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School: Hoxie High School

Grade Level and Course: 11th and 12th grade Environmental Science

Title: Do We Have An Oily Mess?

Topic: Designing and experimenting with various methods to clean up oil spills in diverse habitats.

Summary of lesson:
On the news again: an oil spill. No matter how big or small, an oil spill fills our minds with horrible images of oil-soaked birds, destroyed habitats, and dead plants and animals. With this project, students will be able to identify aspects of cleaning up an oil spill in a created environment. Students will have a variety of materials available to create the environment, destroy it with oil, and then try to clean it up using various methods and science. Each question decided upon by the students will be tested and analyzed. Once the experiment is complete, each individual group will give a presentation based on their design and conclusions. The presentations will include an oral summary and will be presented on posters or with technology such as PowerPoint.

Concepts: Experimental design, oil spill clean up, oil spill effects, methods and equipment for cleaning up oil spills, environmental safety, steps to minimize future oil spills, problems faced in the clean up of oil spills, and various effects of oil spills

Objectives:
The student will determine the best way to clean up an oil spill by
- Designing an experiment that can be replicated using a control with independent and dependent variables that answers a question about oil spill clean up.
- Collecting, then analyzing the data gathered to determine the answer to the problem.
- Recognizing various methods and equipment used in cleaning up oil spills.
- Evaluating the different factors that affect the ability to contain and clean up a spill.
- Comparing and contrasting the Exxon Valdez spill with the Bahia Paraiso spill.

Background for Teachers: Oil spills have become a problem facing everyone on this planet. This lesson provides students with a new perspective on how difficult it is to clean up a spill and the many factors that contribute to the successes and failures that come about in cleaning up a spill. Oil spills affect marine resources and organisms that are linked together by the food chain, as well as by the physical environment and the damage it sustains when an oil spill occurs. The physical damage leaves its effects in the animals, plants, and the habitats that the oil spill contaminates. In addition, the oil itself is toxic to the environment and its many living organisms. The effects caused by the oil spill depend on many factors such as: the type of oil, the oil's properties, the geology of the habitat in which the oil spill occurs, spill location, and response to clean up the spill. Other factors that should be considered during an oil spill are the oil's surface tension

with the water, density (specific gravity), and viscosity. There are also natural factors that may help to reduce the effects of oil spills. These natural factors include weathering, evaporation, oxidation, biodegradation, and emulsification. (These make good vocabulary words while taking roll.) More advanced response techniques are used to clean up oil spills such as: mechanical recovery of the oil, chemical methods to remove the oil, or biological methods to degrade the oil. In this lesson, students will devise an experiment to answer a question pertaining to how an oil spill is cleaned up and investigate the effects of oil in the created environment. See Appendix A for teacher notes that give sources and add to the background information.

Background for Students:
Students should be aware of the different methods and equipment for cleaning up an oil spill and of the natural factors that play a role in the clean up efforts. Students should also investigate the effects of such oil spills as the Exxon Valdez and the Bahia Paraiso spills. Students should also know the basics to what causes oil spills (not just tankers) and the environmental impacts of the oil spills. See Appendix B for student information and Appendix C for laboratory handout.

Procedure:
- Give students the handout located in Appendix B one day prior to beginning the activity, so that they can become familiar with the material.
- If a computer lab is available, allow students to look at this website on their own and answer the questions throughout the tutorial. It is a wonderful tutorial and photo gallery on the Exxon Valdez spill and oil spills. Once finished, let them search different resources on oil spills.
- On the starting day, ask students to name the most famous oil spill. Discuss its effects on the environment and how scientists and volunteers dealt with the spill to clean it up. Compare and contrast it to another oil spill. Appendix A should help with the organization of the discussion.
- The questioning should lead into a discussion about the background information on oil spills. Let the discussion lead into the assignment. Appendix A should also help with this.
- Tell the students they will be designing and carrying out an experiment based on the clean up an oil spill.
- Tell the students they should design an experiment that will test various methods and equipment used in the clean up of an oil spill or factors that affect the clean up of a spill, such as: natural occurrences, oil types, or habitat types.
- Let the students know that they will also be responsible for participating in the design and experimentation of the group idea.
- Let the students know they are also responsible for participating in a five-minute oral presentation of their design, experiment, collection, and analysis of the experiment chosen to the rest of the class on the designated presentation days.
- Next, tell the students that all ideas, design, collection, and analysis should be included in their lab notebook.
- Go over the rubric located in Appendix D with the students and give them a copy of the rubric.

