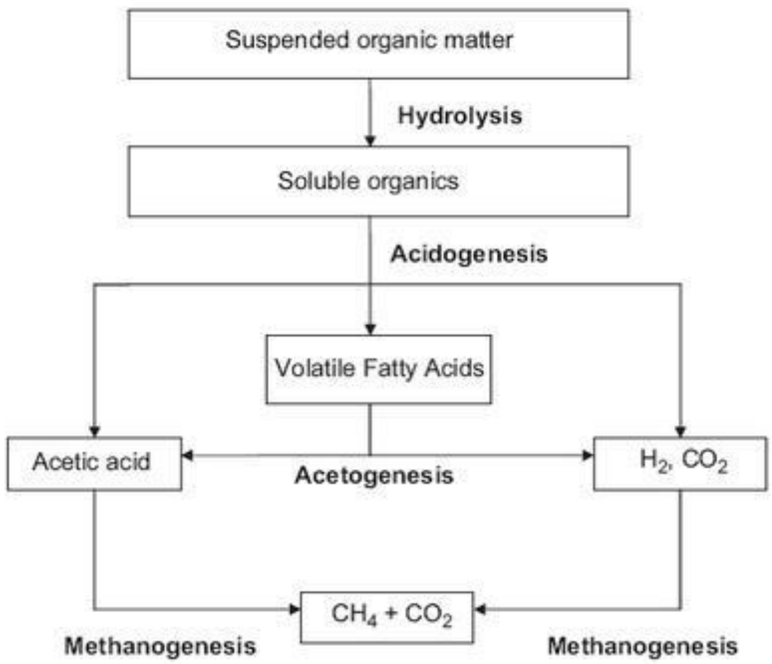
However in the third stage, referred to as "Alkaline fermentation", proteins and organic acids are decomposed by anaerobic bacteria into simple substances like ammonia, organic acids and gases.

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 (Extra reading)

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.



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, CO_2 and H_2.

Methanogenesis

In this step the acetic acid, CO_2 and H_2 are converted into methane. In a stable digestion process around 70% of the methanogenesis converts acetic acid into CH_4 and CO_2, 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.

4. NITROGEN REMOVAL

Nitrogen in wastewater is found as Organic Nitrogen, Ammonia Nitrogen, Nitrate Nitrogen and Minor amounts of nitrite. All these forms are of nitrogen in wastewater effluents are potentially harmful. Nitrogen in the form of Ammonia is toxic to the fish. Most Nitrogen, when oxidized to nitrate may be used by the plants as nutrients. Nitrate itself is the causative agent of methemoglobinemia. Excess quantities in any form contributes to eutrophication of surface.
Nitrogen enters the aquatic environment from both natural and man-made sources. The large single source of Nitrogen is urea, which is together with Ammonia, comprises approximately 85% of the nitrogen excreta by man. Nitrogen can be removed from the waste water by progressive biological oxidation of the oxidation of Nitrogen compounds to nitrites and nitrates followed by conversion into Nitrogen gas. Thus, Nitrogen removal is in two distinct steps:

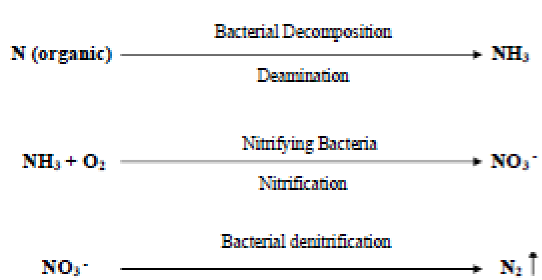
(i) Nitrification

(ii) Denitrification

In **Nitrification** ammonia is oxidized to nitrites and then to nitrates by aerobic nitrifying autotrophic bacteria.

In **Denitrification** nitrates are reduced to nitrogen gas by either autotrophic or heterotrophic bacteria. As a first step, bacterial decomposition releases ammonia by deamination of nitrogenous organic compounds. Continued aerobic oxidation results in nitrification. As a further step, biochemical Denitrification occurs with heterotrophic metabolism in an anaerobic environment.

Bacterial Decomposition



Biological Nitrification:

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.

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

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

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.

