

What is pH and why is it important?

SPN LESSON #19



TEACHER INFORMATION

LEARNING OUTCOME

After using pH paper to test common household liquids and soluble solids, researching acid deposition, and checking the DAS avoided emissions data, students are able to explain the comparative relationship of fossil fuels and PV systems to acid deposition.

LESSON OVERVIEW

Students learn about acids, bases, and pH and relate this knowledge to the problem of acid deposition. Using pH paper, they test common household substances to determine whether they are acidic, basic, or neutral. They are also asked to consider how using photovoltaic panels to generate electricity can reduce the amount of acid deposition.

GRADE-LEVEL APPROPRIATENESS

This Level II environmental considerations lesson is intended for use with students in grades 5–6 or can be used as an introductory lesson for SPN lesson #20, *Using Environmental Models to Determine the Effect of Acid Rain on an Ecosystem*.

MATERIALS

For the class:

- An assortment of common household liquids and soluble solids that includes acids, bases, and neutral substances. Some possible choices include: baking soda solution, vinegar, shampoo, laundry detergent, soda pop, tomato sauce, milk, ammonia, lime juice, cranberry juice, etc.
- 10 to 20 mL of each of the liquids/solutions should be placed in small, labeled containers. Condiment cups with snap-on lids, or baby food jars, work well. Each team of two students should test six different substances.

Per team of two students:

- safety goggles for each student
- 1 copy of the Acid Test Data Sheet for each student
- 1 tweezers/forceps
- paper towels
- 1 waste container for depositing used pH paper
- 6 different substances to test
- 12 pieces of pH paper (If strips are being used, cut each strip in half. A 2- to 3-cm piece of pH paper is adequate if students use the tweezers to dip the paper into the liquid.)

SAFETY

- Ammonia is a strong cleaner and should be diluted about 10 to 1 for this activity. Do not use bleach.
- Students should wear safety goggles.
- Students should be prepared for spills.
- Instruct students in the safe handling of potentially harmful substances. Be sure to warn them:
 - (a) never to taste the substances;
 - (b) to smell them only by wafting the odor from the top of the container toward the nose;
 - (c) if substances are spilled on the skin, to wash the skin thoroughly with water.

TEACHING THE LESSON

Before class:

1. Gather together the substances to be tested. These should be liquids or substances that will dissolve in water; examples are baking soda, vinegar, citrus juices (orange, lemon, lime), dilute ammonia, tap water, soda pop, shampoo, detergent, etc. Do not use bleach.
2. Label enough small containers so that each pair of students can test six different substances. Small plastic condiment containers with snap-on lids, or baby food jars, work well since they can be labeled, sealed, and stored. Those containing nonperishable liquids can be put away with the liquids still in them, and they will be ready for use again next year. Those containing juices and other perishable substances can be rinsed, dried, and put away, ready to be refilled.
3. Run off enough copies of the Word Definition Sheet and the Acid Test Data Sheet so that every student will have one of each. Make a few extra copies of the Acid Test Data Sheet in case of spills.

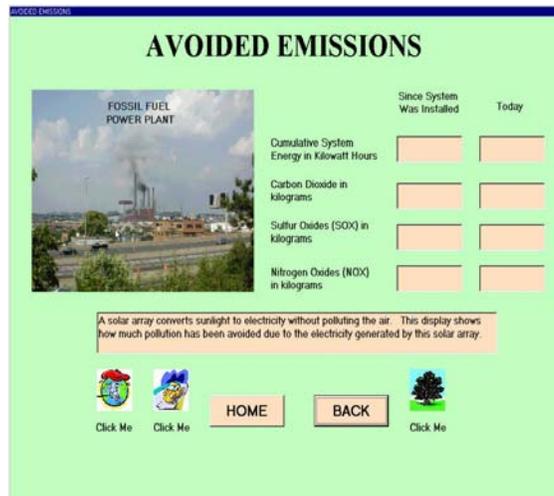
During class:

