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Investigation of the Socio Economic Impact of Oil Spill Remediation on the Health of People in Oil Bearing Localities in the Niger Delta.

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ABSTRACT

Crude oil is the major source of income to the Nigerian economy, which accounts for about 70% of government revenue and more than 83% of the country's total export earnings. Crude oil spills are frequent events in Nigeria and in the past 50 years, it is estimated that 10–13 million tons of oil have been spilled into the environment and more than 77% of it have not been recovered. The spills are caused by sabotage, oil exploration activities, equipment failure, pipeline corrosion, and tanker accidents. This study investigated the socio economic impact of oil spill remediation on the health of people in oil bearing localities in the Niger Delta and the different remediation technologies for polluted water, soil, and sediment media that are appropriate for the local Nigerian environmental conditions. The characteristics of the Nigerian crude oil have been discussed, and the basic factors to be considered in cleaning crude oil contamination were explored. Bio stimulation was identified to have a high potential for cleaning polluted sediments in the Niger Delta. The limitations of the methods/techniques are discussed, and the future technological prospects are highlighted in this review.

Keywords*: Oil-Spills, Socio-Economic, Remediation, Health of people, Niger-Delta*.

Background Information

The marine environment is affected by a number of human induced stressors and the degradation can be seen not only in coastal areas but has spread to very remote areas in the deep seas as well as in polar areas. Coastal areas are being urbanized throughout the world (Adati, 2012). There has been a global migration of humans from inland areas to the coastal areas, a phenomenon obvious in East Asia but also very pronounced in South Asia, the Mille East, Europe and the Americas. Pollution is spreading via water and air as well through direct dumping. Human induced changes in drainage areas affect the input of sediment into coastal waters leading to erosion, and construction, land filling and dredging also results in affected erosion and sedimentation patterns. Fishing is a major factor affecting the environment of the seas, both because the balance of the ecosystem is affected by the refuse dumps into the sea which has affected the aqua life of fish, and through the damage caused by the use of destructive fishing gear (Ekanem & Nwachukwu, 2015).

Maritime industry activities, basically crude oil shipping are the prime factor causing maritime pollution, for example from accidents during oil transportation and ballast water tank transfers of harmful aquatic species between different places in the ocean. In addition, there are the wastes disposed into the sea, especially plastics that remain for several years without decomposition. Ships and marine platforms also release exhaust gases containing Sox (SO_2,SO_4) and NOx (NO_2,NO_4) as well as green-house gases. Ships also release wastewater into the sea. Furthermore it has been estimated that container ships lose over 10,000 containers at sea each year which could contain dangerous cargoes (Getter, Ballou, & Koons, 2015). In addition to that the discharge of cargo residues from bulk carriers has a potential risk of polluting environmentally high sensitive areas as well as economically and commercially important strategic locations, like ports, channels and beaches. Oil spills can have devastating effects on waterways and oceans. In the oil, the poly cyclic aromatic hydrocarbons (PAHs) content cause most of the toxicity but the physical nature of oil, i.e. the stickiness is a major problem for a number of organisms such as birds. Spills of oil has a numerous negative impact both short and long term, resulting in economic and financial losses. Also the recovering and clean-up processes are very costly; examples cases such as the clean-up from the Exxon Valdex or the Deep water Horizon.

Remediation is the process of returning soil, water or air functionality that existed prior to contamination. Variety of techniques exist for remediation depending on the media (e.g. air, water, or soil) and contaminant (e.g. heavy metals, PCB) (Gomes, Dias-Ferreira & Ribeiro, 2013). Given the peculiar (i.e. variable habitat, interlinked water bodies and variable soil types) nature of the Niger Delta environment (UNEP, 2011), unsuccessful remediation attempts have been reported due to the use of inappropriate technologies. Thus, it is imperative to explore an approach or a combination of technologies that would be appropriate and sustainable for the varied Nigerian environments.

Oil contamination originating from anthropogenic activities such as drilling operations and transportation is a well-known and well-studied environmental pollution problem (Iyayi, 2004). The oil spills occurring in the Niger Delta have received less attention in global media, despite significantly higher impacts on human health and the local ecology (UNEP, 2011). Oil spills mainly impact vegetation and wildlife, such as seabirds. Most of the impacts are due to the physical characteristics of the oil. The adhesive properties lead to reduced mobility and dissolution of natural fats and waxes on body surfaces, feathers etc. (NRC, 2003; ITOPF 2011a).Certain aromatic petroleum hydrocarbons may also cause direct toxic impacts due to ingestion or penetration through body surfaces such as gills (Heubeck, 2013).An estimated 2 million tons of oil is released into the environment annually from human and natural processes (NRC 2003).Toxic effects may also occur if the oil is fresh and contain a high amount of light aromatic hydrocarbons. The Niger River has a total length of about 4100 km and is the third longest river in Africa. The Niger River basin covers a drainage area of 2.3 million km^2, about 7.5 % of the African continental landmass. The river starts in the Guinea Highlands and flows through Mali and Niger on its way to Nigeria. The average annual discharge from the Niger River into the Gulf of Guinea is 177 km^2 (Nwilo & Badejo, 2008). The Delta stretches from the Benin River in the west to the Bonny River in the east. It is a vast flood plain built up by the accumulated sediments washed down the Niger and Benue Rivers. The mangrove and freshwater swamp forest of the Niger Delta is the largest in Africa, and the third largest in the world, covering some 70 000 km^2. However, in many places, the forests have been extensively logged and agriculture has encroached into the wetland (Mmom & Arokoyu 2010). The high rainfall and river discharge during the rainy season combined with the low, flat terrain, and poorly drained soils cause frequent and widespread flooding and erosion. Often over 80 % of the delta is affected by seasonal floods stretching from the Benin River in the west to Bonny River in the east (Moffat & Linden, 1995). The tidal range at Port Harcourt is on average 1.8 m. Nigeria has

Africa's largest reserves of oil and gas within its borders and most of these resources exist in the Niger Delta and on the continental shelf of the country. Oil extraction in the Niger Delta has been going on since the 1950s and Nigeria exports around 15 million tonnes of oil every day, ranking one of the top 15 exporters in 2009 (CIA, 2012). The reserve of crude oil in Nigeria is estimated to be 270 billion tonnes, making it one of the top 10 largest reserves in the world in 2011 Central Intelligence Agency (CIA, 2012). Oil exports accounts for 95 % of the foreign exchange earnings and 80 % of the budgetary revenues. The quality of the extracted oil is considered good, as it has low content of sulfur (0.14%) and a high content of lighter fractions (EIR 2005). Oil spills have occurred repeatedly for decades in the Niger Delta and large parts of the land and wetlands are chronically affected by oil spills. Due to the influence of the tides and at times floods in connection with rains, spilt oil is rapidly distributed over large areas and re mobilized with rising tides. The oil originates from leaking pipelines, wellheads, and flow stations; from spills in connection with transport of mostly stolen oil; from illegal tapping of the wells; and from artisanal refining under very primitive conditions. The Niger Delta has been the scene of a long series of conflicts, two of the most serious being the Biafra War in 1967–1970, and the Ogoni Uprising in the 1990s. The violence has been centered on the cities of Warri in Delta State and Port Harcourt in Rivers State (Human Rights Watch 2005; Idemudia 2009; UNEP, 2011). As a result of these conflicts, oil companies for decades found it difficult to carry out oil production in parts of the Niger Delta. One such area is Ogoniland, immediately east of Port Harcourt. This area consists of four local government areas (LGAs): Eleme, Tai, Gokana, and Khana with a total population of 830 000 (UNEP, 2011). During 2009–2011, at the request of the Federal Government of Nigeria, the United Nations Environment Programme (UNEP) carried out a survey of the nature and extent of oil pollution in Ogoniland. The assessment covered contaminated land, ground and surface water, sediments, vegetation, air pollution, public health, industry practices, and institutional issues. The assessments were made in collaboration with a number of partners in the region including experts from Rivers State University of Science and Technology, Nigerian Government, agencies at national, state, and local government levels, traditional rulers, and various community groups. An additional objective was to determine appropriate remediation measures to rehabilitate contaminated sites to the level of international standards.

