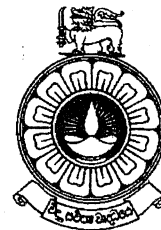# THE OPEN UNIVERSITY OF SRI LANKA
Department of Civil Engineering
Bachelor of Technology (Civil) - Level 6

CEX 6233 – ENVIRONMENTAL ENGINEERING

FINAL EXAMINATION   -   2007/2008

039

Time Allowed: **Three hours**   **Index No.** ☐☐☐☐

Date : 12ᵗʰ May, 2008   Time : **0930 - 1230**

Answer any <u>FIVE</u> questions. All questions carry equal marks.

Q1.

(a) Flooding is associated with an increased risk of infection. The major risk factor for outbreaks associated with flooding is the transmission of communicable diseases. Floods may indirectly lead to an increase in vector-borne diseases through the expansion in the number and range of vector habitats.

(i) What is the difference between water-borne diseases and vector-borne diseases? Explain briefly.   (01 marks)

(ii) Describe the water relationship in the case of waterborne and Insect vector borne diseases occur due to flooding. Also name two diseases for each category.
                    (02 Marks)

(iii) Describe the transmission mode of each of those categories   (02 marks)

(iv) What are the control measures available to prevent such communicable diseases?
                    (02 Marks)

(b) Bolgoda Lake has been polluted over decades due to nutrient enrichment from different point and non point sources. At present the lake system is identified as an environmental protection zone by the Central Environmental Authority (CEA).

(i) What is meant by 'nutrient enrichment' of lake and streams?   (1.5 marks)

(ii) According to your knowledge, what would be the reasons for above nutrient enrichments?   (1.5 marks)

(iii) $CuSO_4$ is sometimes used to control algae growth in water bodies. However cu is also a substance that is controlled due to health effects. Suppose that 45Kg of bag of copper sulfate, $CuSO_4$ is dissolved in a lake to control algae growth. The lake volume is 30ha.m. If the chemical is completely dispersed throughout the lake volume, check whether the concentration of copper is within the acceptable limits. The CEA standard for Cu in inland water bodies is 0.3mg/l. The maximum allowable levels can be taken as 1/8ᵗʰ of dilution. Molecular weights of Cu=63.5, S=32; O=16   (04 marks)

(c) For Seethawaka Industrial Estate, water is supplied from Kelani River through the intake at Awissawella. The BOI regularly tests the water quality of the river at the intake for drinking as well as for industrial purposes. They do sampling and carry out tests for coliforms regularly.

(i) List two different methods of collecting samples for water quality testing?
                    (01 mark)

(ii) What is the difference between total coliform count and fecal coliform count? What are the steps in determine the total and fecal coliform counts using the Multiple Tube Fermentation Technique (MPN method)? (02 marks)

(iii) A 10 ml water sample was tested for fecal coliforms using the membrane filter method. A total of 22 colonies of fecal coliforms were counted on the filter after incubation at 44.5°C. What was the fecal coliform count of the sample? (01 marks)

(iv) The weight of a clean glass fiber filter is 345mg. After filtering a 100ml sample the weight of the filter plus retained solids is found to be 380mg. After ignition in a furnace at 550°C, the weight of the filter and residue is 360mg. Compute the concentration of suspended solids in the sample and the percentage of volatile solids. (02 marks)

Q2.

(a) In water treatment, coagulation and flocculation are employed to separate suspended solids from water.

(i) What is the mechanism behind the coagulation and flocculation with regard to removal of suspended matters? (02 marks)

(ii) Why should you avoid overdosing coagulants? (01 mark)

(iii) What is the difference between coagulants and coagulation aids? Name two of each type commonly used in water treatment systems. (01 marks)

(iv) A public water treatment system provides water for 50,000 people a city, where the per capita demand of water is 240lpcd. Assuming the losses and wastages are about 15% estimate the amount of alum needed in Kg/day for the treatment plant if the Jar test shows that the required dosage is 16mg/l when pH level is 6.5. Also explain that how would you maintain pH level at 6.5 in treatment plant? (02 marks)

(b) An ideal horizontal flow sedimentation tank is operating on a continuous flow basis with a discrete suspension of particles which exhibits common behavior of discrete particles.

