CEE 577 28 March 2012

# MID-TERM EXAM

Closed book, 1 sheet of notes allowed.
Answer 2 of the following 3 questions. Please state any additional assumptions you made, and show all work.

I. (50%) The Cape Fear River receives runoff from dozens of hog farms in central North Carolina. Each results in a certain dischage of nitrate-nitrogen and contributes to the loading of the river. The effective drainage area of the hog farms that impacts the Cape Fear is 200,000 ha. Assume that prior to creation of the farms, when the drainage basin was 100% pristine piedmont, the nitrate-nitrogen level in the Cape Fear was constant at 0.20 mg/L. Now the level is substantially higher as shown in the table below.

a. Determine the total nitrate-nitrogen concentration for each day using the standard log-log model
b. Using this information, estimate the effective export coefficient for the hog farms during this 10-day period in units of kg-nitrate-N/ha/yr.
c. Comment on the role of rainfall on the nitrate-nitrogen export coefficient for this watershed. Will it increase, decrease or stay the same as rainfall increases? Explain your answer.

| Day | Flow ($m^3/s$) | Nitrate-Nitrogen Concentration (mg/L) |
|---|---|---|
| 1 | 30 | |
| 2 | 45 | 0.56 |
| 3 | 60 | |
| 4 | 65 | |
| 5 | 100 | |
| 6 | 180 | 1.45 |
| 7 | 350 | |
| 8 | 200 | |
| 9 | 150 | |
| 10 | 100 | |

II. (50%) Estradiol (E2) has been observed to undergo degradation to Estrone (E1) in rivers at halflives ranging from 0.2 days to 9 days (Jurgens et al., 2002)[1]. Although both are powerful estrogenic compounds capable of profoundly affecting native fish, E2 is about 10 times as potent as E1.

A. Calculate the range of first order rate constants for the biodegradation of E2 to E1.
B. Assuming the concentration of E2 in the Assabet River just downstream of the Marlborough WWTP outfall (mile point (MP) 32) is 25 ng/L, calculate the expected high

[1] Environmental Toxicology and Chemistry, Vol 21, No.3, pp.480-488.

and low concentration at the confluence with the Concord River (i.e., at MP 0). Other assumptions: (1) average stream velocity of 0.12 miles/hr, (2) no other point sources downstream of the Marlborough WWTP outfall, (3) the river flow increases by a factor of 2 between MP 32 and MP 0, and (4) this increase in flow comes from runoff that is free from E2.

C. Taking the worst case scenario (high estimate from "B"), determine the relative drop in estrogenicity in the Assabet River water from MP 32 to MP 0. Consider only E2 and E1 and assume E1 does not degrade.

D. Again taking the worst case scenario, determine relative drop in estrogenicity if E2 is also removed by attachment to particles that settle at 0.1 ft/hr. Assume only half of the E2 binds to these particles and assume that the average stream depth is 5 ft.

III. (50%) On a separate sheet of paper, answer any five (5) of the following questions.

A. Calculate the % loss of CBOD as water moves 2 kilometers downstream in a river flowing at 0.01 m/s. Assume the CBOD deoxygenation rate is 0.12 $d^{-1}$, and the CBOD settling rate is 0.10 $d^{-1}$.

B. Describe how you would determine ultimate BOD from a wastewater sample.

C. What is the concentration of dioxane in a lake 1 year after Acme Chemical Company (ACC) initiates operation on its shore. The lake has an area of 100,000 $m^2$, an average depth of 1 m, and an outflow of 1000 $m^3$/day. Dioxane decays at a 1$^{st}$ order rate of 0.5 $yr^{-1}$, and assume ACC discharged 11 kg/yr to the lake on the day it opened and this discharge increased linearly to 14.65 kg/yr by the end of year 1. Assume there was no dioxane in the lake before ACC started operation.

D. Describe what happens when a wastewater with ammonia is discharged into a flowing river. Be specific on the chemical changes and microbial ecology.

E. Is it common to add an inhibitor to the BOD test? Why or why not?

F. Does SOD cause an increase, a decrease or no change in CBOD? Explain.