UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2018

Module Number: CE4305 **Module Name: Water and Wastewater Engineering**

[Three Hours]

[Answer **all questions**, each question carries **ten marks**]

[Use **separate books** to answer **Section-A** and **Section-B**]

SECTION – A

Q1. A new water supply scheme has been proposed to provide water to a rural community with 25,000 population in Southern Sri Lanka. As the first step, the relevant information must be gathered to plan it.

a) The proposed water supply scheme must to be designed to serve the present as well as future population. List 4 other factors (excluding the population), which should be considered in calculating the projected water demand for this community.

[1.0 Mark]

b) A stream called 'A' and **groundwater** have been identified as the potential water sources for the above water supply scheme. Table Q1 shows the average concentrations of the key water quality parameters of groundwater and the stream. Draw a schematic diagram of a possible treatment train for each of the stream 'A' and groundwater, considering the engineering, economic and energy factors. Explain briefly the reasons for the selection of unit operations in each treatment train.

Table Q1: Average concentrations of water quality parameters

	pH	Turbidity, NTU	Fe, mg/L	Mn, mg/L	Total Coliform, MPN/100 mL	Fecal Coliform, MPN/100 mL
Ground Water	6.8	5	8	4	3	0
Stream-A	7.2	55	3	1	85	10

[5.0 Marks]

c) Assume that the above proposed water supply scheme will only supply water for domestic uses, and the per capita water demand is 110 L/capita/d. Calculate;

i) the maximum daily demand, and

ii) the maximum hourly demand for this water supply project.

[2.0 Marks]

d) Usually, the 'NRW' in some of the water supply projects in Sri Lanka is high as 50%. Explain briefly the 'NRW', which the water engineers have identified as a great issue for water utilities.

[2.0 Marks]

Q2. a) What is meant by 'Hardness' in water and explain briefly the issues related to high hard water. It was found from a laboratory study that Ca and Mg concentration in a tube well water were 35 mg/L and 30 mg/L, respectively. What is the 'Total Hardness'" of this water?

[2.0 Marks]

b) Explain the role of the "Coagulation aids" in the process of coagulation and flocculation in water treatment. Give two (2) examples for the commonly used coagulation aids.

[1.0 Mark]

c) A water treatment plant is being designed to process 24,000 m^3/d of water. A square-shaped rapid-mixing basin with a depth of water being equal to the width, will be used for the coagulation process. The velocity gradient and the hydraulic retention time will be 900/s and 30 s respectively. Assume that the flow is turbulent inside the mixing basin, and the absolute viscosity of the water is 0.00131 $N.s.m^{-2}$ at 10 ° C.

i) Determine the possible dimensions for the mixing tank

[1.5 Marks]

ii) Calculate the power requirement (in kW) for the mixing tank.
Assume that a turbine with a shaft speed of 125 rpm, and an impeller constant of 3.8 is used to provide the required power for rapid mixing. Calculate the turbine diameter. Check the compatibility of the turbine diameter with the tank dimensions. Following equation is applicable for the power imparted to the water by turbine mixers:

For turbulent flow, $\boldsymbol{P = k.\rho.n^3.D^5}$

G = velocity gradient, s^{-1}
V = volume of water in the mixing tank, m^3
μ *= absolute viscosity,* $N.s.m^{-2}$
P = power requirement (W)
k = Impeller constant
ρ *= mass density of the fluid* (kg/m^3)
D = diameter of impeller (m)
n = revolution per second (rev/s)

[2.0 Marks]

iii) According to the jar test and a pilot plant analysis, the optimum coagulant dosage is 20 mg/L at pH 6.8 for raw water of the above water treatment plant. What is the monthly alum requirement for this plant?

[1.0 Mark]

f) It is required to design two flocculators for the above treatment plant. A flocculator having a retention time of 20 minutes can provide energy of 1 J/L.

   i) Calculate the Velocity gradient in a flocculator

[1.5 Marks]

   ii) Determine the "Camp NO" for the above flocculator

[1.0 Mark]

Q3 a) A water-associated disease can be defined as a disease in relation to water supply and sanitation, and there are four (4) basic categories. Name these 4 categories giving an example for each category.

[2.0 Marks]

b) Sand (fine coarse) is commonly used as filter media in water treatment plants. Discuss briefly the properties of sand used in filter beds for water treatment.

[1.5 Marks]

c) It is required to design rapid sand filters for water treatment with a water flow rate of 24,000 m^3/d. Assume that 0.6 % of filtered water is needed for the backwashing process, and totally 20 minutes per day is spent for backwashing. Design filter bed dimensions for this water treatment plant. Take the filtration rate as 6,500 L/ m^2/ h, Length to width ratio as 1:3 and the depth of the sand bed as 50 cm.

