WASTE WATER TREATMENT

Primary treatment :

1. The purpose of primary treatment is to remove pollutants like large floating and suspended solids, grit, oil grease etc.
2. Large floating rubbish is removed by screening. Waste water is passed through a screening tank consists of parallel steel bars followed by wire mesh screen with small openings.
3. After screening waste water is passed into grit chamber for sufficient amount of time. Heavy materials like sand grit etc. are settled down and disposed.
4. Now waste water is passed through a primary settling tank or primary clarifier. The flow rate is reduced with a detention time of about 2-3 hours. Most of the lighter suspended solids settle down due to gravity and are removed manually or by mechanical scrapping.
5. Fine suspended particles and colloidal particles are removed by the process coagulation. Generally electrolytes are added for coagulation. The common coagulant is alum $Al_2(SO_4)_3.18H_2O$.
   For proper coagulation waste water is mixed with coagulant in a rapid mixing chamber for 90 seconds. Then waste is allowed to pass through gentle mixing chamber for about 30 minutes.

Secondary treatment :

1. The purpose is to remove dissolved solids and oxygen demanding wastes.
2. The effluent from primary settling tank is first subjected to aerobic oxidation. For this purpose there are some systems like trickling filters, rotating biological contractor, active sludge unit and oxidation pond.
3. **Trickling filter** is consists of circular filter beds usually about 1.5 m deep and surrounded by circular brick wall.
   - The filter beds are made up of rock or plastic and the diameter varies from 3 to 10 cm.
   - Individual filters are covered with a gelatinous film containing bacteria, fungi, algae and other micro-organisms
   - The spaces between the filters are sufficient to allow circulation of air.
   - The waste water is sprayed over this circular filter beds by rotating distributor
   - The bottom of the filter beds is provided with perforated floor through which incoming air passes.
   - The biodegradable wastes are absorbed by the filter bed surfaces and undergo aerobic oxidation by microorganisms
   - The efficiency of trickling filter depends on temperature, pH, nature of waste and air supply.
   - About 60% to 80% of oxygen-demanding wastes can be removed in trickling filter.
   - Advantage---simple to operate
     Disadvantage---costlier, efficiency decreases with high amount of organic waste.

4. **Rotating biological contractor**
    - It is consists of a series of closely packed circular discs which are attached with a rotating horizontal shaft.
    - 40% of the circular discs are submerged in the tank containing waste water.
    - The circular discs are covered with gelatinous film containing microorganisms (bacteria, fungi, algae etc.
    - As the discs rotate the submerged portions absorb organic wastes and when they come out they are exposed to air and aerobic oxidation starts.
    - Advantage---very efficient, high load of organic wastes can be handled, high rate of removal of biodegradable waste.
5. **Activated sludge unit**
    - It is an aeration tank where effluent from primary sedimentation tank and microorganisms (recycled from the sludge of secondary settling tank) are mixed thoroughly
    - Air is pumped into the mixture and agitated by mechanical stirrers. The mixture is kept in constant turbulent motion.
    - About 3 to 6 hours of aeration is needed for sewage and 6 to 24 hours for industrial wastes.
    - Then the mixture is flowed to the secondary settling tank for sedimentation.
    - After settling the effluent is separated from the sludge.
    - Some portion of the sludge is recycled to aeration tank to maintain effective microbial population for fresh treatment.
    - Advantage: about 95% of oxygen-demanding wastes can be removed by this process.
6. **Oxidation pond**
    - It is large shallow pond (0.5m to 1.5m depth) where waste water mainly sewage water is treated through microbial decomposition.
    - Both aerobic and anaerobic decomposition of organic waste can occur, so it is also called facultative pond.
    - The aerobic degradation mainly takes place near the surface. The oxygen required by bacteria is obtained from atmospheric oxygen dissolved in water and the oxygen produced by algae by photosynthesis.
    - The waste which settles at the bottom of the pond are degraded anaerobically by anaerobic bacteria to produce methane, ammonia and carbon-dioxide gas.
    - Advantage---cheap and simple
      Disadvantage---bad odour is present due production of methane and ammonia gas. It requires larger space.

