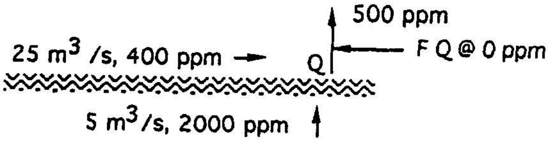
Hw Sol- ME 485- CH 1 - MASS & ENERGY TRANSFER

SS DiJulio

1.7




Upstream of take-out: $C = \dfrac{25\ m^3/s \times 400\ mg/L + 5\ m^3/s \times 2000\ mg/L}{(25 + 5)\ m^3/s} = 667\ mg/L$

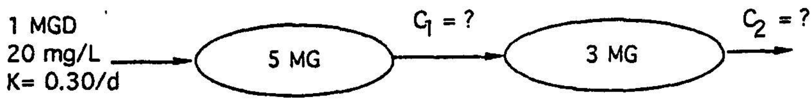
Drinking water @ 500 ppm:

$$500\ mg/L \times (Q + FQ)\ m^3/s = 667\ mg/L \times Q\ m^3/s$$

$$500(1+F) = 667$$

$$F = \frac{667}{500} - 1 = 0.333 \quad \text{(that is, 1/3 pure water)}$$

**1.9**




Lake 1: Input = Output + KCV

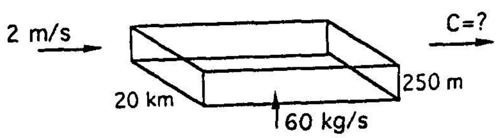
$$1\ MGD \times 20\ mg/L = 1\ MGD \times C_1 + 0.3/day \times 5\ MG \times C_1$$

$$C_1 = \frac{20}{1+1.5} = 8.0\ mg/L$$

Lake 2: $1\ MGD \times 8.0\ mg/L = 1\ MGD \times C2 + 0.3/d \times 3\ MG \times C2$

$$C_2 = \frac{8.0}{1+0.9} = 4.2\ mg/L$$

**1.11**

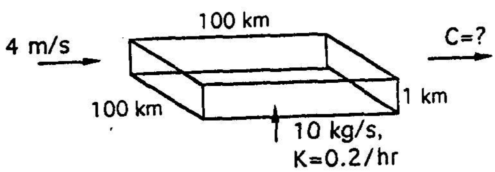



CO Input rate = Output rate

$$60\ kg/s \times 10^6\ mg/kg = 20 \times 10^3\ m \times 250\ m \times 2\ m/s \times (CO)\ mg/m^3$$

$$CO = \frac{60 \times 10^6}{20{,}000 \times 250 \times 2} = 6\ mg/m^3$$

**1.12**




Input rate = Output rate + KCV

Input rate = $10\ kg/s \times 10^9\ \mu g/kg = 10 \times 10^9\ \mu g/s$

Output rate = $100 \times 10^3\ m \times 10^3\ m \times 4\ m/s \times C\ (\mu g/m^3) = 4 \times 10^8\ C\ \mu g/s$

Decay rate = $\dfrac{0.2/hr}{3600\ s/hr} \times C\ (\mu g/m^3) \times 10^5\ m \times 10^5\ m \times 10^3\ m = 5.55 \times 10^8\ C\ \mu g/s$

$$C_\infty = \frac{10 \times 10^9}{4 \times 10^8 + 5.55 \times 10^8} = 10.5\ \mu g/m^3$$

**1.13** $C_\infty = \dfrac{S}{Q + KV}$ (1.20)

$S = 10 \times 10^9 \, \mu g/s$

$Q = 1 \text{ m/s} \times 10^5 \text{ m} \times 10^3 \text{ m} = 1 \times 10^8 \text{ m}^3/\text{s}$ (new value at 1 m/s wind)

$KV = \dfrac{0.2/\text{hr}}{3600 \text{ s/hr}} \times 10^5 \text{ m} \times 10^5 \text{ m} \times 10^3 \text{ m} = 5.55 \times 10^8 \text{ m}^3/\text{s}$

