

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	: CVX6533 Environmental Engineering
Academic Year	: 2020/2021
Date	: 09 th February 2022
Time	: 1400-1700hrs
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 a Closed Book Test **(CBT)**.
 7. Answers should be in clear handwriting.
 8. Do not use the red colour pen.
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Question 1

- (a) Our planet's environment consists of complex networks of interlinked systems.
- (i) Coastal hypoxia is a severe issue in coastal ecosystems. Explain the demerits of hypoxia, drawing an example from a coastal ecosystem in Sri Lanka.
 - (ii) Discuss the causes of coastal hypoxia and ways to overcome such a situation.
 - (iii) Negative and positive feedback loops are common in earth systems. Explain both, drawing examples from the environment.

[06 marks]

- (b) (i) What do you understand by the self-purification property of a stream? Explain the factors affecting this property.
- (ii) Explain the difference between dilution processes if the wastewater effluents are disposed of in stream and sea.

- (iii) Wastewater of 560 L/s with a BOD of 50mg/L, DO of 3 mg/L, and temperature of 25°C enters a river where the flow is 28m³/sec, and BOD = 4.0 mg/L, DO = 8.2mg/L and temperature of 20°C, K₁ for waste is 0.10 per day at 20°C. The velocity of water in the river downstream is 0.18 m/s and has a depth of 1.2m. Determine the following after mixing water with the river water;

1. The combined flow of discharge
2. BOD
3. DO

[10 marks]

- (c) Imported compost application for local agricultural fields attracted the attention of many professionals and farmers.
- (i) Briefly discuss the merits and demerits that can expect due to such application.
 - (ii) Discuss long term issues that would occur to the agricultural ecosystem.

[04 marks]**Question 2**

- (a) (i) What is meant by sludge recycling or return sludge? What is advantageous of having secondary biological treatment plants. Explain briefly.
- (ii) How do you determine the sludge recycling rate if SVI and MLSS concentrations in the reactor provide?
- (iii) The MLSS concentration in an aeration tank of activated sludge process a 2500 mg/L, and the sludge volume after 30 minutes of settling in a 1000 ml graduated cylinder is 180ml. Determine the SVI. Indicate the units.

[08 marks]

- (b) (i) What is meant by 'equivalent population'? Explain how it is helpful in the wastewater treatment process.
- (ii) A meat processing plant discharges 10,000 m³/d of wastewater containing 1400mg/L of BOD, 960 mg/L of Suspended solids, 2500 mg/L of COD, and 460 mg/L of grease. Calculate the BOD equivalent population and the equivalent hydraulic population.
- [08 marks]**
- (c) Outline the alternative methods for processing and disposal alum-coagulation wastes from surface water treatment. If two lagoons are used for storage and dewatering the waste slurry, what is your recommended method for operating the lagoons? If the sludge in the lagoon is a viscous liquid at the time a lagoon must be emptied, how can the sludge be dewatered for disposal in a landfill?
- [04 marks]**

Question 3

- (a) (i) F/M ratio is essential in activated sludge treatment systems. Explain why the lower F/M are recommended for lower operating temperatures.
- (ii) What design criteria to consider for determining the aeration tank's capacity. List them.
- [04 marks]**
- (b) An average operating data for conventional activated sludge treatment plant is as follows:
- | | |
|--------------------------------------|----------------------------|
| Wastewater flow | = 50000m ³ /day |
| Volumet if aeration tank | =15500 m ³ |
| Influent BOD | =200mg/L |
| Effluent BOD | =25 mg/L |
| Mixed liquor suspended solids (MLSS) | =3000mg/L |
| Effluent suspended dolids | =40 mg/L |
| Waste sludge suspended solids | =12000mg/L |
| Quantity of waste sludge | =250 m ³ /day |
| MLVSS/MLSS | =0.8 |

Based on the information given above, determine;

- (i) Aeration period (hours)
- (ii) Food to microorganism ratio (F/M) (Kg BOD per day/KgMLVSS)
- (iii) Percentage efficiency of BOD removal
- (iv) Sludge age (days)

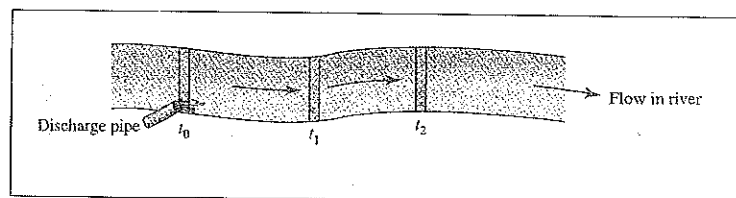
[10 marks]

- (c) (i) Domestic wastewater can be effectively stabilized by the natural processes that occur in shallow ponds. List the type of maturation ponds or stabilization ponds that can be used.
(ii) Discuss the advantages and disadvantages of the stabilization ponds.
(iii) Stabilization ponds can emit obnoxious gases that affect global warming. Describe how this happens, stating the gases that can emit from maturation ponds.

[06 marks]

Question 4

- (a) A river (Figure shown below) described as "plug-flow reactor". Mass balance is simplified by selection of system boundaries. Oxygen is depleted by BOD exertion. Oxygen is gained through reaeration. Sketch this diagram in your answer book and draw the oxygen depletion curve for the river from upstream to downstream. Also, name the main five zones to show the resuming of the river eco system. (Fit to scale is not required).



