The Black Tide

Key Concepts

1. A variety of methods are used to clean up oil spills.

2. A number of factors affect cleanup in a spill: the type of oil, type of shoreline, weather, and actions of the seas.

3. A variety of ways are used to clean up oil spills, including "mopping" up the oil, skimming it off the surface, burning the oil, applying chemicals to break up the oil, relying on micro-organisms to break down the oil, or cleaning up the oil when it reaches the shoreline.

4. Oil spill cleanup involves choosing the method that will do the least damage to the environment under the operative circumstances. No foolproof methods of cleanup exist. Many techniques create new problems. For example, the disposal of the oily waste materials exists when oil is removed by absorption.

Background

Oil spills pose one of the greatest threats to rocky habitats and intertidal inhabitants. News broadcasts from the 1989 *Exxon Valdez* spill in Alaska portrayed the loss of marine life and the difficult process of trying to clean up rocky shores.

A staggering total of six million tons of oil enter the marine environment annually. General public perception notwithstanding, some 60% of this oil pollution is consumer related, coming from industrial and non-industrial sources, such as shipping, auto and boat maintenance, crankcase leaks and oil changes, and urban run-off! Of the remaining pollution, 30% is oil supply related (refineries, tanker accidents, offshore rigs) and 10% comes from natural seeps and atmospheric fallout.

Oils transported by tankers differ greatly. Some are light and volatile while others, such as crude and crankcase oils, are heavy or viscous. The rate of evaporation for any oil is related to the viscosity. Light oils, like kerosene, can evaporate completely in one day while only a small portion of the heavier oils evaporate, making heavier oils more persistent in the environment.

The different components of an oil (or different types of oil) behave differently when mixed with water. Some of the components will dissolve into the water and are toxic to marine life. Other components can trap water into the surface oil slick forming an emulsion (milk is an emulsion of water and animal fat). This emulsion will increase the volume of the slick, perhaps as much as three or four times, and will often form a mixture as viscous and sticky as honey.

In instances where the oil quickly dissolves or disperses in water, the impact on the marine environment may not be readily visible, even though the dissolved or dispersed oils may be very toxic to marine life. A 1993 spill near the Shetland Islands north of Scotland dispersed in a few days. Although the oil seemed to disappear, the toxic compounds were mixed into the water and contaminated or "tainted" many fish. Although uncommon, some oils adhere to sediment and organic matter, forming droplets which sink, transporting the contaminants to the seafloor.

Point out to students that often the oil being transported is crude oil. Crude oil contains thousands of different chemicals, from waxes to light and volatile liquids and gases. Immediately upon release into the sea, the oil begins to change. The volatile components begin to evaporate and the oil changes chemically when exposed to the sun. The evaporation causes the obnoxious smell associated with spilled oil. This is the most toxic stage of the spill.

If the seas are turbulent with high winds or swift currents, the oil will disperse across and throughout the water. This action produces oil droplets of varying sizes. The larger droplets rise back to the surface, while smaller ones remain in the water column.

Standard operating procedures when responding to spills involves first, stopping the source of the spill, then containment of the spilled oil, followed by the removal of oil from the contained area. The following is a list of containment and removal techniques:

1. **Booms and skimmers** to contain and collect oil (CALM seas)
2. **Vacuum** (CALM water only)
3. **Absorbents:**
    a. straw, sawdust become waterlogged and difficult to remove
    b. synthetic absorbents; absorb oil but not water
    c. problem of oiled absorbent disposal (the contaminated materials must be treated as toxic waste)
4. Sinking **agents**: sand, clay, cement
    a. sink to sea floor and impact bottom dwellers
    b. natural degradation of oil retarded at depth
    c. droplets are released from sediments and rise to surface again
    d. PROHIBITED in U.S. waters

5. **Burning:**
   a. Leaves residue: toxicity is undetermined but scientists think the residue is relatively inert
   b. pollutes air (similar to smoke from forest fire or wood stoves)
   c. must be performed within 24-48 hours of spill (before volatile compounds evaporate)
   d. has a very high removal efficiency: greater than 90% of oil removed from water if burned (Where does it go? Field tests have indicated that approximately 10% goes into smoke, 1-2% is left as residue and the rest is combusted.)
6. **Chemical dispersants:** increase dispersability of oil, remove it from the water surface and scatter the oil in the water column. Instead of floating on the surface, the oil moves in three dimensions as a "fog" in the top 1-3 m of the water. May help birds and sea otters and reduce shoreline impact, but what about fish? The dispersed oil may affect plankton or larval fish over the short term, but does not appear to affect adult fish because the oil is quickly diluted to low concentrations.
   a. Early types did more harm than good: toxic
   b. Now many are water based rather than solvent based, making them less toxic.

