CIVE 3331 - ENVIRONMENTAL ENGINEERING
Spring 2003

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Purpose: Exercises related to Lecture # 6. These exercises develop skills in selected environmental chemistry problems. Critical thinking is exercised in determination of analogies between lecture examples and the problems in this exercise set. Direct relationships to various accreditation objectives are highlighted in **Bold** type in the following sections. The exercises start on the next page.

Relevant ABET EC 2000 Criteria: Criterion 3 Program Outcomes and Assessment

(3-a) an ability to **apply knowledge of** mathematics**, science,** and engineering.
(3-e) an ability to identify, formulate, and solve engineering problems.
(3-k) **an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.**

Relevant CEE Educational Objectives:

(3) Emphasize problem-identification, problem-formulation and **communication skills**, **problem-solving techniques** and the **many facets of engineering design** throughout the curriculum.

(5) **Prepare every student to develop the skills for critical thinking and lifelong learning.**

Relevant CEE Program Outcomes:

ii. **Students should acquire the ability to solve practical civil engineering problems by applying the knowledge of mathematics, science**, **engineering, modern techniques**, **skills and practical tools they gained in their courses.**

Exercise_006-1

(This exercise requires typeset answers)

In a standard 5-day BOD test,

a) Why is the BOD bottle stoppered?
b) Why is the test run in the dark (or in a black bottle)?
c) Why is it usually necessary to dilute the sample?
d) Why is it necessary to seed the sample ?
e) Why is ultimate BOD not measured?

Exercise_006-2

Incoming wastewater, with BOD_5 nominally equal to 200mg/L but known to vary as much as 10% (+/- 20 mg/L) is treated in a well-operated secondary treatment plant that removes 90% of the BOD. You are to ***design*** a 5-day BOD test with a standard 300mL bottle, using a mixture of treated sewage and dilution water (no seed). Assume the initial DO is 9.2 mg/L.

a) Determine the maximum design volume of wastewater to put into the BOD bottle if you want at least 2.0 mg/L of DO at the end of the test (the remainder of the water will be dilution water), and your test must accommodate the entire range of expected BOD concentrations.
b) Determine the minimum design volume of wastewater to put into the BOD bottle if you want at least a 2.0 mg/L decline in DO at the end of the test (the remainder of the water will be dilution water), and your test must accommodate the entire range of expected BOD concentrations.
c) At the nominal BOD5 value, if you make a mixture of ½wastewater and ½diluent, what DO would you expect after 5 days?

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Exercise_006-3

(This exercise requires typeset answers – but any calculations can be handwritten)

The following data were obtained for a BOD test that was made to evaluate how a plant was operating. Analyze the data to determine the %-BOD being removed by the plant. If the plant is supposed to remove a nominal value of 85% of the BOD, would you say the plant is operating properly? Prepare a brief explaination for your answer.

	Initial DO (mg/L)	Final DO (mg/L)	V_{waste} (mL)	$V_{diluent}$ (mL)
Untreated Sewage	6.0	2.0	5	295
Treated Sewage	9.0	4.0	15	285

Exercise_006-4

The following data are for four wastewater samples. Determine the L_o (ultimate BOD) for these four wastes by plotting the data and using the EXCEL solver feature to fit an exponential curve to each of the data series. Fit the curve by minimization of the sum of squared error (SSE on the spreadsheet), by changing cells for k and L_o. Report the L_o and decay constant. Repeat the analysis using the method in problem 5.14 of the textbook for L_o. Compare the two results (the values of Lo should be pretty close by either method). The spreadsheet depicted below is available on the course website.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Waste_1			Waste_2			Waste_3			Waste_4		
2		k	0.26		k	???		k	???		k	???	
3		Lo	249.35		Lo	???		Lo	???		Lo	???	
4	Time(day)	BOD(t)_1	Lo(1-exp(-kt))	Error^2	BOD(t)_2	Lo(1-exp(-kt))	Error^2	BOD(t)_3	Lo(1-exp(-kt))	Error^2	BOD(t)_4	Lo(1-exp(-kt))	Error^2
5	0	0	0.00	0.00	0	???	???	0	???	???	0	???	???
6	1	57	57.09	0.01	62	???	???	38	???	???	41	???	???
7	2	102	101.11	0.80	104	???	???	72	???	???	79	???	???
8	3	134	135.05	1.10	142	???	???	104	???	???	101	???	???
9	4	160	161.22	1.48	179	???	???	123	???	???	121	???	???
10	5	184	181.40	6.79	200	???	???	142	???	???	140	???	???
11	6	199	196.95	4.19	222	???	???	151	???	???	152	???	???
12	7	207	208.95	3.80	230	???	???	167	???	???	159	???	???
13			SSE	18.16		SSE	???		SSE	???		SSE	???
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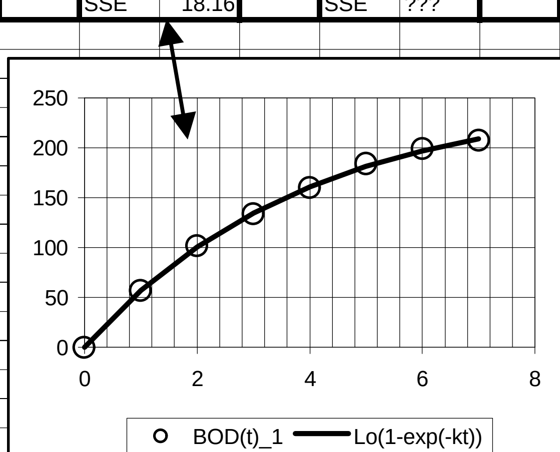

Exercise_006-5

A wastewater has BOD_5 equal to 180 mg/L and a reaction rate k equal to 0.22/day. It also has a TKN value of 30 mg/L.

a) Find the ultimate carbonaceous oxygen demand (CBOD).
b) Find the ultimate nitrogeneous oxygen demand (NBOD).
c) Find the remaining BOD (nitrogeneous + carbonaceous) after five days.

Exercise_006-6

Suppose some pond water contains 10.0 mg/L of algae that can be represented chemically as $C_6H_{15}O_6N$. Using the following reactions to estimate the theoretical carbonaceous oxygen demand and the total theoretical nitrogenous oxygen demand.

$C_6H_{15}O_6N$ + $6O_2$ => $6CO_2$ + $6H_20$ + NH_3

NH_3 + $2O_2$ => NO_3^- + H^+ + H_2O

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