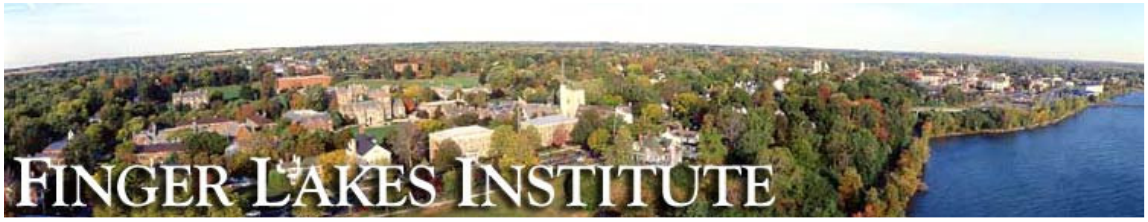

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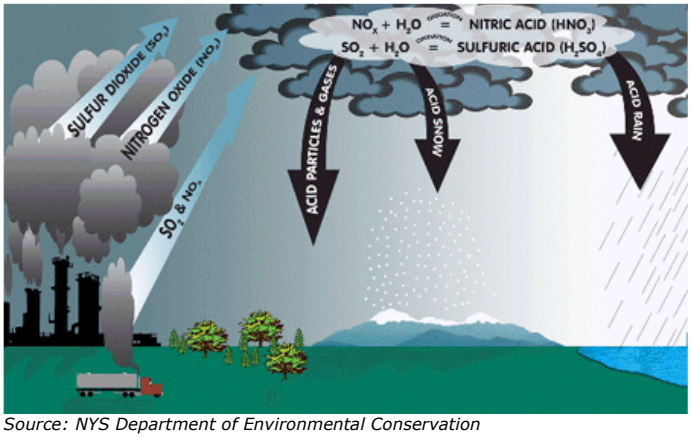
Acid Rain Student Worksheet

Lesson Introduction

What is acid rain?
Acid Rain is a term used to describe the phenomena of rainfall that contains lower than normal readings of pH due to inputs of sulfur dioxide and nitrogen oxide compounds into the atmosphere. These compounds come from power plants and other industries that burn fossil fuels for energy. Scientists are concerned about acid rain and its impact on the environment. For this lesson we will focus specifically on the affects of acid rain on lakes and aquatic life although acid rain's impacts are much broader.

How Acidic is Rain in New York State?
A pH scale is used to measure acidity, with 0 being the most acidic and 14 the most alkaline. A value of 7 is neutral. Solutions with a pH of less than 7 are acids, while those with a pH greater than 7 are bases. A decrease in pH represents an increase in acidity, and an increase in pH represents a decrease in acidity. The scale also is logarithmic, meaning that a one-unit change actually represents a tenfold change. Rainfall is somewhat acidic by nature, due to atmospheric carbon dioxide (gas) reacting with precipitation (rain drops) to make carbonic acid, a weak acid. The acidity of rainfall is critical for the weathering of rocks and formation of soils on land. Without it there would not be the needed minerals and nutrients in soils to grow plants. However, acid rain is intensifying this weathering process and can have negative impacts on the landscape and surface waters where transported ions and sediments end up. While normal rainfall is slightly acidic (about 5.5) the average pH of rainfall in New York State ranges from 4.0 to 4.5 - 30 times more acidic than "normal". Below is a graph that illustrates the acid rain cycle.



Source: NYS Department of Environmental Conservation

Acid Rain and the Environment
When acid rain falls to the earth it interacts with landscape features which affects how it will impact the environment. Much of the research on the detrimental effects of acid rain has been conducted in the Adirondack region of New York State because of the igneous/metamorphic nature of the underlying bedrock in this region. Soils in the Adirondacks are thin, slightly acidic, and lack the ability to neutralize the inputs from acid rain. In the Finger Lakes region however, calcareous soils and limestone outcrops which contain CaCO 3 (calcium carbonate) are dominant in the landscape and provide a "buffer" against acid rain.
Source: Lajewski, C.K. et. al. Geological Society Bulletin 2003.

