Acid Rain and Its Effect on Surface Water

Acid rain can be very harmful to the environment. It can kill fish by lowering the pH of lakes and rivers. It can harm trees and plants by burning their leaves and depriving them of nutrients. It can also weather away stone buildings and monuments. But why is it more of a problem in some places than others?

To answer this question, let’s first look at how rain becomes acidic. Carbon dioxide, CO₂, is a gas found naturally in the air. When CO₂ dissolves into rain droplets, it produces a weak acid called carbonic acid, H₂CO₃. This makes rain slightly acidic naturally. Rain of pH 5 to 6 is common and does not generally cause any problems. When fossil fuels are burned, however, gases such as sulfur dioxide, SO₂, are released into the air. When sulfur dioxide dissolves into rain droplets, sulfuric acid, H₂SO₄, is formed. This rain can be as acidic as pH 4. Figure 1 shows the trend of rain pH in the United States in a typical year. Notice that the most acidic rain occurs over and downwind from heavily populated and industrialized areas.

![Figure 1: Typical rain pH in United States.](image)

Acid rain is more harmful to some areas than others. This is because some water resists changes in pH better than others. Water that resists a change in pH is said to be buffered. Depending on the buffering capacity of the surface water, one area could be heavily damaged by acid rain that does not seem to harm another at all.

In Part I of this experiment, you will study how rain naturally becomes acidic due to CO₂ in the air. You will monitor the pH of water as you add CO₂ by blowing through a straw. In Part II, you will study the effect of acid rain has on the pH of different water types. The pH will be recorded as sulfuric acid is added dropwise to several different types of water.

**OBJECTIVES**

In this experiment, you will

- Use a pH Sensor to measure pH.
- Use a pH Sensor to study the effect of dissolved CO₂ on the pH of distilled water.
- Study the effect on pH of dissolving H₂SO₄ in various waters.
- Learn why some bodies of water are more vulnerable to acid rain than others.
MATERIALS

- computer
- Vernier computer interface
- Logger Pro
- Vernier pH Sensor
- 100 mL beaker
- waste cup
- ring stand and utility clamp
- straw
- wash bottle with distilled water
- soft water
- hard water
- buffer solution
- dilute H₂SO₄ in dropper bottle

PROCEDURE

Part I CO₂ and Water

1. Obtain and wear goggles! CAUTION: The sulfuric acid used in Part II of this experiment is a strong acid. Contact with sulfuric acid will damage your skin, eyes, and clothing!

2. Connect the pH Sensor to the Vernier computer interface. Important: For this experiment your teacher already has the pH Sensor in pH soaking solution in a beaker; be careful not to tip over the beaker when connecting the sensor to the interface.

3. Prepare the computer for data collection by opening the “16a Acid Rain in Water” file in the Earth Science with Vernier folder.

4. Add 50 mL of distilled water to a clean 100 mL beaker.

5. Lower the pH electrode into the beaker so that the water is covering the glass bulb.

6. Give a straw to the group member who will be blowing into the water.

7. Click to begin collecting data. After one data pair has been collected, begin blowing through the straw into the distilled water. You may take breaths as needed, but try to keep a fairly constant stream of air going into the water. Data collection will stop after 60 seconds.

8. When data collection has stopped, click the Statistics button, , to determine the maximum and minimum pH values. Record the maximum and minimum pH in the Part I Data Table.

9. Print copies of the graph as directed by your teacher.

Part II Effects of Acid Rain on Surface Water

10. Open the “16b Acid Rain in Water” experiment file for Part II.

11. Rinse the pH electrode thoroughly with distilled water.
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12. Wash and dry the 100 mL beaker. Get a new 50 mL portion of distilled water. Lower the pH Sensor into the distilled water.

13. Start measuring the pH by clicking [Collect]. Note that a new button [Keep] is available.

14. When the reading has stabilized, click [Keep] to take a pH measurement. Type 0 to indicate the number of drops of acid you have added and press ENTER.

15. Add 1 drop of sulfuric acid to the water. CAUTION: Handle the sulfuric acid with care. It can cause painful burns if it comes into contact with skin, eyes, or clothing.

16. Stir thoroughly. When the pH is stable, click [Keep]. Type in the number of drops of acid added to the beaker and press ENTER.

17. Repeat Steps 15 and 16, adding 1 drop at a time, until you have added 10 drops of acid.

18. Click [Stop] when all measurements have been made.

19. Store your data by choosing Store Latest Run from the Experiment menu.

   Acid Rain in Soft Water

20. Repeat Steps 11–19 using 50 mL of soft water instead of distilled water.

   Acid Rain in Hard Water

21. Repeat Steps 11–19 using 50 mL of hard water instead of distilled water.

   Acid Rain in a Buffer solution

22. Repeat Steps 11–19 using 50 mL of a buffer solution. You do not need to choose Store Latest Run on this last run.

23. Click on the Statistics button, [Stats], to display Statistics boxes for all the runs on the graph. The maximum and minimum pH values will be displayed in the Statistics boxes. Use these to fill in the minimum and maximum pH values in the Part II data table.

24. Print copies of the graph as directed by your teacher.
DATA

Part I CO₂ and Water

<table>
<thead>
<tr>
<th>Maximum pH</th>
<th>Minimum pH</th>
<th>ΔpH</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Part II Effects of Acid Rain on Surface Water

<table>
<thead>
<tr>
<th>Distilled Water</th>
<th>Soft Water</th>
<th>Hard Water</th>
<th>Buffer Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum pH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum pH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔpH</td>
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</tr>
</tbody>
</table>

PROCESSING THE DATA

1. Calculate the change in pH (ΔpH) for the water in Part I and record in the Part I data table.

2. Calculate the change in pH (ΔpH) for each of the Part II trials and record in the Part II data table.

3. Compare the ΔpH values. Which test gave the largest pH change? Which test gave the smallest pH change?

4. Hard water is said to be “naturally buffered.” From the result of this experiment, explain what this means.
5. Many aquatic life forms can only survive in water with a narrow range of pH values. In which type of water—hard or soft—would living things be more threatened by acid rain? Explain.

![Figure 3: Typical water hardness as mg/L calcium carbonate.](image)

6. Figure 3 shows the general trend in hard and soft water in the United States. There are numerous coal-burning electric power plants in Illinois that produce sulfur dioxide. As the prevailing winds carry the pollutants northeastward, they contribute to acid rain over the Northeast. Based on what you have learned in this lab, do you think that Ohio and New York will be affected the same by this acid rain? Why or why not?
7. A similar situation exists in Europe where air pollutants from highly industrialized Germany are more harmful to Scandinavian water life than to water life in Germany. Use the results of this experiment to predict the relative hardness and softness of Germany and Scandinavia’s water.

EXTENSIONS

1. Test ocean water in the same way you tested hard and soft water. How does it compare?

2. Do library research to get more information on the effects of acid rain on streams and lakes.
Vernier Lab Safety Instructions Disclaimer

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This copy does not include:

- Safety information
- Essential instructor background information
- Directions for preparing solutions
- Important tips for successfully doing these labs