Your Name:

CEE 370	Fall 2019

Homework #7

BOD Problems

1. **BOD test modeling problem I**
   If the BOD of a municipal wastewater at the end of 7 days is 60.0 mg/L and the ultimate BOD is 85.0 mg/L, what is the rate constant?

2. **BOD test modeling problem II**
   Assuming that the data in Problem 1 were taken at 25°C, compute the rate constant at 16°C.

3. **BOD WW model**
   The BOD_5 of the raw Clarksville wastewater is 225 mg/L. A long term BOD test has revealed that this wastewater also has an ultimate carbonaceous BOD of 325 mg/L. Plant effluent testing has shown that the BOD_5 drops by 92% across the plant. Long term tests on the effluent also show that the BOD decay coefficient is half the original value in the raw wastewater.

   a. What is the BOD decay coefficient of the raw wastewater?

   b. What is the ultimate carbonaceous BOD of the effluent wastewater?

4. **BOD Testing**
   a. What sample size (in percent) is required for a BOD_5 of 350.0 mg/L if the oxygen consumed is to be limited to 6.00 mg/L?

   b. Assume a standard BOD_5 test is being done with a 300 mL sample bottle. Present your answer as both required volume of sample (in mL and as sample size in percent (as asked for in the text).

Stream Modeling problems

5. **Point of mixing problem.**
   The Waramurngundi tannery with a wastewater flow of 0.011 m^3/s and a BOD_5 of 590 mg/L discharges into Djanggawul Creek. The creek has a 10-year, 7-day low flow of 1.7 m^3/s. Upstream of the Waramurungundi tannery, the BOD_5 of the creek is 0.6 mg/L. The BOD rate constants (k) are 0.115 day^{-1} for the Waramurungundi tannery and 3.7 day^{-1} for the creek. Calculate the initial ultimate BOD after mixing.

6. **Parameter Estimation Problem.**

a. Compute the deoxygenation rate constant and reaeration rate constant (base e) for the following wastewater and stream conditions

Source	k (day^{-1})	Temp (°C)	H (m)	Velocity (m/s)	η
Wastewater	0.25	20			
Mill River		20	2.2	0.7	0.4

b. In addition, calculate the values of k_d and k_r if the temperature is 10ºC.

7. **River Model for DO I.**

The initial ultimate BOD after mixing in the Bergelmir River is 12.0 mg/L. The DO in the Bergelmir River after the wastewater and river have mixed is at saturation. The river temperature is 10°C. At 10°C, the deoxygenation rate constant (k_d) is 0.30 day^{-1}, and the reaeration rate constant (k_r) is 0.40 day^{-1}. Determine the critical point (t_c) and the critical DO.

8. **BOD and Toxicant River Model**

Consider Monkey creek, a free-flowing stream with a mean water velocity of 0.1 ft/s. At milepoint zero, there is a discharge of 5 cfs of the Clarksville WWTP effluent. The total streamflow above this point is 20 cfs. Ignore any BOD in the upstream water. The Secchi depth for Monkey Creek is 3 ft, however, the average depth is 12 ft. Note that you will need to use some information from supplemental problem #1.

a. What is the BOD_5 of the river water at a point 5 miles downstream of the Clarksville outfall?

b. If the concentration of benzo[a]pyrene just above the Clarksville outfall is 23 $x10^{-6}$ mg/L, and there is no benzo[a]pyrene in the WWTP effluent, what will the concentration be 5 miles downstream? Consider that this compound undergoes photolysis (k_p = 0.847 d^{-1}).

9. **River Model for DO II.**

The town of Edinkira has filed a complaint with the state Department of Natural Resources (DNR) that the City of Quamta is restricting its use of the Umvelinqangi River because of the discharge of raw sewage. The DNR water quality criterion for the Umvelinqangi River is 5.00 mg/L of DO. Edinkira is 15.55 km downstream from Quamta.

a. What is the DO at Edinkira?

b. What is the critical DO and

c. Where (at what distance) downstream does the critical DO occur?

d. Is the assimilative capacity of the river restricted?

The following data pertain to the 7-day, 10-year (7Q10 – note the typo in your book) low flow at Quamta.

Parameter	Wastewater	Umvelinqangi River	Units
Flow	0.1507	1.08	m^3/s
BOD_5	128		mg/L
BOD_u		11.4	mg/L
DO	1.00	7.95	mg/L
k at 20°C	0.4375		day^{-1}
Velocity		0.390	m/s
Depth		2.8	m
Temperature	16	16	°C
Bed-activity coeff		0.200	

10. River Model for DO III

Under the provisions of the Clean Water Act, the U.S. Environmental Protection Agency established a requirement that municipalities had to provide secondary treatment of their waste. This was defined to be treatment that resulted in an effluent BOD_5 that did not exceed 30 mg/L. The discharge from Quamta (Problem 9) is clearly in violation of that standard. Given the data in Problem 9, rework the problem, assuming that Quamta provides treatment to lower the BOD_5 to 30.00 mg/L.

11. BOD Waste Load Allocation.

What amount of ultimate BOD (in kg/d) may Quamta (problem 9) discharge and still allow Edinkira 1.50 mg/L of DO above the DNR water quality criteria for assimilation of its waste?

12. Graphical Representation. .

As an add-on to Problems 9, 10 and 11, produce a graph of dissolved oxygen concentration versus distance downstream from the wastewater discharge point, and show 3 plots on the graph, one for each problem. An efficient method to solve these problems is to create a generic Excel spreadsheet with cells for input of parameters in the problem and then cells for calculating the deficit and DO level as a function of travel time and travel distance. You will also find it convenient to set up your spreadsheet to calculate initial conditions for ultimate BOD and DO in the wastewater/river mixture, allowing for ease in changing loading conditions (as required in Problems 10 and 11).

Assigned: 4 November 19
Due: 15 November 19

Your Name:

Answer Page
Fill in the boxes with the correct answer.

You will only get credit for a problem if you (1) fill in the box with the correct answer, (2) your answer is legible, and (3) you include attach page(s) with calculations backing up your answer, when requested for the problem.

Problem #

1		day^{-1}

2		day^{-1}

3	a.		day^{-1}
	b.		mg/L

4	a.		%
	b.		mL

5		mg/L

6	a.		day^{-1}
	b.		day^{-1}

7	a.		day
	b.		mg/L

8	a.		mg/L
	b.		ng/L

9	a.		mg/L
	b.		mg/L
	c.		km downstream
	d.		Restricted (yes/no)

10	a.		mg/L
	b.		mg/L
	c.		km downstream
	d.		Restricted (yes/no)

11		kg/d

12	graphs	