[05 marks]

- (b) A city in western province with 150,000 people discharges its treated wastewater with a flowrate of $1\text{ m}^3/\text{s}$ having an ultimate BOD of 25.0 mg/L and DO of 1.8 mg/L into a discharge point, the river has a BOD of 3.6 mg/L and a DO of 8.6 mg/L . The saturation DO is noted as 10 mg/L , $k_d = 0.59\text{ day}^{-1}$, and $k_r = 0.76\text{ day}^{-1}$. Assuming given value is at the stream temperature, determine;
(i) the critical DO and critical distance,
(ii) the DO at 12 km downstream.
(use the following equations with the usual notation if required.)

[09 marks]

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

$$D_c = \frac{k_d L_a}{k_r - k_n} \left(e^{-k_d t_c} - e^{-k_r t_c} \right) + D_a e^{-k_r t_c}$$

- (c) (i) In Sri Lanka, there is a trend to develop dumping sites near the waterways. Discuss the consequences of having dumpsites near the waterways.
(ii) Write actions that can propose for controlling leachate from such dumpsites highlighting the phenomena "from open dumps to controlled dumps"

[06 marks]

Question 5

- (a) Kelani river basin is one of the most crucial river basins in Sri Lanka, which provides water for a considerable percentage of the Sri Lankan population. However, pollutant load in the Kelani river increases day by day due to the increase of industries in the riverine.
- How do you estimate the pollutant load?
 - The Central Environmental Authority will gazette the 'polluter pay principle' for protecting surface water sources. What components to be considered in the polluter pay principle to charge from the polluters.
 - Emerging contaminants microplastics are becoming a severe issue of water sources. What would be your suggestions to protect water sources from such

[06 marks]

- (b) A leak was detected from petroleum tankers near a river. It releases carcinogenic pollutants into the river with a flow rate of $0.002 \text{ m}^3/\text{day}$. The concentration of pollutants is $480 \mu\text{g}/\text{L}$, and water provides to the downstream city. River water moves at $5 \text{ m}^3/\text{day}$ with zero concentration of carcinogen. [$C_t = C_0 e^{-kt}$]

- Estimate the carcinogen concentration at the mixing point?
- If the decay rate is $0.22/\text{day}$, what would be the carcinogen concentration at the intake of groundwater supply just 80 Km away from the source?
- Calculate the lifetime risk of getting cancer from drinking this water if the protency factor is 0.34 . Assume that the water required for drinking per person is three litre/d and average weight per person is 65 kg and that the life expectancy is 70 yrs . The risk is given as $\text{Risk} = \text{CDI} \times \text{PF}$

[09 marks]

- (c) (i) Due to the new normal condition of the COVID-19 pandemic, the city reservoirs are becoming more eutrophic. What would be the closest reason for such a situation? Explain briefly.
- (ii) Highway traffic noise can reduce by introducing noise control structures. For example, for the 2 Km stretch of the Meerigam-Kurunagala highway constructed at the ground level in a high residential area, list three methods that you propose to control the noise generated by the highway traffic.

[05 marks]

Question 6

- (a) When gaseous and particulate emissions, be it from vehicle exhaust, industrial stack, or other sources, are released into the atmosphere, its fate is almost impossible to predict. It is due to the complex of factors that influence its subsequent pathways.
- Meteorological factors are primarily influencing factors for spreading air emissions. List five of those.

- (ii) Terrain factors such as heat islands impact urban chimney plumes (stacks) more than rural areas. Explain how heat islands affect the ground more rapidly than rural plumes.

[06 marks]

- (b) (i) What are the components of photochemical smog. With the aid of a sketch, briefly explain.
 (ii) The primary ambient air quality standard stipulated in Sri Lanka for NO_2 is $100 \mu\text{g}/\text{m}^3$. What is this in ppm? Temperature and pressure are given as 298 K and 1 atm. The molecular weights of N and O are 14 and 16, respectively.

[06 marks]

- (c) (i) Why CFCs are given special attention in the sense of atmospheric concentrations?
 (ii) Most refrigerators, freezers and automobile air conditioners use CFC-12 as the refrigerant. What is the chemical composition of CFC-12?
 (iii) "Open dumps contribute to global warming". Do you agree with the above statement? Discuss briefly with your justification.
 (iv) Discuss how such emissions can be controlled in open dumps at developing countries.

[08 marks]

Question 7

The Northwestern province supports several power plants, including the first coal-fired power plant in Sri Lanka, located at Norichcholai on the Kalpitiya peninsula; similarly, a wind power plant with six turbines is also located right next to this plant. However, the country is severely suffering from a 'power crisis'.

- (a) Compare a coal-fired power plant and a wind power plant in terms of power generation, necessary infrastructure and contribution to global warming.

[05 marks]

- (b) What would be the three most significant environmental impacts of the coal-fired power plant during the operational phases with justification? (your priority list to be justified)

[05 marks]

- (c) List two methods that can be used to mitigate the contribution of a coal-fired power plant to global warming.

[03 marks]

- (d) What is the original source of the energy released in a coal-fired power plant and a wind power plant? Explain your answers.

[04 marks]

- (e) List other renewable energy sources where Sri Lanka has the potential to develop. Explain your answer with justifications.

[03 marks]