

## CE 418 Homework I

Spring 2019

Due February 6

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**Problem 1** Class Text Problem 2.1. Do your state's (*Illinois's*) water planning agencies take an integrated approach to water resource planning? Explain. *Document your answer with a citation to a hardcopy or web publication.*

Illinois utilizes an "integrated watershed management approach" for surface water through a watershed approach which receives input from other agencies such as the Illinois State Water Survey and Geologic Survey, but does not give cooperating governmental and non-governmental groups enforcement responsibility or any final say in planning decisions. This does not fit the higher level of cooperation or the distributed and overlapping authority of the examples given in the class text.. Greater detail can be found at <https://www2.illinois.gov/epa/topics/water-quality/Pages/planning.aspx> and the following report link is an example of the approach on groundwater and surface water <https://www.nbwil.org/wp-content/uploads/2018/03/Illinois-Integrated-Water-Quality-Report-Illinois-EPA-Bureau-of-Water.pdf>

**Problem 2** Carbondale Southeast Wastewater Treatment Plant must provide treatment so that minimal nitrogen nutrients are discharged, because the Big Muddy River receives too much nitrogen. Is this due to a technology or water quality based regulation? Cite several sentences from the class text to justify your conclusion.

This is quality based regulation, because it is determined by the nitrogen assimilation ability of the Big Muddy River rather than the technology used to achieve the quality level. See the class text, page 11, "Water quality standards establish a designated use for a specified section of a water body, which is then balanced with the maximum amount of waste the water body can assimilate. Technology based standards are effluent limitations based on the levels of pollutant removal that can be achieved by modern wastewater treatment technology."

**Problem 3** Class Text Problem 8.6. Why can coliform bacteria be used as indicators of drinking water quality? Discuss the limitation of coliforms as an indicator. Why is a positive test for fecal coliforms in a public water supply considered more serious than a positive test for total coliforms?

Three parts to question: 1) Coliform bacteria can be used as an indicator organism, because they appear in large (easily measured) numbers in the excrement of warm blooded animal (that can transmit) pathogens in the same excrement. 2) the limitations of the test are that it is a poor indicator of viral pathogens, some pathogens have a slower die-off rate than coliforms in the natural environment or in the presence of disinfectants, and give no indication as to whether the source animal was infected with pathogens or not. 3) Positive fecal coliform (FC) tests are more serious than positive total coliform tests, because there are natural sources of coliform bacteria in soil and water than through feces. Thus a positive FC test shows greater potential for a water supply contaminated with pathogens.

**Problem 4** Research the Walkerton E. coli incident using a web-based search and describe the most important lesson you believe was learned. Give at least one website citation that backs your conclusion.

In the Wikipedia discussion of the Walkerton, Ontario E. coli contributing causes at [https://en.wikipedia.org/wiki/Walkerton\\_E.\\_coli\\_outbreak#Contributing\\_causes](https://en.wikipedia.org/wiki/Walkerton_E._coli_outbreak#Contributing_causes)

multiple coinciding problems such as nearness of a cattle feedlot to the well source, heavy rains sweeping cattle waste into a shallow well with insufficient isolation from surface waters, and a malfunctioning

disinfection system. A published research paper (referenced below) cited the following main points (the last being what I believe is the most important lesson).

- 2000+ gastroenteritis cases, 65 hospitalized, 7 dead (*E. coli* O157:H7 identified)
- Large storm lead to contamination of shallow well supplies with cattle waste
- Insufficient chlorine dose to inactivate *E. coli* O 157 was cited
- Canadian Government noted importance of multiple layers of protection (best ag practice, monitoring, effective treatment, storm warning)

Hrudley, S.E., Huck, P.M., Gillham, R.W., and Hrudley, E.J., "A fatal waterborne disease epidemic in Walkerton, Ontario: comparison with other waterborne outbreaks in the developed world," *Water Science and Technology*, Vol. 47, #3, 7-14.

**Problem 5** Class Text Problem 8.15. List the regulated disinfected by-products. What is their source in (treated) drinking water. In addition, describe the difference between a THM and a THM precursor (NOM)? Are both human health hazards by themselves?

The regulated DBPs are THMs (chloroform, dichlorobromoform, dibromochloroform, and bromoform) and the five haloacetic acids (HAA5: monochloroacetic acid  $\text{ClCH}_2\text{COOH}$ , dichloroacetic acid  $\text{Cl}_2\text{CHCOOH}$ , trichloroacetic acid  $\text{Cl}_3\text{CCOOH}$ , monobromoacetic acid  $\text{BrCH}_2\text{COOH}$ , dibromoacetic acid  $\text{Br}_2\text{CHCOOH}$ ). Additional questions: The difference between a THM and a THM precursor is that the organic compound which is a precursor (Natural Organic Matter – NOM) can be converted to a THM when oxidized and a halogen element is bound to the resultant molecule, but is not an actual THM. It only has the potential to become one. Only the actual THM is a regulated health concern, because precursors are only mildly toxic, even at relatively high levels.

