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**
Academic Year	: 2021/2022
Date	: 09th February 2023
Time	: 0930 hrs-1230hrs
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.

Question 1

(a) Ecosystem encompasses both the living (biotic) and non-living (abiotic) components and creates complex networks of interlinked systems.

(i) The dynamic nature of the ecosystem due to the interactions between and interdependence of the various components. List three such components.

(ii) Biomagnification is caused due to food webs. Considering a toxic pollutant in a lake, illustrate how food chain biomagnification occurs and its impacts on humans.

(iii) Microplastic in water has drawn attention in the recent past. Explain how microplastics get into aquatic ecosystems.

[06 marks]

(b) Communicable diseases are spreded mainly by air and water. Poor sanitation is the main reason for water-related communicable diseases can be categorized in to five type of water relationships.

(i) Mention those five water relationships and write one disease caused by each main water related diseases.

(ii) Providing pathogen-free water to consumers is important. Coliform bacteria can be used as indicators of drinking water quality. Why? Explain, highlighting its characteristics

[06 marks]

(c) (i)What is meant by "Coastal hypoxia"? is a severe issue in coastal ecosystems.

(ii)Explain the demerits of prawn farms at the Coastal beltin noth western province in Sri Lanka. , drawing an example from a coastal ecosystem in Sri Lanka.

(i) An effluent from a fertilizer manufacturing plant contains NO_3 60 mg/l and it relases to a stream with a flow rate of 0 2 m^3/s. The receiving stream has a NO_3 level of 1.6 mg/l and a discharge of 5 m^3/s. Compute the stream flow and the NO_3 concentration downstream of the mixing zone. Assume that the effluent is completely mixed in the stream water.

[08 marks]

Question 2

(a) Jar test is used for water treatment plants to measure the coagulant dosage to be applied.

(i) What is the reason for adjusting pH before adding the coagulant?

(ii) Explain the difference between 'coagulant' and 'coagulant aid' by providing examples for each category.

(iii) A city water works treat $200x10^6$ litres/day of water for public water supply. A laboratory experiment shows that the optimum coagulant dosage is 8mg/l for the coagulation process. Determine the quantity of coagulant required per week by waterworks if the turbidity of water remains unchanged.

[08 marks]

(b) (i)Explain the method of cleaning the slow and rapid sand filters when clogged.
(ii)A city water treatment works needs a water treatment plant with eight slow sand filters. Following data are given.
Population to be served = 10,000 persons
Quantity of water to be supplied = 180 lpcd
Rate of filtration = 30 $m^3/m^2/day$
Length of each bed is twice the width. Compute the dimensions of a slow sand filter.

[06 marks]

(c) A river supply water to a small town through a plant serves for about 2 million population with a demand rate of 200 lpcd. If the retention time of the sedimentation tank is 2.4 hrs, estimate the required capacity of the sedimentation tanks.

[06 marks]

Question 3

(a) (i)In many places in Sri Lanka, people consume RO-treated water for drinking. The long-term basis usage of RO water for drinking is not recommended. Why?
(ii) Trihalomethanes (THMs) come as a by-product during chlorination. What are the health risks of THM in drinking water? How it happens. Explain briefly.

[06 marks]

(b) A city water treatment plant uses chlorine for the disinfection process. At the chlorine contact basin, average design flow is 0.2 m^3/s and contact time is 18 minutes. It has estimated that the break point chlorine demand is 6mg/l, and the chlorine residual maintained is 1.5 mg/l.

(i) What is the volume of the chlorine contact basin?
(ii) Estimate the quantity of chlorine needed in kilograms per day.
(iii) What are the possible effects of chlorination on natural waters containing colour-causing compounds?

[07 marks]

(c) A river has an average velocity of 1.7m/s and a reoxygenation constant of 0.4 d^{-1}. Below the outfall, the ultimate oxygen demand is 12mg/L and the Kr= 0.21 d^{-1}. And Kd =0.14 d^{-1}. It is saturated with oxygen at 10mg/L when the organic pollutant is discharged. Estimate pollutant concentration 10 Km from the mixing point? Assume that any data is needed.
(The Streeter – Phelps equation is given on the last page with usual notations)

[08 marks]

Question 4

(a) A reservoir with constant volume $5x10^6$ m^3 is fed by a pollution free stream with average flow rate of $10m^3/s$ in dry zone of Sri Lanka. A non-conservative pollutant with a concentration of 150mg/l flows into the reservoir ,especially during the rainy season through stream water. The pollutant has a reaction rate of coefficient *K* of 0.25/day.

(i) Find the steady state concentration of pollutants in the reservoir.

(ii) What are the assumptions you made to solve the above problem.

(iii) The small cascade reservoir which uses for irrigation purposes is located downstream of the main reservoir with inflow of 0.10 m^3/s. If the effluent from the small reservoir must have pollutant concentration of less than 50mg/l, how large must be the small tank?

[08 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 m^3/day. The concentration of pollutants is 480µg/L, and water provides to the downstream city. River water moves at $5m^3$/day with zero concentration of carcinogen. [$C_t = C_o e^{-kt}$]

(i) Estimate the carcinogen concentration at the mixing point?

(ii) If the decay rate is 0.22/day, what would be the carcinogen concentration at the intake of groundwater supply just 80 Km away from the source?

