University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2013
Program: B.Sc. Engineering (Civil)

Course Title: Environmental Engineering IV   Course Code: CE 433
Time:2 hrs.   Full Marks: 100

(Answer any four from the five questions listed below.)

Assume any reasonable value for missing data, if any.

Q.1(a) Describe the concept of natural succession in lakes. Briefly describe classifications of lake according to the degree of enrichment with nutrients and organic matter. (10)

Q.1(b) In a typical lake section, show different layers during summer stratification along with the temperature and DO profile. (5)

Q.1(c) Explain the simple phosphorous model for lakes. A lake (surface area = 200x106 m^2) is fed by a stream with an average flow of $30 m^3/s$ and having an average phosphorous concentration of 0.005 mg/L. A wastewater treatment plant adds 10mg/L of phosphorous with a flow of $0.4 m^3/sec$. The settling rate of phosphorous is estimated to be 10m/year. (i) Estimate average phosphorous concentration in lake, (ii) Estimate phosphorous removal rate at treatment plant to keep phosphorous concentration below 0.01 mg/L. (5+5)

Q.2(a) List important sources and sinks of DO in rivers and stream. What are the key model assumptions used in derivation of the classic Streeter-Phelps oxygen sag equation? List limitations of oxygen sag curve equation. (4+3+3)

Q.2(b) Derive expressions for rate of de-oxygenation and rate of re-aeration in the classic Streeter-Phelps oxygen sag equation for a river receiving organic waste. (5+5)

Q.2(c) Explain the effect of temperature and NBOD on the shape of the DO sag curve. (5)

Q.3(a) List the categories of water pollutants. Discuss the sources and effects of: (i) thermal pollution, and (ii) Heavy metal pollution. (4+2+2)

Q.3(b) Define BOD. What is the difference between CBOD and NBOD? Describe a typical problem in determining BOD_5 of wastewater samples in laboratory. What is usually done to overcome this problem? (2+2+2+2)

Q.3(c) For a BOD test (at 25°C) initial DO= 7.5 mg/L. After 5 days, DO=2.3 mg/L. Given, dilution factor = 45, BOD rate constant, k = 0.20 /day at 20°C, and θ = 1.047. (4.5+4.5)

(i) Calculate BOD5 at 20°C.

(ii) Calculate BOD remaining after 5 days at 20°C.

Q.4(a) A BOD test is run using 100ml of treated wastewater mixed with 200ml of pure water. The initial DO of the mix is 9.0 mg/L. After 5 days, the DO is 4.0 mg/L. After a long period of time, the DO is 2.0 mg/L and it no longer drops. Ignoring nitrification, what would be the remaining BOD after seven days have elapsed? (13)

Q.4(b) What do you mean by waste assimilation capacity of streams? Mention the factors controlling waste assimilation of a stream for the following types of pollutants: (i) Oxygen demanding wastes, (ii) Pathogens, (iii) Persistent pollutants. (3+3+3+3)

Q. 5 A public community discharges 2.8 m^3/sec of untreated domestic wastewater, through a storm-water outfall into a river. The untreated wastewater has an ultimate BOD of 220mg/L with no dissolved oxygen in it. Upstream of the storm-water outfall, the river has a flow rate of 12 m^3/sec, a velocity of 0.35 m/sec, ultimate BOD of 5.0 mg/L, and a DO content of 7.8 mg/L. The saturation value of DO (at river temperature) is 9.0 mg/L. The de-oxygenation co-efficient (k_d) is 0.52 day^{-1}, and the re-aeration co-efficient (k_r) is 0.71 day^{-1}. Assume complete mixing immediately downstream of the outfall and that the river has same cross section and flow rate both upstream and downstream of the outfall. Further assume the wastewater and the river has the same temperature. (Use normal graph paper for solving this problem)

(i) What are the initial oxygen deficit (D_o) and the ultimate BOD just downstream of the outfall (before any reaction takes place)? (5)

(ii) Calculate DO at distances, in kilometers: 5, 10, 15, 20, 25, 75, 100, 130, 160, and 210 downstream the outfall. Draw the DO profile using a plain graph paper. (5)

(iii) From the DO profile, estimate the distance downstream of the outfall when the river becomes completely devoid of oxygen (i.e. DO = 0). (5)

(iv) Estimate the length of the river stretch, in kilometers, that remains under septic condition (i.e., DO = 0). (5)

(v) Estimate the distance downstream of the outfall where the river can restore back to DO level of 5.0 mg/L when different fish species and other aquatic life forms could survive. (5)

$$D_t = \frac{k_d L_0}{k_r - k_d}\left(e^{-k_d t} - e^{-k_r t}\right) + D_a . e^{-k_r t}$$

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

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