Various Approaches To Clean Oil Spill – An Overview

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Abstract : An oil spill is due to the release of liquid petroleum hydrocarbon into the environment, especially the marine ecosystem, due to human activity, and to the environment. Oil spills can be caused due to the release of crude oil from tankers, offshore platforms, drilling rigs, wells, refined petroleum products among others. Oil spill is a problem that has confronted oil companies and Environmental Protection Agencies since the early 19th century. Oil spills can cause destruction to marine ecology, relocation and payment of compensation to affected communities.

***IndexTerms* - Oil spill, crude oil, marine ecosystem.**

1. INTRODUCTION

Oil spill is an environmental pollution. It is commonly referred to the marine oil spills in which crude oil, refined petroleum products, oil refuse or oil mixed in waste is released into the ocean waters. Oil floats on sea water and freshwater (rivers and lakes). Heavy oils can sink in freshwater very rarely. Oil spreads out across the water surface to form a thin layer called an oil slick. As the oil continues spreading, the layer becomes thinner and thinner, finally a very thin layer called a sheen, which looks like a rainbow. Oil spills can be very harmful to marine birds, mammals, fish and shellfish. Oil spill happens due to negligence, equipment failure and natural disasters. Oil spills occur throughout the world. There are inland and oceanic spills. Oil spills require quick action so that they cause as little damage as possible.

According to the Environmental Protection Agency (EPA), oil releases threaten public health and safety by contaminating drinking water, causing fire and explosion hazards, diminishing air and water quality, compromising agriculture, destroying recreational areas, wasting non-renewal resources and costing the economy millions of dollars.

The Deepwater Horizon oil spill in the Gulf of Mexico was a massive disruption to the entire ecosystem. It was estimated that 4.9 million barrels of oil flowed into the gulf over 87 days until British Petroleum capped the well head. The impacts were widespread and a full extent of the long term effects is still under study. To better understand the effects that an oil spill has on an ecosystem, a full knowledge is needed of the fate of the oil after it is released. There are several ways for the degradation and dispersion of aquatic released oil including dissolution, emulsification, absorption, mixing, evaporation, biodegradation, photo degradation, and chemical reactions [1, 2, 3, 4]. Contributions from dissolution were higher for the Deepwater Horizon oil spill than Gulf of Mexico oil spills due to the depth of the well head (1500 m) and the addition of chemical dispersants. Additionally, biodegradation and photo degradation have been shown to be two of the most significant degradation mechanisms in previous oil spills [5, 6]. Initial studies reported on biodegrading bacteria in water plumes from the Deepwater Horizon oil spill [7]. Biodegradation has been shown to be useful for the degradation of small molecules; however, it is slower in the nutrient deficient surface waters of the open Gulf of Mexico [8,9,10]. Furthermore, higher molecular weight alkanes and polycyclic aromatic hydrocarbons (PAH) are resistant to biodegradation as well as dissolution and evaporation. For these recalcitrant compounds, photochemical transformations become of extreme importance as an initial step in promoting bioavailability and further degradation.

2. METHODS OF CLEANING OIL SPILL

2.1 BOOMS AND SKIMMERS:

Booms are physical barriers to oil, it can be made of plastic, metal, or other floating materials, which slows and contains the spread of oil. Oil spill removing teams use booms using mooring systems, such as anchors and land lines. Booms will be commonly placed

- Across an entrance to the ocean, such as a stream outlet or inlet, to close that entrance so that oil cannot pass through into marshland and other sensitive habitats.
- The places where the boom can deflect oil from sensitive locations such as shellfish beds, beaches.
- Surrounding a sensitive site, to prevent oil from reaching it.

There are three main types of boom hard boom, sorbent boom and fire boom.

Hard boom is a floating piece of plastic that has a cylindrical float at the top and is weighted at the bottom so that it forms a "skirt" under the water. If the currents or winds are not too strong, booms can be used to make the oil go in a different direction which is called "deflection booming". Sorbent boom looks like a long sausage made out of materials that absorbs oil. Sorbent booms don't have the "skirt" that hard booms have, so they can't contain oil for long time. Fire boom looks like metal plates with a floating metal cylinder at the top. There are thin metal plates that make the "skirt" in the water. This boom can contain oil long enough that it can be lit on fire and burned up.

2.2 SKIMMERS

These are boats and other devices that remove oil from the sea along a coastline. Oil is skimmed from the sea surface by a ship or boat. Sometimes, two boats will tow a collection boom, allowing oil to concentrate within the boom, it is then picked up by a skimmer.

2.3 NATURAL DISPERSAL

Oil will be broken down naturally if it is left undisturbed. This is due to the action of the sunlight, weather and waves. If the oil spill happens close to coastal regions and does not threaten wildlife, the best corrective measure is to leave it. Oil always floats in salt water and mostly in fresh water. Lighter oils will normally disperse faster than heavier oils, however, the heaviest crude oil can sometimes sink in fresh water. When oil breaks down it will mix with water, along with other particles such as sand, to form tar balls. These are not seen as a threat to the environment.

