1.85 WATER AND WASTEWATER TREATMENT ENGINEERING
TAKE-HOME FINAL EXAM
DUE TUESDAY MAY 10, 2005 AT 1:00 PM

This is an open-book exam, with the exception that you are asked to restrict your use of Internet sources to the links included on the 1.85 course webpage and to routine information sources like unit conversions. Unlike the homework, collaboration is not permitted—please do not work with others on this exam.

1. Summarize two major aspects of water and wastewater treatment that reflect fundamental physical, chemical, or biological principles. An example (which you cannot use for your answer!) is that different biological reactions have different associated free energies and the most energetically favorable reaction will dominate in wastewater treatment—such as oxidation with oxygen in an aerobic reactor. Each of your summaries should discuss both the aspect you identify and the fundamental principle(s) involved. Limit your summary to one handwritten or one-half typewritten page each. (30 points)

2. A fully-mixed activated sludge aeration tank was designed using the following parameter values measured at 20°C: K_s = 40 mg COD/L; $k_d(20)$ = 0.1 day^{-1}; and $\mu_{max}(20)$ = 6 day^{-1}. The design sludge age for the system using these parameters was 5 days.

   A world-famous wastewater engineer from MIT wants to bring this design to his home town in Alaska—for which a reasonable design temperature is (brrrr!) 0°C. What should be the new design sludge age to achieve the same effluent quality as the original design achieved at 20°C?

   You can assume the influent COD concentration is identical in both cases. Also assume that K_s is the same in both cases but that k_d and μ_{max} vary with temperature as:

$$\mathbf{k_d(T) = k_d(20)\,1.04^{(T-20)}}$$
$$\mathbf{\mu_{max}(T) = \mu_{max}(20)\,1.07^{(T-20)}}$$

   where, T = temperature in °C;
   $k_d(T)$ = value of k_d at temperature T.

   (20 points)

3. Short answer questions (5 points each, 30 total):

a. Would increasing the rate of sludge withdrawal from a gravity sludge thickener increase, decrease, or leave unchanged the total solids flux and why?

b. Shallow streams with rocky bottoms generally show higher rates in converting ammonia to nitrate than deeper streams with mud bottoms. Why?

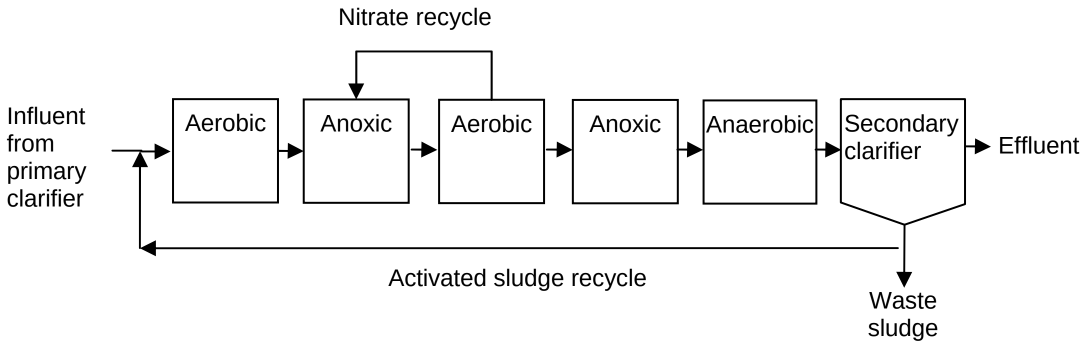
c. In turning over my garden compost bin this spring, I found that most of it was nicely decomposed after a year of composting but that the leaves at the bottom of the pile were wet and hardly broken down at all. Why? (The bin is about 3 feet on each side and about 3 feet deep.)

d. In the first lecture, we viewed pictures of the sedimentation basins at the Chattahoochee Water Treatment Plant in Atlanta Georgia. In some of the photos the basins were being washed of the sediment that had been settled from the incoming river water. The City of Cambridge treatment plant uses dissolved air flotation for its sediment removal and does not have the sediment accumulation problems of the Chattahoochee plant. Would you recommend to the Chattahoochee plant that they consider DAF as an alternative for their plant? Why or why not?

e. Under overloaded conditions, treatment plants will sometimes pass all of the influent wastewater through the primary clarifiers, but then bypass a portion of the flow around the secondary system (aeration tanks and secondary clarifiers) and discharge it without secondary treatment. Assuming there is adequate hydraulic capacity to send all flow through the secondary system, why might bypassing be a better option than sending all of the flow through the secondary system?

f. Wastewater treatment plant performance was very poor throughout the countries of Central and Eastern Europe prior to their economic transition—many plants were overloaded and operating poorly. After the economic change, wastewater treatment plant performance improved dramatically once the governments changed from charging almost nothing for household water supply to charging a realistic (higher) fee. Why?

4. Miracle Engineering (whose slogan is "If it works, it's a Miracle!") has developed a new biological treatment system for removing BOD, nitrogen, and phosphorus that they call the Phodenbar process. The system has the following components:



a. Miracle claims their design will be effective in removing phosphorus, nitrogen, and BOD from municipal wastewater. Identify any aspects of their design that are flawed with respect to these removal goals and why those aspects are flawed. (10 points)

b. Assuming the influent flow and characteristics, the sequence of tanks (aerobic, anoxic, aerobic, anoxic, anaerobic), and the tank sizes cannot be changed, what changes could you make to this system to improve the treatment? Explain how or why they would improve the treatment. (10 points)