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ACCESSMENT OF THE EFFECT OF OIL SPILL REMEDIATION TECHNIQUE ON GDP OF THE NIGER DELTA.

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ABSTRACT

Crude oil is the major source of income to the Nigerian economy, it 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. In most cases, simple and cheap remediation methods are employed which do not adequately consider the complexity of the different polluted media. This study reviewed the different remediation technologies for polluted water, soil, and sediment media that are appropriate for the local Nigerian environmental conditions. Both full-scale and pilot-scale case studies were reviewed. Ex- situ trenching and treatment are recommended for groundwater treatment and bio remediation is recommended for contaminated soils. The limitations of the methods/techniques are discussed, and the future technological prospects are highlighted in this review.

Keywords : Crude oil, Spills, Niger-Delta, Bio remediation, Techniques.

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. (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. Spills of oil has a numerous negative impact both short and long term, resulting in economic and financial losses.

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). However, due to their visibility and dramatic appearance, oil spills still attract the attention of the media and consequently the public and politicians, as in the case of the Deep water Horizon blowout in the Gulf of Mexico in 2010. However, 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.Many of the toxic as well as non-toxic hydrocarbons evaporate and are degraded by microorganisms quite rapidly Nuclear Regulatory Commission NRC 2003; International Tanker Owners Pollution Federation Limited (ITOPF 2011b). However, there may be adverse long-term effects under particular conditions (Peterson et al. 2003). An estimated 2 million tons of oil is released into the environment annually from human and natural processes (NRC 2003). About half of this comes from natural seepage of oil into the sea and coastal environments from oil deposits on the continental shelf (NRC 2003). Once oil has contaminated wetlands such as marshes and mangroves, it is often very difficult to remove without causing further damage to these environments (Nenibarini, 2014). Oil slicks may enter such areas during high tide and as the tide recedes, oil is deposited on the vegetation causing asphyxiation of the plants. Toxic effects may also occur if the oil is fresh and contain a high amount of light aromatic hydrocarbons. Obviously, if the mangrove vegetation dies, many plants and animals associated with this ecosystem will also suffer due to the keystone character of the mangrove vegetation. 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). Most of the lowland rain forests that used to characterize the areas landward from the swamp forests are now derived Savannah or agricultural land with only small areas of more or less degraded coastal rainforest left. 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. As a result of the contamination of oil in mangroves and wetlands as well as on land, oil has penetrated into soils down to several meters and has contaminated ground waters over large areas. This has resulted in the contamination of water wells as a particularly serious concern from a human health perspective (UNEP 2011). jDuring 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.

According to Brussaard., Peperzak, Witte, & Huisman (2009) measurements on the ES-2009 spill specified that slick concentration and dissolved oil compounds were high and spread from the water body and travelled directly underneath the slick to distances of at least 500 m from the spill even though slick was not visible after 20hour. They also discovered that the dissolved oil components were available immediately to the biota in the earliest spill samples (2hours & 6hours after the spill). These data helps conclude that accidental oil availability even in smaller quantities in the marine ecosystem is of much concern and hence studies on the impact of oil spills on marine organism needs to be assessed. Also rising demands for marine oil exploration is likely to increase rather than decrease hence an increased frequency of small spills. Various researches has documented oil toxicity at its highest during the initial stages of a spill hence even smaller spills can possibly cause prolonged impacts and pose a serious risk to marine ecosystem health and biota. For instance, major shipping routes on the North Sea is recurrently contaminated with oil, either from unintentional spills or maybe from natural oil and gas seeps discovered a lot of unsupervised and undocumented spills within the major shipping routes on the North Sea. Even though some of these spills were small and not visible on the surface water, they release very high C30-C38 concentrations (above 80 µg/l), significant alkane and PAH levels (20-60 µg/l) and showed high toxicity values.

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?

Objectives of the Study

To access the effect of oil spill remediation technique on GDP of the Niger Delta.

Research Questions:

To what extent does the effect of oil spill remediation influence the GDP of the Niger Delta?

Hypotheses

Ho_1: There isno significant relationship between oil spill remediation techniques on GDP of the Niger Delta.

Justification of the Study

This study has both theoretical and practical significance. Theoretically, it will add to already existing body of knowledge on the impact oil spill remediation techniques on the marine environment. Given the vast information on how maritime oil pollution affects the marine environment, the study will serve as a significant reference material for students, scholars and the general public.

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

Table: Annual number of oil spills

Years	Number of spills	Quantity spilled(Barrels)
2013	537	17,658.10
2014	673	66,906.84
2015	844	17.526.37
2016	522	4,062.20
2017	1087	10,302.16
2018	2089	18,421.98
2019	2478	20,312.23

Source: DPR (2019)

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.

Remediation for Oil Spills

Remediation of oil spills is a serious issue because of its adverse effects on the biosphere. Oil spreads on the top surface of water and form a horizontal smooth and slippery surface known as slick. It forms thin coating on the bird's feathers which loses its insulating properties and results in freezing death. It will also reduce the amount of oxygen dissolving from air in water which is necessary for marine life. Oil spill has toxic impact on aquatic animals and damages their food resources and habitats. Therefore, proper remediation must be done after oil spillage.

