Title: Oil Spill In a Pan

This lesson plan is a compilation of several similar activities:
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Theme: It is difficult and expensive to contain and clean up an oil spill.

Objectives:
- Students will experiment with ways to contain and clean an oil spill.
- Students will evaluate the challenges and efficiencies of various clean-up techniques.
- Students will compare the success of different technologies under different conditions.

Duration: 60-90 minutes

Age Range: 6th-12th Grade

Materials:
- Vegetable oil
- Black tempera paint
- Eye dropper
- Clean up materials:
    - Nylon net
    - Nylon hose
    - Styrofoam
    - String
    - Straw or sticks
    - Fur or hair
    - Detergents
    - Seaweed/pondweed
    - Absorbent pads
    - Spoons, etc.
    - Large disposal containter (coffee can, etc.)
- "Habitat" materials:
    - Grass
    - Mud

    - Rocks
    - Sand
- Fan (optional)
- Saltwater
- Freshwater
- Worksheets
    - Clean-Up Response Worksheet
    - Clean-Up Cost Sheet
- Pencils or pens
- Newpapers
- Aluminum pans or plastic bins (3 per group)
- Stop watches
- Ice cubes
- Hot water

Background:

This hands-on activity is meant to simulate the challenges of containing and cleaning up an oil spill. This version of the activity has been adapted from many sources and includes an economic component as well as habitat and climate comparisons. It can be simplified for use with younger students or shorter duration.

Many different clean-up techniques were used following the *Exxon Valdez* Oil Spill. Below a brief description of each technique is given. For more detailed information on various clean-up techniques and their merit, see references cited in the appendices. There are basically four ways to actively clean up oil spills: mechanical containment & recovery, application of dispersants, shoreline clean-up, and in-situ burning of oil. Another response, not always recognized, is "no response." After the *Exxon Valdez* Oil Spill, NOAA studied sites that were not actively cleaned up and documented considerable survival and recovery of marine life.

<u>Mechanical skimming</u> of oil is considered the response method least harmful to the environment, but it requires large quantities of equipment and personnel, as well as fair weather. It is a multistage process – first you need to contain the oil, then you need to recover the oil, next you need to temporarily store and transport the oil, remove the water from the oil, and finally dispose of the oil. In each stage the oil is handled, so special safety equipment and training is needed. The process is time-consuming and can bottleneck at any stage, breaking down the system. Equipment used can include skimmers, booms, suctioning devices, and buckets.

<u>Chemical dispersants</u> are used to break oil into small droplets in the upper part of the water column. They cause a chemical change to occur in the oil that allows it to disperse into the water column. This removes oil from the surface, potentially reducing impact on surface-feeding and -breathing animals. However, as the oil disperses through the water column and sea floor, it may increase the impacts on other species. Some of these species, such as small invertebrates and fish may

consume or absorb bits of oil and then be consumed by larger predators, increasing the threat of bio-accumulation (toxins being concentrated as you go up the food chain). Some studies show that dispersants speed up natural dispersion, degradation, and evaporation. Other studies show that the dispersants themselves are highly toxic and may be ineffective in cold waters. To be effective, dispersants must be applied soon after a spill, since weathered oils are hard to disperse. Mixing energy from wind and waves is also needed. Pre-approval is required from the government before dispersants can be applied on a spill.

Shoreline clean-up involves the physical removal of oil from beaches. This is the most labor and equipment intensive response method. Techniques must be chosen carefully. Removal of oiled sediments and biotic materials can sometimes create environmental problems such as beach erosion. Pressurized hot water used to wash oil off of rocks can kill intertidal invertebrates. Running heavy equipment on shorelines can sometimes do more damage than the oil. A variety of shoreline clean-up methods are available. The one(s) used depends on the beach type, location, type of oil, and the equipment and manpower available. Citizen clean-up programs after the *Exxon Valdez* Oil Spill involved many different shoreline clean-up techniques, such as oiled seaweed pick-up on beaches. Seaweed is a natural oil collector so the more picked up meant less oil spread back out to bays and estuaries. Pom-poms made of oil-absorbent material were also used to pick up oil, and oil-absorbent pads were used to wipe off individual rocks. A rock washing program was developed by tying rocks in special bags where they would be washed by the tidal action of the ocean. Once back in the ocean, the oil can be picked up by mechanical skimming. Bioremediation, the use of fertilizer to increase populations of oil eating bacteria, was also tried.

Bio-remediation is the use of bacteria to eat the oil. There are many kinds of bacteria that occur naturally that consume oil to get their nutrients. This response method involves the release of large quantities of bacteria into the oiled area to eat the oil. While a useful tool, this has to be managed carefully and used in moderation to control oxygen depletion. If too many bacteria are added, they will use all the oxygen in the area, leaving none for the other organisms, often resulting in a dead zone, where nothing can live and there is a die-off of animals. This was a common method used in the Gulf of Mexico after the Deepwater Horizon spill.

