Overview

Students explore pH with an emphasis on soil pH. This activity uses soils and vinegar solutions.

Background

One of the significant factors in growing successful gardens or crops of any kind is the pH of the soil. A simple explanation of pH is whether a solution is an acid, base or neutral. The pH scale is numbered from 0 to 14. Seven is neutral, and distilled water would have a pH of 7.0. Solutions below 7.0 are acidic, and those above 7 are basic or alkaline. Examples of alkaline solutions are lye soap – pH between13 and 14, bleach – pH 13, a solution of ammonia – pH 11, Milk of Magnesia – pH 10, baking soda – pH 9, sea water – pH 8. Examples of acid solutions are black coffee – pH 5, tomato juice – pH 4, vinegar – pH between 3 and 4, orange juice – pH 3, lemon juice – pH 2, gastric acid – pH 1, battery acid – pH between 0 and 1.0. Human skin has a pH of 5.5, while human blood is 7.3 to 7.4. (Note: Temperature will alter pH.)

How does this relate to soils? Soils are not a solution. This is true, but soils capable of growing plants contain about 25 percent water and 25 percent air. Mineral transport into a plant's roots is accomplished when those minerals are dissolved in the water found in soil and those minerals are absorbed as the water is taken in. That is the solution we are actually evaluating. Since water molecules cling to soil particles, it is very difficult to remove the water solution to test it. So, we test the moist soil. Most soils in the Eastern United States have a pH between 6 and 6.9.

Soil pH is determined by the parent material of the soil. The rocks that weather to produce soil minerals also dissolve elements into solution. Rocks such as limestone will result in soils with higher pH. Plant material, microorganisms, decomposition, amount of rainfall, temperatures and animal waste, all alter soil pH. Acid rain caused by the burning of fossil fuels also affects soil pH more significantly than a more neutral pH and will cause additional leeching of soil and rock minerals that further affect soil pH. An interesting map of the world's soils by pH can be found at *http://www.globalsoilmap.net/content/soil-ph-map-world-based-hwsd* and the impact of rain is easily seen. Soils in Florida have a median pH of 6.1, but can vary widely across the state. Soils growing slash pine can be quite acidic. Soils formed from calcium-rich limestone or seashells will be alkaline. So, in coastal areas and South Florida, pH will be higher – above neutral to alkaline. Florida's common building materials, concrete and stucco, will also create alkaline conditions in soils near buildings, sidewalks, walls or where water draining from those structures flows over or through soils.

Time:

Groundwork: 45 minutes

Exploration – Soil pH: 45 minutes

Exploration – How does pH affect plants?: 45 minutes setup, three-to-four weeks ongoing observations

Making connections: Ongoing

Materials:

- **Red cabbage water**
- **Baking soda**
- **Glasses with water**
- **Wide-range pH paper (0-12)**
- **pH test kits for soil**
- **A variety of common household liquids and beverages (milk, orange juice, cola, pickle juice, dish detergent, vinegar)**
- **Garden soil**
- **Bean plants**
- **White vinegar**
- **Copies of student handout pages**

Standards At-A-Glance

Florida Standards Met:

SC.2.E.6.3, SC.2.L.17.2, SC.3.N.1.6, SC.3.N.1.7, SC.3.P.8.3, SC.3.N.1.2, SC.3.N.1.3, SC.4.E.6.3, SC.4.E.6.6, SC.4.P.8.1, SC.8.P.8.4, SC.8.P.8.8, SC.912.P.8.8, SC.912.P.8.11, LAFS.5.W.3.7, LAFS.5.W.3.8, LAFS.6.W.3.7, LAFS.7.W.3.7, LAFS.8.W.3.7, LAFS.68.WHST.3.7, LAFS.5.SL.1.1, LAFS.6.SL.1.1, LAFS.7.SL.1.1, LAFS.8.SL.1.1

Next Generation Science Standards:

5-PS1-3, MS-LS1-5

The goal of most farmers is to maintain a soil pH between 6.0 and 7.0 for most crops.

