

Adverse Impacts of Oil Spills on Marine, Lowland and Upland Ecosystems of Niger Delta of Nigeria and the Control Measures

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ABSTRACT

An oil spill is the accidental or deliberate release of oil into the environment whether terrestrial or marine. Oil spill pollution is a growing environmental concern that harms both terrestrial and aquatic ecosystems. The Niger Delta Region of Nigeria is a plausible victim of these frequent oil spillages caused by equipment failures, corrosion, human errors, willful damages of pipelines and installations and accident etc. The released oil impacts the soil fertility of the region, the surface water, ground water aquifer and the entire marine habitats leading to health challenges, diseases and death, unemployment, and poverty in the region. Pollution sometimes traverses through the food chain to the human consumers. Possible remedial actions include prevention of oil spills, prompt intervention when they occur by containment, recovery and clean up of the spills. Environmental restoration may be required to resuscitate the soil fertility to continue to support agricultural efforts of the local communities in the region.

Keywords: Pollutions, Spills, Impacts, Fertility, Contaminants, Marine, Lowland, Upland, Ecosystem.

INTRODUCTION

This study examines the adverse environmental impacts due to oil spills on land and marine habitats and the control measures. Particular focus is on the land and Marine Environments of the Region, where most of the oil explorations and exploitation activities are rampant.

The spill impacts are both on the physical and biological components of the ecosystem including the marine and land environments. In the process, soil fertility and water quality are adversely impacted by the pollution.

The extend of pollution is directly proportional to the impact on soil fertility and the water quality in the ecosystem.

Oil spills in land or marine environment can have wide-spread impact and long-term consequences on the soil fertility, wildlife, fisheries, coastal and marine habitats, human health and livelihood, as well as recreational resources of coastal communities and the ancestral heritage. Oil spill effects on fish, sea birds and other marine life are mostly due to the smothering and physical contamination or due to the toxicity of the chemical components of the oil. Ezeji et al (2007).

The fisheries and mariculture sector are impacted by the physical oiling of equipment and contamination of seafood leading to tainting and the effects on commercial and subsistence fisheries lead to substantial losses.

The repercussions of contaminated seafood on public perception are very serious and requires restoration of market confidence and public health assurances. The impact of oil spills on land, coastal and marine environments can be both short and long term. The degree of the damage caused by an oil spill event depends primarily upon the quantity of oil spilt, the chemistry and properties (type) of the oil and the sensitivity of the biological resources impacted in the ecosystem. Pyagbara, L. (2007).

Oil Impacts on Soil

The incidence of oil spillage constitutes serious soil degradation in the Niger Delta of Nigeria. Resulting in extensive depletion of the soil flora and fauna in the ecosystem. Ezeji et al (2007). These spills are caused from equipment failures, leaks from corroded equipment, vandalism (sabotage) and other operational defects. The spilled crude oil from the source, through a plausible transport mechanism and exposure pathway, gets to the innocent receptors - soil, vegetation, surface and ground water, marine environment, animals and humans - and pollute the environmental media. The soil fertility, measured by physical, chemical and biological parameters, is adversely affected. Abii et al (2009). High oil concentration on soil not only reduces the amount of water and oxygen available for plant growth, but also interferes with soil-plant - water relationships through direct physical contact (coating of root tissues) thereby adversely affecting soil fertility and plant growth. Okoye et al (2014).

The impacts include loss in the productive capability and capacity of soil, with implications on living organisms and economically on the people in the polluted area, and consequently high poverty rate and unemployment. This study examined the application of enhanced natural attenuation process in the remediation of oil polluted soil in the Lowland and upland Ecosystem in the Niger Delta. It examined the effect of oil pollution on soil fertility in the region, examined the relationship between soil nutrients and oil pollutants in the polluted soil in the study area and how intervention by enhanced natural process of bioremediation improve soil fertility.

