NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL AND WATER ENGINEERING

WASTEWATER ENGINEERING

TCW 3104

Main Examination Paper

December 2024

This examination question paper consists of 6 pages.

Time Allowed: **3 Hours**

Total Marks: **100**

Examiner's Name: **Eng F .Mudhindi**
Miss S Ncube

INSTRUCTIONS

1. Answer any **(five) 5** questions .
2. Use of calculators is permissible.

ADDITIONAL INFORMATION

None

MARK ALLOCATION

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

QUESTION 1

(a) On what date is World Toilet Day celebrated annually, and what is the primary objective of this global event? (2)

(b)State any three (3) Sustainable Development Goals (SDGs) related to sanitation? .

. (3)

(c) Define "onsite sanitation technology" and describe any three (2) different types and their suitability. (5)

d) **Figure 1** shows a type of a sanitation technology used in Zimbabwe.

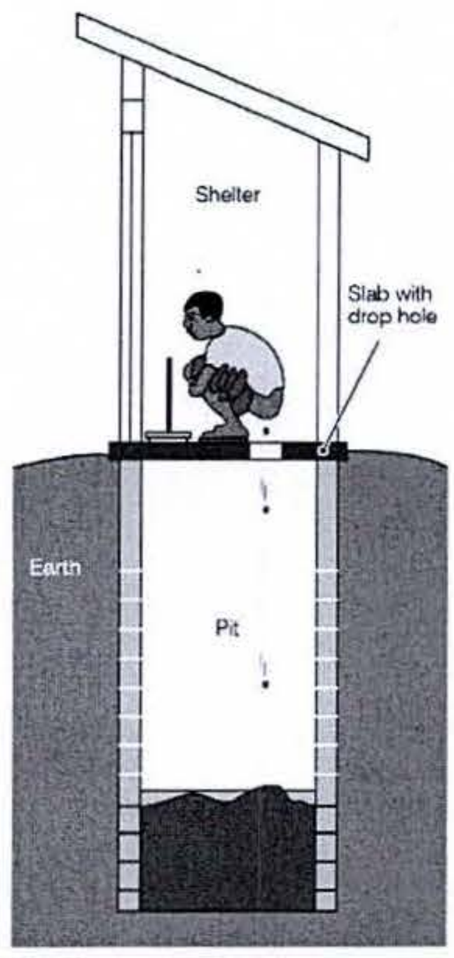

Fig .1

i. What type of a sanitation technology is this? (1)

ii. How can we improve this sanitation technology In Fig 1 to control odour and flies

. (3)

e) A school campus with 180 students also accommodating 30 households of teachers, relies on a treated water supply sourced from a nearby river. Given the low groundwater table in the region and an average annual temperature of 22°C, with an average household size of 7 people,

i. Suggest an onsite sanitation technology for the school campus

. (1)

ii. Design the onsite sanitation technology proposed for the school campus.

. (5)

QUESTION 2

Conduct a comparative analysis of the three major sewage treatment plants in Bulawayo: Southern Area Sewage Treatment Plant (SAST), Magwegwe Ponds, and Thorngrove Sewage Treatment Plant. The analysis should focus on the following aspects:

- Operational Efficiency
- Treatment Processes
- Capacity
- Challenges
- Future Outlook
- Service Area (20)

QUESTION 3

(a) Calculating BOD in Wastewater

i. Describe the procedure for conducting a 5-day BOD test (3)

ii. How can the BOD test be used to assess the effectiveness of wastewater treatment processes? (2)

iii. A wastewater sample has an initial DO of 9 mg/L. After 5 days of incubation, the DO is 3 mg/L. Calculate the 5-day BOD of the sample (2)

iv. A wastewater treatment plant receives a flow of 10,000 m^3/day with a BOD5 of 200 mg/L. What is the organic load on the plant in kg BOD/day (3)

v. A wastewater sample is diluted by a factor of 10 before being subjected to a 5-day BOD test. The initial DO of the diluted sample is 8 mg/L, and the final DO after 5 days is 2 mg/L. Calculate the 5-day BOD of the original wastewater. (3)

vi. Determine the ultimate BOD of a sewage sample obtained from the inlet of one of the sewage works in a remote area in Mabale . The prevailing temperature is 28 oC . The decay coefficient at this temperature is 0.13 per day. The six-day BOD is estimated at 240 mg/L at the same temperature. You are given that nitrogen of the raw sewage is 28 mg/L while phosphorous is 4 mg/L. (5)

vii. In certain cases the BOD may be near zero and high values of COD recorded in municipal wastewater, what could be the reason(s) for this? (2)

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QUESTION 4

(a) Activated Sludge Process

i. Describe the typical phases of the activated sludge process (3)

ii. What factors influence the design of an activated sludge system (3)

iii. Explain the concept of sludge retention time (SRT) and its impact on system performance. (2)

iv. How is the sludge age controlled in an activated sludge process? (2)

v. What is the significance of the food-to-microorganism ratio (F/M ratio) in activated sludge systems? How does it affect the efficiency of the process? . (4)

vi. A wastewater flow of 10,000 m^3/d with a BOD5 of 200 mg/L enters an activated sludge process. If the desired effluent BOD5 is 20 mg/L and the MLSS concentration is 3000 mg/L, calculate the required volume of the aeration tank (3)

vii. Given a wastewater flow of 5000 m^3/d and a food-to-microorganism ratio (F/M) of 0.3 kg BOD/kg MLSS/day, calculate the required mass of MLSS in the aeration tank. (3)

QUESTION 5

(a) A waste stabilization pond system consisting of facultative and maturation ponds is designed for a residential estate. The effluent standards require a maximum of

1000 FC/100 mL and 20 mg/L of BOD. The incoming wastewater flow rate is 9000 m^3/day with an influent BOD of 350 mg/L and a coliform count of 1 × 10^8 FC/100 mL at a temperature of 18°C.

i. Design the facultative pond (5)

ii. Determine the number of maturation ponds required to achieve the effluent standards if the retention time (tm) is 8 days. (5)

(b) With the aid of diagrams describe the following methods as used in wastewater treatment

i. Ultrafiltration

ii. Nano- Filtration

iii. Microfiltration (10)

QUESTION 6

(a) Biological Nutrient Removal (BNR)

i. Describe the basic principles of a sequencing batch reactor (SBR). (5)

ii. What are the key phases of an SBR cycle? Explain the purpose of each phase. (5)

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(a) Describe the following BNR processes

i. the A2/O process, (5)

ii. the Modified Ludzack-Ettinger (MLE) process. (5)