**Problem 6** Class Text Problem 8.20. If a river with a seasonal low flow of 200 cfs has a water quality standard for phosphorus of 2 mg/L as P, find the TMDL for P. Diffuse agricultural runoff contributes 10 lbs of P per day. If the margin of safety is set at 4 lb per day, what would be the maximum waste load allocation of P from a wastewater treatment plant discharging to the river? Ignore other point and nonpoint sources.

The problem statement above has a typo in the concentration of 2 rather than 0.02 mg/L in the text. The solution below is for 0.02 mg/L

The allowable river load at low flow is

$$W_{low} = Q_{low} C_P \quad \text{where } C_P = 0.02 \text{ mg/L P} \quad \& \quad Q_{low} = 200 \text{ cfs}$$

$$W_{low} = \left(200 \frac{\text{ft}^3}{\text{s}}\right) \left(0.02 \frac{\text{mg}}{\text{L}}\right) \left(\frac{7.48 \text{ gal}}{\text{ft}^3}\right) \left(\frac{1 \text{ MG}}{1 \times 10^6 \text{ gal}}\right) \left(\frac{86,400 \text{ s}}{\text{day}}\right) \left(\frac{8.34 \text{ lb/MG}}{\text{mg/L}}\right)$$

$$W_{low} = 21.46 \frac{\text{lb}}{\text{day}} \text{ P} \quad \text{this must be reduced by the}$$

& diffuse load of 10 lb/day P & a margin of safety  $4 \frac{\text{lb}}{\text{day}} \text{ P}$

$$W_L = 21.46 - 10 - 4 = 7.56 \frac{\text{lb}}{\text{day}} \text{ P} \quad \text{allowable discharge load}$$

**Problem 7** Coagulation, chlorination and filtration are extremely effective in control of Giardiasis outbreaks. How can this explain why groundwater sources can be exempted from the requirement of having those treatment units?

The soil and geologic materials above the well withdrawal point act as a very effective granular media filter.

**Problem 8** Class Text Problem 8.26. Listed below are total solids and suspended solids (*test*) data on an industrial wastewater sample. Calculate total and volatile solids (*concentrations from the total solids test*), and from the suspended solids test suspended solids and dissolved solids. Note that *the Total Solids "Weight of dish plus dry solids" should be 85.490 g rather than 69.049*. Additionally, determine the volatile suspended solids.

Total solids data

Weight of empty dish = 85.337 g

Weight of dish plus dry solids = **69.049 g**

Weight of dish plus ignited solids = 85.375 g

Volume of wastewater sample = 85 mL

Suspended solids data

Weight of glass-fiber filter disk = 0.1400 g

Weight of disk plus dry solids = 0.1530

Weight of disk plus ignited solids = 0.1426

Volume of wastewater filtered = 200 mL

$$\text{Total Solids Test } TS = \frac{(85.490 - 85.337) \text{ g}}{0.085 \text{ L}} = \frac{1.153 \text{ g}}{0.085 \text{ L}} = 13.53 \frac{\text{g}}{\text{L}} = 1353 \frac{\text{mg}}{\text{L}} //$$

$$TVS = \frac{(85.490 - 85.375) \text{ g}}{(0.085 \text{ L})} = \frac{0.115 \text{ g}}{0.085 \text{ L}} = 1.353 \frac{\text{g}}{\text{L}} = 1353 \frac{\text{mg}}{\text{L}} //$$

$$\text{Suspended Solids Test } SS = \frac{(0.1530 - 0.1426) \text{ g}}{(0.20 \text{ L})} = \frac{0.0104 \text{ g}}{0.20 \text{ L}} = 0.052 \frac{\text{g}}{\text{L}} = 52 \frac{\text{mg}}{\text{L}} //$$

$$VSS = \frac{(0.1530 - 0.1426) \text{ g}}{(0.20 \text{ L})} = \frac{0.0104 \text{ g}}{0.20 \text{ L}} = 0.052 \frac{\text{g}}{\text{L}} = 52 \frac{\text{mg}}{\text{L}} //$$

Problem does not ask for an assessment of the sample, but one can conclude by examining volatile components that the waste must have very high volatile dissolved solids (say sugar) and low salts & soil, because since

$$TDS = TS - TVS = 1800 - 1353 = 447 \text{ mg/L (salts \& soil)}$$

$$\& FSS = SS - VSS = 65 - 52 = 13 \text{ mg/L (soil)}$$

$$\text{Finally } VDS = TVS - VSS = 1353 - 52 = 1301 \text{ mg/L (sugar or other dissolved organic)}$$

