KATHMANDU UNIVERSITY
End Semester Examination
July/August, 2024

Marks Scored:

Level : B.Sc./B.Tech.
Year : III
Course : ENVE 304
Semester : II
Exam Roll No. :
Time: 30 mins.
F. M. : 20
Registration No.:
Date : 16 AUG 2024

SECTION "A"
[20 Q. × 1 = 20 marks]

Make reasonable assumptions for any missing data or information. Mark [X] *the best possible answer.*

1. A 20cm dia sewer is laid at a slope of 0.004 and is designed to carry a discharge at a depth of 10cm with Manning's coefficient n=0.014, the design discharge is ___ L/s.
[ ] 9.6 [ ] 19.2 [ ] 0.009 [ ] 0.02

2. Self-cleansing velocity is:
[ ] the minimum velocity of flow required to maintain a certain amount of solids in the flow
[ ] the maximum velocity of flow required to maintain a certain amount of solids in a sewer
[ ] such flow velocity as would be sufficient to flush out any deposited solids in a sewer
[ ] such flow velocity as would be sufficient to ensure that sewage does not remain in the sewer

3. A wastewater sample with a BOD concentration of 250 mg/L and a flow rate of 100 m^3/day is discharged into a system. If 1 person equivalent = 50 g BOD/day, what is the total population?
[ ] 2500 [ ] 500 [ ] 12500 [ ] 5000

4. Which of the following is not related to Dry Weather Flow (DWF)?
[ ] Flow that occurs in sewers in separate sewerage system
[ ] Flow that occurs during dry seasons in combined system
[ ] Depends upon the rate of water supply, weather conditions and infiltration of groundwater
[ ] Includes Domestic sewage, industrial wastes and storm water

5. Which of the following screen has the sieve size of 0.5mm to 6mm.
[ ] Coarse [ ] Fine [ ] Micro [ ] Macro

6. The head loss through a bar screen when fifty percent of the flow area is blocked off due to the accumulation of coarse solids is ____ m, when approach velocity = 0.6 m/s, velocity through clogged bar screen = 0.9 m/s and empirical discharge coefficient = 0.6.
[ ] 0.033 [ ] 0.24 [ ] 0.066 [ ] 1.8

7. Which of the following is NOT a function of an equalization tank in wastewater treatment?
[ ] Dampens daily variations in flow rate and pollutant loading
[ ] Equalize the oxygen content of the wastewater
[ ] Maintains the efficiency of the biological treatment plant.
[ ] Reduces the required size of downstream treatment processes

8. In wastewater treatment, a process where organic matter is decomposed by microorganisms in the absence of oxygen but utilizing NO_x as an electron acceptor is classified as:
[ ] Aerobic [ ] Anaerobic [ ] Facultative [ ] Anoxic

9. Which of the following is not a desirable characteristic of filter media in trickling filters for wastewater treatment?
[ ] High specific surface area [ ] High percentage void space
[ ] Resistance to chemical corrosion [ ] Disintegration during placement

10. Wastewater with a BOD_5/COD ratio of 0.6 is typically characterized by:
[ ] High proportion of refractory organic matter
[ ] high concentration of suspended solids
[ ] predominantly biodegradable organic load
[ ] low biological oxygen demand

11. During winter, the Mean Cell Residence Time in an activated sludge process is increased to:
[ ] Improve nitrification and denitrification
[ ] Enhance sludge settling properties
[ ] Compensate for reduced microbial activity
[ ] Increase organic loading rate

12. SVI is calculated by dividing the volume of settled sludge after 30 mins by the concentration of:
[ ] Mixed liquor suspended solids [ ] Total suspended solids
[ ] Volatile suspended solids [ ] Fixed suspended solids

13. Which of the following is *NOT* an example of Submerged Fixed Bed Reactors (SFBR)?
[ ] Fixed Bed Biofilm Activated Sludge Process (FBAS)
[ ] Anaerobic Filter (AF)
[ ] Rotating Biological Contactor (RBC)
[ ] Trickling Filter (TF)

14. The primary limitation in nutrient removal in Horizontal Flow Bed constructed wetlands is:
[ ] Limited oxygen availability [ ] Lack of appropriate plant species
[ ] Insufficient hydraulic retention time [ ] High Organic Loading

15. Which form of phosphorus is directly available to microorganisms for growth and metabolism?

[ ] Particulate phosphorus
[ ] Soluble phosphorus
[ ] Ortho-phosphorus (PO_4^{3-})
[ ] Soluble unreactive phosphorus

16. To enhance biological phosphorus removal in an activated sludge process, which of the following operational strategies would be most effective?

[ ] Increasing the sludge age
[ ] Providing alternating aerobic and anaerobic conditions
[ ] Increasing the dissolved oxygen concentration in the aeration tank
[ ] Higher primary coagulant dose

17. Waste Activated Sludge (WAS) is primarily generated from which wastewater treatment process??

[ ] Primary [ ] Secondary [ ] Tertiary [ ] Sludge digestion

18. Which of the following is NOT a common sludge dewatering technique?

[ ] Centrifugation
[ ] Belt filter press
[ ] Aerobic digestion
[ ] Gravity thickening

19. To enhance the drying efficiency of sludge in drying beds, it is crucial to:

[ ] Minimize the exposed surface area of the sludge
[ ] Maximize the sludge layer thickness
[ ] Ensure good air circulation through the sludge
[ ] Shade the drying beds from sunlight

20. If a wastewater treatment plant processes 50,000 m^3/day of wastewater with an influent suspended solids concentration of 400 mg/L and achieves a 75% removal efficiency in the primary sedimentation tank, the approximate daily production of primary sludge is _____tons/day.