The exploitation of oil in the Niger Delta region has brought to bear oil spillage and its numerous problems. Such problems include contamination of water bodies, danger to aquatic life, and destruction of farmlands. According to Sydney, 2016 between 1976 and 1996, it was estimated that over 6,000 oil spills occurred in the Niger Delta region and about 2-million barrels of crude oil leaked into the environment. This calls for serious concern knowing that this ecosystem is a major source of livelihood for the inhabitants of the region. Oil was first discovered in the region in 1956 and since the early 1970s oil has dominated the country's economy. Oil exploration has over the years impacted negatively on the physical environment of the oil-bearing communities.

Oil exploitation has increased the rate of environmental degradation and has perpetuated food insecurity as a result of death of fish and crops as well as loss of farm lands and viable rivers for fishing activities leading to loss of livelihood. There is no doubt that the disastrous effect of oil spill impedes agricultural productivity and fishing to be specific, which in the long-run has an adverse consequence on the economic life of the inhabitants of this region. Furthermore, studying the prospects and challenges of environmental impact of oil exploration in the Niger Delta region of Nigeria and the remediation of contaminated lands in the region, Odalonu, 2015 argues that resolving the technical dilemma of the clean-up mechanism and identifying social impediments will be the key success driver of the United Nations Environmental Programme action plan, which was recently adopted by the government of Nigeria for the clean-up of the Niger Delta.

The marine environment has been continuously threatened by oil spills in spite of the essential technical developments in the safety of extraction and transport of crude oil and gas. These spills pose and cause severe and decade long havoc on marine and coastal ecosystems and the organisms that sustain them. Within the period of 2010-2014, 5,000 tons of the average 10,000 billion tons of crude oil transported by sea yearly was spilled due to accidents, cleaning operations or other causes. For example, washing ballast tanks account for 36,000 metric tons (11.2 million gallons) of oil entering the oceans globally every year; human induced activities and non-tank vessels. Although natural seeps releases oil into the marine environment, the oil is mostly released at low rates to which deep sea organisms are adapted to unlike the unexpected swift discharge of large quantities that occur during an oil spill or extraction accident. The enhanced technical standards for oil production has reduced large spills (which ranges from 7-700 tons and above 700 tons of oil) drastically during the past decades to an average of 5.2% for the 7-700 tons and 1.8% for those above 700 tons per year, whiles smaller spills (less than 7 tons of oil) representing an estimated 80% of all recorded spill has been going unnoticed and unreported. The concentration of dissolved and dispersed hydrocarbons that marine organisms are exposed to is highest during initial stages of the spill. Hence the major toxicity mechanisms for smaller spills are from immediate exposure which disappears from sight during the first few days without the oil been necessarily degraded from the sea surface.

Problem Statement

As oil is spilled on land and water, it rapidly sinks into the soil and on landing, some volatile fractions escape into the surface and this may result in leaching depending on the soil. Oil spill clean-up is one major problem and maintaining the cleaned spill to avoid further pollution of other areas is yet another problem. Oil spill remediation involves scrapping or tilling the visible contaminated surface of the soil. How to clean the volatile fractions that have already escaped into the soil is a big burden and how to contain the cleaned spill is quite a challenging problem altogether. Onshore, the cleaned spill is an admixture of sand and crude oil and it is usually tilled and gathered to a place for microbial degradation through biological remediation which takes a long time. Another problem is that efforts to clean up a polluted area is usually slow and late and sometimes the clean-up is non-pragmatically done as no one is handy to question the effectiveness of the clean-up exercise. Experts claim that it is virtually impracticable to clean up a despoiled area to a pristine level. Given this assertion, the question naturally arises: what level of clean-up is safe and acceptable? How can the volatile fractions of the oil in the soil be remediated with modern techniques?

Aim and Objectives of the Study

1. To investigate the socio economic impact of oil spill remediation on the health of people in oil bearing localities in the Niger Delta

Research Questions

1. To what extent does the effect the socio economic impact of oil spill remediation influence the health of people in oil bearing localities in the Niger Delta?

Hypotheses

H_{O1}: There is no significant relationship between socio economic impacts of oil spill remediation on the health of persons in oil bearing localities of the Niger Delta.

Justification of the Study

Practically, management of maritime companies, multinational corporations in the oil industry, development agencies, non-governmental organizations, and multilateral organizations, who want to better understand better oil spill remediation techniques that will suit the sustainability of the marine environment, will find this study useful. Finally, this study will provide update on the development issues under consideration, therefore provoking further research interest and inquiry among students and researchers.

Conceptual Review

Oil Production in Nigeria

The challenges of processing and transporting logistics crude and gas is of great concern to the environment of Niger Delta and Nigeria generally.

Nigeria has been a member of Organization of Petroleum Exporting Countries (OPEC) since 1971. It has the largest natural gas reserve in Africa, has the second largest oil reserve in Africa and is the African continents primary oil producer. As of the 1980s oil revenue provided 90% of Nigeria foreign exchange earnings and 85% of the government revenue (with estimated reserves extending beyond 20-30 years (NNPC, 1984). Shell D'Arcy the pioneer oil company in Nigeria, commercial production in 1958 with a production rate of 5100 barrels per day and a peak production of 2.44 million barrels per day over the next few years (Amu, 1997). According to NNPC (1984) through OPEC, production rates dropped to 1.5 million barrels per day from the activities of 10 international companies working 122 fields, containing over 970 oil wells. Nigeria has four oil refineries with an estimated total refining capacity of 445,000 barrels per day (Onuoha, 2008; Anifowose, 2008). The first and oldest being the Port Harcourt refinery, commissioned in 1965. It had an initial capacity of 35,000 barrels per day, which was later expanded to 60,000 barrels per day of light crude oil. The Port Harcourt refinery has a second refinery with a capacity of 150,000 barrels per day (Odeyemi and Ogunseitan, 1995; Ukoli ,2005). Anifowose and Onuoha (2008) stated in their studies that the region has about 606 oil fields with 355 situated onshore; 251 situated offshore with 5,284 drilled oil wells and 7,000km of oil and gas pipelines.