When the oil reaches the shoreline, many other methods may be employed, among them are:

7. **Manual pick up:** The most common method of dealing with oil on the shoreline employs hand collection of oil, usually with absorbent materials.
8. **High pressure flushing:** May result in increased penetration of oil into sediments. The *Exxon Valdez* experience has shown that low pressure flushing would have been less damaging to organisms. Low pressure washing, however, may not work on very thick oil.
9. **Mechanized equipment:** Earth movers expose shoreline to erosion, affect organisms and habitat.

   To date, most techniques have been only marginally successful. The mixed oil and water that is removed presents a disposal problem. One technique that holds promise for having few inherent environmental dangers involves the use of bacteria.

10. **Bioremediation:** Oil-eating bacteria are naturally occurring micro-organisms which break down the oil into harmless compounds. There are about 40 different types of bacteria and fungi that metabolize oil. It is a very slow process, however, and the conditions must be favorable for the growth of the bacteria. Growth of bacteria is affected by temperature, availability of small droplets of oil, (microbes work around the outside

edges of an oil slick, so small droplets rather than a large pool of oil allows them to work faster by increasing the "edges" or surface area available to them) and the presence of nitrogen and phosphorus as nutrients for the bacteria.

Research in using microorganisms to clean up oil is relatively recent, but continues to bring promise. Bioremediation has been used successfully for some time on land-based oil spills around oil rigs and on contaminated soil from leaking underground storage tanks at gas stations. On land, the temperature and nutrient levels can be better controlled to encourage micro-organism growth. Bioremediation tests on the *Exxon Valdez* spill have been inconclusive. It appears that on the beach, a thin coating of oil disappeared faster when nutrients favorable to oil-eating bacteria were applied. It took several weeks for noticeable change to occur. So far attempts to encourage microbe growth in open water situations have not worked as well.

Students may be interested in comparing the 1989 Valdez, Alaska, spill to some of the following famous petroleum accidents. The grounding of the tanker, *Exxon Valdez***,** released 10.5 million gallons (250,000 barrels) of crude oil into the fragile waters of Prince William Sound. (This represents one fifth of its total cargo of 55 million gallons of

North Slope crude.) It is often difficult to compare spills because a variety of units are used to report their magnitude: gallons, barrels (abbreviated "bbl." and equivalent to 42 gallons), tons (this changes with the viscosity of the oil).

Torrey Canyon: March 1967, English Channel. About 860,000 bbl. of crude oil spilled and fouled over 135 miles of the French coast.

Argo Merchant: December, 1976, Nantucket Island, U.S.A. 183,000 bbl. spill may have caused damage to the plankton in the Georges Bank (debate on this point continues).

Santa Barbara Blowout: January 1979, California. Some 100,000 bbl. of crude oil were released, over 40 miles of California coastline was covered by oil.

Ixtoc I: June, 1979, Yucatan Coast and Texas beaches. From 2,450,000 to 3,500,000 bbl. of oil spilled over an eight month period from a blowout on this exploratory well in the Bay of Campeche.

Materials

For each group students:

Day One

- non-flammable container (aluminum pie plates work well and are reusable)
- used motor oil*
- 2 eyedroppers for the oil and detergent (or oil and detergent in separate dropper bottles)
- sand
- cotton balls
- straw or hay
- small pieces of Styrofoam, cardboard, nylon stockings
- plastic spoon
- designated "dump" for oily material (milk cartons work well)

Day Two

- non-flammable container
- used motor oil*
- detergent, concentrated liquid
- water
- disposable syringe (to measure one milliliter)
- graduated cylinder (50 ml)
- 2 test tubes (50 ml) and rubber stoppers that fit
- test tube rack
- labels or grease pencil
- alcohol burner
- wood splints
- safety goggles

Note: Used motor oil may contain certain hazardous materials. Students should use care in handling, avoiding contact with skin and immediately wiping up spills.

