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INDIAN INSTITUTE OF TECHNOLOGY Kharagpur — *B.Tech. (Civil Eng.)*

CE 31005 WATER AND WASTEWATER ENGINEERING — *Autumn 2011*

FINAL EXAM — **Maximum: 100 Points**

Time: 3.0 hours

Instructions: *Please answer Sections I and II in separate answer scripts.*

Section 1: Water treatment *[50]*

1. Design a sedimentation basin to treat a flow of 25,000 m^3/d. Design for an overflow rate of 30 m^3/m^2-d, 4-h detention time and 250 m^3/m-d weir-loading rate. Use a rectangular basin with a length-to-width ratio of 4:1. [10]
2. Design an aeration tower for a design flow rate of 6,000 m^3/d with a height of 10 m, length: width ratio of 2:1 and 20 min detention time. If the air supply rate is 0.5 m^3/min-m^3 of tower volume, estimate the total air requirements on a daily basis. [10]
3. Calculate head loss through a clean bed of uniform sand. The sand grains have 0.5 mm diameter and the depth of the bed is 0.3 m. Bed porosity is 0.4, shape factor is 0.85, and specific gravity of sand is 2.65. Water temperature is 25 deg C, and the filter has a hydraulic loading rate of 4 m^3/m^2-h. Use the Carmen-Kozeny equation. Dynamic viscosity of water at 25 deg C is 0.89 x 10^{-3} N-s/m^2. [10]
4. Residual chlorine and chlorination data are provided below. Plot the chlorination curve and determine breakpoint chlorine dose. A free chlorine residual of 2 mg/L is to be maintained in the effluent of the water treatment plant. What is the initial chlorine demand and the total chlorine demand (kg/d) for a flow rate of 200 L/s? [10]

Chlorine applied, mg/L	Chlorine residual (free or total), mg/L
1	0
2	1
3	2
4	3
5	2
6	1.7
7	2.3
8	3
9	3.75
10	4.5

5. Estuarine regions are areas where large-scale settling of colloidal clay and other particles occurs. Explain based on your knowledge of the double layer model and particle-particle interactions why that happens? [5]
6. Explain the four different types of settling processes, i.e., Type I, type II.....in a sentence or two. Which types of settling processes are applicable in water treatment and which ones are used in wastewater treatment, and why? [5]

Section II

Answer all Questions. Clearly mention assumptions if any.

1. a. For an industrial wastewater activated sludge process, the amount of bsCOD in the influent wastewater is 500 g m^{-3} and the influent nbVSS concentration is 100 gm^{-3}. The influent flowrate is 1000 m^3d^{-1}, the biomass concentration is 2000 gm^{-3}, the reactor bsCOD concentration is 50 gm^{-3}. If the cell debris fraction f_d is 0.10 and the VSS production rate is 1380 g VSS/m^3.d, determine the net biomass yield, volume of the reactor tank, and the active biomass fraction in the MLVSS. The kinetic coefficients are given as following: k: 5 g bsCOD/g VSS.d; K_s: 60mg/L BOD; Y: 0.4 g VSS/g bsCOD; kd: 0.10 g VSS/g VSS.d **(5)**

1. b. Prove by applying mass balance in the complete-mix reactor that the effluent soluble concentration is only a function of the SRT and kinetic coefficients for growth and decay and is not related to the influent soluble substrate concentration. **(10)**

1. c. Using data given in **Q. 1a.**, estimate the SRT of the reactor to get 97% removal of soluble substrate concentration. **(5)**

1. d. Assuming the F/M ratio to be maintained as 0.10 g BOD/g VSS.d, estimate the hydraulic retention time of aeration tank. **(5)**

2. a. Explain the characteristics and mechanism of trickling filters used to provide biological wastewater treatment with a suitable process flow diagram. **(5)**

2. b. Discuss advantages and disadvantages of attached growth process over the activated-sludge process. **(5)**

2. c. A municipal wastewater having a BOD of 250 gm^{-3} is to be treated by a single stage trickling filter. The desired effluent quality is 25 gm^{-3} of BOD. If the filter depth is 1.83 m and the recirculation ratio is 2:1, find the required filter diameter. **(5)**

3. Give the generalized sludge-processing flow diagram with a brief description of each process. **(10)**