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HANDS-ON ACTIVITIES

Acid Rain and its Effect on Surface Water

- Go Direct pH
- Go Direct Conductivity

Effect of Temperature on Dissolved Oxygen

- Go Direct ODO

Reflectivity of Light

- Go Direct Light and Color

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, CO_2, is a gas found naturally in the air. When CO_2 dissolves into rain droplets, it produces a weak acid called carbonic acid, H_2CO_3. 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, SO_2, are released into the air. When sulfur dioxide dissolves into rain droplets, sulfuric acid, H_2SO_4, 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.

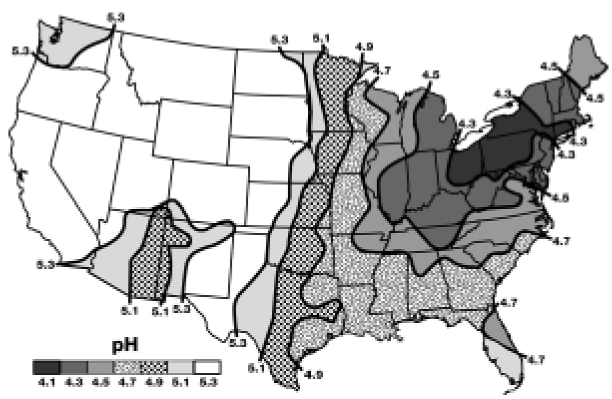

Figure 1 Typical rain pH in United States

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 CO_2 in the air. You will monitor the pH of water as you add CO_2 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

- Use a pH Sensor to measure pH.
- Use a pH Sensor to study the effect of dissolved CO_2 on the pH of distilled water.
- Study the effect on pH of dissolving H_2SO_4 in various waters.
- Learn why some bodies of water are more vulnerable to acid rain than others.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct pH
100 mL beaker
waste
ring stand and utility clamp
straw
wash bottle with distilled water
soft water
hard water
buffer solution
dilute H_2SO_4

PROCEDURE

Part I CO_2 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. Launch Graphical Analysis. Connect the pH Sensor to your Chromebook, computer, or mobile device.

3. Set up the data-collection mode.

   a. Click or tap Mode to open Data Collection Settings.

   b. Change Rate to 1 sample/s and End Collection to 60 s.

   c. Click or tap Done.

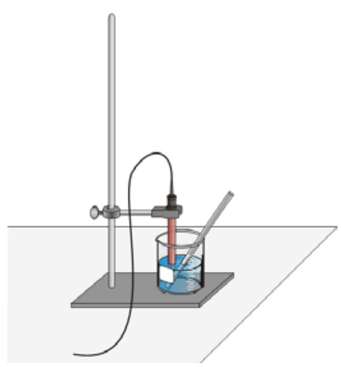

Figure 2

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 or tap Collect to start data collection. After one data pair have 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. Determine the maximum and minimum pH values.

   a. Click or tap Graph Tools, , and choose View Statistics.
   b. Record the maximum and minimum pH in the Part I data table.
   c. Dismiss the Statistics box.

9. Print the graph as directed by your teacher.

Part II Effects of Acid Rain on Surface Water

Acid Rain in Distilled Water

10. Set up the data-collection mode.

    a. Click or tap Mode to open Data Collection settings.
    b. Change Mode to Event Based.
    c. Enter **Drops** as the Event Name and leave the Units field blank.
    d. Click or tap Done.

11. Rinse the pH electrode thoroughly with distilled water.

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. Click or tap Collect to start data collection.

14. When the pH reading displayed on the screen stabilizes, click or tap Keep. Enter **0** (the number of drops). Click or tap Keep Point to save this data pair.

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 or tap Keep. Enter the number of drops of acid added to the beaker and click or tap Keep Point.

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

18. Click or tap Stop to stop data collection.

19. Click or tap the graph to examine pH and drop number values. **Note**: You can also adjust the Examine line by dragging the line.

20. Record the maximum and minimum pH values in the Part II data table.

Acid Rain in Soft Water

21. Repeat Steps 11–20 using 50 mL of soft water instead of distilled water. **Note**: The previous data set is automatically saved.

Acid Rain in Hard Water

22. Repeat Steps 11–20 using 50 mL of hard water instead of distilled water. **Important**: Do not store this final run.

23. It is often helpful to view all three runs on one graph for comparison.

    a. To display multiple data sets on a single graph, click or tap on the y-axis and select the data sets you want to display. Dismiss the box to view the graph.

    b. Print the graph or sketch it in the space below, labeling each line with the type of water used.

DATA

Part I CO_2 and Water

Table 1		
Maximum pH	Minimum pH	ΔpH

Part II Effects of Acid Rain on Surface Water

Table II			
	Distilled Water	Soft Water	Hard Water
Maximum pH			
Minimum pH			
ΔpH			

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.