Teaching Hints

"The Black Tide" is a simulation activity which gives your students an opportunity to investigate some of the problems relating to oil spill removal. The activities are straight forward and provide an insight into the sticky mess that is an oil spill.

Since the likelihood of oil spills is increasing because of the aging of the tanker fleet, and since the technology of the field is changing rapidly, supplementary reports by students can help to keep these materials current. The United States Coast Guard Marine Safety Office nearest you is an excellent source of current information and samples of absorbent materials that are used in oil cleanup.

Preparation:

Duplicate the student worksheets (one set per student or group). Collect the required materials for each group and set out materials for easy access.

You may wish to encourage students to bring materials from home that they think would remove oil from their "oceans". If sand or dirt is used as a sinking agent, emphasize the fact that because of the damage it does to bottom dwellers, it is prohibited in U.S. waters as a cleanup method.

Procedure:

1. Read through the investigations prior to class and anticipate any problems your class might have. This is an interesting and timely activity. Have fun.

2. Distribute the student worksheets. This activity is best performed in small groups. If equipment limitations are a problem, have groups begin at different points in the activity.

   Have students gather the necessary materials to complete the activity and proceed on their own, following the stepwise procedures in the student pages and recording their observations. Circulate through the lab as the investigations are performed. Be available to answer questions and spot difficulties.

   Caution your students to immediately wipe up any spills. If you provide crankcase oil for students in this experiment, remind them that this used oil also contains other hazardous substances. These substances are mixed with the oil as it is used in the engine and are a by-product of internal combustion.

3. On day two, the burning of oil poses some problems. Be sure your students use the amount of oil stated and that they wear protective goggles at all times while trying to ignite the oil slick. The chances of the oil igniting are very small, because oil must be several inches thick to burn. Refresh your class and yourself with fire extinguisher locations. The risks are minimal but advance planning always pays off.

   Ask the class about the three things needed for burning: Oxygen (in the air), Fuel (the oil), and Heat (burning splint). Ask for their ideas concerning why the oil does not burn. In this case there is not enough heat applied to ignite the oil. To overcome this problem, the Coast Guard sometimes uses

napalm (a gelatinous, highly volatile form of gasoline) to create a fire which produces enough heat to ignite polar oil spills. If the oil in polar regions is not removed quickly, it becomes encapsulated in the icebergs and reappears again as the ice melts in the spring.

4. When students have completed the activities, allow time for a class discussion. You may choose to ask for a class vote on which material was most effective in cleaning up oil. If so, list the materials provided on the chalkboard and record the votes by each item. "The class has decided that ( ) is the most effective cleanup material. Let's suppose that the *Exxon Valdez* spill was cleaned up with ( ). You now have 8 million tons of oily ( ). Where do we put it?" Discuss possible disposal options for oily materials. Lead the class to see that there is no good answer: burying contaminates the water system, burning pollutes the air. Just because the oil is removed from the water does not get rid of the problem of disposal.

5. Cleanup: When it is time for cleanup, set a good example in the way that you handle wastes from this activity. Have students absorb as much oil from their ocean as they possibly can. Dispose of the oily materials in the milk cartons, well sealed.

   This is a fitting time to discuss the fact that consumer related activities and run-off are a major source of oil pollution in the marine environment. The equivalent of the *Exxon Valdez* oil spill (11 million gallons) is disposed of each year into sewage systems.! Discuss the proper disposal of used oil after the oil is changed in a car. **Used oil should never be dumped on the ground** or on a gravel driveway. Rain water carries oil disposed of in this fashion as run-off into a stream, lake or salt water bay. **Used motor oil should never be dumped in a storm sewer drain.** This oil eventually ends up in water supply systems, streams, lakes or bodies of salt water. When oil is disposed of in landfills, surface water can carry oil from the disposal site into nearby streams or rivers or into the ground water. Just one quart of oil can contaminate up to 2 million gallons of drinking water.

