International Journal of Environment and Pollution Research, 12(1),75-94, 2024

Print ISSN: 2056-7537(pri5nt)

Online ISSN: 2056-7545(online)

Website: https://www.eajournals.org/

Publication of the European Centre for Research Training and Development -UK

A Review on the Effects of Crude Oil Spill on Aquatic Life (Fish) in The Niger Delta, Nigeria

***Igbani Flourizel[1]; Tatah Gideon Weapngong[2] and Odekina Martins Ukwubile[3]**

[1&2]Department of Fisheries and Aquaculture, Faculty of Agriculture and Life Sciences,

Federal University Wukari, KM 200 Katsina-Ala Road, PMB 1020 Wukari, Taraba State, Nigeria.

[3]Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, Rivers State, Nigeria.

doi: https://doi.org/10.37745/ijepr.13/vol12n17594 Published December 27, 2023

Citation: Igbani F., Tatah G.W and Odekina M.U. (2024) A Review on the Effects of Crude Oil Spill on Aquatic Life (Fish) in The Niger Delta, Nigeria, *International Journal of Environment and Pollution Research*, 12(1),75-94

ABSTRACT: *The discovery of crude oil in commercial quantities in the Niger Delta was echoes of riches and wealth to the region and the country, Nigeria but the Niger Delta environment and aquatic ecosystems suffers great anthropogenic pollutions to its biodiversity: birds, animals, plants and crops; fishes and wildlife. This article has reviewed the effects of crude oil spill on the aquatic life (fish) in the Niger Delta, examining cases of oil spill incidences, impacts of oil exploration and exploitation on the environment, management of oil spill on living aquatic resources; biomagnification and threat to biodiversity and food security. It also examined the extent of crude oil removal techniques, and finally proffer possible mitigations and compensations for oil spills incidences in the Niger Delta. We are left with a great question: can gas flaring and illegal refineries be stopped, in the Niger Delta? The Niger Delta waters and the aquatic biodiversity should be protected; the government and multi-national oil companies should launch a clean-up programme on the affected areas/the region, and the management of spills (both of catastrophic and local dimensions) will play a leading role by enacting and enforcing stringent environmental laws that will protect the oil producing communities/areas. Government should be able to identify natural resources (such as wetlands and coastal zones) in Nigeria and monetary investment in environmental protection of vulnerable areas should be seriously looked into.*

KEYWORDS: pollution, fish, biodiversity, mitigation, bioremediation, aquatic resources, wetland, biomagnification

INTRODUCTION

Nigeria is one of the leading oil producers in the world. It is ranked sixth at global level, first in Africa, and exports about 1.8 million barrels per day (NBS. 2006). Most of the oil exploration activities are concentrated in the Niger Delta, which contains the world's largest wetland, with extensive fresh water swamp, forest and rich biological diversity. Over half of the area is crisscrossed with creeks and dotted with small islands whereas the remaining is a lowland rainforest zone (UNDP. 2006). The large population of the country, which stood at 140 million in 2006 (NPC. 2006), places a great demand on the energy sector. The sector provides employment for the survival of many people and more importantly it serves as a major source of foreign exchange. Oil production generates the greatest proportion of foreign exchange and internal revenue earning for the federal government. For instance, it accounts for more than 90% of foreign exchange earnings and about 80% of government internal revenue (NDDC. 2006). The overall contribution of the oil sector to the National economy grew from an insignificant 0.1% in 1950 to 87% in 1976 (Achi, 2003). And, between the year 2000 and 2004, oil accounted for about 79.5% of the total government revenues and about 97% of foreign exchange earnings (UNDP. 2006). Despite these enormous financial gains, there are problems associated with oil exploration. In Burutu local government area, a study was carried out and it was discovered that, there are many cases of oil spillage over the years. For example, between 1981 and 2007, there were 14 incidents of oil spillage, whereas between 1996 and 2006, the total volume of oil spills was 124,377 barrels. These spills have affected the livelihood and socio-economic activities as well as the environment of the people. For instance, fishing, which is the predominant occupation and means of livelihood of the people, does not yield much benefit anymore. Similarly, the spills have impacted negatively on both the pH value of soil and the hydrocarbon content of the water. The consequences are that people now migrate to other towns for greener pasture. Also, there is loss of fishing ground and disappearance of livelihoods for the people (Akpofure *et al*., 2000).

In Nigeria, the amount of oil entering into water bodies has raised concern over the sustainability of coastal and marine life. The trend of oil spillage in the country indicated that the first oil spill occurred in Bomu on the 19th July 1970 during which 150 barrels of oil was spilled (MPN. 1998). Other notable incidents include the Funiwa five well blowout in 1980, during which 400,000 barrels of crude oil were spilled; the Oyakama oil spill in 1980, with an estimated discharge of 30,000 barrels; the Oshika oil spill in 1983, with 10,000 barrels and the Idoho–QIT24 pipelines oil spill in January 12 1998 resulting in the release of about 40,000barrels (6000 tones) of Qua Iboe light crude oil. Another notable spill is the Forcados spill in July 1979, which spilled 600,000 barrels of crude oil. The highest volume of spill occurred in 1999, with 155,041.33 barrels spilled. It was followed by 74,749.52 barrels spilled in 1997; 69,338.68 barrels were spilled in1998. The lowest volume of spill (6147.59 barrels) was recorded in 1989. Shell Petroleum Development Company (SPDC) had 1672 spills, followed by Nigeria Agip Oil Company (NAOC). The immediate causes of oil spillage have been attributed to one or a combination of the following: break-up of pipelines or damage to or leakage of oil pipelines, oil tank overflow; rupture or failure of loading, floating or under-busy hose; broken flange connections or flow lines (MPN. 1998). Most spillages occur during the process of transportation of crude through pipelines or tankers from one location to another (Ogbogbo 2004). Frequent spillages involving a few gallons are caused by cleaning operations, malfunction of sea valves, and carelessness during connecting and disconnecting of hoses, and sometimes by non-observance of rules. These may happen anywhere within the port and are restricted to operations at terminals or specifically to oil tankers. These may result from damage or mechanical failure, and most often take place during loading or discharging operations in the vicinity of terminal. The serious and catastrophic spillages from tankers following collision, grounding or other damage of vessel are rare compared with the above, and may occur anywhere along tanker routes (Baker, 1981).Research findings show that oil spillage has an effect on the environment. In the literature of marine toxicology, there are many studies related to questions on the degree of biological danger from oil spill, ranging from studies which report on the absence of harmful effects (in water with an oil concentration of approximately several ppm or mg/l), to studies which show damage to the vitality of aquatic organisms even in the presence of small amounts of dissolved oil hydrocarbons (in the hundredth and thousands ppm or mg/l) (Isyban and Izrael, 1988; GESAMP. 1993).

According to Toxic concentration from spills causes destruction of organisms or irreversible damage to vitally important functions for caviar (embryos), larvae and fingerlings of marine animals, which reaches minimum values of 0.01 to 0.1 mg/l of dissolved oil hydrocarbon and is usually much lower than for adults. He noted that there is a wide range of toxic and threshold concentration. Benthos and demersal forms (including many kinds of fish living in constant contact with polluted sediments) are especially vulnerable. Bottom fish show tumors, mutation and diseases of cancerous character when the concentration of some dissolved aliphatic hydrocarbons (DAH) in sediments is in the range of 3 to 5 mg/l or higher (Alexander, 2007). UNDP. (2006) has also documented the toxic and carcinogenic effects of exposures to high concentrations of hydrocarbons.

