19. AEROBIC SECONDARY TREATMENT OF WASTEWATER

19.1 Activated Sludge Process

Conventional biological treatment of wastewater under aerobic conditions includes activated sludge process (ASP) and Trickling Filter. The ASP is developed in England in 1914. The activated sludge process consists of an aeration tank, where organic matter is stabilized by the action of bacteria under aeration and a secondary sedimentation tank (SST) is used, where the biological cell mass is separated from the effluent and the settle sludge is recycled partly to the aeration tank (Figure 19.1). Recycling is necessary for activated sludge process. The aeration conditions are achieved by the use of diffused or mechanical aeration.

The diffusers are provided at the tank bottom, and mechanical aerators are provided at the surface of the water, either floating or on fixed support. Settled raw wastewater and the returned sludge enter the head of the tank, and cross the tank following the spiral flow pattern, in case of diffuse air aeration, or get completely mixed in case of completely mixed reactor. The air supply may be tapered along the length, in case of plug flow aeration tank, to match the quantity of oxygen demand. The effluent is settled in the settling tank and the sludge is returned at a desired rate.

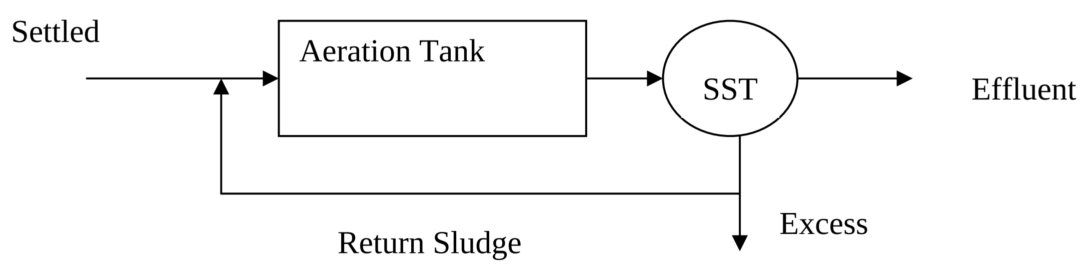

Figure 19.1 Conventional Activated Sludge Process

Loading Rate: The organic matter loading rate applied to the reactor is quantified as kg of BOD applied per unit volume of the reactor per day, called as volumetric loading rate, or kg of BOD applied per day per unit mass of microorganisms present in the reactor (i.e. in the aeration tank), called as organic loading rate or F/M. This can be calculated as stated below:

Volumetric loading = $Q \times L \times 10^{-3} / Vol$

Where, L = Influent BOD_5 to aeration tank, mg/L

Q = Flow rate, m^3/day

Vol. = Volume of aeration Tank, m^3

Organic Loading Rate, F/M = Q x L / (V x X_t)

Where, X_t = MLVSS concentration in the aeration tank, mg/L

The F/M ratio is the main factor controlling BOD removal. Lower F/M values will give higher BOD removal. The F/M can be varied by varying MLVSS concentration in the aeration tank.

Solid Retention Time (SRT) or Mean Cell Residence Time (MCRT): The performance of the ASP in terms of organic matter removal depends on the duration for which the microbial mass is retained in the system. The retention of the sludge depends on the settling rate of the sludge in the SST. If sludge settles well in the SST proper recirculation of the sludge in aeration tank is possible, this will help in maintaining desired SRT in the system. Otherwise, if the sludge has poor settling properties, it will not settle in the SST and recirculation of the sludge will be difficult and this may reduce the SRT in the system. The SRT can be estimated as stated below:

$$\text{SRT} = \frac{\text{kg of MLVSS in aeration Tank}}{(\text{kg of VSS wasted per day} + \text{kg of VSS lost in effluent per day})}$$

Generally, the VSS lost in the effluent are neglected as this is very small amount as compared to artificial wasting of sludge carried out from the sludge recycle line or from aeration tank.

Sludge Volume Index: The quantity of the return sludge is determined on volumetric basis. The sludge volume index (SVI) is the volume of the sludge in mL for one gram of dry weight of suspended solids (SS), measured after 30 minutes of settling. The SVI varies from 50 to 150 mL/ g of SS. Lower SVI indicates better settling of sludge.

Quantity of Return Sludge: Usually solid concentration of about 1500 to 3000 mg/L (MLVSS 80% of MLSS) is maintained for conventional ASP and 3000 to 6000 mg/L for completely mixed ASP. Accordingly the quantity of return sludge is determined to maintain this concentration. The sludge return ratio is usually 20 to 50%. The F/M ratio is kept as 0.2 to 0.4 for conventional ASP and 0.2 to 0.6 for completely mixed ASP.

Sludge Bulking: The sludge which does not settle well in sedimentation tank is called as bulking sludge. It may be due to either a) the growth of filamentous microorganisms which do not allow desirable compaction; or b) The production of non-filamentous highly hydrated biomass. There are many reasons for sludge bulking. The presence of toxic substances in influent, lowering of temperature, insufficient aeration, and shock loading can also cause sludge bulking. Proper supply of air and proper design to maintain endogenous growth phase of metabolism will not produce bulking of sludge. The sludge bulking can be controlled by restoring proper air supply, eliminating shock loading to the reactor, or by increasing temperature of the wastewater or by small hypochlorite dosing to the return sludge line to avoid the growth of filamentous hygroscopic microorganisms.