[ ] 5 [ ] 15 [ ] 25 [ ] 35

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Make logical assumptions wherever required. Some useful information/formula are provided at the last.

SECTION "B"
[7 Q. × 5 = 35 marks]

Answer *ANY SEVEN* questions.

1. A developing city has a projected population of 30,000 residing over an area of 20 hectares, find the design discharge for the combined sewer for the following data:
   a. Rate of water supply = 150 lpcd
   b. Runoff coefficient = 0.4
   c. Time of entry = 20 mins and Time of travel = 10 mins

2. Water is supplied in a town at the rate of 200 lpcd which has the population of 100,000. Design a sewer running 0.7 times full at maximum discharge. Check for self-cleansing velocity at maximum and minimum discharge. Take a constant value of N=0.013 at all depths of flow. The sewer is to be laid at a slope of 1 in 500. Take a peaking factor of 3. Assume 80% of water supplied to the town appears as sewage.

3. Differentiate between first stage BOD and second stage BOD with proper diagram.

4. A stream, saturated with DO, has a flow of 1.2m^3/s, BOD of 4 mg/L and re-oxygenation rate constant of 0.3 per day. It receives an effluent discharge of 0.25m^3/s having BOD 20 mg/L, DO 5 mg/L and BOD reaction constant 0.13 per day. The average velocity of flow of the stream is 0.18 m/s. Calculate the DO deficit at point 20 km and 40 km downstream. Assume that the temperature is 20°C throughout and BOD is measured at 5 days. Take saturation DO at 20°C as 9.17 mg/L.

5. Design a grit chamber for population of 40,000 with water consumption of 170 lpcd. Assume 80% of water supplied to the town appears as sewage and peak factor of 2.5. Assume suitable horizontal velocity and HRT.

6. Draw a mass balance diagram for a completely mixed cellular recycle system, and derive the equations:

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

where, μ = growth rate constant,
θ_c = mean cell residence time,
θ = Hydraulic retention time,
Y = Yield coefficient,
S_0 = influent substrate concentration,
S = effluent substrate concentration and
k_d = microorganism decay coefficient.

P.T.O.

7. A trickling filter is experiencing reduced treatment efficiency. Investigate potential causes for this decline and propose remedial actions.

8. Lalitpur Municipality, a rapidly urbanizing area in Nepal, faces increasing challenges in managing its wastewater. Ward No. 2, with a population of 6,000 people, lacks an adequate wastewater treatment system. The community's per capita water consumption is estimated at 150 liters per day. The region experiences a diverse climate with average winter and summer temperatures of 12°C and 22°C, respectively. To address this issue, a vertical flow constructed wetland (VFCW) is proposed as a sustainable and environmentally friendly solution for treating domestic wastewater generated by the ward. Design and size a suitable VFCW system to effectively treat the domestic wastewater.

9. Discuss briefly (***ANY TWO***):
   a. Rainfall Dependent Inflow and Infiltration
   b. Fate of carbon and energy during aerobic and anaerobic metabolism process
   c. Mean Cell Residence Time

SECTION "C"

[2 Q. × 10 = 20 marks]

Answer *ANY TWO* questions.

10. Representative operational data for a conventional activated sludge process is summarized as follows:
   - ✓ Wastewater flow = 5000 m^3/day
   - ✓ Volume of aeration tank = 15,500 m^3
   - ✓ Influent BOD = 200 mg/L
   - ✓ Effluent BOD = 25 mg/L
   - ✓ Mixed Liquor Suspended Solids (MLSS) = 25 mg/L
   - ✓ Effluent Suspended Solids = 40 mg/L
   - ✓ Waste sludge suspended solids = 12,000 mg/L
   - ✓ Quantity of waste sludge = 250 m^3/day

   Based on the operational data provided above, determine:
   a. Aeration period or Hydraulic Retention Time (in hours)
   b. Food to micro-organisms ratio (in kg BOD per day per kg MLSS)
   c. Percentage efficiency of BOD removal
   d. Sludge age (days)

11. A design discharge for MBBR reactor is 1.5 MLD which contains the BOD load of 175 mg/L BOD (in the primary effluent).
   a. What is the BOD loading rate to the reactor in g/day?
   b. What would be a suitable design SALR to use for a target of 90-95% removal?
   c. If the MBBR carrier has a specific surface area of 600 m^2/m^3 and design carrier fill % of 40%, what would be the required volume of carrier and required MBBR tank volume?
   d. If the design carrier % void space is 60%, what would be the volume of liquid in the MBBR reactor?
   e. Calculate the average hydraulic retention time at design wastewater flow.

12. A small city in Northern Europe with a population of approximately 40,000 faces increasing challenges in wastewater management. The city generates an average wastewater flow of 3,800 m^3/day with a BOD_5 concentration of 200 mg/L. Due to the region's cold climate, with average winter temperatures not exceeding 8°C, the city is considering a facultative lagoon system as a primary treatment option. Use the following steps to design and size the selected treatment option.

a. Select a reasonable depth.
b. Calculate the surface area based on the BOD_5 areal load.
c. Calculate the volume and hydraulic detention time.
d. Calculate the volumetric loading (kg BOD_5/(1000 m^3. day)).
e. If degradation in a facultative lagoon can be modelled as a first-order process with a degradation rate of 0.2 day^{-1}, what will be the effluent concentration from the lagoon?