Example: 2

Design low rate trickling filter for secondary treatment of sewage generated from 10000 persons with rate of water supply 170 LPCD. The BOD_5 after primary treatment is 110 mg/L and BOD_5 of final effluent should be 20 mg/L. Consider C=5.358.

Solution

$$\frac{S_t}{S_o} = \frac{1}{1+C\left(\frac{D^{0.67}}{Q_L^{0.5}}\right)}$$

Provide depth D = 1.5 m

Sewage flow = 10000 x 170 x 0.80 x 10^{-3} = 1360 m^3/d

Now, $$\frac{20}{110} = \frac{1}{1+5.358\left(\frac{1.5^{0.67}}{Q_L^{0.5}}\right)}$$

$$0.182\left(1+\frac{7.03}{Q_L^{0.5}}\right) = 1$$

$$\therefore\ Q_L^{0.5} = 1.562$$

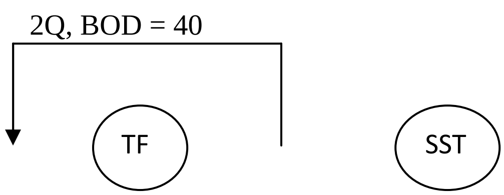
Q_L = 2.441 m^3/m^2-d where, Q_L = flow/area

$\therefore$ Plan area = $\frac{1360}{2.441}$ = 557.35 m^2

Hence, Diameter of trickling filter = 26.64 m

Example: 3

Design high rate trickling filter for the data given above except effluent BOD_5 = 40 mg/l since polishing treatment is provided after high rate trickling filter. Consider recirculation ratio of 2 and filter depth of 1.8 m.



Q T

BOD = 110

BOD in the effluent,

Q x 110 + 2Q x 40 = (1 + 2) Q.S_0

∴ S_0 = 63.33 mg/L

$$\frac{40}{63.3} = \frac{1}{1+5.358\,(\frac{1.8^{0.67}}{Q_L^{0.5}})}$$

Q_L = 186 m^3/m^2-d

Waste water flow is 1360 m^3/d

∴ Recycle flow = 2720 m^3/d

and total flow = 4080 m^3/d

∴ Area of Trickling Filter = $\frac{4080}{186}$ = 21.94 m^2

∴ Diameter = 5.285 m

Example :4

Design a single stage biotower (super rate trickling filter) for the following data:

Average wastewater flow = 500 m^3/d,

Influent BOD = 160 mg/L

BOD removal in primary treatment = 30%,

Effluent BOD required = 20 mg/L

Filter depth = 5.0 m; Recycle ratio R/Q = 2

Pilot plant studies using synthetic packing have shown a removal constant K = 2.26 at 20^0 C, and n = 0.5 (Reynolds & Richard, 1996). The winter wastewater temperature = 15^0 C. Provide minimum two filters in parallel.

Solution:

$$\frac{St}{S0} = e^{(-\frac{KD}{Q_L^{0.5}})}$$

Now, $K_{15} = K_{20}\, 1.035^{(T-20)}$

$= 2.26 \times 1.035^{(-5)}$

$= 1.903$ per day

BOD_5 in incoming wastewater to biotower = 160 (1-0.30) = 112 mg/L

Recycle flow = 2Q and BOD = 20 mg/L

Therefore, 112 (Q) + 2Q x 20 = 3Q. S_0

Hence, $S_0 = 50.67$ mg/L

Substituting values in the equation

$$\frac{20}{50.67} = e^{\left(-\frac{1.903\ x\ 5.0}{Q_L^{0.5}}\right)}$$

Solving we get, $Q_L = 104.8\ m^3/m^2.d$

Wastewater flow = 500 m^3/d

Hydraulic load on filter = 500 + 2 x 500

= 1500 m^3/d

Area required = 1500/104.8 =14.313 m^2

Hence, diameter required for each biotower when two are provided in parallel = 3.02 m

19.3 Ponds System for Treatment of Wastewater

It is a shallow body of water contained in an earthen basin, open to sun and air. Longer time of retention form few days to weeks is provided in the pond. The purification of wastewater occurs due to symbiotic relationship of bacteria and algae. The ponds are classified according to the nature of the biological activity which takes place within the pond as aerobic, facultative and anaerobic. These are cheaper to construct and operate in warm climate as compared to conventional treatment system and hence they are considered as low cost wastewater treatment systems. However, they require higher land area as compared to conventional treatment system.

19.3.1 Classification of Ponds

Aerobic Ponds: In aerobic pond the microbial population similar to ASP exists along with algae. The aerobic population release CO_2, which is taken up by the algae for their growth. Algae in turn release O_2, which helps in maintaining the aerobic condition in the pond. Very shallow depth of aerobic pond (0.15 to 0.45 m) is used for the treatment of wastewater for removal of nitrogen by algae growth. For general wastewater treatment depth of 0.5 to 1.2 m may be used. The solar radiation should penetrate to the entire depth of the pond to support photosynthesis to keep entire pond content aerobic. When shallow ponds (0.5 m deep) are used for tertiary treatment of wastewater, they are very lightly loaded and such ponds are called as *maturation pond*. These maturation ponds may release oxygen in atmosphere during day time.

