

Civil and Environmental Engineering

CIVE 4407: Municipal Engineering

Assignment No. 1 (assigned Sept. 18)

Due date: Start of class October 4 (at the tutorial)

Question 1. A solids analysis is to be conducted on a wastewater sample. The procedure followed is outlined below.

1. A crucible and filter paper are dried to a constant mass of 25.123 g
2. 200 mL of a well-mixed wastewater sample is passed through the filter
3. The crucible, filter paper, and removed solids are dried at 105°C for a period of 24 hours reaching a constant mass of 26.321 g
4. 100 mL of the filtrate is placed in an evaporation dish that has been pre-weighed at 277.125 g
5. The sample is evaporated at 105°C for a period of 24 hours to a weight of 277.876 g
6. Following the drying procedure, the crucible and evaporation dish are placed in a muffle furnace at 550°C for a period of 1 hour. After cooling, the mass of the crucible is 26.183 g and the mass of the evaporation dish is 277.616 g

Determine the following solids characteristics:

- a) The dissolved (~~filterable~~) solids (mg/L)
- b) Suspended (~~non-filterable~~) solids (mg/L)
- c) Total solids (mg/L)
- d) Organic fraction of the ~~filterable~~ dissolved solids (i.e. volatile dissolved solids) (mg/L)
- e) Organic fraction of the ~~non-filterable~~ suspended solids (i.e. volatile suspended solids) (mg/L)
- f) Total organic fraction (i.e. total volatile solids) (mg/L)

Solution Q1:

- a) The dissolved (filterable) solids (mg/L)
 $277.876\text{ g} - 277.125\text{ g} = 0.751\text{ g}$

$$(0.751\text{ g}/100\text{ mL}) \times 1000\text{ mL/L} = 7.51\text{ g/L} = 7,510\text{ mg/L}$$

- b) Suspended (non-filterable) solids (mg/L)
 $26.321\text{ g} - 25.123\text{ g} = 1.198\text{ g}$

$$(1.198\text{ g}/200\text{ mL}) \times 1000\text{ mL/L} = 5.99\text{ g/L} = 5,990\text{ mg/L}$$

- c) Total solids (mg/L)
 $a + b = 13,500\text{ mg/L}$

- d) Organic fraction of the filterable solids (i.e. volatile suspended solids) (mg/L)
 $277.876 \text{ g} - 277.616 \text{ g} = 0.260 \text{ g}$

$$(0.26\text{g}/100 \text{ mL}) \times 1000 \text{ mL/L} = 2.6 \text{ g/L} = 2,600 \text{ mg/L}$$

- e) Organic fraction of the non-filterable solids (i.e. volatile dissolved solids) (mg/L)
 $26.321 \text{ g} - 26.183 \text{ g} = 0.138 \text{ g}$

$$(0.138 \text{ g}/200 \text{ mL}) \times 1000 \text{ mL/L} = 0.69 \text{ g/L} = 690 \text{ mg/L}$$

- f) Total organic fraction (i.e. total volatile solids) (mg/L)
 $d + e = 3,290 \text{ mg/L}$

Question 2. Health Canada's website has a lot of useful information about drinking water and pathogens in drinking water. Using the following website: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/giardia_cryptosporidium-eng.php, answer the following questions:

- What are Giardia and Cryptosporidium?
- How can drinking water become contaminated with these parasites?
- Have these parasites been found in Canadian drinking water supplies?
- Are water supplies tested for Giardia and Cryptosporidium?

Solution:

- a. What are Giardia and Cryptosporidium?

Protozoans; These two organisms are important disease-causing parasites of humans. Giardia causes an intestinal illness called giardiasis or "beaver fever." Cryptosporidium is responsible for a similar illness called cryptosporidiosis.

- b. How can drinking water become contaminated with these parasites?

-Feces from humans/animals enters water – then consumed/contacted with person

-This may occur by direct contamination of water supply (pollution) followed by subsequent use of that supply or by ineffective water treatment.

c. Have these parasites been found in Canadian drinking water supplies?

Yes – low levels of both parasites, especially *Giardia*, were detected in Canadian drinking water (study by health Canada). Only a small fraction of the parasites appeared to be viable and their ability to infect humans was not determined. Their spread in swimming pools has also been reported.

d. Are water supplies tested for *Giardia* and *Cryptosporidium*?

