LESSON 2: Oil Remediation

Teacher's Guide

Objective: In this lesson, students will begin by learning about oil spills, their effects on the environment, and how they can be cleaned up by both human effort and natural forces. They will read a passage about these methods and discuss further ideas, then use the modeling software to simulate the spread of oil in the ocean after a spill.

Inquiry question: What happens to oil in the ocean?

Time Required: One class period

Materials:
- Interactive whiteboard or projector with internet access and a StarLogo Nova account
- Individual copies of the *Lesson 2 Student Guide* on page 19 of this curriculum
- Individual copies of Oil Spill Remediation and Cleanup reading on page 17
- A closed jar or bottle containing ¼ cooking oil and ¾ water

Standards Addressed:
6th Grade: SC.6.E.7.5, SC.6.N.1.3, SC.6.N.3.4
7th Grade: SC.7.N.1.3, SC.7.N.3.2, SC.7.N.1.5
8th Grade: SC.8.N.1.5, SC.8.N.1.6, SC.8.N.3.1, SC.8.E.5.10
Middle School Computer Science: SC.68.CS-PC.2.8, SC.68.CS-CS.1.2, SC.68.CS-CS.1.4, SC.68.CS-CS.1.3, SC.68.CS-CS.2.11

PROCEDURES

In this lesson, students explore the fate of oil released into a body of water. This discussion and reading is designed to help students think through the fate of oil in the environment. They will learn about the properties of oil and natural weathering processes. This is followed by a reading about oil spill remediation.

Step 1

Begin the lesson with a demonstration using the jar of water and cooking oil. Note how the two substances separate, and the oil floats to the top. Students may already be aware of the insolubility of oil, and it may be appropriate to discuss polarity and/or density, depending on the science background of the students and the goals of the lesson.

NOAA's Office of Response and Restoration has a web page that summarizes what happens to oil in the environment without human intervention (*https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/oil-types.html*).

Step 2

Use think-pair-share after this reading to answer the first question- what are the properties of various oils, and how do they impact how the oil acts in an ecosystem as well as its impacts on the ecosystem. Encourage students to use examples from their own lives, such as proper disposal of cooking oil and motor oil, and why there are special instructions for storm drains. For additional connections to local government and civics, emphasize the relationship between the responsibilities of citizens and the responsibilities of petrochemical companies.

The student guide on page 15 includes a graphic from NOAA and a matching exercise to familiarize students with these processes. The class will read through the descriptions of each process as they examine the graphic. Have them explain their reasoning for choosing each type of weathering to go in the blanks. Again, it may be helpful to use think-pair-share to ensure that all students have understood the vocabulary before moving on to the next step.

Step 3

Once the class has discussed the weathering processes, have them develop a class list of ways that humans can intervene to remove accidental spills of oil from the environment.

Step 4

Next, students will read the passage on pages 17-18 of this curriculum about oil spill remediation methods. It may be beneficial to pass these out only after the brainstorming session to ensure that students are using prior knowledge and original ideas rather than copying directly from the text. For advanced students or for further enrichment, you can find a detailed report about the Deepwater Horizon oil spill and how it was affected by microbes at *http://archive.gulfcouncil.org/docs/Microbes_and_Oil_Spills.pdf*.

Step 5

After reading, follow up with "Can Microbes Clean Up Our Oily Mess? - Instant Egghead #58" episode from Scientific American (see link at right).

YouTube video on bathtub ducks lost at sea
https://www.youtube.com/watch?v=a_HWlFzgQiM

Application of learning

1. Ask students if the duck model in StarLogo Nova would be a good program to start a model of an oil spill. Why or why not?
2. Which members of the system or environmental variables will be important to a scientist modeling an oil spill?

Step 6

Revise the ***Model Oil Ver1*** in StarLogo Nova. The model shows the dispersal of oil. The first StarLogo Nova Model will be modified to add in a rate of oil loss to the system (e.g., 1 % lost per time interval) to show that we can program this into the model.

