PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester I — Academic Year: 2003
Date: 30 September, 2003 — Time :1:30 to 4:30 pm
Subject: 223- 471 Wastewater Engineering & Design — Room: R 201

Instructions:
1. There are a total of **seven (7) questions**, please **answer any six (6) questions**; Total points = 300
2. Only dictionary and a hand held calculator are permitted for use during the examination.
3. All questions should be answered in English.
4. Read the question carefully and answer only what is required.

Professor S.K. Banerji

1. (50 points) A rock trickling filter system has to be designed for a town in Thailand. The existing Primary Treatment plant is being upgraded to a secondary plant using this process. The data available for design are as follows:

   Design Flow: 24,000 m^3/d
   Average BOD concentration to the Secondary process = 165 mg/L
   pH = 7.2 ; NH_4- N = 25 mg/L; Organic – N = 15 mg/L;
   Total – P = 12 mg/L
   Recirculation ratio for the filter = 1.0
   Use NRC equation to determine the volume of the trickling filter.

$$E = \frac{100}{1 + 0.443\sqrt{\frac{W}{VF}}}$$

   $F = (1+R)/(1+0.1R)^2$

   Assume final effluent BOD = 25 mg/L
   Assume any other data needed.

   a. (30 points) Determine the size of the filters (diameter and depth)
   b. (5 points) Size of recirculation pumps
   c. (15 points) Organic and hydraulic loading rates.

Name ……..… Student I.D. ……

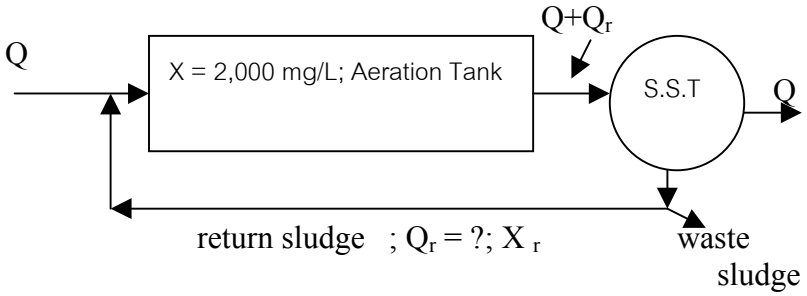
2. (40 points) a. Secondary settling tanks have to be designed for an Activated Sludge plant. The Average flow to the aeration tank was 20,000 m^3/d and the return activated sludge flow was 5,000 m^3/d, such that the secondary settling tank inflow was 25,000 m^3/d. The MLSS in the aeration tank was 1,800 mg/L. The overflow rate for the settling tank should not exceed 20 m^3/m^2.d and the solids loading rate (SLR) should be <6 kg/m^2.hour. Determine the size of settling tank (diameter and depth).
   (10 points) b. What concentration of BOD and Suspended solids do you expect from the settling tank?

3. (50 points) The design F/M ratio for an Activated Sludge process was 0.3 kg BOD/kg MLVSS.day. The influent BOD (S_o) to the secondary process was 150 mg/L and the average MLSS in the aeration tank was expected to be 2,200 mg/L. The design flow Q was 18,000 m^3/d, the return sludge flow rate was 5,000 m^3/d and the hydraulic retention time in the aeration tank was 7.5 hours. The final effluent BOD (S) from the treatment process was expected to be 20 mg/L. Assume MLVSS is 80% of MLSS. Determine the following:
   a. The volume of the aeration tank, V in m^3.
   b. Specific substrate utilization rate, U in kg BOD/ kg MLVSS.d
   c. Mean cell residence time, θ_c in days;
   d. BOD loading rate based on tank volume, kgBOD/m^3.d

   [Given : $F/M = S_o/(\theta.X)$; $U = (S_o - S)/(\theta.X)$; $1/\theta_c = Y\,U - k_d$;
   Note: X = MLVSS; Y = 0.52; k_d = 0.06/d]

4. (50 points) Answer if the following statements are **True or False**:
   a. Trickling filter plastic media has much less surface area than rock media per unit volume. ……. True……..False.
   b. The NRC equation for trickling filter does not consider wastewater temperature variations in the design. …… True …….False.
   c. Porous fine bubble diffusers for transferring oxygen to wastewater in an aeration tank are more efficient than coarse bubble non porous diffusers. …… True …….False.
   d. In the Modified or High Rate Activated Sludge process the BOD loading rate is quite low so the BOD removal is quite high. …….True …… False.
   e. Rising sludge occurs in a secondary settling tank following an activated sludge process because the nitrate-N entering the tank is denitrified by the denitrifying bacteria producing N_2 gas. These gas bubbles attach to settled sludge particles and rise to the surface. …….True …….False.

5. (25 points) a. Determine the Sludge Volume Index (SVI) in mL/g for a sample of sludge which was settled in a 1 L graduate cylinder. After 30 min of settling the volume of the settled sludge was 72 mL. The MLSS of the sludge sample determined separately was 2,340 mg/L. Is this good settling sludge?
   (25 points) b. If this sludge (in part a.) was being returned to maintain a MLSS of 2,000 mg/L, determine the sludge return flow rate to the aeration tank in m^3/d. The influent flow to the aeration tank from primary settling tank was 15,000 m^3/d. (Note : 10^6 /SVI = X_r ,return sludge concentration). Assume no solids come from with the influent flow to the secondary process.



6. (50 points) A facultative 3-celled lagoon has to be designed for a small town. The design population of the town is 2300 people. The lagoon BOD loading should be limited to 40 kg/ha.d. The average influent BOD concentration is 180 mg/L and the average design flow is 600 m^3/d. Determine the required area of the three cells of the lagoons. The second cell area should be about 30 % of the first cell and the third cell area should be about 10 % of the first cell. Also determine the average hydraulic retention time (HRT) for the system. Assume a reasonable depth for the lagoon.

7. (10 points) a. Under what conditions does Overland Flow Land Application process for wastewater treatment becomes the choice between other alternatives/
   (10 points) b. What are the key mechanisms for the removal of total-N from the applied wastewater in land application treatment systems?
   (10 points) c. What minimum pretreatment for the applied wastewater must be provided before the use of Slow Rate Land Application process?
   (10 points) d. In the Slow Rate Land Application process for treating wastewater, what purposes does the vegetation on the surface serve?
   (10 points) e. What are the final products (i.e. what is formed after the reactions are completed) in a Facultative lagoon system for treating wastewater?