4. Give each pair of students a Word Definition Sheet. Ask them to work together to complete the grid. Assign half the student pairs the word *acid* to look up and the other half the word *base*. Explain that they are to complete the sheet for the assigned word. This sheet is a modification of a map illustrated in “Concept of definition: A key to improving students’ vocabulary,” by R. Schwartz and T. Raphael, 1985, in *The Reading Teacher*, 39 (2), copyright 1985 by the International Reading Association.
 - (a) What is it? Students should provide a definition of the word *acid* or *base*. Ask each pair of students to look the word up, talk about it, and develop their own definition.
 - (b) What are some examples? Students should list examples of an acid or a base.
 - (c) Students should write three sentences that provide more information about the word. These sentences could include a description of what an acid (or base) does or is like. One sentence may provide information about what a base (or acid) is not. The sentences should describe qualities/characteristics of an acid or a base.
 - (d) Ask students to share some of their findings. Compile a class word map for *acid* and another for *base*. Do this on a large sheet of newsprint so that the maps are in view as students test their substances. Another option is to post all of the word maps around the room. In both instances, the maps can be revisited and perhaps modified at the conclusion of the lesson.
5. Group the students into teams of two. It might be good to pair a “base” specialist with an “acid” specialist. Review with students the proper way to handle the substances and other materials/equipment. Demonstrate how to use the tweezers to dip the pH paper into the liquids. Caution students not to drop the pH paper in the containers.
6. Provide each team with the six substances they are to test and two copies of the Acid Test Data Sheet. For each substance to be tested, have students list its name, how it reacted (what color the pH paper

turned), its pH, and whether the substance is an acid, base, or a neutral substance. Instruct students to add each of their substances to the pH scale at the top of the sheet. If you think they will have trouble fitting in the names of the substances, tell them to number the substances and then just draw a line and write the number of the substance on the line. They do not need to write the entire name.

- Using the information on pH on the data sheet, relate the idea of acidity to the pH scale. As an example of the importance of pH, explain that certain animals live only in ponds and lakes that are above a certain pH. If the pH is lowered too much, those animals die. One way that the pH of a body of water can be lowered is by acid precipitation (rain, snow, sleet). Have students read the “Why worry about acid rain?” sheet, and then discuss with them the concepts described. Have students complete the activity.

Note the schematic from your school’s Data Acquisition System (DAS) provided here. Have a student or students go on computer to access the DAS system and find this



“Avoided Emissions” section. The person(s) will be able to determine the amount of sulfur oxides and nitrogen oxides that would have gone into the atmosphere if the same amount of electricity had been generated using fossil fuels rather than by your PV system. Discuss with students the potential impact of increased use of photovoltaic panels to generate electricity. Help them recognize that decreased dependence on fossil fuels for electricity will decrease the acidity of precipitation, and will help lakes and streams return to an appropriate pH as a result. This is especially true for bodies of water in the Adirondacks of New York State.

- After the discussion, have students revisit their word maps and make additions or changes to what they had originally recorded. On the reverse side of their map sheets, have them compose a draft paragraph that describes pH and its importance to and connection to living things. Drafts can be exchanged within or across pairs to obtain feedback before a final draft is completed.

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION

Activity Analysis

Word Definition Sheet

Student responses will vary. Check to be sure that the definitions provided are reasonable and appropriate. The same is true for the examples and sentences. Make sure that each sentence provides additional information about the word. This activity is designed to provide students with a conceptual basis for the lesson by allowing them to investigate and discuss the terms *acid* and *base*. It is important to allow students to revisit their definition sheets after completing the other parts of the lesson.

Acid Test Data Sheet

Students should have a variety of substances. They sometimes have difficulty with differences in pH for the 5–7 range. Check to see that students’ results are reasonably close to what you expect them to be.

Also check to see that students have added each of their six substances to the pH scale at the top of the sheet.

Why worry about acid rain?

Make sure students have added one of the organisms to their pH scale on the Acid Test Data Sheet and correctly answered the question. Answers will vary, depending on the organism selected and the liquids used.

3. What can be done to decrease the amount of acid deposition?

Burn fewer fossil fuels. Walk and don't drive. Turn the lights out when not in the room.... A variety of conservation measures are acceptable responses. Students might also suggest that using alternative energy sources, or cleaning the sulfur out of fossil fuels, will help.

4. How would using photovoltaic panels to generate electricity help to reduce the amount of acid deposition?

The photovoltaic panels do not give off sulfur dioxide and nitrogen oxides. Therefore, using the panels helps to reduce the problem of acid deposition.

Summary Statement: On the reverse side of their map sheets, have students write a statement that describes pH and its importance to and connection to living things.

pH is important because substances such as our stomach acids tend to be at a certain pH in order to work properly. pH is also important because it must be at certain levels in order for living organisms to survive.