(i) List the zones in an ideal sedimentation basin? (01 marks)

(ii) A suspension consists of two types of discrete particles, A an B. Type A particles have specific gravity of 2.65 and diameter 0.05 mm while type B have specific gravity (Ss) 1.85 and diameter 0.3 mm. The suspension is dilute enough to assume that each individual particle is not affected by the other particles. Determine which type of particles settle at first in the sedimentation basin.

Stoke's law is given as $v_s = \dfrac{gd^2(S_s - 1)}{18\upsilon}$ with usual notations. (02 marks)

(iii) Two parallel rectangular settling tanks are designed to treat a flow of 18,900 m^3/d. The surface loading rate and the detention period is $30m^3/m^2$.d and 4 hrs respectively. Suggest suitable dimensions for the settling tank system. Peak factor for the maximum design flow is 1.2. (Length: width ratio for each tank should be within 3:1 to 4:1) (04 marks)

(c) Fertilizers and pesticides are considered as most significant groundwater contaminants from agricultural activities. Especially when the soil is very sandy this occurs

seriously. Kalpitiya Peninsiula and Vauniya districts are severely facing groundwater contamination by nitrogen..

(i) Organic Nitrogen is converted to other form by bacteria and fungi. Show graphically the changes in nitrogen forms in polluted water under aerobic conditions.

(02 marks)

(ii) Explain how groundwater is getting contaminated by fertilizers and pesticides and what measures can be taken to prevent these pollution? (02 marks)

(iii) Nitrates are of particular concern in groundwater used for drinking. Why? Briefly explain. (01 mark)

(iv) Nitrification reactions are given in the following equation.

$$NH_3 + 2O_2 \rightarrow NO_3^- + H^+ + H_2O$$
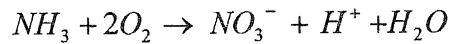
Where molecular weight of N=14; H=1; O=16. If the concentration of Nitrogen is 45mg/l, find the final or ultimate nitrogenous oxygen demand (NBOD) and the ratio of the ultimate NBOD to the concentration of nitrogen in the waste. (02 marks)

Q3.

(a) A tourist hotel located at the western coast in having a wastewater treatment plant with rotating biological contractors (RBC) as shown in the figure Q3(a). The hotel wastewater generation is estimated as $175m^3/d$. Treated wastewater is reused for watering the lawn at the hotel premises. The MLSS of the aeration tank has estimated as 350mg/l. Details and the flow diagram of the wastewater system are as follows:
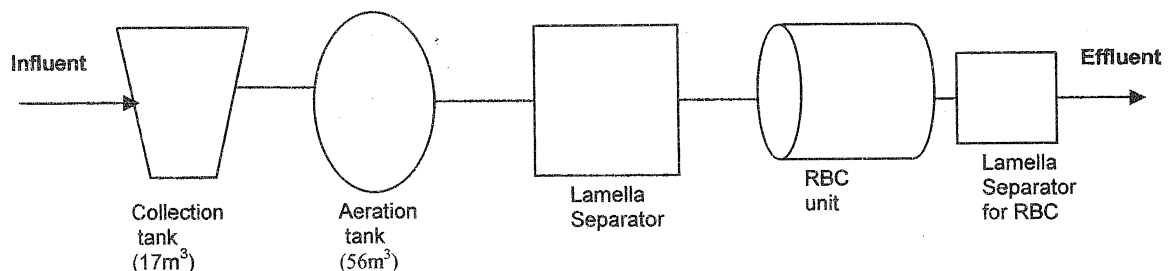

Figure Q3(a) Existing wastewater treatment system

The wastewater was analyzed and the results are shown in the following table.

