Effect of ocean acidity on marine animals

Keywords: Environment, Ocean, Ocean acidification, pH

Meta Description

This educative experiment is aimed to raise awareness about the devastating effects of ocean acidification on shelled marine organisms.

Learning Objectives

The main goal of this experiment is to show the devastating effects of ocean acidification on marine animals possessing a calcium carbonate shell.

Another objective is to show what happens to the egg shell when placed in acidic and basic environments and to relate the results to what would happen to a shelled marine organism.

Key Terms

pH

Scale used to show how acidic or basic a substance is.

Fossil Fuel

A natural fuel derived from plant/animal remains.

Corals

Invertebrates that belong to the phylum Cnidaria.

Ecosystems

An ecosystem consists of all the living organisms occupying a specific area in a given time, the interactions between them as well as the interactions with the physical environment.

Base

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A chemical that reacts with an acid to form a salt. It releases hydroxide ions when in solution.

Method

Step 1
Place 50 mL of vinegar in a jar together with 100 mL of water. Label this jar as acidic.
Step 2

Place 50 mL of bleach in a jar together with 100 mL of water. Label this jar as basic.

Step 3

Place 150 mL of water in a jar and label this as neutral.
Step 4

Place an egg in each of the jar and seal them with either a lid or with stretch and seal.

Step 5

Leave for 24 hours and observe any differences on the egg.

Step 6
If nothing happens, repeat steps 1-5 but this time using constantly the same eggs.
Step 7

Finally, remove the eggs and see what has happened to the egg shells.

Alternative Method

Instead of using a jar, you can use a beaker if you are in a lab. It is important to seal the beaker to prevent any potential spills.

If you do not have any vinegar, use your science brain to locate other acidic food items present at your home. You might want to use lemon juice or even ketchup instead.

Precautions

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This experiment can turn out to be messy, hence it is ideal to place the jars on a tray so that any spillages can be contained. It is also ideal to keep hand towels close by.

Some children can be allergic to eggs, therefore be careful if any weird behaviour is observed during/after the experiment.
http://www.mayoclinic.org/diseases-conditions/egg-allergy/basics/definition/con-20032721

Bleach is very dangerous therefore it is ideal that it is only handled by the demonstrators. To show the importance of lab safety it is ideal to advise the children to wear lab coats, safety goggles and gloves while performing the experiment.
http://www.premiereproducts.co.uk/Admin/Downloads/MSDS/MSDS%20-%20Liquid%20Bleach.pdf

Narrative

The burning of fossil fuels leads to an increase in carbon dioxide in the environment. The increased levels of carbon dioxide in the air causes more carbon dioxide to dissolve in the ocean which in turn leads to an increase in the acidity of the ocean. This is termed ocean acidification and some of the effects of this devastating phenomena are represented through this experiment.

Questions

What is ocean acidification?

Increase in the acidity of the ocean causing a decrease in pH.

Why were eggshells used?

To represent the calcium carbonate shells of marine organisms.

Why was vinegar used?

To show the effects of acid on calcium carbonate.

Why were bubbles produced in the vinegar solution?

Carbon dioxide

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What causes ocean acidification?

Increase in atmospheric carbon dioxide levels.

Brief Explanation

It could be seen from this experiment that the shell placed in the vinegar solution was no longer present/very diminished after the experiment was performed. The vinegar (containing acetic acid), is an acid which reacts with the calcium carbonate (base) present in the eggshell. This is an acid-base reaction and is represented below:

acetic acid (vinegar) + calcium carbonate (eggshell) ? calcium acetate + carbon dioxide + water

Calcium acetate is highly soluble hence can easily dissolve away.

This experiment demonstrates what happens to shelled organisms, that use calcium carbonate as the building block for the shells, during ocean acidification. Ocean acidification occurs when an increase level of carbon dioxide in the air forces more carbon dioxide to dissolve in the water. Carbon dioxide reacts with water to form carbonic acid which leads to a lowering of pH i.e. increase in acidity. This in turn causes the shells of marine organisms to dissolve.

$CO_2 + H_2O$? H_2CO_3 ? $HCO_3^- + H^+$

http://news.nationalgeographic.com/news/2014/05/140502-ocean-snail-shell-dissolving-acidification-climate-change-science/

As long as we continue to add to the carbon dioxide in the atmosphere, there will continue to be carbon dioxide dissolving in our oceans. Apart from affecting the shelled marine organisms, increase in ocean acidity makes it more difficult for corals to build skeletons. This is disastrous as corals provide important homes for many sea organisms.
https://www3.epa.gov/climatechange/kids/impacts/signs/acidity.html

Detailed Explanation

Following the experiment it can be seen that there was no observable change in the egg shell when placed in water and in the basic solution. However, when placed in the vinegar, the eggshell disappeared to expose the membrane. This is as the eggshell is made of calcium carbonate which reacts with the acetic acid in vinegar through an acid-base reaction. This is represented by the following equation:

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CaCO3 (s) + CH3COOH(l) Ca(CH3COO)2(aq) + CO2(g) + H2O(l)

The calcium acetate product is soluble in water and hence is easily washed away. The formation of the carbon dioxide gas is what caused bubbles to appear in the vinegar solution.

