pH Test #2: Manipulating a liquid's pH (From a series of 5)

Adapted from: "Acid Tests" in *Environmental Education in the Schools*. Braus, Judy and David Wood. Peace Corps, 1993.

Grade Level: intermediate

Duration: 25 minutes

Setting: lab or classroom

Summary: After learning about the pH scale, students will return an acidic solution to a neutral pH by adding solutions and substances that will neutralize the acid.

Objectives: Students will understand that adding other substances can change the pH of the original substance. They will discuss how some management practices have used this knowledge to fix the pH of waterways.

Related Module Resources:
- "pH Test #1, #3, #4, #5" Activ.
- "pH, Plants and Fish" Activity
- "pH People" Activity
- HANBOOK: p. 57-63
- FIELD MANUAL: p.33-35
- pH Information/Fact Sheet
- Interactive pH scale poster

Vocabulary: pH, neutral, acidic, basic, acid precipitation, liming

Materials (Included in Module):
- PH measuring device – pH paper, meter or Hach pH kit (kit will take longer)
- Small, clear plastic cups
- Certain liquid solutions: vinegars, lemon juice, lemonade, bleach, ammonia, distilled water, spring water, sodas, seltzer
- Baking soda, antacids
- Interactive pH Scale Poster

Additional Materials (NOT Included in Module):
- Certain liquid solutions: creek/pond/ground/tap water, acid mine drainage, sodas, coffee, milk, orange juice, cleaning agents, others

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

7th Grade
4.3.7.B Describe how human actions affect the health of the environment.
- Explain how acid deposition can affect water, soil and air quality

10th Grade
4.3.10.B Explain how multiple variables determine the effects of pollution on environmental health, natural processes and human practices.
- Explain how human practices affect the quality of the water and soil

12th Grade
4.1.12.C Analyze the parameters of a watershed.
- interpret physical, chemical and biological data as a means of assessing the environmental quality of a watershed

BACKGROUND:

Water (H_2O) contains both hydrogen ions (H^+) and hydroxyl ions (OH^-), and other solutions also contain free hydrogen ions within them. A **pH** test measures the concentration of free hydrogen ions, which will indicate whether a solution is acidic or basic.

The values for pH are arranged on a scale from 0 to 14. A pH of 7 indicates the solution is **neutral** and the concentration of H^+ is equal to the concentration of OH^-. Pure distilled water is considered neutral. Values of pH less than 7 are considered **acidic** (more H^+ are present, less OH^-). Values of pH greater than 7 are considered **basic** (less H^+ are present, more OH^-). Because pH is based upon a log scale, ($pH = -\log_{10}[H^+]$), each unit change in pH indicates a ten-fold difference in the concentration of hydrogen ions. For example, lake water at pH 5 is ten times more concentrated with H^+ than water at pH 6.

The pH of a solution does not remain constant. It can be influenced by other substances (liquids, gases, or solids) that come in contact with the original solution. With these additions, the pH may rise (making it more basic) or the pH may be lowered (creating a more acidic condition). Human activity often alters the pH of our rainwater and waterways.

Although most of us are aware of acid rain, **acid precipitation** can also include snow, hail, and sleet. Cars and coal-burning factories cause acid precipitation by releasing sulfur dioxide (SO_2) and nitrogen oxide (NO_x) into the environment. Through a reaction with atmospheric water, these chemicals are changed into sulfuric acid (H_2SO_4) and nitric acid (HNO_3), which are the chemicals in acid rain. Both of these acids can dissociate (break apart) to produce extra hydrogen ions, thus lowering the pH of the rain and any creeks that the rain enters.

Another Western Pennsylvania problem that lowers the pH of our waterways is acid mine drainage (AMD). Acid mine drainage is often the product of water running through abandoned mine operations or in some cases current mining. Through numerous chemical reactions, water passing through overburden (soil and crushed rock leftovers from mining coal seams) creates sulfuric acid, iron, and other metals to be released. The sulfuric acid (H_2SO_4) can dissociate adding extra hydrogen ions to water (lowing pH).

Inputs of acid can cause creek water to have an unnaturally low pH. Such changes in pH can cause serious problems for the organisms living in an aquatic habitat. Sometimes streams are able to combat against acid inputs (extra hydrogen ions). A stream's ability to resist changes in pH when acid is added is called **alkalinity**. A creek that has high alkalinity is well buffered so large inputs of acid (maybe from acid rain or AMD) will have little affect on the overall stream pH.

The amount of carbonate (CO_3^{-2}) and bicarbonate (HCO_3^{-}) in water helps to determine its alkalinity. The more of these present, the better chance the water has to resist a change in pH (called alkalinity). Bicarbonate can react with free hydrogen ions to create carbonic acid (H_2CO_3), raising the pH. The carbonic acid can also react with calcium carbonate ($CaCO_3$), which is a component of limestone and sandstone rocks in Pennsylvania, and after a few more reactions, additional free hydrogen ions in the water will be used up (raising or maintaining the pH).

