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

**CEX 6233 – ENVIRONMENTAL ENGINEERING**

**FINAL EXAMINATION - 2010/2011**

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

Date: **13th March, 2011** Time : **0930 - 1230**

**Answer any FIVE questions. All questions carry equal marks.**

*Question 1.*

**(a)** Engineering constructions can cause rapid environmental changes that can seriously disrupt environmental systems. Discuss briefly the causes and effects that Sri Lanka has experienced in recent past. [04 marks]

**(b)** Many waterborne diseases are caused by pathogenic bacteria and it is one of the major tasks of water treatment to reduce their numbers and render them harmless.
(i) What is '*E-coli*' and where do they live? [02 marks]
(ii) Why indicator organisms are used to evaluate the sewage pollution of water? [02 marks]
(iii) How '*E-coli*' is fit for use as an indicator organism to investigate presence of pathogenic bacteria? [03 marks]

**(c)** Suppose 0.5 g/day of carcinogenic material leaks into a 15,000$m^3$ reservoir in north central province. If the carcinogenic material has reaction rate coefficient of 0.35/day and complete mixing occurs.
(i) What would be the steady state concentration of the carcinogenic material in the reservoir? [04 marks]
(ii) Suppose 70Kg of individual drank 2L/day of that water for 5 years. Estimate the maximum risk of cancer due to that exposure to the said carcinogenic material. Oral carcinogenic potency factor is 3.4 $(mg/kg/day)^{-1}$; Risk= CDI x potency factor [05 marks]

*Question 2.*

**(a)** In water treatment unit processes, settling velocity and overflow rate are two important terms in sedimentation zone designing.
(i) Explain the difference between Type I, Type II, and Type III in horizontal sedimentation. [03 marks]
(ii) Write the relationship between settling velocity ($V_s$) and overflow rate ($V_o$). [02 marks]
(iii) A city water treatment plant has an existing horizontal flow sedimentation tank with an overflow rate of 17$m^3/d.m^2$ and it wishes to remove particles that have settling velocities of 0.1mm/s, 0.2mm/s, and 1mm/s. What percentage of removal should be expected for each particle in an ideal sedimentation tank? [05 marks]

**(b)** (i) Calculate the theoretical detention time or volume of thank if you are given the flow rate and the volume of the tank or detention time. [03 marks]

(ii) Five parallel flocculation basins are to be used to treat a wastewater flow of 0.150 $m^3/s$. If the design detention time is 30 minutes, what is the volume of each tank? [02 marks]

**(c)** The city needs an expansion of the treatment plant to cater for the growing population. They are planning to install rapid sand filters after their sedimentation tanks. The design loading rate to the filter is 200 $m^3/d.m^2$. How much filter surface area should be provided for their design flow rate of 0.5 $m^3/s$? If the maximum surface area per filter box is to be limited to $50m^2$, how many filter boxes are required? [05 marks]

*Question 3.*

**(a)** The concentration of dissolved oxygen in a river is an indicator of the general health of the river. All rivers have some capacity of self purification system. When using the DO sag curve to determine the adequacy of wastewater treatment, it is important to use the river conditions that will cause the lowest DO concentration.

(i) Sketch a series of curves that show deoxygenation, reareation, and DO sag in a river. [02 marks]

(ii) Calculate the DO at a point 1.609km downstream from a waste discharge point for the following conditions. Report answers to two decimal places. Rate constants are to be temperature adjusted. [08 marks]

| Parameters | Stream |
|---|---|
| $K_d$ *(at 20°C)* | 1.911 $d^{-1}$ |
| $K_r$ *(at 20°C)* | 4.49 $d^{-1}$ |
| Flow | 2.4 $m^3/s$ |
| Speed | 0.100 m/s |
| $DO_0$ (after mixing) | 0.00 |
| Temperature (°C) | 25 |
| $BOD_L$ (after mixing) | 1100 kg/d |

$$DO_c = \frac{K_r}{K_d} L_0 e^{-k_d t};\ k = k_{20}\,\theta^{(T-20)};\ \theta = 1.047$$

**(b)** (i) Name the "limiting nutrient" and explain why it is a limiting nutrient. [02 marks]

(ii) What are the effects of oxygen demanding wastes on rivers? [02 marks]

**(c)** A standard five- day BOD test is run using a mix consisting of four parts distilled water and one part wastewater (no seed). The initial DO of the mix is 9.0 mg/l and the DO after five days is determined to be 1.0 mg/l.