   Used oil is recyclable. The only proper method of disposal is to return the used oil to a service station recycling center or collection depot so that it can be re-refined into motor lubricant again or used as fuel. Encourage your students to identify locations in your area that will take used oil to recycle. In Washington State, the recycle hotline number is 1-800-RECYCLE.

   As part of the follow-up and clean-up activities, you may want to demonstrate Coast Guard absorbent material. This is the most effective way to pick up oil. Cut the material into small pieces and have students use them at the end. Absorbents pick up the oil and not the water because of the material's affinity for oil and not for water.

Key Words

absorption - the process of taking in, soaking up; in this case, the uptake of oil by a given material

booms - a barrier composed of floats, a skirt and an anchoring system; used to enclose floating oil, divert oil, or protect an area

by-products - something produced in the making of something else; side effect

containment - to hold within, enclose

density - mass per unit volume

dispersant - a chemical which causes oil to distribute widely

emulsify - to make or form an emulsion

emulsion - a colloidal suspension of one liquid in another liquid (particles in a colloid do not settle out over time)

model - a simplified representation of a system or phenomenon with any hypotheses required to describe the system or explain the phenomenon, often mathematically

simulation - activity that imitates a real life situation

viscous - having the property of viscosity (degree of resistance to flow in liquids); sticky, thick, adhesive

Extensions

1. Contact your local town or city administration office to obtain information about how the problems of urban run-off, and waste oil products are handled.

Answer Key

Text questions

1. Realize that some students may have little familiarity with this concept. The three ways of removing oil from the surface of the ocean listed might include any of the following:
    a. burning
    b. suction
    c. sinking
    d. skimming
    e. soaking it up (absorption)
    f. detergents
    g. bacteria
    h. others suggested by your students

2. a.-b. The correct answers are shown below:

physical coating Birds, mammals and intertidal animals are often smothered by crude oils.

physical coating Animals coated with oil lose the insulation provided by their feathers and often die by hypothermia.

chemical toxicity Animals that preen their feathers or fur can swallow enough oil to suffer direct toxic effects.

3 a. If only one in 10 oiled birds was found, 5,200 (520 x 10) birds actually died in the 3.66 miles of beach surveyed.

b. If the same rate of mortality is applied to 200 miles of beach, 284,153 birds died, i.e.:

$$\frac{\text{5200 birds}}{\text{3.66 miles of beach}} = \frac{\text{x birds}}{\text{200 miles of beach}}$$

c. Predators who feed on oil soaked birds ingest toxic oil compounds and face illness and/or death depending upon the quantities eaten.

4. Sea otters are especially harmed when physically coated with crude oil because the oil mats the fur, reducing its insulating properties, often leading to hypothermia.

5. Aside from direct economic impacts, humans are affected by the degradation of the aesthetic environment, by the diminution of species and resulting decrease of stability of the ecosystem, and by health problems associated with direct contact with the oil or by ingestion of fish and other products contaminated by the oil.

Technique I - Absorption

Analysis and Interpretation

a. Answers will vary depending on materials available.

b. Answers will vary depending on experimental results. Often, the nylon stocking works best to absorb the oil.

c. While answers will vary depending on experimental results, usually some oil remains even with the best material.

d. Absorbents remove the oil pollution problem from the water and place it on the land.

e. Answers will vary. Discuss the problems with each of the techniques (e.g., burning, burying, etc.)

f. 1. $\frac{\text{100 pounds}}{\text{bale}} \times \frac{\text{25 pounds of oil}}{\text{1 pound of straw}} \times \text{40,000 bales} = \text{100,000,000 lbs. of oil}$

2. $\frac{\text{100,000,000 pounds of oil}}{\text{7 pounds per gallon}} = \text{14,285,714 gallons of oil}$

The point of these manipulations is to show the vast amounts of oil we are dealing with.

