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COMPREHENSIVE REVIEW ON OIL SPILLAGE AND ITS VARIOUS REMEDIATION METHODS

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Abstract **:** Oil spills are of great concern, and spills at sea can be life threatening to marine flora and fauna. Natural oil spills can occur through petroleum seep, which occurs due to activity inside the earth causing the escape of liquid or gaseous hydrocarbons to the earth's surface. Very large spills farther from the shore can also have serious impacts since a longer stretch of coastline may be affected as the oil spreads out and, even with dilution, levels may remain high enough to have serious effects on aquatic and shoreline ecosystems .Oceans and seas contain a variety of habitats characterized by different communities of animals and plants. Physical characteristics such as temperature, salinity, substrata, depth, light intensity, and wave exposure determine the type of marine habitats and the animals and plants that are adapted to them. These varieties of ecosystems respond in a different way to the oil spill thus effecting their habitat and environment . This paper reviews the remediation of marine oil spills, focusing on the various ways oil and its derivatives contaminate and their effects on the marine ecosystem. The numerous remediation techniques for oil spills are the main topic of this review article . It focuses on diverse physical, chemical, and biological procedures as well as on current advances in oil spill remediation strategies.

Index Terms : : **Oil spillage, Petroleum, Remediation, Booms, Skimmers, Dispersant, Microbial Bioremediation.**

I INTRODUCTION :

Oil is a hydrocarbon-based substance that is increasing in demand due to industrialization. Oil spillage is a controversial aspect of oil exploration. It is spilled on land and can cause damage to the habitat, but when it is spilled into an aquatic environment, it can spoil organism. The greatest oil spill in American history occurred in the Gulf of Mexico in 2010 as a result of the Deepwater Horizon disaster. Aquatic environments adjust severity of an oil spill by natural activities such as emulsification, oxidation, weathering, evaporation, and biodegradation.

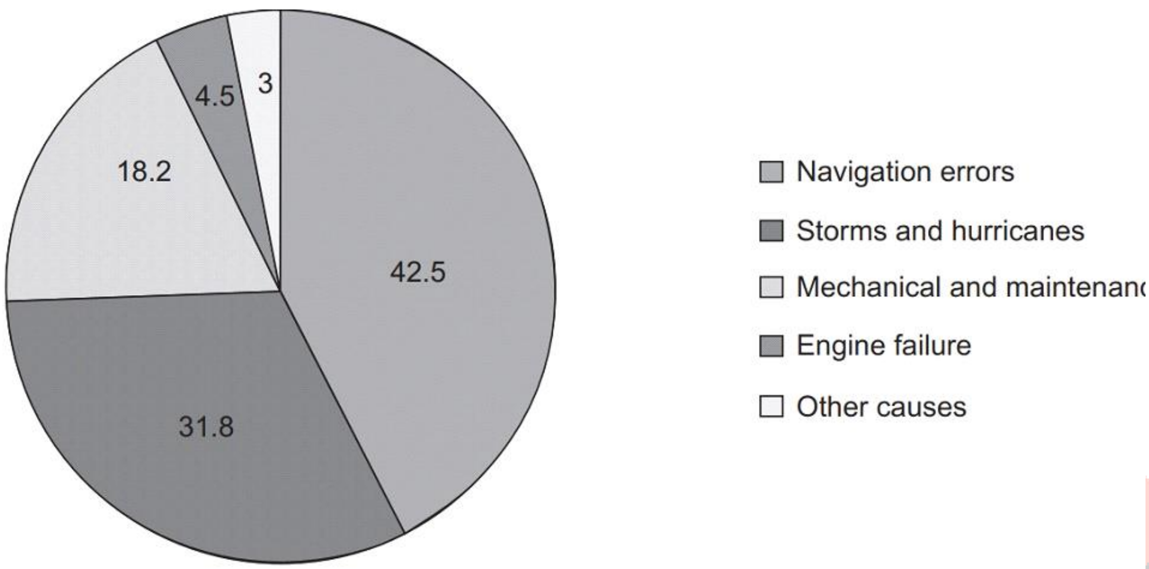
The oil spreads out rapidly on water surfaces to form a thin layer called an oil slick. As the oil continues spreading, the oil slick layer becomes thinner and thinner and finally becomes a very thin layer called a sheen, which often looks like a rainbow. In developed countries, many oil spill events are reported and prompt actions are taken to remedy the affected ecosystem. The effects are generally more catastrophic at sea than on land, since the spills can spread faster for hundreds of nautical miles and form a thin coating of oil on water bodies. Hence, marine oil spills, particularly large-scale spill accidents, have received greater attention. Thus, it is necessary to develop a number of strategies to combat environmental degradation brought on by oil spills.