Below are links to bedrock maps of the regions discussed.
Finger Lakes
Adirondacks

Acid rain has many negative impacts on the environment. Acid rain can alter the pH of surface water such as lakes and streams stressing aquatic life that is adapted to certain pH levels. Acid rain also can erode concrete buildings and monuments. And the particles in acid rain can aggravate health problems for people with respiratory illness like asthma or bronchitis.

The following links will provide further information about acid rain, pH levels and impacts on the environment.

Glossary

What is Acid Rain?
pH and Water Quality
Acid Rain Impacts on the Environment

Lesson Objectives

In this lesson you will be investigating the relationship between acid rain and pH levels in two lakes: Morehouse Lake in the Adirondacks and Seneca Lake in the Finger Lakes. To do this you will be using data on pH levels collected from both lakes for the years 1993-2003 and making two charts. You will be using these charts along with the charts provided in the lesson to answer the questions A-E. Although the charts will help you to answer some of the questions you will need to refer to the website links found at the bottom of the page for further information. At the end of this lesson you should have completed:

- Two charts: Avg pH in Morehouse Lake; Avg pH Seneca Lake
- Answered questions A-E using your generated charts, the charts provided and the website links as references.

Activity

Make two charts showing a line graph of the average pH concentrations in the surface waters of a lake in the Adirondacks - Morehouse Lake, and for a lake in the Finger Lakes region - Seneca Lake, for the years 1993-2003. Follow the steps below. Note: Action steps are put in *italics*.

Step 1) *Copy and use paste special* to copy the data sets (including the headers) shown here into an Excel file.

Data

Morehouse Lake		**Seneca Lake**	
Year	Avg pH	Year	Avg pH
1993	5.6	1993	8.3
1994	5.1	1994	8.2
1995	4.4	1995	8.2
1996	4.2	1996	7.9
1997	5.6	1997	8.1
1998	6.1	1998	8.5
1999	6	1999	8.7
2000	6.3	2000	8.7
2001	5.9	2001	8.7
2002	6.3	2002	8.5
2003	5.8	2003	8.8

Step 2) To make a chart of the variables *highlight* the data sets for Morehouse Lake.

Step 3) Go to the control bar at the top of the page and *select Chart Wizard*  .

Step 4) *Select* (XY) scatter plot with a Chart sub typeof scatter with data points connected by smooth lines. *Click on Next.*

Step 5) *Click* on the tab for series and name the series Avg. pH.

Step 6) *Click Next*. Label the X value **Year** and the Y Value **pH**.

Step 7) In the Chart Title Field *Title* the chart **Avg pH in Morehouse Lake**.

Step 8) *Click* next.

Step 9) Place chart as a new sheet - *click* on new sheet and name it Morehouse Lake.

Step 10) *Click* finish.

Step 11) Repeat steps 1-10 by *clicking* on the sheet 1 tab at the bottom of the page and starting the process over for the Seneca Lake data set.

Step 12) The charts are now done but will be more comparable if you set the scale of the XY axis to be the same for each chart.

Step 13) Set the scale of the X axis by *clicking twice* on the X axis line and *clicking* on the scale tab making the changes to the scale as follows: X Axis: Min. 1993 Max 2003; Major Unit 2, Minor Unit 0.4

Step 14) Set the scale of the Y axis by *clicking twice* on the Y axis line and *clicking* on the scale tab making the changes to the scale as follows: Y Axis: Min. 0 Max 9 Major Unit 1 Minor Unit 0.2.

You now should have two charts showing a linear graph of the average pH values for both lakes from 1993-2003.

Answer the questions below. Additional information can be found at the wesbites listed under reference websites.

