

Fifth Grade Earth Science

OIL SPILLS AND DUST BOWLS: Earth's Systems

Background Information

Earth is comprised of four interconnected systems: geosphere, hydrosphere, atmosphere, and biosphere. All of Earth's processes are due to energy and matter cycling within and among these four systems. Because these systems are so connected, it is important to understand both individual characteristics of each system independently as well as features of their interactions with each other.

The geosphere includes all of the solid or liquid rock and soil that composes the core, mantle, and crust of Earth. The hydrosphere includes all water, including oceans, lakes, glaciers/ice, rivers, groundwater, and even atmospheric water/water vapor. The atmosphere includes all gases surrounding the Earth, and is organized by layers starting closest to Earth and moving outward as the troposphere, stratosphere, mesosphere, and thermosphere. The biosphere includes all living organisms that reside on or in the geosphere, hydrosphere, or atmosphere.

Earth's four spheres are in constant interaction with each other. Humans (biosphere) use water (hydrosphere) for many reasons on a daily basis. Different types of weather are caused by the interactions between the atmosphere with the hydrosphere and/or geosphere. One such set of interactions resulted in the creation of oil over the course of millions of years. Living organisms (biosphere) died, and their remains collected on either the ocean (hydrosphere) or land (geosphere) floor. Over millions of years, continuous dirt and pressure (geosphere) built up over the remains, turning them into oil. Oil is the most highly sought after and used non-renewable energy source on Earth. It is considered non-renewable because its creation takes *much* longer than a human lifespan, and it is being used in much higher volumes than can be re-created.

Because of the industrial demand for oil, oil extraction and transportation play a large part in the World economy. Unfortunately, crude (unrefined) oil can have extremely negative effects on Earth's four spheres if it is spilled or uncontained. For example: oil can erode the geosphere much quicker than normal erosion from water or weathering; oil and water do not mix, so oil will float on the surface of water, possibly affecting the temperature of the water as well as its ability to evaporate; oil releases aerosols into the atmosphere, contributing to the worsening effects of greenhouse gases; and living things need air and water to grow, and the presence of oil can prevent either or both from getting to the organism.

Another example of the interactions between Earth systems and how humans can affect them happened in the 1930s. The Dust Bowl was the name given to the drought-stricken parts of the central United States, which suffered severe dust storms. A series of wet years (hydrosphere and atmosphere interactions) created a misunderstanding of the region's ecology and farmers intensely cultivated lands (biosphere and geosphere interactions) that should not have been used. Rising wheat prices and the need for wheat during World War I encouraged farmers to plow up millions

of acres of native grassland to plant wheat, corn and other crops.

As the United States entered the Great Depression, wheat prices fell and farmers tore up even more grassland in an attempt to harvest a bumper crop and break even. Crops began to fail 1931 because of drought, exposing the bare, over-plowed farmland. Without deep-rooted prairie grasses to hold the soil in place, it began to blow away. Eroding soil led to massive dust storms and economic devastation for the farmers. Billowing clouds of dust would darken the sky, sometimes for days at a time. The dust drifted like snow and residents had to clear it with shovels. Dust worked its way through the cracks of even well-sealed homes, leaving a coating on food, skin and furniture and caused respiratory problems for many people. Some severe dust storms, often called “black blizzards” carried Great Plains topsoil as far as Washington, D.C. and New York City, and coated ships in the Atlantic Ocean with dust. Regular rainfall returned to the region by the end of 1939, bringing the Dust Bowl years to a close. <https://www.history.com/topics/great-depression/dust-bowl>

Performance Expectation

ESS2-1 Earth Systems: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

<https://www.nextgenscience.org/pe/5-ess2-1-earths-systems>

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems: Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.

Science and Engineering Practices

Developing and Using Models: Develop a model using an example to describe a scientific principle.

Obtaining evaluating and communicating information: Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.

Crosscutting Concepts

Systems and System Models: A system can be described in terms of its components and their interactions.