(iii) 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 Risk=CDIx PF

[08 marks]

(c) Considering the immense dilution capacity of the Ocean and close proximity to the sea, a sea outfall is identified as the preferred disposal option. Would you recommend this disposal of treated effluent to the coastal belt? Justify your answer.

[04 marks]

Question 5

(a) (i)F/M ratio is essential in activated sludge treatment systems. Explain importance of the maintenance of F/M ratio in efficient treatment.

(ii)why the lower F/M are recommended for lower operating temperatures.

[05 marks]

(b) An average operating data for conventional activated sludge treatment plant is as follows:

Wastewater flow	= $10000m^3$/day
Volume of aeration tank	=12000 m^3

Influent BOD	=400mg/L
Effleuent BOD	=10 mg/L
Mixed liquor suspended solids (MLSS)	=3000mg/L
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)BOD removal Efficiency

[08 marks]

(c) (i)How equivalent population is helpful in the wastewater plant design?.

(ii)A canary plant discharges 25,000 m^3/d of wastewater containing 2400mg/L of BOD, 1000 mg/L of Suspended solids, 1500 mg/L of COD. Calculate the BOD equivalent population and the equivalent hydraulic population. Assume the water usage as180 lpcd and BOD of 58mg/Lpcd.

[07 marks]

Question 6

(a) A leak of a container with carcinogenic pollutant releases into the ground water aquifer with a flow rate of 0.01 m^3/day. The concentration of pollutant is 250µg/l and the aquifer supplies water to the downstream city. If the groundwater moves at 0.05m^3/day with zero carcinogen concentration, estimate the followings. $C_t = C_o e^{-kt}$

(i)Estimate the aquifer carcinogen concentration at the mixing point?

(ii)If the decay rate is 0.022/day, what would be the carcinogen concentration at the intake of ground water supply just 50 Km away from the source?

(iii)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 2 litre/d and average weight per person is 70 kg and that the life expectancy is 70 yrs. The risk is given as Rsik=CDIx PF

[10 marks]

(b) (i) What are the components of photochemical smog. With the aid of a sketch, briefly explain.

(ii)List the preventive actions that can be taken place to reduce the air pollution in a metropolitan city in a developing country?

[05 marks]

(c) (i)How Open dumps contribute to global warming. Explain briefly drawing attention to the gaseous emissions of open dumps.

(ii) State suggestions to control such emissions. Focus your answer to the developing countries.

[05 marks]

Question 7.

(a) (i) How do you categorize air pollutants into primary and secondary pollutants? Explain briefly, giving an example for each category.

(ii) Recent research identifies that SO_2 concentration in a city is about of 0.34 ppm. What is the equivalent concentration of SO_2 in mg / m^3 at 28°C and 1 atm. The molecular weights of S and O are 32 and 16, respectively. Temperature and pressure are given as 298 K and 1 atm.

[06 marks]

(b) The combined effects on global temperature by greenhouse gases can be expressed by the equation shown below.

$$\Delta T = (\Delta T_d/\ln 2) \times \ln [(CO_2)/(CO_2)_0] + 0.057[(N_2O)^{0.5} - (N_2O)_0^{0.5}] + 0.016 [(CFC\text{-}12)^{0.5} - (CFC\text{-}12)_0^{0.5}]$$

The following table shows the approximate pre-industrial concentrations (year 1850) and year 2005 concentrations of green house gases.

Gas	1800	2000	Assumed growth rate (2000-2075)
CO_2	280 ppm	368 ppm	0.57%
N_2O	285ppb	305 ppb	0.5%
CFC-12	0 ppb	0.40 ppb	2.5%

(i) Estimate the combined equilibrium temperature change for 2000.

(ii) Using the assumed growth rate, estimates the equilibrium temperature increase due to NO_2 (compared to pre-industrial times) in the year 2075. Assume ΔT_d is 3°C;

$\{C_t = C_o e^{rT}\}$

(iii) Estimate the CO_2 concentration at 28 °C of year 2000 in g/m^3. Molecular weight of C and O are 12 and16 respectively.

[07 marks]

(c) Sanitary landfill is one of the most suitable methods for the final disposal of solid waste. A community with a population of 31,000 generates solid waste 6.4lb/capita.d. If the compacted specific weight of solid wastes in landfill= 800lb/yd^3 and the Average depth of compacted solid waste=20ft

(i) What aspects should be considered when selecting land for sanitary landfilling? List them

(i) What is the rate of solid waste generation in the above community

(ii) Estimate the required volume and the area required per year for land filling.

[07 marks]

Supplementary

CDI (mg/kg/day)=Total dose(mg)/[Body weight(kg) *Life time (days)]

$$Risk = CDI \times potency\ factor$$

$$C(t) = C(0)e^{-Kt}$$

$$r_u = -\frac{\mu_m S X_{avg}}{K_s + S}$$

$$\frac{1}{\theta_c} = \frac{Y\mu_m(S_o - S)}{(S_o - S) + (1+\alpha)K_s ln(S_i/S)} - k_d$$

$$\frac{F}{M} = \frac{QS_0}{\forall X}$$

$$DO = DO_s - \left[\frac{k_d L_0}{k_r - k_d}\left(e^{-k_d t} - e^{-k_r t}\right) + D_0 e^{-k_t t}\right]$$

$$t_c = \frac{1}{k_r - k_d} \ln\left\{\frac{k_r}{k_d}\left[1 - \frac{D_0(k_r - k_d)}{k_d L_0}\right]\right\}$$