Date: Tuesday, November 4, 2019

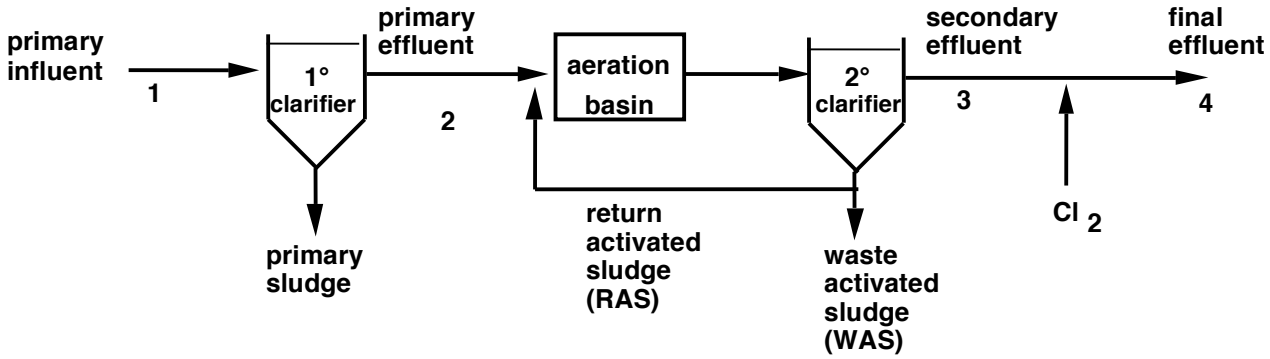
Topic(s): Analysis of wastewater samples throughout a treatment process

Report: Group Lab, hard copy due Tuesday, November 11

Preparation: 1. Read lab handout.

This week is a continuation of the wastewater analysis lab. Today you will complete the 7-day BOD test by measuring the final DO concentrations, and measure suspended solids in your samples.

You'll recall the schematic below of a conventional secondary wastewater treatment facility:



Suspended Solids

Wastewater contains different types of suspended solid material, including sand, grit, detritus, fecal material, trash, etc. Most of the large and heavy solids are removed in the screening and grit removal process. Therefore, the **primary influent (1)** contains mostly organic solids, many of which can settle out by gravity under quiescent conditions in the primary clarifier. After settling, the **primary effluent (2)** contains smaller, lighter organic solids that may be broken down and biodegraded. Next, in the activated sludge system, we grow an entirely new type of solid material – a slurry of microorganisms, and it is these microorganisms that degrade the dissolved pollutants. They also hydrolyze (solubilize) any remaining organic solids into dissolved material to be broken down. These microorganisms cannot be discharged into the receiving water, so the secondary clarifier's purpose is to settle these out and produce a **secondary effluent (3)** low in solids. Finally, the disinfection process serves to inactivate any remaining pathogens and, while not removing any solid material per se, should produce a **final effluent (4)** low in solids.

Suspended solids in wastewater may be either organic or inorganic. The sum of the two is called **Total Suspended Solids, or TSS.** The organic solids can be ignited and incinerated in a 550°C furnace, leaving the inorganic solids behind. We call the suspended solids that burn off Volatile Suspended Solids, or VSS. The stuff that doesn't burn off is called Fixed Suspended Solids, or FSS. VSS + FSS = TSS.

Procedures. *Wear safety glasses and gloves for this experiment. You are working with real samples of wastewater that have the potential to contain pathogenic microorganisms. Be careful and use prudent lab technique. Separate your lab bench into a 'clean' side for notebooks, pens, etc., and a 'dirty' side, whereon you will perform your experiments. You will be using open flame, so tie back long hair.*

Total Suspended Solids – DO THIS PART FIRST

1. You will perform duplicate filters on each of the four wastewater samples. Hence, each group will have 8 pans.
2. Mark eight pans using a mechanical pencil or sharp metal implement. Use a descriptive identifier, such as 8A1, 8A2, 1C7, etc.
3. Record the mass of the clean, dry filter + pan. ("Mass filter + pan")
4. Assemble the filtration apparatus, using forceps to place a filter in the upper housing.
5. Filter an appropriate volume of sample through the filter under vacuum. Approximate values are listed below:
    a. Primary Influent: 40-60 ml
    b. Primary Effluent: 40-60 ml
    c. Secondary Effluent: 1 L (8am) 500 mL (10 am)
    d. Final Effluent: 1 L (8am) 500 mL (10 am).