Facultative stabilization Ponds: Most of the ponds exist in facultative nature. Three zones exist in this type of ponds. The top zone is an aerobic zone in which the algal photosynthesis and aerobic biodegradation takes place. In the bottom zone, the organic matter present in wastewater and cells generated in aerobic zone settle down and undergo anaerobic decomposition. The intermediate zone is partly aerobic and partly anaerobic. The decomposition of organic waste in this zone is carried out by facultative bacteria. The nuisance associate with the anaerobic reaction is eliminated due to the presence of top aerobic zone. Maintenance of an aerobic condition at top layer is important for proper functioning of facultative stabilization pond, and it depends on solar radiation, wastewater characteristics, BOD loading and temperature. Performance of these ponds is comparable with conventional wastewater treatment.

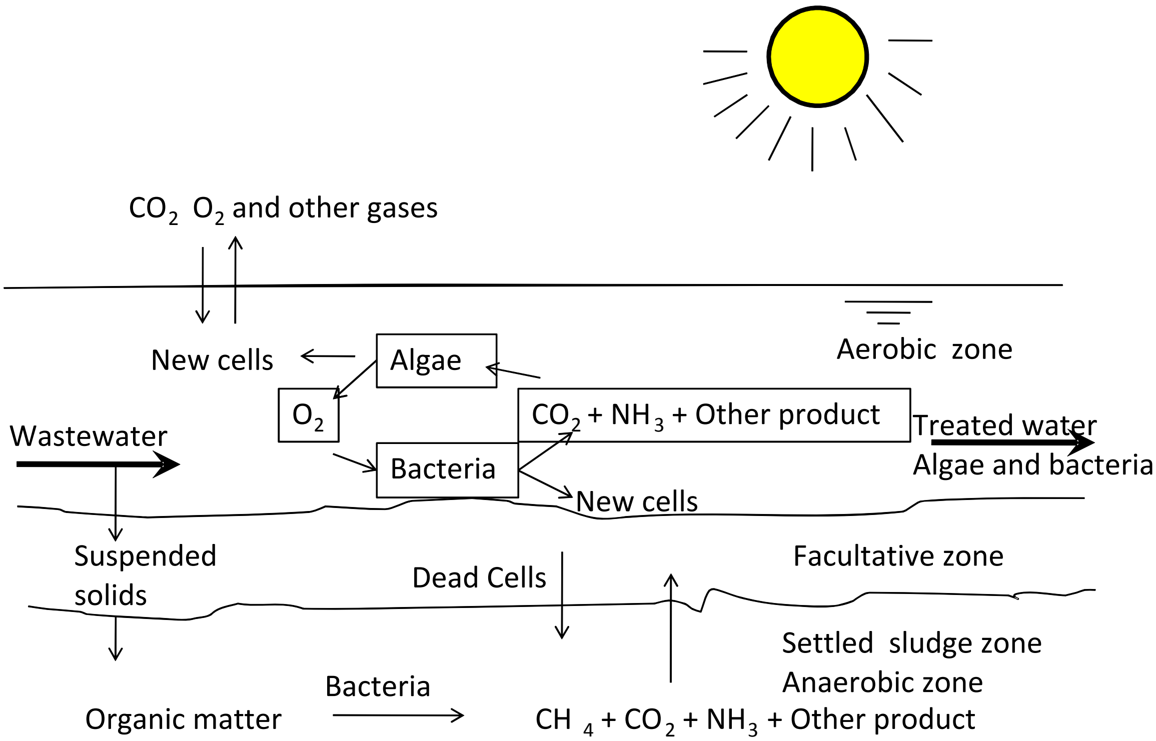


Figure 19.14 Facultative stabilization pond

Anaerobic pond: In anaerobic pond, the entire depth is under anaerobic condition except an extremely shallow top layer. Normally these ponds are used in series followed by facultative or aerobic pond for complete treatment. The depth of these ponds is in the range of 2.5 to 6 m. They are generally used for the treatment of high strength industrial wastewaters and sometimes for municipal wastewater and sludges. Depending upon the strength of the wastewater, longer retention time up to 50 days is maintained in the anaerobic ponds. Anaerobic lagoons are covered these days by polyethylene sheet for biogas recovery and eliminating smell problem and green house gas emission in atmosphere.

***Fish pond*:** It can be part of maturation pond or altogether separate pond, in which fish are reared. Sometimes, fishes are also reared in the end compartment of primary pond.