- Show the materials available for the lesson to the students before getting started. Then, give students a few minutes to look over the materials.
- Pass out the student laboratory handout located in Appendix C.
- Go over the handout and answer any questions the students might have about experiment design or safety.
- Let the students group themselves (3 to 4 in a group) and begin brainstorming. During this time, the students should decide on a specific aspect, question, or prediction on oil spill clean up. Also, tell the students they should decide on how to set up their habitat(s).

- Questions students might have after brainstorming:

1. Which method of clean up is most effective in cleaning up an oil spill?
    - Short-term activity – approx. time to gather data: one or two days
    - There are many different methods to cleaning up a spill and these are explained in more detail in the teacher notes located in Appendix A. Some methods of clean up include absorption, containment, vacuuming, biological, and chemical.
2. Do different types of oil clean up better than other types?
    - Short-term activity – approx. time to gather data: one or two days
    - A way to measure this would be to get the original weights of the environments using bathroom scales; the weights when oil is added, and finally the weights of the environments after clean up efforts are exhausted. Controls such as amount of oil introduced to the environments, what is used for clean up, and habitat similarities should be considered.
3. Does the viscosity (or specific gravity, surface tension) of the oil affect clean- up methods?
    - Short or long-term activity depending on what would be tested.
    - Oil is less dense than water, so it floats. Adding soap makes the oil clump and sink (which is a hazard to the ocean). Soap also breaks surface tension of water, which could hinder oil containment.
4. What are the limiting factors (wind, waves, current, weather) when cleaning up an oil spill?
    - This could be long-term with weather, especially if local weather conditions are used.
    - Short-term activity – approx. time to gather data: one or two days
    - Some of these natural factors will help with the clean up of an oil spill and others will hinder the process.
5. Are biological agents better at cleaning up an oil spill than chemical agents?
    - Long-term activity – biological and chemical agents take longer to break down the oil than other methods of clean up. In the past it has taken about two weeks to gather data on the biological clean up.
    - Approx. time to gather data: two weeks

6. Will oil-eating bacteria clean up an oil spill better than mechanical methods?
    - Long-term activity for the biological part (two weeks), but short term for mechanical methods (one or two days).
    - Biological agent – oil eating bacteria
    - Mechanical – skimmers, boomer, absorbents
7. Do oil-eating bacteria clean up oil spills of different weights at the same rate?
    - Long-term – approx time to gather data: two weeks
    - Here the weighted oil would be different weights of motor oil.
8. Can an oil spill be cleaned up using only natural methods?
    - Short-term activity – approx. time to gather data: one or two days
    - Natural methods would include simulated wind, waves, current, weather, or combination of any of these.
9. Is it faster to clean up an oil spill in sand, pebbles, or dirt?
    - Short-term activity – approx. time to gather data: one or two days
    - This one will be interesting. Sand makes oil clump and can be used in clean up. Pebbles will allow it to flow through the habitat. Dirt is porous and will allow oil through, also.
10. How are animals and plants affected in a spill?
    - This could be a short or long-term activity depending on what the students are testing.
    - Factors that could be tested include the oil's effects on the coats of animals (simulated such as down feathers and fake fur) or the effects on bird eggs (chicken eggs would be a good substitute to bird eggs) over a period of exposure time.

- Once the student laboratory handout is complete, have students turn it in for approval.
- After approval of the experimental design, the students will conduct projects according to the approved plan.
- Allow students time to set up experiments (created environments and scenarios), collect data using their own data tables/procedures, repeat the experiment, and analyze the results.
- Allow students time to do any adjustments and organize the presentation.
- Use class time for students to give oral presentations over their design, predictions, data, analysis, and overall experience in the lab.

Management suggestions:

- All materials will be laid out in a designated area of the classroom. If something else is needed and is a reasonable request, it will be placed on the table when it is acquired. Once the experimenting starts, only one person from each group will be allowed to get materials.
- Students will be allowed to group themselves in groups of 3 to 4 people. For my lesson, each person of the group will have a designated job, which will be assigned by a draw of the card (task manager, time keeper, group officiator, data collector). Assigning jobs to each of the group members is optional, but this helps me with management and gives each student a responsibility of their own to accomplish.

However, all other members have to help with other jobs and participate with the group.

- Task manager: keeps all materials available for the group
- Time keeper: manages time and helps out with other jobs in the group
- Group officiator: this is like the manager, keeps all other group members on task, and makes sure the project is going as planned
- Data collector: this is the main person that writes down the data colleted

***If the design is long-term, it is best to rotate jobs each day. This even works on most short-term projects.

- Each group will be given their own ample space to work in. All groups will be provided their own table and chairs. Also, outside space is available if needed.