MATERIALS AND METHODS

A farmland settlement contaminated with crude oil located in Egbeda, Rivers State, Nigeria, was used for the study. The test soil obtained was sandy soil. The preliminary process of bioremediation took a period of 24weeks. The bioremediation process comprises field experiment and laboratory simulation, with some physiochemical and microbial analyses. Soil sample were taken from the sampling grid design points. Samples were taken from a depth of 0-0.50metres. The concentration of total petroleum hydrocarbon (TPH), nitrogen and phosphorus were determined via laboratory analysis. These physiochemical parameters were monitored once every two weeks for a period of 24weeks.

Remediation by Enhanced Natural Attenuation (RENA) Techniques:

Applied RENA techniques:

The following techniques were employed to treat the contaminated farmland.

Spiking of Test Soils with Water

The soils were spiked with water uniformly to soften the soil and to allow the water penetrate the soil matrix.



Figure 1: Spiking of the Soil

Initial Tilling

The soils were tilled in a week after they were spiked, that is mixing the soil and breaking the lumps. This was done using shovel, composite samples were collected and sent to the laboratory for physiochemical and microbial evaluation.

Secondary Tilling

The soils were tilled and homogenized a week after the initial tilling. The lumps were broken to very fine particles with a shovel and a rake. The essence of the tilling and homogenization was to uniformly distribute the petroleum contaminants and break up the soil lumps to fine particles thereby increasing the surface area. The composite samples were taken for analysis.

Windrow Construction

Windrows/ridges were constructed after the secondary tilling of the test site. The ridges measured about 2feet high and 4feet wide. The windrows are made to achieve better aeration and optimize the efficiency of the attenuation processes in action, which exposes the microorganisms to oxygen, and aids in the biodegradation process of the petroleum hydrocarbon. Soil samples were taken for analysis.



Figure 2: Windrows Construction

Breaking Down of Windrows

The windrows were broken down after standing for between 4 and 5 weeks, after construction. Soil samples were taken for analysis.



Figure 3: Broken Windrows and Nutrient Application

Addition of Water

Additional water was added to the sandy soil to enhance the biodegradation of the petroleum hydrocarbons by the microorganisms when it penetrates the soil.

Addition of Fertilizer

Fertilizer application was done manually by sprinkling the fertilizer over the contaminated area and mixing over with the contaminated soil. The process enhances the biodegradation of the petroleum hydrocarbon Soil

Sampling and Analysis

The topsoil samples of the farmland were taken at intervals of two weeks from 0.5metres deep. They were taken using an auger machine into polypropylene bags, free from hydrocarbon contamination. This process is called augering. The soil samples were taken for immediate physico-chemical and microbial analysis in the laboratory.



Figure 4: Soil Sampling

Physico-Chemical and Microbial Analysis

Total phosphorous, total nitrogen and total petroleum hydrocarbon contents in the soil samples were determined by the method of Association of Analytical Chemists (1990).

RESULTS AND DISCUSSIONS

In the enhanced process, Phosphate depletion fluctuated between 0.83mg/l to 3.6mg/l as the minimum and maximum values respectively. From Week 1 to Week 2, there was a slight increase in concentration (2.63mg/l), which decreased in Week 4. Between Week 4 and Week 12, there was another slight increase (3.6mg/l), which finally decreased to 0.86mg/l in Week 24. Percentage reduction in phosphate concentration was 76.94%. This evidence was a pointer to the fact that the microbes needed the nutrients to be able to biodegrade the contaminants. At the end of 24weeks, the nutrient concentration spiked up again, indicating improvement in the soil fertility profile (Fig.4a.) While in the unenhanced process, phosphate availability at the end of week 24 was low. (Fig. 4b).