Parameter	Influent	Effluent
BOD mg/l	200	30
COD mg/l	590	200
TSS (mg/l)	153	98
pH	6.7	6.2

(i) There was inherent bad smell of sewage at the RBC unit. Why? (01 marks)

(ii) What is the function of lamella separators? (01 marks)

(iii)Typical design values for volumetric load, F/M ratio are 0.16-0.4 kg/BOD/m^3.day and 0.05-0.15 kg/BOD/kg MLVSS day respectively. Check whether this aeration tank satisfies the above parameters. (04 marks)

(iv) Estimate the removal efficiencies of BOD, COD and TSS of the system? (1.5 marks)

(v) How do modify the system for better treatment? (1.5 marks)

(vi) What is meant by effluent polishing? List two different systems used to polish a secondary effluent. (02 marks)

(b) A factory discharges 10,000 m^3.d of sewage into a nearby river. The stream has a minimum flow of 0.4 m^3/s, depth of 2.5 m and a velocity of 5kmph. Saturate value of DO at 20°C is 9.09mg/l. Other information pertaining to the stream and the sewage are as follows:

	Temp (°C)	DO(mg/l)	BOD_5(mg/l)
Stream	20	8.5	10
Sewage	25	1.0	200

Modified Streeter-Phelps oxygen-sag equation is $t_c = \dfrac{1}{k_r - k_d} \ln\left[\dfrac{k_r}{k_d}\left(1 - \dfrac{D_o(k_r - k_d)}{k_d - L_o}\right)\right]$

Where $k_r = \dfrac{3.9 u^{1/2}}{h^{3/2}}$; with usual notations.

(i) What is the composite temperature at the downstream? Assume complete and instantaneous mixing along the cross section of the stream. (1.5 marks)

(ii) The deoxygenation constant (k_d) evaluated at 20°C =0.35 d^{-1}. Determine the critical oxygen deficit, Dc, and its location Xc in km. (7.5 marks)
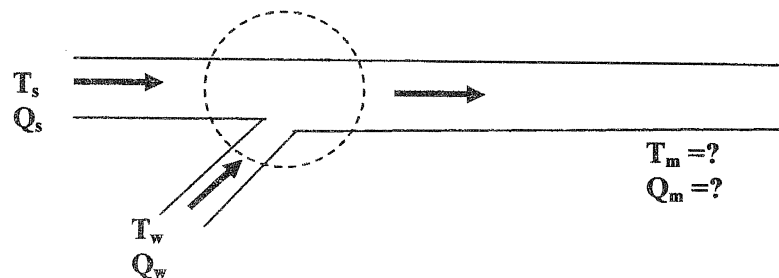

Figure Q3 (b)

Q4.

(a) An ice-cream manufacturing factory at Rathmalana area releases their wastewater to the Lunawa Lagoon. To issue the Environmental Protection License (EPL), the Central Environmental Authority has asked them to upgrade the treatment plant. The management of the factory seeks your assistance to improve their wastewater treatment plant. The BOD level of the influent is around 1600mg/l and in present effluent is 200mg/l.

(i) If you are a consultant for the above organization, what will be your suggestion to reduce the BOD levels to that given as 30mg/l by CEA. Sketch the flow diagram of the treatment process, which you are proposed and explain each unit process giving reasons. (03 marks)

(ii) The treated water finally should be disposed of. What methods available are for disposed of this waste water? (02 marks)

(iii) What are the advantages and disadvantages of such disposal techniques? (02 marks)

(b) A 10^6 liters/day conventional activated sludge plant has an effluent BOD of 200 mg/l. The primary settler removes 30% of that BOD. The Plant is equipped with an aeration tank 18m long x 5m width x 3m deep. The mixed liquor suspended solids (MLSS) concentration is maintained at 1600 mg/l.

(i) Calculate the aeration period and the F/M ratio. (03 marks)

(ii) The success of an activated sludge system depends on the settling of the solids in the final settling tank. Suppose that the sludge in a system has started to "bulk" and experiments show that the volume of the settled sludge (30 minutes) is 300 ml both before and during bulking and the SVI is 100 and 250 respectively. What are the MLSSs before and during the bulking problem? (03 marks)

(c) Chlorination is the most common application for disinfection of drinking water to destroy microorganisms that cause diseases in humans. Sometimes chlorine produce disinfection by-product called Trihalomethanes (THMs) such as the carcinogen chloroform ($CHCl_3$). Suppose a municipal drinking water supply has an average chloroform concentration of 70μg/l. Average life expectancy of an adult is 70 yrs.

