

CHARACTERIZATION OF CRUDE OIL IMPACTS AND LOSS OF LIVELIHOOD IN THE NIGER DELTA, NIGERIA: A FISHERIES PERSPECTIVE

By

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Abstract

Fishes are the most successful group of vertebrates and their number is bigger than all terrestrial vertebrates together. However, fish kill occasioned by oil spills has reduced fish population and habitat, contributed to the loss of livelihood, economic dislocation and food value chain poisoning, in the Niger Delta region of Nigeria. Despite the attendant health, environmental and socio-economic impacts of oil spills on fisheries and fisherfolks, government at different levels is yet to consider sustainable livelihood structures for local communities that suffer deleterious effects of the oil spills. This has severely impoverished the local population whose livelihood is traditionally farming and fishing. In this review, we characterize the toxicity of hazardous substances in crude oil, the impacts on fish mortality, turbidity, declined productivity of plankton, destroyed biodiversity, health status of fishes, dissolved oxygen and loss of livelihoods. A participatory needs assessment for fisherfolks in the Niger Delta, to identify a sustainable livelihood alternative for local fisherfolks, is recommended. In addition, immediate remediation of polluted sites and rivers in the region is urgently required to enable fisherfolks to return to their traditional livelihoods. This research would serve as an exemplar to regions with similar context as the Niger Delta suffering Impacts of natural resources mining.

Key Words: Oil spills, ecosystem balance, biodiversity, fisheries, livelihood

1. INTRODUCTION

Nigeria is the largest producer of oil in Africa, and the fragile Niger Delta region is the hub of oil and gas production in the country (Zabbey, 2009; Sam *et al.*, 2017). The region is made up of the nine states (Figure. 1), has an estimated population of 31 million people. The region is about 20,000sq/km (Chinweze and Abiola-Oloke, 2009) and encompasses four main flourishing and rich ecological zones: coastal barrier Islands, mangroves, fresh water swamp forest and lowland rainforest (World Bank, 1995). The ecosystem of the region is highly diverse and supports numerous species of terrestrial and aquatic fauna and flora as well as human life. Nigeria's mangrove, in terms of area covered, is the largest in Africa with an estimated 10,515 km² (Onyena and Sam, 2020). The greater expanse of the mangroves is found in the Niger Delta (Spalding *et al.*, 1997). Crude oil is a natural endowment that is expected to be of immense benefits to its host (Oviasuyi and Uwadiae, 2010). However, one of the major environmental problems in the Niger Delta is the incessant occurrence of oil spills right from the inception of oil production (Nwilo and Badejo, 2005a; Wakocha *et al.*, 2011; Raji and Abejide, 2013; Onyena and Sam, 2020). Oil spills may occur as a result of pipeline leakage, pipeline rupture, accidental discharges, engineering failure, vandalism or in the process of oil theft or artisanal refining of crude oil (Adelana *et al.*, 2011; Achebe, 2012; Ayuba, 2012). Oil spills are endemic in the Niger Delta and the resulting pollution has affected the area for decades, damaging the soil, surface and groundwater and air quality.

The largest proportion of petroleum entering the environment comes from anthropogenic sources (Wang and Stout 2007). Approximately five million metric tons of crude and refined oil enter the environment each year from anthropogenic sources (Edwards *et al.*, 2003). The main sources of oil spill on the Niger Delta region are ageing of the pipelines; vandalization of the oil pipelines; oil blow outs from the flow stations; releases, both accidental and deliberate, from oil tankers on the high sea and the disposal of used oil into the drains by the road side mechanics (Nwilo and Badejo 2005a). Nwilo and Badejo (2005b) have documented that 88% of the oil spill incidences are traceable to equipment failure, vandalism, oil blowouts from the flow stations, accidental and deliberate releases and oil tankers at sea. Similarly, Oteh and Okpo (2012) reported that corrosion accounts for 50% of the spills, 28% due to sabotage, and 22% to oil production drills and operations in the Niger Delta.

