UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: September 2019

Module Number: CE7304 **Module Name: Environmental Management**

[Three Hours]

[Answer **all questions**, each question carries twelve marks]

Q1. a) Sulfur Dioxide (SO_2) is a major air pollutant emitted from cane sugar manufacturing industry. Following are several options available to reduce SO_2 pollution from such industrial activities: (1) Installing a condenser to recover SO_2 for reuse; (2) Inducing options to undergo chemical reactions to produce different and less objectionable emissions; (3) Reducing or eliminating the production of SO_2 using cleaner technology; (4) Selectively removing SO_2 from a gas stream by absorption (gas to liquid); (5) Installing a fume incinerator. List these methods in the hierarchical order with respect to waste minimization giving reasons for your selection.

[3.0 Marks]

b) "'Life-Cycle Assessment (LCA)' is an environmental management tool as well as a way to achieve the sustainability in both the industrial sector and construction field." Rationalize this statement.

[2.0 Marks]

c) (i) Identify **five** environmental resource factors likely to be affected during the operational phase of the following development project:

A dam is to be constructed to divert water from a main river to a proposed reservoir through a 20-*km* long canal. Main objectives of this project are preventing downstream flooding, supplying irrigation and safe drinking water demand to surrounding townships. Average population affected by flooding is estimated to be 20,000. About 15 % of the affected community is engaged in illegal sand mining in the reaches (upstream and downstream) close to the proposed dam. These reaches are highly polluted due to the illegal disposal of urban waste and possess eroded banks. The majority of the population is engaged in small-scale agriculture like paddy and other alternate crop cultivation and small-scale businesses. People are poor. The percentage of people without access to safe drinking water and sanitation are 35 % and 45 %, respectively. The project area will occupy a few paddy fields.

State an environmental impact, which will be imposed on each identified environmental resource factor.

[3.0 Marks]

(ii) For the above project, construct an outline of a weighting-scaling checklist that could be used to compare three alternative sites to locate the main component of the project in developing an Environmental Impact Assessment (EIA) report.
One of the alternatives should be an imaginary proposed site. The checklist should include at least 5 decision factors, an imaginary weight for each decision factor and an imaginary scale for each alternative. A composite index for each alternative has to be obtained based on the imaginary weights and scales.

[4.0 Marks]

Q2. a) A food processing industry produces a wastewater flow of 500 m^3/d with BOD_5 (Biochemical Oxygen Demand) of 500 mg/L This industry pays the municipal council in order to have its waste treated and disposed of at a central treatment facility. The treatment charges are calculated using the 'assessment - surcharge formula' by allowing all users to pay the same amount of treatment for an 'assessment rupee', after which a surcharge is applied. Every user has to pay a fixed amount of money annually, i.e. 'annual assessment', to the municipality for the sewage treatment. The average annual assessment of a commercial establishment of 5.0 persons is Rs. 60 000. BOD_5 contribution per a commercial establishment is 120 g/capita.d. The industry has been assessed at Rs. 20 million. The operating cost for removing BOD_5 is Rs. 50 per kg BOD_5 removed. Assume that all users are entitled to the same amount of treatment per assessment rupee. What would be the annual surcharge of this industry?

[3.0 Marks]

b) A dairy industry located on a river bank has been discharging its treated wastewater effluent into the river for several years because it has been making its effluent characteristics comply with the 'effluent discharge standards'. Recently the river has been identified as to be heavily polluted. The discharge of the above effluent is suspected to be the major source of the river pollution.

(i) Discuss briefly the adverse effects on the river ecosystem due to the discharge of this effluent.

[2.0 Marks]

(ii) Condition of the river indicates 'effluent discharge standards' is not the option suitable for the prevailing state of the river. Name another type of standard which can be applied on this industry in favor of the river water quality, and explain why it is preferred to the 'effluent discharge standards'.

[2.0 Marks]

(iii) Describe briefly how to apply 'economic tools (strategies)' to decrease the pollution load of this industry.