Mixing Conditions: The aeration tank can be of plug flow type or completely mixed type. In the plug flow tank, the F/M and oxygen demand will be highest at the inlet end of the aeration tank and it will then progressively decrease. In the completely mix system, the F/M and oxygen demand will be uniform throughout the tank.

Flow Scheme: Sewage addition may be done at a single point at the inlet end of the tank or it may be at several points along the aeration tank. The sludge return is carried out from the underflow of the settling tank to the aeration tank. The sludge wastage can be done from return sludge line or from aeration tank itself. Sludge wasting from the aeration tank will have better control over the process, however higher sludge waste volume need to be handled in this case due to lower concentration as compared to when wasting is done from underflow of SST. The compressed air may be applied uniformly along the whole length of the tank or it may be tapered from the head of the aeration tank to its end.

19.1.1 Aeration in ASP

Aeration units can be classified as:

1) Diffuser Air Units
2) Mechanical Aeration Units
3) Combined Mechanical and diffused air units.

19.1.1.1 Diffused aeration

In diffused air aeration, compressed air is blown through diffusers. The tanks of these units are generally in the form of narrow rectangular channels. The air diffusers are provided at the bottom of tank. The air before passing through diffusers must be passed through air filter to remove dirt. The required pressure is maintained by means of air compressors.

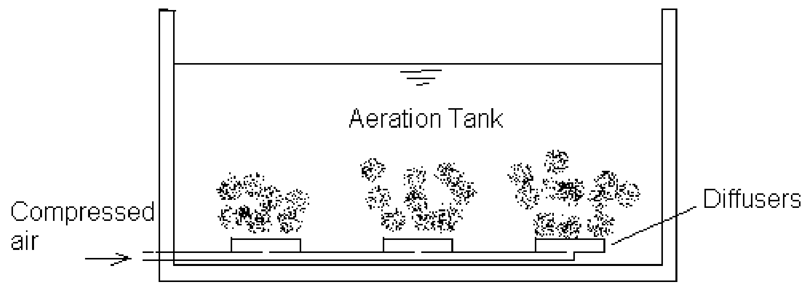

Figure 19.2. Typical air diffusers arrangement

Types of air diffusers

a) <u>Jet diffusers</u>: These diffusers give direct stream of air in the form of jet downward and strike against a small bowl kept just below the nozzle of the jet. The air flashes over the surface of the bowl and escapes in the form of fine bubbles.

b) <u>Porous diffusers</u>: Manufactured in the form of tubes and plates from grains of crushed quartz, aluminum oxide or carbon fused to form a porous structure. These are tile shaped or tubular shape. 10 to 20 % area of the tank is covered with porous tiles. The supply of air is done through pipeline laid in the floor of the tank and is controlled by the valves. Depending upon the size of the air bubbles these can be classified as fine or medium bubble diffused-air aeration device.

In common practice, porous dome type air diffusers of 10 to 20 cm diameter are used. These are directly fixed on the top of C.I. main pipes laid at the bottom of the aeration tanks. These are cheap in initial as well as maintenance cost.

Air Supply: Normally air is supplied under pressure of 0.55 to 0.7 kg/cm^2. The quantity of air supplied varies from 1.25 to 9.50 m^3/m^3 of sewage depending on the strength of the sewage to be treated and degree of treatment desired. The oxygen transfer capacity of the aerators depends on the size of air bubbles, for fine bubble oxygen transfer capabilities of aeration device is 0.7 to 1.4

kg O_2/KW.h. For medium bubble it is 0.6 to 1.0 kg O_2/KW.h, and for coarse bubble it is 0.3 to 0.9 kg O_2/KW.h.

19.1.1.2 Mechanical Aeration Unit

The main objective of mechanical aeration is to bring every time new surface of wastewater in contact with air. In diffuse aeration only 5 to 12% of the total quantity of the air compressed is utilized for oxidation and rest of the air is provided for mixing. Hence, mechanical aeration was developed. For this surface aerators either fixed or floating type can be used (Figure 19.3). The rectangular aeration tanks are divided into square tank and each square section is provided with one mixer. The impeller are so adjusted that when electric motors starts, they suck the sewage from the centre, with or without tube support, and throw it in the form of a thin spray over the surface of the wastewater. When the wastewater is sprayed in the air more surface area is brought in contact with the air and hence aeration will occur at accelerated rate. Detention period of the aeration tank treating sewage is usually 5 to 8 hours. The volume of aeration tank should be worked out considering the return sludge volume.

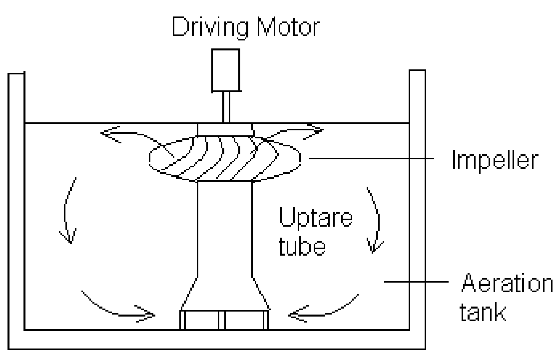

Figure 19.3. Typical arrangement of the surface aerator supported on conical bottom tube