The increasing dependence of the Nigerian economy on hydrocarbon exploration and extraction has led to severe pressures on the environmental components and other receptive systems(Ite, Ibok, Ite and Petters, 2013)resulting from accidental and incidental discharge of hydrocarbon and its products into the environment. Soil contamination in the Niger Delta has become widespread and assumed international concern (UNEP, 2011), affecting local fisher folks and farmers whose economic wellbeing is dependent of rivers and alluvial fertile soil. There is increasing concern as large volumes of toxic organic substances continually enter the coastal environment of the Niger Delta (Linden and Palsson, 2013) through different routes including leachate and seepage during operations, extraction, transportation, distribution storage, and refining (UNEP, 2011). These routes involve human activities, which can be prevented or controlled to minimize spills especially with proper monitoring of oil infrastructure with state-of-the-act technology (Zabbey, 2016), even though spillage cannot be completely eliminated until effective regulatory oversight are in place and advanced technology for detection of oil spills are implemented. Leaks from wellhead, pipelines, overflows and dumping of slurry in the environment are other routes that could be controlled to reduce spills (Kadafa, 2012). On the other hand, basic oil spill prediction models and methodology alongside baseline or near real time data to evaluate oil spill damages in the region are lacking (Anifowose, Lawler, Van der Horst and Chapman, 2016). Hydrocarbons through these routes continue to cause land contamination even as the operators report that they apply best available technology (BAT) in preventing discharges (Steiner, 2010). Although, operators claim to use BAT, oil spills from facilities are bound to continue provided the facilities remain aged and the interdiction of these critical infrastructure continues unabated(Church, Scaparra, and Middleton,2004).

Oil Spillages in the Niger Delta Region

The United Nations Development Programme (UNDP, 2011) describes the situation in the Niger Delta as a region suffering from administrative neglect, crumbling social infrastructure and services, high unemployment, social deprivation, abject poverty, filth and squalor, and endemic conflict (Osabohien & Osuagwu, 2017). No other sentence describes squarely the condition in which more than 30 million people have found themselves as a result of oil exploration and exploitation activities, yet the situation has progressively continued to deteriorate; chiefly as a result of the nonchalance of the stakeholders and oil companies in the region - with little or no hope in sight. Oil spillage and gas flaring which is the most referenced form of pollution resulting from oil exploration and exploitation in the Niger Delta have had consequences on the Niger Delta region (Akpan, 2012). The situation has affected the living conditions of the people who depend solely on the environment for their subsistence, ranging from fishing, agricultural activities, provision of portable water, recreational activities such as swimming, pure and refined air and green/clean land and water ways. This incidence has continued for decades and still threatens any hope for a sustainable living. The petroleum industry in Nigeria is practically the most significant source of revenue. Petroleum production and export plays a dominant role in Nigerian's economy and account for about 90% of her gross earnings. Oil and gas alone have generated 40 per cent of Nigeria’s national GDP over recent decades. The country also has a proven crude oil reserve of 37,070 billion barrels and a proven natural gas reserve of 5,111 billion cu/meters. In spite of this seemingly hopeful statistics, the Niger Delta which lays the golden egg is a subject of frustration and hopelessness as the negative effects of oil exploitation and exploration has continued to degrade the environment and the lives of the people of the region. While oil spill has played a significant role in the devastation of the flora and fauna, and the general landscape of the region; it has most importantly contributed in affecting the livelihood of the people by affecting farming and fishing communities. Gas flaring on the other hand has also continued unabated while further exacerbating household living conditions by causing air pollution in host communities and contaminating farm produce with significant effect on livelihood in the region. In addition, and in respect to its impact on livelihood, Otuoke, 2011 reported that about 70% of the people of the Niger Delta region live below poverty line; less than $1 a day with a clear absence of the basic amenities. Damages from oil operations are chronic and cumulative and have acted in a severely impaired coastal ecosystem and compromised the livelihoods of the region’s impoverished residents. In spite of this, the sickening impact on livelihoods is yet to be fully appreciated. It is in the light of this that this study weighs in to discuss the impact and consequences of oil pollution notably oil spillage and gas flaring on the livelihood of the people of the Niger Delta (Akpan, 2012).

The Niger Delta extends over about 70,000 km2 (27,000 sq mi) and makes up 7.5% of Nigeria's land mass. It is the largest wetland and maintains the third-largest drainage basin in Africa. The Delta's environment can be broken down into four ecological zones: coastal barriers islands, mangrove swamp forests, freshwater swamps and lowland rain forests. The region has an estimated regional population of nearly 30 million people ; and comprise of 9 States including Rivers, Bayelsa, Akwa Ibom, Delta, Imo, Abia, Ondo, Cross River and Edo as observed in Ogbija et al, (2015) . However, majority of the oil pollution and gas flaring occur in the core Niger Delta states of Bayelsa, Rivers, Delta, and Akwa ibom states respectively. It is also the region of Nigeria where majority of the oil exploration activities are carried out. The area host a number of International Oil Companies (IOC'S) including Shell whose activities is more prominent in the region. Oil exploration began in 1956 when Shell discovered an oil well in Oloibiri in Bayelsa State.

An estimated 9 million- 13 million (1.5 million tons) of oil has been spilled into the Niger Delta ecosystem over the past 50 years; 50 times the estimated volume spilled in Exxon Valdez oil spill in Alaska 1989 (FME, NCF, WWF UK, CEESP-IUCN 2006). The first oil spill in Nigeria was at Araromi in the present Ondo state in 1908 (Tolulope, 2004). In July 1979 the Forcados tank Terminal in Delta state incidence spilled 570,000 barrels of oil into the Forcados estuary polluting the aquatic environment and surrounding swamp forest (Ukoli, 2005; Tolulope, 2004). The Funiwa No.5 Well in Funiwa Field blew out an estimated 421,000 barrels of oil into the ocean from January 17th to January 30th 1980 when the oil flow ceased (Ukoli, 2005; Gabriel, 2004; Tolulope, 2004), and 836 acres of mangrove forest within six miles off the shore was destroyed. The Oyakama oil spillage of 10th may 1980 with a spill of approximately 30,000bbl (Ukoli, 2005). In August 1983 Oshika village in River state witnessed a spill of 5,000 barrels of oil from Ebocham Brass (Ogada-Brass 24) pipeline which flooded the lake and swamp forest. The area had previously experienced an oil spill of smaller quantity; 500 barrels in September 1979 with mortality in crabs, fish and shrimp. Eight months after the occurrence of the spill there was high mortality in embryonic shrimp and reduced reproduction due to oil in the lake sediments (Gabriel, 2004). The Ogada-Brass pipeline oil spillage near Etiama Nembe in February 1995 spilled approximately 24,000 barrels of oil which spread over freshwater swamp forest and into the brackish water mangrove swamp. 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. 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, 2004; Twumasi and Merem, 2006; Uyigue and Agho 2007). Nigeria National Petroluem Corporation (NNPC) estimates 2,300 cubic meters of oil has spilled in 300 separate incidences annually between 1976-1996 (Twumasi and Merem, 2006). Table 2.1 below show some of the oil polluted sites in the Niger Delta region.

Causes of Oil Spillage

Oil spillage often results from sabotage or theft, human error, accidents and operational discharges of petroleum hydrocarbon into the environment. Oil bunkering is also a source of oil spill.