Oil Spill Remediation Techniques

Marine oil spill control and clean up is the most debatable issue because it is not possible to clean up all the oil introduced into the marine water. Current remediation techniques are: (a) physical (b) chemical (c) thermal and (d) biological (Larson, 2010).

(i) **Physical remediation methods**: Physical methods are commonly used to control oil spills in a water environment. They are mainly used as a barrier to control the spreading oil spill without changing its physical and chemical characteristics. A variety of barriers are used to control oil spills including: (a) booms (b) skimmers and (c) adsorbent materials (Fingas, 2011; Vergetis, 2002).

(ii) **Booms**: Boom are a common type of oil spill response equipment which are used to prevent spreading of the oil spill by providing barrier to oil movement which can improve the recovery of oil through skimmers or other response techniques.

(iii) **Skimmers;** A skimmer is a device for recovering spilled oil from the water's surface. Skimmers may be self-propelled, used from shore, or operated from vessels. The efficiency of skimmers is highly dependent upon conditions at sea. In moderately rough or choppy water, skimmers tend to recover more water than oil. Different types of skimmers offer advantages and drawbacks depending on the type of oil being recovered, the sea conditions during cleanup efforts, and the presence of ice or debris in the water.

There are three types of skimmers: **Weir skimmers** use a dam or enclosure positioned at the oil/water interface. Oil floating on top of the water will spill over the dam and be trapped in a well inside, bringing with it as little water as possible. The trapped oil and water mixture can then be pumped out through a pipe or hose to a storage tank for recycling or disposal. These skimmers are prone to becoming jammed and clogged by floating debris. **Oleophilic ("oil-attracting") skimmers** use belts, disks, or continuous mop chains of oleophilic materials to blot the oil from the water surface. The oil is then squeezed out or scraped off into a recovery tank. Oleophilic skimmers have the advantage of flexibility, allowing them to be used effectively on spills of any thickness. Some types, such as the chain or "rope-mop" skimmer, work well on water that is clogged with debris or rough ice.

Suction skimmers operate similarly to a household vacuum cleaner. Oil is sucked up through wide floating heads and pumped into storage tanks. Although suction skimmers are generally very efficient, they are vulnerable to becoming clogged by debris and require constant skilled observation. Suction skimmers operate best on smooth water, where oil has collected against a boom or barrier.

Skimmers: These devices can be used in conjunction with booms to recover oil from water surface without changing its properties so it can be reprocessed and reused. Skimmers consist of disks, belts, drums and brushes (Larson, 2010; & Hammoud, 2001). They may be self-propelled, used from shore or operated from vessels.The success of skimming depends on the type and thickness of the oil spill, the amount of debris in the water, the location and the weather conditions. They are generally effective in calm waters and subject to clogging by floating debris.

Chemical remediation methods: Chemical methods are used in combination with physical methods for marine oil spill remediation as they restrict the spreading of oil spill and help to protect the shorelines and sensitive marine habitats**.** Various chemicals are used to treat the oil spills as they have capabilities to change the physical and chemical properties of oil (Vergetis, 2002). The chemicals used to control oil spills include: (a) dispersants and (b)solidifiers**.**

Dispersants: Dispersants consist of surfactants (surface active agents) dissolved in one or more solvents and stabilizer . Dispersants have capabilities to break down the slick of oil into smaller droplets and transfer it into the water column where it undergoes rapid dilution and can be easily degraded (Lessard and Demarco, 2000).

The dispersants available today are less toxic and more effective compared to the compounds that were previously used (Lessard and Demarco, 2000). These concentrated types of dispersants include: Slickgone NS, Neos AB3000, Corexit 9500, Corexit 8667, Corexit 9600, SPC 1000™, Finasol OSR 52, Nokomis 3-AA, Nokomis 3-F4, Saf-Ron Gold, ZI-400, Finasol OSR 52 (USEPA, 2011b).

Dispersants proved their capabilities to treat up to 90% of spilled oil and are less costly than the physical methods (Holakoo, 2001). They can be used on rough seas where there are high winds and the mechanical recovery is not possible. They also allow for rapid treatment, slow down the formation of oil-water emulsions make the oil less likely to stick to surfaces (Including animals) and accelerate the rate of natural bio degradation by increasing the surface area of the oil droplets. Applicability of dispersants depends on type of oil, temperature, wind speed and sea conditions (Nomack and Cleveland, 2010).

Solidifiers are dry granular (hydrophobic polymers) materials that react with oil and change its liquid state into solid rubber like state that can be easily remove by physical means. Soldiers can be applied in various forms including dry particulate and semi-solid materials (pucks, cakes, balls, sponge designs). They are contained in booms, pillows, pads and socks or packaged forms (Delaune et al., 1999).

