

IMPACT LAB DAY 1: Climate Change and Rising Sea Levels

PART 1: OCEAN ACIDIFICATION

Introduction

This lesson introduces students to the chemical relationship between carbon dioxide (CO₂) and water, emphasizing how CO₂ forms carbonic acid and alters pH. Students will use bromothymol blue, a pH indicator, to observe how CO₂ from various sources, including human breath, carbonated water, and chemical reactions, affects acidity. This prepares students to understand the environmental implications of increasing atmospheric CO₂, particularly in marine systems.

Safety

- Both the instructor and students must wear properly fitted goggles throughout the activity.
- Students should wash their hands after completing the lab.
- Dispose of all liquid waste in the secure container for special disposal.

Materials for Demonstration

Initial Demonstration

- Bromothymol blue indicator solution
- Water
- 2 clear plastic cups
- Straws

Final Demonstration

- 2 glass flasks
- Tealight candle
- Match or lighter
- Bromothymol blue indicator solution
- Water
- 2 clear plastic cups

Materials for Each Group

- Water
- Bromothymol blue indicator solution in cup
- Carbonated water in wide, clear, plastic cup
- Baking soda in wide, clear, plastic cup
- Vinegar
- 2 small clear plastic cups
- 4 wide clear plastic cups
- 4 taller, clear, plastic cups
- Graduated cylinder

About the Materials

Explain to students that they will be working with bromothymol blue, a pH indicator that appears blue-green under neutral conditions and shifts toward yellow as the solution becomes more acidic. Tap water varies slightly in pH, so the exact initial color may range from green to blue. Any of these starting conditions is acceptable.

Instructions

Step 1: Demonstration: CO₂ from Breath Lowers pH

Teacher Preparation

- Mix 5 mL of bromothymol blue into 100 mL of water to create the indicator solution.
- Distribute approximately 25 mL of this solution into each of two clear cups for the demonstration.
- Prepare an additional batch for student groups, ensuring each group receives at least 80 mL.

Procedure

1. Hold up both cups of indicator so students can clearly see the initial color.
2. Insert a straw into one cup and blow gently into the solution, ensuring the straw reaches the bottom.
3. Continue until the indicator color shifts from blue-green to yellow.

Guiding Questions

- **Does blowing into the indicator solution affect its pH?** Yes, the color change indicates a decrease in pH.
- **Does the solution become more acidic or more basic?** More acidic.

Concept Explanation

Inform students that CO₂ reacts with water to form carbonic acid, a weak acid that is responsible for the observed change in pH.

Step 2: Student Investigation: CO₂ from Carbonated Water

Question to Investigate

Does carbon dioxide released from carbonated water cause an indicator solution to become more acidic?

Teacher Preparation

- Provide each group with 25 mL of carbonated water in a wide plastic cup.

Procedure

1. Measure 30 mL of indicator solution and split it evenly into two small cups.
2. Prepare one large cup containing water and another containing carbonated water.
3. Place one small cup of indicator into each large cup.
4. Cover each nested pair of cups with an inverted tall cup to contain escaping CO₂.
5. Gently swirl both setups and observe any color changes.

Expected Results

Only the indicator exposed to carbonated water will turn yellow, confirming that CO₂ escaping from the carbonated water dissolved into the indicator and formed carbonic acid.

Step 3: Discussion of Observations

Ask students:

- **Did either indicator change color?** Only the indicator paired with carbonated water changed color.
- **What does the color change indicate about the pH?** The indicator shows increased acidity.
- **Why did only one setup experience a color change?** Carbonated water released CO₂, which dissolved into the indicator solution and formed carbonic acid.

Explain that they have now seen CO₂ released from breath and carbonated beverages induce similar changes in pH.

Step 4: Producing CO₂ Through a Chemical Reaction

Question to Investigate

Will CO₂ generated by the baking soda–vinegar reaction acidify the indicator solution?

Teacher Preparation

- Place ~½ teaspoon of baking soda in small cups for each group.
- Provide 50 mL of vinegar in wide cups for each group.