The DPR Annual Statistical Bulletin (2017) gives a summary of oil spill incidence report and incidence summary. From Table 2.1, it can be deduced that about 65.13% of oil spilled in 2017 was due to sabotage; 17.38% was by yet to be determined causes; 14.35% was as a result of natural accidents, corrosion, equipment failure and human error; while 3% was due to "mysterious" circumstances. These estimates as conservatives as they seem are constantly been disputed by oil companies who argue that the bulk of the oil spill (as much as 90%) occurring in the region are caused by sabotage or vandalism. Also from Table 2.1, 2017 recorded a total of 1087 oil spills with an average of 91 spill incidences per month. Consequently, within the last five years, an average of 733 spill incidences have been recorded annually; with a total average of 23,000 barrels spilled per annum. Nigeria has witnessed incessant oil spill incidences in the past five decades with devastating consequences on land and coastal environment in the Niger Delta region. The Niger Delta region have experienced on the average 273 oil spills resulting to about 115,000 barrels of crude oil spilled annually between 1976-2017 . Also, between January 2012 and August 2017, about 6,333 oil spill incidents were recorded; while according to Jenison, 2017, 1,879 spill incidents were recorded between January 2017 and October 2017. In addition, 1.08 million barrels of crude oil worth about N14, 846.71 million was lost in 2016. Environmental groups conversely say more than 300 spill cases occur yearly. In sum, it is generally held that between 9 million and 13 million barrels have been spilled in the Niger Delta since 1958, and by 2010 that was an equivalent of one Exxon Valdez every year for that period .This is in contrast and a far cry to the only 10 spills reported across all of Europe between 1971 and 2011 according to Jenison, 2017 (Twumasi and Merem, 2006).

Effect of Oil Spillage

Oil spills are mainly caused by equipment failure, operational errors, and leaks from obsolete pipes or willful damage – (that is sabotage). Many of the oil facilities and operations are located within sensitive habitats – including areas vital to fish breeding, sea turtle nesting, mangroves and rain forests. These areas have been severely damaged, contributing to increased biodiversity loss, pollution of water and land resource, deforestation which has culminated in poverty, as a result of the loss of their livelihood. Due to the many forms of oil-generated environmental pollution evident throughout the region, farming and fishing have yielded limited output compared to the pre- oil exploration years. Also drinking water sources are polluted, thus potable water have become very scarce. The presence of oil spillages causes a major impact on the riverine ecosystem is a likely determinant of the poor environmental condition in oil producing communities along the Nigerian coastal waters.

The effect of oil resource extraction on the environment of the Niger Delta has had a lot of negative effect on the region. Eteng (1997: 4) stated that "Oil exploration and exploitation has over the last four decades impacted disastrously on the socio-physical environment of the Niger Delta oil-bearing communities (of which Ibeno LGA is a part), massively threatening the subsistent peasant economy and the environment and hence the entire livelihood and the basic survival of the people."

While oil extraction has caused negative environmental problems in this area, the Nigerian State has benefited immensely from petroleum since it was discovered in commercial quantities in 1956 (Adabanwi, 2001). The Central Bank of Nigeria (C.B.N) 1981 annual report stated as follows:

"Oil which was first discovered in 1956 and first exported in 1958 accounted for more than 90% of Nigerian exports by value and about 80% of government revenue as at December 31, 1981… The overall contribution of the oil sector to the national economy also grew from an insignificant 0.1% in 1959 to 87% in 1976."

Nigerian oil industry has affected the country in a variety of ways and also on the other hand, it has fashioned a remarkable economic landscape for the country. However on the negative side, petroleum exploration and production also have adverse effects on fishing and farming, which are the traditional means of livelihood of the people of the oil producing communities in Nigerian costal region (Worgu, 2000).

Therefore, if the oil industry is considered in view of its enormous contribution to foreign exchange, it has achieved a remarkable success. On the other hand, when considered in respect of its negative impact on the environment and socio-economic life of the immediate oil bearing local communities and it inhabitants, it has left a balance sheet of ecological and socio-physical disaster.

The coming of oil in Nigeria has achieved excellent changes to Nigeria economy. The oil businesses has contributed a noteworthy offer to Gross Domestic Product (GDP) and represented the heft of Federal Government Revenue and remote trade profit since mid-1970. According to Worgu (2000), oil slicks from oil investigation and generation exercises influences the physical, organic and tasteful estimation of the earth and the financial life and strength of the nearby individuals and even inaccessible condition. A portion of the advert impacts of oil slick are; environment, social, financial and health impacts.

Socio-Economic Impacts:

The sudden passing of marine lives and human starts in the area has been ascribed to oil exploration activities due to use of contaminated water and fish. Angling is an imperative part of the country's horticultural division involving about 20% of Gross Domestic Product (CBN, 1994) however sometimes angling grounds have been relinquished in these networks following catastrophe this achieves neediness and low pay in such regions. Oil contamination likewise influences the travel industry locales, for example, the shorelines and stores. This prompts decline inhabitant and non-occupant get-away/joys guests in the spill influenced regions thus influencing organizations, for example, eateries, inns and part water crafts. ITOPE (2009) expressed that oil slick contamination of land and water prompts impedance and loss of recreational exercises, for example, jumping and games. Owabukeruyele (2009), oil slick effects deplorably on the socio-physical condition as it undermines the delicate subsistent laborer economy and biodiversity and consequently social job and very survival of the general population. Oil spillage likewise achieve low expectation for everyday comforts , some of which incorporates absence of clean drinking water , social civilities and loss of employment coming about to bedlam in the region. All these have likewise led to common agitation in such communities.

Health:

Oil spillage has achieved diverse maladies and well being challenges. At the point when oil is spilled on water, it achieve increment substance and biochemical oxygen request and if such water is devoured causes affliction, for example, the runs, kidney issue, hypertension. It likewise causes skin infection whenever utilized on the skin to shower. These contaminations likewise influence amphibian lives and at times it's eaten by people, for example, debased fish, crabs and shrimps can cause serious heath challenge.

Theoretical Review

Strain Theory

Strain theorist, believe that most people share similar values and goals. They want to earn money, have a nice home, drive a great car, and wear stylish clothes. They also want to care for their families and educate their children. Unfortunately, the ability to achieve these personal goals are stratified by social economic class, while the affluent may live a big life, the poor are

shut out from achieving their goals, because they cannot always get what they want, they begin to feel frustrated and angry towards governmental policies, organization and individual who they feel as the ones that are thwarting their goal – a condition referred to as strain (Adishi, 2016). Generally, strain is related to criminal motivation of people who feel economically and socially humiliated, annihilated and may perceived that they have the right to humiliate the Psychologists warn that under these circumstances those who consider themselves losers begin to fear and envy the winners who are doing very well at their expense. If they fail to take risky, aggressive, tactics, they are surely going to lose out in social competition and have little chance of future success. These generalized feelings are precursors to high oil thefts, illegal bunkering and pipe-line vandalism in Niger Delta, which is related to anomic theory by Merton.
According to Adishi (2016), he posited that Merton‘s first line of argument is that everybody in a system cannot be expected to achieve the success goals of the society. And since this is the case, it is imperative that the culture must do two things. It must place a very strong emphasis on the institutionalized means which it has created for use by its members. But more importantly, the society must drive home into the social psyche of its members the equally emphatic necessity of following institutionalized means for their own independent value (Igbo, 2008). Igbo, (2008) went further to posit that members of a society must come somehow to perceive rule adherence and conformity to institutionalized structures as something which provides intrinsic satisfaction of its own. Sociologist Robert Agnew substantially revised Merton‘s theory in order to make it more broadly explanatory of criminal behaviour and insecurity in modern day. Agnew (2002) argued that failure to achieve material goals (the focal poin t of Merton‘s theory) is not the only reason for committing crime and criminality. Crime and criminality may be related to anger and frustration as the case of the Niger Delta militants towards oil facilities. Merton argued that it created not just sudden social change and structure but holds out the goals to all its members without giving them equal means to achieve them. This lack of integration between what the system calls for and what the structure permits trigger over strain that may lead to aggression. It can cause norms to break down and no longer effectively guide or it becomes a paradoxical relation. In Nigeria today, after long years of injustices melted on the Niger Delta people and bottled emotion as a result of suppression by the military, the advent of democracy which allow people to express themselves as a result of democratic windows of self-expression and urge for fundamental human rights against the working of the state and security sector generally stressed the working relationship between security sector, government and the people of Niger Delta, hence high risk factors (strain) and new security challenges.

