B.Sc. Engg. (CEE)/6th Sem. 12th May, 2023 (Friday) (12)

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

TERM: FINAL SEMESTER EXAMINATION — SUMMER SEMESTER: 2021-2022
COURSE NO.: CEE 4633 — TIME: 3 Hours
COURSE TITLE: Waste Water Engineering and Environmental Sanitation — FULL MARKS: 150

There are **6 (Six)** 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 an equalization tank geometry for an earthen basin and describe briefly. **(3)** (CO1, PO1)

(b) Sketch process flow diagrams of a typical wastewater treatment plant using an equalization basin with in-line equalization and off-line equalization. Explain briefly. **(5)** (CO1, PO1)

(c) Design an equalization basin required for the following cyclic flow pattern. Provide a 25% excess capacity for equipment, unexpected flow variations and solids accumulation. **(17)** (CO3, PO3)

Time, h	Flow, m^3/s	Time, h	Flow, m^3/s
0000	0.0481	1200	0.0718
0100	0.0359	1300	0.0744
0200	0.0226	1400	0.0750
0300	0.0187	1500	0.0781
0400	0.0187	1600	0.0806
0500	0.0198	1700	0.0843
0600	0.0226	1800	0.0854
0700	0.0359	1900	0.0806
0800	0.0509	2000	0.0781
0900	0.0631	2100	0.0670
1000	0.0670	2200	0.0583
1100	0.0682	2300	0.0526

Design and sketch the equalization basin with proper dimensions.
How the hydraulic loading rate to equalization basin can be reduced?

2. (a) Sketch an aerated grit chamber and describe briefly. **(4)** (CO1, PO1)

(b) Sketch a process flow diagram to treat a municipal wastewater that has a high concentration of suspended solids, organic matter and pathogens. Also, illustrate a sludge treatment option. Describe briefly the wastewater and sludge treatment processes. **(6)** (CO1, PO1)

(c) A wastewater treatment plant treats 2000 m^3/d of high strength wastewater in an anaerobic reactor operated at 35°C. The biodegradable soluble COD concentration of the wastewater is 3500 mg/L. Determine the amount of **(15)** (CO2, PO2)

methane gas that will be produced with 90% COD removal, where net biomass yield of 0.04 g volatile suspended solids (VSS)/g COD is used. Assume COD equivalent of VSS equals 1.42 kg COD/kg VSS & 64 g COD/mol, and ideal gas constant (R) = 0.082057 atm·L/mole·K. If the total gas contains 65% methane, determine the total gas produced from the wastewater.
What will happen if you use aerobic reactor for methane generation?

3. **(a)** Do you think treated industrial effluent with pH of 5, TS of 2100 mg/L, As of 0.2 mg/L, BOD of 120 mg/L and COD of 410 mg/L is allowed to discharge into inland water in Bangladesh according to ECR, 1997 and why? **(4)** (CO1, PO1)

(b) Explain the principle of attached growth media in RBC system with a diagram. **(6)** (CO1, PO1)

(c) Analyze an RBC system for organic and nitrogen removals in a treatment plant where design inflow of wastewater is 4 Mgal/d (15140 m^3/d), influent & effluent SBOD are 70 and 6 mg/L respectively, and influent & effluent NH_3-N are 18 and 2 mg/L respectively. Assume that the surface area in the first stage is 19% of the total surface area and the surface area of high-density media is 67% of the total surface area whereas the remaining is for standard media. Consider that the power consumption is 2.5 kW per shaft and the lowest wastewater temperature is 55°F (12.8°C). Figs. 1 and 2 shows the RBC process design curves for SBOD and NH_3-N respectively (Appendix). **(15)** (CO2, PO2)
Sketch the RBC staging arrangements of three trains with four-stage operation.
What will be impact if a few more RBC units are applied in series or parallel?

4. **(a)** Sketch a diagram of a typical circular gravity thickener and describe briefly. **(4)** (CO1, PO1)

(b) Sketch process flow diagrams of a common wastewater treatment plant using a trickling filter with direct recirculation of effluent and with indirect recirculation. Explain briefly. **(6)** (CO1, PO1)

(c) As a Design Engineer, you are assigned to design a single stage rock-media trickling filter for secondary treatment in a wastewater treatment plant. The wastewater flow rate is 2000 m^3/d with a BOD_5 concentration of 400 mg/L. Primary clarification removes 30% of the BOD_5. The design load capacity is 20 m^3/m^2·day and filter depth is 1.5 m. Direct recirculation pump operates at 2.78 m^3/min to the filter. Wastewater temperature is 20°C. Determine the hydraulic loading rate, organic loading rate, effluent BOD_5 concentration and overall plant efficiency. **(15)** (CO3, PO3)
Design and sketch the trickling filter with proper dimensions.
How the hydraulic loading and organic loading rates to trickling filter can be reduced?