Oil spills appear to be increasing over the years in the Niger Delta (Binuomoyo and Ogunsola, 2017). The estimated barrels of crude oil spilled annually in this region is about 240,000 barrels (Ordinioha and Brisibe, 2013). There have been over 3,854 reported cases of oil spillage in Nigeria from 1986 to 2000 (Adeyemi, 2004). UNDP (2006) estimated that about 6,800 spills totaling 3 million barrels of oil were recorded in the Niger Delta region between 1976 and 2001. Some notable oil spills documented by Zabbey (2009) include GOCON's Escravos spill (1978), Forcados Terminal Spillage (1980), Oyakama pipelines spill (1980), Abudu Pipeline Spill (1982), Ikata Pipeline Spill (1984), Okoma Pipeline Spillage (1985) and Oshika Pipeline Spill (1993), the massive Oloibiri Well 14 oil spill (2004), Bodo oil spills (2008 and 2009) and K. Dere spill (2009). In January 1998, 40,000 barrels of crude oil was spilled by Mobil in Eket but the largest spill in Nigeria was the offshore well blowout in January 1980 with a spill of approximately 200,000 barrels of oil into the Atlantic Ocean from an oil facility which damaged 340 hectares of mangrove forest (Nwilo and Badejo 2005a). A compendium of some spills in the region has also been provided by Tolulope (2004), Gabriel (2004), Ukoli (2005), Ayuba (2012), Ajide (2013) and Binuomoyo and Ogunsola (2017).

The Shell Petroleum Development Company (SPDC) since 1989 recorded an average of 221 spills per year in its operational area involving 7,350 barrels annually (SPDC, 1995). From 1976-1996 a total of 4647 oil spill incidences spilling approximately 2,369,470 barrels of oil into the environment of which 1,820,410.5 (77%) were not recovered. Most of these oil spill incidences in the Niger Delta occur on land, swamp and the offshore environment (Nwilo and Badejo, 2005a, 2005b; Twumasi and Merem, 2006; Uyigue and Agho 2007). NNPC estimated that about 2,300 cubic meters of oil have been spilled in 300 separate incidences annually between 1976-1996 (Twumasi and Merem, 2006). In 2001 the western operations of the Shell Petroleum Development Company (SPDC) recorded a total of 115 incidences of oil spills in which 5,187.14 barrels of oil were spilled and 734,053 barrels of the spilt oil representing 14.2% were recovered (SPDC, 1995).

As a result, the local population in the region are exposed to plausible risk through ingestion (e.g. when they consume fish from polluted rivers or cassava cultivated on polluted soil), dermal contact (e.g. when they bath water from polluted rivers) or inhalation (e.g. when they breathe in soot from the crude oil refinery) (UNEP, 2011), particularly the poorest and those who rely on traditional livelihoods such as fishing and agriculture (Amnesty International, 2011). This has resulted in severe health impacts which include reproductive defects, DNA mutations, leukemia and cancer of the lung, bladder, bone, brain and scrotal (Nadal *et al.*, 2004; Song *et al.*, 2006). Repeated exposure to oil-related contamination causes various forms of cancer in aquatic animals, especially a form that can easily integrate with their cell and corrupt the DNA (Victor *et*

al., 2018), which in turn affects man through the food chain. It has also been reported that chronic human exposure to any of the oil-related contamination causes an increased rate of birth defects, gene mutations, and cancers (Barhoumi *et al.*, 2016). Other health problems that are related to chronic exposures to hydrocarbons include decreased immunity, cataracts, kidney damage, liver damage, breathing problems, asthma or (lung function abnormalities), skin redness and inflammation (Victor *et al.*, 2018). Similarly, given the local population are primarily fisherfolks and farmers, incidents of oil spills in the last 5 decades have destroyed these livelihood structures and dislocated the local economy (Sam and Zabbey, 2018). Despite these livelihood impediments, sustainable alternatives are yet to be provided to the local population.

The scenario is different in other natural resource dependent economies within the African continent. For example, Ghana's economy is partly dependent on natural resource exploration and exploitation, however, the government developed roadmaps for livelihood development, environmental conservation, and public health protection. Given that natural resource mining affects access for land for agriculture, communities that host mining activities are engaged in participatory decision-making and formalized social development intervention projects (Ofori and Ofori, 2019). Thus, alternative livelihood structures provided in such communities meet the needs of the local population given their involvement in the decision-making process.

Within the Niger Delta region, fishing is one of the traditional livelihoods that previously sustained the local economy. Fisherfolks have suffered the enormous impacts of oil spills offshore, without an alternative livelihood provided for them. The toxicity of crude oil or refined petroleum on fishes has received increased attention from researchers (Dighiesh *et al.*, 2019; Monteiro *et al.*, 2018). Heavy metals, a critical composition of crude oil, affect fish life directly or indirectly (Monteiro *et al.*, 2018). However, the extent of damage depends on the quality and quantity of the pollutants, duration of exposure and the species of fish. Agbogidi *et al.* (2005) indicated that irrespective of the concentration, crude oil produces aqua-toxicological effects which are deleterious to aquatic life. In addition, harmful fishing practices such as the use of dynamites in water bodies produce narcotic effects and readily outright mortality of fish and other fauna. Damages arising from dynamite explosion are nonselective, killing all stages of fishes and other living materials within the system (Zabbey, 2009). Powell (1998) studied impacts of the GENECO barge, Ikata, Okoma and Oshika oil spillages on fisheries and reported 50% reduction in fish abundance, total loss of species lacking accessory air-breathing organs and major loss of species without any obvious physiological pattern. On this premise, this review aimed to bring into perspective the various impacts of oil exploration and exploitation on the fisheries of the Niger Delta region of Nigeria. It is believed that this information will enlighten and sensitize relevant authorities such as the international community, Nigerian government, oil companies, host communities, researchers and fisheries professionals on crude oil related activities on the fisheries of the Niger Delta region.