Technique II - Sinking

Analysis and Interpretation

a. Answers will vary depending upon available materials.

b. Answers will vary depending upon observations and the degree of care exercised in performing the investigation. Most will probably say yes, that most or all of the oil was removed from the surface.

c. The major environmental effect of sinking the oil will be oil pollution of the ocean bottom. Sinking the oil just puts the problem out of sight. ("Out of sight, out of mind?")

d. This question asks for an opinion. The evidence presented indicates that sinking is not a good method for cleaning up the pollution caused by oil spills. The burden is just placed on a different group of organisms. We now know that the effect of oil on bottom dwelling plants and animals can be devastating. This information prompted a prohibition of this technique in U.S. waters.

e. Answers will vary. The submerged oil might reduce sunlight and therefore photosynthesis. It might move in subsurface currents to shelf areas and end up on the bottom anyway, etc. The point should be made that this technique is not a solution, the spill is not gone, we just cannot see it doing its damage.

f. The bottom dwelling (benthic) animals and plants are most likely to be affected by the sunken oil spill.

Technique III - Chemical Dispersants

Analysis and Interpretation

a. The immediate effect is that the oil breaks up (is emulsified) by the detergent.

b. Answers depend upon the experimental results. The emulsified oil may separate if the detergent is weak, or it may remain emulsified. The control will remain non-dispersed.

c. A good dispersant should not harm living organisms, act at a wide range of temperatures and in a variety of conditions. It should also be easy to use, readily available and inexpensive. Any one of these criteria will suffice for the answer, all of them will provide a springboard for discussion.

Technique IV - Burning

Analysis and Interpretation

a. Answers will vary depending upon experimental results. Most will have difficulty in igniting the oil. Light weight oils are easier to ignite. As a result, spills of light weight oil are sometimes burned. Spills are also often burned in polar regions. To overcome the ignition problem, the Coast Guard sometimes uses napalm (a gelatinous, highly volatile form of gasoline) to create a fire which produces enough heat to ignite polar oil spills.

b. Air pollution will occur if the oil is burned. Hence, the problems that burning oil might cause are the same as those caused by air pollution (respiratory problems, photo-chemical smog, deterioration of air quality, etc.). It may be worth noting that an oil spill burn usually only lasts 1-2 hours and, as such, is not an on-going source of pollution. Oil burns with a greater chance of producing photo-chemical smog or deterioration of air quality for any period of time result from uncontrolled burns from accidents such as the Kuwait fires or tanker fires.

c. This question calls for an opinion. Burning puts about 10% of the oil into the atmosphere as various compounds and 88% into the atmosphere as the products of combustion (largely CO_2 and H_20). The remaining 1-2% is left as residue. While burning is not a 100% effective method for the removal of oil, there is evidence enough to argue that it is the best alternative in certain situations.

d. One possible situation in which burning might be chosen would be an oil spill close to shore that could not be contained and removed before it caused damage. A second might be a highly volatile and toxic spill. Your students may recognize or create other situations. For example, in Arctic waters where there are icebergs, the Coast Guard BURNS the oil. If the oil in polar regions is not removed quickly, it becomes encapsulated in the icebergs and reappears again as the ice melts in the spring. The importance of this question lies in other discussions regarding the trade-offs inherent in the use of any of the methods discussed.

Technique V - Evaporation

Analysis and Interpretation

a. Answers depend upon the experimental observations.
b. Simulation of weather factors, chemical factors, (salinity, pH, etc.) and sunlight would make the model more realistic.

Technique VI - Microbial Degradation

Analysis and Interpretation

a. Three factors which influence the rate of degradation may be selected from:
   1. type of shoreline or sediment
   2. available nutrients
   3. temperature
   4. pressure at different depths
   5. availability of small droplets of oil

b. As the surface area increases, the rate at which the oil is degraded would be expected to increase if all other factors remained constant.

An Overview . . .

a. While the answers will vary, most students will probably say the absorption technique had the least harmful effects on the aquatic environment.

b. Oil reaching the shoreline coats beach substrates killing beach organisms. The first few hours the oil is on the beach are critical because the wave action forces the oil into the sands and the deeper it goes, the less likely it is to be removed or removable. As a result, plants and animals beneath the surface do not escape the problems caused by an oil spill on the surface because the oil migrates downward through the sand.

c. Beach cleaning takes several forms, all damaging to the beach ecosystem. Sand beaches are scraped and the oily sand carried off to become a toxic landfill product. Although detergents cause oil to penetrate deeper into the sand, they are sometimes used to clean beaches. Steam cleaning of rocks and gravels is also a technique which has been used. Beach cleaning techniques emphasize the importance of at-sea containment and cleanup.

d. The living organism can use the oil for food, and break down the complex oil molecules into simpler molecules that can be used by and/or are not toxic to other animals and plants. The advantage is that the oil is chemically changed into non-harmful products and not just physically moved.

e. The answers should be obvious but they should also provide an opportunity for a summary discussion of the work to this point.

f. There are many questions we should ask before we use any new product to combat oil spills, including:
   1. What is the effect of the product on the animals and plants?