Empirical Review

Alof & Jonas, (2013) investigated Oil Contamination in Ogoniland, Niger Delta. The result of the study showed extensive oil contamination of rivers, creeks, and ground waters in Ogoniland, Nigeria. The levels found in the more contaminated sites are high enough to cause severe impacts on the ecosystem and human health: extractable petroleum hydrocarbons (EPHs) ([10-C40) in surface waters up to 7420 lg L-1, drinking water wells show up to 42 200 lg L-1, and benzene up to 9000 lg L-1, more than 900 times the WHO guidelines. Extractable petroleum hydrocarbons (EPHs) concentrations in sediments were up to 17 900 mg kg-1.Polycyclic aromatic hydrocarbons concentrations reached 8.0 mg kg-1, in the most contaminated sites. The contamination has killed large areas of mangroves. Although the natural conditions for degradation of petroleum hydrocarbons are favorable with high temperatures and relatively high rainfall, the recovery of contaminated areas is prevented due to the chronic character of the contamination. Oil spills of varying magnitude originates from facilities and pipelines; leaks from aging, dilapidated, and abandoned infrastructure; and from spills during transport and artisanal refining of stolen oil under very primitive conditions.

Kadafa, (2012) investigated the Environmental Impacts of Oil Exploration and Exploitation in the Niger Delta of Nigeria. He found out that Oil exploration and exploitation has been on-going for several decades in the Niger Delta. It has had disastrous impacts on the environment in the region and has adversely affected people inhabiting that region. The Niger Delta consist of diverse ecosystems of mangrove swamps, fresh water swamps, rain forest and is the largest wetland in Africa and among the ten most important wetland and marine ecosystems in the world, but due to oil pollution, the area is now characterized by contaminated streams and rivers, forest destruction and biodiversity loss in general making the area an ecological wasteland. This affects the livelihood of the indigenous people who depend on the ecosystem services for survival leading to increased poverty and displacement of people. The oil industry located within this region has contributed immensely to the growth and development of the country which is a fact that cannot be disputed but unsustainable oil exploration activities has rendered the Niger Delta region one of the five most severely petroleum damaged ecosystems in the world. Studies have shown that the quantity of oil spilled over 50 years was a least 9-13 million barrels, which is equivalent to 50 Exxon Valdez spills (Kadafa, 2012).

Getter, Ballou, & Koons (2015) assessed oil exploration and spillage in the Niger Delta region Elum,Monini, & Henri-Ukoha (2016) critically assessed the effect of oil exploration on poverty in the Niger Delta region of Nigeria. The author's extensive review of the literature and drawing conclusion from the empirical findings restate the neglect of the region and the consequences of pollution as a drawback to economic progress. Their study further concludes that the greatest negative tendency associated with the exploration and exploitation of oil in this region is environmental degradation.

Ojimba (2012), while examining the effects of environmental degradation on human health in nine selected oil communities in Delta State, Nigeria using cluster and principal component analysis, observed that gas flaring has a statistically significant, but dangerous impact on human health in the affected areas giving the high temperature and emission to the atmosphere. Nonetheless, the problem of illegal bunkering and vandalizing petroleum pipelines contribute immensely to oil spillage and degradation of the environment. He observed that oftentimes illegal bunkering and petroleum pipeline vandalization results from destructive tendencies of restive youths, who were aggrieved by government neglect of oil producing communities and corruption of the ruling class in amassing wealth through collaborations with oil companies. Unfortunately, these social vices perpetrated by the youths have a counter-effect in increasing the level of oil spills on the environment and the negative effect on water and land agricultural produce.

Research Design

The studies adopt an exploratory and experimental method. Composite soil samples would be taken at different topographical positions in the Gbaramatu, Bonny Island and Ekeremo remediation site in Delta, Rivers and Bayelsa State. The depths of soil sample at the surface ranged from 0-15cm and at the sub-surface were between 15cm-30cm. These soil samples would be oil-dried, grounded with wooden roller, sieved through a 2mm mesh, labeled and packaged in polythene bags for laboratory analysis.

The soil was analyzed for microbiological parameters, bacteria and fungi degraders, heavy metals and total hydrocarbon contents (THC). Additionally, three sets of questionnaires would be administered to collect information from the oil company (SPDC), the oil spillage clean-up company, and the host community.
However, this study employed the cross-sectional survey design and an experimental design. Bhattacherjee (2012) 'In cross-sectional field surveys, independent and dependent variables are measured at the same point in time (e.g., using a single questionnaire)'. In addition to the fact that cross-sectional survey can be used in both exploratory and descriptive research, the design has the advantage of allowing the researcher to collect data, which can be used in drawing conclusion about a much larger population, while the Experimental design is the process of planning an experiment to test a hypothesis. .

Method of Data Collection

For the purpose of this study, data would be collected through secondary source. Since this research focuses on oil spill remediation, data would be obtained majorly from National Oil Spill Detection and Response Agency (NOSDRA) Nigerian Ports Authority annual bulletin and Nigerian Maritime Administration and Safety Agency (NIMASA) and National Bureau of Statistics and Federal Ministry of environment. All data collected was subject to analysis, verification and classification.

Methods of Data Analysis

Experimental Analysis

Bio remediation is an approach that facilitates the natural bio degradation process of hydrocarbons through the provision of nutrients and oxygen required by microbes. Bio remediation technologies are cost-effective and resource conservative approaches *(Susarla et al., 2002; Lim et al., 2016)*. Three distinctive approaches are adopted in the context of bio remediation, namely, bio augmentation, bio stimulation and bio ventilation.
Bio augmentation is used to enhance the performance of the microbial population through the addition of bacterial with specific catabolic activities, strains or enrichment consortia to increase the rate of contaminant degradation *(Lim et al., 2016)*. One challenge of this approach is that there is no single strain of bacteria that has the requisite metabolic capacity to degrade all oil components. Thus, studies recommend diverse types of bacteria strains and fungi for the remediation of hydrocarbon contaminants *(Lim et al., 2016)*.

Determination of pH

Twenty grams of air dried soil samples would be weighed into a 50mL beaker and 20mL distilled water was added and allowed to stand for 30mins. The solution would be filtered and the filterate will be used to determine pH of soil sample. Hach pH meter would be used to determine the pH. Meter would be calibrated using pH calibration buffer solution for pH 4, 7 and 10. The electrode of the meter would be dipped into the filtrate and the pH meter readings taken to the nearest 0.05unit.

Determination of level of pollution

Calculation of Index of geo accumulation (I-ego)

The degree of metal and Total Petroleum Hydrocarbon (TPH) pollution at different sites would be assessed in terms of seven contamination classes in order of increasing numerical value of the index as shown in Table 1 (Matina et al,2011). It was applied to unravel levels of accumulation of heavy metals and Total Petroleum Hydrocarbon (TPH) at the different sites.

$$I\text{-}geo = Log_2 Cn/1.5Bn) \qquad (3.1)$$

Where Cn is the concentration of the heavy metal or Total Petroleum Hydrocarbon (TPH) in the contaminated sample and Bn is the concentration of the metal or Total Petroleum Hydrocarbon (TPH) in the unpolluted (control) samples. The factor 1.5 would be introduced to minimize the effect of the possible variations in the background or control values which may be attributed to lithogenic variations in the soil.

