

## Chapter 5. The Idea of pH

### Lesson 1. The pH Scale

**Overview:** Contaminants that influence the quality and usefulness of water can be chemical, physical, or biological. Many household and industrial items washed down the sink contaminate our water supply and reduce water quality. Pollutants like car exhaust, industrial smoke, anti-icing agents for highways and roads, highway oil and spilled gasoline end up in our water as chemical contaminants. Indirectly, exhaust and smoke end up in our water as part of acid rain precipitation and deposition. An important property of water that determines its reaction with many substances is acidity, which we measure as a property called pH. To understand chemical contamination of water, a person must consider pH. Many chemical contaminants have the ability to raise and lower the pH of water from its natural systems, and the health of their associated fisheries, aquatic insects and plants.

**Purpose:** The purpose of this activity is to introduce to the students the idea of pH and its affect on the quality of surface water systems.

#### **Materials Needed:**

- Bolt of string or spool of thread
- Scissors
- Supply of plastic or paper cups
- Rulers
- Masking tape
- Strips of paper (1" wide x 5-6" long)
- Pens or pencils
- Meter sticks
- Tape

#### **Procedure:**

1. \_\_\_\_\_ When class begins, ask the students if they have ever heard of the term pH. Most likely they have not. Ask them if they know what the word "acidic" means. It may be useful to tell them to give examples of things they know are acidic; ask them to explain why they think the item is acidic. For instance, what causes something to be acidic? Ask them what they know about things that are acidic. If it is necessary, give examples of acidic items to begin discussion. Ask the students how it would feel if any of these substances got into their eyes. Make them avoid using the words "good," "bad," or "it hurts," when describing their feelings. You want them

to really specify the feeling associated with acidity. Explain to them that acids can burn eyes or any body tissue if the substances are acidic enough. Ask them what effect does something acidic have on wood, metal, paper, plastic, and why?

2. \_\_\_\_\_ Repeat the procedure with the term "basic." The students may be more naïve to this subject. If they are, ask them how it feels to get soap in their eyes. Again, make them avoid using the words "good," "bad," or "it hurts," when describing their feelings. Explain that soap is basic, and just like the items that are acidic, basic things can burn their eyes and even their skin if they are basic enough. Ask them how it would feel if they did not wash the soap off after bathing.

3. \_\_\_\_\_ Finally, repeat the discussion with things that are neutral. Tell them it might be useful to think of substances that would not burn their eyes. Explain to them that our bodies, most plant and animal systems, and surface and groundwater systems work at or near neutral pHs. If a non-neutral substance is introduced to these systems it may be harmful. Ask the students what happens when water is mixed with an acid or a base.

4. \_\_\_\_\_ Explain that "pH" measures acidity and basicity. A scale of 1 to 14 measures pH. One is most acidic. Seven is neutral. Fourteen is most basic. Tell them that pH is a measurement of the hydrogen ion. It is not important that they understand what a hydrogen ion is. It is necessary only that they know that it is the hydrogen ion that makes a substance acidic. The more hydrogen ions in a liquid, the more acidic it is.

5. \_\_\_\_\_ At this point, have the students assemble into groups of four. Distribute scissors, a ruler, a meter stick, tape, paper and pens to each group.

6. \_\_\_\_\_ Explain that each unit on the pH scale is ten times more acidic than the one above it. It is also ten times more basic than the one below it. With the help of the string, the students can understand the difference between the different levels of pH. Have them cut pieces of string and label them with a small strip of paper and tape accordingly:

Size of string	Label
1 mm	pH 14
1 cm	pH 13
10 cm	pH 12
1 meter	pH 11
10 meters	pH 10
* You may want to tape out 10 meters on the floor for convenience.	

7. \_\_\_\_\_ Make sure as they are cutting and labeling the string, that they order them on a table in front of them. After the students have finished cutting, remind them

that each piece of string represents an amount of hydrogen ion. Explain that they are looking at only pH's from 14 down to 10. Ask them to imagine the length of a football field. Tell them that this would be the length of string for pH 9. They do not have string this long. They should write "pH 9 = the length of a football field" on a strip of paper and place it next to the 10 meter string on the table. For each successive pH unit, the groups should multiply the number of football fields by ten until they arrive at a pH of 1. For each pH unit, they should write the pH and number of football fields on a strip of paper. Place the pieces of paper in order on the table.

8. \_\_\_\_\_ When the students have finished with this procedure, have them look at the 1 mm piece of string associated with a pH of 14. Then have them look at the length of football fields associated with the pH of 1. Ask them for the difference in hydrogen ion between a pH of 14 and a pH of 1. Tell them that another way to illustrate this idea is to use a balance - 1 mg = pH 14, 10 mg = pH 13, 100 mg = pH 12, 1000 mg = 1 g = pH 11, ect.

9. \_\_\_\_\_ This is an appropriate time to explain that contaminants come in a variety of forms, some physical, some biological and some chemical. Many chemical contaminants are so because they are either acidic or basic. If time permits, question the students about the idea that most surface and ground water systems have a pH between 5 and 8. Ask the students why they think this is so. Again, explain that water in its pure state has a pH near 7. This variation in the pH of natural systems results from interactions of soil, rock and rainfall in contact with that of water. When water passes through air, smoke, soil, rocks, rubbish, peat or debris, the pH of water changes to reflect the hydrogen ions in these materials. Introducing a large amount of chemical contaminant may change the pH (or the amount of hydrogen ion) in a neutral lake or river dramatically. This will often cause heavy die-offs of many fish, insects or plants that live in or around that lake or river. \*Have the students save the string and paper strips for lesson two.

**Lesson Learned:** pH is measured on a scale of one to 14. One is most acidic. Seven is neutral. Fourteen is most basic. Each unit on the pH scale is ten times less acidic (more basic) than the unit below it. Something that is not acidic is neutral or basic. All aqueous liquids have a pH.

**The lesson above was adapted from "What is Water Quality? A Resource Guide for 4-H Leaders and Teachers,"** 80 pages of activities and experiments related to water quality. (\$5.00) Order from the Montana 4-H Program at Montana State University-Bozeman. Phone 406-994-3501.