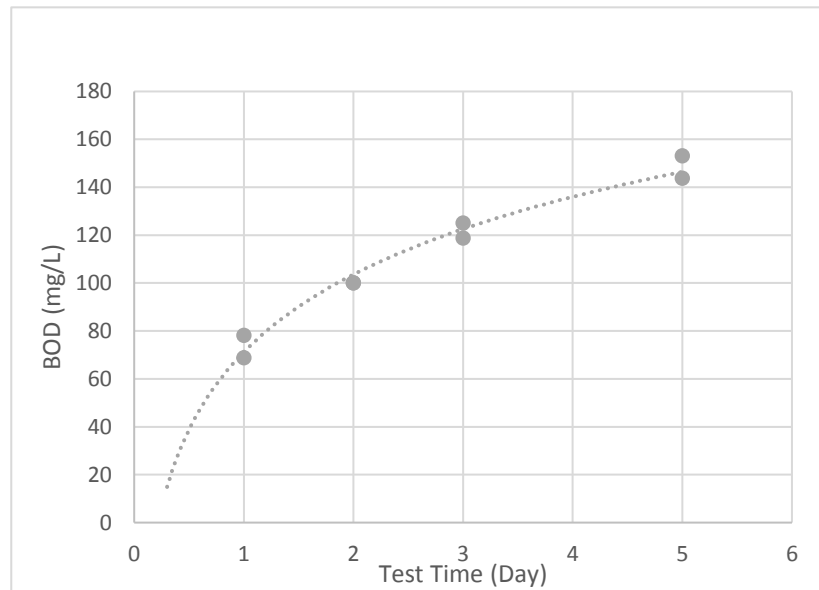
↳ volatile dissolved solids

**Problem 9** Class Text Problem 8.29 *with the exception below in italics*. A BOD test was conducted on a raw wastewater sample. The wastewater portion added to each **300 mL** BOD bottle was 8 mL. The dissolved oxygen values and incubation periods are listed below. Plot a BOD versus time curve and determine the 5-day BOD. *Rather than use the given BOD bottle volume of 300 mL, change the volume to 250 mL.*

Bottle Number	Initial DO (mg/L)	Incubation Period (day)	Final DO (mg/L)
1	8.4	0	8.4
2	8.4	0	8.4
3	8.4	1.0	6.2
4	8.4	1.0	5.9
5	8.4	2.0	5.2
6	8.4	2.0	5.2
7	8.4	3.0	4.4
8	8.4	3.0	4.6
9	8.4	5.0	3.8
10	8.4	5.0	3.5

The spreadsheet below calculates the  $BOD_t$  values for  $t > 0$ , with the  $BOD_5$  as the arithmetic average of the two measured values. The plot uses a logarithmic trendline, but the “first order” BOD model of the next problem (10) could also be used and extended all the way back to  $t = 0$ .

$DO_i$ (mg/L)	$DO_f$ (mg/L)	$BOD_t$ (mg/L)	$V_{bottle}$ (mL)	$V_{sample}$ (mL)	$P$ (mL/mL)
8.4	6.2	68.75	250	8	0.0320
8.4	5.9	78.125			
8.4	5.2	100			
8.4	5.2	100			
8.4	4.4	125			
8.4	4.6	118.75			
8.4	3.8	143.75			
8.4	3.5	153.125			



**Problem 10** For the curve generated for the previous problem, use Excel Solver to estimate  $L$  and  $k$ . Also estimate the base-10  $k$  as well as the base- $e$   $k$ .

The spreadsheet below uses the BOD model  $BOD_t = L_0 (1 - e^{-k't})$ , with the Solver squared error minimized to  $ssqerr = 295.62$  for  $k' = 0.5627 \text{ day}^{-1}$  and  $L_0 = 154.4 \text{ mg/L}$ . The base 10  $k = k'/2.303 = 0.2444 \text{ day}^{-1}$ . Note also that the BOD model plot goes through the origin, but the log fit used above does not.

t	BOD	Model	sqerr	k'	Lo	Plotting Detail		
1	68.75	66.43824	5.344232	0.562735	154.3815	0	0	0
1	78.125	66.43824	136.5803			1	68.75	66.43824
2	100	104.2847	18.35883			1	78.13	66.43824
2	100	104.2847	18.35883			1.5		88.00625
3	125	125.8439	0.712222			2	100	104.2847
3	118.75	125.8439	50.32388			2	100	104.2847
5	143.75	145.1211	1.879866			2.5		116.5709
5	153.125	145.1211	64.0627			3	125	125.8439
		ssqerr	295.6209			3	118.8	125.8439
						4		138.1251
						5	143.8	145.1211
						5	153.1	145.1211
						5.5		147.3922
						6		149.1063
						6.5		150.4001