II CAUSES OF OIL SPILLS :

Natural disasters like earthquakes, adverse weather conditions, and hurricanes are responsible for the dumping of crude oil and gas into the oceans.

Anthropogenic activities are the activities of man that cause oil. They could be caused by pipeline vandalism, terrorist attacks, deliberate oil spills during conflicts, and washing of tankers and other boats into the ocean. Other sources of oil spills include discharges from offshore drilling, technical issues with drilling equipment, tank clean-ups, and leaks from oil ships.

Fig 1 Causes (percentage) of oil spillage



III. IMPACT OF OIL SPILL ON ENVIRONMENT :

Oil comprises four major compounds such as saturated hydrocarbons, aromatic hydrocarbons, resins, and asphaltens. High percentages of polycyclic aromatic hydrocarbons (PAHs).The oil spill impacts the environment by causing physical changes, ecological changes, and chemical toxicity. Meteorization refers to physical-chemical reactions that occur between oil and sediment, air, and water.

The oil's toxicity, the loss in light transmission ,the drop in dissolved oxygen, suffocation, and harm to marine birds are the short-term effects .

Long-term consequences are linked to modifications in crucial biological processes such reproduction, recruitment, the loss of food, and habitat deterioration.

The bioaccumulation of the harmful components of the oil that moves the pollutant up the food chain. The most crucial thing is to protect the unaffected areas and remove more oil when it arrives in big amounts from the polluted areas.

3.1 Impact of oil spill on soil quality

Oil contamination affects the quality of soil (texture) and its fertility. the availability of carbon dioxide for a living organism’s respiration is depleted due to the coat formed on the soil surface by an oil spill . Crude oil contamination on soil distorts germination rates, degrades farmland, kills plants and small trees, permeates into groundwater, and harms aquatic life. Large areas of mangrove have been destroyed by oil spills. Oil can affect aquatic animals in many ways, including changing their reproductive and feeding behavior, and causing tainting and loss of habitat. Oil spill also affects aquatic food chains, ecosystem biodiversity, aquatic nursery grounds, and leads to poisoning of aquatic life.

3.2 Socioeconomic impact due to oil spill

oil spillage has socioeconomic impacts on the oil-producing communities. humans can be affected by oil spills in three major ways: oil can affect ecological processes that cause direct harm, e.g., health impacts from eating seafood with bioaccumulated oil toxins; oil spill stressors can change intermediary processes, e.g., economic impacts on fishers caused by oil spill damage to fisheries; and stressors can directly harm humans, e.g., health impacts from breathing oil vapors. It is therefore important to restore the ecosystem, ensure conservation, and protect human health.

3.3 Effect on tourism Industry

Generally, tourists come to beaches for sailing, swimming, rafting, fishing, parachute gliding, but when dead birds, sticky oil and huge tar balls are seen on beach make uncomforting for sailing, swimming, rafting, fishing, parachute gliding.

Oil spills are a major cause of marine pollution, and the removal of hydrocarbons from the marine environment is essential to prevent their effects on living organisms. The possible ways of oil spill removal are given below.

IV PHYSICAL REAMIDIATION METHODS :

4.1 Booms

Booms are stationary floating objects that are used to stop oil from spreading across the water's surface. Governments all over the world utilize them as a principal ocean response strategy to stop oil from spreading and to keep the oil at a sufficient thickness. They are made up of three components: wires, skirt, and free-board. Skirt and cables hold the boom's individual sections together while free-board floats above the water's surface and keeps oil from escaping.

