SCIENCE AT HOME

OCEAN ACIDIFICATION

GRADE: **10**

SNC2D, SNC2P
SUBJECT: SCIENCE
STRAND: CLIMATE CHANGE
TOPIC: OCEAN ACIDIFICATION
EXPECTATIONS: SNC2D: D3.1, D2.2, D2.3, D2.4, D2.6, D3.3
SNC2P: D1.1, D3.1, D2.2, D2.3, D2.4, D2.6, D3.3
VIDEO: youtu.be/iuLE5ihLbzo

INTRODUCTION:

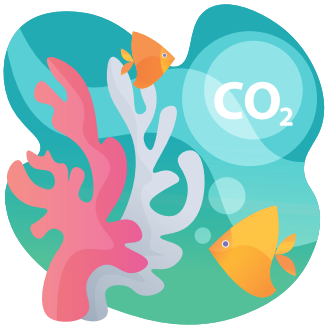
Historically, changes in climate have been influenced by a combination of human and natural factors, but these days climate change is mostly due to human activity, like fossil fuel use and modern agricultural practices. (The words "climate" and "weather" are sometimes used interchangeably, but there is a clear distinction between them: weather indicates the current state of atmospheric conditions, whereas climate reflects weather over many years.) Greenhouse gases are needed for Earth to retain heat from the Sun. But human activity has created an excess of these gases, so that now too much of the Sun's heat gets trapped in our atmosphere.

The increase in greenhouse gas emission also affects our ocean. The ocean is a natural carbon sink that accumulates and stores carbon-containing chemical compounds. By absorbing much of the excess carbon and heat from the atmosphere, the ocean helps regulate the Earth's temperature. Chemicals, such as carbon dioxide from the atmosphere, dissolve into the ocean's surface and then move into the deep ocean.

This is the chemical formula for how CO_2 reacts with water:

$$CO_2 + H_2O \rightarrow H_2CO_3$$

This chemical reaction results in the formation of carbonic acid (H_2CO_3). The increased concentration of carbonic acid in our oceans is altering the chemistry of marine ecosystems in a process known as "ocean acidification."



ACTIVITY: Testing acidification

Make a simple red cabbage juice acid-base indicator right in your kitchen, then use it to explore the reaction between CO_2 and water.

TIME: 30 minutes

SAFETY:

Never leave the stove unattended.

Don't drink any of the solutions.

WHAT YOU NEED:

- Red cabbage
- Heat-resistant container (to hold the indicator)
- Clear containers
- Paper cups (smaller than the clear containers)
- Water
- Baking soda

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WHAT YOU NEED (continued):

- Vinegar
- Measuring cup
- 1 tbsp measuring spoon
- ½ tsp measuring spoon
- Pot to boil water
- Strainer (optional)
- Plastic wrap
- Tape

WHAT YOU DO:

Chop the red cabbage into small pieces. Put the cabbage into a pot, and add just enough water to cover it. Bring it to a boil, then turn the heat down and simmer gently for about 10 minutes. After cooking, strain out the cabbage and keep the liquid — your indicator!

Measure 100 mL of tap water into two clear containers. Add one tablespoon of red cabbage indicator liquid into each of the two containers. Stir.

Slide an empty paper cup into one of the containers and tape the container and the cup together on one side, lip to lip. Don't let the bottom of the paper cup get wet. Do the same with the second container and another paper cup.

Into one of the paper cups, put half a teaspoon of baking soda followed by one teaspoon of vinegar. Quickly place a sheet of plastic wrap over the mouth of the container and seal it tight — and use a lid if you have one handy.

Seal the other container too.

Observe.

If possible, take a photo every two minutes for 10 minutes, or make a time-lapse video.