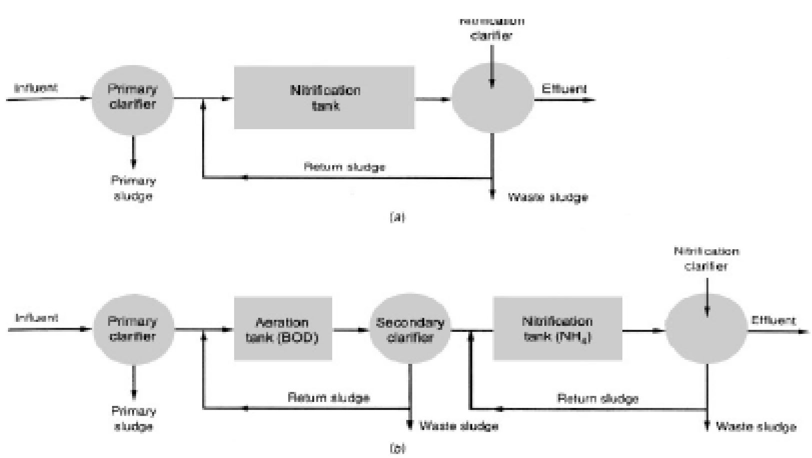


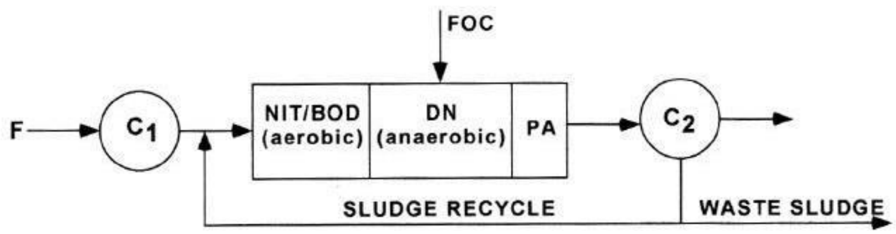
Fig. 5.1 (a) Single stage (b) Separate stage Nitrification Process

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 (CH_3OH) has been used as a carbon source in denitrification. The nitrogen gas produced is in the form of nitric oxide (NO), nitrous oxide (N_2O) or nitrogen gas (N_2).

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

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



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.

5. ELECTRO COAGULATION

♦ Electrocoagulation is a process of destabilising suspended, emulsified or dissolved contaminants in an aqueous medium by introducing electrical current into the medium. The electrical current provides the electromotive force causing the chemical reactions.

♦ Although the **electrocoagulation** mechanism resembles the **chemical coagulation** – the cationic species being responsible for the neutralisation of surface charges – in many ways it is very different.

♦ Electrocoagulation, the passing of the electrical current through water, has proven very effective in the removal of contaminants from water. Electrocoagulation systems have been in existence for many years using a variety of anode and cathode geometries, such as plates, balls, fluidised bed spheres, wire mesh, rods, and tubes.

Objectives:

- Typically to shift induced **pH** towards neutral.
- Removing heavy metals.
- Removing suspended and colloidal solids.
- Destabilizing oil and other emulsions.
- Removing fats, oils and grease.
- Removing complex organics and

- Destroying and removing bacteria, viruses and cysts.

Advantages:

- Treats multiple contaminants.
- Sludge minimization.
- Capital cost significantly less than conservative technologies.
- Operating cost significantly less than conservative technologies.
- Low power requirements;
- Generally, no chemical additions.
- Low maintenance.
- Minimal operator attention and
- Consistent and reliable results.

Construction:

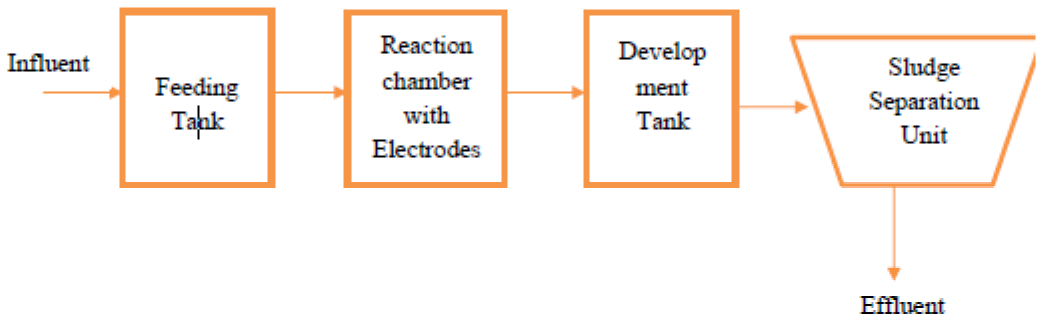


Fig. 5.8 Electro Coagulation Process

SOAK PITS

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

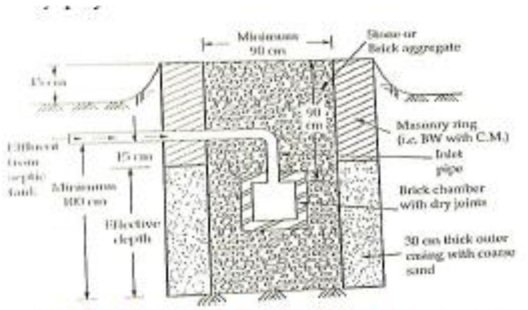


Fig. 5.12 Unlined soak pit filled with stone or brick aggregates

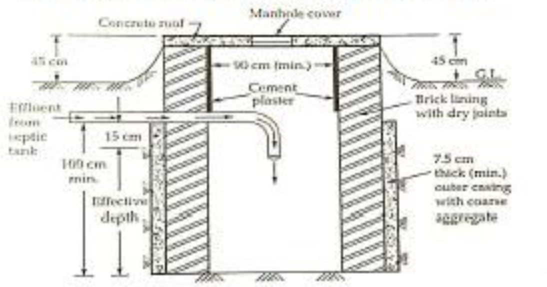


Fig. 5.13 Lined soak pit

♦ The soak pit should be between 1.5 and 4 m deep, but as a rule of thumb, never less than 2 m above the groundwater table.
♦ It should be located at a safe distance from a drinking water source (ideally more than 30 m).
♦ The soak pit should be kept away from high-traffic areas so that the soil above and around it is not compacted. It can be left empty and lined with a porous material to provide support and prevent collapse, or left unlined and filled with coarse rocks and gravel.
♦ The rocks and gravel will prevent the walls from collapsing, but will still provide adequate space for the wastewater. In both cases, a layer of sand and fine gravel should be spread across the bottom to help disperse the flow.
♦ To allow for future access, a removable (preferably concrete) lid should be used to seal the pit until it needs to be maintained.

Advantages:

- Can be built and repaired with locally available materials.
- Technique simple to apply for all users.
- Small land area required.
- Low capital and operating costs.

Disadvantages:

- Primary treatment is required to prevent clogging.
- May negatively affect soil and groundwater properties.

ECO – TOILET

The term “eco-toilet” broadly refers to any toilets that by design minimize the contamination of clean water and also may have other environmental benefits. Eco-toilets range from toilets that merely package human waste for collection and disposal (thereby avoiding the mixing of wastes with clean water and minimizing the volume for easier disposal) to toilets that create nutrient-rich compost from

human waste. **Composting toilets** use little or no water to send “waste” to chambers where it decomposes naturally in the presence of air, turning it into carbon-dioxide, water, and compost. A variant of the simple composting toilet incorporates
urine diversion (separation of urine from the solid faecal matter) and collects the urine in a separate container. This may allow for nutrient recovery from the urine.

Advantages:

1. Composting toilets are waterless systems. They help in environmental conservation by saving water that is normally used in copious amounts in conventional flush toilets. The waterless toilet saves more than 6,600 gallons of water annually for each person that visits the bathroom. 2. The composting toilet allows for on-site treatment of wastes making the process resourceful and cost-effective

3. The humus is far much safer to use and can be applied in non-edible gardens.

4. The use of composting toilets eliminates the potential threat of harmful by-products flowing into rivers and oceans. This helps in reducing environmental degradation.

5. The toilet is cheap to maintain as it uses basic materials. It is possible to add garden trimmings and vegetable peelings with toilet waste to enhance the decomposition process in the compost.

6. Composting toilets are hygienic. Batch system composting toilets enhance natural bacteria that allow the compost to kill toxins in human waste.