CE 326 Principles of Environmental Engineering
Chemical Concepts

Introduction

Some of the common uses of water that are dependent on quality are domestic and industrial water supplies, water based recreation, propagation of aquatic life, and aesthetic enjoyment. Drinking water requires the highest quality for obvious reasons and must be free of health hazards such as pathogens, toxic compounds, and carcinogens. Aesthetic factors such as clarity, taste and odor, and chemical stability are also important. The water quality standards for drinking water are found in the Safe Drinking Water Act (SDWA). See pages 217-222 in your text (Davis and Cornwell, 2008).

In this laboratory several common measures of water quality will be determined using simple chemical and biological techniques. The purpose of the laboratory is to provide a general introduction to water quality as it relates to various sources of water. The water quality parameters to be demonstrated include pH, alkalinity, hardness, turbidity, color, and microbial quality.

pH is a measure of the hydrogen ions in solution and gives an indication of the acid or alkaline conditions of a sample. For practical purposes, it is the negative logarithm of the hydrogen ion concentration. pH is important in every phase of water treatment including chemical coagulation, disinfection, corrosion control, and biological processes.

Alkalinity is a measure of the capacity of a water to neutralize an acid. The alkalinity of natural water is primarily due to anions associated with weak acids, and the most important of these is the bicarbonate ion (HCO₃⁻).

Hardness is associated with polyvalent cations. Calcium and magnesium are usually the most abundant ions contributing to hardness. Hardness cations are removed in precipitation reactions and can form scale in hot water pipes and water heaters.

Color in water is an undesirable condition that may be caused by either organic or inorganic materials such as clay particles or humic substances (high molecular weight, slowly biodegradable organic compounds that result from natural decay processes). Prepared standards containing potassium chloroplatinate are frequently used in estimating color in water samples. Color units correspond to the concentration of chloroplatinate (K₂PtCl₆) in the standards.

Turbidity is a measure of the light scattering nature of a water sample. It correlates with the concentration of suspended matter in the sample. Turbidity is an indication of the performance of filtration in water treatment. Suspended matter is a concern because it is an indication of poor treatment performance and may interfere with the disinfection processes by harboring and shielding microorganisms.

Microbiological quality of a water source may be tested in a variety of ways. Due to the difficulty in measuring specific pathogens (disease causing organisms), surrogate measurements such as fecal coliforms and streptococci are often made.
Equipment and Materials:
- pH meter
- Glassware: Beakers, flasks, burettes, etc.
- Samples: (1) Lake Laverne water, (2) tap water, (3) carbonated beverage, and (4) lemon juice
- Solutions: Methyl orange, EBT, pH buffers, 0.02 N H₂SO₄, 0.01 M EDTA, m-FC broth (Fecal Coliform media)
- Equipment: Membrane filters (0.45µm), Petri dish with pad, tweezers, filter apparatus, etc.

Procedures:

pH - measure the pH of all the samples.
1) Into 30 ml beaker, pour approximately 25 ml of lime and carbonated beverage sample. For Tap and Lake water sample, you may use larger-sized beakers
2) Standardize the pH meter with buffer pH 7, and then slope with either pH 4 or 10 buffer, depending on the range of the pH of interest.
3) Measure the pH of the samples.

Alkalinity - measure the alkalinity of (1) the Lake Sample and (2) tap water.
1) Using graduated cylinder, add exactly 50 ml of each sample into 125-ml flask or larger.
2) Using dropper, add 5 drops of methyl orange indicator solution.
3) Titrate against 0.02 N H₂SO₄ until color change from yellow to orange.
4) Calculate the alkalinity:

\[
\text{ALK, mg/L as CaCO}_3 = \frac{\text{ml of acid} \times \text{N} \times 50,000}{\text{ml of sample}} \quad \text{where N = Normality of the acid}
\]

Hardness - measure the alkalinity of (1) the Lake Sample and (2) tap water.
1) Using volumetric cylinder, add exactly 25 ml of each sample and 25 ml of deionized water (dilution water) into 125-ml flask or larger. Deionized water tap (marked DW) is located at the sink.
2) Add 2 ml of pH 10 buffer (to facilitate dye coloring) and add 2 scoops of EBT powder (dye) into the flask.
3) Titrate against 0.01 M EDTA until the color change from wine-red to blue.
4) If everything is right, less than 15 ml of EDTA solution should be used to complete titration within 5 min (to prevent formation of CaCO₃).
5) Calculate the hardness:

\[
\text{Hardness, mg/L as CaCO}_3 = \frac{\text{ml of EDTA} \times \text{B} \times 1,000 \times \text{dilution factor}}{\text{ml of sample}} \quad \text{where B = mg CaCO}_3 \text{ equivalent to 1.00 ml of EDTA titrant = 1; dilution factor = 2; ml of sample = 50 ml}
\]

Color - measure the color of (1) the Lake Sample (2) Tap water
1) Compare color of the sample water in Nessler tube with standards provided in the same tube rack. Dilution may be required if the color in the sample tube is more intense than the standard tubes.