One method of increasing the pH of waterways is called **liming**. This is the process of adding calcium carbonate ($CaCO_3$ - limestone) to the water. Liming is most often done in lakes and wetlands, though rivers, streams and entire watersheds have also been limed. Acid mine drainage is also treated through liming.

There are some drawbacks to liming. In addition to being expensive, liming is not a long-term solution. Indeed, if acid precipitation continues to fall, calcium carbonate has to be added frequently (often yearly) to maintain a certain pH. Lime powder can sometimes settle to the bottom of the waterways and act just like sediment – smothering fish and insect eggs, filling in spaces where creatures would live, or clogging gills. Moreover, liming has been shown to affect terrestrial plants near the waterway and zooplankton in the water. Because of the drawbacks of treating acid inputs to waterways, it is most important to <u>prevent</u> or minimize the creation of acid precipitation and acid mine drainage that causes acidic waterways.

OVERVIEW: Students make an acidic solution with vinegar. They will then return the solution to a neutral pH by adding solutions and substances that will neutralize the acid. They will do this using their knowledge of the pH scale and the pH values of various solutions and substances.

PROCEDURE:

1. If the class has not already performed pH Test #1, they should do it prior to this activity. If they cannot, discuss the different pH values of household/common liquids with the students. An excellent way to display this information is to use the *Interactive pH Scale Poster* (enclosed in the module).

2. Divide the students into groups. There should be two to five students in each group.

3. Have each group put ¼ cup tap water into a container and measure the pH by any method described in the Test Kit Instruction Section of the Module Resource Guide.

4. Tell the groups to add a small amount of vinegar to the water and measure the pH again. You may want students to use a pipet or eyedropper to add vinegar if they cannot pour small amounts. They should continue adding vinegar until the solution has a pH of 4.

5. Tell the students that they must now return the pH of the water to its original pH (using the substances used in pH Test #1: vinegar, lemon juice, cola, distilled water, liquid antacid, antacid tablets like Rolaids, baking soda solution, powdered lime solution, coffee, milk, tap water, etc.) Tell students the goal is to return the pH to its original value by adding the smallest amount of ONE substance.

   CAUTION: Do not use ammonia in this activity.

DISCUSSION:

Talk to the students about what they did to the solution to turn it back to its original pH. What was most successful? *Rolaids/antacid should be most effective in small amounts. Baking soda would also work well.*

Ask students what they or their parents do when they get acid indigestion in their stomach. *Have them realize that they add calcium carbonate to their stomach using antacids and Rolaids – look at the ingredients of these – so in essence, they are "liming" their stomach to rid the extra acid.*

Ask the students to relate the experiment to a possible or actual management practice for lakes/wetlands. *In some areas, people have added lime pellets or powder {Calcium Carbonate $CaCO_3$} to lakes to make them less acidic. Although relatively successful, this method has drawbacks. See the Background section of this activity.*

Have the students think of the drawbacks that might be associated with such management practices. *See the Background section.* Consider the possible affects for organisms if chemicals were added to the lake. *See the Background section.* How much lime should be put in the lake? *Too much would cause problems, so the resource managers would want to be careful with their calculations.*

Explain to students what acid mine drainage is. Ask them how they think it can be corrected. *Often to address the pH problem of acid mine drainage, calcium carbonate {lime/limestone} is also added.*

Help the students to come to the conclusion that one solution to correcting acidic rain and acidic waterways is to stop or reduce acid rain and acid mine drainage to begin with.

EVALUATION:

- Explain how pH can be altered in an aquatic system. How might pH be lowered? How might pH be raised?
- What are some substances that could be used to raise the pH of a liquid?
- Explain how this knowledge could be applied to lake/wetland/creek management.

EXTENSIONS AND MODIFICATIONS:

- Have students conduct alkalinity tests on their vinegar solution and on some of the solutions that they used to correct the vinegar solution's pH.
- Have students work in groups doing a number of the different "pH and Acid Test" activities at different stations.
- Have student discover which will reduce acidity quicker – a full tablet of Rolaids (simulating a piece of limestone rock) versus a crushed Rolaid (simulating crushed limestone). *(Crushed should be quicker because of more exposed surface area for reaction).*

NOTES (TEACHERS, PLEASE WRITE ANY COMMENTS ABOUT THIS ACTIVITY BELOW):

COMMON LIQUIDS / SOLUTIONS AND THEIR pH

Gastric juices – pH about 1 *(You will not test this)*
Battery acid – pH about 1 *(You will not test this)*
Lemon juice – pH about 2
Lemonade – pH about 2
Acid Mine Drainage – pH between 2-5
Vinegar – pH about 3
Cola / Sodas – pH between 3-4.5
Tomato Juice – pH about 4
Acid rain – pH between 4 –5.6
Normal rain – pH about 5.6
Saliva – pH about 6.5 *(You May Not Want To Test This)*
Distilled water – pH about 7
Northwest PA streams – pH usually between 7- 8.5
Human Tears / Blood – pH about 7.5 *(Do Not Test This)*
Egg White – pH about 8
Sea Water – pH about 8
Baking soda in water – pH between 8-9
Ammonia – pH about 11
Bleach – pH about 12