Extended Activities

- Create a large pH scale (two or three meters long). Have students make labels using large index cards and position them at the correct pH on the scale. Next, have students make cards for the animals listed on the "Why worry about acid rain?" sheet. They could draw the animals or find pictures of them and also provide labels. The animal cards should then be positioned on the large pH scale. This would provide a graphic representation of the pH scale and the impact of pH on aquatic organisms.
- Provide students with clean, plastic containers and ask them to bring in water from ponds, lakes, and streams in the area. Caution them to collect the water when an adult is present. Students should label the container with the source of the water, then check the pH of the samples and record the values on a large map of the area. It would be a good idea to provide students with narrow range pH paper. This will provide them with more accurate data and a greater variety of readings. With the type of pH paper typically used in the school laboratory, readings will likely vary from 4 to 7. Narrow range paper will provide gradations such as between 4 and 5. Discuss with the class the "health" of the water in terms of pH and ask students to use what they know about pH and its impact on living organisms to determine which organisms they should expect to find living in the water.

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ADAPTED ACTIVITY

"Question: What is pH and why is it important?" from *Energy and Safety: Science Activities for Elementary Students*. New York Energy Education Project. Published by the Research Foundation of the State of New York. 1984.

Data for the *Animals Affected by Acid Deposition Chart* came from: Chiras, Daniel D. *Environmental Science: A Framework for Decision Making* (High School Edition), page 455. Addison-Wesley Publishing Company, California. 1987.

BACKGROUND INFORMATION

The acidic or basic nature of a liquid is important in determining the uses of the liquid. The enzymes in stomach liquids, which are acidic, aid in digestion. The strong acidic or basic nature of toilet bowl cleaners promotes effective cleaning. The acidity of automobile battery fluids makes the production of electrical energy possible. The above examples illustrate positive uses for acidity and/or alkalinity (basicity). Sometimes there is too much of one or the other and problems arise as a result. For example, if our stomachs are too acid, we get a stomachache. It is important for children to understand the idea that liquid substances may have these characteristics and that certain effects may result.

Whether a liquid is acidic, basic, or neutral is measured by a quantity called pH. pH is a measure of how much hydrogen, in an ionic form, is in the solution. pH measurements are on a scale ranging from 1 to 14, with 1 being the most acidic and 14 the most basic. If a solution has a pH of 7, it is said to be neutral. The pH scale is a “power of 10” scale. In other words, something with a pH of 9 is ten times more basic than something with a pH of 8.

There are several techniques used to measure pH. pH paper and litmus paper are commonly used when the measurements do not have to be precise. When accurate measurements are needed, pH meters are used. In this activity, pH paper is used since it is easily obtained, is relatively inexpensive, and provides “colorful” results.

The issue of acid deposition is one that has energy, environmental, economic, and scientific/technological ramifications. (One step in determining if a body of water has been affected by acid precipitation is to measure its pH accurately over time and under various conditions.) Since the major contributor to acid deposition is the burning of fossil fuels in cars, factories, and power plants, students should be helped to understand that acid deposition is actually an energy issue.

Students should be aware of the fact that the use of all energy sources and many modern conveniences has environmental consequences. Acid deposition is one issue that has prompted a great deal of research, in the hope that some time in the future prompt and appropriate remedies become known and can be applied. Using alternatives to fossil fuels in electric generation is one way of dealing with the problem now. The display for the photovoltaic system shows how much sulfur dioxide and nitrogen oxide is kept out of the air as a result of using solar energy to generate electricity. Students should become aware that there are multiple ways of dealing with energy and environmental issues, that there are benefits and burdens of each, and that trade-offs must be considered.

REFERENCES FOR BACKGROUND INFORMATION

Miller, Kenneth and Joseph Levine. *Biology*. Pearson Education, Inc. Upper Saddle River, NJ, 2003.

Smith, Leo. *Ecology and Field Biology*. 4th edition. HarperCollins Publisher, New York, NY, 1990.

Wright, Richard T. and Bernard J. Nebel. *Environmental Science: Toward a Sustainable Future*. Pearson Education, Inc. Upper Saddle River, NJ, 2002.

National Acid Precipitation Assessment Program
NOAA, MailCode R/SAB
1315 East-West Highway
Silver Spring, MD 20910
E-mail: napap@noaa.gov

The National Acid Precipitation Assessment Program (NAPAP) is an interagency scientific research, monitoring, and assessment program that examines the effects of sulfur and nitrogen oxides on the environment and human health.

Web resources

<http://www.geog.ouc.bc.ca/physgeog/contents/8h.html> This is an excellent site developed by Michael J. Pidwirny, Ph.D., Department of Geography, Okanagan University College. It includes extensive background information on the sources of sulfur and nitrogen oxides and the formation of atmospheric acids. There are several colorful diagrams that illustrate pH, the processes involved in the formation of acid precipitation, and the deposition of the by-products of acid precipitation.