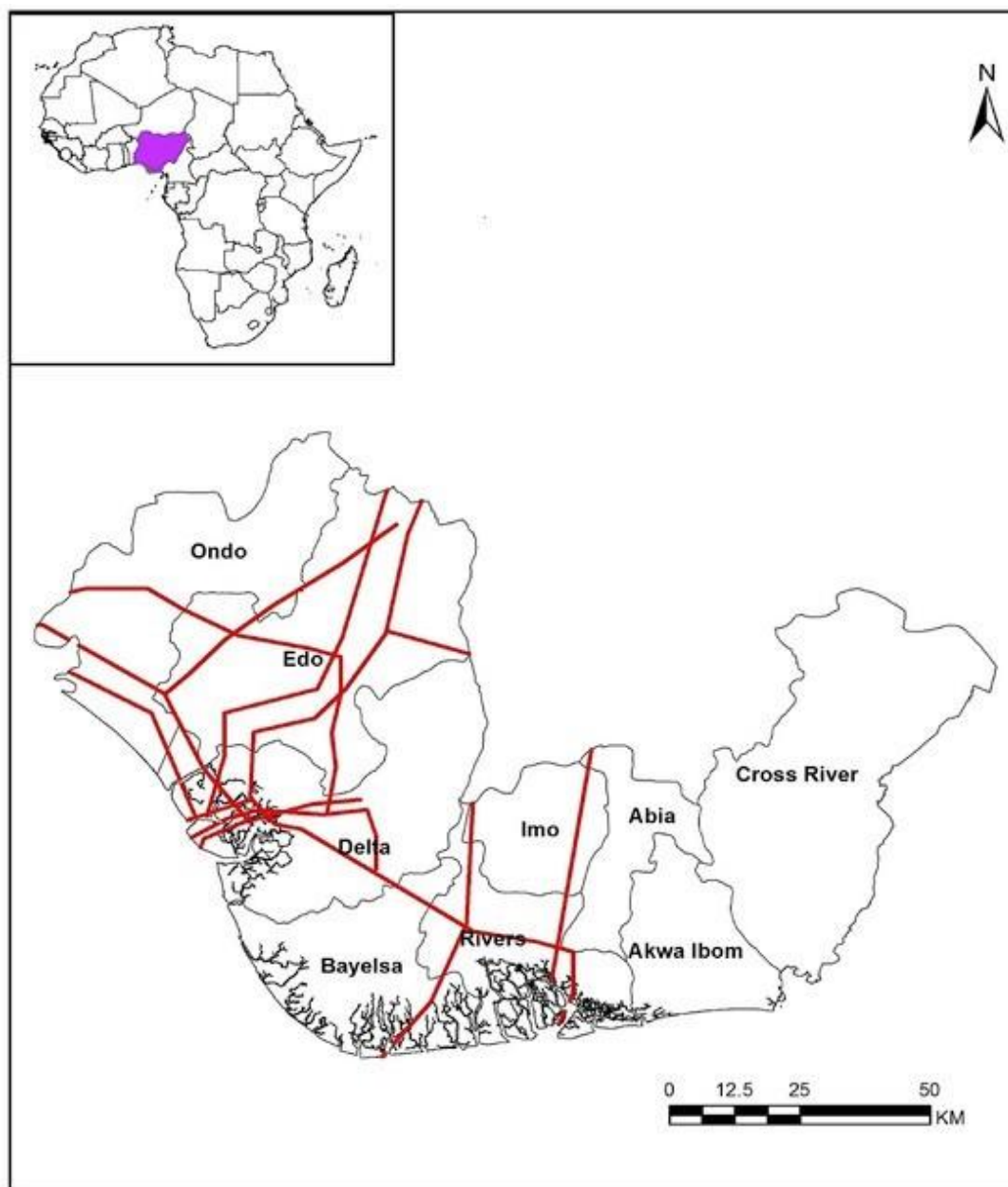


Fig. 1. Africa showing the Niger Delta region and oil pipeline network (red lines) (Sam *et al.*, 2017).