NIGER DELTA AREA

This region, which covers a land mass of over 70,000 km^2, cuts across 800 oil-producing communities, and is the worst hit by oil spillage and gas flaring (Opukri and Ibaba 2008); with an extensive network of more than 900 oil wells, 100 flow stations and gas plants, over 1,500 km of trunk lines, and some 45,000 km of oil and gas flow lines, the Niger Delta has become synonymous with oil pollution, recording an average number of 221 oil spills per year (Osuji, 2001). Nigeria flares 17.2 billion cubic metres of natural gas per year in conjunction with the exploration of crude oil in the Niger Delta (Nwoko, 2014). The oil spill and gas flaring affect both flora and fauna components of the fragile ecosystem. Oil spill poses a major threat to the environment in Nigeria. If not checked or effectively managed, it could lead to total annihilation of the ecosystem, especially in the Niger Delta where oil spills have become prevalent. Life in this region is increasingly becoming unbearable due to the high effects of oil spills and many communities continue to groan under the degrading impacts of oil spills (Oyem, 2001). Environmental pollution arising from oil prospecting and exploration in the Niger Delta area of Nigeria has impacted negatively on the biodiversity of the affected areas. The main stresses arise from leakages of crude oil, gas flaring and the escape of other chemicals used in production processes. Effects on the flora and fauna of freshwater ecosystems in this part of Nigeria have been noticed. The government has established laws for protection of the environment from oil exploration, but these must be made effective in terms of implementation, enforcement and monitoring by responsible agencies. Oil spills in the Niger Delta have been a regular occurrence, and the resultant environmental degradation of the surrounding environment has caused significant tension among the people living in the region and the multinational oil companies operating there. However, Ibeanu (1999) has asserted that benefits from crude oil to oil producing communities are meagre, which comes from institutions and oil companies. In addition, the incidence of corruption, poor planning, limited capacity, bottleneck bureaucracies, elite capture of benefits, and limited community involvement has led many commentators to describe these governmental agencies as total failures (Mukoro, 2009; Ogele, 2016). This explains the current state of restiveness as a consequent of lack of basic development infrastructures. Idemudia (2005) critically examined the different Community Development Partnerships (CDPs) initiatives undertaken by Exxon Mobil and Total within their corporate-community relations strategy in the Niger Delta. He argued that while partnerships have the potential to improve the impact of business affirmative duties on host community development, the failure to integrate negative injunction duties into such partnerships undermines its contributions to host community development. Jike (2010) and Ukwayi et al. (2013) gave an incisive theoretical overview of the continuing conflict between oil companies and host communities in the region. He recommended a scenario for reciprocal empowerment between oil companies and the host community. Also, to check the frequent oil spills, more stringent regulations should be enforced. For instance, the law regulating the age of pipelines should be stringent enough to deter any violators. Adherence to standard operational procedures for oil exploration and exploitation should be pursued. The cost of failure to adhere to such standards should be high enough to make infringements a no-go area. Modern technologies of extraction should be adopted by these companies to reduce the negative impacts of their activities on the environment and people. The policy on replacement of ageing pipelines should rigorously be pursued, and deadline for ending gas flaring should not be extended. Unfortunately, this was not the case as gas flaring still persists in the Niger Delta.

Petroleum companies should monitor worn-out pipelines and replace them appropriately. Facilities for storing petroleum products should always be maintained to best quality; outdated pipelines and other drilling and related infrastructures should be upgraded to the latest and best facility. Best safety measures should be adhered to in drilling sites to avoid blowout from flow stations. Regulations should be put in place to maintain oil spill free exploration and exploitation. Hence, other methods should also be employed in the detection and management of oil spills including the Nigerian Sat-1 for monitoring oil spill incidences, international cooperation to fight oil smugglers, Geographic Information System (GIS) for managing oil spill incidents, Environmental Sensitive Index (ESI) maps, and creation of awareness. National Oil Spills Detection and Response Agency (NOSDRA) should be well-equipped for timely detection of oil spills and rapid response thereof. For instance, if NOSDRA had been well-furnished with modern technology for oil spills detection, the case of unknown quantities of spill in 2001 and under-reporting by the oil companies could not have occurred. Besides government policies, more non-governmental initiatives such as Clean Nigeria Associates (CAN), Niger Delta Environmental Survey (NDES), Living Earth Nigeria Foundation (LENF), Our Niger Delta (OND), and Environmental Rights Action (Ugochukwu and Ertel, 2008) should be encouraged to assist in challenging the nonchalant attitude of oil companies and the government.

Aim and objectives

The aim of this review was to examine the effects of crude oil spill on aquatic life (fish) in the Niger Delta waters.

Objectives of this review were to:

i) Determine the causes of oil spillages in the region, Niger Delta;
ii) Ascertain the effects of oil spillages to aquatic life (fish) in the region;
iii) Examine the degree of implementation of government laws for the protection of the environment and aquatic life (fish) from oil exploration and exploitation in the Niger Delta.

IMPACT OF CRUDE OIL SPILL ON THE LARGER ENVIRONMENT

The Niger Delta region, is located in the oil rich vegetation of Nigeria, the rainforest, which covers a land mass of over 70,000 km square area; cuts across 800 oil-producing rural/urban communities, and is the worst hit by oil spillage and gas flaring. With an extensive network of more than 900 oil wells, 100 crude oil flow stations and gas plants, over 1,500 km of trunk lines, and some 45,000 km of oil and gas flow lines, the Niger Delta has become synonymous with oil pollution, recording an average number of 221 oil spills per year (Osuji, 2001; Achebe *et al*., 2002). Nigeria flares 17.2 billion cubic metres of natural gas per year in conjunction with the exploration of crude oil in the Niger Delta (Nwoko, 2014).

The oil spill and gas flaring affects both flora and fauna components of the fragile ecological systems. After Shell British Petroleum, which discovered and drilled oil at Oloibiri, then old Rivers State in Ogbia Local Government Area; Nigeria joined the ranks of oil producers in 1958. Exploration rights in onshore and offshore areas adjoining the Niger Delta were later extended to other foreign companies such as Mobil, Chevron, Total, etc. According to Azaiki (2003), further exploration and production activities, were hampered between 1967 and 1970 by the Nigerian civil war. Total production from Nigeria's oil fields in the Niger Delta region increased from 308 million barrels in 1970 to 703,455 million barrels in 1991. The peak of its production came in the 1980s when the total output was 753.5 million barrels per annum, out of which 93% was exported overseas. Nigeria has a total of 159 oil fields and 1,481 wells in operation according to the Ministry of Petroleum Resources (Nwilo and Badejo, 2006). Nigeria has four (4) oil refineries with an estimated total refining capacity of 445,000 barrels per day (Onuoha, 2008). As at 2016, daily production of crude oil stood at 1,999,855 barrels per day making Nigeria the largest oil producer in Africa, the seventh largest under OPEC and thirteenth largest in the world (US EIA. 2017). Oil spill occurs when there is a release of a liquid petroleum hydrocarbon into the environment, especially marine areas, due to human activity. Oil spills may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products (such as gasoline, diesel) and their by-products, heavier fuels used by large ships such as bunker fuel, or the spill of any oily refuse or waste oil (Adelana *et al*., 2011).

Adetular (1996) stated that the enormous revenue derived from the oil industry has not been translated to socio-economic development, and that the environmental pollution resulting from oil prospecting, spillage and seepage is increasing. Repeated pollution undermines the ecological basis of a hitherto self-sustaining coherent way of life in oil producing communities. The coming of the multinational companies to Nigeria for oil exploration has led to unquantifiable environmental pollution, especially oil spillage. For example, since the first oil spillage that took place in Bomu on the 9th July 1970, several other incidents have occurred in different parts of the Niger Delta region (MPN. 1998). Over 784 oil spillage incidents took place between 1976 and 1980 in which about 1.3 million barrels of oil were spilled (Ogbogbo, 2004). Recent available data indicated that between 1976 and 2002 there were about 4,625 major oil spillage reported incidents involving release of greater than 3 million barrels of oil (NDDC. 2006).

In Nigeria, 50% of oil spills is due to corrosion, 28% to sabotage and 21% to oil production operations; 1% of oil spills is due to engineering drills, inability to effectively control oil wells, failure of machines, and inadequate care in loading and unloading oil vessels (Nwilo and Badejo, 2006). The main sources of oil spill in the Niger Delta are: vandalizing of the oil pipelines by the local inhabitants; ageing of the pipelines; oil blow outs from the flow stations; cleaning of oil tankers on the high sea, disposal of used oil into the drains by the road side mechanics, tanker accidents, ballast water discharge, etc. (Nwilo and Badejo, 2005). The records between 1976 and 2001 alone indicate that 6,817 oil spills occurred in Nigeria resulting in the loss of approximately three million barrels of oil (UNDP. 2006). This represents an average of 273 oil spills and 115,000 barrels per year spilled in the Niger Delta during the aforementioned period. Some notable oil spills recorded in Nigeria include Bomu 11 Oil Well blowout, 1970; GOCON's Escravos spill, 1978; Forcados Terminal spillage, 1980; Oyakama pipelines spill, 1980; Texaco Funiwa 5-blowout, 1980; Abudu pipeline spill, 1982; Ikata pipeline spill, 1984; Okoma pipeline spillage, 1985; Oshika pipeline spill, 1993; Eket Mobil platform, 1998; the massive Oloibiri Well 14 oil spill, 2004; Bodo oil spills, August 2008 and February 2009; K. Dere spill, April 2009 (Zabbey, 2009). Stakeholders Democracy Network (SDN. 2016) recently reported three cases oil spills occurring in the Niger Delta region. In Delta State, NNPC facility along the Escravos River in Warri South West LGA; Bayelsa State, Nigeria Agip Oil Company near North of Yenegoa and in Rivers State, Total S. A. in Ahoada East LGA. Several studies have evaluated cases of oil spill incidence in the region with emphasis on the aquatic environment, some of these include Kadafa (2012), Nwilo and Badejo (2001; 2005; 2006) and Ukoli (2005). Okpella in Nigeria Edo State suffered its second oil spill in three years when a pipeline belonging to the NNPC (Nigerian National Petroleum Company) ruptured and spilled and a quiet amount of refined crude oil seeped into the environment. The refined crude oil seeped into the underground water supply and then into a stream which provides the villages water. Investigation reveals that more than 53 well in the town have been polluted as speck of refined crude floats on the water (Adetokumbo and Abiola, 2002). In May 2000, a crude oil pipeline of the major oil-producing company ruptured in Etiama Nembe, in Bayelsa State, Nigeria. The surrounding local communities were contaminated heavily with the spilled oil. Ordinioha, (2010) investigated the health effects of this oil contamination among the residents in the affected community, using an interviewer administered questionnaires and had focus group discussions as part of the study tools. He investigated acute health effects of the oil spill in 210 exposed subjects, and their outcomes were compared with those of 210 unexposed subjects. His findings of the investigation indicated that exposure to the spilled crude oil was associated with significant increases in the prevalence of several physical symptoms including diarrhea, cough, headaches, sore throats, itchy eyes, itchy skin, and occupational injuries.