They are divided into two categories: fence booms and curtain booms. Fence booms are made of hard or semi-rigid materials and resemble a floating fence They are abrasion-resistant, lightweight, require little storage space, and are simple to maintain and clean. They are employed to prevent the oil slick from reaching shorelines or biodiversity hotspots. This confined oil can now be cleaned up by the use of skimmers, sorbents, or can be subjected to any other remediation technique. They are effective at stopping oil spills, but only when the seas and environment are calm. They lack hauling flexibility and cannot handle severe winds or ocean currents.

Curtain booms are composed of circular foam-filled chambers that remain over the water surface and have a flexible skirt that remains submerged underwater. Curtain booms are constructed from polyurethane, polystyrene, and cork; however, they are only effective in calm atmospheric and oceanic conditions.

Three physical aspects—buoyancy, roll response, and heave response—are necessary for a boom to function and operate well. Roll response measures the amount of torque needed to spin the boom from its vertical position, whereas buoyancy aids in the boom's flotation on the water's surface. Booms' heave response determines how well they can withstand the vertical motion of water; poor heave response can cause an oil slick to spread.

4.2 Skimmers

Skimmers are devices used in combination with booms to recover oil from oil spills. They can be stationary or mobile, self-propelled, or operated from shores or vessels. The oil is selectively recovered using skimming and/or suction and is pumped into storage units onboard the vessels or at shorelines.

Skimmers are physical/mechanical devices that do not change the oil properties and can be reprocessed and put to use. Skimmers perform best when the oil slick is of considerable thickness, as the oil properties change continuously with time, requiring a selection of skimmers to treat a particular oil spill.

Skimmers are broadly divided into three categories. These categories are namely: (a) oleophilic skimmers (b) suction skimmers (c) weir skimmers .Oleophilic skimmers use oleophilic materials that have more preference for oil absorption than water .They are commonly shaped as disc, drum, belt, brush, and continuous mop chains. The oil is selectively adhered to the surface of these materials and cleaned away by scrapping or squeezing the material. Suction skimmers use vacuum pumps or air suction systems to suck oil directly from the surface of the water, which is pumped into sumps or storage tanks. Weir skimmers have a dam or an enclosure located at the interface of oil and water, where oil flows over the weir and is selectively recovered with a minimal amount of water entrainment. The collected mixture of water and oil is then transferred by gravity or pumps to storage tanks located on vessels on the seashore.

4.3 Sorbets

Sorbents are used to clean oil spills; this method makes use of the adsorption and/or absorption properties of specific materials. These sorbents are used to remove any remaining oil after using booms and skimmers. Sorbents aid in the conversion of oil from a liquid state to a semi-solid or solid-state substance . Oleophilic and hydrophobic sorbent materials preferentially adsorb or absorb oil to recover oil from the water surface.

Natural organic sorbent materials are commonly used to clean oil spills, such as waste agricultural products, industrial, agricultural wastes. while natural inorganic materials such as Vermiculite, Zeolites, activated carbon, organo-clays, glass, sand, and volcanic ash offer a high surface area for sorption, are mechanically and chemically stable, inexpensive, and efficient for remediation of marine oil spills. Synthetic sorbents are artificial (man-made) and widely used sorbent materials for commercial use. Polyethylene (PE), Polyurethane (PU), Polyester, Polyvinyl chloride (PVC), Polypropylene, and Polystyrene (PS) are the most commonly used polymeric materials for the manufacture of synthetic sorbents. Each synthetic adsorbent has its own characteristic porosity and pore structure, and their hydrophobic and oleophilic abilities are much enhanced than their organic and mineral counterparts. The highest oil adsorption capacity being for sorbents made of Polypropylene.

