Lesson 5

Chemical Properties of a River

Introduction

One of the chemical properties that can affect the health of a waterway is pH. In the field, biologists, water managers and concerned citizens measure the pH of water as one part of determining its quality.

In this lesson we will explore the chemical property pH, and discover whether household liquids such as juices and cleaners are acidic or basic. A pigment from red cabbage will serve as our acid-base test indicator.

In chemistry, pH, is an abbreviation for the power of hydrogen or the percentage of hydrogen in water. pH is expressed as a scale from 0-14 and is used to specify how acidic or basic (or alkaline) a water-based solution is. Pure water is neither acidic nor basic and has a pH of 7. Acidic solutions such as vinegar or cola, have a lower pH, while basic solutions such as toothpaste or soaps have a higher pH.

Each creek or river will have its own pH, determined by the type of bedrock it flows over and through, and the type of vegetation around it. Industrial activities such as factory effluent or mining can strongly negatively affect the pH of a waterway. Many species have a very narrow pH range tolerance, and as such any dramatic changes in pH can result in changes in the aquatic insect community, result in dramatic algal blooms, make fish spawning not possible, or render our treatments for safe drinking water ineffective. These are some of the reasons we need to carefully monitor and understand pH in our watersheds.

This lesson plan will lead you through a short activity to help you better understand how to use a simple pH indicator, in this case cabbage, to measure pH of different foodstuff juices and household cleaning substances.

Time: 45 minutes

Safety Note: This activity requires the use of a knife, poisonous chemicals and hot water. Ask an adult to assist you. Always follow the safety advice on the products you are using.

Materials: Fresh red cabbage, sharp knife, cutting board, hot tap water, 7 clear plastic disposable cups, 7 plastic spoons, large plastic bottle, coffee filter and/or strainer.

A range of the household substances which may include:

• strongly acidic, e.g. powdered toilet cleaner

• acidic, e.g. vinegar, lemon juice, white wine, lemonade or citric acid

• weakly acidic, e.g. cream of tartar

• neutral, e.g. pure water, shampoo or baby shampoo

• slightly basic, e.g. baking soda

• basic, e.g. milk of magnesia, washing soda or floor cleaner

• strongly basic, e.g. dishwasher liquid or powder

Instructions

1. Using a sharp knife and cutting board, finely slice three or four red cabbage leaves.

2. Place the cabbage leaves in the plastic bottle, half fill the bottle with hot water and screw the lid on tightly.

3. Shake the bottle for a few minutes until the water becomes a deep purple colour. Leave the solution to cool.

4. Strain the solution through a coffee filter or a fine sieve and add sufficient water to the solution to make about 1 L.

5. In each of the cups, place a small amount of one of the above household substances in the following order: strongly acidic; acidic; slightly acidic; neutral; slightly basic; basic and strongly basic.

6. Now half fill each cup with the red cabbage water and stir the solution. If arranged in order, the jars should display a spectrum of colours from cherry red (strongly acidic), pink-red (acidic), lilac (slightly acidic), purple (neutral), blue (slightly basic), green (basic) and yellow (strongly basic).

7. This rainbow of colours occurs because purple

cabbage is what is known as a wide range pH indicator. Purple cabbage contains a natural pigment known as anthocyanin. When more hydrogen ions (H+) are present, anthocyanin reacts with these and turns red. When hydrogen ions (H+) and hydroxide ions (OH-) are in balance in a neutral solution, it remains purple, when there is an abundance of hydroxide ions (OH-), it turns yellow or green. Human-caused factors and natural influences can increase or decrease the amount of hydrogen ions in our watersheds, thus changing the pH of the water. Most living things have evolved a tolerance for a narrow range of pH values that are close to a pH of 7, or neutral, and any changes outside of this narrow range can have negative impacts on fish egg survival, aquatic insect survival, or aquatic plant productivity.

Summary

The things we eat and drink are mostly acidic, and the things we use for cleaning are generally basic. Basic substances usually taste unpleasant, but a cleaning agent usually needs to be basic to remove dirt and grease.

Substances that are acidic or basic make the eyes sting, so things like baby shampoo are made to be neutral.

Acids

Acids are a very common group of chemical compounds, many of which occur naturally. Acids can be strong or weak.

Citric acid, which occurs naturally in lemons, is a weak acid. Hydrochloric acid (used for soldering) and sulfuric acid (battery acid) are very strong acids.

Bases

Bases (often called alkalis) are another group of chemical compounds that have different chemical properties from acids. When bases and acids are added together, they will neutralise each other's properties.

We describe whether things are acidic, basic or neutral by using a scale called the pH scale. The pH scale ranges from zero to 14. A substance with a pH of:

- 0 is a very strong acid
- 3 – 5 is a weak acid
- 7 is neutral
- 8 – 9 is a weak base
- 13 – 14 is a very strong base

Pure water has a pH of seven and is regarded as neutral.

Acids and bases can be detected by a group of chemical compounds called acid-base indicators. One of the first known naturally occurring indicators was a type of lichen called litmus. Litmus turns red in the presence of an acid or blue with a base.

Most indicators used today to detect acids and bases are man-made. However, many plant pigments, such as the red cabbage you used, contain chemicals that act as acid-base indicators.

pH and our Watersheds

In general, most natural water sources in the Columbia Basin Kootenays are very close to neutral. Some are slightly acidic, especially if they have a lot of rotting vegetation inputs like leaves or needles from trees. Others are slightly basic, like creeks that flow over or through limestone, dissolving some of the rock on the way and picking up minerals that make it more basic. Life in our creeks is well adapted to this narrow range of pH, from just below 6 to just above 8 on the pH scale, but human activities can push a creek's pH outside this range. If the water in our watersheds receive too much untreated mine waste water, or industrial or agricultural pollutants, it can drastically affect the pH of the water in that watershed. This, in turn, can affect how well fish eggs survive or how many aquatic insects are able to live in that creek. This is why water managers constantly test the pH and other chemical properties of the water in our creeks.

Resources

For a great summary video of this experiment, check out this Sci Guys video.