2) Calculate color: Color = estimated color units x dilution ratio (No dilution in this lab)

**Turbidity** - measure the turbidity of (1) the Lake Sample, (2) Tap water.

To save time, turbidimeter has been standardized against a known set of standards (<0.1, 20, 200, 1000, 2000 and 4000 NTUs) prior to the lab period. Avoid touching the side of turbidity tubes by bare hand since finger print may increase turbidity.

1) Pour each sample into the turbidimeter tube up to the top of the white line (approximately 30 ml). Cap it and wipe the side of the tube clean, using Kim wipe paper. From now, hold the tube by the cap.

2) Drop silicone oil onto the side of the tube and wipe the oil off but leave only thin layer on the glass surface. This will minimize any scratch on the tube since the oil has the same reflective index as that of the glass.

3) Place the tube into the turbidimeter and close the lid.

4) Measure turbidity (in terms of NTUs).

**Microbial quality** - measure fecal coliform of (1) the Lake Sample.

1) Obtain Four(4) Petri dish with pad from lab instructor and write your **group name/section/volume (either 0, 5, 10,or 20 ml)** on the **writing area** at the **bottom** of the plate (Each pad was soaked with sterilized m-FC broth prior to the lab). 0-ml sample means that 20 ml of sterilized deionized water was used, instead of sample.

2) Make sure that the coliform plate, filter, filtration device, 95% ethanol, tweezers, and Bunsen burner are nearby.

3) **Sterilize the tweezers** by dipping the tweezers into 95% ethanol and put into flame of the Bunsen burner. The tweezers will burn momentarily.

**Caution** make sure that there is not too much alcohol on the tweezers before burning and that the flame is put out and the tweezers are cooled down somewhat before using**Caution**

4) Set up the filtration device and rinse inside the funnel thoroughly with sterilized deionized water to decontaminate any possible bacteria from previous use.

5) Using the sterilized tweezers, remove the filter (only white color membrane with grid marks on one side) and place it on the filter holder with **grid side up**.

6) Pour 20 ml of sterilized deionized water into the funnel and turn on the vacuum pump.

7) When there is no sample left on the filter, rinse the funnel and graduated cylinder with sterilized deionized water into the funnel.

8) After all water has been pulled through the filter, turn off the pump and use the tweezers to remove the filter from the filter holder (Sterilize the tweezers again if needed).

9) Place the filter **with grid side up** onto the pad in the plate.

10) Repeat step 3) to 8) for the Lake sample volume 5, 10, and 20 ml. Add sterilized deionized water to make the sample volume more than 10 ml before turning the pump on to evenly distribute the sample on the filter membrane.

11) When finish, Stack all Petri dish together and give them to lab instructor for further incubation in 44.5 ± 0.2 °C for 24 ± 2 hours

Revised by Jack Duangmanee 02/05/07, edited by tge
12) Assign representative(s) from each group to count the fecal coliform on Friday after class. Meet lab instructor at room 112 in Town Engineering Bldg. (the same laboratory)

13) Counting the fecal coliform:
   a. Count only the colonies that appear blue or greenish-blue (fecal coliform); do not count those that appear grey, buff, or colorless (non-fecal).
   b. Usable plate will have the number of blue colonies from 5 to 50 (for small Petri dish).
   c. Report in terms of Colony forming Unit (CFU/100ml):

      Fecal coliform (CFU/100ml) = \text{the number of colonies} \times \frac{100 \text{ ml}}{\text{sample volume (ml)}}

   d. If there are more than one usable plate, average the CFUs. If the colonies on every plate are more than 50, report as “TNTC” (Too Numerous To Count) and more dilution of original samples is needed.

Report

Calculate the average results for all the groups (use conventional units, e.g. mg/L) for the results listed on the course webpage. Write a brief discussion on the results and the differences in the results between samples.