MODULE 3

SOLVED NUMERICAL PROBLEMS

Problem 1: Grit chamber designing Problem : Determine the dimension of channel for a maximum wastewater flow of 25,000m^3/d in which a flow-through velocity of 0.26 m/s will be maintained. If the settling velocity for particles is found to range from 0.020 to 0.026 m/s, depending on their shape factor. (Consider Depth = 1.5×width)

Solution: Assume a rectangular cross section part with a depth of 1.5 times of width.

$A_x = W \times D$

$= W \times 1.5W$

$= 1.5\ W^2$

$$A_x = \frac{Q}{vh} = \frac{25000(m3/d)}{0.26(m/s)} = 1.11289\ m^2$$

$W = 0.86m$

$D = 1.29m$

Assuming a settling velocity of 0.023 m/s, then detention time t_d :

$t_d = D/v_t$

$= 1.29m / (0.023m/s)$

$= 56\ s$

Then length, $L = t_d \times v_h$

$= 56s \times 0.26\ m/s$

$= 14.56\ m$

Tank Dimension: **L = 14.56 m**

W = 0.86 m

D = 1.29 m

Problem 2: The mole fraction of O_2 is 0.48 atm. Find the concentration of O_2 in water (in mg O_2/ litre of water) at 20 ^oC.

Solution:

We know that; $x_A = \left(\left(C_A \text{ (in g/L)} \times 18 \right) \Big/ \left(MW_A \text{(in g/mol)} \times 10^3 \right) \right)$

Given; $x_A = 0.48$,

$MW_A = 32$ g/mol

Then,

$$C_A = (0.48 \times 32 \times 10^3) / (18)$$

$$C_A = \mathbf{853.33\ g/L}$$

Problem 3: If a ground water contains H_2S at concentration of 2 mg/l, determine the concentration of H_2S in head space of a closed tank containing the ground water at at 20 ^oC. Given that for H_2S, Henry's constant (H) is equal to 5.15×10^2 atm at 20 ^oC

Solution:

$$p_{H_2S} = \frac{C_{H_2S} \text{ (in mg/L)} \times H \times 18}{\left(MW_{H_2S} \text{(in g/mol)} \times 10^6 \right)}$$

$p_{H_2S} = \frac{2 \times 5.15 \times 10^2 \times 18}{\left(34 \times 10^6 \right)} = 5.453 \times 10^{-4}$ atm=545.3 ppm_v (volume basis assuming total pressure inside tank is 1 atm).

$$C_{H_2S} = \frac{p_{H_2S} MW_{H_2S}}{RT} == \frac{5.453 \times 10^{-4} \times 34}{0.0821 \times 293} = 0.00077 \text{ g/L} = 0.77 \text{ mg/L}.$$

Problem 4: For 40,000 m^3/d wastewater, Calculate the volume of the flocculator tank, in which 42 mg/L alum dosage with flocculation at a G_t value of 4.32×10^4 that produces the optimal results and and the water temperature is 20^0C. Determine the requirment of alum in per week and volume of tank.

Solution:

(a) Alum requirement:

42 mg/L = $(42 \times 10^{-6}\text{kg}) / (10^{-3}\text{m}^3)$

= 0.042 kg/m^3

Weekly alum required = (7d/week)×(0.042 kg/m^3)×(40,000 m^3/d)

$= 11{,}760$ kg/week

(b) Volume of tank:

Assume an average G value of 30 s^{-1}

$$G_t = 4.32\times10^4$$
$$= (4.32\times10^4)/30$$
$$= 1440 \text{ sec}$$

Volume of tank, $V = Q\times t$

$$= (40{,}000 \text{ m}^3/\text{d})\times(1440 \text{ sec})$$
$$= (40{,}000 \text{ m}^3 / 24\times60\times60 \text{ sec}) \times (1440 \text{ sec})$$
$$= 666.67 \text{ m}^3.$$

Problem 5: Design a primary clarifier which can remove 65% of the suspended solids at average flow of 4500 m^3/d with peak flows as high as 13000 m^3/d of any wastewater treatment plant. Given the required surface area of basin=150 m^2.

Solution: For the circular tank, the diameter d

$$d = (4A/\pi)^{1/2}$$
$$= (4\times150 \text{ m}^2 / 3.14)^{1/2}$$
$$= 13.82 \text{ m}$$

Assuming a side wall depth of 4 m, volume of tank = 4×150

$$600 \text{ m}^3$$

And detention time at average flow

$$= \frac{600 \text{ m}^3}{4500 \text{ m}^3/\text{d}} = 0.133 \text{ d} = 3.2 \text{ h}$$

At peak flow condition, the overflow rate

$$= \frac{13000 \text{ m}^3/\text{d}}{150 \text{ m}^2} = 86.66 \text{ m/d}.$$

UNSOLVED PROBLEMS

1. What would be the major steps for waste water treatment?
2. Discuss the various steps of wastewater treatment? Describe all steps with their main purpose.
3. Discuss about the following process:
   (a) Screening
   (b) Aeration
   (c) Sedimentation
   (d) Clarification
   (e) Electrodialysis
   (f) Reverse osmosis
   (g) Ion exchange
4. Determine the effect of primary treatment on the performance of secondary treatment.
5. Differentiate between hard ground water & turbid surface water via flow-sheet.
6. Name and characterize three most significant components of wastewater.
7. What are the common engineering methods of removing solids from wastewater?
8. What is the flow equalization process? Discuss about the advantages and disadvantages of flow equalization.
9. Which types of flow equalization is more efficient, in- line equalization or off- line equalization?
10. What do you mean by HTU & NTU?
11. What are the various factors that affect removal of VOCs in aeration process?
12. How you calculate solubility of gases?
13. Define Henrys' Law. Explain the effect of temperature on solubility of gases?
14. Describe the following aeration process:
    (a) Diffused or Submerged Aeration
    (b) Spray aeration
    (c) Water fall type of aeration
15. Differentiate between coagulation and flocculation?

16. Explain coagulation process of wastewater treatment. What is the role of Al^{3+} & Fe^{3+} in the coagulation process? Discuss about the factors which decide the chemicals for coagulation process. What are the advantages and disadvantages of coagulation process?
17. Explain gravitational settling phenomena and its types. What is drag-coefficient (C_D)? Define the Stoke's law. Discuss about various types of gravitational settling phenomena.
18. Differentiate between following settling processes
    (a) Discrete particle settling
    (b) Flocculation settling.
    (c) Hindered settling
19. Explain filtration, its types and application in wastewater treatment? Describe various mechanisms involved in the filtration processes.
20. Classify various membrane processes and differentiate between them. Which types of materials are used in commercial membranes manufacturing?
21. What is membrane fouling?
22. Give the advantages & disadvantages of various membrane technologies?
23. Explain reverse osmosis process.
24. Differentiate between physio-sorption and chemi-sorption?
25. Discuss various factors which control the adsorption process?
26. Define the electrochemical treatment (ECT) process? Discuss about the factors which affect the ECT Process?