Akpofure et al. (2000) noted that oil exploration has caused pollution and has destroyed many hectares of land in the oil producing areas. Mashes, which constitute an important component of river, estuarine, and coastal ecosystems are extremely sensitive to oil pollution, and can be severely damaged by spills, which block carbon fixation by stifling plant transpiration; through this mechanism and others can kill marsh vegetation (Pezeshki *et al*., 2000). Osuagwu, (1984) examined the impact of petroleum activities on the agricultural sector and observed that although the oil boom attracted economic and political power to Nigeria, it unfortunately led to environmental devastation, socio-economic deprivation and general under development of very oil producing communities. Fishes will be exposed to spilled oil by direct contact. In this case, their gills will get contaminated or their eggs will absorb some components of oil and die. They will also eat contaminated food without knowing it and also die in the short run. Hence, they will suffer changes in their hearts and respiratory rates. Some will even have enlarged livers, stunted growth, fin eruption, a variety of biochemical and cellular changes; reproductive and behavioural responses will evolved. Furthermore, chronic exposure to certain chemicals found in the oil may cause genetic abnormalities/mutation or cancer in some species. This will in turn affect humans through bio-magnification (Akpofure et al., 2000).

Studies on crude oil spills from the Idoho production platform to Mobil Qua Iboe Terminal in Akwa Ibom State showed that health conditions normally associated with oil operations like skin disorder like ashes, corruptions and discharges were recorded and were linked with oil acne (a kind of skin eruption resulting from exposure to crude oil). Oil field workers has been reported to have skin eruptions as a result of exposure to crude oil, which also is seen among local fishermen who get in contact with incidences of major oil spill. Other disease conditions like gastro-intestinal and respiratory disorders were also linked to the oil spill. Their prevalence rates were slightly higher after the spill. The poor seafood and water supply quality, which were equally attributed to the oil spill also affected the health of the communities negatively. A number of studies have shown that the general impacts of petroleum exploration in Nigeria's Niger Delta seems more on the negative perspective (Akpan and Akpabio, 2003). The inhabitants of this region heavily depend on the aquatic environment for daily living, mostly in the form of fishing, farming and gathering. Consequently, oil exploration and exploitation have had far reaching negative environmental, social as well as economic impacts on the host communities. When oil spill reduces fish productivity and farming in the community, members of the community, most times in groups tend to relocate either voluntarily or involuntarily. Consequently, loss of ancestral homes, familiar surroundings, religious and other cultural artifacts are the psychological and social problems associated with displacement (Nwilo and Badejo, 2006). Also, the price of fish, a local staple food, rise as much as tenfold and many fishers find alternative ways to make a living. Local drinking water sources are contaminated and health hazard is also a major issue in the environment when oil spill occurs. People in affected areas suffer from various health ailments including difficulty in breathing and skin wounds.

Amnesty International, (2011) reported on the effects of the oil spills in Bodo, a town in the Ogoni land, stated that the spills had caused headaches and eyesight problems. Some of the spill-oil leads to environmental degradation and frequent violent clashes amongst the host communities in the 1990s which were further aggravated by lack of benefits and compensations from oil revenues, gives rise to occupational disorientation of host communities and exacerbation of poverty (Opukri and Ibaba, 2008). With the contamination of traditional fishing grounds and the fishing communities suffering from hunger and poverty, these could influence the communities to be aggressive. Stakeholders' Democracy Network (SDN) (2016) suggests a causal link between environmental and wider socioeconomic frustrations within the local communities, and escalation of tensions to violence caused by cases of oil spills (Opukri and Ibaba, 2011).

IMPACT OF OIL SPILL ON AQUATIC LIFE (FISH)

The harmful effects of oil spill on the aquatic ecosystem are enormous, the fishing industry is an essential part of Nigeria's sustainability because it provides much needed proteins and nutrients for humans, but with the higher demand on fishing, fish populations are declining as they are being depleted faster than they are able to restore their numbers through recruitments. Oil contamination affects the fish population and affects the fisher folks wholly on fishing to support their families. Spills in populated areas often spread out over a wide area. The utilization of dissolved oxygen by bacteria feeding on the spilled hydrocarbons also contributes to the death of fish. An impact assessment of the 1983 Oshika oil spill by Powell (1986) confirmed the death of floating and submerged aquatic vegetation especially water lettuce, crabs, other fishes and birds. Olujimi et al. (2011) they observed that in the Niger Delta, pollution of rivers through oil spillage have resulted in massive extermination of fishes thereby threatening the social and economic life of the communities whose livelihood depends on the contaminated waters. Ibaba (2001) observed that in Oloibiri, fishing activities have been grounded and aquatic life virtually castrated by many years of oil prospecting and exploration. In a survey carried out by Nwoko (2014) on the impact of oil pollutions in the Niger Delta, 87% of the Ogoni land community agreed that fish yields had declined due to oil pollution in their community. Oil kills plants, destroyed fish breeding grounds and animals like gastropods in the estuarine zone. Garrity and Levings, (1990) stated that major oil spills heavily contaminate coastal shorelines, causing severe localized ecological damage to the near-shore community. Ever since the discovery of oil in Nigeria in the 1950s, the country has been suffering the negative environmental consequences of oil development. The growth of the country's oil industry, combined with a population explosion and a lack of enforcement of environmental regulations has led to substantial damage to Nigeria's environment, especially in the Niger Delta region. Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment has caused significant tension between the people living in the region and the multinational oil companies operating there. It is only in the past decade that environmental groups, the Federal Government, and the foreign oil companies operating in the Niger Delta began to take steps to mitigate the impacts. Large area of the mangrove ecosystem have been destroyed. The mangrove forest was in the past a major source of wood for the indigenous people. In some places it is no longer in a healthy enough state to sustain this use. Oil that is spilled in and not cleaned will have an impact on the local environment, spreading over a wide area and affecting both terrestrial and marine resources, inappropriate clean up actions can make the situation worse, the development of the region has led to the degradation of some sites reducing their value and use. In the past, spills have also necessitated the complete resettlement of some communities. Loss of agricultural land, for example, translates into loss of livelihood for farmers while the psychological and social problems associated with displacements include loss of ancestral homes, familiar surroundings, religious and other cultural artefacts (NDES, 1997). Oil settles on beaches and kills organisms that live there; it also settles on ocean floor and kills benthic (bottom-dwelling) organisms such as crabs. Oil poisons algae, disrupts major food chains and decreases the yield of edible crustaceans (Nwilo and Badejo, 2005). It also coats birds, impairing their flight or reducing the insulative property of their feathers, thus, making the birds more vulnerable to cold. Oil endangers fish hatcheries in coastal waters and contaminates the flesh of commercially valuable fish (Agunobi *et al*., 2014). In the Niger Delta, large areas of the mangrove ecosystem have been destroyed. The mangrove was once a source of firewood for the indigenous people and a habitat for the area's biodiversity, but is now unable to survive the oil toxicity (Nwilo and Badejo, 2005). Oil exploration by seismic companies involves surveying, clearing of seismic lines, and massive dynamiting for geological excavations. The explosion of dynamite in aquatic environments leads to narcotic effects and mortality of fish and other faunal organisms (Zabbey, 2004). Destabilization of sedimentary materials associated with dynamite shooting causes increase in turbidity, blockage of filter feeding apparatuses in benthic fauna, and reduction of plant photosynthetic activity due to reduced light penetration. The overall effects of oil spill on biota and ecosystem health are manifold. Oil interferes with the functioning of various organ systems of plants and animals. It creates environmental conditions unfavorable for life; for example, oil on a water surface forms a film layer which prevents oxygen penetration into water bodies, and this in turn leads to suffocation of certain aquatic organisms. Crude oil contains toxic components, which causes outright mortality of plants and animals as well as other sub-lethal damage. Generally, toxicity is dependent on the nature and type of crude oil, the level of oil contamination, the type of environment, and the selective degree of sensitivity of individual organisms. Leakages and fire incidents are also associated with gas production and transportation. In 2004, the