No – there are no reliable methods for detecting these parasites on a routine basis. This is largely because the methods underestimate the number of organisms present and do not provide any information on their capacity to cause illness in humans. Tests that do exist take longer than is practical for daily monitoring.

Question 3. The tragedy at Walkerton (2000) had a significant impact on drinking water quality and health in Canada. Briefly describe:

a. what happened?

b. how could it have been prevented?

c. repercussions in terms of drinking water in Ontario

Solution:

(a)

- Contaminated surface runoff entered municipal drinking water wells
- O157:H7 strain of *E. coli* bacteria
- Residents experiencing diarrhea, gastrointestinal infections and other symptoms of *E. coli* infection
- seven people died
-

(b)

- prevented through better understanding of risk of surface runoff entering well
- isolation of wells and/or changes in farming procedures in vicinity of wells
- better treatment/disinfection
- better trained operators
- better water quality monitoring and alarms

(c)

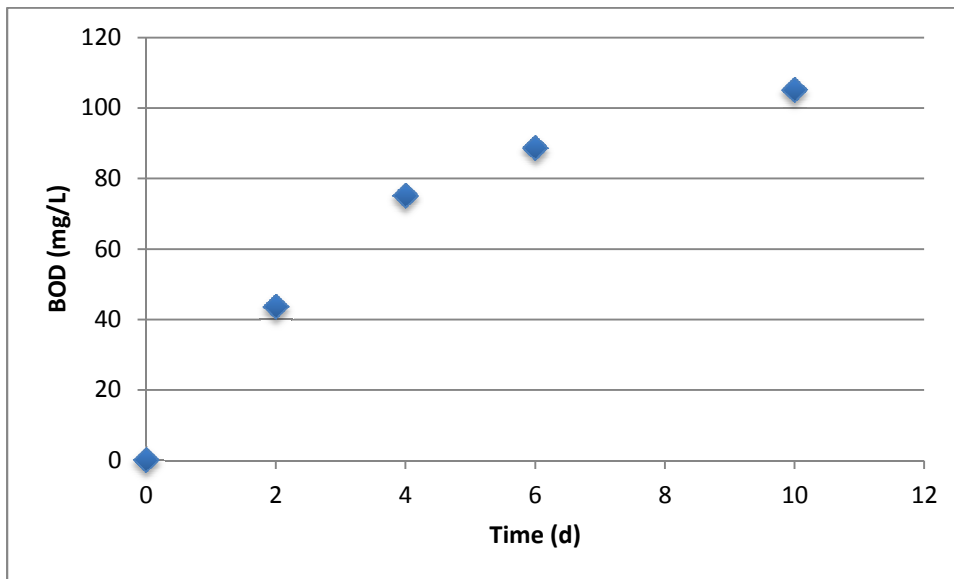
- regulations became much more stringent and enforced
- all water supplies had to do a risk assessment
- all WTP had to meet new regs within certain time and funding was made available
- source water protection

Question 4. A Biochemical Oxygen Demand (BOD) test was conducted on the effluent of a wastewater treatment plant. The wastewater portion added to a 300 mL BOD bottle was 20 mL., and the dissolved oxygen (DO) values listed below were measured. Plot a graph of BOD vs time to determine the 5-day BOD value.

Time (days)	Dissolved oxygen concentration (mg/L)
0	8.5
2	5.6
4	3.5
6	2.6
10	1.5

Solution:

Time (d)	DO (mg/L)	Doi-Dof	Dilution	BOD (mg/L)
0	8.5	0	0.067	0
2	5.6	2.9	0.067	43.5
4	3.5	5	0.067	75
6	2.6	5.9	0.067	88.5
10	1.5	7	0.067	105



BOD5 = approximately 80 – 82 mg/L

Question 4. Briefly describe the purpose and benefits of jar testing and pilot testing.

Solution:

Jar testing:

- Allows testing of a wide variety coagulation/flocculation/settling parameters such as various pH, coagulants, coagulant aids, dosages, mixing energies, mixing times
- Can be done to aid design or for optimization
- Low cost and quick
- Limitations: batch treatment, rather than flow through (ideal conditions)
- Compact

Pilot Testing:

- More expensive and time consuming
- More realistic – flow-thru rather than batch
- Results are more representative of full-scale
- Can also include filtration & disinfection rather than just coagulation, flocculation and settling
- Can take a lot of space (e.g. filter columns have to be as tall as a filter, e.g. 4-5 m)

Question 5. What is zeta potential and why is it important in optimizing coagulation?

