NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENVIRONMENTAL SCIENCES

DEPARTMENT OF ENVIRONMENTAL HEALTH

MASTER OF SCIENCE DEGREE IN ENVIRONMENTAL HEALTH

ENVIRONMENTAL ENGINEERING

EEH 5203

Final Examination Paper

April 2025

This examination paper consists of **FIVE** pages

Time Allowed: **3 hours**

Total Marks: **100**

Special Requirements: **None**

Examiner's Name: **Mr. M.Y Khozah**

INSTRUCTIONS

1. Answer **QUESTION ONE** and any **THREE** questions
2. **QUESTION ONE** carries **40** marks, while the rest of the questions carry **20** marks each

MARK ALLOCATION

QUESTION	MARKS
1.	**40**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
6.	**20**
TOTAL	**100**

Question One (Compulsory)

a. When designing a settling tank for a municipal wastewater treatment facility, engineers must consider several critical criteria, including weir loading rate, overflow rate, and detention time.

Given the following parameters for a proposed settling tank:

Total weir length (L)	50 meters
Depth of the tank (D)	3 meters
Desired weir loading rate (W)	40 $m^3/m/d$
Tank volume (V)	1,500 m^3
Average daily flow (Q)	1,800 m^3/d

i. Calculate the required overflow rate (V_o) for the tank. **[2]**

ii. Determine the detention time (T) for the settling tank based on the provided tank volume and average daily flow. **[3]**

iii. Discuss how each of these criteria (weir loading rate, overflow rate, and detention time) influences the design and operational efficiency of the settling tank. What would be the implications if one or more of these criteria are not met? **[5]**

b. You are a process engineer at a municipal wastewater treatment facility that has recently undergone an upgrade to increase its treatment capacity. The facility has two aeration tanks, and you are tasked with evaluating their performance to ensure optimal treatment efficiency.

	Parameters for Aeration Tank A	**Parameters for Aeration Tank B**
Mixed Liquor Suspended Solids (MLSS)	4,000 mg/L	6,500 mg/L
Volume of Aeration Tank (V)	1,500 m^3	1,200 m^3
Suspended Solids in Wastewater Effluent (SSe)	120 mg/L	200 mg/L
Quantity of Wastewater Effluent (Qe)	2,500 m^3/d	1,800 m^3/d
Suspended Solids in Waste Sludge (SSw)	25,000 mg/L	30,000 mg/L
Quantity of Waste Sludge (Qw)	150 m^3/d	80 m^3/d

i. Calculate the sludge age (in days) for both Aeration Tank A and Aeration Tank B. **[3]**

ii. Compare the sludge ages of both tanks. What do these values indicate about the operational conditions of each tank? **[3]**

iii. Discuss how the calculated sludge ages might impact the overall treatment efficiency and quality of the effluent. **[5]**

iv. Based on your analysis, recommend operational adjustments or modifications that could be made to either tank to optimize sludge age and improve treatment performance. **[4]**

c. At the Riverbend Wastewater Treatment Plant, the engineers are assessing the Food-to-Microorganism (F/M) ratio to optimize the biological treatment process. The following data has been collected:

Average daily flow (Q)	1,200 m^3/d
Wastewater BOD (BOD)	300 /L
Tank volume (V)	500 m^3
Mixed liquor suspended solids (MLSS)	2,500 mg/L

i. Calculate the F/M ratio for the treatment process. **[2]**

ii. What does this ratio indicate about the biological treatment conditions in the aeration tank? **[3]**

d. At the Green Valley Wastewater Treatment Plant, the management team is preparing for an upcoming expansion due to a significant increase in the town's population. The plant's current design includes an aeration tank with a volume of 500 m^3, which has been effective in treating wastewater thus far. Recently, the engineers recorded that the average daily settled wastewater BOD has risen to 30,000 g/d, primarily due to new residential developments and increased commercial activity in the area. The team is concerned about how this increase in BOD will affect the plant's treatment capabilities.

i. Calculate the BOD loading for the aeration tank in g/m³/d. **[2]**

ii. Analyze the implications of this BOD loading on the treatment process. **[3]**

iii. What challenges might the treatment facility face with this new loading, and what strategies could be implemented to maintain effective treatment? **[5]**

Question Two

a. Describe the following types of filtration systems used in potable water treatment:

i. Slow sand filtration **[3]**

ii. Rapid gravity filtration **[4]**

iii. Pressure filtration **[3]**

b. Give a detailed account of how filters are cleaned at a water treatment plant. **[10]**

Question Three

Discuss the advanced wastewater treatment methods that can be used to remove toxic substances.**[20]**

Question Four

Discuss the water treatment methods applicable at a small scale, explaining the processes involved, their benefits, and their limitations. **[20]**

Question Five

Describe the engineering principles used to improve the environmental quality of

i. Air **[6]**

ii. Water **[8]**

iii. Land **[6]**

Question Six

a. Sanitation systems can be classified as on-site or off-site, dry or wet. Briefly explain and give an example for each group

i. On-site wet systems **[4]**

ii. Off-site wet systems **[4]**

iii. On-site dry systems **[4]**

iv. Off-site dry systems **[4]**

b. Briefly explain Factors influencing the choice of a technical sanitation system suitable for a particular place. **[4]**