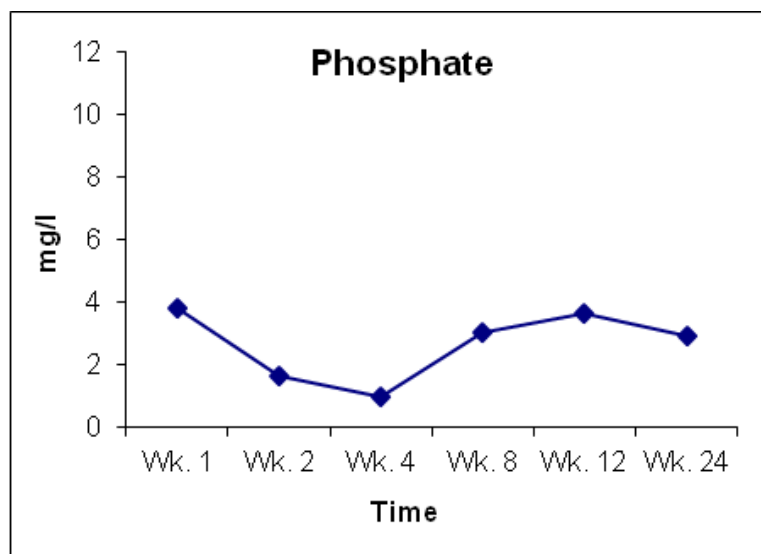


Fig.4a: Temporal variation in Phosphate Concentration in Enhanced Process

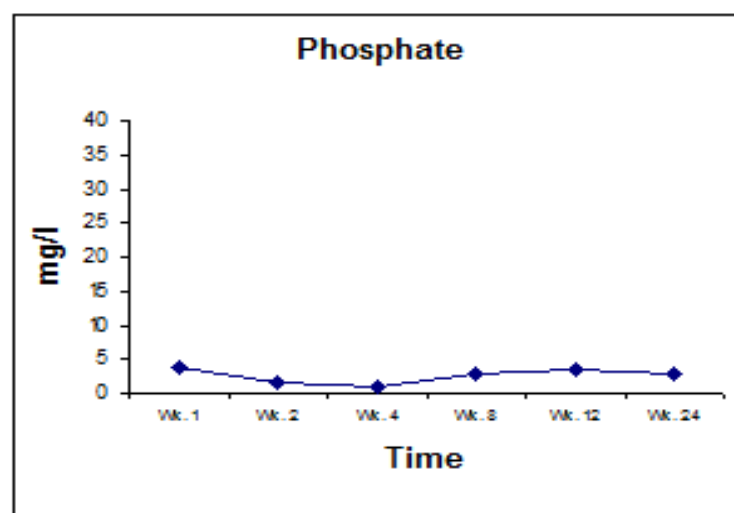


Fig. 4b: Temporal variation in Phosphate Concentration in UnEnhanced Process

The highest TPH value for the heavily polluted soil in the enhanced process was 19,790 ppm as shown from the sampling result. This value responded to the treatment as it decreased to 3,059.06 ppm in Week 2. There was further slight reduction in TPH value to 938ppm in Week

4. Continued intervention resulted in further reduction in value in Week 8 (671.956ppm). By the last week of the project, (Week 24), the TPH value has decreased to 271.53ppm. The maximum TPH value was 19,790ppm and the minimum value was 271.35ppm. The percentage reduction in TPH was 98.62% (Fig.5a).

For the unenhanced process, the highest TPH value was 19,790ppm with a very slow degradation to a value of 16,276.5ppm. The slow degradation trend, however is attributed to by the non enhanced nature of the treatment process. The percentage reduction was 17.75% indicating poor degradation trend. (Fig.5b).

