

Acid Rain: A Danger to Our Forests?

Overview

Students predict the product (an acid) of a simple nonmetal oxide reacted with water and evaluate the effects of varying concentrations of this acid on garden radish.



Title

Acid Rain: A Danger to Our Forests?

Investigative Question

What are the effects of acid rain on plants?

Overview

Students predict the product (an acid) of a simple nonmetal oxide reacted with water and evaluate the effects of varying concentrations of this acid on garden radish.

Objective

Students set up an experiment in which plants are exposed to varying amounts of sulfates (acidity), measure the growth of the plants over several weeks, record the data, and write a lab report.

Materials

Per group: deflagration spoon, rubber bands, small chunks of sulfur, matches, plastic cups, 2 saucers or plastic lids to serve as saucers, potting soil, radish seeds, two 2-liter plastic soda bottles (clear) with tops, scissors, rubber or plastic tubing. Student Pages 1, 2, 3, and 4, hand drill (to be shared by all groups), acid-resistant goggles, gloves, and aprons.

For the introductory activity: 500 or 1000-ml Erlenmeyer flask fitted with a one-hole stopper, acid base indicator (bromthymol blue, universal indicator, or phenolphthalein), and the materials noted above for creating sulfates.

For the extension activity: graph paper with 1-cm squares.

Time

Two 50-minute class periods and two or three minutes for several students from the class every day for six weeks.

Advance Preparation

Assemble materials and copy student pages.

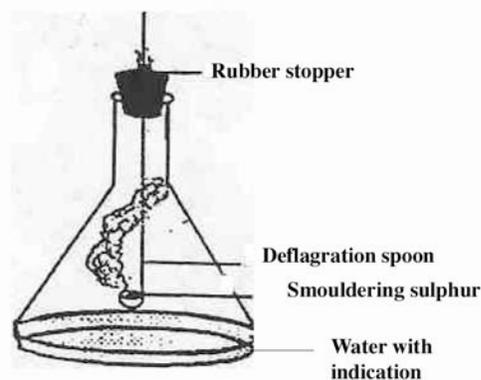
Introducing the Activity

Explain that when sulfur is burned, it forms various sulfates. These sulfates combine with water in the air to make sulfurous and sulfuric acid.

Demonstrate by burning sulfur in a deflagration spoon suspended in a closed Erlenmeyer flask.

Demonstration:

1. Place 20 ml of water in the bottom of a large Erlenmeyer flask.
2. Add several drops of an acid/base indicator to the water.
3. Insert a deflagration spoon through a one-hole stopper and secure it with a rubber band.
4. Ignite a small piece of sulfur in the spoon and immediately lower it into the flask.
5. Observe the color change in the water.



Procedure

1. Ask students to read the background material on Student Page 1 or present that material as a mini-lecture. Some expansion and explanation of this material will probably be necessary for most classes.
2. Divide students into groups. These groups now conduct the lab described on Student Pages 2, 3, and 4. Each student is responsible for writing a lab report at the end of the experiment.

Assessing the Activity

1. Ask students if any species of plants grow and thrive in habitats that are very acidic? Have students prepare a one-page report on a couple of plant species that live in two habitats, a bog and a flood-plain forest. How do the two habitats differ? How are they the same? What conditions dictate what plants grow in each habitat?
2. Ask students to find information about a plant community (and its location) that has been severely affected by acid rain. Encyclopedias and the Internet are good places for students to search for information.

Extending the Activity

Leaf area can be measured as an indication of a plant's health. Provide students with graph paper divided into 1-cm squares. Ask them to estimate the total leaf area of each of their plants (all leaves) at the end of the experiment and record this information on their data sheets.

References

Bowersox, V.C., D. A. Dolske, D.F. Gatz, K.E. Kunkel, S.J. Vermette, and W.M. Wendland. 1994. Page 170 *in* The Changing Illinois Environment: Critical Trends. Technical Report of the Critical Trends Assessment Project Volume I: Air Resources. Illinois Department of Energy and Natural Resources, Springfield.