Nigerian Liquefied Natural Gas (NLNG) pipeline traversing the Kala-Akama and Okrika mangrove swamps (in the Niger Delta) leaked and caught fire. The fire burned uncontrollably for three days; local plants and animals inhabiting the affected area were killed (Zabbey, 2004). It must be stressed that incident such as this one can result in the elimination of whole population of endangered species which have restricted distribution and extinction will set in. During construction of the NLNG gas plant in Bonny, footprints of *Hippopotami* were seen (Zabbey, 2004). These giant animals, known to have flourished in the Finima area which the NLNG plant complex now occupies, have vanished completely since then. Whether the rare Finima *Hippopotamus* population all died out or embarked on forced migration to some relatively 'safe' and undisturbed area remains unclear.

In any case, it is well-known that wildlife caused to migrate by anthropogenic disturbances are prone to suffering ecological catastrophes. Fishing, the main livelihood of most residents has also failed to return to pre-oil spill levels even as fisher folks have resumed their fishing activities. Many affected residents especially in the worst affected areas have not recovered from the loss of their livelihood and income (Obienusi *et al*., 2014). When oil spill occurs near the shore, the whole adjoining district is invaded by nauseating pungent smell as air current carries volatile components for a filed. The risk of fire is high so that ships and boats mowed near the harbor are usually warned to leave. Swimming and other recreational activities are suspended (Okonkwo and Eboatu, 1999). Several studies documental cascades of events indirectly affecting individual survival or reproduction after sub-lethal exposures. Oil exposure resulted in lower growth rates, reproductive impartment, abnormal developments in fish, a decline in mating and the appearance of smaller eggs in seabirds, cascades of indirect effects were also present after the oil spill, where indirect interaction lengthened the recovery process on rocky shorelines for a decades or more for example; an initial loss of cover habitat led to losses of important grazers and promoted blooms of unwanted ephemeral green algae and opportunistic barnacles (Zheng et al., 2014).

MITIGATION AND COMPENSATION OF VICTIMS OF OIL SPILLAGE IN THE NIGER DELTA

Mitigation

A complex of mechanical, chemical, and biological approaches can be applied for the remediation of petroleum hydrocarbon contamination. The commonly used mechanical techniques include collection and skimming, wiping, water flushing, tilling, as well as cutting vegetation and burning (Ndimele, 2008). Mechanical removal of oil spills are usually utilized as an initial strategy for cleaning up in aquatic and terrestrial environments. However, they can be expensive and need specialized equipment. Therefore, other methodologies can be considered. In situ burning of oil is an alternative treatment, which can be used for quick removal of thick film of oil spilled on a water body or land. However, its application is limited according to the condition of the environment. For example, some plant communities like needle grasses are sensitive and may be damaged or eliminated by fire. In addition, *in situ* burning could threaten human health and environ-mental resources due to the smoke and the probability of flashback and secondary fires (Frynas, 2012). Thermal desorption is an ex situ burning technique that is growing in popularity and use. It uses heat to burn, decompose, or destroy the contaminants in soil leaving the mineral content of the soil after treatment. Sorbents are oleo-philic and hydrophobic materials used for oil spill cleanup in offshore and onshore lines. They can be classified into inorganic minerals (e.g. Clay, zeolites, silica gel), synthetic organics (e.g., poly-urethane and polypropylene), and agricultural products (e.g., straw, mangrove barks, kenaf). Both inorganic minerals and synthetic organic products have high sorption capacity, but they have low retention capacity and low decomposition, respectively. Agricultural-based sorbents are relatively cheap, abundant, and eco-friendly; however, low sorption capacity and low hydrophobicity are their shortcomings (Ndimele, 2008). The other commonly used method is the application of chemical materials such as dispersants, cleaners, demulsifiers, bio-surfactants, and soil oxidizers. But due to disagreements on effectiveness and possible toxicity effects of chemical materials, there are widespread concerns over their applications (Pezeshki *et al*., 2000; Ndimele, 2010; Kang *et al*., 2010). For instance, Corexit, oil mixture and other dispersants have been shown to be toxic on aquatic species. Corexit has been reported to change, the intracellular oxidative balance and impede mitochondrial functions in mammalian cells and affect human health (Zheng *et al*., 2014). Biological treatment is another cleanup technique that developed in the 1980s, which uses the natural ability of microorganisms and/or plants for removing pollutants. On site operation of this technology can be less expensive and causes minimum site disruption, and therefore, it has the greater public acceptance (Jagadevan and Mukherji, 2004). However, biological treatment is most effective at sites with low to medium level of contamination (Schnoor, 1997); also, the method may require more time to reach optimal operational conditions to achieve the remedial goals and, there are mechanisms involved in biological treatment of water affected by crude oil spill which can be discussed as follows:

Bioremediation Techniques Using Micro-Organisms

Some microbial organisms are able to break down petroleum hydrocarbons into simpler products through enzymatic processes to obtain carbon and energy for growth. These processes are termed as biodegradation. Biodegradation is an intercellular activity which can occur aerobically or anaerobically (Jagadevan and Mukherji, 2004). Anaerobic degradation is much slower than aerobic degradation and uses Fe, Mn, sulfate, and CO_2 instead of oxygen as electron acceptors. In these reactions, hydrocarbons act as an electron donor. Due to the complexity of petroleum hydrocarbons, a single microorganism type with distinctive enzymes is not able to do a complete degradation. Recognition of indigenous microbial populations in petroleum-contaminated soil or water has been investigate. Usually, a cooperation of diverse microorganisms is required to degrade almost all of the components. There are a host of species of bacteria, *archaea*, and fungi involved in the biodegradation process (Adelana *et al*., 2011). Attempts to accelerate the rate or extent of microbial activities can result in the increase of hydrocarbon removal from a contaminated area (Leahy and Colwell, 1990; Ebuehi *et al*., 2005). There are a variety of physicochemical pre-treatments that can be used in these cases (Haritash and Kaushik, 2009). The application of chemical solvents such as acetone and the use of ozone and UV radiation, oxidation, and also thermal treatments have been reported to be effective in increasing the rate of diffusion of contaminants in media and consequent bio-availability (Lee *et al*., 2001; Haritash and Kaushik, 2009; Ishak and Malakahmad, 2013). However, their application is limited because of the formation of harmful chemical residues, high expenses, and energy consumption (Makkarand and Rockne, 2003). Moreover, the acceleration rate of degradation may be done by addition of indigenous or well adapted microorganisms to existing native microbes in the contaminated soil, which is termed as bio-augmentation (Roldán-Martín *et al*., 2007; Liang *et al*., 2009; Khan *et al*., 2013). Similarly, the supply of oxygen can be increased in polluted soil using techniques such as bioventing, land farming, and composting to maintain aerobic conditions (Malakahmad and Jaafar, 2013).