5. **(a)** Sketch a diagram to show groundwater pollution from pit latrines and explain it. **(4)** (CO1, PO1)

(b) Define septic tank. Where can we use septic tank? Sketch the various components of a septic tank. **(6)** (CO1, PO1)

(c) Design a septic tank to serve a family of 10 people who produces 90 lpcd of wastewater. The tank is to be desludged every 3 years. Assume that the design temperature is 25°C, sludge accumulation rate is 0.06 m^3/cap.yr, tank cross-sectional area is 3 m^2 and the minimum scum clear depth is 75 mm. **(15)** (CO3, PO3)
Design and sketch a two-compartment septic tank with proper dimensions.
Can you discharge the effluent of septic tank to the Turag River? Explain

briefly.
How can you treat the effluent of septic tank?

6. **(a)** Sketch the various components of a SBS system and describe briefly. **(4)** (CO1, PO1)

(b) Describe any two conventional types of sewerage systems with diagrams. **(6)** (CO1, PO1)

(c) Design two circular secondary clarifiers for a wastewater treatment plant using a biotower for treatment of industrial wastewater. The wastewater flow rate is 1500 m^3/d with a BOD_5 of 180 mg/L and suspended solids of 200 mg/L. The biotower uses indirect recirculation and operates at a recycle ratio of 2:1. A design sidewater depth of 3 m is selected with a maximum overflow rate of 1.6 $m^3/m^2 \cdot h$. Use a peaking factor of 2. **(15)** (CO3, PO3)

Design and sketch the secondary clarifier with proper dimensions.
How can you adjust the design if the biotower uses direct recirculation and operates at a recycle ratio of 2:1?
What will happen if the biotower uses direct recirculation and operates at a recycle ratio of 1:1?

Formulae:

$$F = \frac{1+R}{(1+0.1R)^2} \qquad E_1 = \frac{100}{1+0.4432\sqrt{\frac{W_1}{VF}}} \qquad t_h = 1.5 - 0.3 \log (Pq)$$

$$V_h = 10^{-3} P q t_h \qquad V_d = 0.5 \times 10^{-3} \times P t_d \qquad d_{sc} = 0.82 - 0.26 A$$

$$k_T = k_{20} (\theta)^{T-20}$$

Appendix:

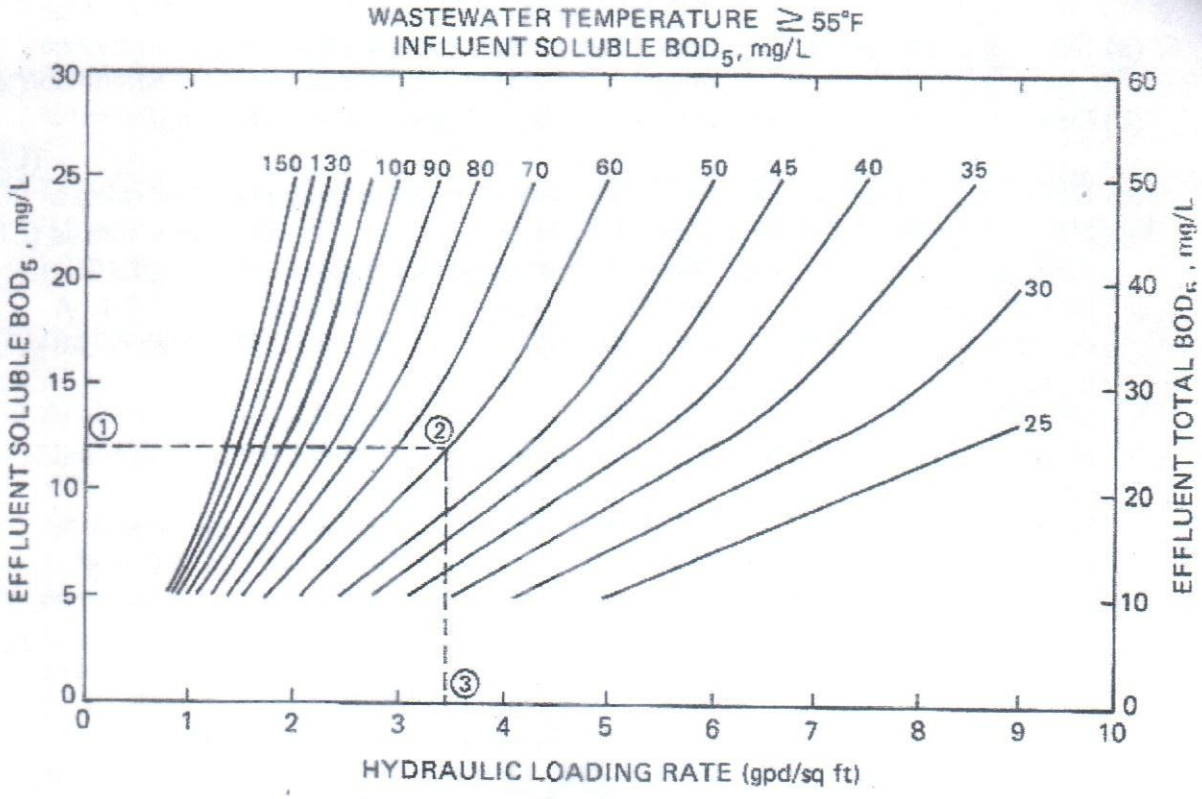

Fig. 1 RBC process design curves for SBOD.

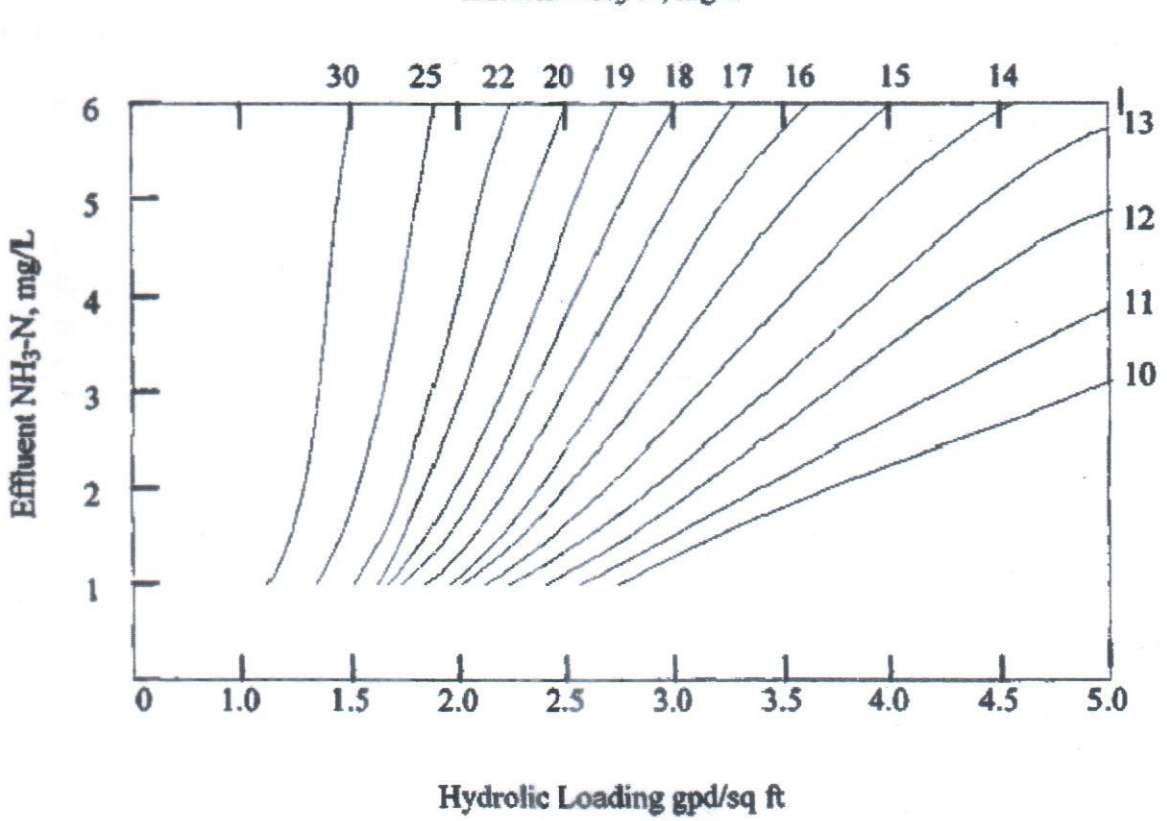

Fig. 2 RBC process design curves for NH_3-N.