Safety cautions:
Apron, goggles, and gloves should be worn at all times. If dealing with bacteria, proper aseptic procedure should be followed. Instructions for all chemical components will be provided if needed. Students should not be up and about without permission, except for the task managers who will also gather materials when needed. This is one reason I assign jobs when working in groups.

Decision-making and critical thinking:
Students will only have an introductory lesson to oil spills and clean up. From this information, the student will determine questions, controls, dependent variables, independent variables, and experimental designs to conduct an investigation on oil spill clean up. Example questions are included in the procedure section, but other questions or predictions can be used. Students first have to decide on a question, and then decide on the design and collection of data. In addition, students will have to decide the habitat or environment in which their oil spill will occur. Critical thinking will be used in the analysis of the data and in designing the presentation. The students will be making decisions and thinking critically throughout this project.

Extensions:
Possible extensions to the project:

- Testing other variables.
- Comparing and contrasting student data using technology such as excel spreadsheets and graphs.
- Discuss comparisons of oil breakdown by bacteria with processes within the human body
- Comparisons of student projects to the Exxon Valdez tanker oil spill and the Bahia Paraiso tour ship spill.
- Trace the effects of oil spills on the food chain and an ecosystem.
- Testing other types of pollution in a created environment.
- A lead into water pollution or organic chemistry with the hydrocarbon structures of oil.

Assessment method:
The oral presentation will be used as assessment and will follow the rubric given to the students at the beginning of the lesson.

Sources: Research going on in the lab I am working in includes the effects of pollution in aquatic environments on the enzyme activity of flathead minnows. The idea to use oil spill clean up came about when working in the lab and talking to my mentor about possible pollutions that could harm the enzyme (acetylcholinesterase) we are studying. Many possibilities came up including a link with oil spills. As we talked, the dangerous effects of oil spills came up and the various clean up methods were discussed. From this conversation with my mentor, I began to look into the topic and found that it would be a good topic for an inquiry activity. Background information for this project was found on the EPA website (www.epa.gov). It has great background information on this topic as well as many others. Other web resources are found in the teacher notes located in Appendix A.

Do We Have An Oily Mess? - Materials list

Freshwater – I recommend distilled water.

Saltwater – To make saltwater: Add 38 g of NaCl to 1 L of water. If more "ocean" is needed, add 152 g of NaCl to 1 gallon of water. (It also works to use kosher salt found in the grocery section of Wal-Mart, by the canning products, in the place of laboratory NaCl). This simulates the ocean.

Plastic containers –various sizes of plastic containers such as plastic shoeboxes to put the habitat in
Glass jars with lids – used to house the habitat
Aluminum pie pans – used to house the habitat
Cake pans – used to house habitats
Plastic cups – used to house the habitat or scoop oil. Could also be cut and used as a containment device.
Petri dishes – used to house the habitat.
Test tubes with racks – used to house the habitat

Rocks – used to make habitat
Clay - used to make habitat
Sand (course and fine) - used to make habitat or can be used to clean up the oil
Pea gravel - used to make habitat
Course gravel - used to make habitat

Motor oil of different weights – used as the oil in the spill
Vegetable oil - used as the oil in the spill. Different types (Olive oil, Canola oil) or maybe even different brand names could be experimented with.

Bathroom scales – to get any weights that might be needed (this could determine how much oil was removed, example: difference in the weight of environment before "oil spill" and after.
Balance – same as scales above, but for smaller habitats (test tube or petri dish oil spills)

Cotton balls – absorbent, used to clean up a spill
Styrofoam peanuts – absorbent, used to clean up a spill
Paper towel strips – absorbent, used to clean up a spill
Newspaper – absorbent, can also be used to cover the work area (recommended)
Sawdust – absorbent will make the oil clump
Gauze – absorbent, used to clean up a spill
Sponges – absorbent, used to clean up a spill
Peat moss – absorbent, used to clean up a spill
Shredded Wheat cereal – absorbent, can also be broke in half and used to scoop the oil
Coffee filters – absorbent, could also be used to make a containment device or oil scoop
Cedar wood chips – absorbent, used to clean up a spill
Hay – absorbent or can be used to make devices to clean up a spill

Fur scraps - students can try to clean it to see the effects of oil on furry critters
Feathers – down feathers are good to use, students can try to clean them to see the effects of oil on our flying friends
Artificial flowers – used to simulate the effects of oil on flowers and fauna
Fuzzy birds with nests – mom had these in the attic, they are fuzzy and can be found at a craft store like Hobby Lobby
Eggs – oil is dangerous to eggs of birds when exposed, test the effects
Pipe cleaners – make small animals out of these to see the effects

