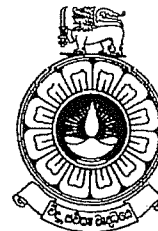**THE OPEN UNIVERSITY OF SRI LANKA**
Department of Civil Engineering
Bachelor of Technology (Engineering) - Level 6

CEX 6233 – ENVIRONMENTAL ENGINEERING

FINAL EXAMINATION   -   2015/2016

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

Date: 29ᵗʰ November, 2016   **Time : 0930 - 1230**

Answer any FIVE questions. All questions carry equal marks.

Question 1

(a) In ecosystems all plants and animals are in some way related to each other.
(i) What are the characteristics of a stable ecosystem?   [02 marks]
(ii) Why is species diversity important for an ecosystem?   [02 marks]
(iii) What information is needed to compute the diversity index?   [02 marks]
(iv) What is indicated by low diversity index of an ecosystem?   [02 marks]

(b) (i) Explain 'food chain biomagnification' and its repercussions using two examples.
[04 marks]
(ii) What are the ecological consequences of untreated wastewater disposal to the the marine environment?   [02 marks]

(c) (i) An Environmental Impact Assessment study of a mini hydropower project recommended having an 'e-flow' (environmental flow) equal to the 90% of the low flow condition. Explain the need of maintaining e-flow and how it impacts the environment.   [03 marks]
(ii) The development of a commercial city (Port City) requires filling the sea and it is recommended to use deep sea sand for that purpose. Discuss the consequences of such an action to the marine eco-system.   [03 marks]

Question 2

(a) It is needed to provide a proposal for the design and construction of a new water treatment plant for a city. The plant will treat surface water from a nearby irrigation tank that experienced frequent algal blooms during the dry season.
(i) Explain the methods available to overcome algal blooms in reservoir water permanently.   [02 marks]
(ii) Describe at least three temporary solutions that can be given for avoiding algae coming into the treatment plant.   [02 marks]

(b) The physical water quality in the irrigation tank in Q 2(a) is heavily influenced by the catchment conditions. The catchment is characterized by rich, humic soils, irrigable lands and substantial parts of the catchment contain natural forest. The

average rainfall for the catchment is 1,500 mm. The rainfall is evenly distributed throughout the year and the catchment streams are managed effectively to minimize the potential for erosion during rain events.

With the aid of a schematic diagram, describe the conventional processes that are likely to be recommended. Include the following points in your description and the diagram.

      a. The selection of the treatment processes to be used;

      b. The correct order of each unit process physical quality of water to be treated

      c. A brief description of each unit process including their objectives and key design parameters

      d. The location of chemical dosing points

      e. If sludge produces the method of sludge disposal

[10 marks]

(c) A small water treatment plant has a raw water inflow rate of 0.6 m³/s. Laboratory studies have shown that the raw water is with uniform particle size and experimentation has found that all the particles settle at a rate of $v_s = 0.004$ m/s. A proposed rectangular settling tank has an effective settling zone of Length = 20 m, Height = 3 m, and Width = 6 m.

(i) Could 100% removal be expected? If not, give the percentage of removal.

[04 marks]

(ii) What is the distance at which the particles are expected to settle? [04 marks]

Question 3

(a) A rectangular settling tank of a water treatment plant has an inflow of 2 m³/min and a Suspended solids concentration of 2000mg/L. The effluent goes to the rapid sand filtration while the concentration of sedimentation sludge coming out of the bottom is 18,000 mg/L (underflow) and flow to the filter is 1.8 m³/min.

(i) Determine the flow rate of sedimentation sludge (Underflow). [03 marks]

(ii) Compute solids concentration of effluent goes to the rapid sand filter [03 marks]

(iii) What is the area of sand filters in m²? Suggest the number of sand filters if one is reserved for an emergency. Assume filtration rate appropriately. [03 marks]

(iv) Discuss utilization of water treatment sludge collected in the settling tanks following flocculation basins. Assume that PAC (poly aluminum chloride) is used as the coagulant in this treatment process. [02 marks]

(b) Reverse Osmosis is adversely used for the CKDu prevalence areas in North Central Province to provide potable water for underprivileged communities. Discuss the advantageous and disadvantageous of Reverse osmosis that can be used for removing hardness? [03 marks]

(c) (i) Cultural eutrophication is one of the most significant on worldwide water quality problems. What is it? Why is it a problem and how can it be solved? [03 marks]

(ii) What are the two mechanisms known to contribute oxygen to surface waters?

[01 marks]

(iii) Eutrophic lakes gives bad smell in early mornings when compare to the day time. Describe the reason behind it. [02 marks]

Question 4

(a) What changes can occur over time in a community that will affect wastewater composition and the flow rate? [02 marks]

(b) A municipal wastewater treatment plant uses two sedimentation tanks operating in a part of lime soda softening process. Each clarifier has a diameter of 12m, a side water depth of 5m, and an outlet weir length of 80m. The design flow rate is 66L/s. Estimate the detention time and surface overflow rate. [06 marks]

(c) A municipal wastewater treatment plant discharges treated effluent into a stream that has no other flow during some parts of the year. The characteristics of the wastewater are:

Flow = 0.1 m^3/s
Dissolved Oxygen = 6 mg/L
Temperature = 20 °C
k_1 = 0.23 d^{-1}
Ultimate BOD (L) = 280 mg/L
The velocity in the stream is 0.5 m/s, and the reoxygenation constant k_2 is assumed to be 0.45 d^{-1}.