2. Does the product turn the oil into an even more toxic waste?

3. What is the chemistry of interactions between the product and the chemicals found in the marine environment?

Your students will have many more ideas. Make the point by way of summary that we need to know as much as we can about a product before we begin widespread use in the environment (whether that environment is aquatic or terrestrial).

This activity is adapted from “The Oil Spill Problem” produced by Project COAST, University of Delaware.

The Black Tide

The coastal waters of the United States are heavily traveled. With major oil refineries located along the coastline, oil tanker traffic is common. Half of all the oil used in the U.S. moves by tanker. In spite of great efforts made to prevent oil spills, accidents do happen. The disasters we thought could never happen, have happened. The night of March 24, 1989, saw the tanker, *Exxon Valdez,* run aground in Prince William Sound. Over 10.5 million gallons of Prudhoe Bay crude oil spilled from a long gash in the hull. Currents and wind carried the oil over an area the size of Delaware. The 10.5 million gallons spilled from the *Exxon Valdez* represented only about 1/6 of the oil aboard the tanker. Even so, the accident has been labeled the nation's worst oil spill.

1. Everyone concerned with the spill wanted to remove the oil. Think of three ways in which oil might be removed from the surface of the ocean. List them below:

a.

b.

c.

Previous oil spills have demonstrated the disastrous effects of oil on marine life. The oil spill in Alaska's Prince William Sound released a large amount of oil into a particularly fragile environment. Alaska crude oil is a mixture of lightweight toxic chemicals and thick tars.

2. Crude oil can kill by physically coating animals with thick tars and by chemical toxicity. The following statements show some of the impacts of oil on animals:

a. Write "physical coating" in front of the following statements which are related to damage from physical coating.

b. Write "chemical toxicity" in front of the following statements which are related to damage from chemical toxicity of the spill .

_____Birds, mammals and intertidal animals are often smothered by crude oils.

_____Animals coated with oil lose the insulation provided by their feathers and often die by hypothermia.

_____Animals that preen their feathers or fur can swallow enough oil to suffer direct toxic effects.

The devastating impacts to fish and wildlife appeared immediately. Eight days after the spill, Alaska Fish and Game personnel identified 520 oiled birds on less than four miles of beach. These birds represented 20 of the 30 species found in the Sound. Most of the birds killed are never found. They sink and are carried away, or scavenged upon by predatory.

3 a. Biologists believed that they were only finding one in 10 oiled birds. If this was, in fact, the case, how many birds actually died in the 3.66 miles of beach surveyed?

b. By the eighth day, the spill had covered much more beach than that surveyed. If the spill had affected 200 miles of shoreline, how many birds may have been killed?

c. What is the likely impact of eating oil soaked birds on predators?

Alaskan sea otters initially appeared to be the marine mammal species most affected by the spill. Otters rely on the insulating properties of fur to maintain body temperature. The oil mats the fur and animals quickly suffer hypothermia. Hypothermia, which can be fatal, is the lowering of body temperature due to loss of body heat. Approximately half of the 100 sea otters the recovery center had received within the first week died. At that point, Alaska Fish and Game estimated 2,000 otters were at risk from the spill.

4. Why are sea otters especially harmed when physically coated with crude oil?

Humans are not immune to the damage caused by a major oil spill. The environmental impacts of the Alaska spill are coupled with the economic impacts. Fishing in Prince William Sound provides a livelihood for many people. The anticipated loss of income to individual fishermen and people dependent on the fishing industry was estimated at $112 million for the 1989 season alone. An additional $60 million in tourism was jeopardized. Clearly the effects of a major oil spill are devastating.

5. Economic impacts are not the only impacts of the oil spill on humans. What is one impact that affects humans but cannot be measured in dollars and cents?