UNPACKING WHAT HAPPENED:

In the experiment above, the pH of a solution was altered by carbon dioxide gas. The baking soda and vinegar, which were added to one of the paper cups, reacted according to this chemical formula:

$$\underset{\text{baking soda}}{NaHCO_3} + \underset{\text{vinegar}}{CH_3COOH} \rightarrow \underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O} + \underset{\text{sodium acetate}}{CH_3COONa}$$

After 15 minutes, three new chemical compounds were formed, one of which was carbon dioxide gas. It filled the sealed container. And it reacted with the water in the cabbage juice solution to create carbonic acid:

$$\underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O} \rightarrow \underset{\text{carbonic acid}}{H_2CO_3}$$

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UNPACKING WHAT HAPPENED (continued):

Carbonic acid is acidic, so it decreased the pH of the cabbage juice solution, changing its colour from dark purple to light purple. The solution in the other container did not change colour. This is your control, showing the colour of cabbage juice in a neutral solution, with a pH of 7.

WHY THIS MATTERS:

Humans began burning large amounts of fossil fuels around 275 years ago, which has led to the acidification of our ocean. Over time, the ocean has become 30% more acidic, and it will become increasingly acidic unless something is done.

The extra carbon dioxide that reacts with the ocean water forms carbonic acid. This lowers the water's pH. As levels of carbonic acid in the ocean increase, levels of carbonate — a naturally occurring base — decrease. Before the acidification of the ocean, much of the carbonate in it was free to react with calcium and to form calcium carbonate, a compound used by marine organisms to build seashells and corals. With greater acidification, the ocean has less free carbonate, since so much of it reacts with the extra hydrogen ions produced through acidification, and turns into bicarbonate.

$$\underset{\text{carbonate}}{CO_3^{2-}} + \underset{\text{hydrogen ions}}{H^+} \rightarrow \underset{\text{bicarbonate}}{HCO_{3-}}$$

This decrease in oceanic calcium carbonate means weaker shells and coral. These are structures that many marine organisms depend on for their survival. Consider coral. As temperatures increase in the ocean due to climate change, coral colonies lose their algae, a process called "bleaching." Ocean acidification adds insult to injury, because with less oceanic calcium carbonate available to repair the damage caused by bleaching, the coral is more vulnerable to disease and can die. What happens to organisms that depend on the coral for food, habitat and protection?

TAKING IT FURTHER:

Using what you learned in the first experiment, devise an experiment of your own that uses organic materials to mimic the chemical composition of coral, seashells or other oceanic organisms. Add household organic material — such as egg shells, apple slices and orange peels — into the cabbage juice indicator before placing the paper cups inside the containers. Be sure to add baking soda and vinegar to the cup in one container and none to the cup in the other (the control), as you did before.

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TAKING IT FURTHER (continued):

Wait one hour, then observe your organic material. Has it begun to dissolve or degrade due to the acidification of the cabbage juice? Do you notice a difference between the organic material in your experimental container in comparison to your control container?

What will happen if you give the experiment even more time?

In the first experiment, we used baking soda and vinegar. Can you find a different way to get CO_2 into the container?

Think about the living organisms that might be affected by acidification and what may happen to them in such an environment.

Experimentation helps us understand the process of acidification, but what can you do to improve the environment in the real world? Find your own way to make a difference. It's okay to start small and work your way up.

Ask yourself:

How can you reduce your carbon footprint within your own home and neighbourhood?

How can you reduce the amount of energy you use on a daily basis?

Can you make different transportation choices to reduce your impact on climate change?

How can buying local goods reduce your carbon footprint?

Who can you talk to about making changes in your community that will support your efforts?

How can you advocate for change at a higher level — for instance, in the natural resources sectors?

MORE ONLINE:

Ocean Acidification: The other carbon dioxide problem
https://www.pmel.noaa.gov/co2/story/Ocean+Acidification

Climate change seeps into the sea
https://www.nasa.gov/topics/earth/features/climate_acidocean.html

How does climate change affect coral reefs?
https://oceanservice.noaa.gov/facts/coralreef-climate.html

What is coral bleaching?
https://oceanservice.noaa.gov/facts/coral_bleach.html

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