(i) What is the 5-day BOD of the wastewater? [03 marks]
(ii) Will the stream maintain a minimum DO of 4 mg/L? [02 marks]
(iii) If the flow of the stream water upstream of the outfall has a temperature of 20 °C and has no demand for oxygen and is saturated with DO at 10 mg/L, how great must the stream flow be to ensure minimum dissolved oxygen of 4 mg/L downstream of the discharge? [03 marks]
(iv) What is the dissolved oxygen at 5 km downstream, if there are no additional flows?

{The Streeter – Phelps equation is given as

$$D = \frac{k_1 L_o}{k_1 - k_2}(e^{-k_1 t} - e^{-k_2 t}) + D_o(e^{-k_2 t})$$

with usual notations.}
[04 marks]

Question 5

(a) (i) Is municipal solid waste is a hazardous material? What constituents of MSW might make it a hazardous material? [02 marks]
(ii) Explain the effect of source separation on the calorific value or heating value of municipal solid waste if the solid waste supposed to be incinerated. [03 marks]
(iii) Why determination of composition analysis of municipal solid waste is important? [02 marks]

(b) Trichloroethylene (TCE) is coming out from an industry and leaks into a reservoir through ground leakage of storing tank and complete mixing occurs to give the TCE concentration of 250ppb (0.25mg/l). Surrounding community consume tank fish from the above reservoir as it was their practice for several decays. Investigators revealed that the problem has started from the TCE leakage. Suppose you are hired to estimate the cancer risk of the area. You are given with the following facts.

Cancer potency factor for an oral dose of TCE is 1.1×10^{-2} (mg/kg day)$^{-1}$.
Potency factor for an oral dose of TCE is 1.1×10^{-2}(mg/kg-day)$^{-1}$.
Lifetime of a normal person is 65 yrs.
{Risk =CDI * Potency factor}
{CDI (mg/kg/day)=Total dose(mg)/[Body weight(kg) *Life time (days)]}

(i) If the bio concentration factor for TCE is given as 10.6 l/kg, estimate expected concentration of TCE in fish. [01 mark]
(ii)Estimate the chronic daily intake CDI, if a 70- Kg person consumes 45g of fish for 200 days per year for 45 years. [03 marks]
(iii)Estimate the maximum risk of cancer due to the above exposure of TCE. [03 marks]

(c) Traffic noise in roadside is a considerable problem in main cities in Sri Lanka.
(i)Provide three_strategies that can be implemented to reduce traffic noise. [03 marks]
(ii)List three methods that can be implement to control noise pollution generated by the highway traffic. Your answer should address specifically to highways. [03 marks]

Question 6

(a) (i) Air pollution is almost always caused by a gas or particulate matter. List the five classifications of particulate pollutants which are higher than 0.01 microns (μm). [03 marks]
(ii)What is meant by 'PM$_{10}$' and 'PM$_{2.5}$'? [02 marks]
(iii)The measurement of PM$_{10}$ was tested round a thermal power plant in the north western Sri Lanka using a high–volume sampler. A clean filter is found to weigh 10.0 g for the test and after 24 h in a high volume sampler, the filter plus dust weighs 10.10 g. The air flows at the start and end of the test are 1,700 L/min and 1,100 L/min, respectively. Compute the particulate concentration? [04 marks]

(b) A stack gas contains carbon monoxide (CO) at a concentration of 10% by volume. What is the concentration of CO in μg/m^3? (Assume 25 °C and 1 atmospheric pressure) [03 marks]

(c) (i) List major sources and effects of indoor air pollution. [02 marks]
(ii)Engineers use the air exchange concept for indoor ventilation. What is the definition of 'air exchange'? [03 marks]
(ii) A small room is to be used for a photocopying machine, and there is a concern that the ozone level may be too high unless the room is properly ventilated. The volume of the room is 25,000 L, and it is recommended that the number of air changes per hour be 30. What flow of air must the fan deliver in L/h? [03 marks]

Question 7

"Small" hydropower plants are hydropower plants with a capacity of 1 MW to 10 MW. There have been over 150 small hydropower plants approved in Sri Lanka over the past 25 years, mostly in the forested areas of the Wet Zone. The forests in these areas contain many endemic species of plants, birds, amphibians and fish.

These hydropower plants usually have only a small water storage capacity that is enough for a few hours of operation at peak capacity each day. The water used for power generation is returned to the same river or stream at a lower elevation.

(a) Why are these power plants designed to operate for only a few hours on the average day? [4 marks]

(b) List the three most important environmental and social impacts (a total of three impacts) you would expect during the <u>operational phase</u> of a small hydropower plant. Justify the impacts you have selected. [4 marks]

(c) Explain how you would mitigate the three impacts of the operational phase that you have identified in section c). [4 marks]

(d) List the conditions that you would include in the IEE or EIA to ensure that the mitigatory measures identified in section d) are implemented. [4 marks]

(e) Discuss the advantages and disadvantages of replacing these small hydropower plants by solar power plants. [4 marks]

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