Procedure

1. Prepare two wide cups containing 25 mL of vinegar each.
2. Add 15 mL of indicator solution to two small cups.
3. Add baking soda to one vinegar cup.
4. Place each indicator cup inside its corresponding vinegar setup.
5. Cover both setups with inverted tall cups and gently swirl.
6. Observe for color changes.

Expected Results

The indicator in the cup with the chemical reaction will turn yellow. The vinegar-only setup remains blue-green and serves as a control.

Step 5: Discussion

Students should conclude that:

- Vinegar alone did not lower the indicator's pH in this setup.
- The observed color change was caused by CO₂ produced during the reaction of baking soda and vinegar.

Step 6: CO₂ from Combustion

Materials

Tea light candle, lighter, two flasks, bromothymol blue indicator, water.

Teacher Preparation

Prepare dilute indicator (3 mL indicator in 50 mL water). Divide equally into two small cups.

Procedure

1. Light a candle and hold one flask over it for 10 seconds.
2. Turn the flask upright and add 25 mL of indicator to both the heated flask and an unheated control flask.
3. Swirl both and compare color change.

Expected Results

The flask exposed to the candle flame will display a yellow shift due to CO₂ produced during combustion.

Step 7: Class Explanation

Ask students:

- ***What gas was produced by the flame?*** CO₂, confirmed by its effect on the indicator.

Step 8: Connecting Lab Results to Ocean Acidification

Explain that the same reaction CO₂ dissolving in water to form carbonic acid, occurs in the world's oceans. Increased CO₂ levels reduce ocean pH, a process known as ocean acidification, which can harm marine ecosystems

Step 9: Why Acidification Harms Shell-Forming Organisms

Highlight the following points:

- The ocean is naturally slightly basic (pH ~8).
- Even a small change (e.g., to pH 8.1) significantly impacts marine organisms.
- Shell-forming organisms rely on carbonate ions to build calcium carbonate (CaCO₃) shells.
- Excess H⁺ ions from carbonic acid bind with carbonate ions, producing bicarbonate, which cannot be used for shell formation.
- Over time, overly acidic water can dissolve existing calcium carbonate shells.

Step 10: Research Extension

Assign students to investigate solutions for reducing atmospheric CO₂ emissions. Encourage exploration of renewable energy technologies, carbon reduction strategies, and innovations that reduce fossil-fuel use. Students may present findings in any approved format.

PART 2: RISE OF SEA LEVELS

Introduction

Lead a discussion on global ice distribution and how melting ice contributes to sea-level rise. Emphasize the distinction between ice on land (glaciers, ice caps) and ice floating in the ocean (sea ice).

Students should predict which type of melting will cause sea levels to rise and justify their reasoning.

Designing the Experiment

Instruct students to work in groups to design an experiment addressing the central question:

Which type of melting, land ice or sea ice, causes sea level to rise?

Students should identify variables, control conditions, and planned procedures, and record their design clearly.

Conducting the Experiment

Groups will use trays, molding clay, water, ice, and heat lamps to simulate melting ice. Students must:

- Follow their designed procedure

- Record measurements
- Compare observed results with initial predictions

Each group will later present its explanations.

PART 3: BUILDING A SEA WALL

Introduction

Discuss how rising sea levels affect coastal communities and the role of structural defenses such as sea walls.

Design the Experiment

Students will:

- Work in groups
- Design a sea wall intended to resist wave impact and rising water
- Justify their chosen materials and structure
- Build and test their sea wall models

They must record performance results and explain which design choices were most effective.

Do the Experiment

Put all the materials in the center of the table (see materials section). Tell the students to get the materials and do the experiment in accordance with how they planned.

Students must record their results on the paper chart provided. They will explain their results to the class and also why they think their idea is the best way to go.

