CVEN 5534: Wastewater Treatment
Spring 2008

Assignment 3: Due Thursday, February 21

Using the growth-decay stoichiometry and rate matrix on the next page:

1. Wastewater containing 300 g/m^3 COD is to be treated for 90% COD removal. The reaction rate is assumed to be first order with respect to COD concentration because the concentration of cells is constant.

$$r_S = -kS_S$$

where: r_S = rate of COD consumption ($g/m^3/d$), k = first-order reaction coefficient = 5 d^{-1}, and S_S = COD concentration (g/m^3)

a. Compare the required system volumes for
   i. An ideal single tank CSTR
   ii. An ideal plug flow reactor
   iii. A CSTR cascade with 2 cells
   iv. A CSTR cascade with 4 cells

b. How will the ratio of required volumes change for 99% removal?

c. What would the relative volume ratios in part a be for a zero-order reaction: $r_S = -k'$ where the zero-order reaction coefficient, $k' = 75\ g/m^3/d$?

2. Chlorine contact basins for disinfection of water are typically designed as a plug flow reactor? Why is that? (Explain by means of formulas, graphs or text.)

3. Develop rate expressions for:

   a. Net growth rates for heterotrophic and autotrophic (nitrifying bacteria)
   b. Net consumption/production rates for soluble COD, ammonia nitrogen, nitrate, and oxygen

4. Develop a formula for the steady-state concentration of viable cells, "X," as a function of, S_o, $\hat{\mu}$, K_s, b, and τ for the chemostat example problem worked in class. Using the conditions in the problem what is the cell concentration for a hydraulic retention time of 50 hours?

5. A completely mixed lagoon treatment system is to treat wastewater with 450 mg/L influent COD. The discharge permit requires that maximum effluent COD $\leq$ 45 mg/L. Assume that the heterotrophic cell growth rate is described by Monod kinetics, with $\hat{\mu} = 1\ d^{-1}$, $K_s = 75$ mg/L COD, and $b = 0.03\ d^{-1}$. The wastewater design average flow rate is 400 m^3/d. Assuming that COD is the rate determining substrate and that the cells can be modeled as CSTR's, compare the

required total volume for a one-cell lagoon to that required for a two-cell lagoon in order to meet the discharge COD standard.

a. calculate the effluent concentration of cells for the one-cell and two-cell lagoon systems.