2. Overview of Crude Oil Composition and Toxicity

Crude oil is a natural, heterogeneous mixture of hydrocarbons, with potentially 20,000 chemical components (Marshall and Rodgers, 2004). Crude oil, natural gas/condensates, solid bitumen and oil sand are all components of petroleum (Wang and Stout, 2007). Its composition varies widely, and each oil component has different physico-chemical properties, including viscosity, solubility and variation in its bioavailability and toxicity (McGenity *et al.*, 2012). When oil is spilled in water, it undergoes numerous chemical, physical and biological processes

which alter its toxicity. These processes are collectively referred to as Weathering (Figure 2). The bioavailability and persistence of specific hydrocarbons, the ability of an organism to accumulate and metabolize, fate of the metabolized products, metabolites of the hydrocarbon interphase with the normal metabolic process may alter an organism's chances of survival and reproduction in the environment (Ayuba, 2012). The most important weathering processes include spreading, evaporation, dissolution, dispersion into the water column, water-in-oil emulsification, photochemical oxidation, microbial degradation, adsorption of suspended particulate matter and stranding on the shore or sedimentation to bottom sediments (Wang and Stout, 2007). When oil spillage occurs, the crude oil floats on water and spreads. The volatile components soon evaporate leaving a viscous oil-slick and a wave action causes the oil slick to form a sticky heavy emulsion which eventually results to the death of a large number of planktonic organisms, fish, birds and other animals (Sam *et al.*, 2017; Sam and Zabbey, 2018). Oil spilled into the aquatic environment initially spread on the surface depending on its relative density and composition. While the slick may remain, wave action can cause it to drift over large areas covering both open seas and terrestrial habitats (CDCP, 2010). The water-soluble fraction (WSF) of crude oil may be available and has been shown to be toxic to the organisms in the aquatic environment (Dighieshet *et al.*, 2019). This is because the WSF comprises of toxic components such as the polycyclic aromatic hydrocarbons (PAHs), mono-aromatic hydrocarbons like benzene, toluene, ethylbenzene, xylene (BTEX); phenols, heterocyclic compounds and heavy metals (Rodrigues *et al.*, 2010). Hydrocarbons present in crude oil are toxic to many organisms especially those at early life stages (Lee *et al.*, 2011; Dighieshet *et al.*, 2019).

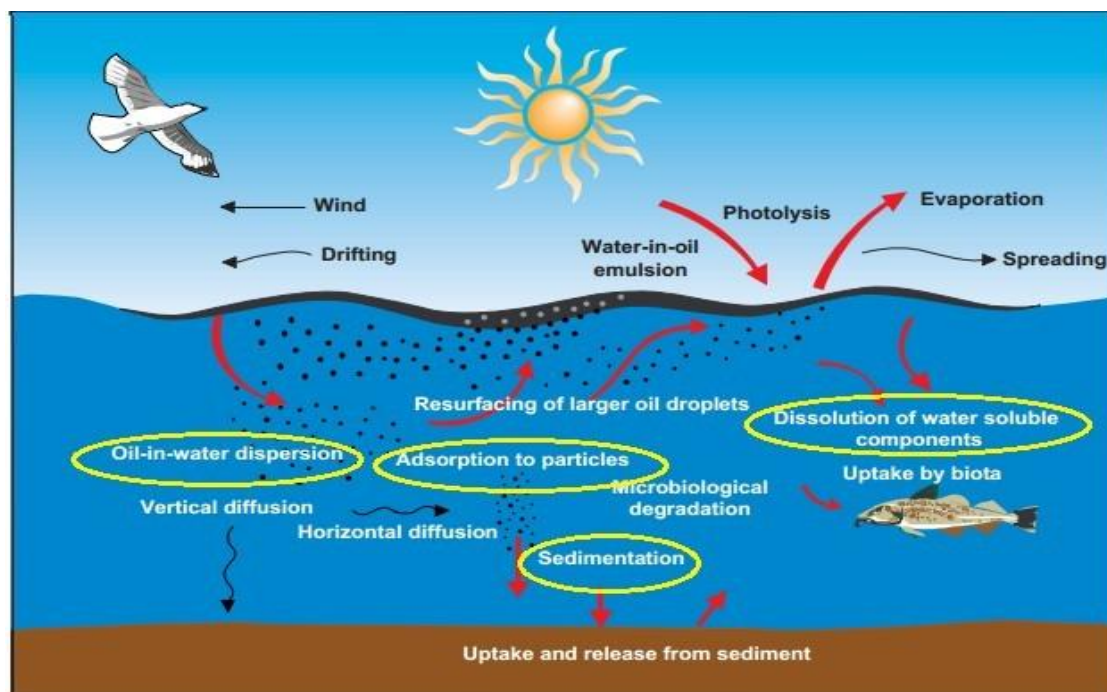


Figure 2: An overview of processes that influence the weathering of oil in aquatic environment showing the different pathways through contaminants enters an aquatic receptor (Sørensen (2012).