Anaerobic digestion of sludge

The material left after secondary treatment of waste water and removing the effluent water is called the sludge. It can be dried and used as fertilizer or can be anaerobically treated.

- The sludge containing insoluble organic polymers (carbohydrate, protein etc.) are hydro lysed to form soluble derivatives by hydrolytic bacteria
- Then acidogenic bacteria convert the substances to sugar, amino acids, ammonia and other compounds.
- Methanogenic bacteria then convert those compounds to methane and carbon-dioxide.
- Methane and carbon-dioxide gas mixture produced in this way is known as biogas, which is a source of renewable energy.
- The methanogenic bacteria are very sensitive to temperature, pH and oxygen, so proper condition should be maintained for sludge digestion.

Tertiary Treatment

1. The purpose is to remove dissolved nutrients mainly N and P and toxic metals.
2. P can be removed by precipitation with coagulant like alum or lime or ferrichloride.

$Al_2(SO_4)_3 + PO_4^{3-} \rightarrow AlPO_4 \downarrow + SO_4^{2}$-

$Ca(OH)_2 + PO_4^{3-} \rightarrow Ca_3(PO_4)_2 \downarrow$

$FeCl_3 + PO_4^{3-} \rightarrow FePO_4 \downarrow + Cl^-$

3. N_2 which is present in form of ammonia is converted to nitrate by aerobic bacteria. The nitrate is converted to nitrogen gas by anaerobic bacteria.
   $NH_4^+ + O_2 \xrightarrow[Bacteria]{Aerobic} NO_3^- + H^+ H_2O$
   $NO_3^- \xrightarrow[Bacteria]{Anaerobic} N_2 + CO_2 + H_2O$
4. Then water is passed through activated charcoal to remove fine suspended solids , some bacteria and small quantities of organic matter.
5. Heavy metals are removed by some absorbents (ALM Series) and by Ion exchange process.
6. Finally the water is disinfected and become suitable for drinking.

Hardness of water

1. Water which cannot form foam or lather with soap easily is known as hard water and the characteristic is called hardness. Ground water is harder than surface water.
2. Hardness of water is mainly due to presence of Mg^{+2} and Ca^{+2} ions. When carbonate and bicarbonate salts of Mg and Ca cause hardness, it is called carbonate hardness. When chloride, sulphate and phosphate salts of Mg and Ca cause hardness, it is called non-carbonate hardness.
3. Carbonate hardness can be removed by boiling, so they are called temporary hardness.
   But boiling leads to scaling of calcium carbonate or magnesium carbonate.
   $Ca(HCO_3))_2 \rightarrow CaCO_3 + CO_2 + H_2O$
4. Permanent hardness can be removed by soda lime process or ion exchange process.
5. In soda lime process quick lime (CaO) or hydrated lime, $Ca(OH)_2$ is used.
   $Ca(HCO_3)_2 + CaO \rightarrow CaCO_3 + H_2O$

6. To remove sulphate and chloride ion soda ash is also added.
   $MgSO_4 + Ca(OH))_2 + Na_2CO_3 \rightarrow Mg(OH)_2 + CaCO_3 + Na_2SO_4$
7. In ion exchange process hard water is treated with natural zeolite or synthetic resin. Here Mg^{+2} and Ca^{+2} are exchanged by Na^{+}.
   $CaCl_2 + NaR \rightarrow NaCl + CaR$
8. Problems with hard water--- -i) consumes lots of soap.

   ii) when heated precipitation of calcium carbonate and magnesium carbonate are formed creating a rock like scaling. This can clog hot water pipes, reduce efficiency of boilers and water heaters.

   iii)With reduced efficiency of water heaters electric consumption also increases.