(iv) **Thermal remediation method**: In situ burning is a simple and rapid a thermal mean of oil spill remediation that can proceed with minimal specialized equipment (fire resistant boom, ignites) with higher rates of oil removal efficiency. Since the late 1960s, in situ burning is widely used to remove spilled oil and jet fuel in ice covered waters and snow resulting from pipeline, storage tank and ship accidents in the USA and Canada as well as several European and Scandinavian countries (Mullin and Champ, 2003).This method of oil spill response is effective in calm wind conditions and spills of fresh oils or light refined products which quickly burn without causing any danger to marine life. However, the residue may sink and cover up an underground water resource. Removal of the residue can be achieved through mechanical means (Davidson et al., 2008).

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.

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)*.

(a) 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.

(b)Determination of Conductivity

Twenty grams of air dried soil samples would be weighed into a 50 mL beaker and 20 mL distilled water was5 added and allowed to stand for 30 mins. The solution would be filtered and the filtrate used to determine the conductivity of soil sample. Hach conductivity meter would be used to determine the conductivity. The conductivity meter would be calibrated using conductivity calibration solution. The electrode of the meter would be dipped into the filtrate and the conductivity meter readings taken to the nearest 0.05unit.

(c) Determination of Total Petroleum Hydrocarbon (TPH) in Soil

Ten grams (10g) of the sample would be weighed into extraction bottle and 20mL of extraction mixture (dichloro methane (DCM): Hexane: acetone) in ratio 2:2:1 would be added. The mixture would be sonicated for 1hr and the organic aqueous layer would be decanted. Extracted organic phase would be dried using anhydrous sodium sulphate salt and concentrated using vacuum rotary evaporator gas to about 1.0mL. Round bottom flask was rinsed to make the final volume of the extract to 1.0ml. One micro litre (1.0 pL) of the final extract would be injected into already *calibrated Gas Chromatograph (HP 5890, USA) equipped with capillary column. The peak areas would be used in the quantification. All QA/QC procedures would be strictly followed.

Extract would be fractionated by using column packing. The column would be packed by placing 1g of glass wool into the column and gently packed. One milliliter (1ml) of silica gel was placed on it and 1ml of sodium sulphate would be added on top of the silica gel. The column would be pre-conditioned by running 10mL of n-hexane through the column. One milliliter (1ml) of the concentrated extract would be placed on the column and eluted with 10mL n-hexane. Eight milliliter (8ml) of the eluents was taken and discarded and the remaining 2mL would be collected and kept in a 2mL vial for aliphatics. To the same column, 10mL of DCM would be allowed to drain through the column and 8mL of the eluent would be collected and discarded. The remaining 2mL was collected into a vial and kept for aromatics. One microlitre (1.0 pL) of the aromatic and aliphatic extract would be injected into already TPH calibrated standard GC and result would be expressed in mg/kg.

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.

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.

Hypothesis

H_0 There is no significant relationship between oil spill remediation techniques on GDP of the Niger Delta

Regression Analysis Gross Domestic Product (GDP) and oil spill remediated space (OSR) Model at 5% Level of significance.

Dependent Variable: OSR

Method: Least Squares

Date: 07/29/23 Time: 13:24

Sample: 2010 2022

Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.07E+09	7.04E+08	2.945886	0.0146
CTP	-275.3477	197.7775	-1.392209	0.1940

R-squared	0.162356	Mean dependent var	1.11E+09
Adjusted R-squared	0.078592	S.D. dependent var	5.30E+08
S.E. of regression	5.09E+08	Akaike info criterion	43.08518
Sum squared resid	2.59E+18	Schwarz criterion	43.16600
Log likelihood	-256.5111	F-statistic	1.938247
Durbin-Watson stat	0.956304	Prob(F-statistic)	0.194042

Source: Researcher's computation from appendix B

Table above shows the regression result for Gross Domestic Product (GDP) and oil spill remediated space (OSR). The coefficient of GDP is negative. This negates the theoretical expectation that an increase in GDP will promote oil spill remediated space (OSR) in the Niger Delta. More importantly, the R^2 calculated is 0.162 which means that about 16.2 percent of the total variation in the model is explained by independent variable GDP while the remaining 83.8 percent is explained by variables not captured in the model but covered by the error term. By extension, the overall model is not significant and equally characterized by seemingly lesser degree of auto correlation too.

Furthermore, the calculated t-value of -1.39 (in absolute term) is less than the criterion value. Simply put, 19 percent t-value calculated hence, the null hypothesis which says that that there is no significant relationship between Gross Domestic Product (GDP) and oil spill remediated space is accepted.

Model for hypothesis

$REG = b_0 + b_1 CTP + U_{2t}$ (2)

Where

OSR = oil spill remediated space

GDP = Gross Domestic Product

b_0 = Autonomous oil spill remediated space

b_1 =Coefficient of estimate

U_{2t} = Error term

Aprioro, $b_1 > 0$

CONCLUSION AND RECOMMENDATIONS.

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)

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

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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