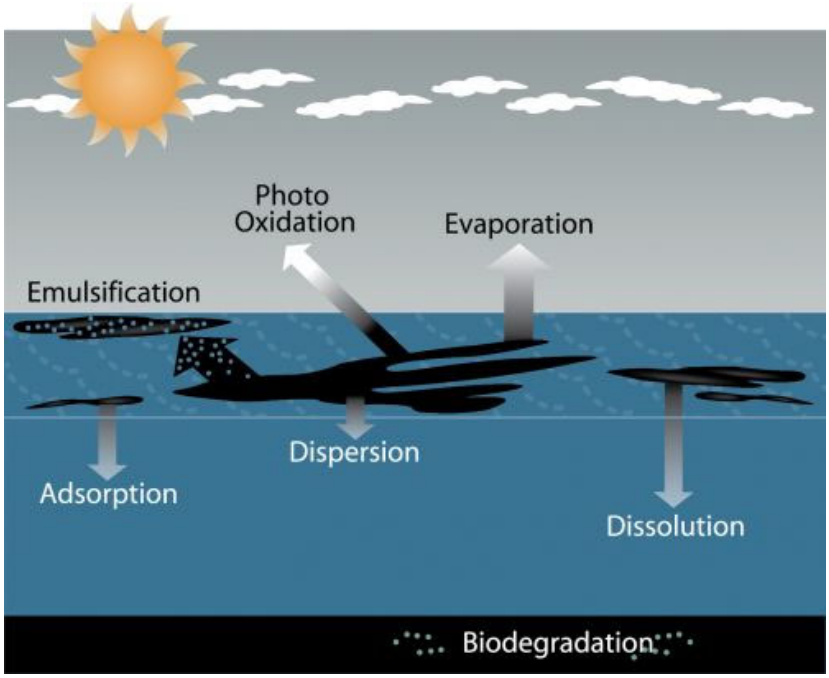
NAME_____Class _____ Period_____

QUESTION: What happens to oil in the ocean?

Activity 1

With a partner, talk about some properties of oil (cooking oil, motor oil, gasoline, etc.). How do these properties affect how oil acts in the environment and how it impacts ecosystems? Be prepared to share at least one idea with the class.

Match the descriptions below with the processes named in the diagram from NOAA's Office of Response and Restoration.



Source NOAA: https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/weathering-processes-affecting-spills

1. _____ is the process by which one substance is attracted to and adheres to the surface of another substance without actually penetrating its internal structure (includes sedimentation).

2. _____ is the degradation of substances resulting from their use as food energy sources by certain microorganisms including bacteria, fungi, and yeasts.

3. _____ is the distribution of spilled oil into the upper layers of the water column by natural wave action or application of chemical dispersants.

4. _____ is the act or process of dissolving one substance in another.

5. _____ is the process whereby one liquid is dispersed into another liquid in the form of small droplets.

6. _____ is the process whereby any substance is converted from a liquid state to become part of the surrounding atmosphere in the form of a vapor.

7. _____ is sunlight-promoted chemical reaction of oxygen in the air and oil.

List the ways oil might be “removed” from an ecosystem. What are some advantages and disadvantages to each method?

Read the passage “Oil Spill Removal and Cleanup.” Are any of your ideas being used in real-life oil spills?

Activity 2

Apply What You Learned

Log into StarLogo Nova (use the StarLogo Nova guide if you need help). Open Model Oil Ver1 in StarLogo Nova.

1. How well does this model show what happens during an ocean oil spill?

2. What could we add to this model to make it more accurate?

3. How could we add the unused blocks on the right-hand side of the coding workspace to model how microbes act on oil in the ocean?

Reading: Oil Spill Removal and Cleanup

By Karolyn Burns, M.S.

The ocean is the largest ecosystem on earth, but it is still vulnerable to pollution and contamination by human activities, especially close to shore. Oil spills are the one of the most common sources of marine pollution. According to the U.S. Department of Energy, 1.3 million gallons (4.9 million liters) of petroleum are spilled into U.S. waters from vessels and pipelines in a typical year (https://fas.org/sgp/crs/misc/RL33705.pdf). A major oil spill could easily double that amount, such as the Deepwater Horizon oil spill in the Gulf of Mexico in 2010. Oil spills vary in severity and in the amount of damage they cause due to variables like the type of oil, location of the spill, weather, and interactions with microbes.