This experiment was conducted to show what happens to shelled marine organisms that use calcium carbonate as the building block for their shells when exposed to an acidic environment. The acidic environment was represented by the vinegar solution. The shells allow for protection and attachment of muscles, hence some marine organisms cannot do without these shells.
https://www.scientificamerican.com/article/how-are-seashells-created/

The phenomena of ocean acidification is leading to the shells of animals in fact being thinner.

Ocean acidification occurs due to the seawater absorbing carbon dioxide. As the carbon dioxide from the burning of fossil fuels accumulates in the atmosphere, some of it gets absorbed by the ocean. This in turn causes the following reactions to occur:

CO2(g) + H2O(l)? H2CO3(aq) ? HCO3-(aq) + H+(aq)? CO32-(aq) + H+(aq)

As can be seen by the above equation, hydrogen ions are generated which lead to an increase in the acidity of the ocean.

The reaction of vinegar with water to release hydrogen ions is shown below:

CH3COOH(l) + H2O(l)?CH3COO-(aq) + H+(aq)

An increase in the acidity of the ocean leads to a reduction in the calcium carbonate present for aquatic organisms to build their shells and skeletons. Skeletons are required for corals which are important reef builders. The effects of ocean acidity are detrimental to coral reef ecosystems causing the thinning and disappearing of coral reef ecosystems. This in turn affects the estimated 3.2 million species that inhabit coral reefs.
http://dujs.dartmouth.edu/2012/03/the-decline-of-reefs-effects-of-increased-carbon-emissions-on-coral-ecosystems/

Applications and Research

Research

The European Commission released an article in April 2017 stating that the effects of ocean acidification are putting the Norwegian fishing industry at risk. This is of great economic concern since Norway is the second larger exporter of fish and fish products in the world!
http://ec.europa.eu/environment/integration/research/newsalert/pdf/ocean_acidification_puts_norwegian_fish

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Research

A 2 year project to be co-ordinated in Norway in the year 2018 is aimed towards understanding better the effects of ocean acidification and warming on the social behaviour of marine organisms. This project is to be fully funded by the European Union.
http://cordis.europa.eu/project/rcn/209836_en.html

Research

A few years ago a multi-disciplinary project was commenced in January 2010 and ended in May 2014. This brought together researchers to help understand the causes of change in reef health and to improve the management of the Caribbean reefs. Europe took part in this project together with the Caribbean, USA and Australia.
http://cordis.europa.eu/result/rcn/161225_en.html

Research

Another EU funded project this time in the UK which lasted a total of three years (2012-2015) aimed to develop a new stable isotope technique to monitor ocean carbonate budgets as well as to evaluate the sulfur isotope record of the oceans. The outcome helped to constrain the timing and future effects of the anthropogenic carbon dioxide on the overall health of the biotic and abiotic components of the ocean.
http://cordis.europa.eu/project/rcn/100200_en.html

Investigation

Investigate the action of other household items on the egg shell. Use your science knowledge to observe what substances are more acidic than others.

If you happen to be next to a beach, collect some seashells and this time perform the experiment using actual seashells. See if the results compare to what happened to the eggshell.

Make the experiment a little bit more fun by attaching a balloon to the neck of a conical flask where the shells with the vinegar are placed and see what happens to the balloon. The balloon should inflate since the decomposition of calcium carbonate present in the eggshell leads to the generation of carbon dioxide gas.

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Subjects

Biology
Chemistry

Education

Preschool
Primary
Secondary

Time Required

1 day or more
Preparation: 10 mins
Conducting: 1 day
Clean Up: 10 mins

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Cost

0 – 10 €

Recommended Age

3 – 6
6 – 9

Number of People

1 participant

Supervision

Not Required

Location

Indoors
Laboratory

Materials

3 eggs
3 jam jars
Stretch and seal
Water
Vinegar
Bleach

Contributors

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Sources

Ocean Acidification Experiment:
Impacts of carbonated seawater on mussel and oyster shells

Ocean Acidification: The Other Carbon Dioxide Problem

Ocean acidification and eggshells

Ocean Acidification by the Alliance for Climate Education

Acid Test: The Global Challenge of Ocean Acidification

Demystifying ocean acidification and biodiversity impacts

Ocean Acidification

The Effects of Ocean Acidification on Pteropod Shells

Experiment with shells and vinegar: ocean's acidification

Additional Content

Why is the ocean important?
(Beginner)

OCEAN ACIDIFICATION
(Intermediate)

Increasing ocean acidity could impact fish spawning (Advanced)

Cite this Experiment

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