Panty hose – can be used as a skimmer on the waters surface when put into the embroidery loop
Embroidery loops – used to make a skimmer with pantyhose or a boomer with a more course material
Tweezers –
String – can be used to make equipment for cleaning up the spill

Index cards – can be used to make equipment for cleaning up the spill
Tape – good for making mechanical clean up devices or holding things in place
Popsicle sticks - good for making mechanical clean up devices
Toothpicks - good for making mechanical clean up devices
Rubber bands -
Plastic spoons - good for making mechanical clean up devices or scooping the oil
Straws - good for making mechanical clean up devices
Scissors, Glue, Markers, stopwatch

Thermometers – check temperature of environment
Hot plates – in case water temperature is tested
Ice- in case water temperature is tested
Floor fan with different speeds to simulate wind

Medicine dropper – used for "vacuuming" oil

Pipets - used for "vacuuming" oil
Magnifying glasses – some might want to do microhabitats
Testing strips- pH paper – some might test pH and oil spills
Food coloring – for coloring the water, it helps the effect in some cases
Tongs
Rulers
Liquid detergent – causes the oil to clump and sink to the bottom of the "ocean"

Oil eating bacteria - Mighty Bugs – Oil Eater, Brown Marine Service, Inc., Pensacola, FL, 1-800-234-3471 (This is a microbial cleaner that is not hazardous or harmful to the environment).
http://www.brownmarine.com/mightybugs.htm
*Neo Science has a kit with the oil-eating bacteria and you can just order the bacteria for $24.95 from Blue Spruce Scientific Supply. There is also a substance called Bio One that could be used (www.1biotechnology.com/BioOne.html).

Correlation to National Standards:

Teaching Standards:

- A: Teachers of science plan an inquiry-based science program for their students.
- B: Teachers of science guide and facilitate learning.
- C: Teachers of science engage in ongoing assessment of their teaching and of student learning.
- D: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.
- E: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

Content Standards K-12:

- As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes: evidence, models and explanation, constancy, change, and measurement; form and function.

Content Standards 9-12:

- A: As a result of activities in grades 9-12, all students should develop abilities necessary to do scientific inquiry and understandings about scientific inquiry.
- F: As a result of activities in grades 9-12, all students should develop understanding of personal and community health; population growth; natural resources; environmental quality, natural and human-induced hazards; science and technology in local, national, and global challenges
- G: As a result of activities in grades 9-12, all students should develop understanding of science as a human endeavor; nature of scientific knowledge; historical perspectives

Appendix A – Teacher Notes

***Check websites after each introduction for more information.**
Oil spills are an important topic in environmental science. Many factors contribute to the clean up of an oil spill including:

Type of oil: The old saying – oil and water do not mix. Most oils are lighter than water and float on top. If the surface tension of oil is higher (as in cold water), it will not spread as easily and if lower it will spread rapidly. Each type of crude oil and refined product has distinct physical properties that affect the way the oil spreads or breaks down. Lighter products spread quickly and do more damage to the shore than heavier oils. Furthermore, heavier oils do not spread as easily and may be harder to clean up. (http://www.oil.com)

Mechanical Recovery: These are booms, skimmers, and absorbents that are used to contain and pull the oil from the water. Booms contain and control the spread of oil to make it easier to remove. Skimmers recover the oil from the surface of the water. Absorbents are used to blot the oil from the waters surface by picking up and holding the oil in porous regions of the material. (www.oilspill.state.ak.us)

Biological/Chemical Methods: Biological and chemical agents catalyze the rate at which natural methods break down oil spills. These agents biodegrade oil by using it as a source of food.

Natural Methods: Factors such as wind, current, waves, evaporation, and weather cause the oil to undergo physical and chemical changes that results in the break down or dispersion of oil in the water. (http://www.offshore-environment.com/oil.html)

Exxon Valdez: In 1989, this oil tanker ran aground and spilled millions of tons of oil into Prince William Sound in Alaska. Even now, the oil still remains in some locations and the damage is still occurring. (http://www.fakr.noaa.gov/oil)

Bahia Paraiso: Also in 1989, this supply ship ran aground off the coast of Antarctica spilling diesel and other petroleum products into the ocean. This spill disrupted research in the area and threatened the environment. (http://www.antarcticmarc.com/bahia.html)

Oil-eating bacteria: **PDM-7 ™ HC** BIOLOGICAL HYDROCARBON DIGESTANT found at http://www.brynlewis.com/phaseiii/hydrocarbon.html.

