Effects of Ocean Acidification

Grade Level: 7

Subject Area: Life Science

Virginia Standards of Learning: LS. 11, LS. 12

Objectives:
Students will:

- Test the pH of several samples
- Conduct experiments to investigate the effects of adding CO_2 to water and the effects of acids on marine organisms with calcium carbonate shells
- Understand the connection between adding CO_2 to the atmosphere and ocean acidification
- Understand the concept of ocean acidification
- Understand the effects of ocean acidification on marine organisms

Summary:
Students will conduct two experiments to understand ocean acidification. The first experiment will show students that the addition of CO_2 to water lowers the pH of the water and makes it more acidic. The second experiment will show the students the effects an acid, or more acidic water, has on calcium carbonate. Through discussion, the students will make connections between added CO_2 to the atmosphere, ocean acidification, and its effects on marine organisms that have calcium carbonate shells or skeletons.

Vocabulary: pH, acid, base, ocean acidification

Materials:

For each group you will need (designed for 2-5 students per group):

- 2, 250 mL beakers
- Tap Water
- Straw
- Several squirts of red cabbage pH indicator (see *Preparation* section for instructions on how to make this indicator) from a squirt bottle
- 1 copy of the pH color scale, provided at the end of this guide
- Small piece of chalk or small oyster shell
- White vinegar

Compiled in 2010 by education staff at the Chesapeake Bay National Estuarine Research Reserve in Virginia for use in the B-WET *Chesapeake Studies in the Classroom* program. This lesson was modified from the *Ocean Acidification Lab* created by the Ocean Carbon and Biogeochemistry Program.

You will also need:

- 2 large chicken eggs
- 2, 600 mL beakers
- pH indicator paper or pH test kit (enough for either the class as a whole or each group to conduct three tests)

To make the red cabbage pH indicator you will need:

- 1 head red/purple cabbage
- Pot to boil cabbage in
- Stovetop
- Bottle(s) or jar(s) for storage of about 1L of cabbage solution
- Strainer
- Water

Procedure:

Preparation:

1. At least 24 hours before conducting this activity place each egg into a 600 mL beaker filled with vinegar. The egg should be completely submerged in vinegar. The shell of the egg will dissolve, but the inner membrane surrounding the egg will remain.

2. The day of the activity, pour off the vinegar and add water to the beaker. This will reduce the vinegar smell left on people's hands after they reach into the beaker and feel the egg.

3. The night before the activity, prepare the red cabbage pH indicator. Roughly chop 1 head of red/purple cabbage. Place the cabbage in a pot with enough water to cover the cabbage, and bring the water to a full rolling boil. Turn off the heat and allow cabbage to sit in the water until the water is dark purple (about 10 min.). Pour the liquid into a storage bottle or jar – use a strainer to filter out cabbage pieces. Be careful to avoid spilling the cabbage liquid – it will stain countertops and clothing. Allow the liquid to cool. Refrigerate the liquid when not in use. Liquid should be used within 2-3 days. One head of cabbage provides about 1L of liquid.

Activity:

Experiment 1:

1. Fill a 250 mL beaker with about 250 mL of tap water.

2. Add red cabbage pH indicator to the water in the beakers, enough for you to clearly see the color (several squirts from a squirt bottle or pipet).

3. Pass one beaker out to each group.

4. Either as a class or each group, test the pH of the water in the beaker using either the pH indicator or pH test kit. You can also have students match the color of the water with the pH color scale provided in order to determine the pH.

5. Explain to the students that they will be blowing into this water through a straw. What is gas do we exhale? The answer is carbon dioxide (CO_2). The students will be observing what happens to the pH of the water as they add CO_2. (See the background information section at the end of this guide for additional information on ocean acidification.) Without sucking up any water, students should place the straw into the tap water and blow through the straw. They should move the straw around so that bubbles flow through all the liquid. They should continue to blow until they can observe a change in color of the tap water. This usually does not take more than 45-60 seconds. It's ok to take quick breaks to breathe.

6. Have the students test the pH of the tap water again, using either the pH paper, test kit, or color scale.

7. Did the pH increase, decrease, or stay the same? Is the water more acidic or basic as a result of adding $CO_{2?}$ Discuss with students why the pH changed. When CO_2 mixes with water it creates an acid and causes the water to become more acidic.