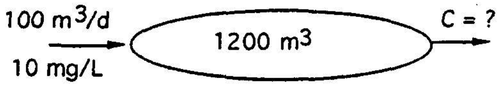
$$C_\infty = \frac{10 \times 10^9 \ \mu g/s}{(1\times10^8 + 5.55\times10^8)\text{m}^3/\text{s}} = 15.26 \, \mu g/m^3$$

$$C(t) = [C_0 - C_\infty]\exp[-(K + Q/V)t] + C_\infty \qquad (1.29)$$

$$C\,(2\text{hr}) = [10.5 - 15.26 \mu g/m^3]\exp\left[-\left(\frac{0.2}{\text{hr}} + \frac{10^8 \text{m}^3/\text{s} \times 3600 \text{ s/hr}}{10^{13}\text{m}^3}\right)2\text{hr}\right] + 15.26 \mu g/m^3$$

$= 12.3 \, \mu g/m^3$

**1.14**




a. Input rate = Output rate (conservative)

$100 \text{ m}^3/\text{d} \times 10 \text{ mg/L} = 100 \text{ m}^3/\text{d} \times C \qquad C = 10 \text{ mg/L}$

b. Change input concentration suddenly to 100 mg/L, $C_\infty = 100$ mg/L, C (7days) = ?

$$C(t) = [C_0 - C_\infty]\exp[-(K + Q/V)t] + C_\infty \qquad (1.29)$$

$$C\,(7\text{ hr}) = [10 - 100 \text{ mg/L}]\exp\left[-\left(0 + \frac{100 \text{ m}^3/\text{d}}{1200 \text{ m}^3}\right) 7 \text{ d}\right] + 100 \text{ mg/L} = 49.8 \text{ mg/L}$$

**1.15**


now $K = 0.20$/day

a. Input rate = Output rate + KCV

$100 \text{ m}^3/\text{d} \times 10 \text{ mg/L} = 100 \text{ m}^3/\text{d} \times C \text{ mg/L} + 0.20/\text{d} \times C \text{ mg/L} \times 1200 \text{ m}^3$

$$C = \frac{100 \times 10}{100 + 0.20 \times 1200} = 2.94 \text{ mg/L}$$

b. Change input suddenly to 100 mg/L, C(7 days) = ?

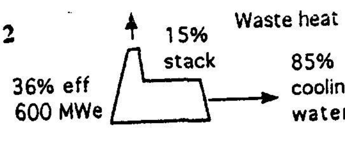
$$C_\infty = \frac{S}{Q + KV} = \frac{100 \text{ m}^3/\text{d} \times 100 \text{ mg/L}}{100 \text{ m}^3/\text{d} + 0.20/\text{d} \times 1200 \text{ m}^3} = 29.4 \text{ mg/L}$$

$$C(t) = [C_0 - C_\infty]\exp[-(K + Q/V)t] + C_\infty$$

$$C(7\text{ d}) = [2.94 - 29.4 \text{ mg/L}]\exp\left[-\left(\frac{0.20}{\text{d}} + \frac{100 \text{ m}^3/\text{d}}{1200 \text{ m}^3}\right) \times 7\text{d}\right] + 29.4 \text{ mg/L}$$

$= 25.8$ mg/L

**1.22**




$$\text{Heat input} = \frac{600 \text{ MWe}}{0.36} = 1667 \text{ MWt}$$

Heat to cooling water = 0.85 x (1667 - 600) MW = 907 MWt

$$\text{Evaporation rate} = 907 \times 10^3 \text{ kW} \times \frac{1 \text{ kJ/s}}{\text{kW}} \times \frac{\text{kg}}{2465 \text{ kJ}} \times \frac{\text{m}^3}{10^3 \text{ kg}} = 0.37 \text{ m}^3/\text{s}$$