In-situ burning is the technique of burning the spilled oil. It creates a temporary air pollution problem that may pose a risk to people and animals exposed to the smoke. Unwanted fires can also happen, and controversy exists about this method’s effectiveness and hazards. Burning works best on fresh oil within the first 24-48 hours. Specialized equipment and trained personnel are necessary.

Preparation:

Set up this activity outside if possible. If not, use old newspapers to cover the floor. Mix vegetable oil and black tempera paint and beat well to create pretend crude oil students can safely work with.   Fill two tubs per group with saltwater. Leave one tub as only water, but include “habitat” materials along one side of the other tub to represent intertidal habitats such as marshes, sandy beaches, and rocky intertidal zones. Give each group a different type of intertidal habitat: rocky intertidal (large rocks), sandy beach (sand), salt marsh (grass), mud flats (mud/clay), cobble beach (small rocks/pebbles), etc. Set up a clean-up material purchase station along one table.

Introduction:

Break students into groups and have each group gather around a tub of water. Introduce the lesson to students by explaining that you are going to create an oil spill in each pan. Their challenge is to investigate various containment and clean-up techniques. Discuss with them various clean-up products and methods, such as: skimmers and booms, dispersants (detergents), oiled seaweed or pompoms, absorbent pads, suctioning (eye dropper) and collecting with buckets. Each of these clean-up techniques comes with a cost: the cost of the material itself and the cost of disposal. Explain to students that each group has a $100,000 budget for their clean-up and oil disposal. Allow students to list alternative methods and experiment with them during the clean-up. Have students answer the first two questions of the worksheet.

Activities & Procedures:

Begin by placing a tablespoon of oil in the “open ocean.” Start the timer for one minute. As you wait for the oil spill response to begin, explain to students that they are trying to contain and remove the oil from the open ocean bin. If oil touches the edge of the open ocean bin, then it has moved into intertidal habitat – when this happens, you will place 1 tablespoon of oil into the tub with intertidal habitat. The students’ task is to contain, remove, and dispose of the oil as quickly as possible while staying within their $100,000 budget. If the oil cannot be contained and makes its way into the intertidal habitat, their task expands to include cleaning the habitat as best as possible.

After the minute passes, let the containment and clean-up begin! Students can send one representative per group to the purchase station to pick up materials and note the purchase on their cost sheet.

After two to three minutes, simulate a storm in each ocean tub by blowing or using a fan to move the oil around. Check tables to add a tablespoon of oil to the intertidal habitat bin as needed if the oil reaches the edge of their open ocean tub. (If any group is successful in containing and removing the oil before it reaches the edge of the tub, congratulate them on their efficiency, but still give them a new challenge by placing a tablespoon of oil in their intertidal habitat tub.)

Continue the activity for 25 minutes, or until groups have reached their limit of clean-up activities. Have groups tally up their clean-up cost and estimate what percent of the oil was removed from the open ocean and intertidal habitat bins. Students should record this data on their worksheet and answer questions 3-5.

Have students share their data and record it on the board. What containment and clean up techniques seemed to be most successful? Which ones were least successful? Which techniques seemed to clean or contain the most oil for the least amount of cost? Did different techniques work better in different habitats? Did students develop any new materials or techniques? Analyze cost and percentage cleaned data to identify mean, median, and mode. As a group, identify the three most successful techniques that worked across habitats.

Now, it is time to change the climate and location of the spill. Allow each group to choose a new climate/location: warm saltwater with the same intertidal habitat type (80 degrees Fahrenheit), ice-filled seas (ice cubes), or a land-based spill (grass/dirt on either sides of the tub with a freshwater river or lake in the middle). Spill 1 tablespoon of oil into each tub, wait one minute, and then let students begin the clean-up with a new $50,000 budget and 15 minutes of time (since they only have one tub to clean). Be sure to simulate another storm by blowing on the tubs or using a fan. In the terrestrial habitat, sprinkle freshwater to simulate rain.

Have students tally up their cost, estimate the percent of oil they removed, and answer the final questions on the worksheet. Share this data with the class. Were the same techniques successful in different climates and locations?

Wrap-Up:

Lead a class discussion, or have students reflect in writing about their experience. Have them first summarize what they learned about oil spill clean-up and identify the major challenges that they faced. Were they realistic challenges? What environmental factors influence clean-up and oil composition? In a new paragraph, ask students to state their opinion of the best techniques to clean up an oil spill. Are these techniques better than no response? Finally, students should respond to the prompt, "How clean is clean enough?" This is an area of debate among scientists, agency representatives, and local people who disagree about what "clean" really is. Ask students to explain how they would determine if an area affected by a spill was sufficiently cleaned and restored.

