19.4 Aerated Lagoon

Aerated lagoons are one of the aerobic suspended growth processes. An aerated lagoon is a basin in which wastewater is treated either on a flow through basis or with solids recycle. Oxygen is usually supplied by means of surface aerators on floats or on fixed platforms or diffused air aeration units instead of photosynthetic oxygen yield as in case of oxidation pond. The action of the aerators and that of the rising air bubbles from the diffuser are used to keep the contents of the basin in suspension. They are constructed with depth varying from 2 to 5 m.

The contents of an aerobic lagoon are mixed completely. Depending on detention time, the effluent contents of about 1/3 to ½ the value of the incoming BOD in the form of cell tissue. Before the effluent can be discharge, the solids must be removed by settling. If the solids are returned to the lagoon, there is no difference between this and modified ASP.

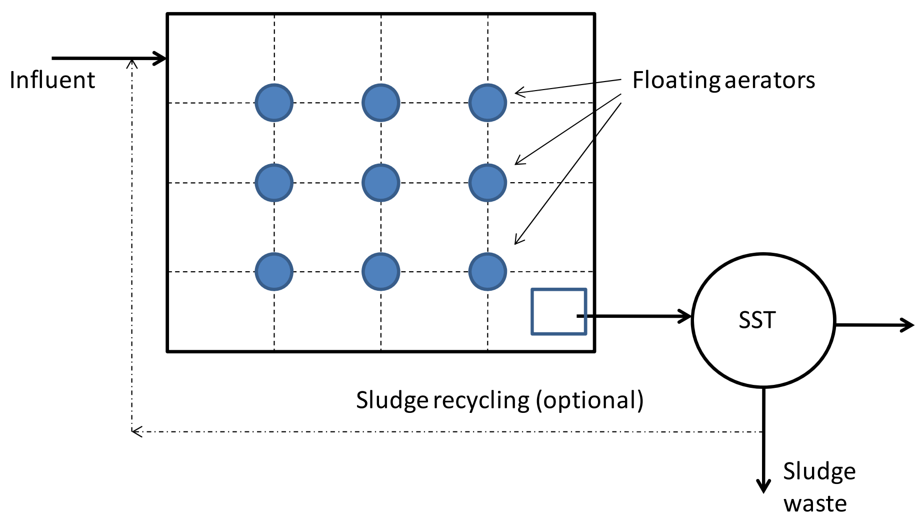


Figure 19.17 Aerobic lagoon

The mean cell retention time should be selected to assume, 1) that the suspended microorganisms will easily flocculate by sedimentation and 2) that the adequate safety factor is provided when compared to mean cell residence time of washout. The oxygen requirement is as per the activated sludge process. In general, the amount of oxygen required has been found to vary from 0.7 to 1.4 times the amount of BOD_5 removed.

Aerated lagoons have the advantages such as ease of operation and maintenance, equalization of wastewater, and a high capacity of heat dissipation when required. The disadvantages of aerated lagoons are (Barnhart, 1972) large area requirement, difficulty in process modification, high effluent suspended solids concentration, sensitivity of process efficiency to variation in ambient air temperature.

Aerobic lagoons: In aerobic lagoons, power levels are great enough to maintain all the solids in the lagoons in suspension and also to provide dissolved oxygen throughout the liquid volume. Aerobic lagoons are operated with high F/M ratio and short MCRT. These systems achieve little organic solids stabilization but convert the soluble organic material into cellular organic material. Based on the solid handling manner, the aerobic lagoons can be classified into (i) aerobic flow through with partial mixing, and (ii) Aerobic lagoon with solid recycle and nominal complete mixing (Arceivala, 1998).

Aerobic flow through with partial mixing: This type of aerobic lagoons operate with sufficient energy input to meet the oxygen requirement, but the energy input is insufficient to keep all the biomass in suspension. The HRT and SRT are the same in this type of lagoon. The effluent from this lagoon is settled in an external sedimentation facility to remove the solid prior to discharge.

Aerobic lagoons with solid recycle: This type of lagoons are same as the extended aeration activated sludge process with the exception that the aeration is carried out in an earthen basin instead of a reinforced concrete reactor basin and longer HRT than the extended aeration process. The oxygen requirement in this type of lagoon is higher than the aerobic flow through lagoons to keep all the biomass in suspension. The analysis of this type of lagoons is same as the activated sludge process.

19.5 Moving Bed Biofilm Reactor (MBBR)

Moving bed biofilm reactor is developed by Norwegian company, Kaldnes Miljoteknologies. This mainly attached growth process where media is not stationary and it moves freely in the reactor to improve substrate removal kinetics. Small cylindrical shaped polyethylene carrier elements (sp. density 0.96 g/cm^3) are added in aerated or non-aerated basins to support biofilm growth. Cylinders of 10 mm ø and 7 mm thick with a cross inside are popularly used.