Bioremediation Techniques Using Plants

Plants have different mechanisms for the removal and/or degradation of organic hydrocarbons from impacted soils. Although only a few degradation processes occur directly in plant tissues, most degradation are the result of the complex association of roots, root exudates, rhizosphere, and microbes, which is termed as rhizo-remediation (Cai *et al*., 2010; Ndimele *et al*., 2011; Khan *et al*., 2013). The specific physiology and biochemistry of plant roots along with the activity of rhizosphere microorganisms make plant metabolic systems able to remediate toxic xenobiotics (Meagher, 2000). The ability of plants for remediation is clearer knowing that there are more than 100 million miles of roots per acre that offers a great potential for restoring large areas of surface and depth contamination (Merkl *et al*., 2004; Anderson *et al*., 2008; Gerhardt *et al*., 2009). The root system of higher plants is associated not only with soil environment but also with a vast community of metabolically active microorganisms. The living plants create unique habitats on and around the roots where the microbial population is considerably higher than that of root free soil environment (Lu *et al*., 2010). Around 40 % of a plant's photosynthate can be exuded by plant roots into the soil as sugars, organic acids, and aromatic compounds, which are rich in carbon and energy for micro-organisms growth (Khan *et al*., 2013). These exudates can initiate the chemotactic response of microbes for motility towards the roots and formation of root colonization, which consequently stimulate growth and activity of microorganisms for the degradation of organic pollutants (Leigh *et al*., 2002; Gerhardt *et al*., 2009). Studies showed that each species have distinct chemical compositions and rates of exudation which have different effects on microorganisms (Grayston *et al*., 1998; Yang and Crowley, 2000; Bais *et al*., 2006). Therefore, the degradation activity is influenced by the individual composition of plant exudates (Gleba *et al*., 1999). Plant roots are also able to provide oxygen for microorganisms in the rhizosphere and increase the oxidative degradation of hydrocarbons through the penetration into the soil and improvement of the soil structure. The end products of degradation include alcohol, acids, car-bon dioxide, and water, which are less toxic and less persistent than the primary compounds (Gerhardt *et al*., 2009). In addition to the stimulated microbial activity, the plant also releases enzymes from roots such as de-halogenase, nitro-reductase, peroxidase, and laccase that play a significant role in reduction of organic contaminants (Alkorta and Garbisu, 2001). They contribute in transforming petroleum hydrocarbons by catalyzing the chemical reactions as well as the reduction of bio-availability of the contaminants through binding them in the rhizosphere or into soil organic matter, which is termed as phyto-stabilization (Merkl *et al*., 2004).

In aquatic ecosystems such as lakes, rivers, and wet-lands, there are different types of plants termed macro-phytes thriving in or near water that are emergent, sub-emergent, or floating (Bhatia and Goyal, 2014). They can be possibly used as oil hydrocarbon phytoremediators. One of the characteristics that make them suitable for phytoremediation is their ability to grow fast. They are invasive and rapidly become abundant. Thus, they can be replaced with new growth soon after the damage caused by oil pollution (Bhatia and Goyal, 2014). The fibrous roots of some aquatic plants can provide larger surface and denser rhizospheres for microbial colonization (White *et al*., 2006; Ndimele, 2010) reported that water hyacinths (*Eichhornia crassipes*) fibrous root systems are able to significantly remediate the floating petroleum hydrocarbons on surface waters. Biscuit grasses (*Paspalum vaginatum*) were also reported to be potential candidates for petroleum hydrocarbons phytoremediation. Their root system facilitated survival and growth in diesel contaminated sands (up to 30 g.kg−1). Reeds, dominant coastal wetland plants, can also provide strong vitality and great root surface area which is beneficial for restoring the petroleum-contaminated wetlands (Wang *et al*., 2011). Four fresh-marsh plant species, alligator weed (*Alternanthera philoxeroides*), maiden cane (*Panicum hemitomon*), common reed (*Phragmites australis*), and duck potato (*Sagittaria lancifolia*) effectively phyto-remediated South Louisiana Sweet Crude oil in contaminated mesocosms (Dowty et al. 2001). In aquatic ecosystems, due to hypoxic and anoxic conditions of sediments or soils, anaerobic degradation of crude oil happens which is a very slow and incomplete process. Some macrophytes transport atmospheric oxygen from the shoots to the roots and increase the aerobic respiration of rhizosphere microbes (Pezeshki *et al*., 2000; Moreira *et al*., 2011). This is a natural mechanism of wetland plants, or submerged aquatic macrophytes, which makes them able to oxygenate their root zone to protect themselves against phyto-toxins (e.g., Fe_2+,Mn_2+,and H_2S) (Pezeshki *et al*., 2000). Huesemann *et al*. (2009) have shown that eelgrass (*Zostera marina*), a marine macrophyte, can significantly remove poly nuclear aromatic hydrocarbons and polychlorinated biphenyls in submerged marine sediments. This enhanced rhizosphere biodegradation through root exudates, oxygen, and plant enzymes was the dominant removal process. Red mangrove (*Rizophora mangle*) has also been reported to increase the bacteria density in the rhizosphere ten times more than bulk sediments, possibly through the entry of oxygen into the sediments (Moreira *et al*., 2011). Similarly, the aquatic weed cattails (*Typha* spp.) have been demonstrated to release higher rates of oxygen into their rhizospheres compared to the coastal salt marsh-black rushes (*Juncus roemerianus*) with the difference in oxygen release intensity between plant species found to be related to the redox state of the rhizosphere (Wiebner *et al*., 2002). In a horizontal-vertical flow constructed wetland, cattail and bulrush (*Scirpus lacustris*) removed 99.9 % of phenanthrene; while black rush, a dominant coastal salt marsh plant, effectively reduced total petroleum hydrocarbons (TPH) up to 15% in contaminated sediments (Lin and Mendelssohn, 2009). In floating species, where the root system does not establish into a solid matrix, the ability of plants for bio-accumulation and bio-sorption of pollutants from the liquid medium make them able to be considered as phyto-remediators (Mkandawire and Dudel, 2002; Rahman and Hasegawa, 2011). There are some phyto-remediation studies on floating plants such as water lettuce (*Pistia stratiotes*) and duckweed (*Spirodela polyrrhia*) for removing crude oils of oil-polluted water bodies. However, their performance was not promising (Agbogidi and Bamidele, 2009; Akapo *et al*., 2011). In general, there are few studies to identify the ability of aquatic species for crude oil phyto-remediation. Since most oil spills occur in aquatic environments, the need to test the efficiency of aquatic macrophytes seems to be necessary (Ochekwu and Madagwa, 2013).

Compensation

The Federal Government of Nigeria's (FGN) response to the demand for community development and compensation for the negative effects of oil extraction in the Niger Delta has generally been through the creation of new institutions and the occasional marginal increase in oil revenue allocated to the region, as was done with the 3% increase in 1992 and 13% increase in derivation fund in 2000 (Ajiboye *et al*., 2009; Amodu, 2012; Ebegbulem *et al*., 2013). Over the past few decades, the Niger Delta has received various forms of developmental attention. In 1960, the FGN set up the Niger Delta Development Board (NDDB) based on Sir Henry Willink Commissions report, which specifically recommended special developmental attention for the region. This was before crude oil became the mainstay of the Nigerian economy. The NDDB could not, however, make any significant developmental impacts on the region as it did not reflect Willink's dream of serving as a special developmental agency for the Niger Delta. When oil started dictating the pace of Nigeria's economy, there was growing consciousness among the people leading to more agitation that the commission's recommendations be fully implemented. Consequently, a Presidential Task Force was set up which devoted 1.5% of the Federation Account to the development of the Niger Delta Region (NDDC, 2001).

When the then Babangida administration realized that the 1.5% special account did not make any meaningful impact (mostly owing to the clear instances of restiveness in the region), it set up the Belgore Commission, and among other things, identify the root causes of the incessant clashes and disaffection in the oil region as well as suggesting the best way forward. The Commission's recommendations led to the setting up of the Oil Mineral Producing Area Development Commission (OMPADEC) in 1993. Though, OMPADEC appeared better established than previous agencies; Akpan and Akpabio (2003) observed that its developmental impacts were not quite significant as the Commission suffered a number of fundamental developmental problems namely: a lack of a master plan that would define its developmental agenda and strategies; inadequate funding, official profligacy, and an unfavorable political climate. The failure of these intervention agencies worsened the economic and developmental problems in the region especially in the face of persistent degradation of the ecological system as a result of oil exploration. Consequently, by 1998, the region had become a much more volatile atmosphere characterized by protests, lawlessness, agitation and conflicts (Azaiki, 2003). In 1999, following the inauguration of a democratic government, the NDDC was set up, with the following objectives (NDDC. 2000): policy formulation, master plan conception, surveying of the Niger Delta area, implementation of master plan and evaluation of all developmental actions. In almost all cases, it is clear that intervention programmes for the development of the Niger Delta region have all been well conceived. However, the bulk of the problem of such agencies lies in implementation and financing. Hence, Frynas (2000) asserted that the NDDC was merely an exercise in public relations, while Omotola (2006) argued that OMPADEC was only a vehicle used to siphon money by the political elites and that, it has been unable to deliver on its developmental promise.