(iii) If an adult weighting 70kg drinks 2liters of water daily with the above dosage of THM, calculate the chronic daily intake. (02 marks)

(ii) The oral carcinogenic potency factor is 6.1 x 10^{-3} (mg/kg/day)$^{-1}$, what would be the lifetime cancer risk? Do you agree with the above estimated figure of cancer risk? Explain. (03 marks)

(iii) If a city of 10 million population is served by this water supply scheme what number of extra cancers per year would be expected which is avoidable? (02 marks)

Q5.

(a) Recycling centers have introduced by several local authorities in Sri Lanka. Metals are one of the most economical items.

(i) If you are supposed to work as a SWM consultant, what methods do you suggest to separate various types of ferrous and nonferrous metals? Describe briefly. (03 marks)

(ii) Aluminum food/drink cans are the common nonferrous metal which wants to be separated and recycled. Explain a procedure, which can be adapted to a Industrial Estate in Sri Lanka. (03 marks)

(b) In order to propose a suitable waste management system, a study carried out by an institution obtained the waste composition of a community which is shown in the figure Q5 (c).

(i) Considering the characteristics of each component make a schedule for disposal of each category of waste. (03 marks)
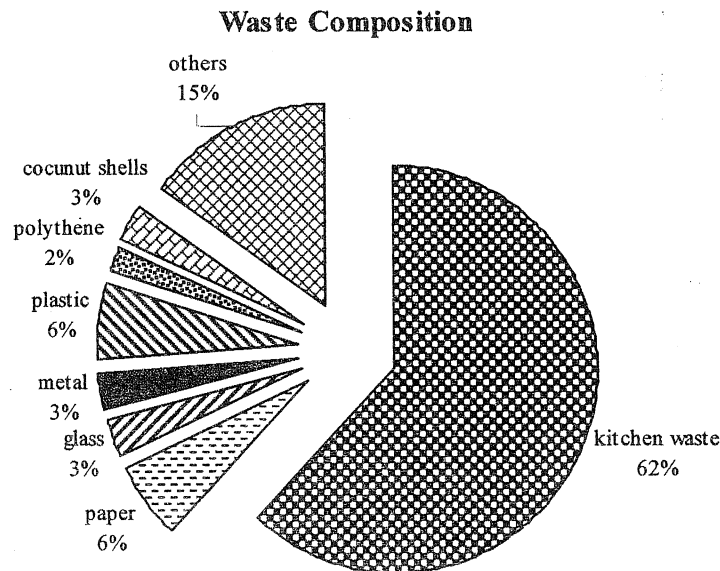
Waste Composition

Figure Q5 (b) Waste composition of a selected community

(ii) Suppose that the above waste composition is estimated omitting the hospital waste generates by the nearby government hospital. It is proposed to dispose solid waste into the ocean after baling. If you are supposed to evaluate the feasibility of ocean dumping of **baled** solid waste including the hospital waste, discuss the acceptability of this method. (04 marks)

(c) Sanitary landfill is one of the most suitable methods for final disposal of solid waste. A community with a population of 31,000 generates solid waste 3kg/capita.d. If the compacted specific weight of solid wastes in landfill 4700kg/m^3 and Average depth of compacted solid waste 6m.

  (i) What aspects should have to be considered when selecting a land for sanitary land filling? List them. (02 marks)

  (i) What is the rate of solid waste generation in the above community (01 marks).

  (ii) Estimate the required volume and the area required per year for land filling. (04 marks)

Q6.

(a) (i) Proposed Weerawila International air port is also wants to prepare for landing 'Concorde' jumbo jets. It is said that air craft noise is the worst gift to metropoliton cities. Why? Briefly explain with the help of a sketch. (04 marks)

  (ii) If a sound source has a pressure of 3000 μPa at 10m distance, compute the sound pressure level in dB and the sound intensity in W/m^2. The density of the air is 1.185. (Use equations $L_p = 20 \log_{10} (P/P_0)$ and $I = P^2/\rho c$ with usual notations if necessary) (03 marks)

(b) Though the fuel charges are increasing pollution due to vehicle emission is increasing day by day.