2.4 DISPERSANTS

Dispersants are sprayed on the surface of oil slick to break down the oil into smaller droplets which are more readily mixed with the water. Dispersants do not reduce the amount of oil entering the environment, but push the effects of the spill underwater. A mixture of oil and water is normally unstable, but it can be stabilized with the use of surfactants; the surfactants will prevent combination of dispersed oil droplets. The effectiveness of the dispersant will depend on the weathering of the oil, waves, salinity of sea water, temperature and the type of oil. Dispersion cannot happen if the oil spreads into a thin layer, because the dispersant requires a specific thickness to work. More dispersant will be required if the waves are low. The salinity of the water is more important for ionic-surfactant dispersants, as salt screens electrostatic interactions between molecules. The viscosity of the oil is another factor; viscosity can retard dispersant migration to the oil/water interface and also increase the energy required to shear a drop from the slick. Viscosities below 2000 centipoise are ideal for dispersants. If the viscosity is more than 10,000 centipoise, dispersion is not possible. Dispersants are not appropriate for all oils and all locations. If the oil is dispersed through the water column it can affect marine organisms. It can also affect organisms that are important in the seafood industry.

2.5 BIOLOGICAL AGENTS:

It include two major types,

1) Surfactant clean up.
2) Biodegradation.

Oil that has washed up along a coast is broken down through a process called biodegradation. Biodegradation happens when bacteria and other micro-organisms break down the oil into harmless substances. Biodegradation process can be sped up by adding fertilizing nutrients like nitrogen and phosphorous, which boost the growth of micro-organisms. When a fertilizer is added to a contaminated area the following things to be checked are rate of release, washout effect and type of nutrients. Washout refers to tide that carries water out to sea and takes some nutrients along with it and type of nutrients.

2.6 CONTROLLED BURNS

The oil slick can also be set fire in a controlled manner which efficiently and rapidly reduces the volume of a threatening oil slick. However there may be concerns over atmospheric emissions.

The above mentioned techniques are not adequate in solving problem of massive oil spillage. Currently, research is ongoing on the possible application of nano-technologies in curbing the ill effects of oil spillage. Nanotechnology can be applied in oil spill remediation.

Various strategies for oil spill cleanup using nanomaterials and nanotechnologies include:

- Usage Of Nanodispersants
- Magnetic Nanocomposites
- Carbon Nanostructures
- Nanostructured Hydrophobic Organoclay
- Nano Metal Oxide Photocatalysis

Among these methods, metal oxide photocatalysis seems to be the most economical and effective in degrading oil spill due to availability of metal oxide nanoparticles and abundance of sunlight.

Photocatalysis is defined as the acceleration of a chemical reaction by catalyst in the presence of solar irradiation/light [11]. In principle when a ultra-violet light (photon) with wavelength less than 390nm and energy greater than the band gap is incident on a metal oxide, photon is absorbed and electrons in the edge of the valence band are excited into the bottom of the conduction band.

Electrons will be injected into the nanoparticles, breaking the exciton, or recombining with the hole. When the nanoparticles are dispersed in a solution, or exposed to a gas flow, the photon generation of exciton by catalyst gives rise to photo catalysis which is a redox reaction. The hole oxidizes the solvent, often water to form highly reactive hydroxyl free radicals (.OH-) capable of generating a chain reaction with crude oil.

Similarly, under aerobic condition, the electron at the interface is capable of reducing any available oxygen; generating super oxide radicals (.O2) which in turn are capable of reacting with water to generate more hydroxyl free radicals. A chain reaction may result in forming more ROS (singlet oxygen molecules, super oxide, peroxides and hydroxides). These free radicals have one or more unpaired electrons in their outer-most shell and are hence capable of initiating and sustaining more chain reactions.

Process	Name
$TiO_2 + h\upsilon \rightarrow h_{VB}^{+} + e_{CB}^{-}$	Charge Separation
$h_{VB}^{-} + H_2O \rightarrow OH^{\bullet}$	$OH^{\bullet}$ Generation (VB)
$e_{CB}^{-} + O_2 \rightarrow O_2^{\bullet -} + H_2O \rightarrow OH^{\bullet}$	$OH^{\bullet}$ Generation (CB)

Nanoparticles because of their large surface area-volume ratio (size effect) are reactive and generate reactive oxygen species (ROS) through enhanced catalysis under solar irradiation. The generation of free radicals could degrade crude oil mixture into less hazardous components mainly CO2 and H2O that can escape safely through evaporation.

2.7 Surface Effect

Properties of nanomaterials result from both surface and quantum effects. Whilst the former occurs as a result of large surface area -to -volume ratio, the latter is as a result of quantization of electron motion. Surface effect (effect of particle size reduction on the fraction and re-arrangement of surface atoms of materials) is important in achieving photocatalysis.

In order to improve efficiencies of photocatalysis, Ying Y. H. et al [12]for example, employed nitrogen-doped TiO2 nanotube (N-TNT) thin films under visible light radiation. It is believed that in addition to doping other strategies such as:

- Detection and identification of reactive radical species (.OH-, .O2-, and H2O2),
- Finding out optimal ROS concentration for effective degradation.
- Characterization of physicochemical properties of metal oxide nanoparticles for effective degradation.
- Characterization of intermediate products following crude oil spill degradation.
- Comparison of degradation potentials of sun irradiation and solar simulators.
- Scalability and cost.

3. Conclusion

This paper describes various approaches to control oil spill. Metal oxide photocatalysis is the most economical and effective in degrading oil spill due to availability of metal oxide nanoparticles and abundance of sunlight. Photocatalytic generation of ROS offers an excellent method for degrading massive oil spill. Metal oxide nanoparticles such as titanium dioxide and zinc oxide when subjected to solar irradiation generates ROS when coupled with high aspect ratio .Metal oxide nanoparticles catalytic effect can degrade crude oil components in water pollutants into fewer harmful CO2 and H2O compounds. Titanium dioxide nanoparticles have the prospective of providing a greener environment through its applications in oil spill degradation.

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