

## Homework #3

**Due: Oct 27, 23:59**

**\* Answer the following questions. Be sure to clearly show the procedures to solve the problems.**

A chemostat having  $V = 2,000 \text{ m}^3$  receives a flow rate of  $Q = 1,000 \text{ m}^3/\text{d}$  of wastewater containing  $S^0 = 500 \text{ mg BOD}_L/\text{L}$ . Also included in the wastewater is the inert biomass  $X_i^0 = 50 \text{ mg VSS}/\text{L}$ . The following parameters are found for aerobic biodegradation:

$$\hat{q} = 20 \text{ g BOD}_L/\text{g VSS}_a - \text{d}$$

$$Y = 0.42 \text{ g VSS}_a/\text{g BOD}_L$$

$$K = 20 \text{ mg BOD}_L/\text{L}$$

$$b = 0.15/\text{d}$$

$$f_d = 0.8$$

$$k_1 = 0.12 \text{ g COD}_p/\text{g BOD}_L$$

$$k_2 = 0.09 \text{ g COD}_p/\text{g VSS}_a - \text{d}$$

$$\hat{q}_{UAP} = 1.8 \text{ g COD}_p/\text{g VSS}_a - \text{d}$$

$$K_{UAP} = 100 \text{ mg COD}_p/\text{L}$$

$$\hat{q}_{BAP} = 0.1 \text{ g COD}_p/\text{g VSS}_a - \text{d}$$

$$K_{BAP} = 85 \text{ mg COD}_p/\text{L}$$

1. Calculate  $S_{\min}$ ,  $\theta_x^{\min}$  and  $\theta_x$  of the chemostat. (10 points)
2. Calculate effluent VSS, COD and  $\text{BOD}_L$ . (30 points)
3. Calculate the effluent N and P concentrations when influent concentrations are  $50 \text{ mg NH}_4\text{-N}/\text{L}$  and  $10 \text{ mg PO}_4\text{-P}/\text{L}$ , respectively. (20 points)
4. Calculate the amount of  $\text{O}_2$  that should be supplied to the reactor when influent and effluent DO are 6 and 2 mg/L, respectively. (20 points)
5. Assuming that the influent also contains biodegradable particulate organic matter with a concentration of  $100 \text{ mg COD}_L/\text{L}$  and the

hydrolysis rate coefficient is  $k_{\text{hyd}} = 0.2/\text{d}$ , recalculate the effluent VSS, COD, and  $\text{BOD}_L$ . (30 points)

Hints:

- Consider active and inert biomass, and particulate organic matter supplied from the influent (if there is any) as components of VSS.

$(X_v = X_a + X_i + S_p; \text{ in mg VSS/L})$

(for COD→VSS conversion of  $S_p$ , assume  $S_p$  has the chemical formula as that for biomass)

- Effluent COD should include COD of the substrate, SMP, and VSS  
(eff. COD = substrate COD + SMP COD + VSS COD)
  - Conversion needed for VSS: recall 1.42 g COD/g VSS for biomass ( $\text{C}_5\text{H}_7\text{O}_2\text{N}$ )
- $\text{BOD}_L$  stands for "ultimate BOD", the oxygen demand for all biodegradable organic matter
  - $S^0$  is given as " $\text{BOD}_L/L$ ", so substrate is assumed to be fully biodegradable
  - SMP is fully biodegradable
  - active biomass is partially biodegradable (biodegradable fraction =  $f_d$ )
  - inert biomass is non-biodegradable

So: eff.  $\text{BOD}_L$

= substrate  $\text{BOD}_L$  (=COD) + SMP  $\text{BOD}_L$  (=COD) +  $f_d \times$  active biomass COD