Alternative Countermeasures For Oil Spills 3

INTRODUCTION

SEVERAL METHODS exist for containing and cleaning up oil spills in aquatic environments. Chapter two describes how mechanical equipment, such as *booms* and *skimmers*, is used to block the spread of oil, concentrate it into one area, and remove it from the water. Chemical and biological treatment of oil can be used in place of mechanical methods, especially in areas where untreated oil may reach shorelines and sensitive habitats where a cleanup becomes difficult and environmentally damaging. This chapter describes some of the chemical and biological methods that are used by response personnel to contain and clean up oil spills in aquatic environments. Alternative treatment typically involves adding chemical or biological agents to spilled oil and also includes in-situ burning.

Helicopters are often used to apply dispersants to large areas.

TYPES OF SUBSTANCES USED

TWO TYPES of substances commonly used in responding to an oil spill are (1) *dispersing agents* and (2) *biological agents*.

Dispersing Agents

Dispersing agents, also called *dispersants*, are chemicals that contain *surfactants*, or compounds that act to break liquid substances such as oil into small droplets. In an oil spill, these droplets disperse into the *water column*, where they are subjected to natural processes—such as wind, waves, and currents—that help to break them down further. This helps to clear oil from the water surface, making it less likely that the oil slick will reach the shoreline.

The effectiveness of a dispersant is determined by the composition of the oil it is being used to treat and the method and rate at which the dispersant is applied. Heavy crude oils do not disperse as well as light- to medium-weight oils. Dispersants are most effective when applied immediately following a spill, before the lightest components in the oil have evaporated.

Environmental factors, including water salinity and temperature, and conditions at sea influence the effectiveness of dispersants. Studies have shown that many dispersants work best at salinity levels close to that of normal seawater. While dispersants can work in cold water, they work best in warm water.

Some countries rely almost exclusively on dispersants to combat oil spills because frequently rough or choppy conditions at sea make mechanical containment and cleanup difficult. However, dispersants have not been used extensively in the United States because of difficulties with application, disagreement among scientists about their effectiveness, and concerns about the toxicity of the dispersed mixtures. Dispersants used today are much less toxic than those used in the past, but few long-term environmental effects tests have been conducted after a dispersant application. The EPA encourages the monitoring of areas that may see increased dispersant use.

These problems are being overcome, however. New technologies that improve the application of dispersants are being designed. The effectiveness of dispersants is being tested in laboratories and in actual spill situations, and the information collected is being used to help design more effective dispersants. In addition, the EPA maintains an authorized list of chemical and biological agents for use on oil spills.

Biological Agents

Biological agents are nutrients, enzymes, or *microorganisms* that increase the rate at which natural *biodegradation* occurs. Biodegradation is a process by which microorganisms such as bacteria, fungi, and yeasts break down complex compounds into simpler products to obtain energy and nutrients.

Biodegradation of oil is a natural process that slowly—over the course of weeks, months, or years—removes oil from the environment. However, rapid removal of spilled oil from shorelines and wetlands may be necessary in order to minimize potential environmental damage to these sensitive habitats.

Bioremediation technologies can help biodegradation processes work faster. Bioremediation refers to the act of adding materials to the environment, such as fertilizers or microorganisms, that will increase the rate at which natural biodegradation occurs. Furthermore, bioremediation is often used after all mechanical oil recovery methods have been used. Two bioremediation approaches have been used in the United States for oil spill cleanups—*biostimulation* and *bioaugmentation*.

Biostimulation is the method of adding nutrients such as phosphorus and nitrogen to a contaminated environment to stimulate the growth of the microorganisms that break down oil. Limited supplies of these necessary nutrients usually control the growth of native microorganism populations. When nutrients are added, the native microorganism population can grow rapidly, potentially increasing the rate of biodegradation.

Bioaugmentation is the addition of microorganisms to the existing native oil-degrading population. Sometimes species of bacteria that do not naturally exist in an area will be added to the native population. As with nutrient addition, the purpose of *seeding* is to increase the population of microorganisms that can biodegrade the spilled oil. This process is seldom needed, however, because *hydrocarbon*-degrading bacterial exist almost everywhere and non-indigenous species are often unable to compete successfully with native microorganisms.

During the *Exxon Valdez* oil spill cleanup and restoration activities, the Alaska Regional Response Team authorized the use of bioremediation products, including biostimulation and bioaugmentation. Nutrient addition use was approved for approximately 100 miles of the Prince William Sound shoreline. Data collected through a monitoring protocol required by the State of Alaska indicated that nutrient addition accelerated the natural degradation of oil with no observed eutrophication or toxicity.

Proof of the effectiveness of bioremediation as an oil spill cleanup technology was developed on the shoreline of Delaware Bay in 1994. This EPA-funded study, which involved an intentional release of light crude oil onto small plots, demonstrated a several-fold increase in biodegradation rate due to the addition of fertilizer compared to the unfertilized control plots. Bioaugmentation or seeding with native microorganisms did not result in faster biodegradation.

