UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: May-2023

Module Number: CE7254 **Module Name: Water Reclamation and Reuse**

[Three Hours]

- Answer **All Five questions**. Questions carry **Unequal marks.**
- This examination accounts for **60% marks.**
- Clearly indicate all your **assumptions if any**
- **Please attach plotted Graph Q- 4 (Page 4) with your answer scripts**

Assume you have been appointed as a **constancy engineer** in a government project to implement several **water reclamation and reuse projects** in an industrial zone located in Southern Province, Sri Lanka.

Q1. You have been asked by your project manager to prepare a presentation and a technical report to convince the relevant authorities about the **numerous advantages of water reclamation and reuse** and why it's a **sustainable practice** that can help conservation amidst supply demands. Answer the following questions as a consultancy engineer in this project.

a) Some experts say that there is **no "water scarcity"** in this world, but it is a matter of management of water in a **"Sustainable"** way. As an Engineer, do you agree with this? Explain your idea with some examples.

[2.5 Marks]

b) Reusing water may be **"intentional"** or **"unintentional"**. Briefly explain the **unintentional water reuse** with few examples.

[1.5 Marks]

c) **Tertiary wastewater treatment** may take several different forms depending on the quality of the final effluent required. Do you think a country like Sri Lanka needs tertiary treatment of wastewater? **Rationalize your idea.**

[3.0 Marks]

d) The water reclamation and reuse are considered as an adaptation measure as it reduces the pressure on water resources. What is the difference between **"water reclamation"** and **"water reuse"?**

[1.0 Marks]

e) Briefly explain the **conceptual relationship** between the **socioeconomic level** and **water treatment** objectives

[2.0 Marks]

Q2. During one of the visits to this industrial zone, the factory and company owners asked several questions regarding **advanced water and wastewater treatment applications** that they could adapt.

a) One of the industries in this zone is planning to use **ion exchange process** to treat their wastewater. Do you think they can use ion exchange for wastewater treatment? If so, briefly explain what **best applications of ion exchange process** in **wastewater treatment** are.

[1.5 Marks]

b) You need to advise them that the **cycle of an ion exchange column** used for treatment consists of several steps. Briefly explain those steps.

[2.5 Marks]

c) One of the factory managers requested you explain the theory used in **reverse osmosis (RO) membrane**, which he believes is an important technology for handling water and wastewater. How do you explain the RO process. You may use simple diagram(s) to explain it.

[2.0 Marks]

d) Some Engineers suggested using **Membrane Bioreactor (MBR)** technology for the wastewater treatment plants in this industrial zone. MBR is widely used for advanced municipal and industrial wastewater treatment processes. Briefly discuss the **advantages and disadvantages of MBR for wastewater treatments.**

[3.0 Marks]

e) MBR operates over a considerably different range of parameters over the Conventional Activated Sludge (CAS) process. Briefly explain the differences between the **following parameters in MBR and CAS;**

(1) SRT
(2) F/M ratio
(3) MLSS
(4) Sludge Production
(5) Energy Consumption

[2.5 Marks]

f) One of the industries in this zone has already installed a hollow fiber membrane (*in-to-out permeation*) to treat wastewater. The dimensions of the membrane module are as follows.

Outer diameter = 1.40 mm
Inner diameter = 1.0 mm
Membrane length = 50 cm

Permeate of treated water is withdrawn at maximum operating flux, which is equal to 25 *LMH*. To minimize the membrane fouling, *1 min* of **backwashing** is practiced every *8 minutes* of **filtration cycle**. In addition to backwashing, **maintenance cleaning** is performed *15 minutes* every day. The daily average flowrate is *1500 m^3/day*.

i) Calculate the effective area of this membrane module

[2.0 Marks]

ii) What is the net design flux? Assume the peak factor is 1.

[2.0 Marks]

iii) Calculate the number of membrane modules in this plant

[2.0 Marks]

Q3 During the initial discussion, it is suggested to design a **central wastewater treatment plant for this industrial zone**. Many Engineers agreed that **nutrient compounds** frequently present in wastewater are valuable substances although they are becoming increasingly significant in water and wastewater management because the discharge of nutrients can cause several environmental and health related problems

a) **"Nitrification"** ,and **"Denitrifications"** are two possible processes used in biological nitrogen removal. Briefly explain these two process and type of bacteria involved in each process and under which conditions they are operating

[3.0 Marks]

b) Draw a schematic diagram for a combined **Nitrogen and Phosphorus removal** processes in a **typical wastewater treatment plant** and name each unit.

[2.5 Marks]

c) One of the design Engineers suggested using the **MBR process for Nitrogen and Phosphorus removal** rather than typical wastewater treatment. Do you agree with this suggestion? If so, draw a schematic diagram for **the MBR process for Nitrogen and Phosphorus removal** and name each unit process.

[2.5 Marks]

d) The following conditions are to maintain within an aeration tank of a typical Activated Sludge Process.

- *Mean Cell Residence Time: 8 days.*
- *pH: 7.5*
- *DO:1.0 mg/L*

Do you think there is **complete nitrification** within this activated sludge system? Rationalize your answer.

[1.5 Marks]

Q4 It is proposed to use **reuse treated effluent** from the proposed central wastewater treatment plant for **irrigation purpose**. Therefore, design Engineers suggested to use **Ozone as the disinfectant** agent before reuse. Following Table Q-4 shows the disinfection data obtained from pilot scale study to treat wastewater in the above industrial zone.

a) Briefly discuss the advantages and disadvantages of **"Ozonation"** disinfection over the **"UV"** disinfection.