The law which vests the ownership [of oil] in the Federal Government and land in the State Government recognizes suffice rights of parties (i.e. owners and occupiers of land) which are required to be compensated in the event of damage or loss (Eweje, 2006). The compensation payable in the event of oil spillage is hinged on ameliorating the damage caused to private properties, other valuables, or infringement on the occupation or usage of any part of the environment. Compensation, when paid to ameliorate the effect of oil spillage goes to the victims or owners of the properties damaged by the spill as an amendment of the loss or wrong they suffered (Ebeku, 2002). More often than none, payment of compensation with respect to ameliorating injuries or damage caused by oil spillage is said to be an uphill task in Nigeria due to some unfavorable lacuna and grey areas inherent in the Municipal Statutes governing compensation in the oil and gas operations in Nigeria. The grey areas or lacunas in the statutes as the case may be, provide grounds and veritable lee-ways for payment of insufficient compensation or outright refusal of compensation of victims of oil spillages (DPR. 2007). Therefore, there is a problem of ineffective/non-payment of compensation to victims of oil spillage. The problem of non/ineffective payment of compensation seems to be prevalent because the legal and institutional framework for compensation in cases of oil spillage is incoherent and was not articulated to accommodate the menace of oil spillage which is the negative aspect of oil exploration (Francis *et al*., 2011). Similarly, the institutional framework also accounts for the inadequate or meager compensation in cases of oil spillage; and the inadequacy in compensation for oil spill damage had been identified as a major cause of conflict in the host communities/oil producing communities of the Niger Delta region of Nigeria for which the fall out of such conflicts leads to destruction of oil and gas installations, income losses, less of manpower, loss of peaceful coexistence and abduction of expatriates and indigenous oil company workers (DPR. 2014). The fact that the law of compensation is part of the general law of remedies which does not only apply to contract but also covers other elements like disturbances and injurious affections suffered by any part (CEESP-IUCN. 2006); presupposes that the law of compensation covers such areas as personal injuries or disturbances sustained/suffered in the event of petroleum activities and oil spillage in particular.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Since the discovery of oil in Nigeria in the 1950s, the Niger Delta has been suffering the negative environmental consequences of oil development. Oil spill has affected the Niger Delta region drastically including human and environmental degradation; the life expectant in the region is below 50/60 years. The people of this region have lost their traditional means of livelihood (agriculture: fishing and crop production) to oil spills, these economic losses aggravate the poverty level in the region rather than alleviate it. The once pristine environment of the Niger Delta has been severely degraded with the surface and groundwater highly contaminated and unfit for aquatic organisms. Hence, the occurrence of oil spills in the region, the waters are highly degraded and aquatic flora and fauna are severely affected, the fish species in the region have been endangered and some have gone extinct as a result of the pollution caused by the oil spillage. Communities fight against each other over ownership of resources and sharing of empowerment from oil companies, some communities are even displaced with loss of lives. These are some of the negative vices the region goes through; lack of strict compliance to existing environmental protection rules and regulations, with the inability of governmental and non-governmental agencies to enforce these laws have contributed to the pollution of the ecological systems of the Niger Delta; therefore, to make the region to be habitable in the nearest future, it is the utmost task of the Government of Nigeria and Multi-national oil companies to mitigate and restore the Niger Delta ecological systems.

Recommendations

The Niger Delta waters and the aquatic biodiversity should be protected; the government and multi-national oil companies should launch a clean-up programme on the affected areas/the region, and the management of spills (both of catastrophic and local dimensions) will play a leading role by enacting and enforcing stringent environmental laws that will protect the oil producing areas. Government should be able to identify natural resources (such as wetlands and coastal zones) in Nigeria and monetary investment in environmental protection of vulnerable areas should be seriously looked into. There should be an operating standard for the examination of the existing water quality and monitoring, in addition to active monitoring and evaluation systems for water-related projects and services in the region. It is long overdue for the government to stop gas flaring in the Niger Delta, to reduce environmental pollution. The government and multi-national oil companies should establish Freshwater Protected Areas (FPAs) and Marine Protected Areas (MPAs) in the Niger Delta. We are left with a great question: can gas flaring and illegal refineries be stopped in the Niger Delta?

Finally, the establishment of a framework for collaboration through training and financial support by government to strengthen environmental agencies and organizations in their roles as watchdog for ensuring the exchange of information, especially for high risk oil production activities.

REFERENCES

Achebe, C.H., U.C. Nneke and O.E. Anisiji. (2002). Analysis of Oil Pipeline Failures in the Oil and Gas Industries in the Niger Delta Area of Nigeria. *Open Access Journal*. 1-6. Core database.

Achi C. (2003). Hydrocarbon exploitation, environmental degradation and poverty: the Niger delta experience. Paper presented at: The diffuse pollution conference. Dublin. Ireland

Adelana, S. O., Adeosun, T. A., Adesina, A. O. And Ojuroye, M. O. (2011). Environmental pollution and remediation: Challenges and management of oil spillage in the Nigerian coastal areas. *American Journal of Scientific and Industrial Research*, 2(6):834-845.

Adetokunbo, A. and Abiola, O. (2002). Environmental News Service [EWS]: Oil Spill Devastates Niger Delta Community.

Adetular V.A.O. (1996). Oil and the people of Niger delta: a case study of economic, social and cultural impacts of oil pollution. Research Report. Jos, Nigeria: Centre for Development Studies.

Agbogidi, O. M., and Bamidele, J. F. (2009). Suitability of *Pistia stratiotes* Linn. And *Spirodela polyrrhiza* Trev. for the removal of pollutants in oil polluted water bodies. Discovery and Innovation, 19(2).

Agunobi, K. N., Obienusi, E. A. and Onuoha, D. C. (2014). An investigation of the pattern and environmental impact of oil spillage in Etche Local Government Area of Rivers State, Nigeria. *Journal of Natural Sciences Research*, 4(16): 124-137.

Ajiboye, O. E., Jawando, J. O. and Adisa, W. B. (2009). Poverty, oil exploration and Niger Delta crisis. In: The response of the youth. African Journal of Political Science and International Relations, 3(5): 224-232.

Akapo, A. A. R., Omidiji, S. O., and Otitoloju, A. A. (2011).Morphological and anatomical effects of crude oil on *Pistia stratiotes*. The Environmentalist, 31(3), 288–298.

Akpan, N. S. and Akpabio, E. M. (2003). Youth restiveness and violence in the Niger Delta region of Nigeria: Implications and Suggested solutions. *International Journal of Development Issues*, 2(2):37-58.

Akpofure, E. A., Efere, M. L. and Ayawei, P. (2000). The adverse effects of crude oil spills in the Niger Delta. In: Urhobo Historical Society. http://www.waado.org/environment/petrolpolution/oilspills/OilSpills_AdverseEffects.hml.

Alexander, L. (2007). Oil and gas development on the Sakhalin Island: an assessment of changesin the Okhostsk sea ecosystem [Internet]. Available from: http://www.src-h.slav.hokudai.ac.jp/sakhalin/eng/71/leonov.html.

Alkorta, I. and Garbisu, C. (2001). Phytoremediation of organic contaminants in soils. Bioresource Technology, 79(3), 273–276.

Amnesty International (AI.) (2011). Report. UN confirms massive oil pollution in Niger Delta. Retrieved June 19, 2018 fromhttp://www.amnestyusa.org/news/news-item/un-confirms-massive-oilpollution-in-niger-delta.

Amodu, L. O. (2012). Community relations strategies and conflict resolution in the Niger Delta. In: a study of three major oil companies. A Ph.D Thesis, Covenant University, Ota, Nigeria. 244 p.

Anderson, R. G., Booth, E. C., Marr, L. C., Widdowson, M. A., and Novak, J. T. (2008). Volatilization and biodegradation of naphthalene in the vadose zone impacted by phytoremediation. Environmental Science and Technology, 42(7), 2575–2581.

Azaiki, S. (2003). Inequities in Nigerian Politics. In: The Niger Delta, Resources Control, Underdevelopment and Youth Restiveness. Yenagoa, Treasure Books.

Bais, H. P., Weir, T. L., Perry, L. G., Gilroy, S., and Vivanco, J. M. (2006). The role of root exudates in rhizosphere interactions with plants and other organisms. Annual Review of Plant Biology, 57,233–266.

Baker, J. M. (1981). The investigation of oil industry influence on tropical marine ecosystems. Mar Pollut Bull. 12(1):6–10.

Bhatia, M. and Goyal, D. (2014). Analyzing remediation potential of wastewater through wetland plants: a review. Environmental Progress and Sustainable Energy, 33(1), 9–27.

Cai, Z., Zhou, Q., Peng, S. and Li, K. (2010). Promoted biodegradation and microbiological effects of petroleum hydrocarbons by *Impatiens balsamina* L. with strong endurance. *Journal of Hazardous Materials*, 183(1), 731–737.

CEESP-IUCN. (2006). Niger Delta resource damage assessment and restoration project. Retrieved November 1, 2018 from http://cmsdata.iucn.org/downloads/niger_delta natural resource damage assessment and restoration project recommendation.doc.