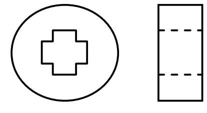
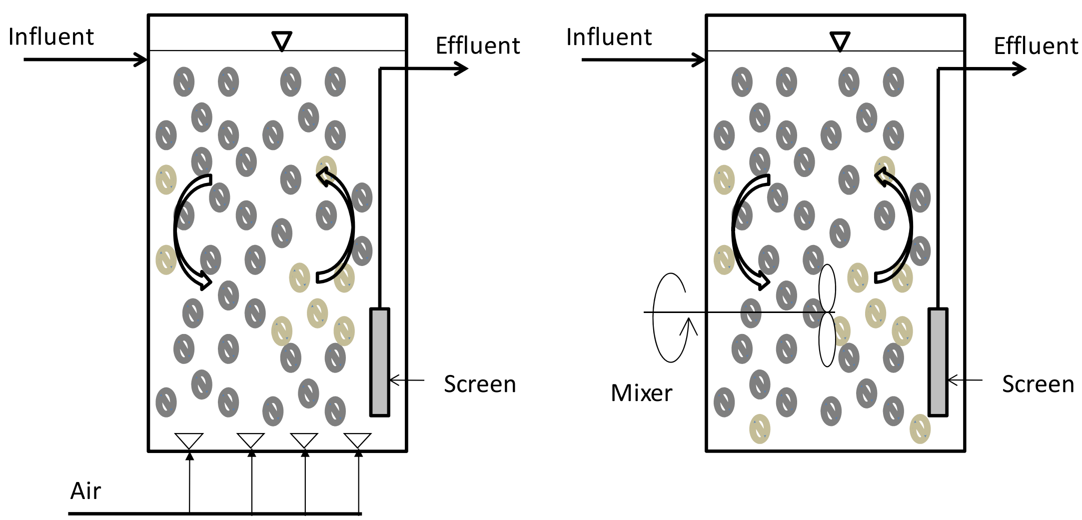


Figure 19.18. Typical polyethylene media used in MBBR

The biofilm carriers are retained in the reactor by the use of a perforated plate (5 x 25 mm slots) at the tank outlet. Thus, this media having larger size cannot escape the reactor along with the effluent. Air agitation or mixers are used to continuously circulate the packing and to keep it moving so as to establish optimum contact with substrate present in wastewater and bacteria attached to the media. Packing may fill 25 to 50% of tank volume, with specific surface area of about 200 to 500 m^2/m^3 of bulk packing volume. This arrangement offers advantage that no return sludge is required and since the media is moving there is no chance of blocking the media which may require back washing. A final clarifier is used to settle sloughed solids. Another advantage is use of more efficient fine bubble aeration equipment is not required, which would require periodic drainage of aeration tank and removal of packing for cleaning of diffusers.



(a) (b)

Figure 19.19 Typical reactors used with suspended packing materials a) Aerobic b) Anaerobic/Anoxic with internal mixer.

MBBR are finding increasing application for post treatment of anaerobically treated industrial effluents and also as a secondary treatment system for treatment of sewage. These reactors can be used for removal of organic matter and also for nitrification and denitrification. Single stage MBBR may meet the effluent standards for treatment of primarily treated sewage. Whereas, to achieve nitrification and denitrification along with organic matter removal multistage MBBR is used with intermediate settler or settler provided at the end of all the reactors. As per the need the first few MBBRs will be anoxic to achieve carbonaceous organic matter removal and denitrification and these will be followed by aerobic MBBR mainly for nitrification and remaining organic matter removal.

Typical design parameters used for MBBR are stated below:

Detention time, h	3 – 5
Biofilm area, m^2/m^3	200 – 250
BOD loading, $kg/m^3.d$	1.0 – 2.0
Secondary clarifier hydraulic loading rate, $m^3/m^2.d$	12 – 20

Questions

1. Why aerobic treatment systems produce more sludge than anaerobic treatment systems?
2. Define SVI. Calculate SVI of the sludge for the laboratory test results furnished below:
   Sludge settled volume (SSV) after 30 min. settling = 280 mL
   MLVSS in aeration tank = 3500 mg/L, ans SS/VSS = 0.8
3. Why recycling of the sludge is necessary in activated sludge process?
4. Describe different types of activated sludge process used.
5. Differentiate between completely mixed activated sludge process and extended aeration activated sludge process.
6. Using microbial growth kinetics derive expression for determination of reactor volume for complete mixed activated sludge process with sludge recycling.
7. Calculate oxygen required per day for treatment of 500 m^3/d wastewater containing 300 mg of BOD /L and TKN of 30 mg/L in activated sludge process. The effluent should have BOD of 20 mg/L and TKN of 3 mg/L. Consider Y = 0.5 mg VSS/mg BOD and k_d = 0.06 per day.
8. Estimate recirculation ratio of for ASP when the MLVSS concentration in the aeration tank is 4000 mg/L and the return sludge concentration is 9000 mg of SS/L. Consider VSS/SS = 0.8.
9. An activated sludge process is to be used for secondary treatment of 10000 m^3/d of wastewater. The BOD of settled wastewater after primary treatment is 150 mg/L and it is desirable to have not more than 10 mg/L of soluble BOD in the effluent.

Consider Y = 0.5; K_d = 0.05 per day; MLVSS concentration in the aeration tank = 3000 mg/L and underflow concentration from the clarifier 10,000 mg/L of SS. VSS/SS = 0.80. Determine i) the volume of aeration tank, ii) sludge to be wasted per day (mass and volume), iii) the recycle ratio, and iv) Volumetric loading and F/M.

10. What is sludge bulking? How it can be controlled?
11. Describe sequencing batch reactor.
12. Describe the working of moving bed biofilm reactor. What advantages this reactor will offer?
13. Describe different types of trickling filter used in wastewater treatment.
14. Design a biotower for treatment of wastewater generated from the housing scheme having population of 5000 persons with rate of water supply 180 LPCD.
15. Classify the ponds used for wastewater treatment.
16. Describe high rate algal pond.
17. Design facultative stabilization pond to treat a domestic sewage of 5 MLD, located at a place where the latitude is 22 ^{o}N and 300 m above mean sea level. The five day 20 ^{o}C BOD of the sewage is 150 mg/L. Suitable other data may be assumed for Indian conditions.