# Geologic Sequestration

This experiment provides an opportunity for students to learn about geologic sequestration as a technique used to reduce carbon dioxide in the atmosphere.

## Background

Carbon dioxide sequestration in geologic formations includes oil and gas reservoirs, unmineable coal seams, and deep saline reservoirs.

Oil and Gas Reservoirs. In some cases, production from an oil or natural gas reservoir can be enhanced by pumping $CO_2$ gas into the reservoir to push out the product, which is called enhanced oil recovery (EOR). Enhanced oil recovery represents an opportunity to sequester carbon at low net cost, due to the revenues from recovered oil and gas. In an enhanced oil recovery application, the integrity of the $CO_2$ that remains in the reservoir is well understood and very high, as long as the original pressure of the reservoir is not exceeded. The scope of this EOR application is currently economically limited to point sources of $CO_2$ emissions that are near an oil or natural gas reservoir.

Coal Bed Methane. Coal beds typically contain large amounts of methane-rich gas that is adsorbed onto the surface of the coal. The current practice for recovering coal bed methane is to depressurize the bed, usually by pumping water out of the reservoir. An alternative approach is to inject carbon dioxide gas into the bed. Tests have shown that $CO_2$ is roughly twice as adsorbing on coal as methane, giving it the potential to efficiently displace methane and remain sequestered in the bed.

Similar to the by-product value gained from enhanced oil recovery, the recovered methane provides a value-added revenue stream to the carbon sequestration process, creating a low net cost option. Another promising aspect of $CO_2$ sequestration in coal beds is that many of the large unmineable coal seams are near electricity generating facilities that are large point sources of $CO_2$ gas. Thus, limited pipeline transport of $CO_2$ gas would be required. Integration of coal bed methane with a coal-fired electricity generating system can provide an option for additional power generation with low emissions.

Saline Formations. Sequestration of $CO_2$ in deep saline formations does not produce value-added by-products, but it has other advantages. First, the estimated carbon storage capacity of saline formations can be large, making them a viable long-term solution. Second, most existing large $CO_2$ point sources are within easy access to a saline formation injection point.

Assuring the environmental acceptability and safety of $CO_2$ storage in saline formations is a key component. Determining that $CO_2$ will not escape from formations and either migrate up to the earth's surface or contaminate drinking water supplies is a key aspect of sequestration research. Although much work is needed to better understand and characterize sequestration of $CO_2$ in deep saline formations, a significant baseline of information and experience exists. For example, as part of enhanced oil recovery operations, the oil industry routinely injects brines from the recovered oil into saline reservoirs.

The Norwegian oil company, Statoil, is injecting approximately one million tons (metric tons, or 1000kg) per year of recovered $CO_2$ into the Utsira Sand, a saline formation under the sea associated with the Sleipner West Heimdel gas reservoir. The amount being sequestered is equivalent to the output of a 150-megawatt coal-fired power plant. This is the largest commercial $CO_2$ geological sequestration facility in the world.

## For Teachers

**Time Required**: 45 minutes

**Procedure**:

**Prep**

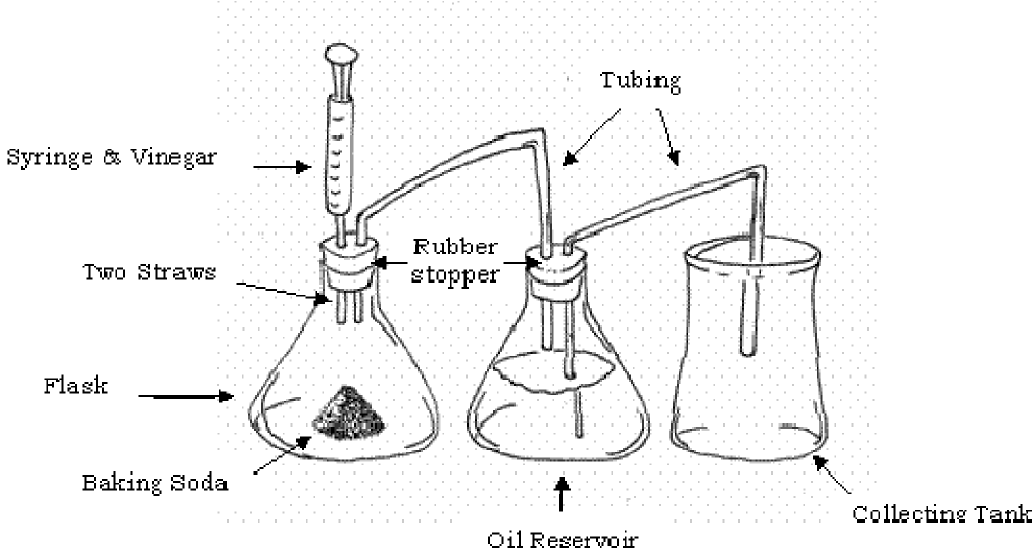
- Prepare 10 lab stations each with the materials listed.
- Photocopy Geologic Sequestration Lab Procedure and Student Sheet.
- Review the teacher sheet and familiarize yourself with geologic sequestration.

**In class**

- Explain that students will conduct an experiment to learn about the method of geologic carbon sequestration.
- Divide students into groups of 3. They should then move to a lab station with the appropriate materials needed to complete the lab.
- Hand out Geologic Sequestration Lab Procedure. Review.
- Allow students to conduct the lab while you roam the room and help.

**For this lab**

Review the diagram below. This is the set-up students should have to ensure a successful lab.