Materials

- Student ‘Breaking News’ sheet, Dust Bowl Images, Dust Bowl Timeline strips
- Video about the creation of oil <https://www.youtube.com/watch?v=0PrSZMOCnWU>
- Articles about Oil (Recommendations below)
- <https://newsela.com/read/overview-oil-sands-keystone-pipeline-environment/id/24148/>
- <https://newsela.com/read/exxonvaldez-anniversary>
- Aluminum containers

- Sand
- Water (room temperature and warm/hot)
- Pipettes
- Oil
- Rulers
- Clear Plastic Cups
- Styrofoam/Insulated Cups
- Hand Lenses
- Medicine Cups
- Radish Seeds

Suggested Implementation

Part One: Earth’s Involvement in the Creation of Oil

Begin with a formative assessment of student understanding. Ask students what they know about oil. It is ok if they talk about household oils (vegetable, olive, baby, etc...), but try to encourage conversation about motor oil, or oil that is used for energy. Conversation points could include

- Where it comes from
- What it’s used for
- Why we need it
- What would happen if we didn’t have it?

Try to lead student conversations to these questions. It is unlikely that students will know where oil comes from/how it is made.

To introduce that topic, this video (<https://www.youtube.com/watch?v=0PrSZMOCnWU>) gives a brief, age appropriate description of the creation of oil. It would be best to have students view the video twice: first, the students will just watch the video, second, the students will take note of the involvement of any of Earth’s ‘spheres’ (geo, hydro, atmosphere, or bio) that they notice. They should see heavy involvement of the geosphere and biosphere, and will likely note the hydrosphere due to the oceanic organisms.

You may wish to have a discussion about how two or more of Earth’s ‘spheres’ work together over millions of year to create oil.

The next step is to have students read a couple articles about oil and its possible effects on Earth’s spheres. The two articles mentioned in the materials section are a good pair because (between the two of them) they mention all four of Earth’s spheres, as well as possible economic and political impacts. One possible implementation method would be to split students into groups, and have them read the articles while focusing on *one* of the four ‘spheres’. For example, the ‘geosphere’ group would read the articles and highlight or take note of any mention or involvement of the geosphere. From there, groups can share out and (along with the knowledge gained from the video) continue the conversation about which ‘spheres’ are most affected by oil.

Part Two: Don't Cry Over Spilled Oil

Suggested Implementation

In this activity, students will be presented with a problem. There has been an oil spill in a local area, and they have to assume the roles of geologists (scientists who study the geosphere), hydrologists (scientists who study the hydrosphere), meteorologists (scientists who study the atmosphere), and biologists (scientists who study the biosphere), in order to learn more about how the oil spill may affect the four spheres.

There are two options for implementation for this activity. One option is to have students rotate through the four roles and complete each 'station'. Another option is to assign students to become 'content area specialists' in one of the four areas, complete that station and report their findings to the rest of the class. Specifics for the four roles/stations are below.

Geologist/Geosphere

For this station, students will be focusing on the question: How is the geosphere affected by the oil spill? One way to analyze the effect of oil on the geosphere is to consider erosion. Depending on the students' experience with problem solving, the teacher may wish to allow the students to brainstorm and come up with the idea to test erosion on their own, or just present them with the issue of water vs. oil erosion. You may also choose to have students write their own procedure, or use the procedure provided below. Erosion is a common process that happens in the geosphere, and occurs when soil or rock is moved from one place to another--usually by water or wind.

Students will use sand to create a large hill within the confines of an aluminum container. They may need to mix a little water in with the sand in order to help it maintain its 'hill' shape (but not too much, you want loose sand on the surface). Once formed, they will use droppers to drop water and oil onto the hill and observe the differences between the two. It may be helpful to designate one side of the hill for 'water testing' and use the other side for 'oil testing'. Students will need to collect data to record in their student pages about the similarities and/or differences between the water and the oil. Possible data points could include, but are not limited to: size of 'dent' left in sand after 'x' drops of water or oil, amount of sand 'picked up' by the water or oil, size of 'drop' after it travels down the hill, speed of drops down the hill, etc. Students may wish to use hand lenses to help with their observations. You may also want to talk to students about experimental controls, for example, releasing all drops from the same height.