Solution:

- Zeta potential is a measure of the charges on the outer layer of a particle
- Allows us to assess effectiveness of coagulation process
- Goal is to get zeta potential as close to 0 as possible (+ve or -ve zeta potential will result in particles that will repel each other)

Question 6. What are the pros & cons of mechanical and hydraulic flocculators in drinking water treatment?

Solution:

- Mechanical:
 - o Moving parts, requires maintenance
 - o Power costs
 - o Better control, can adjust mixing speed and/or change mixer blades
- Hydraulic:
 - o Requires minimum flow to produce swirl
 - o No flexibility to fine-tune
 - o No moving parts or maintenance

Question 7. Find the mixing intensity (G) in a rapid mix (coagulation) tank with water at 30°C (i.e. viscosity of 0.790×10^{-3} Ns/m²) and 0.5°C (i.e. viscosity of 1.786×10^{-3} Ns/m²) that will be produced by a 7.6 kW mixer operating at 75% efficiency in a basin with a volume of 40 m³. Are both mixing energy values within the recommended range for proper mixing of 300-1000/s? If

not, what could be done to make sure that the mixing is always within the recommended range if this is an existing WTP? (note: 1 kW = 1000 N m/s)

Solution:

$$P = 7.6 \text{ kW} \times 75\% = 5.7 \text{ kW}$$

At 30°C:

$$G = [5.7 \text{ kW} / (1.786 \times 10^{-3} \text{ Ns/m}^2 \times 40 \text{ m}^3) \times 1000 \text{ Nm/s/kW}]^{1/2} = 283/\text{s}$$

At 0.5°C:

$$G = [5.7 \text{ kW} / (0.790 \times 10^{-3} \text{ Ns/m}^2 \times 40 \text{ m}^3) \times 1000 \text{ Nm/s/kW}]^{1/2} = 425/\text{s}$$

At 30°C, there's not enough mixing. They would have to replace the mixer with a higher powered one.

Question 8. A WTP that processes 70,000 m³/day has a four compartment flocculation tank with a total length of 25 m, width of 12 m, and depth of 5 m. The paddle flocculator in each of the four compartments has 4 blades, each 25 cm wide and 11.5 long with the centerline of the paddles at a radius (i.e. r) of 1.8 m. Assume the velocity of the water is 30% of the paddle velocity and the drag coefficient is 1.8 (water viscosity of 1.307X10⁻³ Ns/m²). At a rotational speed of 2 rpm, calculate velocity gradient (G).

Solution:

$$V = 25\text{m} \times 12\text{m} \times 5\text{m} = 1500\text{m}^3 \text{ _or if 1 compartment } 360\text{m}^3$$

$$t = \frac{1500\text{m}^3 \times 1440 \frac{\text{min}}{\text{day}}}{70,000 \frac{\text{m}^3}{\text{d}}} = 31\text{min}$$

$$v_p = 2\pi \times 1.8\text{m} \times 2 \frac{\text{rev}}{\text{min}} \times \frac{\text{min}}{60\text{s}} = 0.377\text{m/s}$$

$$v = (1 - 0.3) \times \frac{0.377\text{m}}{\text{s}} = 0.263 \text{ m/s}$$

$$P = \frac{4 \times 4}{2} \times 1.8 \times (11.5\text{m} \times 0.25\text{m}) \times 999.7 \frac{\text{kg}}{\text{m}^3} \times (1 - 0.3)^3 \times \left[2\pi \frac{2\text{rev}/\text{min}}{60\text{s}/\text{min}} \right] \times (1.8\text{m})^3 \times \frac{\text{N}}{\frac{\text{kg} \cdot \text{m}}{\text{s}^2}}$$

$$P = 761 \frac{\text{N} \cdot \text{m}}{\text{s}} \text{ or if only doing one compartment: } 190 \text{ Nm/s}$$

$$G = \left(\frac{761 \text{ Nm/s}}{1.307 \times 10^{-3} \times 1500 \text{ m}^3} \right) = 20 \text{ s}^{-1} \text{ OK}$$

G is within design value of 10 – 60 s⁻¹