[2.0 Marks]

c) An industrial park consists of three types of industries, namely, cane sugar manufacturing, dairy and tannery. Each industry discharges its wastewater to a Central Effluent Treatment Plant (CETP), after applying preliminary treatment

to remove specific pollutants. However, the industrial park has recently become a major source of pollution in the area.

(i) Discuss three possible ways to minimize the pollution arising from the wastewater without going for the end-of-pipe treatment.

[1.0 Mark]

(ii) Describe three environmental management options, which can be used to overcome the pollution due to the emissions and solid waste.

[2.0 Marks]

Q3. Tables Q3 (i) and Q3 (ii) give details of industrial effluents *A*, *B*, and stream condition just upstream to these discharges and saturation DO levels at different temperatures. Following equations are applicable:

$$D_c = \frac{k}{k_2} L_i e^{-k\theta_H^*} ; \theta_H^* = \frac{1}{(k_2 - k)} \ln \frac{k_2}{k} \left\{ 1 - \frac{D_i(k_2 - k)}{kL_i} \right\}; \quad L = L_i e^{-k\theta_H} ;$$

$$D_{O_2} = \frac{kL_i}{(k_2 - k)} (e^{-k\theta_H} - e^{-k_2\theta_H}) + D_i e^{-k_2\theta_H} ; k_T = k_{20} \times \theta^{(T-20)} ; x = \theta_H u$$

D_i = Initial dissolved oxygen deficit at the point of waste discharge, *mg/L*

D_c = Critical dissolved oxygen deficit, *mg/L*

D_{O2} = Dissolved oxygen concentration at any point, *mg/L*

θ_H = Hydraulic retention time, *d*

θ_H^* = Critical hydraulic retention time, *d*

k_2 = Re-aeration constant, d^{-1}

k = Carbonaceous organic matter degradation rate constant, d^{-1}

k_T = Reaction rate constant at $T\ ^0C$, d^{-1}

k_{20} = Reaction rate constant at 20^0C, d^{-1}

L_i = Ultimate *BOD* (BOD_u) at the point of waste discharge, *mg/L*

x = Distance from the mixing point, *m*

u = Velocity, md^{-1}

Table Q3 (i) Details of the industrial effluents A and B, and the stream.

Parameter	Industrial Effluent *A*	Industrial Effluent *B*	Stream
Flow rate, m^3/d	4,000	5,000	45,000
Ultimate *BOD*, *mg/L*	30	25	-
Ultimate *BOD* load, *kg/d*	-	-	225
DO (Dissolved Oxygen) load, *kg/d*	12	10	270
Temperature, ^0C	30	30	25
k at $20\ ^0C$, d^{-1}	0.36	0.36	-
k_2 at $20\ ^0C$, d^{-1}	-	-	0.60
Temperature coefficient (θ)	1.06		

Table Q3 (ii) Saturated DO concentrations at different temperatures.

Temperature(^0C)	21	22	23	24	25	26	27	28	29	30
Saturated *DO* concentration (*mg/L*)	8.9	8.73	8.56	8.4	8.24	8.09	7.95	7.81	7.67	7.54

a) State three deoxygenation and two re-oxygenation means of a stream.

[3.0 Marks]

b) Find the conditions in terms of BOD_u, *DO* and Temperature just downstream to the industrial effluents discharge point in the stream.

[3.0 Marks]

c) Find the time to the critical point of the stream.

[2.0 Marks]

d) Determine the oxygen sag at the critical point of the stream.

[2.0 Marks]

e) Estimate BOD_5 of a sample taken at the critical point of the stream. Consider the temperature at the critical point as the temperature at which the above BOD_5 value should be determined.

[2.0 Marks]

Q4. Answer the questions below based on a project of your choice from the following list: (1) a sea port construction project; (2) a project for constructing a wastewater disposal system; (3) a project for constructing a cane sugar manufacturing industry.

a) What are the aspects to be considered in the scoping and Terms of Reference (TOR) development of the Environmental Impact Assessment (EIA) for the selected project?

[2.0 Marks]

b) Identify the significant environmental and social impacts likely to arise due to this project.

[2.0 Marks]

c) Explain briefly environmental management options to minimize six of the identified environmental and social impacts.

