Student Guide Activity 4 pH: Acidity and Aquatic Environments

A. Introduction to pH and the pH Scale

pH is one of the parameters measured at Cascade Brook. pH is a measure of how acid or alkaline (basic) a solution is. The pH scale goes from 0 to 14. Acid substances, such as lemon juices and vinegar have a pH lower than 7. Substances with a pH higher than 7 are called bases. Examples of these are baking soda and bleach. Any substance having a pH of 7, such as pure water, is neutral.

The pH scale seems to go from 0 to 14, one unit at a time. Actually, the numbers go up by powers of ten (100, 1000, etc) For example, pH 4 is 10 times more acidic than pH 5, and 100 times more acidic than pH 6. This is called a logarithmic scale, and it means that even a small change in pH can have a very strong effect, especially for living organisms. Answer the question below in your Journal.

1. For an animal living in pH 7 water, how much more acidic is pH 5 water?

You can review the pH scale and compare the pH of other familiar substances in the first activity on this site (but don't go on to the lab)
http://www.emu.dk/gsk/fag/fys/ckf/fase1/1fokv/syrer_og_baser/indledning_pH.swf

B. pH in the Environment

Most living things can only survive within a specific pH range, usually somewhere between pH 5 and pH 9. Pure water, at pH 7, is within this range. But when other substances dissolve in water, they often release ions into the water that cause the mixture to become acidic or basic. pH can be raised or lowered both by natural substances in the environment and by man-made chemicals.

Go to: http://www.water-research.net/Watershed/pH.htm and read the section ***What Causes the pH of a Stream to Vary?*** Then answer the questions below in your Journal:

2. What are two natural factors that could affect the pH of a stream?

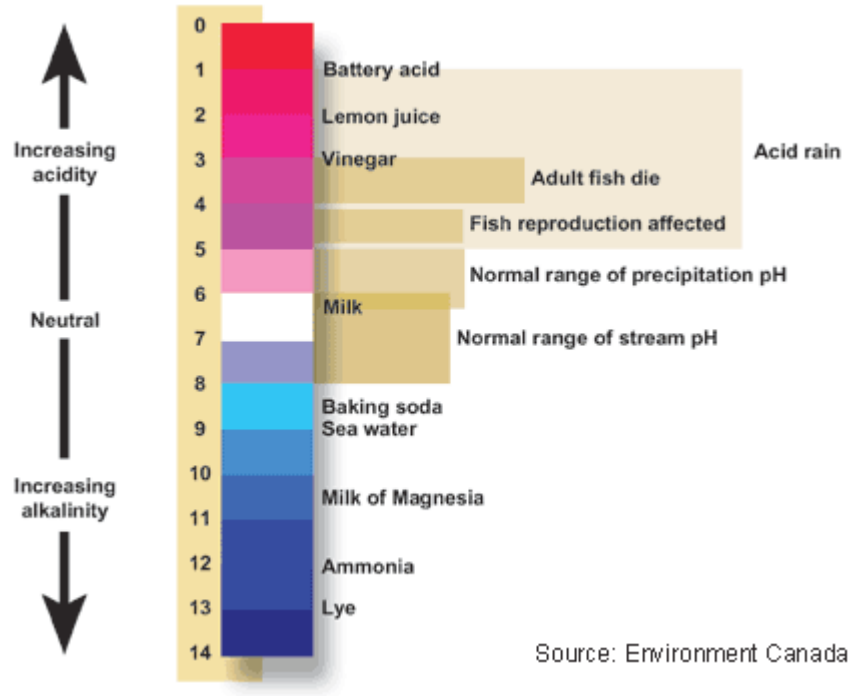
3. What are two examples of human activities that can change the pH of a stream?

C. Acid Rain

In the 1970s people noticed that plants and animals were dying in forests and lakes in the eastern United States. Scientist discovered that the cause was a very particular kind of smoke. Coal-fired plants in the upper Midwest were releasing smoke that contained chemicals like sulfur dioxide and nitrous oxides, compounds that react with water molecules to produce acids. When it rained, these acids landed on trees, buildings, and rivers In New York State. This acid rain has caused extensive damage to buildings and monuments, killed trees and lowered the pH of lakes, rivers and streams. In 1990 a

study showed that one quarter of the 3000 lakes and streams in the Adirondack Mountains had become too acidic to support fish life.