Materials

- Molding Clay (to mimic land)
- Long Plastic trays
- Water
- Seashells
- Pebbles
- Plastic Lids (to make waves)
- Plastic Trees
- Plastic Humans

IMPACT LAB DAY 2: Science of Heat Islands

PART 1: SOIL ORGANISM STUDY

Introduction

In this activity, students will examine soil as a dynamic ecological system composed of mineral particles, water, dissolved chemicals, organic matter, plant material, animals, and a variety of microorganisms. Soil communities differ significantly depending on the physical and biological characteristics of their environment. Students will collect samples from different soil locations and compare the diversity of organisms present. This

investigation encourages students to consider how environmental factors influence community structure within soil ecosystems.

Guiding Question

Do all soils contain the same types of organisms?

Materials

For the Class

- 5 bottles of dilute alcohol
- Microscopes
- Microscope slides

For Each Group

- 1 organism extractor setup
- 1 vial with cap
- 1 small can with ends removed
- 1 piece of cheesecloth and rubber band
- 6 soil samples
- 4 water samples

Procedure

1. **Sampling Overview:** The instructor has prepared five distinct soil samples collected from different environments, such as wooded areas, open fields, and garden spaces. The location of each sample should be recorded at the top of the students' data tables for reference.
2. **Provided Soil Samples:** Instead of collecting soil themselves, students will work with the pre-collected samples. Each sample represents a different soil community and may include soil cores, leaf litter, or surface debris. All samples have been labeled with their collection location and date.
3. **Setting Up the Soil Organism Extractor:** Position the wire grid inside the funnel and seat the funnel in the tripod. Add the top 1.5 cm of the soil sample (or leaf litter) into the funnel. Cover with cheesecloth secured with a rubber band. Add 1.5 cm of dilute alcohol to the vial and position it beneath the funnel spout. Seal gaps with tape or cotton.
4. **Extraction Process:** If available, place a light source 10 cm (4") above the sample to provide gentle heat and illumination. Leave the setup overnight or over the weekend. Without a light source, the setup should remain for 7 days or until the sample has dried thoroughly.
5. **Collecting and Examining Organisms:** Remove the vial and use forceps to separate any visible organisms. Use a dropper to transfer several drops from the vial to a microscope slide. Students should examine the slide under the microscope and identify organisms as accurately as possible. Any organisms that cannot be identified should be labeled "unclassified."
6. **Recording Findings:** Students will document their results in Table 1: Organisms Found in Soil and Water, listing both the number and types of organisms observed.

Table 1: Organisms Found in Soil and Water

Location	Type of Organism

Analysis

Students should provide written explanations describing potential factors influencing variation among sites, such as moisture levels, organic content, pH, sunlight exposure, and the presence of vegetation. Encourage them to compare differences in organism density and diversity between soil types and environments.

PART 2: SOIL NUTRIENTS AND FERTILIZERS

Part I - Testing Soils and Runoff

Introduction

This portion of the lab focuses on the role of soil nutrients, particularly nitrogen, in supporting plant growth. Students will compare nitrate concentrations in two soil samples and analyze how added fertilizer affects nutrient availability and runoff. This exercise models processes relevant to agriculture, water quality, and environmental sustainability. Students will test the nitrogen content of two different soils and then discover how much nitrogen fertilizer is absorbed by the soil and how much it runs off.

Materials

For Each Group

- 2 vials with caps labeled “N” and “B”
- 2 Lab-Aids AB trays
- White scoop
- Stir stick
- SEPUP filter funnel
- Filter-paper circle
- Pipette
- Nitrate color chart
- 30-mL graduated cup with rinse water
- Access to sink, water supply, and a clock with a second hand

For Each Student

- Student worksheet and guide
- Safety eyewear

Procedure

Part A: Testing Soil

1. Add one scoop of potting soil to Vial A and one scoop of local soil to Vial B.
2. Add 5 mL of nitrogen extraction solution to each vial. Cap and shake for 1 minute.
3. Set aside until solids settle enough for the liquid to appear translucent.
4. Once clear, transfer 2 mL from Vial A to Cup A of the AB tray using the pipette.
5. Rinse the pipette and transfer 2 mL from Vial B to Cup B.
6. Add one small scoop of nitrate testing powder to each cup.
7. Stir Cup A, rinse the stir stick, then stir Cup B.
8. Allow mixtures to stand at least 3 minutes.
9. Use the nitrate color chart to estimate nitrogen levels in both samples. Record results.