[3.0 Marks]

b) You need to **estimate the O_3** dose needed to disinfect the wastewater of above central treatment plant sc that the treated coliform value is *200 MPN/100 mL*. Assume the starting coliform concentration is *1.2 x 10^6/100 mL* and that the Ozone transfer efficiency is *85 %*.

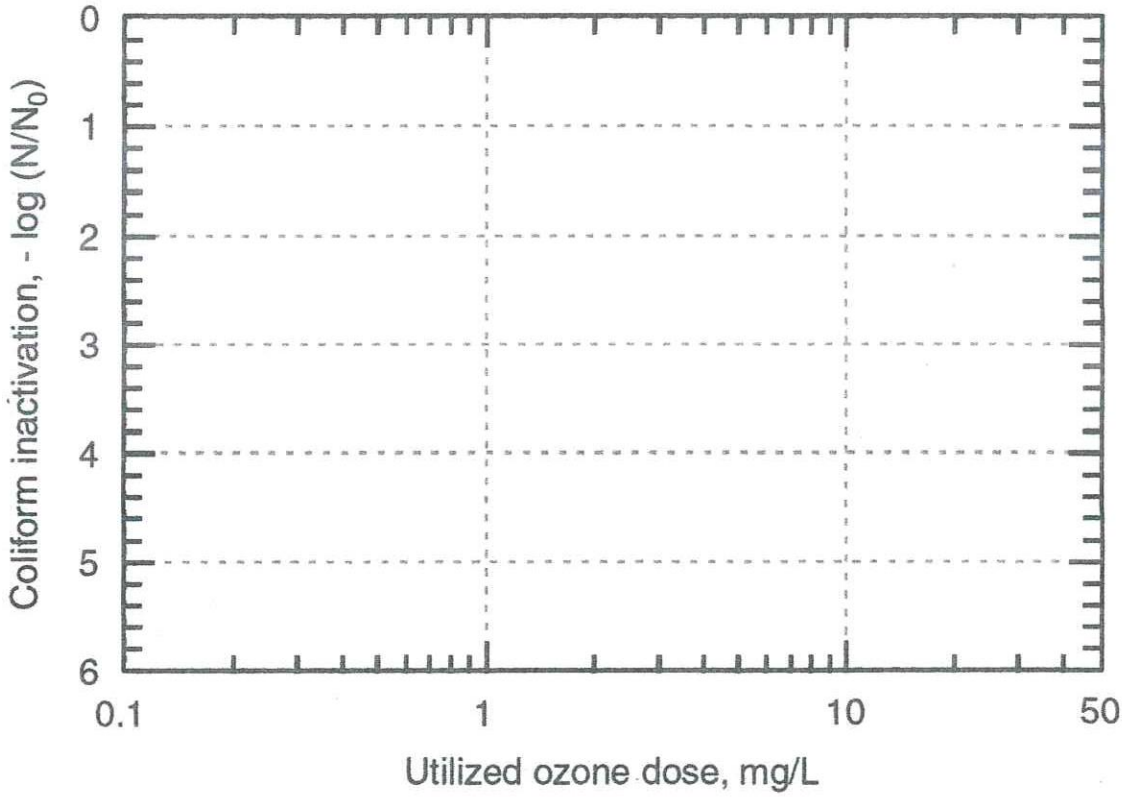
You may use the following equation with usual notation and the **Graph Q-4 (log-log)**.

$$N/N_0 = [(U)/q]^{-n}$$

Please attach plotted Graph Q-4 with your answer scripts

Table Q-4: Disinfection data obtained from pilot scale installation.

Test number	Initial coliform count, N_0, MPN/100 mL	Ozone transferred, mg/L	Final coliform count, MPN/100 mL
1	100,000	1	1575
2	500,000	2	1280
3	4,000,000	5	825
4	950,000	7	90
5	10,000,000	14	105



Graph Q-4-: Log-log graph sheet
(Please attach plotted Graph Q-4 with your answer scripts)

i) Plot the log inactivation data versus the O_3 dose on log-log paper and hence determine the required coefficients. **Please attach plotted Graph Q-4 with your answer scripts.**

[5.0 Marks]

ii) Determine the **O_3 dose required** to achieve an effluent coliform concentration of *200 MPN/100 mL.*

[1.5 Marks]

iii) What is the **log reduction** of this O_3 disinfection system?

[1.5 Marks]

iv) Determine the **O_3 dose that must be applied,** for a transfer efficiency of 85%.

[1.0 Marks]

Q5) Treatment and disposal of sludge are major factors in the design and operation of this proposed central wastewater treatment plant. It is suggested to design a **gravity thickening unit** for this proposed central wastewater treatment plant. You may assume following data.

Influent sludge flow for the thickener = 550 m^3/day
Solid load rating = 40 kg SS/m^2/day
Solid load in influent sludge =1000 kg SS/day

During this design, **hydraulic loading** is considered very important in controlling excessive detention times, which could lead to the release of foul odours. Therefore, hydraulic loading rates ranging from *20–30 m^3/m^2/day* are recommended.

a) Estimate the **sludge volume reduction** when the sludge is thickened from 4% to 8% solids concentration by this thickening process.

[2.5 Marks]

b) Determine the **required surface area** for this thickener. You may need to verify the hydraulic loading rate.

[3.0 Marks]

c) Assuming two circular thickeners will be used in this treatment plant, determine each **thickener's dimensions (Diameter and Volume).** You may use *2.5m* as the side-water depth of a thickener.

[2.0 Marks]

d) Calculate the **hydraulic retention time** for a thickener

[2.0 Marks]

e) Name **three possible disposal methods** for this thickened sludge

[1.5 Marks]