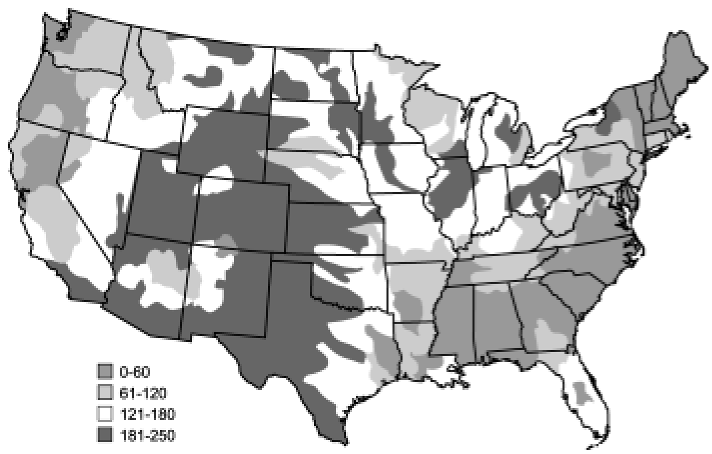

Figure 3 Typical water hardness as mg/L calcium carbonate.

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.

Dissolved Oxygen in Water

(Optical Dissolved Oxygen Probe)

Aquatic life depends upon oxygen dissolved in water, just as organisms on land rely upon oxygen in the atmosphere. Molecular oxygen is used by organisms in aerobic respiration where energy is released during the combustion of sugar in the mitochondria. Without sufficient oxygen, they suffocate. Some organisms, such as salmon, mayflies, and trout, require high concentrations of oxygen in the water. Other organisms, such as catfish, midge fly larvae, and carp can survive with much less oxygen.

Oxygen dissolves at the interface between the water and the air or when aquatic autotrophs release oxygen as a byproduct of photosynthesis. Abiotic factors including temperature and pressure influence the maximum amount of oxygen that can be dissolved in pure water. Biotic life also influences the amount of oxygen that is dissolved.

The following table indicates the oxygen and temperature tolerance level of selected animals. The quality of the water can be assessed with fair accuracy by observing the aquatic animal populations in a stream. These assessments are based on known dissolved oxygen tolerance. If a stream has only species that can survive at low oxygen levels, it is expected to have low oxygen levels.

Table 1		
Animal	Temperature range (°C)	Minimum dissolved oxygen (mg/L)
Trout	5–20	6.5
Smallmouth bass	5–28	6.5
Caddisfly larvae	10–25	4.0
Mayfly larvae	10–25	4.0
Stonefly larvae	10–25	4.0
Catfish	20–25	2.5
Carp	10–25	2.0
Water boatmen	10–25	2.0
Mosquito	10–25	1.0

OBJECTIVES

- Measure the concentration of dissolved oxygen in water using an Optical DO Probe.
- Determine the effect of temperature on the amount of dissolved oxygen in water.
- Apply the results to predict the effect of water temperature on aquatic life.

MATERIALS CHECKLIST

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct Optical Dissolved Oxygen
Go Direct Temperature
two 250 mL beakers
100 mL beaker
polystyrene foam cup
1-gallon plastic milk container
hot and cold water
ice
goggles

PROCEDURE

1. Launch Graphical Analysis. Connect the Optical Dissolved Oxygen Probe and Temperature Probe to your Chromebook, computer, or mobile device.
2. Set up the data-collection mode.
   a. Click or tap Mode to open Data Collection Settings.
   b. Change Mode to Event Based.
   c. Change Event Mode to Selected Events.
   d. Select Average sensor reading over 10 seconds.
   e. Click or tap Done.
3. Click or tap Collect to start data collection.
4. Obtain two 250 mL beakers. Fill one beaker with ice and cold water. Place the polystyrene foam cup into the second, empty beaker.
5. Place approximately 100 mL of cold water and a couple small pieces of ice, from the beaker filled with ice water, into a clean plastic one-gallon milk container.
6. Seal the container and vigorously shake the water for a period of 2 minutes. This will allow the air inside the container to dissolve into the water sample.
7. Pour the water into the polystyrene foam cup.

Figure 1

8. Place the Temperature Probe in the polystyrene foam cup as shown in Figure 1.

9. Place the shaft of the Optical DO Probe into the water.

10. Monitor the dissolved oxygen readings displayed on the screen. Give the dissolved oxygen readings ample time to stabilize (90–120 seconds).

11. When the readings have stabilized, click or tap Keep. **Important**: Do not remove the probes until the 10-second averaging period is complete.

