LIKE OIL AND WATER

EARTH matters
Studies For Our Global Future

introduction

Today, over one-third of the energy used in the United States comes from oil.[1] Every day, Americans use more than 380 million gallons to power personal vehicles, transport food and goods, and to create various kinds of plastics.[2] Many major sources of oil are found deep under the ocean floor and must be drilled out. The process of extracting, processing, and transporting the oil can be hazardous and at times, spills occur. These spills can have devastating effects on marine wildlife and it can take years for an **ecosystem** to recover even after the oil has been cleaned up.

When an oil spill first occurs in the ocean, experts try several methods to contain and clean the spill. Large, floating barriers called **booms** are sometimes put out to keep the oil from spreading further. Because oil is less dense than water, it floats on the surface, so boats called skimmers can remove the oil directly before it reaches a sensitive ocean ecosystem. Another method, which is more controversial, is called **in situ burning**. During in situ burning, oil is set on fire as it floats on the surface of the ocean. However, this only works in certain circumstances and can be dangerous and pollute the air.

Marine life can be affected by oil spills, and birds are especially sensitive to the negative impacts, as their ability to stay warm and dry is compromised when their feathers are covered in oil. To clean birds, rescue groups soak them in a specific concentration of detergent, thoroughly rinse them with sprayers, and then keep them in a rehabilitation pool to allow time for the birds' natural waterproofing oils to be restored.

As we continue to depend on oil to fuel our lifestyles and as our population grows, the risks and effects of spills will remain a reality. Future engineers and scientists will have the important task of finding safe and effective methods to clean-up oil spills and protect the marine ecosystems that are impacted.

Vocabulary: booms, ecosystem, in situ burning

materials

- Cooking oil
- Water
- Paper towels
- Student Lab Worksheet
- Clean-up materials (see list)

concept

A variety of methods can be engineered to clean oil spills and mitigate their negative effects on marine ecosystems.

objectives

Students will be able to:

- Research current methods of oil spill clean-up and their drawbacks.
- Read a graduated cylinder and use data to calculate volume and percentages.
- Use the engineering design process to explore solutions to problems associated with cleaning-up oil spills.
- Design, build, and test prototypes of devices that would help clean-up oil spills.

subjects

Environmental Science (General and AP), English Language Arts

skills

Lab preparation, collecting and analyzing data, reading a graduated cylinder, observing, researching, engineering design, problem solving

method

Students use the engineering design process to create and test prototypes for cleaning up oil spills and rehabilitating marine birds.

For each group:

- 1,000 mL graduated cylinder
- 100 mL graduated cylinder
- Plastic container
- Large cup

procedure

1. Before class, prepare lab stations for each group of four with the following: access to cooking oil and water, 5 x 8 x 8 inch plastic container, large cup, 100 mL graduated cylinder, and 1,000 mL graduated cylinder. In a central location, provide materials students can use in their clean-up efforts. Suggested materials include: cotton balls, foil, plastic wrap, duct tape, masking tape, cut-up pantyhose, paper towels, popcorn, cut-up sponges, bandage pads, rope/string, craft sticks, liquid dish detergent, toothbrushes, etc.

2. Introduce the engineering design process to students. Explain the importance of defining the challenge, researching the problem, creating prototypes, and improving prototypes based on tests.

3. Divide students into lab groups of four and distribute a Student Lab Worksheet to each student. Ask students to decide the following roles for each person in the lab:

    - Leader: ensures all members of the group have an opportunity to contribute and remain on-task during the lab.
    - Recorder: while all members must complete the Worksheet, the recorder is responsible for taking the most detailed notes on each prototype and test.
    - Materials manager: responsible for identifying the materials needed to build a prototype and bringing them back to the table. Also directs the entire group in the clean-up process, ensuring all members do their part.
    - Communicator: shares the group's findings with the whole class after the design process is complete.

4. Assign four reliable students from different lab groups to be Testers of the prototypes. These students should still participate in the challenge with their respective lab groups, but can be called away for 30 seconds at a time to test their peers' prototypes. They may not test their own group's devices.

5. Provide students access to the resources below (either on computers with internet or by printing the articles beforehand) and ask them to complete the first page of the Student Lab Worksheet.

    - NOAA Office of Response and Restoration on types of clean-up
      http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/spill-containment-methods.html
    - National Geographic on Deepwater Horizon
      http://news.nationalgeographic.com/news/2010/11/110127-gulf-oil-spill-dispersants-environment-science/
    - University of Delaware Sea Grant on types of clean-up
      https://www.ceoe.udel.edu/oilspill/cleanup.html
    - Scientific American on oil-eating microbes
      https://www.scientificamerican.com/article/how-microbes-helped-clean-bp-s-oil-spill/
    - CNN reporting on a new device
      https://www.youtube.com/watch?v=FXGGYQ7DDnk

6. Reiterate the constraints of the challenge:

   Students will build a prototype using the materials provided. They must sketch and label their prototype on their Lab Worksheet.

   a. To test their prototype, they will follow the directions to pour the correct amount of water and oil into the plastic testing container. They will then signal to a peer Tester who will time them for 30 seconds. During that time, the students will use the device to remove as much oil as possible from the water and transfer it into the large plastic cup.

   b. After the Tester calls time, the group will measure the amount of oil remaining in the plastic container and then calculate the percent captured by their device, recording this in the data table.

   c. The group will then improve on their design (or scrap it and build a new device), fully sketching out Prototype #2 with labels before testing again.

   d. Each group will have the opportunity to build and test three devices.