(i) Calculate the $BOD_5$? [04 marks]

(ii) Why is it usually necessary to dilute the sample? [02 marks]

*Question 4.*

**(a)** A city wastewater treatment plant has employed an aeration tank. A 2 Litre settleometer was used to perform and Sludge volume Index (SVI) test. The MLSS concentration for the test is 3100 mg/L and the settled sludge volume after 30 min in a 2-L graduated cylinder is 840 ml. What is the SVI? Would you expect this sludge to settle satisfactorily in the secondary clarifier? [04 marks]

**(b)** (i) Why advanced wastewater treatment is needed? What methods/processes can be used for advanced waste treatment? [04 marks]

(ii) An extended aeration plant is employed as a biological nitrification and denitrification process. The volume of the aeration tank is 5500$m^3$ the wastewater flow is 4000$m^3$/d. The raw water is with characteristics given in the table. The operating MLSS concentration is about 4500mg/l and the temperature ranges from 25-28°C. Calculate the volumetric BOD loading, F/M ratio, Aeration period, BOD removal, SS removal and Total N removal efficiencies. [07 marks]

| Wastewater Characteristics | Influent water Quality | Effluent water Quality |
|---|---|---|
| BOD (mg/l) | 270 | 5 |
| SS (mg/l) | 320 | 4 |
| Total N (mg/l) | 49 | 7 |
| $NH_3$-N (mg/l) | 35 | 3 |
| $NO_3$-N (mg/l) | - | 2 |

**(c)** (i) Biological systems can be clarified into four main types. List them. [02 marks]

(ii) What are the methods available for sewage disposal? What issues can be arisen due to use of sewage in irrigation purposes. [03 marks]

*Question 5.*

**(a)** The Government of Sri Lanka recently approved the Atomic Energy Authority of Sri Lanka to conduct a pre-feasibility study of using 'nuclear energy' as a viable option beyond 2020 for power generation. Discuss the possibility of adapting nuclear energy as the future energy source in Sri Lanka highlighting merits and demerits. [04 marks]

**(b)** Discuss general characteristics of MSW generated in Sri Lanka and advantageous/disadvantageous of incinerating that solid waste. [03 marks]

**(c)** (i) Make a sketch showing a cross section of a secure landfill. Briefly describe the bottom liner and leachate collection systems in landfills. [03 marks]

(ii) What are three key characteristics of an MSW sanitary landfill that distinguish it from an open dump? [03 marks]

(iii) In landfilling, what does site hydrology refers to? Why is it important with regard to sanitary landfill design? [03 marks]

(iv) A community of 50,000 people uses 12ha landfill site that can be filled to an average depth of 20m. If MSW is generated at the rate of 25Nper person per day, its compacted unit weight in the fill is 8kN/$m^3$, and the MSW-to -Cover ratio is 5:1, what is the useful life of the site? [04 marks]

*Question 6.*

**(a)** A research has shown that the Rajagiriya area has highly exposed to the unwanted traffic noise. Exposure to the high level noise everyday seriously affects human health. Sri Lanka. Average sound levels in day time of the area was measured as 85B

(i) What are the general guide lines given by the National Environmental Act in 1980 for day time and night time sound levels? [1.5 marks]

(ii) List five factors that noise can be propagate. [1.5 marks]

(iii) What are the main causes for traffic noise? List noise control strategies with examples? [03 marks]

(iv) How noise mapping helps for town planning to abate noise effects. Explain briefly. [02 marks]

**(b)** Central Environmental Authority has been monitored the ambient air quality at Colombo City through Colombo fort monitoring site. Maximum concentration of Particulate Matter ($PM_{10}$) was recorded as $90\mu gm^{-3}$ on 21st January 2011.

(i) Compare with the SL standards given for $PM_{10}$ and the above maximum concentration, comment on the air quality in the Colombo City. Also discuss the health affects that can be expected due to $PM_{10}$ in atmosphere? [02 marks]

(ii) What would be the sources and causes of such high $PM_{10}$ concentration? [02 marks]

(iii) What are the remedial measures that you can suggest to reduce $PM_{10}$ in the atmosphere? [02 marks]

**(c)** (i) Carbon monoxide is the most abundant air pollutant produced by incomplete combustion. 77% of CO in atmosphere is due to motor vehicle exhaust. What are the reasons for incomplete combustion in vehicles? [02 marks]

(ii) How common building material brings air quality problem especially indoor air pollution? Explain briefly giving at least two examples. [04 marks]

*Question 7.*

The first coal-fired power plant in Sri Lanka, which is located at Norichcholai on the Kalpitiya peninsula, was inaugurated last year. A wind power plant, with six turbines, is located right next to this plant.

**(a)** Compare a coal-fired power plant and a wind power plant in terms power generation, environmental impacts, necessary infrastructure and contribution to global warming. [05 marks]

**(b)** List the three most important environmental impacts of the coal fired power plant during the construction and operational phases (three for each phase). You should justify your lists as necessary. [05 marks]

**(c)** Identify measures to mitigate each of the six impacts listed above. [03 marks]

**(d)** List two methods that can be used to mitigate the contribution of a coal-fired power plant to global warming. [03 marks]

**(e)** What is the original source of the energy released in a coal-fired power plant and a wind power plant? Explain your answers. [06 marks]