Department of Petroleum Resources (DPR) (2007). Oil spill data. Department of Petroleum Resources (DPR). http://www.dpr.gov.ng.

Department of Petroleum Resources (DPR) (2014). Nigerian oil industry annual statistical bulletin 2012. http://www.dpr.gov.ng.

Department of Petroleum Resources (DPR). (2004). Oil spillage in the Niger delta (Easternoperations). Port Harcourt: DPR.

Dowty, R. A., Shaffer, G. P., Hester, M. W., Childers, G. W., Campo, F. M., and Greene, M. C. (2001). Phytoremediation of small-scale oil spills in fresh marsh environments: amesocosm simulation. *Marine Environmental Research*, 52(3), 195–211.

Ebegbulem, J. C., Ekpe, D. and Adejumo, T. O. (2013). Oil exploration and Poverty in the Niger Delta Region of Nigeria. In: A critical analysis. *International Journal of Business and Social Science*, 4(3): 279-287.

Ebeku, K .S .A. (2002). Oil and the Niger Delta People in Inter-national Law. Resource Rights, Environmental and Equity Issues, OGEL Special Study Vol. 5, published in November 2002 by Oil, Gas and Energy Law Intelligence (OGEL).

Ebuehi, O. Abiola, I.B. Shekwolo, P. Sigimund, K.I. (2008). Remediation of Crude Oil Contaminated Soils by Enhanced Natural Attenuation Techniques. Pp123-136.

Eweje, G. (2006). Environmental Costs and Responsibilities Resulting from Oil Exploitation in Developing Countries: The Case of the Niger Delta of Nigeria. *Journal of Business Ethics*, 69:27–56. www.jstor.org database.

Francis, P., Lapin, D. and Rossiasco, D. (2011). Securing development and peace in the Niger Delta: A social and conflict analysis for change.

Frynas, J. G. (2000). Oil in Nigeria. In: Conflict and litigation between oil companies and village communities. Hamburg and London: Washington DC: Woodrow Wilson International Centre for Scholars.

Frynas, J. G. (2012). Corporate Social Responsibility or Government Regulation? Evidence on Oil Spill Prevention. *Ecology and Society* 17 (4): 4. 1-13. Ecology and society database.

Garrity, S. D. and Levings, S. C. (1990). Effects of an oil spill on the gastropods of a tropical intertidal reef flat. Marine Environmental Research, 30(2): 119-153.

Gerhardt, K. E., Huang, X. D., Glick, B. R., and Greenberg, B. M. (2009). Phytoremediation and rhizoremediation of organic soil contaminants: potential and challenges. *Plant Science*, 176(1), 20–30.

GESAMP. (1993). Impact of oil and related chemicals and wastes on marine environment. GESAMP Reports and studies. London, United Kingdom: IMO.

Gleba, D., Borisjuk, N. V., Borisjuk, L. G., Kneer, R., Poulev, A., Skarzhinskaya, M., and Raskin, I. (1999). Use of plant roots for phytoremediation and molecular farming. Proceedings of the National Academy of Sciences, 96(11), 5973–5977.

Grayston, S. J., Wang, S., Campbell, C. D., and Edwards, A. C. (1998). Selective influence of plant species on microbial diversity in the rhizosphere. Soil Biology and Biochemistry, 30(3), 369–378.

Haritash, A. K., and Kaushik, C. P. (2009). Biodegradation aspectsof polycyclic aromatic hydrocarbons (PAHs): a review. *Journal of Hazardous Materials*, 169(1), 1–15.

Huesemann, M. H., Hausmann, T. S., Fortman, T. J., Thom, R. M., and Cullinan, V. (2009). *In situ* phytoremediation of PAH and PCB-contaminated marine sediments with eelgrass (*Zosteramarina*). Ecological Engineering, 35(10), 1395–1404.

Ibaba, S. I. (2001). Understanding the Niger Delta crisis. Port Harcourt: *Jiral Publication Company*.

Ibeanu, O. O. (1999). Ogoni –oil, resource flow and conflict. In: T. Granfelt (Ed.).Managing the globalized environment (local strategies to secure livelihood) pp.9-25.

Idemudia, U. (2005). Corporate partnerships and community development in the Nigerian oil industry. In: strengths and limitations. Retrieved September 24, 2018 from, http://www.unrisd.org/$file/Idemudia.pdf.

Ishak, S. and Malakahmad, A. (2013). Optimization of Fenton process for refinery wastewater biodegradability augmentation. *Korean Journal of Chemical Engineering*, 30(5), 1083–1090.

Isyban, A.V. and Izrael J.A. (1988). Anthropogenic ecology of the ocean. Lenningrad, Russia: Hydrometeoizdat.

Jagadevan, S. and Mukherji, S. (2004). Successful *in situ* Oil Bioremediation Programmes: Key Parameters. Biology. Pp. 33-45.

Jike, V. T. (2010). Oil companies and host communities, In: A probable scenario for reciprocal empowerment. *Journal of Human Ecology*, 30(2):131-142.

Kadafa, A. A. (2012). Environmental impacts of oil exploration and exploitation in the Niger Delta of Nigeria. Global Journal of Science Frontier Research, 12(3): 18-28.

Khan, D. A. (2013). Global environmental issues and its remedies. *International Journal of Sustainable Energy and Environment*, 1(8): 120-126.

Leahy, J. G. and Colwell, R. R. (1990) Microbial Degradation of Hydrocarbons in the Environment _ Microbio Rev. 54(3), 305 – 315.

Leigh, M. B., Fletcher, J. S., Fu, X. and Schmitz, F. J. (2002). Root turnover: an important source of microbial substrates in rhizosphere remediation of recalcitrant contaminants. Environmental Science and Technology, 36(7), 1579–1583.

Liang, Y., Zhang, X., Dai, D. and Li, G. (2009). Porous bio-carrier enhanced biodegradation of crude oil contaminated soil. International Bio-deterioration and Biodegradation, 63(1), 80–87.

Lin, Q. and Mendelssohn, I. A. (2009). Potential of restoration and phytoremediation with *Juncus roemerianus* for diesel contaminated coastal wetlands. Ecological Engineering, 35(1), 85–91.

Lu, M., Zhang, Z., Sun, S., Wei, X., Wang, Q. and Su, Y. (2010). The use of goose grass (*Eleusine indica*) to remediate soil contaminated with petroleum. Water, Air, & Soil Pollution, 209(1–4), 181–189.

Makkar, R. S., and Rockne, K. J. (2003). Comparison of synthetic surfactants and bio-surfactants in enhancing biodegradation of polycyclic aromatic hydrocarbons. Environmental Toxicology and Chemistry, 22(10), 2280–2292.

Malakahmad, A., and Jaafar, N. (2013). Oil sludge contaminated soil bioremediation via composting using refinery treatment plant sludge and different bulking agents. In Business Engineering and Industrial Applications Colloquium (BEIAC), 2013 I.E. (pp. 832–835). IEEE.

Meagher, R. B. (2000). Phytoremediation of toxic elemental and organic pollutants. Current Opinion in Plant Biology, 3(2), 153–162.

Merkl, N., Schultze-Kraft, R., and Infante, C. (2004). Phytoremediation in the tropics—the effect of crude oil on the growth of tropical plants. *Bioremediation Journal*, 8(3–4), 177–184.

Mkandawire, M., and Dudel, G. E. (2002). Uranium attenuation from tailing waters by floating macrophyte *Lemna gibba* L. In Uranium in the aquatic environment (pp. 623–630).Springer Berlin Heidelberg.

Mobil Producing Nigeria (MPN) (1998). January 1998 Idoho – QIT 24 pipeline oil spill. Short termenvironmental impact assessment report. Nigeria: Mobil Producing Nigeria.

Moreira, I. T., Oliveira, O. M., Triguis, J. A., dos Santos, A. M., Queiroz, A. F., Martins, C. M. and Jesus, R. S. (2011). Phytoremediation using *Rizophora mangle* L. in mangrove sediments contaminated by persistent total petroleum hydro-carbons (TPH's). *Microchemical Journal*, 99(2), 376–382.

Mukoro, A. (2009). Contending issues in governance and democracy at the local government level in Nigeria: some reflections on the Niger Delta question. In: V. Ojakorotu (Ed.).Contending Issues in the Niger Delta crisis of Nigeria. p. 54-94.

National Population Commission (NPC) (2006). The population of Local Government Areas (LGAs) of Rivers State (2006).