Overall, the goal of this station is for students to observe how both water and oil affect a component of the geosphere, use their data to predict how an oil spill could affect the geosphere in their area, and brainstorm possible solutions to prevent excess erosion in the event of an oil spill.

Hydrologist/Hydrosphere

For this station, students will be focusing on the question: How is the hydrosphere affected by the oil spill? One way to analyze the effect of oil on the hydrosphere is to consider the possible effect on the water cycle--specifically evaporation. Depending on the students'

experience with problem solving, the teacher may wish to allow the students to brainstorm and come up with how to study this relationship on their own, or just present them with the issue of evaporation of water vs. water mixed with oil. You may also choose to have students write their own procedure, or use the procedure provided below.

The water cycle is a continuous cycle of evaporation, condensation, and precipitation. For this station, students will investigate the impact of oil on water's ability to evaporate. Students will get two clear plastic cups and add some water to them. Using a marker or tape, they will mark the level of water in the cup. In one cup only, they will carefully add a layer of oil ~1cm thick. Over the course of the next few days, they will measure the water level in each cup from the original mark, and compare the differences between the two cups.

Overall, the goal of this station is for students to observe how oil affects evaporation in regard to the hydrosphere, use their data to predict how an oil spill could affect the hydrosphere in their area, and brainstorm possible solutions to prevent possible flooding in the event of an oil spill.

Meteorologist/Atmosphere

For this station, students will be focusing on the question: How is the atmosphere affected by the oil spill? One way to analyze the effect of oil on the atmosphere is to consider the possible effect on the water cycle--specifically condensation. Depending on the students' experience with problem solving, the teacher may wish to allow the students to brainstorm and come up with how to study this relationship on their own, or just present them with the issue of condensation of water vs. water mixed with oil. You may also choose to have students write their own procedure, or use the procedure provided below.

The water cycle is a continuous cycle of evaporation, condensation, and precipitation. For this station, students will investigate the impact of oil on water's ability to condense. (**Note: Technically the oil blocks the water's ability to evaporate, which results in no/less moisture in the air to condense. However, at this level, students are not expected to make that connection*). Students will get two insulated cups and add some hot or warm water to them. In one cup only, they will carefully add a layer of oil ~1cm thick. At the same time, students will place two clear plastic cups upside down over the insulated cups. Over the next few minutes, they will use hand lenses to observe what is happening on the interior of the clear plastic cups.

Overall, the goal of this station is for students to observe how oil affects condensation in regard to the atmosphere, use their data to predict how an oil spill could affect the atmosphere in their area, and brainstorm possible solutions to prevent possible decreased rainfall/drought in the event of an oil spill.

