## MODULE 3

### SOLVED NUMERICAL PROBLEMS

**Problem 1:** Find maximum flow rate of wastewater that can be maintained in a aerated lagoon of volume 1 million gallon to treat the wastewater (having BOD of 450 mg/l) at 25°C so that the BOD of treated stream does not exceed 90 mg/l. The reaction coefficient k is 0.308 $d^{-1}$ at 25°C, and the value of $\emptyset$ is 1.06.

**Solution**: Given: S=90 mg/l; $S_0$=450mg/l; V=1 M gallon

Substituting given values in

$$\frac{S}{S_0} = \frac{1}{1 + kV/Q} = \frac{1}{1 + k\theta}$$

$$\frac{90}{450} = \frac{1}{1 + 0.308\left(1/Q\right)}$$

Q=0.077 M gallon/day.

**Problem 2:** A wastewater stream A with 200 $m^3$/h of flow rate and BOD of 300mg/l mixes with stream B having flow rate of 400$m^3$/h and BOD 225mg/l. A completely mixed activated sludge process is used to treat the mixture. BOD of effluent stream is 10 mg/l. Given Y= 0.5, k=5 $day^{-1}$, $K_d$=0.06 $day^{-1}$; $K_s$=100 mg/l and MLVSS= 2000 mg/l. Find

(a) BOD and flow rate of mixture

(b) Mean residence time

**Solution**: Given: $Q_a$=200 $m^3$/h; $Q_b$ =400 $m^3$/h; $BOD_a$= 300 mg/l; $BOD_b$ =225mg/l

$Q_{mix}$= $Q_a$+$Q_b$= 600 $m^3$/h

$$BOD_{mix} = \frac{Q_a\left(BOD_a\right) + Q_b\left(BOD_b\right)}{Q_a + Q_b} = \frac{200(300) + 400(225)}{600} = 250 \text{ mg/l}$$

We know that

$$\frac{1}{\theta_c} = \frac{Y(\kappa)(S)}{K_S + S} - K_d = \frac{0.5(5)(10)}{100 + 10} - 0.06 = 0.167 \text{ d}^{-1}$$

$\theta_c = 6$ days

**Problem 3:** It is desired to reduce the BOD of the wastewater from 100 mg/L to 20 mg/L in a single stage trickling filter with depth 5 m and 4 m radius. The flow rate of wastewater is 4000 $m^3/d$ with TKN 25 mg/L. Calculate volumetric BOD and TKN loading.

**Solution:** Given: Area (A)=$\pi(R^2)$=50.265 $m^2$

Volume (V)=Area × Depth=251.32 $m^3$

$$\text{BOD Loading}=\frac{\left(100\,g/m^3\right)\left(4000\ m^3/d\right)}{251.32\ m^3}=1591.59\ \text{g/m}^3\text{.d}$$

$$\text{TKN Loading}=\frac{\left(25\ g/m^3\right)\left(4000\ m^3/d\right)}{251.32\ m^3}=397.89\ \text{g/m}^3\text{.d}$$

**Problem 4:** A 6 ml sample of wastewater is diluted to 300 ml in a standard BOD bottle. The initial DO level in the bottle is 8.5 mg/l and DO after 5 days at 20°C was found to be 0.5 mg/l. The BOD of the waste is reduced to 40 $g/m^3$ when treated in an aerated lagoon, find the aeration period. Given value of k is 0.23 $d^{-1}$ at 20°C.

**Solution:** Given: Effluent BOD (S)=40 $g/m^3$; k=0.23 $d^{-1}$

$$\text{Influent BOD } (S_o)=\frac{(8.5\text{-}0.5)300}{6}=400\ \text{g/m}^3$$

$$\frac{S}{S_0}=\frac{1}{1+kV/Q}=\frac{1}{1+k\theta}$$

$$\frac{40}{400}=\frac{1}{1+0.23\ \theta}$$

$$\theta=39.13\ \text{day}$$

**Problem 5:** An Activated sludge system of volume 5000 $m^3$ is used to treat 2 Million litre per day wastewater having BOD of 500 mg/l. Calculate hydraulic detention time and F/M ratio assuming the equilibrium volatile suspended solid concentration 0.6 $kg/m^3$.

**Solution:** Given: Volume (V)= 5000 $m^3$; Flow Rate (Q)=2 M litre per day=2000 $m^3$/day; BOD=500 $g/m^3$

$$\text{Hydraulic Detention Time}=\frac{\text{V}}{\text{Q}}=\frac{5000\ m^3}{2000\ m^3/d}=2.5\ \text{day}$$

$$\text{F/M Ratio}=\frac{\left(500\ g/m^3\right)\left(2000\,m^3/d\right)}{\left(600\ g/m^3\right)\left(5000\ \text{m}^3\right)}=0.333\ \text{d}^{-1}$$

**UNSOLVED PROBLEMS**

1. Write a short note on major biological treatment processes used for wastewater treatment.
2. Describe in short an Activated Sludge Process. Sketch a principal scheme of an ASP
3. Describe briefly various types of aeration systems. Write about various operating problems faced in aeration systems.
4. Derive the expression for the fraction of VOCs removed by aeration in complete stirred tank reactor for both surface aeration as well as diffused aeration.
5. Classify lagoons based on degree of mechanical mixing and mention the various design factors that need to be considered for flow-through lagoons.
6. What are the various factors affecting the operation of trickling filter
7. Write advantages and disadvantages of using trickling filter and SBR.
8. Write a short note on upflow anaerobic sludge blanket reactor?
9. What is the objective of a sludge treatment? What are the various methods for sludge treatment?
10. Describe in short various sludge treatment methods.
11. What is sludge stabilization?
12. What is the necessity of sludge disposal? Describe briefly the various methods of sludge disposal.
13. Write various design equation used for the design of trickling filter.
14. Write various steps involved in the operation of SBR.
15. What is dewatering filter? Discuss its types and usage.
16. What is thermal dryer? Discuss its types and usage.
17. Write full forms of
    (a) MLSS
    (b) VSS
    (c) MLVSS
    (d) RBC
    (e) SBR
    (f) VER
    (g) HRT
    (h) SRT
    (i) UASB
    (j) OLR

(k) HRT

(l) GBT

18. Distinguish between

(a) Suspended- and attached- growth processes

(b) Aerobic and anaerobic processes

(c) Nitrification and denitrification

19. Describe the following terms along-with their significance

(m) F/M ratio

(n) MLSS

(o) MLVSS

(p) Volume exchange ratio (VER)

(q) Hydraulic detention time

(r) Solid retention time

(s) Volumetric Organic loading

(t) Hydraulic Loading

(u) Recirculation Ratio

(v) Sludge age or mean residence time

20. Write short notes on following

(a) SBR

(b) RBC system

(c) Sludge Conditioning

(d) Sludge Disinfection

(e) Sludge Dewatering

(f) Sludge Drying

(g) Sludge Composting

(h) Sludge Thickening