The diagram below shows the range of pH considered to be acid rain. Other common substances are shown for comparison. Use the diagram to answer the questions below in your Journal.



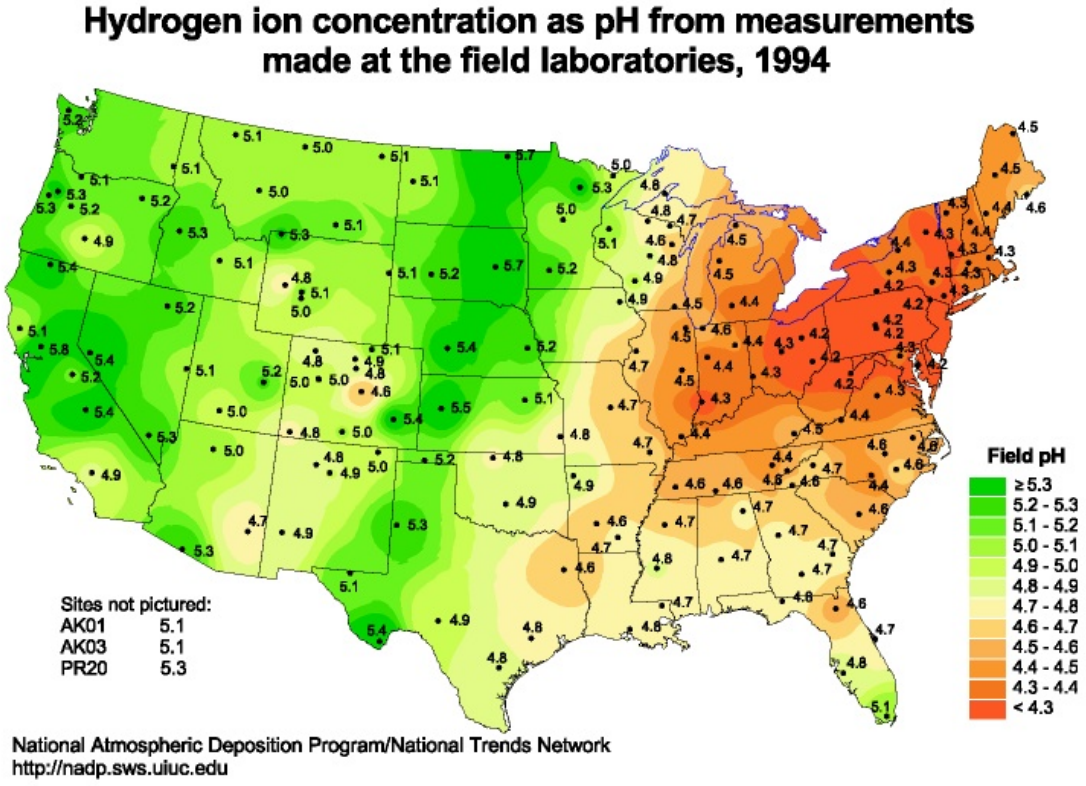
4. What is the pH range of normal precipitation (rain and snow <u>not</u> affected by acid rain)?

If you're surprised that the pH of rain is not 7, remember that rain water contains dissolved gases and other impurities. Carbon dioxide in the atmosphere, combined with water, makes a very mild acid called carbonic acid. Answer the questions below in your journal.

