pH Test #4: Acidic Snow Melt (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: basic

Duration: 15 minutes, additional time to make ice cubes

Setting: lab or classroom

Summary: Students use acidic ice cubes to simulate the effect acidic snow melts have on the pH of waterways.

Objectives: Students will recognize that acid snow occurs, in addition to acid rain. Moreover, they will understand the effect that acid precipitation has on the pH of waterways.

Related Module Resources:
- "pH Test #1, #2, #3, #5"
- "pH, Plants and Fish" Activity
- HANBOOK: p. 57-63; 91-97
- FIELD MANUAL: p.33-35
- pH Information/Fact Sheet
- Interactive pH Scale Poster [B-top]
- Alkalinity Info./Fact Sheet

Vocabulary: acid precipitation, dissociate

Materials (Included in Module):
- pH measuring device – pH paper, meter or Hach pH kit (kit will take longer
- 2 ice cube trays
- lemon juice and/or vinegar
- large plastic cups
- measuring spoon and cup

Additional Materials (NOT Included in Module):
- distilled water
- freezer

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

7th Grade:

4.1.7.B. Understand the role of the watershed.
- Explain how water enters a watershed.
- Explain factors that affect water quality and flow through a watershed.

4.3.7.A Identify environmental health issues.
- Identify various examples of long-term pollution and explain their effects on environmental health

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

4.1.10.E. Identify and describe natural and human events on watersheds and wetlands.
- Identify the effects of humans and human events on watersheds.

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

4.3.12.A. Analyze the complexity of environmental health issues.
- Explain the relationship between wind direction and velocity as it relates to dispersal and occurrence of pollutants.

ACADEMIC STANDARDS (SCIENCE AND TECHNOLOGY)

7TH Grade

3.2.7.B Apply process knowledge to make and interpret observations.
- Describe relationships by making inferences and predictions
- Communicate, use space/time relationships, define operationally, raise questions, formulate hypotheses, test, and experiment.
- Design controlled experiments, recognize variables, and manipulate variables.
- Interpret data, formulate models, design models, and produce solutions.

3.2.7.C Identify and use the elements of scientific inquiry to solve problems.
- Generate questions about objects, organisms and/or events that can be answered through scientific investigations.
- Evaluate the appropriateness of questions.
- Design an investigation with limited variables to investigate a question.
- Conduct a two-part experiment.
- Judge the significance of experimental information in answering the question.
- Communicate appropriate conclusions from the experiment.

BACKGROUND: (read other pH activities for more extensive background information).

The pH test is a common test conducted by scientists to help determine if water is being polluted and is healthy enough to sustain aquatic life. The acid levels in rain have been a long time concern by scientists because acid rain can have damaging affects once it reaches land surfaces.

Although most of us are aware of acid rain, **acid precipitation** can also include snow, hail, and sleet. Natural, uncontaminated rain water is generally somewhat acidic, with a pH of about 5.6. This acidity is due to the natural dissolving of carbon dioxide (CO_2) in precipitation (H_2O) to form carbonic acid (H_2CO_3). The extra hydrogen ions are produced when the carbonic acid **dissociate**s (breaks apart) producing H^+ and bicarbonate HCO_3^-. If the pH of precipitation is lower than normal precipitation (5.6), then it is labeled acidic precipitation.

Because of human activity, we have increased the acidity of some precipitation. Fossil fuel burning, industrial processes, and automotive exhausts have added the atmospheric pollutants of sulfur dioxide (SO_2) and nitric oxide (NO_x). 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 that lowers the pH of the rain and any creeks that the rain enters. It can also return to the earth as other forms of wet deposition (sleet, or snow) or dry deposition (dust particles).

The rain that falls in Pennsylvania averages a pH between 4.0 and 4.5. The most acidic precipitation in the United States centers around Pennsylvania, Ohio, and New York. The Pennsylvania Fish and Boat Commission claims the Pennsylvania receives more acid rain than any other U.S. state. Why is this? Pennsylvania is downwind of and is part of the industrial belt of the country – the big cities along the Great Lakes like Chicago, Detroit, Cleveland, and inland cities in Ohio, Illinois, Indiana, and Pennsylvania. Pittsburgh is also part of this industrial belt. These cities emit air pollutants that create acid rain, and Pennsylvania is in the downwind weather patterns containing this rain.