<http://www.epa.gov/airmarkets/cmap/index.html> This is an Environmental Protection Agency site with access to GIS data downloads and maps showing sensitive areas and other information.

<http://heg-school.aw.com/bc/companion/cmr2e/activity/AP/APWelco.htm> This site is designed to support the text *Biology: Concepts and Connections* by Campbell, Mitchell, and Reece. It provides background information and an introduction to the subject of how science research is done to investigate acid precipitation. The site includes a virtual lab that is too advanced for middle school students but provides excellent background for the teacher.

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA

Standard 1—Analysis, Inquiry, and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Science Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

S1.1: Formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations.

S1.1a: Formulate questions about natural phenomena.

S1.1b: Identify appropriate references to investigate a question.

Standard 4

Living Environment

Key Idea 6: Plants and animals depend on each other and their physical environment.

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

7.1: Describe how living things, including humans, depend upon the living and nonliving environment for their survival.

7.1c: In all environments, organisms interact with one another in many ways. Relationships among organisms may be competitive, harmful, or beneficial. Some species have adapted to be dependent upon each other with the result that neither could survive without the other.

7.2: Describe the effects of environmental changes on humans and other populations.

7.2a: In ecosystems, balance is the result of interactions between community members and their

environment.

Physical Setting

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

2.1: Explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change.

2.1a: Nearly all the atmosphere is confined to a thin shell surrounding Earth. The atmosphere is a mixture of gases, including nitrogen and oxygen with small amounts of water vapor, carbon dioxide, and other trace gases. The atmosphere is stratified into layers, each having distinct properties. Nearly all weather occurs in the lowest layer of the atmosphere.

2.2: Describe volcano and earthquake patterns, the rock cycle, and weather and climate changes.

2.2r: Substances enter the atmosphere naturally and from human activity. Some of these substances include dust from volcanic eruptions and greenhouse gases such as carbon dioxide, methane, and water vapor. These substances can affect weather, climate, and living things.

Key Idea 4: Energy exists in many forms, and when these forms change energy is conserved.

4.1: Describe the sources and identify the transformations of energy observed in everyday life.

4.1b: Fossil fuels contain stored solar energy and are considered nonrenewable resources. They are a major source of energy in the United States. Solar energy, wind, moving water, and biomass are some examples of renewable energy resources.

Standard 6—Interconnectedness: Common Themes: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 1: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

1.4: Describe how the output from one part of a system (which can include material, energy, or information) can become the input to other parts.

Process Skills Based on Standard 4 (Laboratory Skills)

General Skills

1. Follow safety procedures in the classroom and laboratory.
8. Identify cause-and-effect relationships.
9. Use indicators and interpret results.

Produced by the Research Foundation of the State University of New York with funding from the New York State Energy Research and Development Authority (NYSERDA)

www.nyserdera.org

Should you have questions about this activity or suggestions for improvement, please contact Bill Peruzzi at billperuz@aol.com

(STUDENT HANDOUT SECTION FOLLOWS)

Name _____

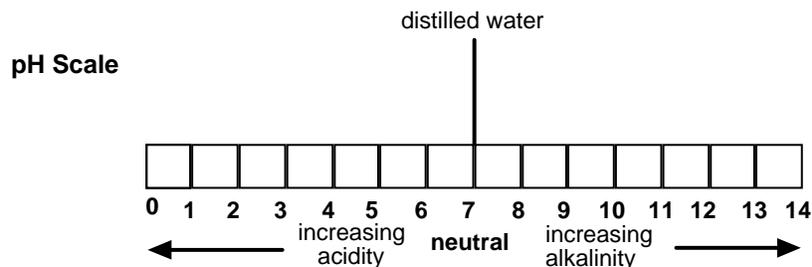
Date _____

WHAT IS pH and WHY IS IT IMPORTANT?

Acid Test Data Sheet

What is pH?

The symbol *pH* stands for a way of classifying substances. The pH scale is a 14-point scale. The middle number, 7, means neutral. Lower numbers indicate increasing acidity; higher numbers indicate increasing basicity. A liquid with a very low pH number is very acidic. One with a very high number is very basic. Pure, distilled water is neutral. Most other liquids are either acidic or basic. How can you tell?