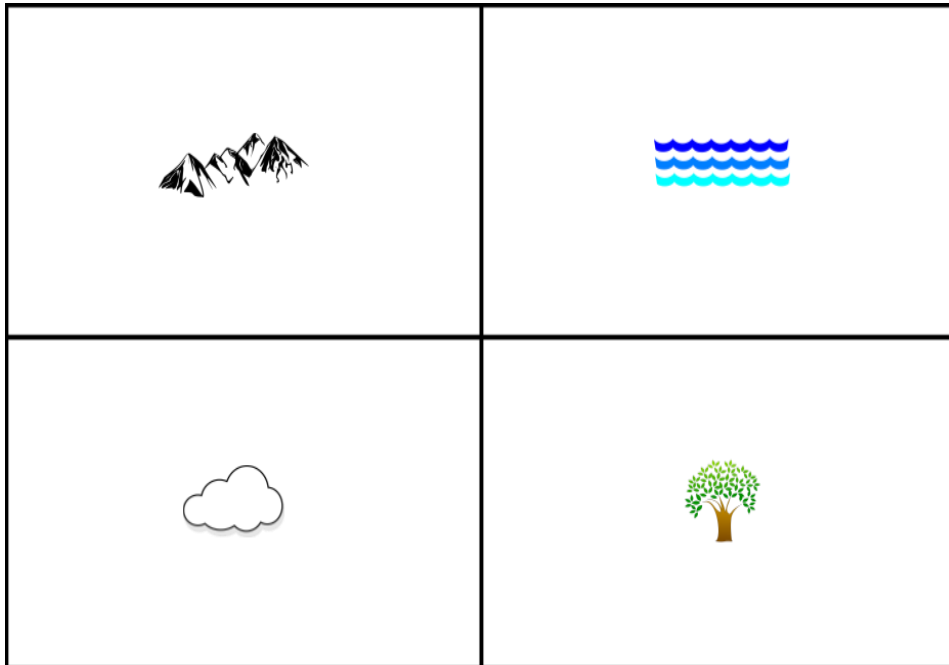
Biologist/Biosphere

For this station, students will be focusing on the question: How is the biosphere affected by the oil spill? One way to analyze the effect of oil on the biosphere is to consider what living things need to live. Depending on the students' experience with problem solving, the teacher may wish to allow the students to brainstorm and come up with testing ideas on their own, or just present them with the scenario of replacing water with oil for a living thing.

An easy way to test the ability of a living thing to live and grow in water vs. oil is to ‘plant’ radish seeds in both water and oil. Students will just need to prepare and label two small cups, one with water and one with oil, and place a few radish seeds in each (at least 3 seeds). In water, radish seeds are able to sprout in a matter of days. In oil, radish seeds will not sprout at all. Because this station requires multiple days, it may be valuable to have students develop certain aspects of the procedure on their own, as well as use extra time on day 1 to determine how they will measure and track data throughout the course of the experiment.

Overall, the goal of this station is for students to observe how oil affects life/plant growth in regard to the biosphere, use their data to predict how an oil spill could affect the biosphere in their area, and brainstorm possible solutions to ensure continued plant growth in the event of an oil spill.

Students may be provided with an organizer (see student page) to brainstorm and predict how the oil spill might affect each ‘sphere’. They can list features of that ‘sphere’, possible positive or negative effects of oil interacting with it, or even possible ways to remove the oil.



Extension

Get the Oil Out

One way to include the 3-5 ETS standards is to extend this lesson by challenging students to further analyze the ‘oil spill’ problem, generate possible solutions to remove the oil from the dirt and/or water, and even test their solutions.

Part Three: Dust Bowl Days

Suggested Implementation

PBS has a series of short videos about the Dust Bowl.