5. According to this diagram, approximately what is the pH range of a normal stream—a stream not affected by acid rain?

6. What is the pH range of Acid Rain, as shown on this diagram?

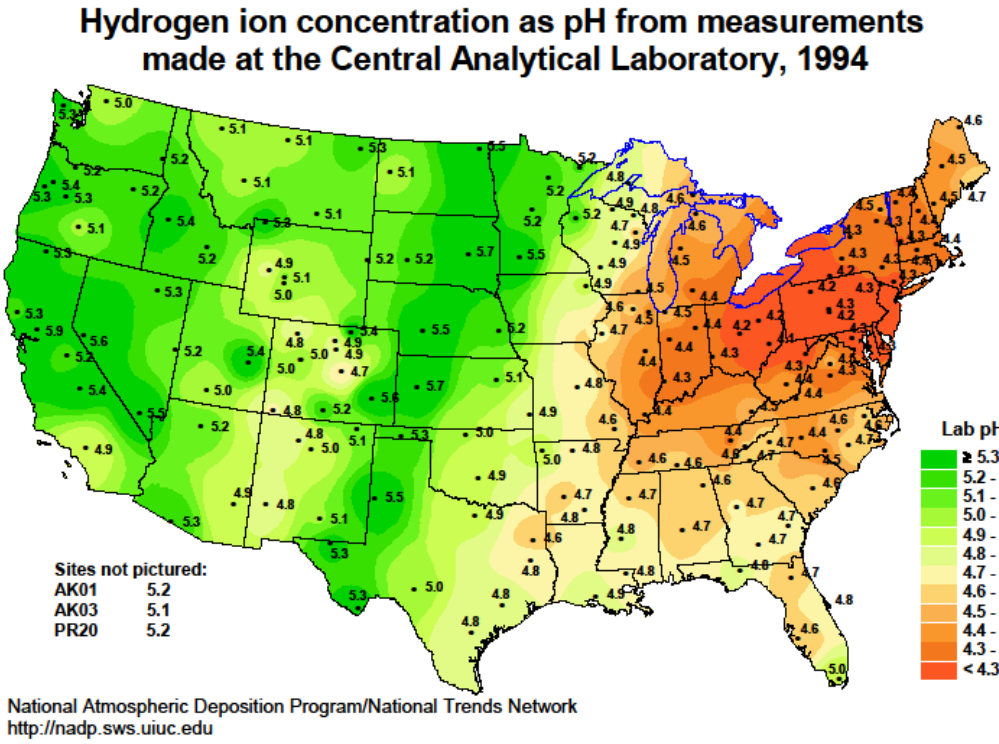
Below is a map showing the pH of rain samples from across the continental US in 1994.



Answer the questions below in your Journal.

7. What do you notice about the differences in the pH of rainfall across the country in 1994? Which part of the country had rainfall with the lowest pH?

8. What was average the pH of rainfall in New York?

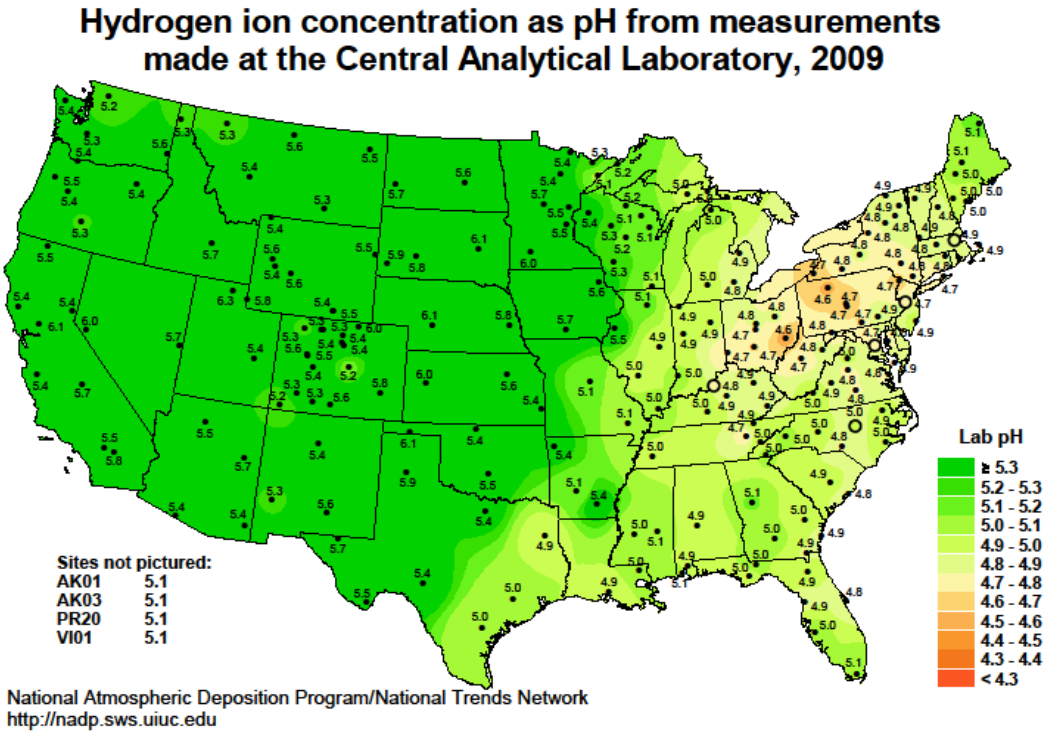


Fortunately several laws were passed a few years earlier which were causing power plants to reduce their emissions of sulfates and nitrous oxides. Compare the 1994 map above with a similar map produced in 2009, seen below. Answer these questions in your Journal.