[2.5 Marks]

d) Explain briefly why Rapid Sand Filters are more popular over Slow Sand Filters even though slow sand filters usually produce high quality waters in terms of physical, chemical and bacteriological quality.

[1.0 Mark]

e) Figure Q3 shows the chlorination curve for the water treatment plant in Q3(c). It is expected to maintain 0.8 mg/L of free chlorine.

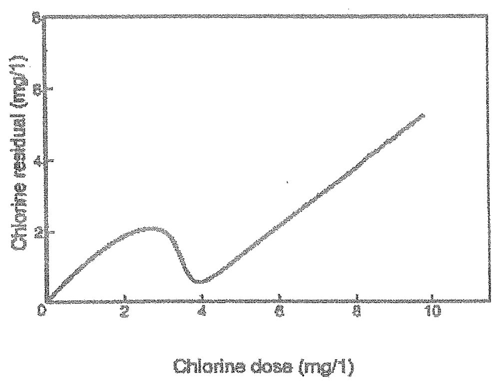

Figure Q5: Chlorination curve

   i) Determine the daily requirement of the chlorine for the disinfection process of this water treatment plant.

[1.0 Mark]

   ii) If the disinfection is in the form of hypochlorite powder that contains 70% available chlorine, how many kilograms of the hypochlorite powder are required by the treatment plant per month to treat the water?

[1.0 Mark]

and final DO after 5 days was 2.5 mg/L. The corresponding initial and final DO of seeded dilution water was 9.2 mg/L and 8.0 mg/L, respectively. The seed control had the standard volume of 300 mL.

i.) Write a formula to obtain BOD value for the above sample giving the notations used.

ii.) Calculate the 5-d BOD (BOD_5) of the above sample using the formula in the part (i).

[4.0 Marks]

c) A Sewerage treatment plant produces 1000 kg of dry solids per day at a moisture content of 95 percent. The solids are 70 percent volatile with a specific gravity of 1.05 and 30 percent non-volatile with a specific gravity of 2.5.

i.) Determine the sludge volume as produce

ii.) Determine the sludge volume after digestion reduces the volatile solid content by 50 percent decrease the moisture content to 90 percent.

[5.0 Marks]

Q6 a) Name two wastewater parameters belonging to each of physical, chemical and biological wastewater characteristics

[2.0 Marks]

b) What is the objective of the recirculation system in a complete-mix activated sludge process?

[2.0 Marks]

c) A coarse bar rack is placed vertically against the approaching flow in a wastewater treatment plant. Table Q6 gives the operating data. Calculate the (i) cross-sectional area; (ii) number of bars; (iii) width and height of the screen; (iv) the initial head loss through the scree; and (v) head loss when the screen is half clogged.

Table Q6: Operating data

Parameter	Unit	Value
Flow rate	L/d	80×10^6
Bar width	cm	1
Clear spacing between the bars	cm	5
Initial channel width	m	0.75
Velocity of the flow through the opening of the bars	m/s	0.6
Gravitational acceleration (g)	m/s^2	9.81

[6.0 Marks]

Equations to be used in the calculations

$$\theta_C = \frac{V X}{Q_w X_r + Q_e X_e}$$

$$Q_r = \frac{Q_0 X}{X_r - X}$$

$$X = \frac{\theta_c}{\theta} \frac{Y (S_0 - S)}{1 + k_d \theta_c}$$

$$Y_{obs} = \frac{Y}{1 + k_d \theta_c}$$

$$S = \frac{K_S (1 + k_d \theta_c)}{\theta_c (Yk - k_d) - 1}$$

$$P_x = Q_0 \frac{Y (S_0 - S)}{(1 + k_d \theta_c)}$$

$$\frac{F}{M} = \frac{S_0}{X \theta}$$

$$s = \sqrt{\left(\left(\sum (X - \overline{X})^2\right) / (n-1)\right)}$$

$$WLR = \frac{Q_0}{Perimeter\ of\ the\ weir}$$

$$Mode = 3\ (Med) - 2\overline{x}$$

$$Y_T = Y_{20} (1.056)^{T-20}$$

$$k_{d\,@T} = k_{d\,@20} (1.056)^{T-20}$$

$$A = \frac{Q_0}{S.L.R}$$

$$Q_0 = Q_e + Q_w$$

$$Recirculation\ ratio = \frac{Q_r}{Q_0}$$

$$U = V \frac{(s)}{(s + w)}$$

$$\frac{A_{net}}{w + s} = \frac{A_E}{s}$$

$$h_L = \frac{1}{0.7} \text{ x } \left(\frac{V^2 - U^2}{2g}\right)$$

$$n = \frac{A_{net} - A_E}{Area\ of\ bars} = \frac{A_{net} - A_E}{Area\ of\ bars}$$