Critical Trends Assessment Project (CTAP). 1994. Page 8 *in* The Changing Illinois Environment: Critical Trends Summary Report of the Critical Trends Assessment Project. Illinois Department of Energy and Natural Resources, Springfield.

State Goals

11,12 (Objectives 11.7.01-06 and 11.4.10-04)

Concept

Strong acids are harmful to plants, but many plants are tolerant of acid and actually need a slightly acidic environment to thrive.

Safety and Waste Disposal

Students should wear acid-resistant goggles, gloves, and aprons while setting up the lab and while treating the plants on subsequent days. All precautions used when working with fire should be observed.

Student Page 1: Background Information

The term "acid rain" is familiar to anyone concerned about the environment. What is acid rain and why is it a concern? Nonmetal oxides, such as CO₂ (carbon dioxide) and SO₂ (sulfur dioxide), form acids when combined with water.

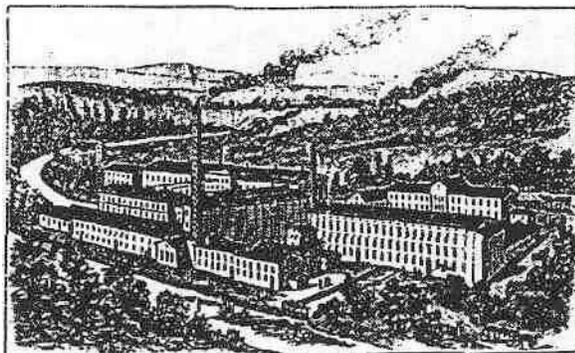
$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ (carbonic acid)

$\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ (sulfurous acid)

These and other sulfates and nitrates normally found in the air combine with water in the air to make rain that is naturally somewhat acidic. When more of these oxides are introduced into the atmosphere, the rain becomes more acidic. At times, rain can become so acidic that it harms the plants it contacts and accumulates in streams and lakes, endangering the aquatic life. Areas adjacent to power plants that produce large amounts of sulfates are often barren of plant growth because of the highly acidic conditions. For plants in a forest, the concern is not so much for acid rain coming in contact with the leaves as it is for the changes that occur in soil fed by acid rain. Increased acidity can also pose a problem for nearby creeks or rivers. Scientists are now investigating how much damage has occurred to plant life and the types and levels of acid that may harm plants.

Oxides enter the atmosphere in two major ways: through volcanic activity and from the consumption of fossil fuels in power plants and automobiles. During a volcanic eruption, carbon and sulfur in the rock combine with oxygen to produce carbonates and sulfates.

Sulfates are formed when fossil fuels containing sulfur are burned for energy. Nitrates and carbonates are also formed during the combustion of petroleum products.



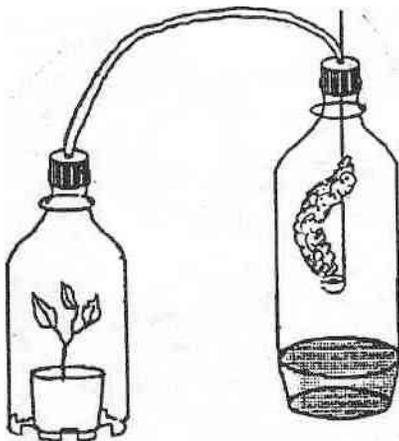
Acid rain is defined as rainwater with a pH less than 5.6. A good portion of this acidity is due to normal amounts of carbon dioxide in the air. The pH range of precipitation in Illinois has been shown to vary from 3.10 to 8.45, with 91.3% of the samples falling in the acid rain category of less than 5.6. The problems thought to be associated with acid rain have not been shown to be a serious concern here in Illinois. No effects from acid rain on forest ecology have been recorded in the state, but the monitoring of rain and surface water has continued so that changes will be immediately detected.