"Acid to Alkaline" lesson

The goal of most farmers is to maintain a soil pH between 6.0 and 7.0 for most crops. A neutral soil pH will not interfere with plant growth nor the uptake of minerals needed by corn, wheat, oats, alfalfa and other field crops. Gardeners and vegetable growers work to maintain the pH required for the crops they are growing. Some crops need a higher or lower pH, having evolved in areas of either acidic or alkaline soils. Blueberries are an example of a crop that needs acidic soil (pH 4.0-5.0). Hydrangea blossoms can be colored from pink to blue depending on the pH of the soil (blue pH 4.5-5.0; less acidic for pink blossoms.) Soil pH can affect both plant nutritional deficiencies on one end of the spectrum to plant nutritional toxicity on the other. Some plant diseases are also caused or exacerbated by improper soil pH. Each plant has adapted to grow and thrive in a particular pH range of soils, which determines which minerals and nutrients the plant can absorb.

Preparation

- Obtain several pH test kits from your county Cooperative Extension office or local gardening shops. Have enough for all groups when the whole class is divided into groups of five students.

- A day before conducting this lesson, chop a red cabbage into small pieces. (If a red cabbage is not available, blackberries, red onions or hibiscus flowers can be substituted.) Cover the cabbage with water and simmer the mixture until the water turns a deep shade of purple. Allow the water to cool; drain and refrigerate the solution.

- Fill three glasses with 1 cup of water and line them up in front of the class. Leave the first just water. To the second, add two tablespoons of vinegar, and to the third add 2 teaspoons of baking soda.

Groundwork

Objective: To distinguish between acidity and alkalinity.

1. Find out what your students already know about acids by asking such questions as: What is an acid? Can you name any? What is a base? Can you name any? Do you think acids or bases are helpful or harmful? What have you heard that leads you to believe this? Generate a list in a visible place.
2. Explain that there are acids and bases, giving examples from the background information provided above, omitting the pH of each. List the examples in a visible place under the headings acids and bases.
3. Explain that there is a pH scale that ranges from zero to 14, with the midpoint of 7 being neutral, and numbers below it representing acids and those above it representing bases. Next to the acids and bases on your list, add the pH of each from the information provided above.
4. Explain that this pH scale is actually representative of the concentration of hydrogen ions. Using the animation found at *www.purchon.com/chemistry/ph.htm* provide a pictorial demonstration of the hydrogen ion concentration changes as you move up or down the pH scale and the acids or bases that are identified.
5. Using the three glasses set up in advance, explain to students that the first glass contains water, the second is a mild acid, and the third is a mild base. Explain that you have a pitcher of water made by cooking red cabbage. Show students its purple color. Ask them to predict what will happen if you pour the cabbage water into the glass with water.
   a. Pour the cabbage water into the first glass — it will turn purple. Discuss with the students that this is as expected since the glass just contained water with a pH near or at neutral.
   b. Pour the cabbage water into the second glass. It will turn red. Explain that the cabbage water acts as an indicator. The water turning red indicates that it is an acid.

a. Pour the cabbage water into the third glass. It will turn green and this indicates that it is a base.

b. Explain that making red cabbage water is time consuming and messy, and while you refrigerated it for use with this class, it would eventually spoil. So, other solutions or pH paper are used to reveal the same information. Display litmus paper and one of the soil test kits.

6. Divide the class into groups of five students, and have the students measure the pH of common household substances such as milk, water, lemon juice, cola, etc. Measure the pH and record results on pH of Common Liquids handout.
7. Explain that acids and bases are all around us, and that they have specific uses. As food scientists and chefs are creating new foods, they consider pH and pH is important in food preservation. As chemists develop dish detergents, laundry soap, bar soap, hand creams, lotions, fertilizers and other products you use every day, pH is monitored and altered to meet the needs of the product user. Imagine putting lotion on your skin only to have it be too acidic. What would happen? (It would burn.)

Exploration - Soil pH

Objective: Determine the pH of the soils in the school garden and how pH influences plant crops.

1. Explain that the pH of soil is very important to gardeners and farmers as they try to raise food and feed crops. Share that soils that have a high pH are not known as basic soils but alkaline soils.
2. Hand out the Soil pH Requirements Chart (page 59) for students. Have students read the chart and identify three crops that need acidic soils and three that require neutral to alkaline soils.
3. Divide the class into groups of five students, and have each group take a soil sample from a different part of the school garden. At least two should be near either the building or sidewalk to see the impact of structures.
4. Provide each group with a soil pH test kit and, following the directions, test the soil for pH.
5. Compare results and make a map of the pH in the garden.
6. Using the Soil pH Requirements Handout (page 60), have each group identify which crops could thrive in soil with the same pH as their group found in the garden.
7. Begin the process to determine what plants might be grown in the school garden.