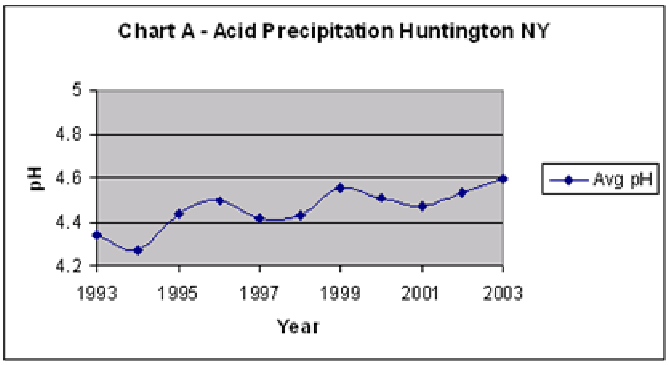
A. What is the general trend of the pH levels in the lakes over the past ten years?

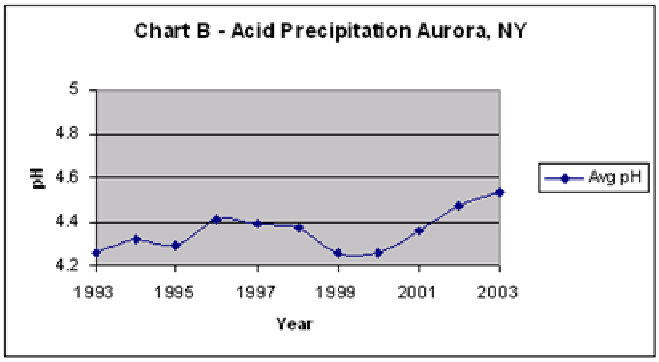
B. How would you explain this trend?

C. Which lake system has a greater potential to buffer the effects of acid rain and why?

D. Charts A & B show the pH of rainfall at a monitoring site in Huntington NY (Adirondacks) and Aurora NY (Finger Lakes) over the past ten years.

- What trend do you see in these charts?
- Explain the possible reasons for this trend.
- Are there any differences or similarities between acid precipitation in the Adirondacks and the Finger Lakes?
- Using the charts you just generated on Morehouse and Seneca Lakes explain how acid rain precipitation in both regions impacts pH levels in the lakes.
- Why there are differences in how the acid rain precipitation affects the pH levels in Morehouse Lake vs. Seneca Lake?





E. Using the charts you made on Avg pH levels in Seneca Lake and Morehouse Lake and the table below answer the following questions about the health of the water body if pH is the only factor.

- During the years 1993-1999 what would the health level of aquatic life have been in Morehouse Lake and how would this have affected aquatic life found in the lake?
- How does the health level of Seneca Lake compare to Morehouse Lake?

pH and Effect on Aquatic Organisms

Health Level	pH	Effect
1	3.0 - 3.5	Unlikely that fish can survive for more than a few hours in this range.
2	3.5-4.0	Known to be lethal to salmon species.
3	4.0-4.5	All fish, most frogs, and insects are absent.

4	4.5-5.0	Mayfly and many other insects absent. Most fish eggs will not hatch.
5	5.0-5.5	Bottom dwelling bacteria (decomposers) begin to die. Leaf litter and detritus begin to accumulate, locking up essential nutrients and interuppting chemical cycling,. Plankton begin to disappear. Snails and clams absent. Mats of fungi begin to replace bacteria in the substrate. Metals (aluminum, lead) normally trapped in sediments are released in the acidified water, which are toxic to aquatic life.
6	6.0-6.5	Freshwater shrimp absent. Unlikely to be directly harmful to fish.
7	6.5-8.2	Optimal range for most organisms.
8	8.2-9.0	Unlikely to be directly harmful to fish. Indirect effects could occur due to chemical changes of the water.
9	9.0-10.5	Likely to be harmful to salmon species and perch if level persists.
10	10.5-11.0	Rapidly lethal to salmon species. Prolonged exposure is lethal to species such as carp and perch.
11	11.0-11.5	Lethal to all species of fish.

Source: Center for Earth and Environmental Science at Indiana University - Purdue University Indianapolis.

Bonus Question
Hypothesize and explain two factors that may cause a body of water to change pH.

Reference Websites

Acid Rain in the Adirondacks
Acid Rain in the Finger Lakes
Impacts of Clean Air Act Amendments of 1990