

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering



Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: CVX7242 - Environmental Engineering Design
Academic Year	: 2022/2023
Date	: 19 th February 2024
Time	: 0930-1230hrs
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
 2. This question paper consists of **Seven (7)** questions in **Six (6)** pages.
 3. Answer any **Five (5)** questions only. All questions carry equal marks.
 4. Answer for each question should commence from a new page.
 5. Relevant charts / codes / equations are provided in last page
 6. This is an Closed Book Test (**CBT**).
 7. Answers should be in clear handwriting.
 8. Do not use red colour pen.
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Question 1

- (a) (i) What are the potential long-term effects of microplastics on marine ecosystems?
(ii) Can microplastics in the air have an impact on human health, and if so, how?
(iii) How do microplastics interact with other pollutants in the environment, and what are the implications of these interactions?

[08 marks]

- (b) A river flows steadily at a speed of 0.5 meters per second. A factory discharges wastewater containing Benzene into the river, leading to a Benzene concentration of 0.5 milligrams per liter after complete mixing. A water supply system located 5 kilometers downstream provides water to the local community. Assuming an average person weighs 70 kilograms and drinks 3 liters of water per day for 365 days a year for 40 years. The reaction rate coefficient (K) for Benzene is 2×10^{-4} per day. The average lifespan of a person is 70 years. (The Streeter – Phelps equation is given in the last page with usual notations)

(i) Calculate the expected steady-state concentration of Benzene at the intake of the water supply system.

(ii) With a potency factor for Benzene of $3 \times 10^{-2} \text{ mg/kg/day}^{-1}$, determine the individual's risk of cancer due to the exposure to Benzene in the water supply.

[08 marks]

- (c) Explain the concept of environmental flow and why it is important in dam design and operation. Discuss briefly.

[04 marks]

Question 2

- (a) (i) Discuss the factors that influence the design of a pipe network.
(ii) Describe strategies for managing and optimizing of designing water distribution system.

[05 marks]

- (b) (i) What is meant by 'equivalent population' in the context of wastewater treatment?
(ii) How is equivalent population calculated. Explain briefly.
(iii) Why is it used in the design and planning of wastewater treatment plants?

[06 marks]

- (c) A town with a population of 50,000, is proposed to design primary sedimentation tanks treating domestic wastewater. The wastewater has a medium strength, with an average water supply rate of 200 liters per capita per day. Assume that 80% of the water supplied becomes wastewater. The wastewater has a suspended solids concentration of 150 mg/L and a BOD_5 of 100 mg/L at 20°C. Design the rectangular tank to have a surface loading

rate of $30 \text{ m}^3/\text{m}^2/\text{d}$ for daily average flow and $80 \text{ m}^3/\text{m}^2/\text{d}$ for peak flow, with a detention time of 1.5 hours. Provide design calculations.

[09 marks]

Question 3

- (a) (i) Wastewater treatment should fulfill two important factors. One without the other is a waste of money. What are those?
(ii) Describe the condition of a primary clarifier one day after the raw sludge pumps broke down.

[06 marks]

- (b) The success of an activated sludge system depends on the settling of the solids in the final settling tank. Suppose the sludge in a system started to "bulk" not settled very well, and the suspended solids concentration of the return activated sludge dropped from $10,000 \text{ mg/l}$ to 4000 mg/L .

- (i) What will this do to the mixed liquor suspended solids?
(ii) What will this in turn do to the BOD removal? Why?
(iii) If the ml in settle sludge (30 min) was 300 ml for both before and during the bulking problem, and the SVI was 100 and 250, what was the MLSS before and after the bulking problem?
(iv) Does this agree with your answer to the section (i) and (ii)

[10 marks]

- (c) One operational problem with trickling filter is "ponding," the excessive growth of slime on the rocks and the subsequent clogging of the spaces so that water no longer flows through the filter. Suggest some cures for the ponding problem.

[04 marks]

Question 4

- (a) A consulting engineer has proposed the following design for a primary clarifier:
 $Q = 0.150 \text{ m}^3/\text{s}$
Influent SS = 310 mg/L
Raw primary sludge concentration = 4%
SS removal efficiency = 60%
Length = 40 m; width = 15 m; depth = 2.2 m
Is this a reasonable design and fulfill the expected performance?

[06 marks]

- (b) (i) A community receives $0.5\text{m}^3/\text{sec}$ of flow into its wastewater treatment plant. The total surface area of the primary clarifier is 2700m^2 and the retention time is 3hr. Find the overflow rate.

- (i) Calculate the design depth of the clarifier.

[07 marks]

- (c) A community with a wastewater flow of 10mgd is required to meet effluent standards of 30mg/l for both BOD and SS. Pilot plant results with the influent of $\text{BOD}_5 = 250\text{mg/l}$. Kinetic constants $K_s = 100\text{mg/L}$, $\mu = 0.25\text{day}^{-1}$ and $y = 0.5$. It is decided to maintain the MLSS at 2000mg/l. Calculate,

- (i) The hydraulic retention time.
- (ii) The sludge age.
- (iii) Required tank volume.

