Bioremediation of Oil Spill Cleanup: Case Studies of Two Major Oil Spills

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1 Introduction

The spill of oil on land or water surface mostly at sea and freshwater bodies whether accidentally or intentionally sometimes is called oil spillage. It happens when a significant amount of hydrocarbons seep into the environment when moving oil through pipelines, tanks, etc., or when there are unforeseen, unexpected incidents such as drilling failures, kicks followed by blowouts, and improper waste disposal techniques [1, 2]. Moreover, sometimes spills may also occur due to natural processes such as earthquakes and submarine seeps, and also each year some amount of crude oil is discharged from natural seeps. In addition, spillage may also occur during the consumption, storage, and usage of oil products such as in fueling an aircraft, gas stations, and truck stops. The consequences of oil spills on the environment are huge and unavoidable.

The ecology and health of mankind are at risk from oil spills in land and marine areas [3]. When oil is spilled on land, it hampers the environment including its flora and fauna as shown in Fig. 1. This can cause water pollution, can have explosions thereby causing air pollution, and even soil pollution, destroying the habitat of animals on both land and marine and having a huge impact on the ecosystem thereby the economy of that particular country. The consequences of oil spills on the environment are already known by the various devastating accidents that occurred in history, which should not repeat again due to carelessness or human error. As a

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D. Deka et al. (eds.), *Sustainable Environment*,
https://doi.org/10.1007/978-981-19-8464-8_7

result, a supported logistical and skilled staff is required to respond appropriately in a timely manner following the occurrence of oil spills [4].

When oil is spilled into water bodies, it harms the aquatic organisms, deep ocean plants, coral reefs, etc., thereby damaging the underwater ecosystem and the overall food chain (Fig. 2). Marine animals are also vulnerable to spillages as their body and skin get affected by the contact of oil and also the ingestion of oils causes various toxicity and health problems to these organisms. Since the fish and other sea organisms we consume get contaminated, the intake of these will eventually cause various health problems to human beings.

Exxon Valdez in 1987, when over 11 million gallons of oil were spilled [7], and Deepwater Horizon in the year 2010, where roughly 4.9 million barrels of oil were leaked, are two noteworthy oil spill events that are remembered in history as being particularly harmful to the marine environment. Additionally, there was the 2002

Fig. 1 Damaged mangrove forest caused by oil spillage [5]

Fig. 2 Impact of oil spill on creatures [6]

prestige disaster and the 1978 Amoco Cadiz oil leak [8]. Among the condensate oil spill accidents, notable ones happened in Uniacke G-72 oil drilling, Nova Scotia, 1984, Montara offshore oil field, Timor Sea, 2009, Elgin production platform, North Sea, 2012 MT Sanchi, East China Sea, 2018 and the most recent one in Baghjan, well no. 5, Duliajan, Assam, 2020.

There are various methods to treat oil spillages such as physical or mechanical, chemical, and biological methods. Physical methods include skimmers and booms, which are some floating devices that prevent oil spills. Skimmers are devices that, like a vacuum cleaner, suck up oil from the ocean surface that is restricted by booms. Chemical approaches employ emulsifiers, dispersants, and other chemicals. Oil spills are treated using dispersants to reduce the size of the droplets. Incorporating microorganisms, nutrients, or oxygen to boost bacterial growth and, as a result, biodegradation of the oil spill are examples of biological techniques [8]. Following its successful use in the Exxon Valdez oil disaster, bioremediation has gained attention as a viable solution for the cleaning of oil spills. Compared to physicochemical methods, bioremediation is a more environmentally friendly technique that is also more inexpensive. Both bioaugmentation and biostimulation involve refilling the polluted environment with nutrients and/or introducing natural or genetically modified microorganisms to a polluted site. These approaches of removing oil spills have primarily been explored in the laboratory and to a minor extent in actual circumstances.

Several regulations, laws, and directives involve oil spill prevention, response, handling, and recovery. Accidental oil spills are, nevertheless, unavoidable, and governments should be prepared to respond appropriately in the event of a leak. The US Environmental Protection Agency has made oil spill prevention and preparation one of its key goals (US EPA 2013). Oil spills can be remedied using a variety of methods, and bioremediation is the greener approach among them, and it is the subject of this report.

1.1 History of Oil Spill Accidents

The first oil spill accident occurred on November 30, 1903, when 1300 tonnes of oil leaked at Port Philip Bay, Victoria, Australia, marking the beginning of the oil spill era. Another incident occurred in 1907 when 7400 tonnes of paraffin oil poured into the sea and along the British shoreline [9].

The Amoco Cadiz oil spill, which contaminated more than 320 km of shoreline by releasing over 227,000 tonnes of crude oil into the sea, was another oil leak incident that happened in 1978. On March 24, 1989, the Exxon Valdez oil tanker collapsed on Bligh Reef in William Sound. Oiling was most intense on the shorelines of Prince William Sound islands which is shown in Fig. 3.

The Deepwater Horizon (DWH) catastrophe that occurred in the Gulf of Mexico in 2010 as a result of a drilling rig explosion is among the most well-known oil spills. More than 700,000 tons of crude were released into the Atlantic Ocean as a result of the catastrophe [9]. As a result of this occurrence, the biodiversity of the living

Fig. 3 Exxon Valdez oil spillage [10]

Fig. 4 BP Deepwater horizon oil spill [11]

organisms was diminished. Cleaning up after the catastrophe was expected to cost tens of billions of dollars. This incident may rank as the major oil leak mishap in recorded history which is shown in Fig. 4 (Table 1).

1.2 Remediation Method of Oil Spillage

The greater the probability of preventing and stopping contamination, the faster the response to the spill [12]. So, the main reason for the oil spill response should be that it must focus on how to remedy the negative things that have already occurred. So, anyhow the spread of this must be stopped, and also the source must not keep on continuing the spill. Also, when there occurs such horror then we must make use of

Table 1 Observation between the Exxon Valdez oil spill and the BP deepwater horizon oil spill

	Exxon Valdez oil spill	BP deepwater horizon blowout
Reason for the occurrence of oil spill	It happened in the year 1989 on March 24, which flooded the shorelines of Prince William Sound islands after the oil tanker of Exxon Valdez turned over in the ocean	It happened on April 20, 2010, when high-pressure oil and gas leaked out from the exploration well and the rig got caught on fire, which then got destroyed in the next two days
Gallons of oil spilled	11 million gallons	4.9 million gallons
Type of oil spilled	North slope Heavy oil	Light Louisiana Oil
API of oil	29	35.2
Impact on living beings, water, and land surface	Life in Alaska was impacted, by various marine creatures, flora, fauna, and livelihood of the people near it, etc	Killed thousands of marine creatures, flora fauna, and their habitat, destroyed deep-sea coral communities, and a reduction in planktonic grazers led to phytoplankton blooms etc
Remediation method used	Bioremediation is extensively used, mostly biostimulation where fertilizers containing nitrogen nutrients were used, and bioaugmentation, various microorganisms such as species of bacteria, fungi, etc., are used	Although chemical subsurface dispersants such as COREXIT 9500 were used. Bioremediation or the hidden microorganisms have played a crucial role in the cleanup
The success of bioremediation	1. A field test revealed that fertilizer increased the rate of degradation when it was added to the microorganisms that feed on hydrocarbons, resulting in the decrease of the spilled hydrocarbons of up to 1.2 percent in a single day 2. Even though these locations had been intensive to moderately oiled in 1989. In 2001 and 2003, the NOAA conducted a test and found out that 97.8% of the dug pits have no traces of oil or minor remains if it was found	In the deep marine cloud of scattered oil, bacterial activity was found which was observed through RNA microarray, and this clearly signifies that microbial degradation or the microorganisms that feed on hydrocarbons are responsible for the decrease in a large portion of the hydrocarbon (PAHs) though it was not seen through naked eyes

the mechanical spill clearance equipment which will be handy and clear the oil spill [13].

The main goal of these treatments is that we must lower the oil spill and transform it into less reactive materials that will not affect our environment much. There are a variety of remedies and reactions to oil spills, including mechanical, synthetic, and eco-friendly techniques [14].

1.2.1 Mechanical or Physical Methods

Mechanical or physical methods include the use of booms, skimmers, wiping with absorbent materials, sediment relocation and tilling, in situ burning, etc.

(a) Oil booms: It is a very easy way to manage the oil spill through the use of oil booms. Here, there are containment booms that are connected through cables, and these structures float around on the water surface. This helps the oil spill to be kept concentrated at a certain place and this way the oil spillage won't spread to a large area. But this process is disadvantageous during storms, tides, or high speeds of wind.
(b) Skimmers: These are used after the oil booms are placed. These skimmers are like vacuum cleaners that would suck the oil from the floor of the water body and helps us to recover the health of the environment back. It generally can collect most of the oil which is spilled, and this is also economically helpful to us.
(c) Sorbents: These are the elements which are used to absorb the oil spill from the water body through absorption or adsorption. This is generally done in a small area or to absorb or adsorb the traces of a large oil spill area.
(d) Burning in situ: In this process, oil on the beach is commonly burned when it comes into contact with something that burns, but this approach has the potential to pollute the air and kill plants and animals [14, 15].
(e) Sediment relocation and tiling: This is done to recover the land area of an oil spill and here the soil from the beach could be relocated to another place or also, or tilling and mixing might be done. Oil may penetrate deep into the seashore sediments as a result of tilling.
(f) Using manual labor: This method is used when manually a person needs to clean the oil spill using different tools for his help. Mechanical equipment is required to clean the oil spills, and also if we want to clean any inaccessible location. This procedure can only be used to clean up sloppy shorelines. The procedure is more cost effective since it may be carried out by untrained personnel with little training.

1.2.2 Chemical Methods

The chemical methods include the use of dispersants, demulsifiers, solidifiers, etc. Here, notably, dispersants have long been employed as a response option in many nations. Dispersants are the first choice in some countries where harsh coastline conditions don't let us use mechanical reactions easily [14]. Chemical approaches, on the other hand, have not been widely employed in the USA because of concerns about their toxicity and long-term environmental impacts, as well as disagreements over their efficacy (US EPA 1999) [15]. Some of the chemicals used are as follows:

(a) Dispersants: These are substances that are used to break up the oil molecules that are present on the ocean floor due to the oil spill. This breakdown of the oil molecule increases the area of the oil molecule leading it to mix with water. Also, this helps the bacteria which will be used to break down the oil. But the main disadvantage is that these are chemicals that would become tarballs that would affect the marine as well as the life on the sea bed [15].
(b) Demulsifiers: These are the substances that would break the emulsion which is created from the oil and water of the ocean [14].
(c) Solidifiers: These are the substances that would polymerize the oil molecules thus not letting them spill any further or allowing them to react to different elements [14].
(d) Film-forming compounds: These are the substances that are used upon the oil spill so that they do not get attached to the shoreline substrates [14].
(e) Chemical stabilization by elastomers: Sometimes elastomers such as gelatin are used upon the oil spill so that it stops the spread of the oil spill, and then it can be chemically held for the further cleaning of the oil spill. But these elastomers are very much toxic to marine species and can suffocate them.

1.2.3 Natural Recovery

Another one is to give natural recovery to the spillages. This is employed only when the oil spillage location is very far away from the shore, then it is allowed to dry from the natural heat of the sun, and the microbial bacteria which is already present in the ocean waters will degrade the oil spill that has occurred. It's one of the most budget-friendly options. It's a time-consuming and unpredictable procedure that needs continual and vigilant supervision. It is not to be confused with "sitting around doing nothing." The location of an oil spill is a critical consideration in its cleanup.

1.2.4 Biological Method

Among the biological methods, bioremediation is proved to be effective, and it is a greener approach. Although traditional measures, such as physical removal, are the first line of defense, they seldom result in comprehensive oil spill cleaning [14]. Bioremediation is the process described as when materials are introduced to accelerate natural biodegradation. This strategy is predicated on the idea that a significant portion of oil components break down rapidly in nature. The effectiveness of remediation of spillages biologically is dependent on how we create and sustain conditions in the polluted environment that encourage increased oil biodegradation rates. Bioaugmentation is the process in which a bacteria family is introduced to the oil spillage area and would reduce the fatalities of the oil spill; another method is biostimulation, where new bacteria families are allowed to grow along with the addition of nutrients in it [14]. In this report, mainly this bioremediation method will be discussed broadly with context to condensate oil spillage.

2 Bioremediation of Oil Spillage

Bioremediation, specifically biostimulation, has been demonstrated to improve oil biodegradation on polluted shorelines in both laboratory and field investigations. Also, biostimulation is a successful strategy, as adding hydrocarbon-degrading bacteria does not improve oil breakdown any more than just adding nutrients. Bioremediation provides several benefits over traditional approaches. For starters, bioremediation is a comparatively low-cost process. For example, the cost of bioremediating 120 km of shoreline during the Exxon Valdez spill cleanup was less than one day's physical washing expenditures.

To detoxify ecologically dangerous pollutants, bioremediation uses microorganisms such as bacteria, fungus, and plants, as well as plants. Phytoremediation is the term for when plants are utilized in the process, while mycoremediation is the term for when fungi are used. To break down pollutants, mycoremediation uses fungi's digestive enzymes. All of these bioremediation sources are aided by the addition of inorganic nutrients, which aid their development and speed up the biodegradation process.

Bioremediation is a time-consuming procedure that might take weeks or months to complete. It is a cost-effective technology, even though a comprehensive economic study of the process has yet to be completed. Other advantages of this procedure include the absence of substantial negative consequences such as the development of secondary pollutants, limited physical damage to the site, efficacy in eliminating harmful substances, simpler mechanical technology, and lower costs. A downside of this procedure is that it necessitates a unique strategy for each contaminated location and spill type [3]. In the sea, bioremediation is a less successful treatment technique, and the existing information is still rudimentary, focusing mostly on the employment of prokaryotic organisms.

The absence of standards for when and how to utilize oil bioremediation is now one of the most significant obstacles to its implementation. Although substantial research on oil bioremediation has been undertaken over the last decade, the majority of already available studies focused on assessing the use of bioremediation in the oil spills around the globe. Only a few experiments have been done and tested, and the results are quite extraordinary. There is an immediate need for a comprehensive and practical set of instructions for oil spill responders to answer issues like when to utilize bioremediation, which bioremediation agents to use, how to apply them, and how to monitor and assess the effects.

As it is evident that natural biodegradation is a very slow process, and it would take a very much time to clean up all the oil spills in time. So, bioremediation strategies are used to control the oil spill. Also, to maximize the impact of bioremediation the physical, chemical, and biological processes must be followed [16].

2.1 Bioaugmentation

Bioaugmentation is used when the main microbes which are required to degrade the petroleum products are used in the oil spills. It is generally required when the microbes which degrade petroleum products are at a low number [16].

To augment the microorganisms which have the highest capacity to feed on hydrocarbons are added to these contaminated areas. This strategy can be approached using a variety of approaches. Nonindigenous microorganisms from other contaminated settings are frequently employed to populate the target location [16]. Microbes from the target location can also be isolated, and mass has grown in bioreactors under laboratory conditions before being employed as inoculum for the target site, and it refers to circumstances where the bioaugmentation is carried out by the polluted site's natural bacteria following enrichment and then reintroduced to the site. Seeding microorganisms in a polluted location can shorten the time it takes for biodegradation to begin [16].

Bioaugmentation was successfully carried out on a minor-scale under controlled circumstances. However, it must be remembered that real-world situations may be unpredictable. Many merchants provide microbial agents that claim to speed up the biodegradation of oil. Bioaugmentation research in the lab, on the other hand, has shown mixed results. 12 commercial microorganisms were tested in the laboratory for the remediation of crude biologically from Alaska's North Slope. When compared to a nutritional control, four products demonstrated an increase in oil biodegradation after 28 days, with considerably greater alkane and aromatic breakdown rates. In several laboratory investigations, microbial seeding was shown to improve oil breakdown in saltwater but in freshwater used weathered Alaskan crude oil in shaker flask microcosms to evaluate ten different commercial microbial products to see if they could compete with indigenous populations. Thus, bioaugmentation may be beneficial in minor-scale research with well-controlled environmental conditions, but this does not imply that it will be effective in the field.

2.2 Biostimulation

Biostimulation is the use of desired microorganisms that can degrade the hydrocarbons specifically [17]. Among the nutrients, some elements such as carbon, phosphorous, and nitrogen are also used to limit the growth of the oil spill. Also, changing the temperature and aeration rate will affect the biostimulation. This is generally done to expand the spread of the bio degraders so that the oil spills can be reduced and stopped. This is also called as nutrient enrichment. Although the biodegradation of oil improves with the use of nitrogen and phosphorus, it is seen that it also depends upon the quality of oil as well as different conditions and quantities of the microorganisms used [18].

Also, to improve the conditions further, aeration can be done where oxygen is introduced to the porous soil which then makes it more ambient for the microorganisms to grow. And this method has shown a good success percentage of 85 from the data. Since the use of nitrogen and phosphorus is detrimental to the environment so uric acid is used which can make a nice association with the hydrocarbons present. But it should be noted that the use of nitrogen has no bad effect because it is already present in the atmosphere in different strata [16].

Biodegradation normally occurs when we have an oil and water interface. As a result, the efficiency of biostimulation is determined by the nutrient content in oily sediment interstitial pore water. The nutrient content should be kept at a level that allows bacteria to grow easily. Excessive quantities of nutrients, like ammonia, can cause toxic reactions when it comes in contact with marine animals; therefore, vigilance is advised [19]. Maintaining an adequate concentration of the nutrient added to that of the oil is one of the most difficult aspects of biostimulation in oil-contaminated coastal environments. The efficiency of these nutritional items in stimulating hydrocarbon biodegradation rates has been compared in several articles.

In conclusion, data from laboratory reports have demonstrated that biostimulation in certain situations and bioaugmentation can speed up the biodegradation of oil and more generally in oceanic habitats. Under specific conditions, oxygen might be in limited quantity just like in freshwater marshlands, etc. Field assessments are still required to validate these findings, though.

2.3 Microorganisms Used for Bioremediation of Oil Spills

Certain species of bacteria, fungi, and yeasts in around 200 numbers are found to be capable to degrade the hydrocarbons containing petroleum. These microbes can be found in the atmosphere in almost all the strata, may it be land or water, and there are many hydrocarbon-degrading microorganisms [16].

Various kinds of indigenous soil bacteria have the capacity of diminishing different petroleum hydrocarbon molecules. Some bacteria can aid in the production of biosurfactants, which improve bioremediation by lowering surface tension and increasing hydrocarbon absorption. However, elements including the availability of food and the kind of oil pollutants have an effect on how quickly hydrocarbons degrade. [20].

Also, there are certain fungi that are capable of this degradation of the hydrocarbons, but they require quite an amount of time to degrade all the hydrocarbons in the pool [21]. Again, there are some yeasts as well who can do this degradation of the petroleum hydrocarbons.

3 Bioremediation Methods Used in Exxon Valdez Oil Spill

In the year 1989, the crushing of the tanker Exxon Valdez on Bligh Reef in Alaska, the US EPA, in collaboration with Exxon Corporation and the state of Alaska, launched the world's biggest oil spill bioremediation effort. Extensive field testing was undertaken at numerous locations [22]. The degradation of hydrocarbons by native microflora on the beaches of Prince William Sound was hastened by supplying fertilizers directly to the contaminated areas, according to field research done by scientists. Laboratory tests confirmed the oleophilic fertilizer's value as a nutrition source [23].

Most decision-makers involved in oil spill cleanup have a strong desire to generate "site-specific" information concerning bioremediation capability. The increase of oil degraders in oil spillage zones may not be the deciding factor for first bioremediation in other incidents due to circumstances. Even though these markers were not first employed in Alaska, they are nevertheless important to consider.

Mineralization investigations that include the total CO_2 generated, for example, can provide valuable preliminary data. The method gives quick, somewhat unambiguous time-course data that can be used to compare different biological therapy alternatives (e.g., the results of supplying nutrients). If crude oil deterioration occurs in contaminated beach, oil mineralization should release significant levels of CO_2 in comparison with an unpolluted beach. Similarly, nutrient additions such as nitrogen could accelerate the biodegradation of oil-contaminated areas (Fig. 5).

Oil mineralization rates from contaminated beach debris can be measured using biometer flask systems intended to capture CO_2 sideways which contains an alkaline solution. After that these beach oil-contaminated materials are taken in the flask, and the saltwater which is fresh is circulated to form a tidal exchange. This experiment was done after the bioremediation field demonstration. This biometer flask experiment is a technique that can become handy for short-term use at a particular site to gather the data of the oil catastrophe for its remedy. Also, this might happen that there might be certain other organic matter which may release carbon dioxide, so we must first measure the oil mineralization. Also, a radio-labeled hydrocarbon can be used along with the uncontaminated beach material to ensure that mineralization in the presence of the oil is much higher than the background.

The following are some of the most important findings and lessons acquired from these investigations:

(a) Oil biodegradation on the Prince Williams Sound shoreline was found to be limited by nutrient concentrations, mainly nitrogen, rather than a lack of hydrocarbon-degrading microorganisms. Snug Harbor's test beaches, for field demonstration of its efficiency of the bioremediation, where Inipol was used, generated some unexpected results. The beaches of the region were chosen because the oil concentration and distribution were supposed to resemble physically washed beaches.

(b) Some oleophilic, as well as some inorganic fertilizers, were used to put into a test on the field. Each was demonstrated to have varying degrees of effectiveness. So,

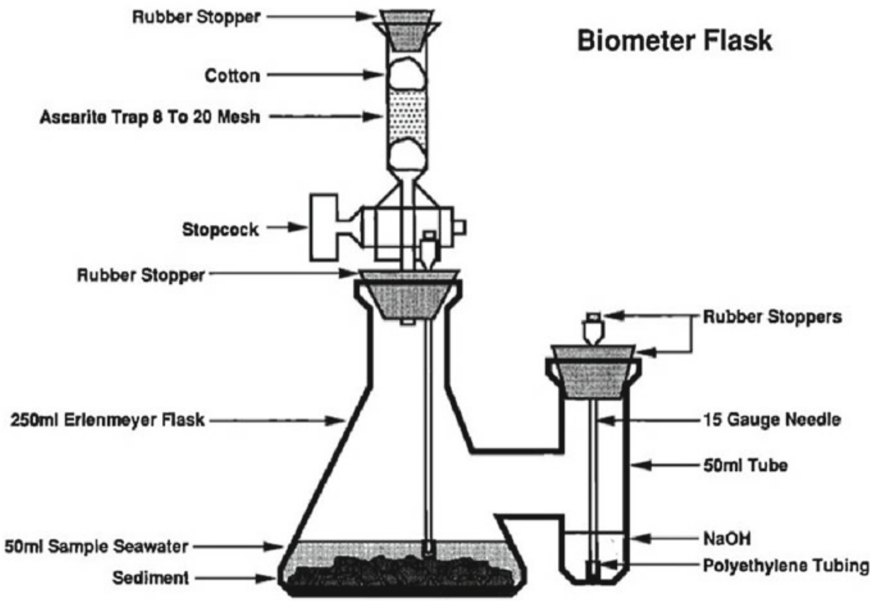

Fig. 5 Modified biometer flasks that are used to count the mineralization of hydrocarbons from contaminated areas samples [24]

nitrogen and phosphorus were used along with Inipol EAP22 and Customblen as bioremediation agents. The section of the solution looked clean and clear two weeks after fertilizer application than the untreated region which is shown in Fig. 6. However, it was later discovered that the oil on the cobble's surfaces had been removed and re-deposited within the beach's surface interstices.

Fig. 6 Snug Harbor on Knight Island, Prince William Sound Effect on test plots by using the Inipol fertilizer to remove oil spillages. We can clearly see the difference between the right to that of the left [24]

(a) It was challenging to assess the rates of oil biodegradation using existing techniques due to the heterogeneous oil dispersion on the polluted beaches. They also discovered that classic biomarkers like pristane and phytane rapidly deteriorated on Alaskan beaches. As a result of this finding, using such biomarkers to draw clear judgments about bioremediation success is no longer possible. Instead, 17(H),21(H)-hopane was utilized. Studies demonstrated that fertilizer treatment increased the rate of oil elimination by a factor of five when compared to natural attenuation, using hopane as the biomarker. This conclusion was reached based on samples obtained repeatedly from a single location.

(b) Bioremediation may improve oil biodegradation on some maritime shorelines, according to the findings of the fertilizer application following the Exxon Valdez spill. However, the Exxon Valdez study's results on bioremediation efficacy are somewhat dubious, in part because the experimental design was not wholly based on basic statistical principles. The lack of replication and the effort to determine too many parameters in a small number of studies, resulting in the confounding of diverse effects, were also major faults. As a result of the lessons learnt from the Exxon Valdez project, "post-Exxon Valdez enthusiasm" has been replaced with more scientifically sound techniques [25].

4 Oil Biodegradation and Bioremediation in British Petroleum Deepwater Horizon Oil Spill

The high-pressure oil and gas erupted from the exploratory well in the Deepwater horizon on April 20, 2010, which was located 77 km offshore in Mississippi Canyon Block 252. 11 guys sadly died as a result of the subsequent fire and explosions. The rig caught on fire and finally sank after two days. This led to the damage of the emergency shutoff equipment, including the blowout preventer (BOP). This also led to the damage of the riser pipe and the riser pipe as well as the BOP equipment leaking the oil from the bottom at multiple broken points. Finally, the well stopped production after 84 days.

This event changed the history of the world and the public and the media compared it to the Exxon Valdez oil spill, which had been the greatest disaster of oil spills till then. The Exxon Valdez disaster came into the picture because of its impact on the wildlife of Alaska as well as the long lawsuits which have been going on for a long time now. Although both the disasters were related to the oil and gas industry, they were completely different in terms of the type of oil spilled, the quantity of oil, and the natural ecosystems affected. Also, the BP Deepwater Horizon was greater in magnitude and it spilled methane (natural gas) into the ocean floor [25] (Fig. 7).

The Exxon Valdez oil spill occurred near the shore, but the Deepwater Horizon oil spill happened 80 km inside the ocean, that too, 1500 m below the surface of ocean water.

Deepwater Horizon oil that was spilled was lighter oil, so it was more biodegradable at first than that of the Exxon Valdez oil spill which had heavy crude. Also,

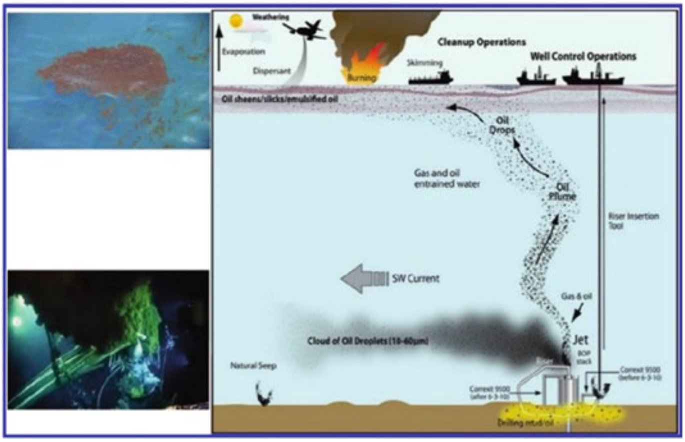

Fig. 7 Deepwater horizon oil spill effect and cleanup [25]

the habitat harmed was also different, the Exxon Valdez oil spill took place at a sub-Arctic zone and the Deepwater Horizon spill occurred in a subtropical region.

The main reason that the bioremediation technique was considered because of the oil that had seeped into the ocean beneath the surface of the water, and it was not possible by any other means to stop this spillage, and after weeks of the spill, the bioremediation was identifies as a new possible way.

At Deepwater Horizon, at a sea depth of 1500 m, COREXIT 9500, a dispersant, was put at the wellhead to decrease the environmental degradation by the oil spill. The main aim was to spread the oil underwater, and not on the surface of the ocean because this may happen that the oil might reach the shores from the surface and also many ships had been there to stop the leaks from the riser pipe and the BOP. And this injecting of the dispersant gave results within 4 h, and the leakage stopped, and the oil spills decreased [25].

Since the oil was allowed to spread underwater, at high pressure and temperature, some droplets floated to the surface and some carried away by currents up to 900–1300 m. This dispersion in the deep sea could lead to reductions in the oxygen concentrations of the ocean but did not result in anoxic conditions of the sea. This type of dispersions in the deep sea having total petroleum hydrocarbon concentrations less than 10 ppm is called das "cloud" [25].

In those "cloud" bacterial activity was seen which showed lower potassium oxide and dissolve oxygen concentrations. Also, the ammonia concentration was higher, and the lower nitrous oxide concentrations were seen. The bacterial activity was higher than that outside of the "cloud." A 16S rRNA microarray identified 951 bacterium subfamilies from 62 phyla; however, only 16 proteobacteria subfamilies were considerably enriched in the cloud, with three Oceanospirillales families dominating.

During the discharge, polynuclear aromatic hydrocarbon concentrations dropped rapidly as distance from wellhead increased reaching 1.0 ppb within 24–32 km in every direction except to the southwest, where a few samples surpassed 1 ppb out to 64 km. Microbial breakdown is responsible for much of the decrease in PAHs [25].

5 Conclusion

The oil spill incidents of the Prince William Sound and the British Petroleum Deepwater Horizon teach us hundreds of importance of degradation through indigenous microorganisms in case of the oil spillages. Most inflamed hydrocarbons can be removed through manner of biodegradation and distinct natural weathering processes, but this may take some time in varying from regions to regions based on the concentration of crude oil. The Exxon Valdez oil spill had a similar effect on oil on shorelines. While there was research on lowering oil concentrations, no particular biodegradation studies were undertaken for the Exxon Valdez spill with its unique deepwater cloud of dispersed oil, as they were for the BP spill with its unique deepwater cloud of dispersed oil.

Biodegradation of oil was mostly due to microorganisms in the Gulf of Mexico, because of the natural seepages and offshore drilling that happen every year which makes the microbiota adapted to it. In some cases, like in the case of Prince William Sound, bioremediation with addition of fertilizer was found to be effective in a way to accelerate oil biodegradation rates and this had enhanced tv.

The main effects of the oil spill must be kept in mind, and then the risk control of the overall process must be looked upon. It must also follow the guidelines to make the environment healthy so that the living organisms as a whole won't be affected. Also, it must be noted that the natural degradation of the oil spills is a great cause but there are certain bacteria, fungi, as well as yeasts who can degrade the spillage of oils and can bring the disaster to under control. The main factor that should be kept in mind is that the ecosystem should be maintained [25].

Acknowledgements The authors highly acknowledge the financial assistance provided by the All-India Council for Technical Education (AICTE) [F. No. 8-129/ RIFD/RPS-NER/Policy-1/2018-19], New Delhi to the Department of Petroleum Technology, Dibrugarh University, Assam, India. The authors also acknowledge the Department of Petroleum Technology, Dibrugarh University, Assam, India, for providing the facilities and resources to carry out this work.

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