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B.Sc. Engg. (CEE)/6th Sem. 17 February, 2023 (Friday)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

TERM: MID SEMESTER EXAMINATION
COURSE NO.: CEE 4633
COURSE TITLE: Waste Water Engineering and Environmental Sanitation

SUMMER SEMESTER: 2021-2022
TIME: 1.5 Hours
FULL MARKS: 75

There are **3 (Three)** questions. Answer **ALL** questions. Programmable calculators are not allowed. Do not write on this question paper. The figures in the right margin indicate full marks and corresponding CO and PO in the brackets. Symbols convey their usual meanings. Assume reasonable values for any design data.

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1. **(a)** Sketch a process flow diagram of municipal wastewater treatment and describe briefly. **(5)** (CO1, PO1)

   (b) A researcher set a sample of municipal wastewater for a BOD (biochemical oxygen demand) in an incubator for 5 days at 20°C. The sample had an ultimate BOD (UBOD) of 330 mg/L and the reaction rate constant for this wastewater was 0.231 d^{-1} (base e) at 20°C. Assume that the temperature coefficient, θ = 1.047. Determine the followings: i) What is the BOD_5 value? ii) On the 3rd day another person adjusted the temperature of the incubator to 25°C for further period of incubation. What is k_{25} (reaction rate constant) value? What is the BOD_2 value? Determine the BOD_5 value again for changing the temperature. iii) If another person adjusted the temperature of the incubator to 35°C (instead of 25°C) on the 3rd day for further period of incubation, what will happen? **(6)** (CO2, PO2)

   (c) As a Design Engineer, you are assigned to design two primary clarifiers for a wastewater treatment plant in a city. The average flowrate of the wastewater is 32,000 m^3/day with a BOD_5 of 220 mg/L and suspended solids concentration of 300 mg/L. The goal is to remove 30% BOD_5 and 60% suspended solids in primary treatment. The surface overflow rate is 40 m^3/m^2.day and depth is 3.5 m. Determine the followings: i) the diameter and surface area of the primary clarifier, ii) the detention time in the primary clarifier and the mass of solids removed in kg/day, and iii) Mass of solids and BOD_5 going to secondary treatment in kg/day.
   Design and sketch the primary clarifier with proper dimensions.
   Do you think rectangular design of the primary clarifier is better and why?
   Select the pollutants in wastewater that can be removed by primary clarifier and justify your statement. **(12)** (CO3, PO3)

2. **(a)** Define blackwater, greywater, industrial wastewater and sewerage. Describe the reasons of wastewater treatment. **(5)** (CO1, PO1)

   (b) A wastewater with a BOD_5 of 25 mg/L is discharged through an outfall to a freshwater stream of mean velocity 0.1 m/s. The DO upstream of the outfall is 8.5 mg/L and the saturation DO is 9.2 mg/L. Assuming the deoxygenation rate **(7)** (CO2, PO2)

K_1=0.25/d and the reaeration rate K_2=0.4/d. Determine the followings: i) the critical time and distance downstream where DO is a minimum, and ii) the minimum DO.
Comments on the water quality downstream of the outfall and the survival of the fish in the stream.
How DO can be increased in the stream?

(c) A completely mixed high-rate activated sludge plant is to treat 15,000 m^3/d of municipal wastewater. The primary effluent going to the activated sludge reactor has a BOD_5 of 1100 mg/L that must be reduced to 150 mg/L prior to discharge to a municipal sewer. Pilot plant analysis gave the following results: mean cell residence time = 5 d, MLSS concentration in reactor = 6000 mg/L VSS, Y = 0.7 kg/kg, k_d = 0.03/d. Determine the followings: i) the hydraulic retention time and volume of the activated sludge reactor, ii) the volumetric loading rate in kg BOD_5/m^3.d to the reactor, iii) the F/M ratio in the reactor, iv) the mass and volume of solids wasted each day at an underflow solids concentration, X_u = 12,000 mg/L, v) the sludge recirculation ratio, and vi) the volume of solids that must be wasted each day, if the solids are wasted directly from the activated sludge reactor instead of from the underflow.
Design and sketch the rectangular aeration tank with proper dimensions.
Do you think wastewater treatment with aeration tank is a stand-alone technique and why?
Select the impurities in wastewater that can be removed by secondary treatment with aeration tank and justify your opinion. **(15)** (CO3, PO3)

3. (a) Develop an expression for the recycle flow (Q_R) for an activated sludge process using the concept of mass balances with a diagram. **(5)** (CO1, PO1)

(b) Describe the microbiological processes in a facultative pond for the treatment of municipal wastewater with a diagram. **(5)** (CO1, PO1)

(c) A three-cell lagoon and pond system is to be designed for municipal wastewater treatment for a small community with a population of 2500. The wastewater design flow is 400 Lpcd with a BOD load of 70 g/capita·d. It is desired to use a three-cell system where the first two cells used as primary lagoons in parallel with an equal area and a secondary pond with the same area. The allowable BOD loading is 2.2 g/m^2·d. Assume the high-water level is 2 m and low-water level is 0.6 m. **(15)** (CO3, PO3)
Design and sketch the diagram of three-cell system with proper dimensions.
Determine the winter storage available in number of days if no losses.
Determine the winter storage available in number of days if losses due to evaporation and seepage are 0.5 mm/d and rainfall is estimated as 0.3 mm/d.

Formulae:

$$t_c = \frac{1}{K_2 - K_1} \ln\left\{\frac{K_2}{K_1}\left[1 - \frac{DO_o(K_2 - K_1)}{K_1 L_o}\right]\right\} \qquad DO_c = \frac{K_1}{K_2} L_o e^{-K_1 t} \qquad X = \frac{\theta_c Y (S_o - S)}{\theta (1 + k_d \theta_c)}$$

$$V_L = \frac{Q S_o}{V} \qquad \frac{F}{M} = \frac{Q (S_o - S)}{VX} \qquad \theta_c = \frac{VX}{Q_w X_u} \qquad Q_R = \frac{Q X - Q_w X_u}{X_u - X}$$