   (i) What are the gases that contribute to air pollution due to petrol engines and diesel engines? List gases separately.   (02 marks)

   (ii) What improvement would you suggesting to reduce such emissions from petrol and diesel engines?   (02 marks)

   (iii) If you are a government policy developer, what are the steps you suggest to reduce such vehicle emissions to the air?   (02 marks)

   (iv) Gas analyzer is very useful when measuring the vehicle emission levels. What are the environmental conditions you have to consider when operating /starting a gas analyzer?   (01 marks)

(c) The dynamic nature of photochemical smog during a sunny day is illustrated in figureQ6(c).
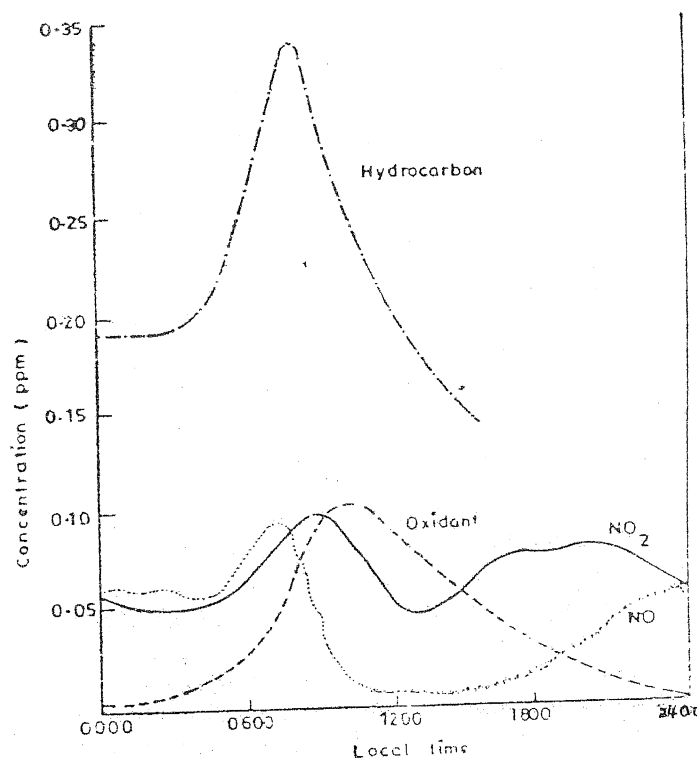

Figure Q6(c). Dynamic behavior of Photochemical smog

(i)Explain the reasons for behavior of photochemical smog with the help of the above curves.   (02 marks)

(ii) How do the curves for NO, NO_2, hydrocarbon and oxidants behave on a cloudy day? Explain.   (02 marks)

(iii) The mean concentration of Nitrogen dioxide (NO_2) in Colombo is $570\mu g/m^3$. What is the equivalent concentration in parts per million (ppm) at a temperature of 25 °C and 1 atm of pressure? Molecular weights of N and O are 14 and 16 respectively.   (02 marks)

Q7.

(a) (i)Explain, with the aid of neat diagrams, what is meant by the terms "global warming" and "greenhouse effect". (06 marks)

(ii)Explain how "global warming" is expected to result in the rise of the mean sea level in the future. (02 marks)

(iii)List three significant impacts that are expected in Sri Lanka due to the rise of the mean sea level. (03 marks)

(b) The United States plans to reduce its contribution to the "greenhouse effect" using ethanol as a substitute for petrol. In the United States ethanol is currently produced from corn (maize). The government of the United States has announced a 20 year plan of subsidies and tax incentives to increase the use of ethanol as a fuel.

(i)Discuss whether the use of ethanol as a substitute for petrol is a good solution in terms of reducing the "greenhouse effect". (05 marks)

(ii) What other environmental, economic and social impacts are expected to result from the use of ethanol as a substitute for petrol? (04 marks)

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