[3.0 Marks]

d) What is "no-action alternative"? In carrying out an EIA for the above selected project, identify four viable options that could be considered under the "analysis of alternatives"

[2.0 Marks]

e) Construct an interaction matrix suitable for an Environmental Impact Assessment (EIA) report developed for the above selected project in order to summarize the environmental impacts during the operational phase. Indicate clearly the environmental resource factors.
(Note: Use the impacts identified in the part (b) and consider an imaginary significance level for each impact identified.)

[3.0 Marks]

Q5. 12.2% of the population in a town does not have proper sanitation facilities. The drainage system in the city is polluted with domestic wastewater. During the wet season, the cesspools and soakage pits saturate and the wastewater overflows freely into the drainage lines. High population density, poor drainage system, frequent sewage overflows into drains etc. have caused health hazards in the area. Therefore, a proper sewage disposal system is a necessity for this town to minimize the spreading of water borne diseases.

In order to improve this situation, a project of constructing a wastewater collection, treatment and disposal system, which will comprise a collection network, treatment system, effluent and sludge disposal system and operation and maintenance facilities, has been proposed. The collection network and the WWTP will be designed to cater a total design period from the year 2023 to 2063.

The wastewater treatment plant (WWTP) will consist of a waste stabilization pond system, which can accommodate 10,000 m^3/d of wastewater including ground water infiltration. The sludge accumulated in anaerobic stabilization ponds will be composted and sun dried. The collection network will be laid on the main roads in the town. The development of the collection network is limited to the populated roads and to roads that has the potential to grow further in near future. The treated effluent will be released into an abandoned irrigation tank (tank 1), which will be rehabilitated before using for the said purpose. The discharge of the treated effluent into the tank 1 may augment the volume of water in another irrigation tank (tank 2), which the overflow water from the former tank drains into. Other than agricultural purposes, the tank 2 is widely used for bathing and washing purposes, particularly by the neighboring residents.

a) Name two viable alternatives for the proposed (i) WSP system (ii) treated effluent disposal system, and (iii) sludge treatment/disposal system.

[3.0 Marks]

b) Estimate the ambient BOD_5 value in the tank 1 and 2 after the discharge of treated effluent in the year 2063. Assume that 30 % of the total volume of water from the tank 1 will overflow into the tank 2 after receiving the treated effluent; and there is no other pollutant inflow to both the tanks.

Table Q5 (b) Data on treated effluent disposal.

Item	Unit	Value
Effluent BOD_5 (Biochemical Oxygen Demand)	*mg/L*	15
Present ambient BOD_5 in the tank 1	*mg/L*	6.6
Present ambient BOD_5 in the tank 2	*mg/L*	5.8
Maximum possible capacity of the tank 1	m^3	40,000
Maximum possible capacity of the tank 2	m^3	110,000

[3.0 Marks]

c) (i) Name three nos. of economic cost aspects and six nos. of economic benefit aspects associated with the above project that can be monetized to estimate a benefit-cost ratio for the above project.

[2.0 Marks]

(ii) At present, the water quality of the tank 1 deteriorates due to the disposal of untreated wastewater through 4 drainage lines connected to the tank. The implementation of the proposed project is expected to improve the water quality by gradually eliminating the pollution load carried by the above 4 drainage lines as the people will not incline to release untreated wastewater into surface drainage. It is expected that the total pollution load carried by these lines will entirely disappear by the design year, 2063. Table Q5 (c) depicts the wastewater data of the 4 drainage lines. Estimate the net economic benefit gained through the improvement of the water quality of the tank 1 due to the implementation of the proposed project. The treated effluent characteristics given in Table Q5 (b) are applicable. The shadow price for BOD_5 is Rs. 2.50 per 1 *kg* of the pollutant load.

Table Q5 (c) Wastewater data of the 4 drainage lines.

Drainage No	Cross Sectional Area (m^2)	Velocity (ms^{-1})	BOD_5 (mg/L)
C1	0.20	0.41	140
C2	0.05	0.10	170
C3	0.06	0.14	200
C4	0.80	0.03	90

[4.0 Marks]