CEE 6570: Biological Processes

Problem Set 4

Due: Wednesday, March 21st

1. (5 points). This question is intended to compare the performance of an aerobic PFR with cell settle and recycle to the performance of an aerobic CSTR with cell settle and recycle. You have an aerated activated sludge system with an influent flow of 10,000 L/d with the following kinetic parameters:

S_0 (mg/L)	500 mg/L
K (mg/L)	30
$\hat{q}$ (g substrate/g VSS-day)	15
Y (g VSS/g substrate)	0.5
b (1/day)	0.05

   a. What is θ_x^{min} for the CSTR system?

   b. What is θ_x^{min} for the PFR system? The approach for determining θ_x^{min} for a CSTR may not apply here, so use the equation from class relating θ_x and effluent S to determine a θ_x at which no removal of S occurs (essentially, the definition of θ_x^{min}). You may want to use the root-finding function available in the matlab script PFR_demo_PS4.m (on blackboard). Assume for now a recycle ratio of r = 1.5. How does this compare to your answer for part (a)?

   c. Plot effluent S for the CSTR and PFR from θ_x^{min} for each system to θ_x = 0.4. Comment on the difference between the performance of the CSTR and PFR, and why the performance of the PFR differs from the CSTR.

   d. What is the effect of the effluent recycle ratio, r, on the performance of the PFR? At θ_x = 0.3, what is effluent S at r = 0.5, 1.5, and 5? Why does this change in the recycle ratio lead to changes in PFR performance? What happens as $r \rightarrow \infty$?

2. (3 points). An industrial waste has the following composition:

   BOD = 500 mg/L (almost entirely lactate)
   NH_4^+-N = 8 mg/L as N
   Available P = 4 mg/L as P

You're considering an aerobic activated sludge CSTR system with a solids retention time, θ_x = 10 days. Assume b = 0.1 day^{-1}. Determine whether or not there is sufficient nitrogen and phosphorus in the waste. If not, then specify any required additions of ammonia-N and phosphate-P.

3. (2 points). Consider a CSTR with recycle, but where reactor *effluent* and not settled cells are recycled. Derive an expression for S to address the question *Does effluent recycle affect the performance of the CSTR?* You may want to approach this problem by drawing a different control volume that includes only the reactor, as shown below.