The behavior of oil spilled at sea depends on many factors:

- the type of the oil
- the weather
- the action of the sea.

All of these factors alter the methods for removing the oil.

How can we deal with oil spills? Standard operating procedures for dealing with oil spills involves first, stopping the source of the spill. The oil is next contained. Finally, the oil is removed from the contained area. In the following activity, you will have a chance to investigate some of the techniques used to clean up oil spills.

DAY ONE

Materials

- non-flammable container
- used motor oil
- plastic spoon
- sand
- straw
- cotton balls
- pieces of Styrofoam, cardboard, nylon stockings
- designated “dump” for oily materials
- water

Technique I - Absorption

You are probably most familiar with this method of oil removal. Absorbents are designed to absorb the oil but not water. Straw has been estimated to absorb from 5-40 times its weight in oil. While it is possible to absorb fresh oil with straw or hay, it is very inefficient when compared with synthetic absorbents. As the oil in a spill “ages” and becomes more viscous, straw, hay and similar materials become virtually ineffective. Most currently used absorbents are synthetic.

Procedure:

1. To create an oil spill, follow these directions:
   a. Add water to the non-flammable container until the water level is within about one inch from the top. This represents your mini-ocean.
   b. Add 5-7 drops of oil to the surface of the water, simulating an oil spill.
2. Examine the supply of materials to determine which may absorb the oil from the water. Try each.
3. Dispose of the oily absorbents in the designated dump.

Analysis and Interpretation

a. List the materials you tried as absorbents:

b. Which of these materials seemed to absorb the most oil but not the water?

c. Was all the oil cleaned up with the “best“ material?

d. What problem or issue does the use of absorbents raise?

e. How would you dispose of the absorbents?

f. 1. Straw has been estimated to absorb from 5-40 times its weight in oil. After a serious tanker crash in San Francisco Bay in January, 1971, the Standard Oil Company of California quickly had 40,000 bales of straw available for use by cleanup crews. If we assume that the average 100 pound bale could absorb 25 times its weight in oil, how many pounds of oil were absorbed by the available straw? Please show your work .

2. If a gallon of the spilled oil weighed 7 pounds, how many gallons of spilled oil were absorbed by the straw?

Technique II - Sinking

A very simple method of oil removal is to simply make it sink to the bottom. How might this be done? Sinking the oil can be brought about by increasing the density of the oil above that of water.

NOTE: This technique is prohibited in U.S. waters.

Procedure:

1. Create an oil spill in the container.

2. Examine your supply of materials to determine which will make the oil sink when added to the surface of the slick. Try it.

Analysis and Interpretation

a. Which material(s) did you use to sink the oil?

b. Does this method remove all (or most) of the oil from the surface?

c. When this method is utilized, what effects will it have on the marine environment?

d. Explain why you think this method is prohibited in U.S. waters.

e. An alternative to complete sinking of the oil is to partially sink it; that is, sink it to a level of 5-6 meters below the surface. What good will this do? Will it remedy the problem?

f. What group of animals and plants is most likely to be affected by the oil spill if the oil is sunk?

DAY TWO

Materials

- non-flammable container
- used motor oil
- detergent, concentrated liquid
- water
- disposable syringe (to measure one milliliter)
- graduated cylinder (50 ml)
- 2 test tubes (50 ml) and rubber stoppers that fit
- test tube rack
- labels or grease pencil
- alcohol burner
- wood splints
- safety goggles

Technique III - Chemical Dispersants

Dispersants cause the oil to become dispersed throughout the water in the form of tiny droplets. The resulting solution is called an emulsion. Detergents were used to emulsify a massive oil spill near Santa Barbara, California. Researchers noted that "the milky white fluid (caused) a scene of progressive devastation and within a few days virtually nothing remained save for tufts of dead and dying algae". The early dispersants did more harm than good. New, less damaging dispersants are now available. You may have seen people use detergents to disperse small oil spills, created by their boats. What happens?

Procedure:

1. Obtain two test tubes, rubber stoppers, and a test tube rack. Label one test tube as the control and the other as the experimental.