    Filter as much sample as you can without blocking the filter. If sample still passes through rapidly, filter more sample. This will improve your precision and accuracy. Record the volume filtered. ("Sample Volume")
6. Transfer the filter back into the pan and repeat with the remaining filters for all four samples.
7. Place the eight pans in the 105°C oven for 30 minutes.
8. After 30 minutes, remove the pans from the oven and measure and record the dry mass of each pan and its contents. ("Dry Mass")
9. Transfer the pans to the 550°C furnace for 5 minutes. This furnace is EXTREMELY hot. Use the furnace gloves and long tongs to do this, under the supervision of Monica Hoover, Deborah Sills, or Mona Mohammed.
10. Remove the pans from the furnace and allow to cool briefly. Measure and record the dry mass of each pan and its contents. ("Ignited Mass")
11. Record in the Google Spreadsheet to me the sample names, initial masses, volumes of sample, and dry masses, and ignited masses.

TSS, in mg/L, is calculated as follows:

$$\frac{(\text{Dry Mass, g} - \text{Initial Mass, g})}{(\text{Sample Volume, ml})} * (1000\ \text{ml/L}) * (1000\ \text{mg/g})$$

VSS, in mg/L is calculated as follows:

$$\frac{(\text{Dry Mass, g} - \text{Ignited Mass, g})}{(\text{Sample Volume, ml})} * (1000\ \text{ml/L}) * (1000\ \text{mg/g})$$

Biochemical Oxygen Demand (BOD)

1. Find your bottles from last week.
2. Turn on the dissolved oxygen meter (it should be calibrated, but check with us to make sure).
3. Measure and record the dissolved oxygen in each bottle and record it in your notes and in the class Google sheet.
4. Determine which of your tests are valid tests, using the conditions given last time.
5. Calculate the 7-day BOD concentrations.
6. Wash the bottles, stoppers, and caps, with soap and water, and leave them inverted in the plastic tubs to drain and dry.

Record your data before you leave lab. You will need to use data for each of the four sample types: (1) raw wastewater, (2) primary effluent, (3) secondary effluent, (4) final effluent.

Deliverable:

This is a group lab assignment, due at the date and time indicated in the header of the first page. You will be required to look at the summary data file (i.e., the Lab 9_10 Google sheet).

You should address the following items:

1. Plot the BOD and TSS concentrations at each point in the process on a column graph (note that a column graph is fine because the location in the treatment process does not have numerical spatial value, just a name identifier). If necessary, place BOD on the primary y-axis and TSS on a secondary y-axis. For BOD, you will have to look at the data from your group and other groups to determine which bottles are valid tests. Use error bars.

2. Plot (column graph) total coliforms and *E. coli*, each in CFU/100 ml, at each point in the process. If necessary, plot total coliforms on the primary y-axis and *E. coli* on a secondary y-axis. You may find that axes with log scales will best illustrate these results.

3. Calculate the % BOD removal of each unit process, relative to the raw wastewater (or primary influent).

4. Calculate the % TSS removal of each unit process, relative to the raw wastewater (or primary influent).

5. Calculate the % removal of total coliforms for each unit process, relative to the raw wastewater (or primary influent).

   [a Table would be a good way to summarize questions 3-5]

6. Comment on the ability of each unit process (primary treatment, secondary treatment, and disinfection) to remove each pollutant (BOD, TSS, and coliforms/*E. coli*). Be specific in your answers, explaining why each process is effective or not effective. Are all the processes intended to treat all the pollutants?

If you perform calculations by hand, include those as an appendix to your lab. If you perform calculations by spreadsheet, include a printout of that spreadsheet (clearly organized), as an appendix. Including these calculations allows me to track any errors or give partial credit in the event of mistakes.