When students have completed the lab, ask them to clean their lab materials and station so that the next class can use the materials.

Discuss experiment results using the discussion questions and teacher background material as a guides.

## Answers to Discussion Questions

- **What caused the oil to leave the reservoir? Be specific.**

  As the reaction between the vinegar and baking soda produced carbon dioxide gas, pressure increased inside the first container and forced the gas into the second container. As the pressure increased in the second container, the only escape route for relieving the pressure is to force liquid out through the tube that is submerged in the "oil" causing it to be pumped into the third container.
- **What percentage of the oil that was added to the reservoir was recovered?**

  Answer will vary.
- **Why can't you recover all the oil from a reservoir using this techniqu**e?

  Some of the oil is located below the surface of the tube and will not be forced out once the level of the oil drops to this point.
- **Where does the CO2 for this type of sequestration come from?**

  CO2 is produced by industries in a variety of ways. It can be the product of a chemical reaction or a combustion process. Companies that produce CO2 as part of their production process could use it for this type of sequestration.
- **What happens to the CO2 once it is pumped into the ground?**

  Usually, the well or reservoir is capped and the CO2 remains trapped underground. However, there is always the possibility that cracks could occur within the sealed reservoir that could allow the CO2 to escape back into the atmosphere.
- **Do you think that this is a practical method to reduce CO2 emissions into the atmosphere? Explain your answer.**

  Large amounts of CO2 could be stored by using this process, and there is some economic gain (recovered oil). This could be a temporary solution to reducing the CO2 presently in our atmosphere. However, measures need to be employed to ensure monitoring of storage areas in case of leaks.

## The Experiment

**Aim:** to use chemistry to simulate oil mining while providing an opportunity for students to understand geologic sequestration as an idea being considered to reduce carbon dioxide in the atmosphere

**Equipment & chemicals**:

- 100 ml of vinegar
- 2 -- #6, two-hole rubber stopper with plastic tubes
- 2 -- 250-ml flask
- 2 lengths of rubber tubing, 45 cm long each
- Safety glasses for each student
- 2 -- 250 ml beaker
- 1 -- 30 ml syringe (no needle)
- Supply of water
- Yellow food colour to represent oil
- Box of baking soda
- Several straws or rigid plastic tubing

**Procedure**:

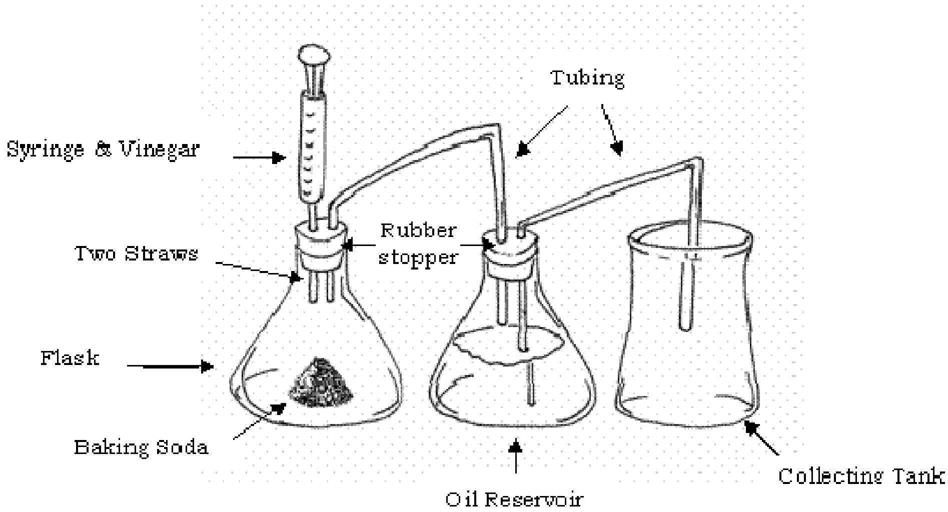



DIAGRAM 1

- Collect equipment and assemble the CO2 generator, oil reservoir and collecting tank using Diagram 1 below. Make sure that all unions are airtight. Place enough baking soda in the flask to cover the bottom.
- Put on your safety glasses.
- Pour about 40 ml of vinegar into a 250 ml beaker. Put the tip of the 30 ml 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 30 ml mark. If you get air bubbles in the syringe, empty it, and repeat the procedure again.
- In your second beaker, add about 200 ml of water and some yellow food coloring, this will represent oil. Pour your "oil" into the oil reservoir. This will represent an underground oil deposit.
- Place the syringe into the straw on the rubber stopper and slowly add 10 ml of vinegar to the baking soda. The gas that is being produced (carbon dioxide) will push oil out of the underground deposit and into the collecting tank.
- Slowly add more vinegar to the baking soda until the oil stops flowing into the collecting tank.
- When you have finished this activity, your instructor will tell you how to clean up your materials. Answer the questions on the Student Response Sheet.

**Results**:

Observe the reaction and draw a labelled diagram to show what happened.

**Discussion and Processing of Data**:

- What caused the oil to leave the reservoir? Be specific.
- What percentage of the oil was recovered from the reservoir?
- Why can't you recover all the oil from a reservoir using this technique?
- Where does the $CO_2$ for this type of sequestration come from?
- What happens to the $CO_2$ once it is pumped into the ground?
- Do you think that this is a practical method to reduce $CO_2$ emissions into the atmosphere? Explain your answer.


## Acknowledgements

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