

Practical Science

Exploring the potential to store CO₂ in the ocean

Time – 45 minutes to 1 hour

This is a practical science session to introduce students to the concept of Carbon Capture and Storage (CCS). Students will use a chemical reaction to create CO₂ and then 'sequester' it using 'oceanic' sequestration. They will determine if ocean (salt) water can hold more dissolved CO₂ than fresh water before it turns acidic.

CCS has been much talked of by the government and media of as a way to reduce the emissions produced by power plants and other industrial plants. Relatively pure CO₂ resulting from industrial processes can be 'sequestered' (effectively removed from the atmosphere) by geological or oceanic sequestration. Geological sequestration is investigated in [Practical Science – simulating geological sequestration of CO₂ in an oil well](#).

For background information about an industrial process producing CO₂ as a by-product, see Background information – CCS in industry – Limestone calcinations.

MATERIALS

One set of materials listed is required for each lab group (two to four students per group)

Materials needed (per lab group of two to four students):

- o 100ml of vinegar
- o 2 – 250ml flask
- o 2 - two-hole rubber stopper with plastic tubes to fit flask
- o 1 length rubber tubing, 45 cm long
- o Safety glasses
- o 1 – 250ml beaker
- o 1 – 30ml syringe (no needle)
- o Supply of water
- o 5g of sea salt
- o Box of baking soda
- o 300ml Phenol Red
- o Straws or rigid plastic tubing
- o Copies of Oceanic Absorption – Lab Procedure sheet
- o Copies of Oceanic Absorption – Student Sheet

PREPARATION

- o Gather all of the necessary lab materials and run a test to be certain of safety procedures.
- o Review the teacher sheet and familiarize yourself with oceanic absorption as a means of carbon sequestration.

IN CLASS

- o Give a basic introduction to the principles behind Carbon Capture and Storage.
- o Explain that students will conduct an experiment to learn about the method of oceanic absorption for carbon sequestration.
- o Divide students into groups of 2-4. They should then move to a lab station with the appropriate materials needed to complete the lab.
- o Hand out Oceanic Absorption Lab Procedure. Review.
- o Allow students to conduct the lab while you roam the room and help.
- o Clean up.
- o Hand out Oceanic Absorption – Student Sheet.

- o Discuss experiment results using the student sheet as a guide.

Oceanic Absorption – Teacher Sheet

Introduction and Teacher Background:

CO₂ is soluble in ocean water, and through natural processes the ocean both absorbs and emits huge amounts of CO₂ into the atmosphere.

It is widely believed that the ocean will eventually absorb most of the CO₂ in the atmosphere. However, the kinetics of ocean uptake is slow, causing a peak atmospheric CO₂ concentration of several hundred years.

One approach to enhancing the rate of CO₂ absorption in the ocean involves adding combinations of micronutrients and macronutrients to those ocean surface waters deficient in such nutrients. The objective is to stimulate the growth of phytoplankton, which are expected to consume greater amounts of carbon dioxide. When carbon is thus removed from the ocean surface waters, it is ultimately replaced by CO₂ drawn from the atmosphere. The extent to which the carbon from this increased biological activity is sequestered is unknown at this point, and would require additional research. Any R&D on natural enhancement would also require complete examination of potential environmental issues.

Direct Injection of CO₂

Technology exists for the direct injection of CO₂ into deep areas of the ocean; however, the knowledge base is not adequate to optimize the costs, determine the effectiveness of the sequestration, and understand the resulting changes in the biogeochemical cycles of the ocean.

To assure environmental acceptability, developing a better understanding of the ecological impacts of both ocean fertilization and direct injection of CO₂ into the deep ocean is a primary focus. It is known that small changes in biogeochemical cycles may have large consequences, many of which are secondary and difficult to predict. Of particular concern is the effect of CO₂ on the acidity of ocean water.

In this experiment, students will determine if ocean (salt) water can hold more dissolved CO₂ than fresh water before it turns acidic.

Oceanic Absorption – ANSWERS

Name:

Date:

1. What test solution turned yellow first?

The fresh water turned yellow first.

2. What does turning yellow indicate in this experiment?

Turning yellow indicates that the solution is saturated with carbon dioxide.

3. What was the concentration of the salt water (percent)? What is the average concentration of seawater?

5 grams of salt in 150ml of phenol red gives a concentration of 3.3% (5/150). The average concentration of salt water (ocean water) is 35 parts per thousand or 3.5%.

4. If there were living organisms in our salt water test solution, how do you think they would be affected?

Answer will vary. It is not known exactly what effects pumping CO₂ into seawater will have on living organisms. The average pH of salt water (ocean water) is approximately 8.2.

5. Do you think that deep-sea water injection is a feasible carbon sequestration method? Explain your answer.

Seawater (salt water) does seem to hold more carbon dioxide than fresh water. However, little is known about what the effects of increasing the amounts of CO₂ in seawater will have on marine organisms. Answers may vary at this point. One possible answer is – until further research is done to study these effects, it may be advisable to limit using deep-sea water as a potential disposal or storage site for CO₂.

Oceanic Absorption – Lab Procedure

1. Be sure you have the materials listed below at your lab station.
 - o Be sure you have the materials listed below at your lab station.

- o 100ml of vinegar
 - o 2 – 250ml flask
 - o 2 - two-hole rubber stopper with plastic tubes to fit flask
 - o 1 length rubber tubing, 45 cm long
 - o Safety glasses
 - o 1 – 250ml beaker
 - o 1 – 30ml syringe (no needle)
 - o Supply of water
 - o 5g of sea salt
 - o Box of baking soda
 - o 300ml Phenol Red
 - o Straws or rigid plastic tubing
2. Make sure that all unions are airtight. Place enough baking soda in the flask to cover the bottom.
 3. Put on your safety glasses.
 4. Pour about 40ml of vinegar into a 250ml beaker. Put the tip of the 30ml syringe into the vinegar making sure that the plunger is all the way down. Keep the tip of the syringe below the surface as you pull back on the plunger to fill it to the 30ml mark. If you get air bubbles in the syringe, empty it and repeat the procedure again.
 5. Put 150ml of phenol red in the testing container. Make sure that the straw that is delivering the carbon dioxide is submerged near the bottom of this flask. It is important that the CO₂ bubbles through the solution.
 6. Place the syringe into the straw on the rubber stopper and slowly add 5ml of vinegar to the baking soda. Let the gas bubble through the testing solution. When the gas production has stopped, add another 5ml of vinegar.
 7. Repeat this procedure until the phenol red turns yellow.
 8. Rinse out your equipment and repeat the experiment except this time dissolve 5g of salt into the 150ml of phenol red.
 9. When you have finished this activity, clean up your materials. Answer the questions on the Oceanic Absorption – Student Sheet.

Oceanic Absorption – Student Sheet

Name:

Date:

1. What test solution turned yellow first?

2. What does turning yellow indicate in this experiment?

3. What was the concentration of the salt water (percent)? What is the average concentration of sea water?

4. If there were living organisms in our salt water test solution, how do you think they would be affected?

5. Do you think that deep-sea water injection is a feasible carbon sequestration method? Explain your answer.