3.0 Impacts of Oil Spill on the Fisheries

Oil exploration and exploitation and its associated oil spills pose significant threats aquatic organisms particularly fishes and ecological balance. The implication of these activities on fisheries (capture and culture) are discussed in the following sections.

3.1 High Mortality of Fish Species and other Aquatic Animals

Oil drifted ashore and into the swamps could be harmful to littoral organisms as well as estuarine fisheries and fish stock (Ewa-Oboho *et al.*, 2006). The effect of floating films or undispersed crude oil on fish eggs and larvae has been investigated. Water extracts of different concentrations of crude oil have been reported to show high toxicity on herring eggs when incubated under 103 and 2.104 ppm with a mean survival time of 2.5 to 3.5 days (Kuhnhold, 1982). Ewa-Oboho and Amu (2009) also reported a severe damage to the larvae of *Heterobranchus longifilis* exposed to crude oil extracts which resulted to their death within one day because of deformed bodies or abnormal flexure of the tail. Acute effects include mortality, narcosis, sub-lethal reproductive effects, and histopathological effects such as lesions in gill epithelium and kidney tissue inflammation.

Toxicological studies on crude oil on fish eggs and fingerlings have been carried out by Lonning (1977). Many workers (Stobber *et al.*, 1978; Cardwell, 1979) have documented the toxicity of oil spills in aquatic environments near big oil industries and generally agreed that fish larvae, fingerlings and eggs are quite a sensitive bioassay test organisms. Also, after the Exxon Valdez oil spill in Prince William Sound, acute (Khan and Nag, 1993; Marty *et al.*, 1997), chronic (Jewett *et al.*, 2002) and histological damages were found in fish. Anderson *et al.* (1974) also recorded mortalities in *Cyprindon variegatus*, *Fundulus similis* and *Menidia beryllina* after exposure to two types of crude oil. Ghatak and Konar (1990) reported that petroleum product n-heptane was toxic to *Tilapia mossambica*.

Death of organisms arising from oil spill may not necessarily be immediate. Olaifa (2012) observed that *C. gariepinus* exposed to WSF of a Nigerian light crude oil did not result in an immediate noticeable change in fish behavior as mortality was only recorded after a 96-hour period.

3.2 Decrease in Biodiversity and Breeding Grounds

All aspect of oil exploration and exploitation has adverse effects on the ecosystem and the local biodiversity (Ayuba, 2012). Damage to mangrove forests varies with the amount and toxicity of the spilled oil product. The degree of impact is a function of oil type, spill volume, duration or re-oiling, extent of oil coverage on exposed roots and degree of substrate oiling (NRC, 2003).

Extensive mangrove area in the delta have been converted for one form of oil facility or the other or degraded by oil pollution. As at 1994, World Bank (1995) reported that 66,000km (Seismic line), 700km (Flow line), 400km (Pipeline) and expanse (flow stations and drilling) of mangrove have been lost for utilization by SPDC alone. Breeding grounds, nursery and schooling areas of fish species are also lost (figure 3). Studies have shown that 60% of fishes in the Gulf of Guinea breed in the mangroves of the Niger Delta (Zabbey, 2009; Nwipie *et al.*, 2020). Ezenwa and Ayinla (1993) reported that oil spillage alone is estimated to amount to 50% reduction in breeding grounds, nursery and schooling areas of fish species within the estuaries,

creeks, lagoons and major rivers. Also, the rate at which the Atlantic Ocean is taking up the land mass is quite alarming and its consequent and destructive effect on breeding grounds, nursery and schooling areas of fish species are clearly shown on the poor catches of artisanal fishermen during a survey by Ezenwa *et al.* (1991).



Figure 3: Sivibilagbara swamp, Bodo after a spill in 2011 (Amnesty International, 2011).

