Major Exam 2006 **CEL 741** ***Surface Water Quality Modeling & Control***

max marks 60

Q(1) A river has flow of 10 m^3/s, a depth of 3 m, and receives a point input of PCB of 1000 g/day. The partition coefficient is 10^5 litres/Kg, average solids concentration is 20 mg/l, and net solids settling velocity is 0.2 m/day. The volatilization loss is 1.5 m/day.

a) Calculate the total PCB concentration at travel time=10 days

b) Calculate the dissolved PCB concentration at travel time = 10 days

Q(2) A lake has the following characteristics:

Volume = 10^{12} m^3, Depth = 20 m, flow= 2.74 x 10^8 m^3/day, suspended solids= 20 mg/l,

Net solids settling velocity =0.2 m/day, partition coefficient= 10^4 litres/kg.

The dissolved allowable concentration should not exceed 0.06 µg/litre

Determine the allowable discharge of this toxicant in kg/year (steady state) assuming dissolved concentration as conservative.

Q(3) The in-lake phosphorus concentration has been measured at 192 µg/litre.

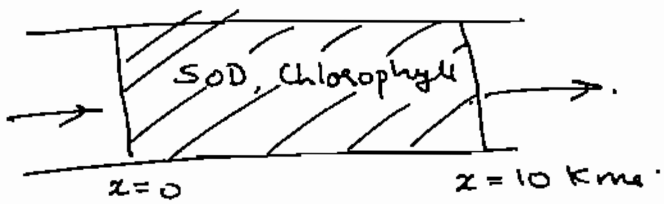
a) If the net settling rate of total phosphorus is 12.4 m/yr, the volume is 10^{10} m^3, the flow is 10^7 m^3/day and the depth is 10 m, what is the present total phosphorus loading to the lake in kg/yr?

b) It is desired to have the phosphorus level reduced to 18.2 µg/litre. What is the new required total phosphorus loading in Kg/yr?

Q(4) A shallow well mixed lake receives inputs of phosphorus that resulted in a substantial growth of aquatic plants of all types, causing a DO variation which is unacceptably high. Data is as follows: Depth = 2 m, flow = 11,000 m^3/day, total incoming phosphorus= 8030 kg/yr, total phosphorus measured in the lake = 20 mg/litre, surface area= 10^6 m^2, daily averaged photosynthetic oxygen production rate = 4 mg/ litre-day. Data have also been collected on the relationship between the biomass in the lake and the total phosphorus resulting into the following relationship $P' = P^{0.8}$, where P is the total phosphorus in µg/litre and P' is the areal chlorophyll level in mg/m^2. Also $P' = P^* H$, where P^* is the chlorophyll concentration in mg/m^3 and H= depth. The carbon to chlorophyll ratio is 100 and the gross growth rate of the plant biomass is 0.2/day. What is the allowable input phosphorus load in kg/yr to meet this restriction? Assume area, settling velocity and flow to remain constant.

P.T.O.

Q(5) A river has the following characteristics for the stretch from travel time x=0 to x=10 Kms

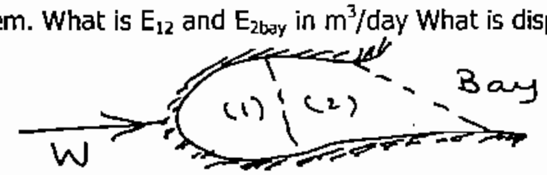


Chlorophyll=20 μg/litre, T=20^0 C, light factor G(I)=0.44, a_{op^*} =0.266 mg DO/ μg Chl, G_{max}=1.88/day, C_s=9.1 mg/litre, sediment oxygen demand=3 gm/m^2–day, aeration rate=0.62/day, effective deoxygenation rate=0.2/day, overall loss rate=0.2/day, photo period=0.5, depth=2m, velocity of flow=1.0 km/day. At x=0, the DO deficit=3 mg/litre, and CBODU=29 mg/litre.

What is the total DO concentration in mg/litre expected at x=10 Kms

Q(6) a) An estuary with no net flow receives an input of 10^3 kg/day. The cross sectional area of estuary is 5000 m^2, E=5x10^6 m^2/day and decay rate=0.1/day. What inflow (in m^3/s) would be required to be discharged to the estuary so that the concentration at the outfall after mixing is reduced by 50% from the concentration at the outfall with no flow in the estuary

b) A harbor of a large bay receives a discharge at one end as shown. The harbor is divided into two segments. A conservative substance is released into segment (1) at 1.0 kg/day. There is no advective flow through the system. What is E_{12} and E_{2bay} in m^3/day What is dispersive flux across interface between segment (2) and bay



S(1) = 12 mg/L
S(2) = 5 mg/L
S bay = 1 mg/L

Formulas: $D = D_0 e^{-K_a t^*} + \frac{K_d}{K_a - K_r} L_0 \left[e^{-K_r t^*} - e^{-K_a t^*} \right] + \frac{(R + S_B' - P_a)}{K_a} (1 - e^{-K_a t^*})$

$P = \frac{W'}{q + v_s}$, $C_T = \frac{W}{Q} e^{-\frac{v_T}{H} t^*}$, $R = 0.1\, a_{op^*} (1.08)^{T-20} P^*$.

$f_d = (1 + K_d m)^{-1}$, $a_{op^*} = 2.67\, a_{cp^*}$,

$P_a = a_{op^*} G_p P^*$, $s = \frac{W}{2A\sqrt{KE}}$, $s = \frac{W}{Q\sqrt{1 + 4\frac{KE}{U^2}}}$

$G_T = G_{max} (1.066)^{T-20}$,

$s = s_0 e^{j_1 x}$, $j_1 = \frac{U}{2E}(1 + \alpha)$, $\alpha = \sqrt{1 + 4KE/U^2}$

$= s_0 e^{j_2 x}$, $j_2 = \frac{U}{2E}(1 - \alpha)$

$v_T = K_1 H_1 + v_v f_{d_1} + (v_s f_{p_1} + v_e f_{d_1})(1 - F_r')$

$F_r' = (v_u + v_e f_{d_2}) / (v_u + v_e f_{d_2} + v_d + K_2 H_2)$.