<http://www.pbs.org/kenburns/dustbowl/watch-videos/#2219206510>

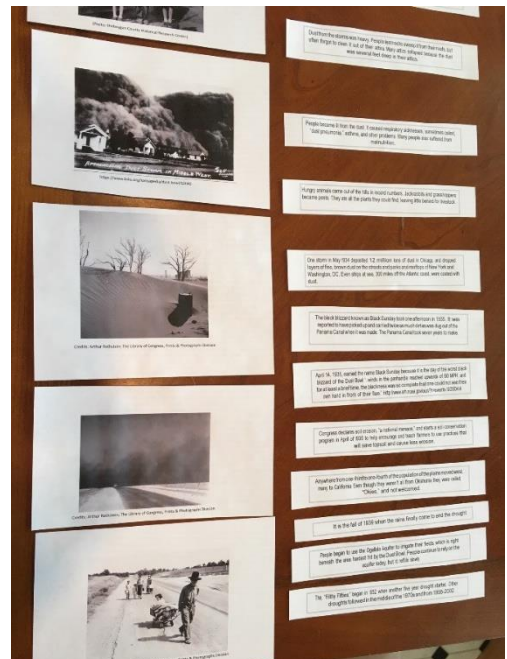
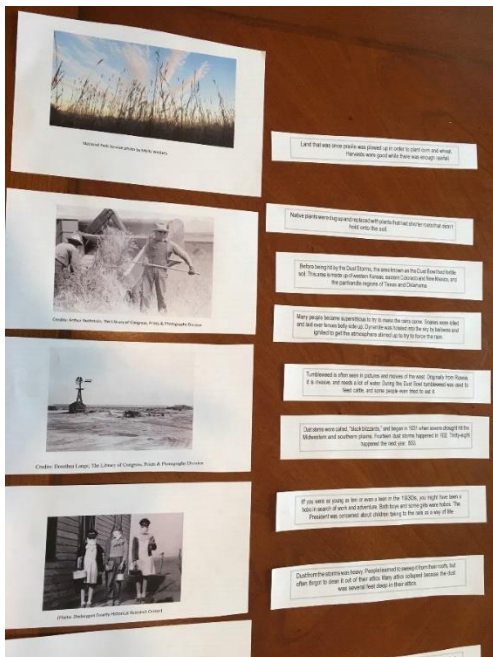
Consider the *Intro* and *Environmental Catastrophe* videos to give students an idea about the causes and impacts of this effect of our interactions with the geosphere and biosphere.

Print off the timeline at the end of these teacher pages and the Dust Bowl Images (separate document). <http://www.pbs.org/kenburns/dustbowl/photos/> This activity can be done as a class or in smaller groups. Each group will need a set of images and the Dust Bowl timeline strips. Ask the students to place the images in order from healthy prairie to the end of the dust bowl in 1939.

Consider placing the photos on a long desk or along a wall. There may be a slight variation in order, but if they can provide rationale, that is acceptable. Ask the students to place the strips near the most appropriate image. Some strips have dates and other don't so there will be variation as well. The students should be prepared to explain why they placed items in the order that they did.

Host a class discussion with questions similar to the following:

- How can humans impact ecosystems (biosphere)? Share some examples.
- Why do you think that humans cannot always predict the consequences of the impacts to the biosphere?
- How are the biosphere, geosphere, and atmosphere related to each other?
- How can we prevent future dust bowls?



Debrief

- What are some examples of the geosphere, hydrosphere, atmosphere, or biosphere working together? Ask students to use the information that they have learned about the dust bowl and create a diagram showing how the biosphere, hydrosphere, geosphere and atmosphere interacted in the scenario. You can use the same graphic organizer that you used for the oil spill activity. They should identify the relevant components of their example and describe relationships (interactions) within and between the parts of the Earth systems identified in their model.
- How are models useful in science?
- Why is it important for different kinds of scientists (i.e., geologist, biologists, etc...) to work together and share their data?

Assessment

The following single point rubric can be used to assess student understanding. For each of the criteria listed below, either circle the proficient description or add notes to a box indicating why the student's performance was either lacking or exceptional.

Areas that need improvement. Developing Performance	Criteria for Proficient Performance	Evidence of exceeding standards. Advanced Performance
	Described interactions between at least two of the following: geosphere, biosphere, hydrosphere, and atmosphere	
	Developed a model that shows interaction between at least two of Earth's spheres	
	Explained how the geosphere, biosphere, hydrosphere, and atmosphere work together to create a comprehensive system	

Accommodations

Procedures may need to be provided for some students.

Extension

Have the students investigate different soil erosion prevention strategies. You can use plastic paint trays as inexpensive stream table, poking a hold in the bottom and catching the runoff in a cup. The students can compare different soil erosion prevention techniques and look to see how much soil has ended up in their cup and how the water clarity differs. If you have enough lead time, you can seed several trays with soil and grass seed at one end to see how plant roots can help to absorb runoff. You can see the paint tray stream tables in action at

<https://betterlesson.com/lesson/635220/investigating-erosion-control-methods>

The Maine Geological Survey also has an activity using more traditional stream tables to investigate erosion control. <https://www.maine.gov/dacf/mgs/education/lessons/act15.pdf>