3.3 Impairment of the Health Status in Fish

A variety of pollutants including crude oil and its products are known to induce stress conditions, which impair the health of aquatic life (Eriegha *et al.*, 2017, 2019a; [Kori-Siakpere, 2000](#); [Agbogidi *et al.* 2005](#)). Earlier reports have also shown that oil pollution impacts negatively on fishery resources ([Kilnhold, 1980](#)). A comparative research conducted by Osioma *et al.* (2013) in two communities (Kokori-Erhoike and Eku) of the Niger Delta region on *Clarias gariepinus* revealed changes in markers of biotransformation and oxidative stress (glutathione S-transferase, superoxide dismutase, catalase and lactate dehydrogenase). They further opined that the fish were relatively under stress in Kokori-Erhoike (an oil producing community) as compared with fish from Eku (a non-oil producing community).

After a spill, pollutants in the water can be absorbed by the gills, pass into the bloodstream and circulates through the body. Furthermore, if the concentrations are high enough, the delicate cells of the gill secondary lamellae can be damaged and this adversely affects the vital function of respiration and salt regulation (Lloyd, 1992). Severe fouling of oil may clog the gills of fish, therefore leading to asphyxiation. Oil pollution also renders the fish more susceptible to disease due to exposure. Crude oil exposure affects air-breathing frequency, blood phosphate levels and ion regulation in an air-breathing teleost fish, *Hoplosternum littorale* (Brauner *et al.*, 1999). Oil exposure studies using zebrafish embryos demonstrated a heart failure syndrome that is lethal to larvae (Incardona *et al.*, 2005). Short-term toxicity in fishes includes lymphocytosis, epidermal hyperplasia, hemorrhagic septicemia (Beeby, 1993). In Brazil, petroleum, diesel, and gasoline were tested on marine Pejerrey (*Odontesthes argentinensis*) larvae and the results revealed several lesions such as hyperplasia in gills, pseudobranchs, and the

esophagus (Rodrigues *et al.*, 2010). Crude oils and their hydrocarbon derivatives have also been reported to cause morphological and developmental abnormalities in fish larvae (Linden, 1976).

Several studies have examined the effect of oils on the developmental stages and the growth of young fish. Moles and Rice (1983) noted that the exposure of pink salmon to sub-lethal concentration of WSF of crude oil for 40 days resulted in significantly smaller fishes compared to the control. Sub-lethal exposure to crude oil during embryonic development altered cardiac morphology and reduced aerobic capacity in adult fish (Hicken, 2011). Exposure of fish larvae to petroleum hydrocarbons has been reported to affect their swimming ability (Carls, 1987). Reduction in swimming ability and deep narcosis of larvae will seriously cripple their ability to feed and to avoid predators. Baltic herring larvae exposed to crude oil showed abnormal swimming behaviour characterized by vigorous swimming up to the surface followed by a slow sinking to the bottom (Linden, 1975).

3.4 Diminution in Dissolved Oxygen Content

The effects of oil spill on the water quality and biota of the aquatic ecosystem have been well researched on and documented (Ogbeibu and Omoigberale, 2005; Omoigberale and Ogbeibu, 2007a, 2007b; Ogbeibu, 2010). Most heavy oils and greases are insoluble in water but remain on the water surface thus blocking oxygen from dissolving in the water and aquatic life forms suffer the consequence (Ademoroti, 1996). Oil in water causes depletion of dissolved oxygen due to transformation of the organic component into inorganic compounds (Beeby, 1993).

Dissolved oxygen concentration present in water reflects atmospheric dissolution, as well as autotrophic and heterotrophic processes that respectively, produce and consume oxygen. Fish obtain oxygen from the small amount which is dissolved as gas in the water (not from the oxygen in the water). In order to extract this oxygen efficiently, the gill structure consists of a very fine sieve through which water is pumped by muscular action of the mouth and pharynx. Due to the arrangement of the lamellae, dissolved oxygen in the water has to cross only a very short distance to get into the blood stream thus increasing the efficiency of oxygen extraction. However, it is this very efficiency that makes fish vulnerable to toxic substances in the water (Lloyd, 1992). At lower dissolved oxygen occasioned by the oil spill, the fish becomes increasingly stressed as the respiratory system becomes inadequate and unable to extract sufficient oxygen from the water to meet their basic metabolic needs (Lloyd, 1992). Also, a progressive significant increase in lactate dehydrogenase (LDH) activity in the liver of catfish at higher crude oil concentrations has been reported by Sunmonu and Oloyede (2007). They agreed that the high activity of LDH showed that crude oil interfered with oxygen supply to the catfish, leading to anaerobic degradation of glucose.

3.5 Impact on Turbidity

Turbidity is a measure of the clarity of water and is determined by the amount of light scattering caused by suspended particles and colloidal material (Boyd, 1979). When oil spilled on water, the clarity of the water is affected. Turbidity level has been shown to have increased significantly with increasing concentrations of WSF of crude oil (Eriegha *et al.*, 2019a).