Materials

safety goggles
pH paper
tweezers
paper towels

6 different liquids in labeled containers
1 waste container for used pH strips
1 container of clean water for rinsing tweezers between tests

Steps

1. Put on your safety goggles.
2. Rinse the tip of your tweezers in the clean water container. Wipe the tweezers dry.
3. Select one of the liquids and record its name in the “Name of substance” column on the pH Data Table.
4. Use the tweezers to pick up one piece of pH paper. Dip the end of the pH paper into the liquid you selected and pull it back out. Be careful not to drop the pH paper in the container.
5. Record the color the paper has turned in the “Color the pH paper turned” column.
6. Match the color of the pH paper with the same color on the pH scale on your container. Record the number for that color in the “pH number” column.
7. Record whether the liquid is an acid, a base, or a neutral substance in “The substance is an acid, a base, or neutral” column. Draw a line on the pH scale above and show where the substance is located.
8. Repeat this process for the other five liquids you have been given.

pH Data Table

Name of substance	pH number	The substance is an acid, a base, or neutral

Name _____

Date _____

Why worry about acid rain?

You have probably heard stories in the news about acid rain. In fact, normal rain is somewhat acidic. Actually, water that is quite acidic may not be all that dangerous to humans. After all, we drink lemon juice, which has a pH of less than 3.

For plants and animals that live in the water, a low pH can be bad. If a lake's pH gets below 5, many fish will die. What causes acid rain?

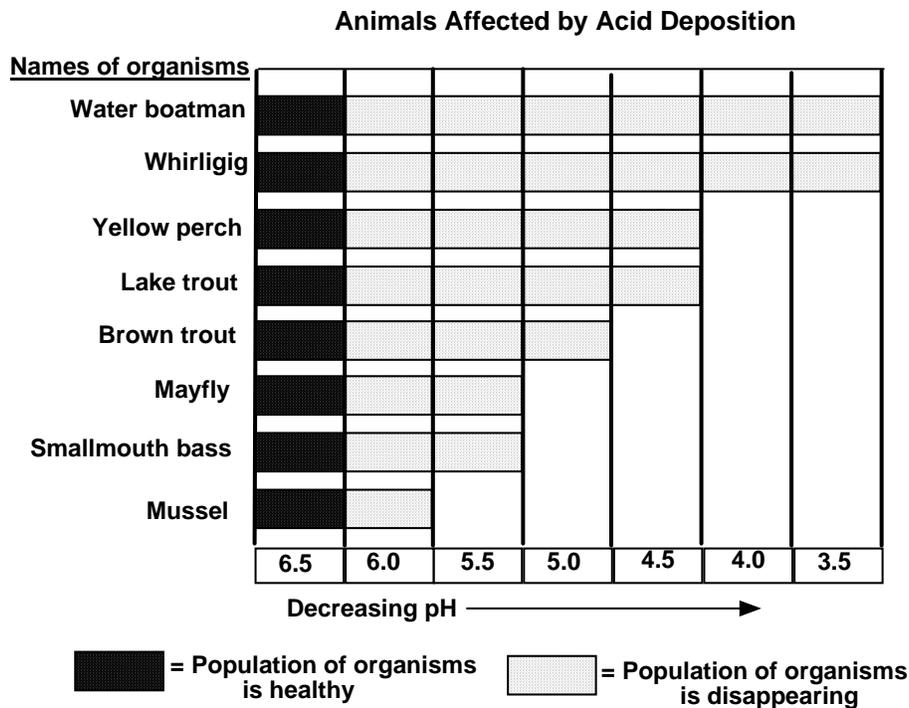
Coal and oil release substances into the air when burned. Some of the substances are acidic. They may settle out of the air, or mix with water vapor in the air. Then the rain or snow forming from this water vapor becomes more acidic.

Sooner or later, the acidic substances get back to ground level. They fall on forests, fields, and lakes. Not all fall as rain, though; some fall as snow or sleet or hail. It is really more accurate to say "acid precipitation" or "acid deposition" than "acid rain."

Scientists are still studying the causes and effects of acid deposition. We do know that exhaust from cars, trucks, and buses is the main source of nitrogen oxides (NO_x). Factories, including smelters and electric generating plants, are the main source of sulfur dioxide (SO_2). Both nitrogen oxides and sulfur dioxide react with water vapor in the air and form acids.

Examine the graph "Animals Affected by Acid Deposition" on the following page.

1. Add one of these animals to your pH scale on your Acid Test Data Sheet.
2. Which substances that you tested have a pH too low for that animal to survive?



We certainly don't want to give up driving cars or using electricity. But we don't want to damage the environment, either.

3. What can be done to decrease the amount of acid deposition?
4. How would using photovoltaic panels to generate electricity help to reduce the amount of acid deposition?

What is it? (definition)

What are some examples?

The Word →

Three meaningful sentences using the word are:

1. _____

2. _____

3. _____