Student Page 2: Acid Rain and Plant Health

Preview of the experiment. Your group will bottle. receive 8 or 10 radish seeds, two plastic cups, potting soil, and planting instructions. After the seeds have germinated and seedling growth has begun, choose one plant from each cup to keep for this experiment and remove the other seedlings. Each group of students will follow a different regime. Group 1: one plant will be exposed to acid once a week; the other plant will be treated the same way but not exposed to acid. This plant will be the control. Group 2: one plant will be exposed to acid once every 3 days; the other plant will be treated the same way but not exposed to acid. Group 3: one plant will be exposed to acid once a day; the other plant will be treated the same way but not exposed to acid. Group 4: one plant will be exposed to acid twice a day; the other plant will be treated the same way but not exposed to acid. All plants in all groups will be exposed to the same light conditions. Caution: You will be required to wear acid-resistant goggles, gloves, and aprons while setting up the experiment and when treating the plants on subsequent days.

1. Cut the bottom from one 2-liter bottle and cut five 2 cm X 2 cm squares from the bottom edge.
2. Use the hand drill to make a quarter-inch hole in one of the bottle caps and two quarter-inch holes in the other.
3. Attach the tubing to both caps.
4. Insert and secure with a rubber band a deflagration spoon in the second hole of the second cap.
5. Pour approximately 100 ml (milliliters) of water into the intact 2-liter bottle and replace the cap into which you have inserted the spoon.
6. Use a pencil to poke five quarter-inch holes in the bottom of each cup; fill the cups with potting soil to about 1 cm from the top.
7. Plant 4 or 5 radish seeds in each cup following the instructions on the package. After the seeds have germinated and seedling growth has begun, choose one plant from each cup to keep for this experiment and remove the other seedlings. Place one cup under the bottomless

8. Place a small chunk of sulfur in the deflagration spoon and light it. Replace the cap on the bottle with the burning sulfur.
9. When the sulfur stops burning, squeeze the bottle a few times so that the sulfates enter the tubing and reach the bottle with the experimental plant. Do not expose the control plant to the burning sulfur and water it with tap water. Repeat steps 8 and 9 as often as your acid regime requires: once a week, every 3 days, every day, or twice a day. (Weekends will be excluded from all counts.)
10. Whenever your plants need to be watered, use the water from the bottle containing the spoon to water the experimental plant and tap water for the control. Add more water to the bottle as needed. The treatment plant should not stay under the plastic bottle except when it is being treated with acid.
11. Continue this regime for six weeks.
12. As your plants grow, measure their heights in centimeters and estimate their leaf areas in square centimeters twice a week. Agree on these days as a class so that all plants are measured on the same dates. Record this information on Student Page 3. You should also record any other variables you observe in the column labeled "Other Observations."
13. Prepare a lab report that includes an introduction, methods used in the experiment, results (the data), and a conclusions/discussion section.



Student Page 3: Data Table

Name _____

Circle the acid regime to which your plant was subjected:

once a week every 3 days everyday twice a day

Experimental Plant

Date	Height (cm)	Leaf area (cm ²)	Other Observations
------	-------------	------------------------------	--------------------

Control Plant

Date	Height (cm)	Leaf area (cm ²)	Other Observations
------	-------------	------------------------------	--------------------

Student Page 4: Preparing Your Lab Report

Remember, your lab report must include an introduction, the methods used in the experiment, the results, and a conclusion/discussion section. The following questions should be answered in your lab report:

1. What was your hypothesis regarding the effects of the acid regime to which you subjected your plant? Was it correct? What data support or refute your hypothesis?
2. Were you able to answer our original question: "What are the effects of acid rain on radish plants?" If not, why not? What data helped to answer this question?
3. Do you think your data were reliable? Where might errors have occurred?
4. Could observed changes be the result of variables that we did not control?
5. Are there other ways to set up this experiment that might result in more meaningful data?