Ndimele, P.E. (2008). Evaluation of phytoremeditive properties of water Hyacinth and Bio-stimulants in Restoration of Oil polluted wetland in the Niger Delta. PhD Thesis, University of Ibadan, Nigeria.

Niger Delta Development Commission (NDDC) (2000). (Establishment, ETC) Act, 2000 No. 6. http:/ / extwprlegs 1 .fao.org /docs /pdf /nig 42654. pdf

Niger Delta Development Commission (NDDC) (2001). NDDC profile, Niger Delta Development Commission, Port Harcourt, Nigeria. Retrieved October 12, 2018 from, htpp://www.nddc.gov.ng.

Niger Delta Development Commission (NDDC) (2006) Niger delta regional development master plan: Draft 3. Directorate of planning, NDDC, Port Harcourt.

Niger Delta Environmental Survey (NDES) (1997). The Niger Delta environmental survey: Terms of reference. Lagos: Environmental Resources Manager Limited.

Nigerian Bureau of Statistics (NBS) (2006). Annual abstract of statistics. Abuja: NBS.

Nwilo, P. C. and Badejo, O. T. (2005). Oil spill problems and management in the Niger Delta. International Oil Spill Conference Proceedings, 1: 567-570.

Nwilo, P. C. and Badejo, O. T. (2006). Impacts and management of oil spill pollution along the Nigerian coastal areas. FIG Publications, 36: 119-133.

Nwilo, P. C. and Badejo, O. T. (2001). Impacts of oil spills along the Nigerian coast. http: //nigerdeltatoday. Wordpress .com 2008/ 10/24 /impacts of oil spills along the Nigerian coast/.

Nwoko, C. N. (2014). Assessing the socioeconomic impacts arising from oil pollutions in the Niger Delta region of Nigeria, In: Including proposals for solution. Ph. D Dissertation. Aalto University, Helsinki.

Obienusi, K. N., Eyo E. A. and Onuoha, D. C. (2014). An investigation of the pattern and environmental impact of oil spillage in Etche Local Government Area of Rivers State, Nigeria. *Journal of Natural Sciences Research*, 4(16): 124-137.

Ochekwu, E.B. and Madagwa, B. (2013). Phytoremediation potentials of water hyacinth (*Eichhornia Crassipes* (Mart) solms) in crude oil polluted water: Applied science Environmental Management, 17(4): 503-507.

Ogbogbo, C.B.N. (2004). The Niger delta and the resource control conflict since 1960–1995[Ph.D. Institute of African studies dissertation]. Nigeria: University of Ibadan.

Ogele, F. O. (2016). Governance of oil and gas sector in Nigeria: Implications for biodiversity and ecosystem services in the Niger Delta region. Ph. D Thesis, Newcastle University. 393 p.

Okonkwo, E.M. and Eboatu A.N., (1999): Environmental Pollution and Degradation, Onis Excel Creations Ltd, Zaria, Book 2.

Olujimi, J. A., Adewumi, E. A. and Odunwole, S. (2011). Environmental Implications of oil exploration and exploitation in the coastal region of Ondo State. *Journal of Geography c and Regional Planning*, 4(3): 110 –121.

Omotola, J. S. (2006). The limits of election monitoring: The 2003 Nigerian general elections. Representation, 42(2):157-167.

Onuoha, F.C. (2008). Oil Pipeline Sabotage in Nigeria: Dimensions, Actors and Implications for National Security L/C. African Security Review Vol. 17 No.3. Institute for Security Studies. www.isso.co.za.

Opukri, C. O. and Ibaba S. I. (2008). Oil Induced Environmental Degradation and Internal Population Displacement. In: The Nigeria's Niger Delta. *Journal of Sustainable Development in Africa*. 10, No.1. www.jsd-africa database.

Opukri, O. C. and Ibaba S. I. (2011). Oil Induced Environmental Degradation and Internal Population Displacement in the Nigeria's Niger Delta. Journal of Sustainable Development in Africa, 10(1).

Ordinioha, B. and Brisibe, S. (2010). "The human health implications of crude oil spills in the Niger delta, Nigeria: An interpretation of published studies", *Nigerian Medical Journal*, vol. 54, no. 1, p. 10.

Osuagwu, H.G.O. (1984). The Direct Effect of the Discovery of Petroleum on the Development of the Nigerian Agricultural Sector. Proceedings of the International Conference on Petroleum and Agriculture organized by the Petroleum Training Institute, Warri. 7th – 10th October, Warri.

Osuji, L C (2001). Post impact assessment of oil pollution in Agbada west plain of Niger Delta, Nigeria: field reconnaissance and total extractable hydrocarbon content. Journal of Applied Sciences and Environmental Management, 5(35), 1569–1578.

Oyem, A. (2001) Christian Call for Action on Nigerian Oil Spill _ Saga – Oxford's Christian Environmental Group.

Pezeshki, S. R., Hester, M. W., Lin, Q., and Nyman, J. A. (2000).The effects of oil spill and clean-up on dominant US Gulf coast marsh macrophytes: a review. Environmental Pollution, 108(2), 129–139.

Powell, C. B. (1986). Sites and species of conservation interest in the Central Axis of the Niger Delta (Section C), report submit-ted to the Natural Resources Conservation Council of Nigeria, Biodiversity Unit, Rivers State University of Science and Technology, Port Harcourt, Nigeria.

Rahman, M. A., and Hasegawa, H. (2011). Aquatic arsenic: phytoremediation using floating macrophytes. Chemosphere, 83(5), 633–646.

Roldán-Martín, A., Calva-Calva, G., Rojas-Avelizapa, N., Díaz-Cervantes, M. D., & Rodríguez-Vázquez, R. (2007). Solid culture amended with small amounts of raw coffee beans for the removal of petroleum hydrocarbon from weathered contaminated soil. *International Biodeterioration and Biodegradation*, 60(1), 35–39.

Schnoor, J. (1997). Phytoremediation: Technology Evaluation Report (TE-98-01). Groundwater Remediation Technologies Analysis Center. *International Journal of Environmental Bioremediation and Biodegradation*, Vol 7(1). 1-19.

Stakeholders Democracy Network (SDN) (2016). Recent oil spills in Delta and Bayelsa States, Nigeria.

Ugochukwu, C. N. C. and Ertel, J. (2008). Negative Impacts of Oil Exploration on Biodiversity Management in the Niger Delta Area of Nigeria. *Impact Assessment and Project Appraisal*, 26(2), 139–147. Retrieved, 31st October, 2012, from the University of Winnipeg Lbrary database.

Ukoli, M. K. (2005). Environmental factors in the management of the oil and gas industry in Nigeria. www.cenbank.org. http:// warmofloor.co.uk/pages/environmental.

Ukwayi, J. Ambekeh, U.L, Chibuzo, C.U, and Undelikwo, V. (2013). Oil Companies and environmental pollution in Nigeria. In Political Economy of Nigeria, ed. CAke, pp.113–140. London and Lagos: Longman.

United Nations Development Programme (UNDP) (2006). Niger delta human development report. Abuja: UNDP.

Wang, J., Liu, X., Zhang, X., Liang, X., and Zhang, W. (2011).Growth response and phytoremediation ability of Reed for diesel contaminant. Procedia Environmental Sciences, 8, 68–74.

White, P. M., Jr., Wolf, D. C., Thoma, G. J., and Reynolds, C. M. (2006). Phytoremediation of alkylated polycyclic aromatic hydrocarbons in a crude oil-contaminated soil. Water, Air, and Soil Pollution, 169(1–4), 207–220.

Wiebner, A., Kuschk, P., and Stottmeister, U. (2002). Oxygen release by roots of *Typha latifolia* and *Juncus* effuses in laboratory hydroponic systems. *Acta Biotechnologica*, 22(1–2), 209–216.

Yang, C. H., and Crowley, D. E. (2000). Rhizosphere microbial community structure in relation to root location and plant iron nutritional status. *Applied and environmental microbiology*, 66(1), 345–351.

Zabbey, N. (2004). Impacts of Extractive industries on the Biodiversity of the Niger Delta Region, Nigeria. Paper Presented at National Workshop on Coastal and Marine Biodiversity Management, Calabar; Cross River State, Nigeria. 7-9 September.

Zabbey, N. (2009). Petroleum and pollution; how does that impact human right? Paper presented at Amnesty International, Forum Syd and Friends of the Earth. Kulturhuast, Stockholm, Sweden.

Zheng, M., Ahuja, M., Bhattacharya, D., Clement, T. P., Hayworth, J. S., and Dhanasekaran, M. (2014). Evaluation of differential cytotoxic effects of the oil spill dispersant Corexit9500. Life sciences, 95(2), 108–117.