Category	Value of Soil Quality
<0	Unpolluted
0-1	Unpolluted to moderately polluted
1-2	Moderately polluted
2-3	Moderately polluted to highly polluted
3-4	Highly polluted
4-5	Highly polluted to very highly polluted
>5	Very highly polluted

Table 3.1: Seven classes of geo accumulation index

Calculation of Contaminant factor (Cf)

The second approach was the application of Contamination factor (Cf) and the degree of contamination. In calculating Cf, the Equation (2) suggested by Hakanson (1998) and Dasaram, *et al.*(2010) would be used.

$$Cf = CV/G \qquad (3.2)$$

Where C^i_{0-1} was the mean content of individual metals or Total Petroleum Hydrocarbon (TPH) from the 6 sample sites and Cin was the pre-anthropogenic concentration of individual metals or Total Petroleum Hydrocarbon (TPH). Cf would be to differentiate between the metals or Total Petroleum Hydrocarbon (TPH) originating from anthropogenic activities and those from natural processes and to assess the degree of anthropogenic influence (Table 2).

Cf <1	Low contamination factor
1 <Cf <3	Moderate contamination
3< Cf < 6	Considerable
6< Cf	Very high contamination
3-4	Highly polluted
4-5	Highly polluted to very highly polluted
>5	Very highly polluted

Table2: Categories-of contamination factors

The third approach used the quantification of anthropogenic concentration of metal or Total Petroleum Hydrocarbon (TPH) by applying the concentration in the control samples to represent the lithogenic metal (Pam et al,2013). This would be calculated in accordance with Equation (2):

$$X - XC$$

Quantification of anthropogenic metal/TPH = x100% (3.3)

X

Where X= average concentration of the metal in the soil under investigation, and Xc = average concentration of the metal in the control samples (Victor, Akinlolu and Cheo, 2006). In this study, the concentration of the control samples would be taken to represent the pre-anthropogenic concentration as suggested by Victor, *et al.*(2006).

T- Test Analysis

The T-test assesses whether the means of two groups are statistically different from each other. The formula for T-test is a ratio. The top part of the ratio is just the difference between the two means or average. The bottom part is a measure of the variability or dispersion of the scores. The formula is essentially another example of the signal to noise metaphor in research. The difference between the means is the signal that, in this case, we think our program or treatment introduced into the data; the bottom part of the formula is a measure of variability that is essentially noise that may make a harder to see the group difference. X_t-X_c

The formula is given below:

$$\frac{Signal}{Noise} = \frac{Difference\ btween\ group\ means}{Variability\ of\ groups}, \qquad \text{T-Value} = \frac{Xt - Xc}{SE\left(Xt - Xc\right)}$$

The top part is easy to compute; just find the difference between the means. The bottom part is called the standard error of the difference.

To compute it, we take the variance for each group and divide it by the number of people in that group. We add these two values and then take their square root.

The specific formula is given below;

$$SE\ (X_T\text{-}X_C) = \sqrt{\frac{Var\ T}{N\ T} + \frac{Var\ c}{N\ c}}$$

Formula for standard error of the difference between the means.

Remember, the variance is simply the square of the standard deviation.

The final formula for the T-Test is shown below:

$$T = \frac{XT - XC}{\sqrt{\frac{Var\ T}{N\ T} + \frac{Var\ c}{N\ c}}}$$

The test will be positive if the first means is larger than the second and negative if it is smaller. Once you compute the T-test value, you have to look it up in a table of significance to test whether the ratio is larger enough to say that the difference between the groups is not likely to have been a chance finding.

It defines the relationship between quantities of oil spilt, Number of fishes affected by oil spills, Job loss affected by oil spill, Number of persons affected by oil spills and environmental degradation and is used to obtain the coefficients associated with oil pollution in the Niger delta region.

The model which defines this relationship is expressed as:

$Y = Bo + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + u$ (3.4)

Where: Y = Total volume of oil spilled, which is the dependent variable

Bo = Constant

Where the following are the inde pendent variables

X1 = Ship operational discharge

X2 = Gross Domestic Product

X3 = Number of fishes affected by oil spills
X4 = Job loss affected by oil spill
X5 =Number of persons affected by oil spills
U= Error term (which accounts for factors that affect quantity of oil split not reflected in the model). Bo is the baseline while B1, B2, B3, B4 and B5 are coefficients of the regression parameters to be estimated.

DECISION RULE
When compared the calculated value of T-test and the value on the contingency table, the decision rule is as follows:

- Accept null hypothesis (H_o) if T-test value is larger than or equal to critical value $t_{\alpha,}$
- Reject the null hypothesis (H_o) if T-test value is less than the critical value t_α and accept the alternate hypothesis (H_A)
  Where α is level of significance which is taken to be 0.05

RESULTS AND DISCUSSION
This chapter focuses on the presentation, analysis and interpretation of the data collected mainly through secondary sources and a laboratory analysis. Hence, the emphasis here is to estimate, analyze and interpret the model as already formulated in chapter three of this thesis. Also, the five hypothesis of chapter one are equally tested. As already stated, we need to note that secondary data were employed in carrying out the tests, supported by other analytical tool. Due to the nature of the hypothesis, a simple multi linear regression model was employed to test each of the five hypotheses. To achieve clarity, we also observed an orderly presentation in this chapter.

Table: Data Presentation

Parameters	A	B	C	D	E	F	P-Value	DPR	CS
Ph	5.74±0.22	5.89±0.13	5.78±0.03	5.67±0.06	5.48±0.08	5.88±0.14	0.015		5.40
TPH mg/kg	2428.33±1	3015.67±28	3014.67±50	700.83±39	193.67±16	448.67±10	<0.001	1000	0.01
CEC Cmol/kg	3.07±0.05	2.99±0.02	2.97±0.07	3.08±0.01	2.74±0.18	3.00±0.01	< 0.003	-	5.31
Cr mg/kg	11.09±0.03	21.66±0.31	10.09±0.23	12.82±0.6	10.84±0.2	4.71±0.34	<0.001	20.00	0.01
Pb mg/kg	2.27±0.04	1.03±0.02	3.61±0.49	1.32±0.7	2.82±0.24	0.21±0.03	<0.001	35.00	0.30
Cd mg/kg	0.00	0.00	0.88±0.29	0.04±0.01	0.55±0.17	2.41 ±0.09	<0.001	100.0	0.70
Zn mg/kg	3.19±0.12	1.79±0.11	11.08±0.19	6.08±0.84	12.88±0.27	8.88±0.27	<0.001	140.0	3.20
Cu mg/kg	7.86±0.08	8.36±0.06	8.36±0.06	4.65±022	4.76±0.25	5.23 ±0.11	<0.0030	31.00	0.01