3.6 Reduction in Primary Productivity and Plankton Abundance

The importance of planktonic organisms in the aquatic environment cannot be over emphasized. Dahlin *et al.* (1985) in a study of the composition of the phytoplankton and

zooplankton communities in the Niger Delta, pointed out that numbers of the zooplankton depend largely on phytoplankton as a food source. Oyairo (1986) however reported a decreased yield in primary productivity in an experiment conducted using crude oil, refined oil and Dual-Purpose Kerosene (DPK) as pollutants on plankton. Crude oil has been found to reduce growth, photosynthetic rate, stem height, density, and above ground biomass of *Spartina alterniflora* and *S. Patens* and may cause their death (Krebs and Tamer, 1981). Crude oil spill at sea forms a surface slick whose components can follow many pathways. Some may pass into the mass of seawater and evidence suggests they may persist for a long time before their degradation by microorganisms in the water. The slick usually becomes more viscous and forms water-in-oil emulsion. Among the biological components of ecosystems, planktonic organisms are particularly susceptible to crude oil pollution. Zooplankton cannot overcome the effects of currents, limiting their capacity to avoid crude oil patches and, potentially, forcing them into highly polluted water masses after crude oil spills. Small crude oil droplets (1–100 µm in diameter) generated by wind and waves and or by treatment with chemical dispersants are effectively suspended in the water column (Mukherjee and Wrenn, 2009).

Effects of oil pollution on zooplankton vary widely depending on intrinsic (e.g., species, life stage, size) and extrinsic factors (e.g., oil concentration, exposure time, temperature, salinity, UV radiation, use of chemical dispersants) (Alcaraz *et al.*, 2010; Saiz *et al.*, 2009). Lethal and sub-lethal effects, including narcosis, alterations in feeding, development, and reproduction, have been frequently observed in zooplankton exposed to petroleum hydrocarbons (Calbet *et al.*, 2007).

3.7 Changes in Histopathological Components in Fish

Crude oil has been known to affect histopathological parameters of fish (Eriegha *et al.*, 2019a). Several studies have demonstrated links between exposures to crude oil and hepatic lesions in different fish species. Flounder (*Pleuronectes americanus*) collected near an oil refinery showed various histological lesions in the liver which were believed to be indicative of the impact of the oil on the health of the fish (Khan, 1998). Amadi *et al.* (2015) have also observed vascular and cellular degeneration, hyperplastic hepatocytes, cytoplasmic vacuolation and inflammation as histological alterations in juvenile *C. gariepinus* after exposure to a refined petroleum product (petrol). Histopathological examinations in the liver of juvenile *C. gariepinus* have indicated alterations such as centrilobular degeneration, atrophy (reduction in number and volume of cells and/or a decreasing amount of intercellular substances) of hepatocytes and multiple foci of hepatocellular coagulation necrosis (Eriegha *et al.*, 2019a). Fish living in the vicinity of drilling platforms which may be exposed to high levels of petroleum hydrocarbons were reported to show hyperplasia of gill epithelium (Grizzle, 1986).

Gills have also been noted to be very sensitive to crude oil or its WSF even at relatively low concentrations (Al-Kindi *et al.*, 2000). Pathological alterations in gills such as lamellae atrophy, diffuse lamellae hyperplasia and moderate diffuse lamellae hyperplasia could lead to an overall reduction in the efficiency of gill filaments to aid in the diffusion of oxygen across the gill lamellae resulting in the development of a hypoxic condition within the fish (Eriegha *et al.*, 2019a). Apart from the impairment of respiratory functions, alterations in the gills could also have tendencies of impairing osmoregulatory functions (Tang and Au, 2004). Mild congestion of cerebral blood vessels, vascular congestion and atrophy of neurons, neuronal necrosis and gliosis as well as the loss of neurons and gliosis have also been observed in the brain of *C. gariepinus* after exposure to crude oil (Eriegha *et al.*, 2019a).

3.8 Disruption of Endocrine System

Crude oil have been found to disrupt the endocrine system (Horng *et al.*, 2010). An endocrine disruptor, or endocrine-disrupting chemical (EDC) is an exogenous substance that alters the function(s) of the endocrine system and consequently causes adverse health effects in an intact organism or its progeny (WHO/UNEP 2013). Disruption of the endocrine system can result in various developmental, reproductive, neurological, immune and metabolic diseases (Khetan, 2014). Polycyclic aromatic hydrocarbons (PAHs) which is a component of crude oil have been linked to reduced investment in gonadal tissues (Booc *et al.*, 2014) and interference with steroid metabolism (Monteiro *et al.*, 2000).