9. How has the picture changed in 16 years?

10. What was the pH of rain falling in New York in 2009?

11. Compare this figure with the level defined as acid rain on the diagram you looked at earlier. Would you say that the acid rain problem in New York was over in 2009, or was New York still experiencing acid rain?



D. What else can be done?

Even though the progress had been made, acid rain is still with us. It will take more than cleaning up power plants to eliminate acid rain for good. Go this site and learn about actions we all can do to help. Then answer the questions in your Journal.
http://www.epa.gov/acidrain/education/site_students/whatcanyoudo.html

12. What are 3 things families can do to help reduce acid rain?

13. What is something you are willing and able to do right now?

E. Acid rain in Cascade Brook?

Our data on pH at Cascade Brook is also from 2009. Use the Graphing Tool to construct a pH graph for the period **Jan 2, 2009 – Dec 31, 2009**, place the graph in your journal. Were the pH levels at the brook consistent with the information on the 2009 map above? Take a close look at the graph and then answer the following questions in your Journal.

14. Remember that a normal stream or brook has a pH of between 6 and 8. In general, how does the pH in Cascade Brook compare with that of a normal brook?

15. Did the pH in Cascade Brook ever fall within the pH range for acid rain, as indicated on the chart above? On what dates did this happen?

16. Notice that on some of these dates the graph shows sharp downward spikes. What are some possible causes of these abrupt low pH events?

To find out whether downward spikes in pH are associated with rainfall, let's look more closely at some dates they occurred. One of them was on October 29th. Make a graph with **October 24th** as the start date, **November 3rd** as the end date, and **Cascade Brook pH** as the parameter. Print this graph or copy it into your Journal.

Now keep the dates the same and make a second graph, this time using **BRF Lowlands Rainfall** as the parameter. Print it or copy it below the first graph in your Journal. Compare the two graphs and then answer the question below in your Journal.

17. What do you observe about the timing of rainfall with the pH changes on October 29th? What's a possible explanation?

Let's look at another downward spike in pH, this time the one on August 20th. Make a graph of pH using August 15th as the start date and August 24th as the end date. Then use the same dates to make a graph of rainfall. Again either print or copy them so you can compare them easily. Answer the question below in your Journal.

18. Is there any correspondence between the drop in pH and rainfall on August 20th?

What's going on? pH in places like Cascade Brook is determined by many factors, and acid rain or surface water is just one. It is influenced by the chemical characteristics of soils and rocks and decomposing organic matter. The pH of rain may vary, and the amount of acidity washing into a stream during a storm can vary too, depending on how long it's been since the last time it rained. Even the monitoring equipment itself could be responsible for occasional high or low readings.

F. Aquatic animals and pH

How does pH in Cascade Brook affect aquatic animals?
The chart below shows the set of animals you and your classmates reported on, back in Activity 2. In the second column you'll find the pH range that's part of a healthy environment for each animal.

Go back to the graph you made earlier of pH over the full year at Cascade Brook and find out how it compares with the information on this chart.

Aquatic Organisms	Optimum PH Range Can survive 0.5 above or below
Vertebrates	
Brook Trout	6.5—7.5
Black Nose Dace	6.0—8.5
Creek Chub	6.0—8.5
Northern Two-lined Salamander	5.5—8.5
Macroinvertebrates	
Stonefly larva	5.0—8.5
Mayfly larva	5.0—8.5
Caddisfly larva	5.0—8.5
Hellgrammite	4.5—8.5
Dragonfly larva	4.5—8.5
Scud (amphipod)	5.5—8.5
Whirligig beetle	4.5—8.5
Water boatman	5.0—8.5
Mosquito larva	4.5—8.5
Leech	4.5—8.5
Aquatic Worm	4.5—8.5

Answer these questions in your Journal.

19. Was the pH at Cascade Brook ever outside the optimum range for your organism?

20. Would your study organism have experienced pH stress at any times during this period? Indicate those times on the graph using a red pencil or pen. What might it have done to try to minimize the effects of stress?

21. Compare your animal with someone else's. Would their animal survive or experience stress?