Part B: Testing Fertilized Soil and Runoff

Students will now assess how fertilizer influences nutrient availability and runoff.

1. Prepare a filtering setup with the funnel and filter paper positioned to drip into Cup A of the AB tray.
2. Add 2 scoops of local soil into the filter paper and gently tamp it down.
3. Measure 5 mL of fertilizer solution into the graduated cup and pour it slowly over the soil.
4. Allow the runoff to collect in Cup A.
5. Transfer 2 mL of runoff from Cup A to Vial A; rinse the pipette.
6. Transfer one scoop of fertilized soil from the filter cone into Vial B.
7. Add 5 mL of nitrogen extraction solution to each vial. Cap and shake both.
8. Once Vial B has settled sufficiently, transfer 2 mL from each vial into Cups A and B of a clean AB tray.
9. Add nitrate testing powder to each cup and mix as previously instructed.
10. After at least 3 minutes, compare nitrate levels using the color chart.
11. Dispose of solutions and wash all equipment.

Analysis Questions

- Ranking soil and runoff samples from highest to lowest nitrate content
- Which sample appears most suitable for plant growth
- Evidence that fertilizer increases soil nitrogen
- Environmental drawbacks of fertilizer use (eutrophication, runoff pollution, etc.)
- Whether fertilizers are universally beneficial or context-dependent
- Why modern agriculture relies heavily on fertilizers despite the long history of plant life on Earth without them

Part II - Soil Components and Fertility

This section broadens students' understanding of soil as a complex mixture of biological and geological components. Emphasize that soil supports terrestrial ecosystems by storing nutrients and hosting a variety of organisms essential for decomposition and nutrient cycling.

Students should explain how soils form, and what the major components are that determine soil fertility?

Analysis Questions

- Describe how agricultural practices (e.g., tilling, fertilization, monoculture) impact ecosystems.
- Draw a model illustrating nitrogen movement through living and nonliving components of an ecosystem.
- Explain how plants flourished before the invention of synthetic fertilizers and why their use has intensified in modern agriculture.

IMPACT LAB DAY3: The “Hit by a Bus” Biodiesel Lab

Introduction

Begin by assessing students' prior understanding of renewable vs. non-renewable fuels. Encourage students to identify what they already know about biodiesel, including its uses, environmental implications, and why it is considered a more sustainable alternative to petroleum-based diesel.

Explain that today's laboratory activity focuses on the synthesis, testing, and evaluation of biodiesel. Students will carry out a chemical conversion that transforms vegetable oil into biodiesel, a process known as transesterification. This lab highlights how a waste material, such as used cooking oil, can be converted into a cleaner-burning, renewable fuel.

Remind students of laboratory protocols and safety expectations before beginning the experiment.

Materials

Chemicals and Reagents

- Vegetable oil
- Methanol
- Potassium hydroxide (KOH) or Sodium hydroxide (NaOH)

Equipment

- 50 mL test tube
- Additional test tubes
- Size 4 rubber stopper
- Hot plate
- Parafilm
- Graduated pipettes
- Beakers

Safety Precautions

Clearly communicate the following safety expectations:

- **Methanol is toxic and flammable:** Students must wear gloves when handling methanol. Any contact with skin requires immediate washing. Methanol must be used only inside a fume hood, and it should never be near an open flame.
- **KOH and NaOH are caustic bases:** These compounds can cause chemical burns on contact with skin or eyes. Ensure students wear goggles and handle these materials carefully.

- **Heated glassware poses burn hazards:** Use heat-resistant gloves or tongs when handling beakers and test tubes that have been warmed on the hot plate.

Emphasize that students must follow all safety instructions precisely throughout the experiment.

