Lab #1: Creating Carbonic Acid

Questions
What is carbonic acid (H_2CO_3)? How does it form? Why is it bad for the environment? Does it occur naturally? Can it be prevented?

Overview
Carbonic acid is formed naturally when carbon dioxide (CO_2) dissolves in water. The amount of carbon dioxide that dissolves in water depends on the temperature of the water, the concentration of carbon dioxide in the air and in the water (partial pressure), and on the agents that can deliver carbon dioxide into the water such as wind and wave action.

The addition of carbonic acid to water changes the pH level of that water. Plants and animals have a limited range of tolerance for the pH levels in water. If the pH level changes appreciable, either becoming more acidic or more basic, plants and animals can be dramatically affected.

Grade Level
4^{th} – 9^{th}

Objectives
In this activity students will:
1. Create and test for weak carbonic acid using two techniques.
2. Understand how carbonic acid is created naturally.

National Standards
Content Standard D: Earth and Space Science
Structure of the earth system
Earth's history

Teacher Preparation
Materials (assume 2 students per group)
1. Plastic clear drinking glass
2. Straw
3. pH paper and HACH carbon dioxide testing kit (CA-23, http://www.hach.com)

Safety

Read MSDS safety sheet before attempting testing with the HACH test kit. Goggles should be worn with HACH kit. Dispose of chemicals as recommended on MSDS sheet. To test using the HACH kit for Carbon dioxide concentration water should be removed from the cup. DO NOT blow into the testing vial that contains the phenolphthalein or Sodium Hydroxide. Removing a few drops of water from the cup for the pH paper testing will only very slightly alter the results of the carbon dioxide concentration test as the water volume has decreased and can be considered negligible. Removing water from the cup for the carbon dioxide concentration test will not affect the results.

Time Frame

20 - 30 minutes.

TEACHING SEQUENCE

Engagement and Explanation

1. Students add tap water to their plastic cup until it is about 1/4 full.
2. Students should test the pH of the water with the pH paper* and the HACH carbon dioxide kit**, record results in appropriate units, pH number for pH paper test and mg/L for HACH test. Tap water is ~pH7. This gives the initial data. * water can be removed from the cup using the straw and dripped onto the pH paper. Though the pH paper is not harmful this eliminates any contamination of the pH paper with the water in the cup.**The carbon dioxide concentration should also not be tested in the cup but in the vial included in the HACH kit at the initial and final tests. Since water is removed before students add their own carbon dioxide (step #3) this will not affect the results.
3. Using the straw, students blow into the water for about 2 minutes.
4. Test the pH of the water using the pH paper (remember to drip water onto the pH paper and not dip the pH water in the water in the cup, then record results.
5. Blow into the cup three more times for 2 minutes each, testing with pH paper every 2 minutes, record results.
6. The pH paper gives a relative idea of the change in acidity of the water with the addition of the carbon dioxide. To quantify the amount of carbon dioxide now in the water students should test the final water with the HACH carbon dioxide test kit, and record results of final data.
7. Graph results of pH level and concentration of carbon dioxide per time. Time should appear on the X axis.

The pH paper tests the pH or acidity level of the water and the HACH kit tests the concentration of carbon dioxide in the water. Students will see that as the concentration of carbon dioxide increased the water became more acidic as they add carbon dioxide to the water.

CO_2 (carbon dioxide)+ H_2O (water) = H_2CO_3 (carbonic acid)

Elaboration

Have your students test the pH of many different water sources. Also try water at different temperatures. DO NOT test varying pH levels on live organisms but research how pH levels are important to living organisms and how tolerant the organisms are of pH change. A study on the tolerance of some organisms to pH levels may be helpful - *Aquatic organisms in acidic environments: a literature review*, Eilers, Joseph M.; Lien, Gregory J.; Berg, Richard G.. Daniels, Charmaine, Editor
Aquatic organisms in acidic environments: a literature review
(Technical bulletin. (Wisconsin Dept. of Natural Resources), No. 150)
Madison, Wisconsin: Wisconsin Department of Natural Resources, 1984
18 pgs.v Found at http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=header&id=EcoNatRes.DNRBull150&isize=M

Exchange

1. Students can discuss what other atmospheric and land based chemicals might become incorporated in to the water and change its pH level.
2. Students can discuss what increasing Ph levels might do to organisms.

Evaluation-questions (answers to some questions may require some additional research)

1. What were the starting and ending pH levels??
2. How did the rate of pH change over time? (slowly?, quickly?, exponentially?)
3. How easy is it to read the pH paper? How precise an instrument is pH paper?
4. How did the water appear as the pH increased?
5. How much blowing did it take to increase the pH level?
6. Why is pH an important measurement?
7. How easily can pH change in nature?
8. Does pH change faster in cold water or warm water?

Author

Zach Smith, Wright Center for Science Education, Tufts University
zach.smith@tufts.edu

Resources

http://www.ec.gc.ca/acidrain/kids.html

http://www.woodrow.org/teachers/esi/2002/Biology/Projects/lab_skills/ls1/

http://www.elmhurst.edu/~chm/onlcourse/chm110/molimages/H2CO3.GIF

http://digicoll.library.wisc.edu/cgi-bin/EcoNatRes/EcoNatRes-idx?type=turn&entity=EcoNatRes000101500007&isize=M

Glossary

pH - Is the measurement of the degree of acidity or alkalinity of a solution and varied with the number of Hydrogen ions. The pH scale is from 0 (very acidic) to 14 (very basic). See last reference above for chart.