2. Fill each test tube with 50 ml of tap water.

3. Add one ml of oil to each of the two tubes.

4. To your experimental tube, add one ml of detergent.

5. Agitate each tube and place in the test tube rack.

6. Observe each tube immediately after agitation and RECORD your observations of their appearance in the space below.

Control:

Experimental:

7. Allow the tubes to stand overnight and then observe them again. RECORD your observations of their appearance in the space below.

Control:

Experimental:

Analysis and Interpretation

a. What was the immediate effect of the detergent on the oil?

b. Did your observations of the second day differ from those of the first day? If so, in what specific ways did the test tubes change from day one to day two?

c. What is one criterion you would expect of a good dispersant?

Technique IV - Burning

Although technological strides have been made in the area of oil spill removal and cleanup, many rather simple and non-technical methods of cleanup are still used. Perhaps one of the most obvious methods of removal is by burning the oil.

Procedure:

1. Add water to the container until the water level is within one or two inches of the top. Do not be concerned with the submerged oil left in the container from Technique II.

2. Add oil to the surface of the water, simulating an oil spill.

3. Ignite a wood splint with the alcohol burner.

4. Use the burning wood splint to ignite the oil slick.

5. RECORD the length of time the oil burns.

Analysis and Interpretation

a. Were you able to ignite the oil? If so, how long did it burn and was there oil left when the flame went out? If not, explain what happened when you tried to ignite the oil.

b. What other type of pollution will probably occur if burning the oil is used as a method of oil spill removal?

c. Do you think that the burning of oil is an effective method for the removal of oil? Please explain your answer.

d. Identify a situation in which you might choose burning as a method of oil spill removal.

Technique V - Evaporation

Some oil spills are never contained, treated, or cleaned up. What happens to the oil from these spills?

Procedure:

1. Obtain a container of water and create an oil spill. Record your observations in the space below.

Oil:

Water:

2. Let the container sit for a week or longer.

NOTE: Water may have to be added from time to time to prevent complete drying.

3. RECORD your observations after the week or longer period.

Oil:

Water:

Analysis and Interpretation

a. Most of the acutely toxic compounds are removed from crude oil in a matter of hours or days by evaporation, or by mixing into the water. Within one to three weeks, most of the components of the oil capable of evaporating, or dissolving into the water, will have done so. However, some toxic compounds persist at very low levels for many months in the thicker accumulations of oil at sea and along the shoreline. How does the character of the oil change with time?

b. This experimental setup is a model of the real world. To make the setup a more realistic model of the world, what other factors should we add?

Technique VI - Microbial Degradation

All of the techniques explored so far have shortcomings. One technique that holds promise for having few inherent environmental dangers involves the use of oil-eating bacteria. Certain species of bacteria occur naturally in the marine environment breaking down oil into harmless compounds. This process is called “microbial degradation”. The breakdown is a very slow process, however. The rate of degradation is strongly dependent on the type of shoreline or sediment and is often limited by available nutrients and/or oxygen, as well as temperature.

To speed up the natural microbial degradation process, low concentrations of nutrients like nitrogen and phosphorus may be added to the water. This increases the growth rate and reproduction of "degraders", thereby enhancing the bio-degradation of the oil.

a. What are three factors which influence the rate of degradation:

1.

2.

3.

On the water surface, NOAA wave tank studies showed that subarctic marine bacteria are capable of degrading the outside of tar balls over a 4-18 month period. As the surface erodes, the tar balls are gradually worn down and broken into smaller and smaller pieces. The process is repeated until the tar ball is totally consumed over a period of several years.

b. Bacteria act on the surface of the oil ball. As the large ball breaks into smaller balls, the surface area increases. What is likely to happen to the rate at which the oil is degraded?

An Overview . . .

a. Of the techniques you tried, which technique removed the oil spill from the water with the least damage to the aquatic environment? Please explain your choice.

b. Uncontained oil can become beached. Discuss the effects of oil reaching the shoreline.

c. How are beaches cleaned?

d. General Electric Corporation has developed and patented a bacterium (yes, a living organism was developed and patented) which is said to eat oil. What advantages do you think this technique might have over those mentioned before?

e. How do you think the old expression, “an ounce of prevention is worth a pound of cure”, could be applied to oil spills?

f. Before we use any new product to combat oil spills, what are two of the many questions we need to ask (and have answered)?

1.

2.