Analysis of the Dupage River Upstream, in, and Downstream of Naperville

Objective: Last week, you tested the quality of different water samples by measuring the degree of hardness. This week you will test other parameters of environmental water, in this case using the river as your source. Water will be collected from the river near McDowell Forest Preserve, the River Walk in Downtown Naperville, and near the DuPage River Park. These will serve as samples upstream, in, and downstream from the City of Naperville, respectively.

You will test two measures of water quality: 1) acidity or basicity of the water and its ability to resist changes in pH and 2) chloride ion content.

Background:

Acidity and Basicity Analysis

Acidity can be easily measured using a pH electrode and meter. This is an instrument that measures the $[H^+]$ concentration by measuring the voltage between two electrodes. The voltage is proportional to the pH of the solution. The measurement is much more precise than pH indicator paper.

Pure rain has a pH of 5.6 which is slightly acidic due to the carbon dioxide in the atmosphere (recall: CO_2 (g) + H_2O (l) $\rightarrow$ H_2CO_3 (aq). Therefore, if water collected in the river comes from pure rain, the pH should be 5.6. If the pH is different, there must be exogenous sources of acid or base.

Excessive acidity is harmful to natural waters. Aquatic plants are unable to grow in soils that are acidic. At pH 6,0, snails and crustaceans die; at pH 5.5, salmon, rainbow trout and whitefish die; at pH 5.0, perch and pike die; at pH 4.5, eel and brook trout die; below pH 4.0, a lake will support very few forms of aquatic life. Spawning is particularly hit hard as the early spring is often the time when the acidity is the worst. In addition to direct effects of the acidity, there are also indirect effects. An increased acidity will allow some metals to become soluble. This is true for lead and aluminum, both of which are toxic to living organisms.

Some bodies of water are able to stave off the effects of acid rain. These bodies of water are *buffered*. A buffer is a solution that is able to resist changes in pH upon the addition of acid or base. Areas of the country that have high concentrations of limestone are more resistant to the effects of acid rain.

Chloride Ion Analysis

The chloride content of natural surface waters depends on the geology of the area. A higher than natural concentration of chloride suggests some source from human activity. The chloride levels in a river system will increase with human use of the water. A common environmental study would include mapping the chloride level of samples along a river system in order to obtain an environmental picture of the local natural water system.

Chloride is not a dangerous pollutant. Instead, it acts as an indicator of high human use of the water being analyzed. Sewage treatment plants do not add chloride to water. The major non-industrial sources of chloride in natural waters are from human and animal waste, salting of roads, water softeners, and kitchen use of salt. It is important to note that humans use water and the water we use goes back into the natural system from which it came. Every sink must have a drain.

The chloride will be quantified using a titration experiment. The chloride will be titrated with silver nitrate.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator used in this experiment is sodium chromate, which is yellow, but reacts with excess silver ion to produce silver chromate, which is red.

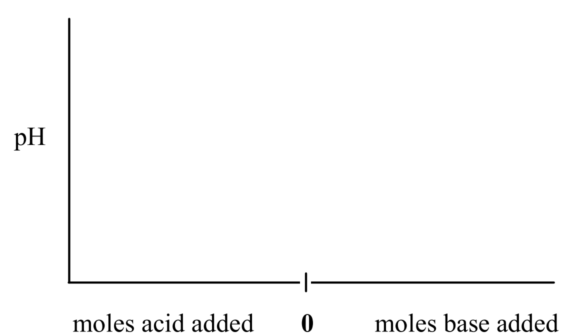
Procedure:

I. **Acidity Analysis**
   A. Calibrate pH meter
      1. The pH meter must be calibrated before use. This is similar to doing a standard curve. Use the pH meter (in calibration mode – see your instructor for details) to analyze two different concentrations of hydrogen ions. The pH meter will then calculate a standard curve, which will then allow it to measure the pH of unknown solutions. Each brand of pH meter will accomplish this task in slightly different manner. Follow the instructions for your pH meter.
   B. Test pH of River Sample #1 and titrate with HCl
      1. Place 50 mL of river sample and a magnetic stirrer in a 100 mL beaker.
      2. Place electrode into sample and measure the pH.
      3. Add 0.1 M HCl to the stirring sample in 0.30 mL increments. Record the pH after each addition. Continue until the pH reaches 2.5.
   C. Test pH of River Sample #1 and titrate with NaOH
      1. Place 50 mL of fresh river sample and a magnetic stirrer in a 50 mL beaker.
      2. Place electrode into sample and measure the pH.
      3. Add 0.1 M NaOH to the stirring sample in 0.30 mL increments. Record the pH after each addition. Continue until the pH reaches 11.5.
   D. Test each river sample in a similar manner as (B) & (C)
   E. Test the Buffering capacity of a 'limestone' bottom lake.
      a. Place approximately 0.01 g of calcium carbonate into 50 mL of *one* of your river samples
      b. Titrate your sample with HCl and NaOH as above.

II. Chloride Ion Analysis
   A. All of your glassware must be thoroughly rinsed twice with deionized water.
   B. Test the indicator color change
      1. In a microwell or test tube, add approximately 1 mL deionized water and 1 drop sodium chromate indicator. Note the color.
      2. In another microwell or test tube, add approximately 1 mL deionized water, 1 drop sodium chromate indicator and one drop silver nitrate. Note the color.
   C. Test each river sample in *triplicate*:
      1. Place 20 mL of water sample and two drops indicator in a beaker.
      2. Titrate the water with 0.01 M $AgNO_3$.

Data Analysis:

1. Graph your titrations of your river samples so that the HCl and NaOH data are on the same graph:
   a. Change your mL of acid or base into moles of acid or base
   b. Enter your data into EXCEL so that your mL of HCl added are negative numbers
   c. Enter your data into EXCEL so that your mL of NaOH added are positive numbers



2. Determine the concentration of chloride in your river samples.
3. Compare the water quality of the different river samples using the chloride ion concentration and pH data.

Questions:

1. A buffered solution resists changes in pH, so one would expect the presence of a buffer to broaden a pH titration curve (see Figure 17.11 on pg 658 for strong acid vs. weak acid (i.e., buffer) titration). Is there a difference between your different water samples in their ability to buffer acid or base?
2. Does the inclusion of limestone increase the buffering capacity of the water samples? Write an equation demonstrating this buffering capacity.
3. How many moles of acid can react with 5 mL of a 3 mM solution of NaOH? Write the equation that describes the reaction.
4. Our blood has a buffering system similar to the buffering system of limestone-bottom lakes. Why is this important?

References:

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Bunce, Nigel, *Environmental Chemistry*. Wuertz Publishing, Canada, 1991.
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