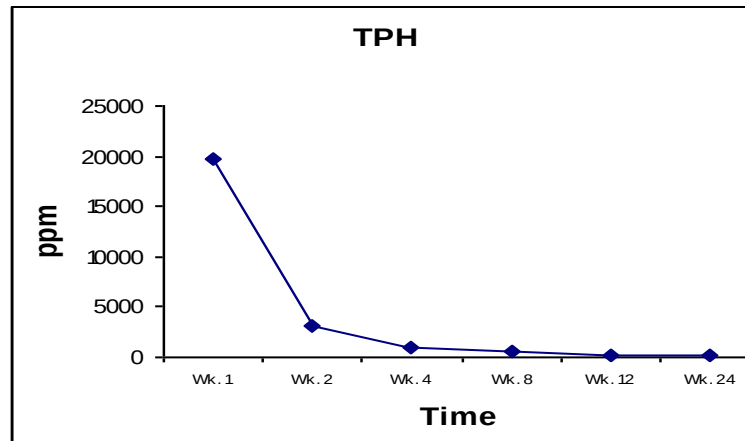


Fig. 5a: Temporal variation in TPH Concentration in Enhanced Process

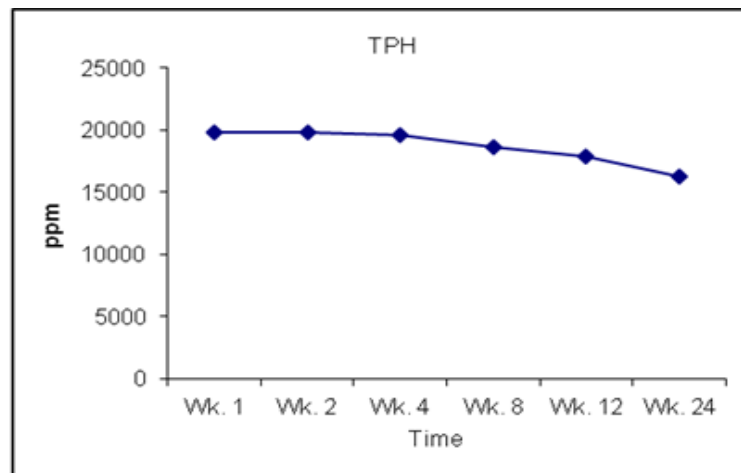


Fig. 5b: Temporal variation in TPH Concentration in UnEnhanced Process

The Marine Habitats

The marine habitats include coastal zones, intertidal zones, sandy shores, rocky shores, mudflats, swamps and salt marshes, estuaries, kelp forests, seagrasses, mangroves, coral reefs, tidal flats, river habitats, marshes and swamp.



Figure 6: The Marine Habitats



Figure 7: Impacted Shoreline

Impacts of Pollution on Marine Wildlife

Important factors relate to the impact of an oil spill on wildlife:

- the spread of the oil slick,
- the type of oil spilled, its fate, transport and weathering characteristics
- the location of the spill,
- the sensitivity of the regional environment, e.g proximity to bird breeding colony, etc.
- the timing of the incident (during seasonal breeding, bird migration), etc. ITOPF. (2011).

Impact On Birds:

Oil-covered birds are practically a universal symbol of the environmental damage wreaked by oil spills. Some species of shore birds may escape by relocating if they sense the danger in time, but sea birds that swim and dive for their food are the most likely to be covered in oil in the event of a spill.

Nesting grounds, with serious long-term effects on entire species are destroyed as well as the migratory pattern. Frink et.al (1995).

Impact On Birds:

By coating the feathers with oil, it becomes impossible for birds to fly since their natural waterproofing and insulation abilities are hindered, leaving them vulnerable to hypothermia and eventual death. King, Mason D., et al (2012).



Figure 8: Impacted Birds with Oil

Impact On Marine Mammals:

Oil spills frequently kill marine mammals such as whales, dolphins, seals and sea otters, sea lions, walruses, polar bears, river otters, beavers, porpoises, and manatees. The deadly damage can take several forms. The oil sometimes clogs the blowholes of whales and dolphins, the fur of otters and seals making it impossible for the animals to breathe properly and disrupting their ability to communicate and may lead to hypothermia and death.

Impact On Mammals:

Long after the spill, impacts persist on marine mammals leading to more dead, threat of species extinction or stunted growth or other damages among other species. Fingas et.al, (2015).



Figure 9: Impacted Mammals with Oil

Impact On Fish:

Oil spills often take a deadly toll on fish, shellfish, and other marine life, particularly if large numbers of fish eggs or larvae are exposed to the oil.

The shrimp and oyster fisheries are usually the first casualties of marine oil spills. In most cases, the fisheries hardly recover. Fish are affected through contacts with the gills, by ingestion, or by eating oiled prey with the contaminant going through the food chain.

Impact On Fish:

The oil contains polycyclic aromatic hydrocarbons (PAHs) which is the most toxic components of oil. Oil vapors can cause damage to the fish's central nervous system, liver, and lungs. Spilled oil can also have long-term reproductive problems in fish that have been exposed to oil. Fukuyama *et. al* (2014).