3.9 Loss of Quality of Fish

Quality can be defined as the characteristics or attributes, which makes fish acceptable to the consumer. In assessing the quality of the fish, the consumer may consider its freshness, the safety of the fish in terms of microbial load and the presence or absence of pathogenic organisms as well as the palatability of the fish (Eyo, 2001). Undoubtedly, fish flesh becomes unpalatable due to bad odour caused by oil spillage.

3.10 Loss of Livelihood of Fisher-Folks

Most communities in the Niger Delta are considered as fishing communities or villages as the majority of the households are involved in fishing, processing, distribution, marketing, and sale of fish resources (Eriegha *et al.*, 2019b; Ovie *et al.*, 2007). The livelihoods of people dependent on fisheries and aquatic resources can be affected by oil spillage. Virtually, every aspect of oil exploration and exploitation have deleterious effects on ecosystem stability and local biodiversity—which the peoples' livelihoods depend upon (Zabbey, 2005). Some notable spills have resulted in the complete relocation of some communities (Ukoli, 2005). Crude oil spillage displaces people, pollutes their waters and the air, damages their farmlands, their flora and fauna (Opukri and Ibaba, 2008). Fisher-folks can fish no more as their fishing nets lie fallow and their source of livelihood disappear. Fisher-folks who used to rely on fishing alone for a living ultimately loss their incomes. Overall, people in the affected areas are now much less able to grow their own food or catch fish.

4.0. Implications of the research

The occupation and primary livelihood structure of the Niger delta population is agriculture (farming and fishing). The economic strangulation occasioned by oil spills in the region has pushed the local population from their traditional livelihoods to makeshift livelihood structures are often illegitimate e.g. artisanal oil refineries, thereby increasingly degrading the environment. This has further fueled the uncordial relationship between oil industry stakeholders e.g. oil companies and host communities and thus affected the oil operations in such communities. As a result, revenue accrual to government is depleted even amongst severe environmental degradation. Communities that host oil operations and suffer primary defects of oil spills, particularly coastal communities involved in fishing, become jobless and impoverished. Once oil spills into the aquatic environment, the shallow waters become inhabitable due to the reduced oxygen available to fishes and other aquatic organisms for respiration. Consequently, fisherfolks travel farther into the ocean to increase fish catch. The farther the fisherfolks travel to access

conducive fishing grounds, the more energy, time and potential risk experienced in the fishing business.

In addition, to increase harvest from the fishing expedition, and given that shoreline oil spills have driven fishes to deeper oceans, fisherfolks are coerced to use dynamites to undertake chemical fishing, and thus contaminate the food value chain. Considering that government at all levels in Nigeria is yet to provide viable or sustainable alternative livelihood to the local population (Sam et al., 2018), particularly the fisherfolks, there is need to undertake a needs assessment to understand possible sustainable alternative livelihood that could resuscitate the economic strangulation and poverty in the Niger Delta region occasioned by oil spills. Also, the government should implement the polluter pays principle by ensuring that appropriate persons or corporate organizations responsible for oil spills are liable and appropriate remediation measures applied. It is expected that while a needs assessment will enable the local communities to participate in the choice of sustainable alternate livelihood, remediation and restoration of polluted rivers and sites would facilitate the return of local communities to their traditional livelihoods. Beyond alternate livelihood, the government should develop adequate policies for water resource management.

5.0 Conclusion

Generally, oil spillage devastates the ecosystem leading to loss of aquatic fauna and flora. Fisher-folks operating in the area are significantly affected as the fish which is their source of livelihood are killed by oil spills. The implication has been declined fish catch during fishing expedition, and thus, increased poverty in the area. In addition, the local population indulged chemical fishing (e.g. use of dynamite) which further exacerbates the situation by providing contaminated fish in the food chain with deleterious health impacts amongst the population. These practices exacerbate the toxicity of hazardous substances, increased fish mortality, reduced turbidity, declined productivity of plankton, destroyed biodiversity, affect the health status of fishes, and reduced available dissolved oxygen and loss of livelihoods. Therefore, stringent measures to prevent new oil spills and effective remedial methods to mitigate the impacts of such spills are strongly recommended. Multinational oil companies responsible for such spillage should be compelled to pay compensation to the host communities so that affected fisherfolks can sustain their livelihood until the environment is healthy. We also recommended a participatory needs assessment to ascertain sustainable livelihood structures desired by the local population. We believe such initiative will ensure cordiality between respective stakeholders in the region.

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