4.4 Thermal method

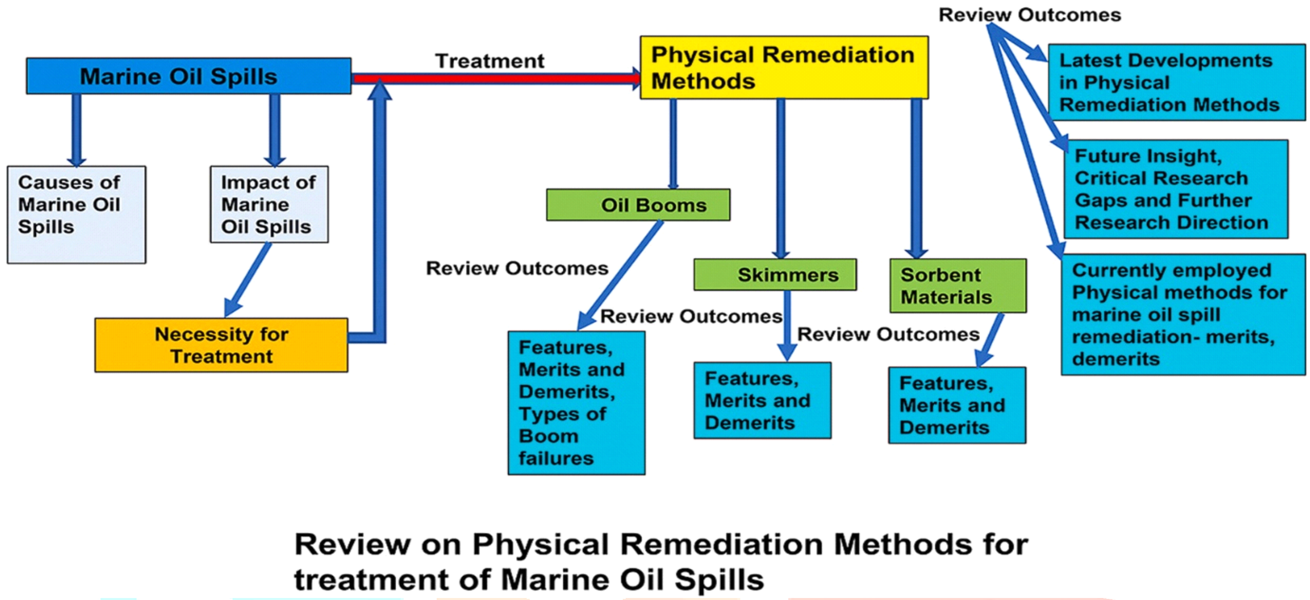
Thermal burning is an effective oil spill response in the open water with calm winds. It is best for refined oil products that will burn quickly without causing danger to marine life. The major constraints are fear of secondary fires, destruction of vegetation and aquatic lives, and risk to human health due to the gases emitted from thermal combustion.

Fire resistance booms are used to accumulate oil and concentrate into a slick that is thick enough to burn .Thermal remediation methods are affected by water temperature, speed, wave amplitude, wind direction, slick thickness, oil type, and amount of weathering and emulsification.

4.5 High-pressure hot water washing

High-pressure hot water washing works well for rocky or gravelly shores where oil traces are still present. A high-pressure jet of hot water can clean the rocks of the remainder oil very efficiently, but can have a detrimental effect on the shore's health and future ability to support vegetation and microfauna. The effect is worse on gravelly shores, as the oil seeps through the gravel into the soil and sediments below.

Fig 2 :Physical remediation methods for treatment of marine oil spills



V CHEMICAL REMEDIATION METHODS

5.1 Dispersants

Oil slicks are weathered into tiny droplets using surface-active substances called dispersants. SlickgoneNS, Neos AB3000, Corexit 9500, Corexit 8667, and Finasol OSR 528 are a few examples. Dispersants can be employed on rough seas when there are strong winds by spraying the water with the chemical from ships or aircraft.

When a dispersant is applied to an oil spill site, the solvent moves the molecules to the oil/water interface since each dispersant molecule has both oleophilic and hydrophilic components. With the aid of this procedure, dirty water can be treated quickly, oil water emulsion formation is slowed down, and the rate of natural biodegradation is increased. It also reduces surface tension and isolates oil droplets from the oil slick. Yet, most dispersants are dangerous because to their flammability.