Table: showed the variations of values of the analyzed chemical parameters at different sampling points and comparison with environmental guidelines and standards for the Petroleum Industry in Nigeria (EGASPIN, 2012) standard. All parameters varied significantly ($P<0.05$) at all sampling points. pH values ranged between 5.89±0.13 and 5.48±0.08 and close to the control sample value of 5.40. pH varied significantly at all the sampling at P = 0.015. Total Petroleum Hydrocarbon (TPH) concentrations ranged from 3015.67±283.93 - 193.67±161.98 mg/kg. TPH values varied significantly at $P < 0.001$. TPH was highest at sampling point B and lowest in sample point E. The values were highly above the control value of 0.01 mg/kg. TPH values were above EGASPIN (EGASPIN, 2012) limit of 1000 mg/kg at sampling points A, B and C while it was below EGASPIN (EGASPIN, 2012) limit at sampling points D, E and F. Cation Exchange Capacity (CEC) varied significantly at different sampling points at $P<0.003$ and ranged from 3.07±0.05 - 2.74±0.18 Coml./kg, with highest value at sampling point A and lowest value at sampling point E. The values were below the control value of 5.31 Cmol/kg. Chromium (Cr) ranged from 21.66±0.31 - 4.71±0.34 mg/kg, and varied significantly at $P < 0.001$, with the highest value at sampling point B and lowest value at sampling point F. The values were highly above the control value of 0.01 mg/kg. The values were below the EGASPIN (EGASPIN, 2012) limit of 20 mg/kg. Lead (Pb) ranged from 3.61±0.49 - 0.21±0.03 mg/kg, and varied significantly at $P < 0.001$, with highest value recorded at sampling point C while the lowest value was recorded at sampling point F. The values were highly above the control value of 0.30 mg/kg. Pb values were below the EGASPIN (EGASPIN, 2012) limit of 35 mg/kg. Cadmium (Cd) ranged from 2.41±0.09 - 0.00 mg/kg and varied significantly at $P < 0.001$, with highest value recorded at sampling point F and lowest value at sampling points A and B. The values were highly above the control value of 0.07 mg/kg. Cd values were below the EGASPIN (EGASPIN, 2012) limit of 100 mg/kg. Zinc (Zn) ranged from 12.88±0.27-1.79±0.11 mg/kg and varied significantly at $P < 0.001$, with highest value recorded at sampling points E and lowest value at sampling point B. The values were highly above the control value of 3.20 mg/kg. Zn values were below the EGASPIN (EGASPIN, 2012) limits of 140 mg/kg. Copper (Cu) ranged from 8.36±0.06 - 3.14±0.13 mg/kg and varied significantly at $P < 0.001$, with highest value recorded at sampling point B and lowest value at sampling point C. The values were highly above the control value of 0.01 mg/kg. Cu values were above the environmental guidelines and standards for the petroleum industry in Nigeria (EGASPIN, 2012) limit of 0.3 mg/kg.

Discussion

Application of Bio remediation on Crude Oil Contaminated Sites

Total Hydrocarbon Content, THC (13.00-17.31mg/l), turbidity (10.70-11.00mg/l), total suspended solids, TSS (10.00-12.00mg/l), and temperature (29.50-29.75oC), all fall within the DPR allowable limits and therefore do not constitute any treat to the recipient marine environment. This was also the case of the chemical oxygen demand, COD (92.10-95.33mg/l), biochemical oxygen demand, BOD (61.25-64.30mg/l), and heavy metals of lead, iron, copper, chromium, and zinc.

The pH of the recipient marine water showed compliance with the DPR standards unlike that of the produced water with a mean value of 6.33. The central discharge point with a pH value of 7.41 indicates the point maximum concentration of the effluent discharge thereby having a near neutral pH.

The total hydrocarbon concentration (THC) was 0.1mg/l at the central discharge point. The north, south, east, and west points had values of 0.01mg/l, 0.01mg/l, 0.03mg/l, and 0.01mg/l. This gives the following implications:

(1) THC emanates from a source and enters the recipient water.

(2) THC entering the recipient water emanates from the central discharge point.

(3) The source concentration is higher than other points.

(4) The recipient water at the east point is slightly affected.

The dissolved oxygen content (DOC) values show a non-compliance with DPR standards. The total dissolved solid (TDS) also show a level of non-compliance with DPR standards.

Other parameters such as nitrate, ammonium ion, cyanide, phosphate, phenols, *E. coli*, and trace metals showed compliance with DPR standards.

In all the physico-chemical parameters evaluated, the central discharge point showed slight variations in value showing that this was the point of maximum concentration before dilution with distance from the discharged point.

It is obvious that produced water have potential impacts on the recipient environment depending on where it is being discharged. For example, discharges to small streams are likely to have a larger environmental impact than discharges made to the open ocean by virtue of dilution that takes place there.

The significant variation ($P<0.05$) of parameters at different sampling points was confirmative of the fact that the level of remediation was not uniform for all parameters or characteristics of the soil at the different sampling points. Since the soil properties or characteristics might be same within the study area before contamination, the concentrations of the crude oil at the different sites/ points before remediation might have varied with the remediation efficiency. The topography of the area might play key role in the velocity of the oil spread and dispersion (Danielson & Weingartner, 2007). Increased velocity of the oil dispersion might reduce the stay time and rate of infiltration of the oil into the soil (Youdeowei, 2012). Stagnancy of oil spills might be responsible for variations in concentration of contaminated sites (Obidi, Onuoha, Nwachukwu, 2010). Another major factor responsible for the varying concentrations of parameters at the different sites/points might be the efficiency of oil recovery (Romero-Zeron, 2012).Oil recovery before remediation from contaminated sites might not have reduced the concentrations of the oil to uniform concentrations at the varying sites or points.

Though the pH varied significantly ($P<0.05$) at the different sampling points, it still remained acidic when compared with the pH of the control sample. Though, the Niger Delta soils have been known to be generally acidic, oil spillage might assist the soil in maintaining acidic pH values. Acidic soil pH affects soil microbial activities and nutrient bio-geochemical cycling (Bolan, Adriano and Curtin, 2013). Acidic pH of soils can affect the availability of soil nutrients and mobility of heavy metals. Heavy metals might be toxic to soil biota and lead to ground water contamination due to infiltration.

That the TPH values were above DPR limit of 1000 mg/kg at sampling points A, B and C while it was below the environmental guidelines and standards for the petroleum industry in Nigeria (EGASPIN) at sampling points D, E and F, implied that the remediation was not uniformly carried out at all the sampling points and that some points in the study area (Gbaramatu, Bonny Island and Ekeremor) were still affected by the oil spill even after remediation. The values were highly above the control value of 0.01 mg/kg. I-geo TPH was >5 which implied that the study area was very highly polluted. Cf value for TPH was 163355.67 which fell in the category of very high contamination, with an anthropogenic impact of 99.99%. The high TPH results confirm petroleum hydrocarbon pollution. Measured TPH values suggest the relative potential for human exposure, and therefore, the relative potential for human health effects. According to Agency for Toxic Substance and Disease Registry (ATSDR,2019)), the compounds in some TPH fractions can also affect the blood, immune system, liver, spleen, kidney, developing foetus and lungs. Certain TPH compounds can be irritating to the skin and eyes. One TPH compound (benzene) has been shown to cause cancer (leukemia) in people. The International Agency for Research on Cancer has determined that benzene is carcinogenic to humans. Some other TPH compounds or petroleum products such as; benzo (a) pyrene and gasoline are considered to be probably and possibly carcinogenic to humans based on cancer studies in people and animals.