Regardless of severity, all oil spills damage the ocean environment. The oil doesn't stay where it is spilled from a well or tanker, but spreads out across the surface of the water and can negatively impact shorelines and habitats for many miles. Oil is less dense than water, so it floats to the surface. This means that, while it is easier to clean up from the surface than it would be on the bottom, it is much more likely to affect marine mammals that must come up to breathe as well are seabirds that land on the ocean's surface.

Oil Booms

Since oil floats to the top, one of the most popular methods of containing an oil spill is the oil boom. Booms are floating, physical barriers to oil, made of plastic, metal, or other materials, which slow the spread of oil and keep it contained. They are most useful when the oil is confined to a single location, as they will keep it from spreading outward. They can also be placed around areas that would be severely damaged by oil, such as shellfish beds and reefs. Oil booms are not helpful when the oil has already spread out over a large area, or if there are large waves or storms that would make them ineffective.

Source: https://commons.wikimedia.org/wiki/File:Pensacola_NAS_oil_boom_4_May_2010_100504-N-6268N-039.jpg

Oil Skimmers

While booms can confine the oil to one area, they do not remove it from the water. This is where skimmers come in. A skimmer is a device for recovering spilled oil from the surface of the water. They can be used from boats or from shore, depending on where the oil spill is. There are several types of skimmer that can be used depending on the type of oil and the conditions on the water. Like oil booms, they are not very effective under rough sea conditions.

Source: https://en.wikipedia.org/wiki/File:Self_adjusting_weir_type_oil_skimmer_Ultraspin.jpg

Oil Absorbers

Certain materials (called sorbents) are very good at soaking up liquids, and can be placed on top of the oil spills so that the oil can be recovered, and this prevents wastage and further pollution. As they need to be collected after taking up the oil this can be expensive and time consuming, so they are most often used in small spills or to remove the final traces of a large spill. There are natural sorbent materials such as peat moss, straw, sawdust, clay, glass wool, and even volcanic ash. There are also synthetic or man-made sorbents that are more effective at soaking up oil, but cost more to use.

In Situ Burning

In situ means on-site, so in situ burning involves igniting the layer of oil on the surface of the water to burn it off. If the layer is thick enough, this can be very effective and remove up to 98% of a spill, though it does come with risks to wildlife and people from toxic fumes. This method works best on a fresh spill, before the oil spreads out over a large area and degrades.

Dispersants

Once the spilled oil has spread out over a large area, it cannot be contained with booms, picked up by skimmers, or burned. The only remaining option is to deal with the oil and try to break petroleum oil into small droplets. Planes spray the oil spill with chemicals called dispersants over a large area, which break up the heavy oil into smaller droplets. These are easier for sun, waves, and microbes to break down, and are more likely to disperse into the water column. This helps to clear oil from the water's surface, making it less likely that the oil slick will reach the shoreline. Different types of oil respond differently to chemical dispersants, and the effectiveness is also impacted by temperature. Disadvantages to this method include creating tar balls from the denser parts of the oil which float to shore, and poisoning marine organisms.

Image source: https://commons.wikimedia.org/wiki/File:C-130_support_oil_spill_cleanup.jpg

Bioremediation

Bioremediation is the process of using microbes to break down or remove harmful and toxic substances from the environment. These microbes can be bacteria, fungi, or algae and they degrade petroleum products by metabolizing and breaking them into simpler and non-toxic molecules. This is often done after as much oil as possible has already been collected from the surface. This is a process that will happen naturally, as there are oil-eating bacteria that live in the ocean and “eat” the oil that seeps from cracks in the earth’s crust. These naturally occurring microbes need lots of oxygen and warm water as well as a food source, and there may not be enough of them to handle a large-scale oil spill, or all of the components of the oil itself.