5.2 Solidifiers

Solidifiers are hydrophobic polymers enhanced by Van der Waals forces that convert oil into a solid rubber state that does not sink and can be easily removed by physical means. There are three types of solidifiers: polymer sorbents, cross-linking agents, and polymers with cross-link agents. Examples include Rawflex, Norsorex, Oil Bond, Molten wax, Elastol, Gelco 200, CI agent, Rubberizer, Jet Gell, Smart Bond HO, etc.

5.3 Chemical stabilisation of oil by elastomers

Experts have recently been using compounds like 'Elastol' to confine oil spills, which gelatinizes or solidifies the oil on the water surface and is easy to retrieve, making the process highly efficient.

5.4 Photooxidation

Oil reacts with oxygen in the presence of sunlight, breaking into soluble products called tars. Some of the aromatic components (PAHs) also break down and are available for microbes for further process.

5.5 Magnetic Nanomaterials

Nanotechnology is an emerging field of science that focuses on the synthesis and development of magnetic nanomaterials (MNMs) due to their exceptional properties. Magnetic nanoparticles embedded within polymeric polystyrene beads with mini-emulsion polymerization is used in oil-water separation. Poly-ethylenimine (PEI) coated magnetic nanoparticles were tested for emulsified oil separation for different types of oils and showed excellent performance. Magnetic nanocomposites synthesized by coating of chitosan on magnetic NPs were used for water purification and adsorptive removal of diesel oil from oil-water mixtures. A novel floating polyurethane foams combined with colloidal (superparamagnetic iron oxide nanoparticles) SPIONs micro-particles was able to soak mineral oil 13.25 times its own weight with 80% particle recyclability.

Magnetic nanomaterials have been developed to recover oil spills from oil-contaminated water. Novel materials with super hydrophobicity and oleophilicity are being developed and coupled with magnetic nanoparticles to synthesize oil spill sorbents. Magnetic adsorbents possess all unique properties as owned by ideal oil sorbents, such as low surface energy, better surface properties, biodegradability, non-sinking property, simple recovery, reusability, eco-friendly nature and large sorption capacity.

VI BIOLOGICAL REMEDIATION TECHNIQUES

A simple and affordable remediation method called bioremediation makes use of microorganisms to break down and metabolise any hazardous element and restore environmental quality. Petroleum hydrocarbons can be biodegraded at temperatures below 0C to more than 80C, but high concentrations of nitrates, phosphates, and iron can limit rates.

6.1 Bio stimulation

It is the adding up of the limiting nutrients such as phosphorus, nitrogen, and various mineral nutrients to stimulate the growth of native microbes capable of degradation. Bioremediation focused on partially alleviating the nutrient limitation of crude oils by adding fertilizers. Rosenberg et al has claimed that the addition of a urea-formaldehyde fertilizer that adheres to oil and selected oil-degrading organisms able to use it as a nitrogen source dramatically stimulated oil degradation

6.2 Bioaugmentation

It is a process in which the known oil eating bacteria are added externally at the contaminated sites.It is used to remove aromatic compounds from contaminated sites, with both abiotic and biotic factors influencing the effectiveness. The most important abiotic factors are temperature, moisture, pH and organic matter content. The indigenous population of microbes has the capability to degrade hydrocarbons, but toxic chemicals inhibit the growth of populations.

Bioaugmentation and bio stimulation processes accelerate hydrocarbon bioremediation by considering concentration, microbes, nutrients, and physical parameters.

6.3 Biosurfactants

These amphiphilic, surface-active compounds produced extracellularly or as a part of cell membrane of microbes help in reducing the surface tension between two phases and thus enhancing the solubilization and contaminant removal.

6.4 Biosparging and Bioventing

Addition of air to indigenous oleophilic microbes in saturated and unsaturated zones, respectively, leading to increased biodegradation of contaminants. Usually carried out for groundwater treatment.

Deep-sea sedimentary hydrocarbon clastic bacteria such as mixed culture of Raoultella sp., Enterobacter sp., and Pseudomonas sp. are used for crude oil spill biodegradation, with the highest percentage of biodegradation being 88.6%, with a constant degradation rate of 0.399 day-1.

6.5 Phytoremediation

It is the process in which plants are used to facilitate the restoration of contaminated site. They can directly uptake the petroleum hydrocarbons into their tissues and release enzymes which stimulate the activity of hydrocarbon-degrading microbes and degradation of contaminants in the rhizosphere due to mycorrhizal fungi and soil microbes

Dispersants stimulate the natural process of biodegradation because microbial attack is at the oil-water interface, and dispersion of the oil dramatically increases the area available for microbial colonization. Dispersants, such as Corexit 9500, increase the available surface area and can increase the rates of biodegradation. Microorganisms such as Alcanivorax, Cycloclasticus and Thalassolituus can degrade various branched chain and straight-chain saturated hydrocarbons and even polycyclic aromatic hydrocarbons.

6.6 Mycoremediation

Fungi have been taken under study related to hydrocarbon degradation. The major fungal phyla/subphyla involved in the biodegradation of oil are the Ascomycota, Basidiomycota, and Mucoromycotina with specific fungal genera including Aspergillus, Penicillium, Cephalosporium, Torulopsis, Saccharomyces, Paecilomyces, Candida, s, Geotrichum, Talaromyces, Cladosporium, Pichia, Fusarium, Alternaria, Polyporus, Rhizopus, Mucor, and Rhodotorula.

Mycoremediation is the utilization of fungi to degrade or remove toxins from the environment. Fungi are so skilled that they break down many robust, long-chained toxins into simpler and less toxic chemicals (Louisiana. oil spill). It has been promoted by mycologist Paul Stamets, who believes that fungi can clean up everything from oil spills to nuclear meltdowns.

A revolution in the field of mycoremediation has been brought by the aptitude of the oyster mushroom (Pleurotus ostreatus)to metabolize several pollutant PAHs. It has shown an extraordinary resistance to salty conditions and is capable of growing and reproducing in seawater. This has led to stirring opportunities in the mycoremediation of marine oil spills. mycelium encased in hemp tubes and is used to suck up oil from surrounding water. Absorbed oil is then broken down by the mycelium present inside the straw, thus, starting the decomposition of oil process, reducing the complex hydrocarbons into simpler, more unstable forms

6.7 Genetically Engineered Microbial bioremediation

The indigenous microbial community at the site of spilled oil is able to degrade hydrocarbons, but the rate of degradation is slow. To achieve complete bioremediation by bioaugmentation, the microorganisms must be capable of adapting with the high salinity water and producing biosurfactants within a short duration. To have such microorganisms, they must be genetically modified by using genetic engineering technique.

Genetic engineering is the technique of manipulation of genetic sequences to enhance the efficacy of bioremediation. Pseudomonas fluorescens HK44 is the first genetically engineered microorganism (GEM) approved for field testing in the United States. It has an introduced lux gene as a reporter gene fused within a naphthalene degradative pathway, allowing it to show bioluminescence as it degrades specific polyaromatic hydrocarbons such as naphthalene. The bioremediation process can therefore be observed by the detection of light.

Anand Mohan Chakrabarty is an American Microbiologist who developed the oil eating superbug Pseudomonas putida by isolating the plasmids from four strains which degrade octane, camphor, xylene, and naphthalene, respectively. Then he inserted all the four plasmids into the one strain of Pseudomonas putida which has capability to degrade octane, camphor, xylene, and naphthalene known as superbug .

6.8 Oil spill eater :

OSEII is a plant-based enzyme that breaks down any hydrocarbon into a natural food source for the native bacteria in the natural environment. It is a bio-enzymatic cleaner that facilitates the tandem benefit of bacteria and enzymes working together, making it fast and easy for the bacteria to biodegrade the petroleum hydrocarbon chemicals to CO2 and water. As long as the surface is damp, the bacteria multiply and continue to remove traces of hydrocarbon for hours, days and even weeks after application.

VII CONCLUSION

More focus should be placed on oil spill remediation in order to lessen the subsequent tragedy that is caused by oil leak. Restoration techniques should be carefully chosen to guarantee efficacy and efficiency. Although several physical, chemical, thermal, and biological methods have been helpful in reaching this crucial objective, biological remediation is especially advantageous since it has proven to be more inexpensive and sustainable. Physical remediation is an eco-friendly measure for oil spill treatment, but its effectiveness depends on environmental and oceanic conditions. Oceans are home to numerous microbial communities that play an important role in nutrient regeneration cycle. Marine-derived fungi can be helpful in degrading the spilled oil by converting the hydrocarbons into more water soluble and less toxic to marine environment. Microbial degradation of oil spill depends on the nature of oil, temperature, nutrients present, composition of oil, and ambient and seasonal conditions. Supplementing the spilled site with microbes to enhance biodegradation or adding oleophilic fertilizers can speed up the biodegradation process. Bioremediation is gaining popularity recently and can be further searched upon for more information. The current research focus on Genetically modified microbes (GEMs) and OSE II are advantageous for the environment because they don't cause any additional environmental pollution. More significantly, the GEM can generate energy and develop by using a range of aliphatic and aromatic hydrocarbons. The development of GEMs should receive more attention in the future in order to reduce the pollution brought on by spilt oils and other hazardous xenobiotic chemicals and OSE II successfully removes dangerous pollutants using nature's own bioremediation process, it is an environmentally acceptable technique of cleanup.

REFERENCES :

1. S Othumpangat and V Castranova, National Institute for Occupational Safety and Health, Morgantown, WV, USA , Oil Spills - Encyclopaedia HYPERLINK "https://www.sciencedirect.com/science/referenceworks/9780123864550" of Toxicology.
2. Dave, D. & Ghaly, A. (2011). Remediation Technologies for Marine Oil Spills: A Critical Review and Comparative Analysis. *American Journal of Environmental Sciences*, *7*(5), 423-440. https://doi.org/10.3844/ajessp.2011.423.440.
3. Abhinav Dhaka, Pradipta Chattopadhyay A review on physical remediation techniques for treatment of marine oil spills
4. Prince Emeka Ndimele [1], Abdulwakil O. Saba [1], Deborah O. Ojo [2], Chinatu C. Ndimele [2], Martins A. Anetekhai [1], Ebere S. Erondu [3] Remediation of Crude Oil Spillage.
5. Al-Majed, A.A., Adebayo, A.R., Hossain, M.E., . A sustainable approach to controlling oil spills. J. Environ. Manag. 113, 213–227.
6. Atlas, R.M., Hazen, T.C., 2011. Oil biodegradation and bioremediation: a tale of the two worst spills in U.S. history. Environ. Sci. Technol. 45, 6709–6715. https://doi.org/10.1021/es2013227.
7. Bhardwaj, N., Bhaskarwar, A.N., 2018. A review on sorbent devices for oil-spill control. Environ. Pollution. 243, 1758–1771
8. Rajeev Kumar & Ashpreet Kaur -Oil Spill Removal by Mycoremediation DOI:10.1007/978-981-13-1840-5_20
9. Prartono, T.; Dwinovantyo, A.; Syafrizal, S.; Syakti, A.D. Potential Use of Deep-Sea Sediment Bacteria for Oil Spill Biodegradation: A Laboratory Simulation. Microorganisms 2022, 10, 1616. https://doi.org/10.3390/ microorganisms10081616
10. Shankar M. Khade and S. K. Srivastava Genetically Modified Microbes for Bio-remediation of Oil Spills in Marine Environment
11. Al-Nasrawi H (2012) Biodegradation of crude oil by fungi isolated from Gulf of Mexico. J Bioremed Biodegr 3:147. https://doi.org/10.4172/2155-6199.1000147.
12. Harpreet Singh, Neha Bhardwaj, Shailendra Kumar Arya, Madhu Khatri, Environmental impacts of oil spills and their remediation by magnetic nanomaterials, ISSN 2215-1532