Figure 10: Impacted Fish with Oil

Impact On Wildlife Habitat and Breeding Grounds:

Most of the marine wildlife breed ashore. The long-term damage to various species, and to the habitat and nesting or breeding grounds is one of the most far-reaching environmental effects caused by oil spills. Often, the laid eggs are contaminated with the oil which in turns affect the morphology of any particular species. Jackson JBC *et.al* (1989



Figure 11: Impacted Wildlife Habitats with Oil

Factually, there is no clear relationship between the amount of oil in the marine environment and the likely impact on wildlife.

A smaller spill at the wrong time/wrong season and in a sensitive environment may prove much more harmful than a larger spill at another time of the year in another or even the same environment.

In summary, small spills may have very large effects than larger spills depending on the prevailing environmental factors. Thus, no need for mere comparison of figures.

Controls/Recovery Measures

The negative effects of oil spill may eventually fade away, but in many cases the long-term effects remain several years after, sometimes even decades, before an area or ecosystem will fully recover from a spill that caused extensive damages.

The seriousness of oil spill impact is mostly a function of the speed of recovery of the damaged habitats and species. Recovery depends upon both the removal of oil which is toxic from the environment and restoring the ecosystem, by replanting, introduction of cultured species threatened by extinction etc.

The key parameter for evaluating recovery success, is the reproductive success of the survivors, the influx of larvae, eggs, juveniles or adults present and the soil fertility in the oil impacted area.

The seriousness of impact and the speed of recovery of the affected habitats and species following an oil spill will to a large extent be determined by factors such as the oil type, oil thickness onshore, type of ecosystem, local geography, climate/season, the vulnerability and sensitivity of the species, biological and physical characteristics of the area and the type of clean up response strategy adopted.

Generally, recovery will proceed faster in warmer climates and on rocky shores compared to cold climates for example, marshes. The long-term effects on deeper bottoms (i.e., if oil sinks and is absorbed in bottom sediments) is also a matter of concern.

Table 1: Indicative Recovery Periods for Different Habitats

Habitat	Recovery Period
Plankton	Weeks/months
Sand Beaches	1 - 2 years
Exposed Rocky Shores	1 - 3 years
Sheltered Rocky Shores	1 - 5 years
Saltmarsh	3 - 5 years
Mangroves	10 years and above

Source: Restoration Ecology in Environmental Science

Controls/Recommendations

- Never use dispersants except the last available option
- Go mechanical all the way



Figure 12: Mechanical Recovery of Spilled Oil in Progress

Recommendations/Photo Gallery

Use mechanical skimming systems such as the self-propelled skimmers and sweepers



Figure 13: Mechanical Recovery of Spilled Oil in Progress



Figure 14: Mechanical Recovery of Spilled Oil in Progress



- Fast and prompt response will be helpful.
- Prompt beach and affected habitat cleaning
- Do proper containment using containment booms and other mechanical devices



Figure 15: Contained Spilled Oil



Figure 16: Contained Spilled Oil



Figure 17: Contained Spilled Oil



Figure 18: Contained Spilled Oil

- Swift recovery of spilled oil from the environment



Figure 19: Temporary Storage Facilities for Recovered Spilled oil



CONCLUSION

With the indebt analysis presented in this study, the study will conclude that marine oil pollution increases the risk of negative environmental impacts and damages to the ecosystem with potential consequences on the social and economic values of the environment leading to unemployment, poverty, diseases and death.

Oil spill incident in marine environment is bad news and should be prevented where it is possible. When it has occurred, prompt and swift clean up and response strategy should be adopted to mitigate extensive damage to the environment.

In selecting clean up response strategy, consideration must be given to the sensitivity of the impacted habitats, the environmental conditions, weather, oil type, volume spilled, species breeding seasons, the biological and physical characteristics of the area etc.

Proper and prompt containment and recovery must be carried out and mechanical deployment must be preferred against use of dispersants to avoid aggravation of impacts on the already stressed ecosystem.

Upon successful clean up, monitoring must be carried out to follow up on the success story to ensure and assure effectiveness while transparently informing and enlightening all the stakeholders including the communities whose environment was impacted.

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