Links to aid in background research:

Department of the Interior, Office of Environmental Policy and Compliance, DOI Emergency Preparedness and Response Strategy: Oil Discharges and Hazardous Substances Releases - http://www.doi.gov/oepc/emerprep.html

Exxon Valdez Oil Spill Restoration Web Site
http://www.oilspill.state.ak.us/

Exxon Valdez Oil Spill Restoration Plan
http://www.oilspill.state.ak.us/pdf/restoration/restorationplan.pdf

U.S. Coast Guard: Marine Safety and Environmental Protection Response Information - http://www.uscg.mil/hq/g-m/nmc/response/index.htm

Environmental Protection Agency: Oil Spill Program - http://www.epa.gov/oilspill/

National Response Team: Ensuring Effective National Oil and Hazardous Substance Preparedness and Response - http://www.nrt.org/

National Oceanic and Atmospheric Administration: Office of Response and Restoration - http://response.restoration.noaa.gov/index.html

www.pollutiononline.com and search the website for oil spills.

Timeline for lesson:

- One day for research with student handout in Appendix B
- One day for discussion, going over the assignment/rubric, grouping, and brainstorming
- One to two days for experimental design, gathering materials, and setting up habitat
- Two days for testing short-term activities or 8 days for testing long-term activities (other activities can be done during this time, because it is mostly collecting data that only takes a few minutes)
- One or two days for data analysis and organizing oral presentation
- One day for oral presentations

Appendix B – Student Information

- To begin, go to the following website, work through the tutorial, and answer the questions in the tutorial on a separate sheet of paper:

http://www.classzone.com/books/earth_science/terc/content/investigations/es0703/es0703page01.cfm

- Once you are finished with the tutorial, visit the following sites and answer the questions:

http://response.restoration.noaa.gov/kids/spills.html

1. What was the largest spill in the United States thus far? _____

2. Name three reasons spills occur?
   _____
   _____

http://www.antarcticmarc.com/bahia.html

1. Why did the public not hear of this oil spill?

_____
_____

2. What happened in 1992 with this situation?

_____
_____

Go through the links at the following website to learn more about the Exxon Valdez oil spill for tomorrow's discussion: http://www.evostc.state.ak.us/facts/index.html
(Q and A, spill map, spill photos, details, lingering oil, settlement, restoration, etc.)

Define the following:

Surface tension
Specific gravity
Viscosity
Evaporation
Oxidation
Biodegradation
Emulsification

Appendix C - Student Laboratory Handout

Names of group members: _____

_____

Safety: Goggles, apron, and gloves are a must!

1. Question/prediction/hypothesis:

2. Experimental Design:
    a. independent variable:
    b. dependent variable:
    c. controls:

3. Changes to be made:

Approval:

Appendix D - Oil Spill Oral Presentation Rubric

Question/prediction:
4 pts – clearly stated
3 pts – stated to some extent, but not clear
2 pts – vaguely stated
1 pt – stated, but not appropriate
0 pts – not stated

Variables:
4 pts – both variables (independent, dependent) clearly stated
3 pts – both variables stated to some extent, but not clear **or** one clear, other vague
2 pts – both variables vaguely stated
1 pt – one variable stated clearly, other not at all
0 pt – no variables stated

Standardizations:
3 pts – all conditions necessary in the trials were controlled
2 pts – most conditions in the trials were controlled
1 pt – few conditions in the trials were controlled
0 pts – too much variability among trials

Replication:
3 pts – group replicated trials 5 times
2 pts – group replicated trials 3 times
1 pt – group performed only once
0 pts – group did not test trials

Data Analysis:
4 pts – data correctly interpreted
3 pts – data interpreted to some extent
2 pts – data vaguely interpreted
1 pt – data interpreted, but incorrect
0 pts – no data interpretation

Participation:
4 pts – student actively involved in all parts of the experiment
3 pts – student participated in some parts of the experiment
2 pts – student participated in only one part of the experiment
1 pt - student is present, but chooses not to participate

Visual Aids:
3 pts – neat, clear, and large
2 pts – one of the above are missing
1 pt – two of the above are missing
0 pts – no visual aids or not adequate

Oral Presentation:
4 pts - Loud, clear, shows comprehension of lesson, and eye contact with listeners is made
3 pts – 3 of the above are shown
2 pts – 2 of the above are shown
1 pt – one of the above are shown
0 pts – no oral presentation or not adequate