Experiment 2:

8. Fill each remaining 250 mL beaker halfway with vinegar. Pass one beaker out to each group of students.

9. Tell students that it is only vinegar in the beakers – the same vinegar you eat, cook with, and clean with at home.

10. Vinegar is an acid. Have the students use the pH indicator paper or the pH test kit to determine the pH of the vinegar. The pH should be around 2 or 3.

11. Give each group a piece of chalk or shell. Have them drop the chalk or shell into the vinegar and observe what happens. The chalk or shell will start to fizz. The acidic vinegar is dissolving the chalk or shell.

12. Explain to students why the vinegar is dissolving the chalk or shell. Both chalk and the shells of most aquatic organisms are made of a material called calcium carbonate. Acid dissolves calcium carbonate.

13. Remind students that calcium carbonate is the same material that makes up the shells of aquatic organisms. Given that, what would happen to those organisms if the ocean became more acidic? Naturally, ocean water has a pH of about 7, which means it is neutral – neither a base nor an acid. If the ocean were to become more acidic, the shells of aquatic organisms could dissolve.

14. Pass the eggs around for students to feel. They can pick them up and hold them in their hand, just remind the students to be gentle. There is only a thin membrane holding the egg white and yolk together.

15. The shell of an egg is also made of calcium carbonate. Explain to students that you left the eggs in vinegar for 24 hours and within that time the vinegar completely dissolved the shell of the egg. The students should make the connection between how vulnerable the inside of the egg is without its shell and how vulnerable aquatic organisms would be if they could not produce or maintain their shells.

Wrap-Up

Much of the discussion for this activity occurs while the students are completing each step. This activity is designed to allow students to make connections between the concepts of ocean acidification as they complete it. Wrap-Up discussion should serve to ensure that students understand the connection between the addition of CO_2 to the ocean, ocean acidification, and its effects on marine organisms. Even though in this example human breathe caused the water to become more acidic, when scientists talk about ocean acidification or climate change they are referring to CO_2 that has been added to the atmosphere or ocean from human activities, such as burning fuel. Humans are not contributing to ocean acidification or climate change by breathing, but by other activities we do that emit CO_2.

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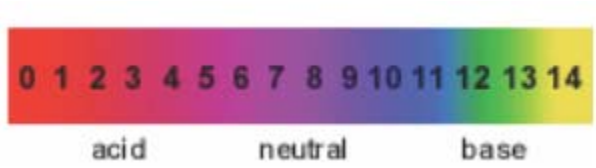
pH Color Scale

The color scale below shows the complete color range of the red cabbage pH indicator. Red colors indicate more acidic fluids, and blue, green, and yellow colors indicate more basic (less acidic) fluids. The color scale is from http://www.greatscience.com/think/projects.php?id=21



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Background Information on Ocean Acidification

Ocean acidification refers to a global scale change in the chemistry of the ocean. It occurs when carbon dioxide (CO_2) from the atmosphere is absorbed into ocean water, causing the water to become more acidic. The ocean provides a tremendous service as it absorbs some of the CO_2 that human activities emit into our atmosphere. In fact, the ocean has absorbed nearly 1/3 of the CO_2 that humans have added to the atmosphere over the past two centuries. The chemistry of saltwater allows for the ocean to resist, or buffer against, changes in its water chemistry when a relatively small amount of CO_2 is added. However, the large quantities of CO_2 being added to our atmosphere and ocean are overpowering the ocean's ability to resist the change. The addition of CO_2 to the ocean and the subsequent acidification of the ocean have severe consequences for marine organisms. There are three main concepts that should be understood about ocean acidification:

1. The chemistry of the ocean is dependent on the chemistry of the atmosphere.
    a. More CO_2 in the atmosphere leads to more CO_2 dissolved in the ocean.

2. More CO_2 dissolved in the ocean makes the ocean more acidic.

3. Changes in ocean acidity impact marine organisms that have calcium carbonate shells and skeletons. It will cause their shells and skeletons to dissolve. Examples of organisms affected by ocean acidification include: some species of phytoplankton, crabs, oysters, and lobsters.

There is a great video of Dr. Jane Lubchenco, administrator of the National Oceanic and Atmospheric Administration (NOAA), discussing ocean acidification. During the video she also conducts a demonstration very similar to the one outlines in this guide. The video can be found at: http://www.noaa.gov/video/administrator/acidification/.

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