Evaluation:

Assess worksheet answers for completeness, neatness, and accurate work. Because each clean up response will vary, use common sense and your own observations to evaluate student answers. Observe student cooperation, participation, and adherence to safety guidelines during group work. Evaluate student understanding of the challenges of containing and cleaning up a spill based on the effectiveness of their clean up techniques, contributions during group discussions, and choice of changed location or climate for the spill.

Oil Spill In A Pan Clean Up Worksheet

Name ____ Date ____________________

Oil Spill Clean-up

1. How do you think oil will interact with the coastline and the plants and animals that live there? Write a hypothesis, an educated guess.

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2. Which materials do you think will work best to clean up the oil? Write a hypothesis, an educated guess.

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3. Describe what happened. Were your hypotheses accurate?

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4. Were you able to stay within your budget?

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5. Write a conclusion about your experience cleaning up an oil spill with your funds and equipment.

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Equipment and Techniques	Cost	Minutes of Use/ # used	Total Cost
Medicine dropper “skimmer”	$100/minute		
Rollers	$1000/minute		
Cotton ball	$20/each		
Oil Adsorbent Pad	$50/each		
Sponge	$50/each		
Nylon	$30/each		
Pipe Cleaner	$50/each		
Burlap Rope Boom	$100/each		
Nylon Rope Boom	$75/each		
Clothes Pin	$100/each		
Popsicle Sticks	$25/each		
Straws	$25/each		
Detergent	$100/tablespoon		
Total Equipment Cost			

Waste Disposal	Cost	Minutes of Use/ # used	Total Cost
Container for Wastewater	$1,000/each		
Discarded Roller	$500/each		
Discarded Cotton Ball	$50/each		
Discarded Oil Adsorbent Pad	$100/each		
Discarded Sponge	$100/each		
Discarded Nylon	$50/each		
Discarded Pipe Cleaner	$100/each		
Discarded Rope	$250/each		
Discarded Popsicle Stick	$50/each		
Discarded Straws	$50/each		
Labor	$1,000/person/minute		
Waste Subtotal			
Equipment and Labor Subtotal			
Total Cost	**Not to exceed $100,000**		

Oil Spill In A Pan Standards

Science As Inquiry and Process: Students develop an understanding of the processes and applications of scientific inquiry.

SA1
Students develop an understanding of the processes of science used to investigate problems, design and conduct repeatable scientific investigations, and defend scientific arguments

The student demonstrates an understanding of the processes of science by:

[6, 7, 8, 9] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating

[10, 11] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating

[9] SA1.2 hypothesizing, designing a controlled experiment, making qualitative and quantitative observations, interpreting data, and using this information to communicate conclusions

[10] SA1.2 reviewing pertinent literature, hypothesizing, making qualitative and quantitative observations, controlling experimental variables, analyzing data statistically (i.e., mean, median, mode), and using this information to draw conclusions, compare results to others, suggest further experimentation, and apply student's conclusions to other problems

[11] SA1.2 recognizing and analyzing multiple explanations and models, using this information to revise student's own explanation or model if necessary

SA2
Students develop an understanding that the processes of science require integrity, logical reasoning, skepticism, openness, communication, and peer review.

The student demonstrates an understanding of the attitudes and approaches to scientific inquiry by:

[9] SA2.1 formulating conclusions that are logical and supported by evidence

[10] SA2.1 examining methodology and conclusions to identify bias and determining if evidence logically supports the conclusions

Concepts of Life Science: Students develop an understanding of the concepts, models, theories, facts, evidence, systems, and processes of life science.

SC3
Students develop an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy.

The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by:

[10] SC3. 2 exploring ecological relationships (e.g., competition, niche, feeding relationships, symbiosis)

[11] SC3.2 analyzing the potential impacts of changes (e.g., climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem

Science and Technology: Students develop an understanding of the relationships among science, technology, and society.

SE1
Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to problems and everyday events.

The student demonstrates an understanding of how to integrate scientific knowledge and technology to address problems by:

[6] SE1.1 recognizing that technology cannot always provide successful solutions for problems or fulfill every human need

History and Nature of Science: Students develop an understanding of the history and nature of science.

SG3
Students develop an understanding that scientific knowledge is ongoing and subject to change as new evidence becomes available through experimental and/or observational confirmation(s).

The student demonstrates an understanding that scientific knowledge is ongoing and subject to change by:

[10] SG3.1 using experimental or observational data to evaluate a hypothesis