One TPH compound (n-hexane) can affect the central nervous system in a different way, causing a nerve disorder called "peripheral neuropathy" characterized by numbness in the feet and legs, and in severe cases, paralysis swallowing. Some petroleum products such as gasoline and kerosene cause irritation of the throat and stomach, central nervous system, depression, difficulty in breathing and pneumonia from breathing liquid into the lungs. However, for the fact that some TPH fractions are persistent pollutants and are present in water and soil, signifies the sure intake of the substances through the roots of plants and presence in the fruits of the plants with higher tendencies for bioaccumulation in aquatic biota spells serious concern. The presence of TPH in the soil serves as a reservoir for PAHs leached into the ground water and as runoff into surface water. Its presence indicates the exposure of humans to health problems. The CEC values were below the control value of 5.31 Cmol/kg. According to Karumam, *et al.* (2015), a low value of CEC implied that the soil had a low capacity to hold cations in exchangeable form. In this study, the CEC values obtained may be classified as low and could be attributed to the loss of binding capacity in the soils due to oil spillage. Therefore, retention of metal ion was low in all the sampling points and this could suggest high leach ability of heavy metals from soils underneath the wastes into underground water, thereby posing a health hazard to humans and other animals that drink this water. The values of Cr were below the EGASPIN limit of 20 mg/kg and highly above the control value of 0.01 mg/kg. This implied that the remediation was efficient in controlling deposits of Cr below established standards. This did not imply that there was no introduction of Cr in the study area due to the oil spillage. I-geo Cr for all sampling points were >5, which implied that the study area was very highly polluted when compared with the value of the control sample. The Cf value for Cr was 1186.89 which fell in the category of very high contamination, with an anthropogenic impact of 99.91% [10]. Though, Pb varied significantly ($P<0.05$) at the different sampling points, Pb values were below DPR limit of 35 mg/kg. This implied that the remediation was efficient in controlling deposits of Pb below established standards. This did not imply that there was no introduction of Pb in the study area due to the oil spillage. I-geo for Pb showed that some points were highly polluted, while others were moderately polluted to unpolluted when compared with the value of control sample. The Cf value for Pb was 6.26 which fell in the category of very high contamination, with an anthropogenic impact of 87.78%.

The values of Cd were below the environmental guidelines and standards for the petroleum industry in Nigeria (EGASPIN) limit of 100 mg/kg and were highly above the control value of 0.07 mg/kg. this did not imply that there was no introduction of Cd in the study area due to the oil spillage. I-geo for Cd showed that some points were highly polluted, while others were moderately polluted to unpolluted when compared with the value of control sample. the Cf value for Cd was 9.26 which fell in the category of very high contamination , with an anthropogenic impact of 89.23%.

The study on Apex Barges spill showed that bio remediation process could affect the physical appearance of the treated oil without degrading the hydrocarbon. Therefore, clearly designed experiments with appropriate controls are required to evaluate the success of any application of bio remediation.

Testing of Hypotheses

Hypothesis

H_{O1}: There is no significant relationship between socio-economic effects of oil spill remediation on the health of persons in oil bearing localities of the Niger Delta

TABLE: Regression Analysis for health of persons (HOP) and oil spill remediated space (OSR) Model at 5% Level of significance

Dependent Variable: OSR

Method: Least Squares

Date: 29/07/23 Time: 13:28

Sample: 2010 2022

Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.65E+08	4.53E+08	1.469643	0.1724
HOP	209992.8	199085.4	1.054788	0.3163

R-squared	0.100119	Mean dependent var	1.11E+09
Adjusted R-squared	0.010131	S.D. dependent var	5.30E+08
S.E. of regression	5.28E+08	Akaike info criterion	43.15685
Sum squared resid	2.78E+18	Schwarz criterion	43.23767
Log likelihood	-256.9411	F-statistic	1.112578
Durbin-Watson stat	0.673889	Prob (F-statistic)	0.316340

Source: Researcher's computation

The regression results in table above shows that there is a positive relationship between health of persons affected (HOP) and oil spill remediated space (OSR). This is because the coefficient of HOP is positive. It means that it agrees with the theoretical expectation that an increase in HOP will enhance the volume of oil spill remediated.

On the other hand, the computed t-value of 1.06 (0.32 percent) is less than the criterion value. Thus, the null hypothesis which says that there is no significant relationship between health's of persons affected and oil spill remediated space is accepted.

Remediation technique for soil and water are different. Many factors are responsible which determine the type of remediation technique that should be used. Type of contamination present and where the contamination has taken place are the two main factors that have to be considered in determining the remediation. Cleaning contaminated soil is not an easy process and needs time to get clean.

Model for hypothesis

$OSR = W_0 + a_1\ HOP + U_{4t}$ (4.5)

Where oil spill remediated space (OSR).

OSR = oil spill remediated space

HOP = Health of Persons affected

W_0 = Autonomous oil spill remediated space

W_1 = Coefficient of estimate

U_{4t} = Error term

Aprioro, $W_1 > 0$

Conclusion

Our continued reliance on oil puts us at risk of environmentally harmful events like oil spills. Therefore, it is imperative to have reliable methods to recover and remediate as much oil as possible at sea before it gets to the shoreline. During the Dee pwater Horizon incident, which was one of the greatest clean up responses, only 24% of the oil was recovered or remediated (Azwell 2013). Inevitably some oil will reach the shoreline, and, depending on the type of oil and type of shoreline, different methods must be considered to remove and remediate the oil without destroying the natural ecosystem. As oil exploration and extraction technology becomes more advanced, progress and investment into environmentally sensitive and effective removal cleanup technologies must keep up (Baker 1995)

Contamination of land with crude oil affects the ecosystem services which nature renders to man and his environment. Several remediation technologies are available for treatment of these lands to return them to original state. However, trial of many of these technologies in the Niger Delta has yielded little or no success due to reasons ranging from soil type to the consequences of use of the technology on the environment. While the remediation by enhance natural attenuation (RENA) method has been unsuccessful due to percolation of crude oil through the mid-soil, the physical remediation methods are labour intensive, expensive and not suitable for large scale contamination as in Niger Delta region and the chemical remediation's methods are expensive and could lead to contamination of other environmental media like air and water through the introduction of solvents and reagents during remediation. The techniques used for remediation depends on factors like oil type, physical, biological and economical characteristics of the spill location, weather and amount of spill. Bio remediation has come out to be the best environment friendly and successful remediation technique. Government policies are also playing a crucial role in the success of remediation techniques and disaster managements. More researches are still required for the development of advances techniques for the remediation of oil spill. The response primary objectives are to prevent the spill from moving onto shore, to reduce the impact on marine life and to speed the degradation of any uncovered oil. To maximize those objectives, the techniques used for remediation will depend on several factors including: type of oil, physical, biological and economical characteristics of the spill location, weather and sea conditions, amount spilled and rate of spillage, depth of water column, time of the year and effectiveness of clean up method.

Recommendations

Clean-up operations should be internalized to avoid the problem of bureaucracy which leads to unnecessary delays in the award of clean-up contracts. To be efficient, if will require oil

companies to have a standing and functional clean-up unit with the latest state – of- the art technology.
To achieve more excellent results, two or more strategies could be combined for clean-up operations. For instance, a combination of bio-remediation and phyto remediation as well as tilling and evacuation of affected soils would certainly be more productive.
Oil companies, as a matter of statutory obligation, should pay compensations to affected communities promptly. This will curb the incidence of community violence and obstructions.
The need for government agencies involved in monitoring programmes to be more pro-active and efficient cannot be over emphasized. They must ensure that the cleanup is promptly carried out, ensure the thoroughness of the exercise, and strict adherence to standards.
Oil companies should as much as possible try to prevent the occurrence of oil spills. This can be achieved by servicing their equipment on a regular basis. They could also employ youths from respective communities as guards to the pipelines to avoid sabotage and also guarantee prompt report of spillage.

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