7. While students are working, write or project the Discussion Questions on the board. Students should discuss these questions as they work on the design process and be prepared to share their answers with the class at the end of three prototype/test cycles.

alternate procedure

To make the challenge more difficult and realistic, assign monetary values to each of the materials you have provided. Give each team a budget and require them to decide how much of each material to "buy" when designing and building prototypes.

discussion questions

1. Why was it important to research before you started designing the solution?

   It's difficult to create the best solution possible without being completely sure what the problem is that needs solving. The more you learn about what's been done before, the better your solution.

2. Was there anything important you found in your research or observations that helped you determine the best way to approach the issue?

   Answers will vary. Students may mention the density of oil and behavior of spills in water, or the different types of real-world spill clean-up methods, such as the use of physical barriers and dispersants.

3. What were some changes you made after your first official test? Did they help?

   Answers may include: using different materials, reducing the number of moving parts of the device, or securing parts of the device that were unstable or broken after testing. Some students may describe starting over with a completely different design after the first test failed.

4. What challenges did you face?

   Answers may include: oil moving around the surface of the container, the large volume of water removed by the device, difficulty keeping the device together when submerged in water, the limited time available for oil removal.

5. What additional challenges would you face if cleaning up an actual oil spill in the real world?

   Answers may include: the large size of the spill, chemicals causing issues in the ecosystem, the distance from shore, importance of treating marine animals gently, danger of spreading the spill while trying to clean it.

6. What was the most effective thing you tried? How could you scale your idea so that it could be used in real life?

   Answers will vary.

assessment

Review the completed Student Lab Worksheets to determine student understanding of the concept and application of the engineering design process.

follow-up activity

Have students research a recent large oil spill, such as the Deepwater Horizon spill of 2010 or another major event. Ask students to write a newspaper article about the incident, including causes of the spill, extent of oil coverage, effects on the local environment, and efforts to contain and clean-up the spill.

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[1] Energy Information Agency. (2017). *U.S. Energy Facts Explained, Consumption and Production.* Retrieved from https://www.eia.govenergyexplained/?page=us_energy_home#tab1

[2] Energy Information Agency. (2016). *Frequently Asked Questions.* Retrieved from https://www.eia.gov/tools/faqs/

LIKE OIL AND WATER | student lab worksheet

Name: ____ **Date:** ____________________

State the challenge: What is the goal of this design challenge? Why is it important?

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Research/Observations: Before you use any materials or make any prototype sketches, use the suggested research resources to prepare for the challenge.

1. Describe at least two methods that are used to clean-up oil spills in the real world.

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2. Explain how you will incorporate some of these methods or elements in your oil-cleaning device. Note that, unfortunately, in situ burning is not an available option for this classroom test.

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3. What are some potential difficulties faced by engineers who clean spills? How could they address these issues?

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4. What are some difficulties you expect to encounter and how will you address them in your planning process?

Prototype and Testing Process

1. Design your prototype and build it using any of the materials provided. Sketch it and label the sketch with all materials used and their intended function. This stage must be complete before you test your device.

2. Measure 900 mL of water using the graduated cylinder and pour it into the plastic container. This represents your marine environment.

3. Measure 100 mL of oil and pour into the plastic container with the water, simulating an oil spill.

4. Call a Tester over to your work station. You will have 30 seconds to test your prototype by using it to transfer as much oil as possible into the large cup, removing it from the marine environment. When the time is up, set your device aside, along with the discarded oil from the plastic cup.

5. Carefully pour the contents of the plastic container (water and remaining oil spill) into the 1,000 mL graduated cylinder. Allow at least one minute for the oil and water to separate.

6. Record the volume of water (not counting the oil) and then the volume of water + remaining oil in your data table. Then use this information to calculate the volume of remaining oil, percentage of total spill remaining, and percentage of total oil spill collected.

7. Record notes about successes and problems with this prototype in the Testing Notes area. This could include practical issues such as parts of your device falling apart, or it could identify concerns such as disrupting the surface of the water or removing too much water with the oil.

8. Wash out your container and graduated cylinder. Revise your prototype and test again. You will ultimately make three devices.

Data Table: Effectiveness of Prototypes

	Initial Water Volume Before Test	Initial Oil Spill Volume Before Test	Volume of Combined Oil + Water Remaining After Test	Volume of Water Remaining After Test	Volume of Oil Remaining After Test	Total Percentage of Oil Spill Remaining After Test	Total Percentage of Oil Spill Captured by Prototype
Prototype #1	900 mL	100 mL					
Prototype #2	900 mL	100 mL					
Prototype #3	900 mL	100 mL					

Prototype #1

Sketch with labels (materials used, intended purpose of each part of device):

Testing Notes:

Prototype #2

Sketch with labels (materials used, intended purpose of each part of device):

Testing Notes:

Prototype #3

Sketch with labels (materials used, intended purpose of each part of device):

Testing Notes: