# MANAGEMENT OF OIL SPILL DISPERSAL ALONG THE NIGERIAN COASTAL AREAS

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**ABSTRACT:**

Nigeria, one of the world's largest oil exporters, has a coastline of approximately 853km facing the Atlantic Ocean. This coastline lies between latitude 4° 10' to 6° 20' N and longitude 2° 45' to 8° 35' E. The Nigerian coast is composed of four distinct geomorphology units namely the Barrier-Lagoon Complex; the Mud Coast; the Arcuate Niger Delta and the Strand Coast. 90-95% of export revenues in Nigeria is from the oil sector. Nigeria's oil reserves are about 31.5 billion barrels, while Nigeria's crude oil production averaged 2.118 million barrels per day in 2002.

Oil spillage is a major environmental problem in Nigeria. Between 1976 and 1996 Nigeria recorded a total of 4835 oil spill incidents, which resulted in a loss of 1,896,960 barrels of oil to the environment. In 1998, 40,000 barrels of oil from Mobil platform off the Akwa Ibom coast were spilt into the environment causing severe damage to the coastal environment. Oil spillage has led to very serious pollution and destruction of flora, fauna and resort centers, pollution of drinkable water, destruction of properties and lives along the Nigerian coast. Oil spillage has also caused regional crisis in the Niger Delta. Factors responsible for oil spillage in the zone are; corrosion of oil pipes and tanks, sabotage, port operations and inadequate care in oil production operations and engineering drills.

Waves, wind drift current, tidal current, ocean currents, bathymetry, vegetation and topography influence oil spill dispersal along the Nigerian coastal waters. Oil spill dispersal can be managed by using oil spill trajectory and fate models, oil booms and mops, surfactant chemicals, oil skimmers, absorbents and gels. The oil producing companies in Nigeria formed in 1981 the Clean Nigeria Association (C.N.A.) as a contingency plan towards managing major oil spill incidents along the Nigerian coast. Government parastatals like Department of Petroleum Resources, Federal Ministry of Transport and Federal Inland Waterways, and non-governmental agencies like the multinationals are stakeholders in the management of oil spillages in the country.

Payment of compensations to spill impacted communities is part of the government's drive in enforcing environmental regulations. Oil pollution in our coastal environment would be managed effectively if our government could set up regional spill response centers along our coastline. The use of area photographs and satellite imageries possibly from the newly launched Nigeria Sat- 1 would go a long way in managing oil spill incidents in the country.

## 1.0 INTRODUCTION

### 1.1 Nigerian Coastal Areas

Nigeria has a coastline of approximately 853km facing the Atlantic Ocean. This coastline lies between latitude 4° 10' to 6° 20'N and longitude 2° 45' to 8° 35' E. The terrestrial portion of this zone is about 28,000 km$^2$ in area, while the surface area of the continental shelf is 46,300km$^2$. The coastal area is low lying with heights of not more than 3.0 m above sea level and is generally covered by fresh water swamp, mangrove swamp, lagoonal mashes, tidal channels, beach ridges and sand bars (Dublin- Green *et al*, 1997).

The Nigerian coast in composed of four distinct geomorphological units namely the Barrier-Lagoon complex; the Mud coast; the Arcuate Niger delta; and the Strand coast (lbe 1988). The vegetation of the Nigerian coastal area is also characterised by mangrove forests, brackish swamp forests and rain forests. The Nigerian coastal zone experiences a tropical climate consisting of rainy season (April to November) and dry season (December to March).

Nigeria is one of the world's largest oil exporters. Nigeria is a major oil supplier to Western Europe and was the 5$^{th}$ largest supplier of crude oil to the United States in 2002 (EIA, 2003). Nigeria's economy is heavily dependent on the oil sector, which accounts for 90-95% of export revenues. Estimates of Nigeria's estimated proven oil reserves range from 24 billion (*Oil and Gas Journal*) to 31.5 billion barrels (OPEC). The majority of these reserves are found in relatively simple geological structures along the country's coastal Niger River Delta, but newer reserves have been discovered in deeper waters offshore Nigeria. The majority of the oil lies in about 250 small (i.e., less than 50 million barrels each) fields. At least 200 other fields are known to exist and contain undisclosed reserves. Nigeria's crude oil reserves have gravities ranging from 21° API to 45° API. Nigeria's main export crude blends are Bonny Light (37° API) and Forcados (31° API). Approximately 65% of Nigerian crude oil production is light (35° API or higher) and sweet (low sulfur content). Nigerian crude oil production averaged 2.118 million barrels per day (bbl/d) in 2002. Nigeria has the potential to increase its crude oil production significantly in the next few years as recent discoveries come on stream.

Nigeria has more than 182 tcf of recoverable gas reserves, which are expected to last for 450 years The quantity of gas reserves in the country is twice as much as Nigeria's considerable crude oil reserves. However, only 23 tcf, or 12 % of the gas reserves, is so far being exploited. The nation has as estimated and additional

undiscovered gas potential of about 100 tcf, making Nigeria one of the world's leading gas producers. The government is making efforts to re-channel these flared and largely untapped resources to several areas of usage.

## 2.0 Causes of Oil Spillage

In Nigeria, fifty percent (50%) of oil spills is due to corrosion, twenty eight percent (28%) to sabotage and twenty one percent (21%) to oil production operations. One percent (1%) of oil spills is due to engineering drills, inability to effectively control oil wells, failure of machines, and inadequate care in loading and unloading oil vessels.

Thousands of barrels of oil have been let loose into the environment through our oil pipelines and tanks in the country. This loss is as a result of our lack of regular maintenance of the pipelines and storage tanks. Most pipelines from the flow stations are obsolete. By international standards, oil pipes ought to be replaced after 15 to 20 years, but most pipelines in use are 20 to 25 years old, making them subject to corrosion and leakage. Some of these pipes are laid above ground level without adequate surveillance, exposing them to wear and tear and other dangers (Oyem, 2001). About 40,000 barrels of oil spilled into the environment through the offshore pipeline in Idoho.

Sabotage is another major cause of oil spillage in the country. Some of the citizens of this country in collaboration with people from other countries engage in oil bunkering. They damage and destroy oil pipelines in their effort to steal oil from them. Pirates are stealing Nigeria's crude oil at a phenomenal rate, funneling nearly 300,000 barrels per day from our oil and selling it illegally on the international trade market.

Illegal fuel siphoning as a result of the thriving black market for fuel products has increased the number of oil pipeline explosions in recent years. In July 2000, a pipeline explosion outside the city of Warri caused the death of 250 people. An explosion in Lagos in December 2000 killed at least 60 people. The NNPC reported 800 cases of pipeline vandalization from January through October 2000. In January 2001, The Nigeria lost about $4 billion in oil revenues in 2000 due to the activities of vandals on our oil installations.

Nigeria lost about N7.7 billion in 2002 as a result of vandalisation of pipelines carrying petroleum products. The amount, according to the PPMC, a subsidiary of NNPC, represents the estimated value of the products lost in the process. The Nigerian government and oil companies say up to 15 percent of the country's two million barrels per day oil production is taken illegally taken from pipelines in the Niger Delta and smuggled abroad.

### 2.1 Review of Oil Spill Incidents in Nigerian

Oil spill incidents have occurred in various parts and at different times along our coast. According to the Department of Petroleum Resources (DPR), between 1976 and 1996 a total of 4647 incidents resulted in the spill of approximately 2,369,470 barrels of oil into the environment. Of this quantity, an estimated 1,820,410.5 barrels (77%) were lost to the environment. Available records for the period 1976 to 1996 indicated that approximately 6%, 25%, and 69% respectively, of total oil spilled in the Niger Delta area, were in land, swamp and offshore environments. Some major spills in the coastal zone are the GOCON's Escravos spill in 1978 of about 300,000 barrels, SPDC's Forcados Terminal tank failure in 1978 of about 580,000 barrels and Texaco Funiwa-5 blow out in 1980 of about 400,000 barrels. Other oil spill incidents are those of the Abudu pipe line in 1982 of about 18,818 barrels, The Jesse Fire Incident which claimed about a thousand lives and the Idoho Oil Spill of January 1998, of about 40,000 barrels. The most publicised of all oil spills in Nigeria occurred on January 17 1980 when a total of 37.0 million litres of crude oil got spilled into the environment. This spill occurred as a result of a blow out at Funiwa 5 offshore station. The heaviest recorded spill so far occurred in 1979 and 1980 with a net volume of 694,117.13 barrels and 600,511.02 barrels respectively.

## 3.0 IMPACTS OF OIL SPILLAGE ON THE ENVIRONMENT

Little is known about the effects of petroleum pollution on shoreline communities (Garrity and Levings, 1990; McGuiness, 1990; Burns et al, 1993; Gesamp, 1993). Major oil spills heavily contaminate marine shorelines, causing severe localised ecological damage to the near-shore community.

Ever since the discovery of oil in Nigeria in the 1950s, the country has been suffering the negative environmental consequences of oil development. The growth of the country's oil industry, combined with a population explosion and a lack of environmental regulations, led to substantial damage to Nigeria's environment, especially in the Niger Delta region, the center of the country's oil industry.