IN-SITU BURNING

IN-SITU BURNING of oil involves the ignition and controlled combustion of oil. It can be used when oil is spilled on a water body or on land. The National Oil and Hazardous Substances Contingency Plan authorizes in-situ burning as a cleanup method but requires approval from the regional response team (RRT) before it can be used. RRT can provide approval through pre-authorization plans and agreements among the federal and state agencies. In-situ burning is typically used in conjunction with mechanical recovery on open water. Fire resistant booms are often used to collect and concentrate the oil into a slick that is thick enough to burn.

Many factors influence the decision to use in-situ burning on inland or coastal waters. Elements affecting the use of burning include water temperature, wind direction and speed, wave amplitude, slick thickness, oil type, and the amount of oil *weathering* and *emulsification* that have occurred. Weathering is a measure of the amount of oil already having escaped to the atmosphere through *evaporation*. Emulsification is the process of oil mixing with water. Oil layer thickness, weathering, and emulsification are usually dependent upon the time period between the actual spill and the start of burn operations. For many spills, there is only a short “window of opportunity” during which in-situ burning is a viable option.

General guidelines for the use of in-situ burning on a water body are as follows:

- Wind speeds of less than 23 mph,
- Waves less than 3 feet in height,
- Minimum slick thickness of 2-3 mm, depending upon oil type,
- Less than 30 percent evaporative loss, and
- Emulsification of less than 25 percent water content.

The major issues for in-situ burning of inland spills are proximity to human populations (burning must take place at least three miles away from population at risk), soil

type, water level, erosion potential, vegetation species and condition, and wildlife species presence. Burning may actually allow oil to penetrate further into some soils and shoreline sediments.

Because it releases pollutants into the air, in-situ burning requires careful air quality monitoring. Devices are pre-deployed near populations to measure particulate levels. If air quality standards are exceeded, the burn will be terminated.

Because in-situ burning uses intense heat sources, it poses additional danger to response personnel. Igniting an oil slick requires a device that can deliver an intense heat source to the oil.

Vessel-deployed ignition devices are soaked with a volatile compound, lit, and allowed to drift into an oil slick. During the *Exxon Valdez* cleanup effort, plastic bags filled with gelled gasoline were ignited and placed in the path of oil being towed in a containment fire-boom. Hand-held ignition systems can be thrown into oil slicks but require personnel to be in close proximity to the burning oil. A recently developed ignition device called the "Helitorch," delivers a falling stream of burning fuel from a helicopter, allowing personnel to maintain a safer distance from the burning slick and distribute ignition sources over a wider area.

Although it can be effective in some situations, in-situ burning is rarely used on marine spills because of widespread concern over atmospheric emissions and uncertainty about its impacts on human and environmental health. However, burning of inland spills is frequently used in a number of states. All burns produce significant amounts of particulate matter, dependent on the type of oil being burned. Burning oil delivers polycyclic aromatic hydrocarbons, volatile organic compounds, carbon dioxide, and carbon monoxide into the air in addition to other compounds at lower levels. In addition, when circumstances make it more difficult to ignite the oil, an *accelerant* such as gasoline may need to be added, possibly increasing the toxicity of the volatilizing particles. Lack of data regarding the environmental and human health effects of burning has also discouraged its use.

In-situ burning will be used more often as federal response agencies learn from its behavior and effects. As in the case of the *New Carissa*, a Japanese freighter that ran aground at the entrance to Coos Bay in Oregon on February 4, 1999, the conditions were favorable for burning. The ship was carrying approximately 360,000 gallons of bunker fuel. Early assessment of the vessel revealed that it was leaking fuel. In order to reduce the potential for oil to spill from the vessel during impending storms, responders ignited the grounded ship with incendiary devices in an attempt to burn the fuel in the cargo holds.

Despite its drawbacks, in-situ burning may be an efficient cleanup method under certain conditions where there are few negative effects on humans or the environment. These conditions include remote areas, areas with herbaceous or dormant vegetation, and water or land covered with snow or ice. In these circumstances, burning can quickly prevent the movement of oil to additional areas, eliminate the generation of oily wastes, provide a cleanup means for affected areas with limited access for mechanical or physical removal methods, or provide an additional level of cleanup when other methods become ineffective. When oil is spilled into water containing a layer or chunks of ice, burning can often remove much more oil than conventional means. Burning can also help to eliminate some volatile compounds that might otherwise evaporate off a slick.

In-situ burning can remove oil quickly.

Photo courtesy of MMS

Although limited, research and development for in-situ burning in the areas of training, fire-resistant booms, and ignition systems have increased in recent years. Investigation into inland environments and vegetative species that are more tolerant of burns is also yielding results which can aid responders. As data regarding the effects of burning oil on the environment and human population increase, consideration and use of in-situ burning may become more frequent when spills occur.

SUMMARY

CHEMICAL AND BIOLOGICAL methods can be used in conjunction with mechanical means for containing and cleaning up oil spills. Dispersants are most useful in helping to keep oil from reaching shorelines and other sensitive habitats. Biological agents have the potential to assist recovery in sensitive areas such as shorelines, marshes, and wetlands. In-situ burning has shown the potential to be an effective cleanup method under certain circumstances. Research into these technologies continues in the hope that future oil spills can be contained and cleaned up more efficiently and effectively.