Whether or not acid rain is a problem to waterways depends on the geology of a region. Areas with rocks, bedrock, and soil that contain calcium carbonate ($CaCO_3$) can neutralize the acid (get rid of the extra hydrogen ions). Luckily, most of Western Pennsylvania is such an area.

Even in areas with calcium carbonate, acid rain does become a problem in major storm events, where surface runoff does not allow the acidic precipitation to come in contact with the buffering geology of the region. Quick acidic snowmelts can also cause these "acid spikes" to a waterway. The stream's pH will eventually recover from these acid spikes, but only after many organisms have been negatively affected. These acid spikes affect small waterways more than larger waterways because large bodies of water can dilute the effect of acidic inputs more. A small stream with low flow can receive an abundance of land runoff from a snowmelt or rain event, filling the stream with the acidic precipitation that has little chance to be buffered.

All aquatic life has a specific pH range that it can tolerate and to which it is adapted. If the pH changes even slightly, it can stress the creatures and may even kill them. At high (9.6) or low (5.0) pH values, the water becomes unsuitable for most organisms.

OVERVIEW: Students use ice cubes to simulate acid precipitation and water to represent a stream or wetland. They melt the ice in the water to discover the effect that an acid snowmelt would have on a waterway.

PROCEDURE:

Teacher Preparation:

1. Take the pH of the distilled water using either the pH meter or pH paper. (See the instructions in the Test Kit Instruction Section of the Module Resource Guide.) Record this value to share with the class later.

2. Pour distilled water into an ice cube tray to make ice cubes (make 1 cube for each test trial your class will conduct). Be sure that the tray is labeled as distilled water. Place it in the freezer.

3. Record the pH of the lemon juice or lemonade (pH ~2) or vinegar (pH ~3). Pour enough of the lemon juice, lemonade, or vinegar into an ice cube tray to make 1 cube for each test trial your class will conduct, plus some extras. Place the tray, labeled as acidic, in the freezer. Once the ice cubes have formed, continue the experiment.

Student Experiment:

1. Have the students fill 2 clear, plastic cups each with 1.5 to 2 cups distilled water or tap water. They should take the pH of this water using instructions from the Test Kit Instruction Section of the Module Resource Guide. Have them record their results on the Data Sheet.

2. Tell students the pH values of the ice cubes (distilled and acidic).

3. Instruct the students to note the time, then place an acidic ice cube (lemon juice or vinegar) in one cup and a distilled water ice cube in the other cup.

4. While the ice cubes melt, they should take the pH of the water in the cup and record the value every 2 or 3 minutes (depending on how warm the classroom is). Tell them to keep the time interval between readings constant.

5. Instruct the students to continue taking and recording pH readings until the ice cubes have fully melted (or time is unavailable). You may want them to continue taking the measurements at timed intervals even after the ice cubes have melted (the pH may continue to change).

DISCUSSION:

Talk to the students about what happened in the experiment. *The pH of the water should have decreased after the acidic ice cubes melted, while the pH of the water with the distilled water ice cubes should not have changed at all or very little.* Relate the experiment to a sudden spring acidic snow thaw.

How would the organisms in a stream be affected if acid snow quickly melted in a spring thaw? *Certain species of fish can be killed by such a rapid and drastic change in pH. Most fish, salamanders and frogs lay their eggs in early spring. The eggs and young of these species are very sensitive to acidity and are often killed by the sudden increase in acidity. Even if the eggs survive, the young that hatch may be deformed. Aquatic insects that cannot tolerate low pH levels may not be able to survive or they may leave the stream, drifting downstream to more suitable conditions. (See pH information sheet for more information on how pH affects aquatic life).*

How does the pH of lemon juice or vinegar compare to acid rain? *It depends on the acid rain, but usually lemon juice or vinegar is more acidic.*

Why were there distilled water ice cubes used? *As a control*.

Discuss why some of the results may have varied between trials. *Maybe the ice cubes were different sizes or the meter was not rinsed thoroughly between each reading.*

EVALUATION:

- Describe some ways that the pH of a stream or wetland could suddenly change and what the effects of this pH change may have on the waterway.
- Realize that acid precipitation includes more than acid rain.
- Properly completed data sheet and/or graphs of the data.
- Discussion questions above.