Exploration - Does pH affect plants?

Objective: Conduct an experiment to determine influence of acidity on plants.

1. Ask: "How can we find out if and how plants are sensitive to different levels of acidity?" Encourage students, in small groups or as a class, to design experiments to examine this question.
2. A sample setup could be:
   a. Plant three bean seeds per four-inch pot, keep in full sun, and thin to one plant per pot when plants are approximately two inches tall.
   b. Prepare solutions with a pH of 3 (1 quart vinegar), 4 (1 quart tap water to ½ cup vinegar), 5 (1 quart tap water to 2 teaspoon vinegar), and 6 (1 quart tap water and no vinegar).
   c. When plants have grown three-to-four inches tall, begin watering with acid solution. Spray on leaves and then water with the rest of the quart.
3. Have students conduct their experiments as designed, record their observations and measurements and develop conclusions. Each group should prepare a report of their experiment and conclusions.

Enrichment

1. What can you infer about the effects of pH on a plant in the garden?
2. How could acid rain affect you? How could it affect a farmer anywhere in the world?

Extensions for Middle and High School students

1. Collect rainwater and determine the pH.
2. Research methods to lower or raise pH.
3. Lower or raise pH in the school garden following the results of the exploration in #2.
4. Select an industry and research how pH plays a role in their product development, research, environmental stewardship, and product manufacturing or processing. Create a poster project, oral report or PowerPoint presentation to give to the class.

Additional Information

The Master Gardener program of Cooperative Extension with the University of Florida has additional information on soil pH and other resources. They can be found through your county Cooperative Extension office or at: *http://gardeningsolutions.ifas.ufl.edu/mastergardener/newsletter/2009/more/soil_ph.shtml*

Soil pH Requirements Chart

Crop	Grows in soil pH	Crop	Grows in soil pH
African Violet	6.0-7.0	Geranium	6.0-8.0
Alfalfa	6.2-7.8	Lettuce	6.0-7.0
Almond	6.0-7.0	Magnolia	5.0-6.0
Alyssum	6.0-7.5	Oats	5.0-7.5
Apple	5.0-6.5	Onion	5.8-7.0
Apricot	6.0-7.0	Peach	6.0-7.5
Asparagus	6.0-8.0	Peanuts	5.6-6.6
Beans	6.0-7.5	Peas	6.0-7.5
Beets	6.0-7.5	Pineapple	5.0-6.0
Begonia	5.5-7.0	Poinsettia	6.0-7.0
Blueberry	4.0-5.0	Potato	4.8-6.5
Broccoli	6.0-7.0	Red Raspberry	5.5-7.0
Cabbage	6.0-7.5	Rice	5.0-6.5
Carnation	6.0-7.5	Rhubarb	5.5-7.0
Carrot	5.5-7.0	Rose	5.5-7.0
Cantaloupe	6.0-7.0	Snapdragon	6.0-7.5
Cauliflower	5.5-7.5	Spinach	6.0-7.5
Celery	5.8-7.0	Strawberry	5.0-6.5
Chrysanthemum	6.0-7.5	Sugar Cane	6.0-8.0
Corn	5.5-7.5	Sweet Cherry	6.0-7.0
Cranberry	4.2-5.0	Sweet William	6.0-7.5
Cucumber	5.5-7.0	Tomato	5.5-7.5
Easter Lily	6.0-7.0	Zinnia	5.5-7.5
Gardenia	5.0-6.0		

Name ___________________________________

Soil pH Requirements Handout

Which plants can grow at the soil pH found?

Soil pH found in school garden soil sample: ___________________________

Possible Plants	Acceptable pH Range

pH of Common Liquids Chart

Name ______________________________

Liquid	pH	Acid or Base?

Acid to Alkaline

Sample Pre-and Post Assessment

1. What is pH?

2. Give an example of an acid.

3. Give an example of a base.

4. List one reason why it is important to test soil pH before planting a plant:

5. Why does the pH of soil vary?