12. Remove the probes from the water sample.

13. Pour the water from the polystyrene foam cup back into the milk container. Seal the container and shake the water vigorously for 1 minute. Pour the water back into the polystyrene foam cup.

14. Repeat Steps 8–13 until the water sample reaches room temperature.

15. Fill a second beaker with very warm water about 40–50°C. When the water in the polystyrene foam cup reaches room temperature, add about 25 mL of the very warm water prior to shaking the water sample.

16. Repeat Steps 8–13 until the water temperature reaches 35°C.

17. When all samples have been taken, click or tap Stop to stop data collection.

18. Click or tap View, ⊞, and choose Table. Record the dissolved oxygen and temperature readings in Table 2.

19. Create a single graph of dissolved oxygen *vs*. temperature to help you answer the questions.

    a. Click or tap View, ⊞, and choose 1 Graph.

    b. Plot dissolved oxygen concentration on the y-axis and temperature on the x-axis. To change what is plotted on each axis, click or tap the axis label and select the correct column.

DATA

Table 2	
Temperature (°C)	Dissolved oxygen (mg/L)

QUESTIONS

1. At what temperature was the dissolved oxygen concentration the highest? Lowest?

2. Does your data indicate how the amount of dissolved oxygen in the water is affected by the temperature of water? Explain.

3. If you analyzed the invertebrates in a stream and found an abundant supply of caddisflies, mayflies, dragonfly larvae, and trout, what minimum concentration of dissolved oxygen would be present in the stream? What maximum temperature would you expect the stream to sustain?

4. Mosquito larvae can tolerate extremely low dissolved oxygen concentrations, yet cannot survive at temperatures above approximately 25°C. How might you account for dissolved oxygen concentrations of such a low value at a temperature of 25°C? Explain.

5. Why might trout be found in pools of water shaded by trees and shrubs more commonly than in water where the trees have been cleared?

Reflectivity of Light

Light is reflected differently from various surfaces and colors. In this experiment, you will be measuring the percent reflectivity of various colors. You will measure reflection values from paper of the various colors using a Light Sensor and then compare these values to the reflection value of aluminum foil. You will then calculate percent reflectivity using the relationship

$$\%\ \text{reflectivity} = \frac{\text{value for paper}}{\text{value for aluminum}} \times 100$$

OBJECTIVES

- Use a Light Sensor to measure reflected light.
- Calculate percent reflectivity of various colors.
- Make conclusions using the results of the experiment.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct Light and Color
white paper
black paper
aluminum foil
2 other pieces of colored paper
ring stand
utility clamp

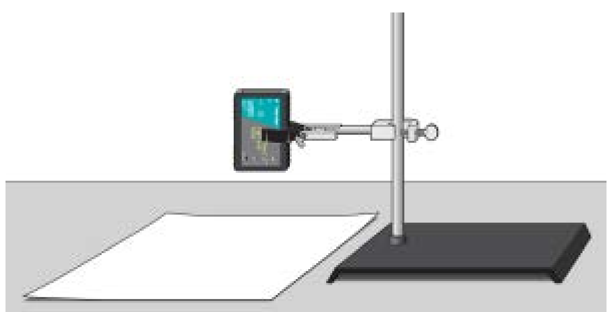

Figure 1

PROCEDURE

1. Launch Graphical Analysis. Connect the Light Sensor to your Chromebook, computer, or mobile device.

2. Click or tap View, ⊞, and choose Meter.

3. Use a utility clamp and ring stand to fasten a Light Sensor 5 cm from and perpendicular to the surface of the table (see Figure 1). The classroom lights should be on.

4. Position a piece of aluminum foil under the Light Sensor.

5. When the reading stabilizes, record the reflected light value (in lux). Lux is the SI unit for brightness of light (which is called illuminance).

6. Obtain pieces of white paper and black paper. Repeat Steps 4–5.

7. Obtain two other pieces of paper of other colors. Repeat Steps 4–5. When you record light values, record the color of the paper as well.

8. Before closing Graphical Analysis, continue to the Processing the Data section.

DATA

Color	Reflection value	Percent reflectivity
Aluminum		100%
Black		
White		
________________		
________________		

PROCESSING THE DATA

1. Calculate the percent reflectivity of each color using the formula given in the introduction. Show your work in the data table.

2. Which color, other than aluminum, has the highest reflectivity?

3. Which color has the lowest reflectivity?

4. What surfaces might give a planet a high reflectivity? Explain.

5. Does the planet Earth have high reflectivity? Why or why not?

EXTENSIONS

1. Design an experiment to test the reflectivity of sand, soil, water, and other materials. Perform the experiment you designed.

2. Design an experiment to determine if there is a relationship between reflected light and heat absorbed by various colors or materials. Perform the experiment you designed.