Aquatic plant ponds: These are secondary ponds in which aquatic plants e.g. hyacinths, duckweeds, etc. are allowed to grow either for their ability to remove heavy metals and other substances from wastewaters, or to give further treatment to wastewaters and produce new plant biomass. This recovered biomass can be used for biodiesel, bioethanol, combustible gas recovery as fuel or many other chemicals can be recovered using these plants as feed stock.

High-rate algal ponds: The high rate algal pond (HRAP) is potentially an effective disinfection mechanism within the requirements of sustainability. In addition to disinfection, nutrient removal mechanisms are also active in the HRAP, specifically those involved in the removal of phosphate. These ponds are not designed for optimum purification efficiency but for maximum algal production. The algae is harvested for a variety of uses, principally high quality algal protein. The ponds are shallow lagoons 20–50 cm deep, with a retention period of 1–3 days. The whole pond is kept aerobic by maintaining a high algal concentration and using some form of mechanical mixing. Mixing is normally carried out for short periods at night to prevents the formation of a sludge layer. Mixing may be required for short periods during the day to prevent a rise in pH in the surface water due to photosynthesis. The pond is commissioned in the same way as a facultative pond except that continuous loading should not be permitted until an algal bloom has developed. Loading depends on solar radiation, and the average loading throughout the year could be 100 to 200 kg BOD $ha^{-1}d^{-1}$. Strong organic sewages inhibit the photosynthetic action due to high ammonia concentrations, which results in the pond becoming anaerobic. High rate algal ponds are designed to promote the symbiosis between the microalgae and aerobic bacteria, each utilizing the major metabolic products of the other. Microalgae grow profusely releasing oxygen from water by photosynthesis. This oxygen is immediately available to bacteria to oxidize most of the soluble and biodegradable BOD remaining from the facultative pond. HRPs are shallower than facultative ponds and operate at shorter hydraulic retentions times (HRTs). At the rapid growth of algae, the pH can raise to above 9 since at peak algal activity carbonate and bicarbonate ions react to provide more carbon dioxide for the algae, leaving an excess of hydroxyl ions. A pH above 9 for 24 hours ensures a 100% kill of E. coli and presumably most pathogenic bacteria.

Primary and secondary ponds: Ponds receiving untreated wastewaters are referred as raw or *primary waste stabilization ponds*. Those receiving primary treated or biologically treated wastewaters for further treatment are called as *secondary waste stabilization ponds*. *Maturation pond* is the secondary pond receiving already treated wastewater either from the ponds or other biological wastewater treatment process, like UASB reactor or ASP. The detention time of 5 to

7 days is provided in these ponds, with the main purpose of achieving natural bacterial die-off to desired levels. In warm climate they often constitute an economical alternative for chlorination. They are lightly loaded in terms of organic loading and the oxygen generated by photosynthesis may be more than the oxygen demand.

19.3.2 Typical Flow Chart of Pond Based Treatment Plant

The typical treatment flow sheets for different types of ponds in use are illustrated in the Figure 19.15. The ponds can be used in series or in parallel. Chlorination of the treated effluent is optional. The primary treatment after screen can be combined in the ponds along with secondary treatment.

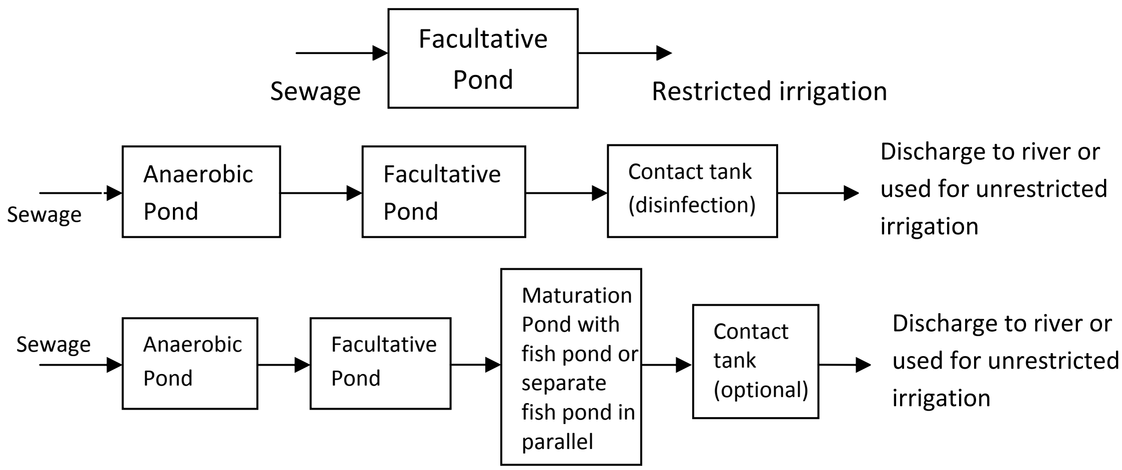


Figure 19.15 Layouts of the waste stabilization ponds