PART 1: SYNTHESIS

Preheating the Oil

1. Heat vegetable oil on a hot plate to approximately 60°C.
 - 60 mL of vegetable oil placed in a 100 mL beaker and heated on a hot plate set to 95°C typically stabilizes around 60°C.
 - If the instructor has preheated the oil, students may skip this step.

Preparing the Catalyst-Methanol Solution

2. Measure 1 mL of methanol into a 50 mL test tube and seal it immediately.
3. Weigh out a single pellet of KOH or NaOH and add it to the methanol. Reseal the tube promptly.
 - This prevents the base from absorbing atmospheric moisture while students complete subsequent calculations.

Calculations

Students must calculate the correct amount of oil to use based on the mass of the NaOH or KOH pellet:

- For NaOH:

$$\text{mass of NaOH (g)} \times \frac{1 \text{ L oil}}{3.5 \text{ g NaOH}} = \text{volume oil needed}$$

- For KOH:

$$\text{mass of KOH (g)} \times \frac{1 \text{ L oil}}{4.9 \text{ g KOH}} = \text{volume oil needed}$$

Students must subtract the 1 mL of methanol already added from the total required volume during their calculation.

Dissolving the Catalyst

4. Add the additional methanol volume (calculated previously) to the test tube.
5. Seal the test tube with a rubber stopper and swirl vigorously until the base pellet has fully dissolved.

Performing the Transesterification Reaction

6. Ensure the preheated oil is still above 60°C.
7. Add the warm oil to the methanol-catalyst mixture in the test tube and reseal it carefully. Remind students that the oil will be hot.
8. Observe initial appearance and note any phase differences.
9. Seal the joint between the stopper and test tube with parafilm.
10. Shake the test tube vigorously for 15 minutes.
11. Allow the sample to settle for 5 to 10 minutes.
12. After settling, students should observe two layers: the upper layer should be biodiesel (less dense), and the lower layer should be glycerol and byproducts.

If the layers appear reversed, students should consider experimental errors or incomplete reactions.

PART 2: TESTING

Students will run three diagnostic tests to determine whether their biodiesel synthesis was successful.

1. **3/27 Test (Solubility Test):**

- This test assesses whether the vegetable oil has been successfully converted into biodiesel.
- Combine 1 mL biodiesel with 9 mL methanol in a test tube.
- Seal and shake thoroughly.
- Observe whether any oil precipitates out.
- No precipitation indicates successful conversion.
- Undissolved oil suggests unreacted or partially reacted triglycerides.

2. **Emulsion Test (Soap Formation):**

This test assesses whether the vegetable oil has been successfully converted into biodiesel.

- Combine 1 mL biodiesel with 9 mL methanol in a test tube.
- Seal and shake thoroughly.
- Observe whether any oil precipitates out.
- No precipitation indicates successful conversion.
- Undissolved oil suggests unreacted or partially reacted triglycerides.

3. **Cloudy Point (Cold-Flow Properties):**

This test determines the temperature at which biodiesel begins to solidify.

1. Place ~5 mL of biodiesel into a test tube.
2. Insert a thermometer using a one-hole stopper.
3. Submerge the tube in an ice bath.
4. Monitor closely and record the temperature at which the biodiesel becomes cloudy.

If the biodiesel is already cloudy, students may proceed cautiously or skip the test depending on the sample quality.

PART 3: EVALUATION

After all groups have completed their synthesis and testing, they gather the class for a shared evaluation.

Lead students through a structured reflection:

- ***What evidence indicates a successful biodiesel synthesis?***
- ***Which conditions or steps appeared to influence the outcome most strongly?***
- ***What inconsistencies or failures occurred, and what might explain them?***
- ***How did test results vary between groups, and why?***

Encourage students to compare samples before discarding anything, as visual comparison often clarifies concepts and highlights potential procedural issues. Emphasize that experimental failure is a valuable learning tool: understanding what *did not* work is just as important as identifying successful methods.