[07 marks]

Question 5

- (a) (i) Discuss the relationship between the F/M ratio and the biomass concentration in an activated sludge system. How does this relationship impact the treatment process?
- (ii) Compare and contrast the F/M ratio with other parameters used to evaluate the performance of activated sludge systems, such as sludge age, food, MLSS, and hydraulic design.
- (iii) The BOD of the liquid from the primary clarifier is 120mg/l at a flow of 0.05 Million Liters per day. The retention time is 3 hours. If the MLSS is 2500 mg/L. Calculate the F/M ratio.

[09 marks]

- (b) (i) Describe the key components of a water distribution network in a town.
- (ii) What factors affect the hydraulic performance of a distribution network?
- (iii) Why is pressure management important in a water distribution system?
- (iv) Discuss the process of upgrading an existing distribution system to meet increased demand.

[07 marks]

- (c) Circular Design and Innovation are key factors to be considered in the construction industry to promote circularity.

- (i) Discuss the concept of "circular materials" and how they can be used in construction projects to minimize environmental impact.
- (ii) How can the circular economy help address global resource scarcity and reduce reliance on virgin materials?

[04 marks]

Question 6

- (a) (i) Outline the key characteristics and operational aspects of a controlled landfill site that distinguish it from conventional open dumping practices, emphasizing the environmental and social benefits of such an approach.
- (ii) Assess the benefits and drawbacks of locating a landfill in a biologically sensitive area.
- (iii) Describe the process of landfill gas production and the methods used to manage and utilize landfill gas.
- (iv) A Community generates 500 tonnes of solid waste per week and a sanitary landfill is being contemplated to handle the waste on the city outskirts. It is expected that the waste will be delivered by a truck on a 5d/week basis. The solid waste has a mean density of 250kg/m^3 . It will be spread in 0.75 m layers and compacted to 0.2m. A daily soil cover of 0.10m and an intermediate cover of 0.2m will be used. A final cover of 0.5m is recommended. Determine the annual horizontal area covered by the solid waste.

[11 marks]

- (b) Discuss the challenges and solutions related to the management of electronic waste (e-waste). Include in your answer the environmental impacts of improper e-waste disposal and the strategies that can be implemented to reduce these impacts.

[05 marks]

- (c) A fertilizer production factory discharge wastewater to a stream with a flow rate of $2\text{m}^3/\text{s}$. with the Nitrate concentration of 60mg/l . If the NO_3 of the receiving water body is 2mg/l . and the rate of discharge is $0.2\text{m}^3/\text{s}$ calculate the Nitrate concentration at the downstream of the mixing zone. Write the assumptions that you made

[04 marks]

Question 7

- (a) (i) To design a sound barrier for a highway, what factors to be considered to achieve the desired noise reduction. Discuss them briefly.
- (ii) Design a sound barrier for a highway with a speed limit of 100 km/h. The barrier should reduce noise levels by at least 10 dB(A) for residents living 50 meters away. Consider the materials, height, and placement of the barrier.
- (iii) How do local zoning laws and environmental regulations impact noise barrier design?

[06 marks]

- (b) An industrial facility emits pollutants at a rate of 50 kg/hr. The facility is located in a rural area with an effective stack height of 20 meters. Calculate the required stack height if the ground-level concentration of the pollutant must not exceed $1\text{ }\mu\text{g/m}^3$. Assume standard atmospheric conditions and a Pasquill-Gifford stability class of D. The Gaussian dispersion model formula for ground-level concentration (C) is given in the supplementary. u is the

wind speed (2m/s); σ_y is the standard deviation of the vertical dispersion (10m) and y is the vertical distance from the stack to the ground (8m)

[06 marks]

- (c) Describe the factors that the plant should consider in determining the stack height to comply with the regulations.
- (i) Discuss how atmospheric conditions, emission rate, and pollutant characteristics influence the design of the stack.
 - (ii) Explain the importance of stack height in reducing the impact of pollutants on the surrounding environment and public health.

[08 marks]

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Supplementary

$$CDI \text{ (mg/kg/day)} = \text{Total dose (mg)} / [\text{Body weight (kg)} * \text{Life time (days)}]$$

$$Risk = CDI \times \text{potency factor}$$

$$C(t) = C(0)e^{-Kt}$$

$$r_u = -\frac{\mu_m S X_{avg}}{K_s + S}$$

$$\frac{1}{\theta_c} = \frac{Y \mu_m (S_o - S)}{(S_o - S) + (1 + \alpha) K_s \ln(S_i/S)} - k_d$$

$$O_2 \text{ required per day} = 1.47 Q (S_o - S) - 1.42 V (x/\vartheta_c)$$

$$\frac{F}{M} = \frac{Q S_0}{V X}$$

$$DO = DO_s - \left[\frac{k_d L_0}{k_r - k_d} (e^{-k_d t} - e^{-k_r t}) + D_0 e^{-k_t t} \right]$$

$$t_c = \frac{1}{k_r - k_d} \ln \left\{ \frac{k_r}{k_d} \left[1 - \frac{D_0 (k_r - k_d)}{k_d L_0} \right] \right\}$$

$$\text{Barrier Height} = \text{Receiver Height} + (\text{Distance} + 1.5 \times \text{Height Distance} \times \text{Noise Reduction})$$

$$C(x,y,z) = [Q / 2\pi u \sigma_y \sigma_z] \exp(-1/2 [(y/\sigma_y)^2 + z^2/\sigma_z^2])$$

Assume if any data required when designing.