EXTENSIONS AND MODIFICATIONS:

- Have students work in groups doing a number of the different "pH and Acid Test" activities at different stations.
- Change the volume of water that the ice cubes melt into (ie. 1.5 cups vs. 5 cups) and have students discover which one will be more affected by the acid ice cube melt. Relate this to a small stream vs. river and how it might be affected by acidic snow melt.
- Discuss how alkalinity would affect this simulation or a real occurrence of acid precipitation. Add some crushed calcium carbonate (Rolaids) to the cups before adding the acidic ice cubes and see how it affects the results or use groundwater instead of distilled water to melt the ice cubes.

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

DATA SHEET: pH TEST #4 – Acidic Snow Melt

Student Name_____ Date_____

pH of Distilled Water in Ice Cube
(data supplied by teacher)
pH = _____

pH of Acidic Solution in Ice Cube
(data supplied by teacher)
pH = _____

Time Elapsed (minutes)	TRIAL 1: Distilled Water Ice Cube	TRIAL 2: Acidic Solution Ice Cube
	TYPE OF WATER BEING USED IN CUPS Distilled Water or Other: _____	
0:00	**Initial pH of Water in Cup before adding ice cube** pH =	**Initial pH of Water in Cup before adding ice cube** pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =
	pH =	pH =

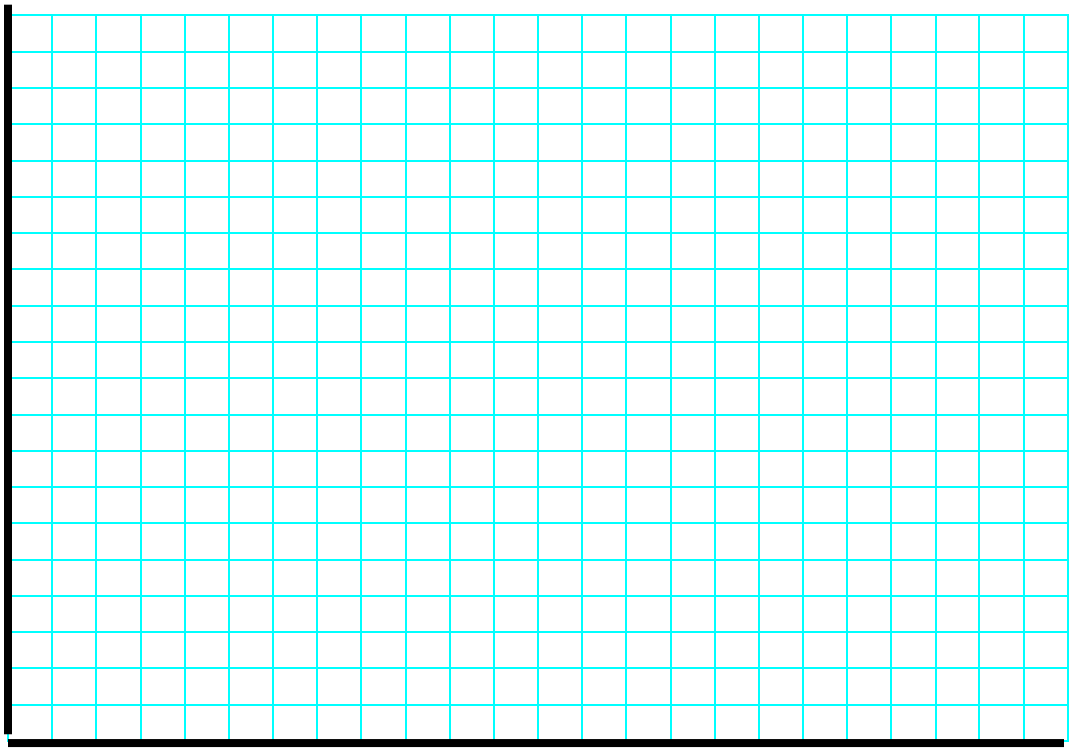
NOTES:

GRAPHS: pH TEST #4 – ACIDIC SNOW MELT

**Optional to use, you may want your student to create their own graph.*

Student Name_____ Date_____

GRAPH TITLE:_____



pH Level

Time Elapsed (minutes)