Oil spills pose a major threat to the environment in Nigeria. If not checked or effectively managed, they could lead to total annihilation of the ecosystem, especially in the Niger Delta where oil spills have become prevalent. Life in this region is increasingly becoming unbearable due to the ugly effects of oil spills, and many communities continue to groan under the degrading impact of spills (Oyem, 2001).

In the Nigerian Coastal environment a large areas of the mangrove ecosystem have been destroyed. The mangrove was once a source of both fuel wood for the indigenous people and a habitat for the area's biodiversity, but is now unable to survive the oil toxicity of its habitat. The oil spills also had an adverse effect on marine life, which has become contaminated; in turn having negative consequences for human health from consuming contaminated seafood. Oil spill has also destroyed farmlands, polluted ground and drinkable water and caused drawbacks in fishing off the coastal waters.

Oil spills in the Niger Delta have been a regular occurrence, and the resultant environmental degradation of the surrounding environment has caused significant tension between the people living in the region and the multinational oil companies operating there. It is only in the past decade that environmental groups, the Nigerian federal government, and the foreign oil companies that extract oil in the Niger Delta have begun to take steps to mitigate the damage. Although the situation is improving with more stringent environmental regulations for the oil industry, marine pollution is still a serious problem

The harmful effects of oil spill on the environment are many. Oil kills plants and animals in the estuarine zone. Oil settles on beaches and kills organisms that live there, It also settles on ocean floor and kills benthic (bottom-dwelling) organisms such as crabs. Oil poisons algae, disrupts major food chains and decreases the yield of edible crustaceans. It also coats birds, impairing their flight or reducing the insulative property of their feathers, thus making the birds more vulnerable to cold. Oil endangers fish hatcheries in coastal waters and as well contaminates the flesh of commercially valuable fish.

In a bid to clean oil spills by the use of oil dispersants, serious toxic effects will be exerted on plankton thereby poisoning marine animals. This can further lead to food poisoning and loss of lives. Another effect of oil slicks is loss of economic resources to the government when spilled oil is not quickly recovered, it will be dispersed abroad by the combine action of tide, wind and current. The oil will therefore spread into thin films, dissolve in water and undergo photochemical oxidation, which will lead to its decomposition. The impacts of some major oil spill incidents are given below.

The movement for the survival of Ogoni People (MOSOP) and other Ogoni activists have on several occasions called on the Nigerian Federal Government to regulate the oil exploration, drilling, and processing activities of Shell Oil and other oil companies in the oil producing regions of Nigeria. The Ogoni have received virtually none of the $30 billion from oil pumped out of their lands, and they have been actively demonstrating against such injustices. Mr. Ken Saro-Wiwa, along with eight other MOSOP members, were arrested and charged with the murder of four traditional chiefs belonging to a pro-government group in the Ogoni region. The murders occurred during a bloody clash in May 1994 between Ogoni activists and Federal Government soldiers. On October 31, 1995, a Federal military tribunal sentenced them to death. On November 10, 1995 the Nigerian Federal Government hanged Ken Saro-Wiwa and eight others, in Port Harcourt.

The death of the Ogoni activists led to the suspension of Nigeria from the Commonwealth of Britain (a group comprising of Britain and its former colonies); Under extreme pressure, the International Finance Corporation cancelled a proposed $100million loan and $80 million equity deal to Nigeria LNG, a company owned by the Nigerian Government and the top oil producers in Nigeria (Shell, Elf and Agip), to produce a gas plant and pipeline in the Niger Delta (TED Case Studies, 1997).

## 4.0 AGENTS OF OIL SPILL DISPERSAL ALONG THE NIGERIAN COAST

Factors such as wind drift current, wind waves, average surface current, tides, sea bottom topography and density of the spilled oil influence oil spill dispersal. Oil on spillage also goes through the process of evaporation, emulsification, dissolution, photochemical oxidation and biodegradation. The factors influencing oil spill dispersal on our coastal waters are described below.

### 4.1 Advection

Advection is the main mechanism that governs the drifting of suspended oil and surface oil slick. The combined effects of surface currents and wind drag cause the advection of the surface oil. The advection of suspended oil is the movement of oil droplets entrained in the water column due to the water current. In most of the oil spill models, drift factor approach has been used, which is considered to be a most practical method for predicting the advection of oil slicks.

### 4.2 Tidal Current

The astronomical forces of the moon and sun cause tides in the ocean which have both vertical and horizontal motions. The tidal current successively completes approximately a 360 degree rotation in one cycle, from one high tide to the next high. The tidal current decreases gradually with increasing depth through the surface and intermediate layers and decreases rapidly with increasing depth near the bottom. Tidal motions combine with topographical feature give rise to three types of tidal currents. These tidal currents are:

a. The rotary type, illustrated by currents in the open ocean and along sea coast.
b. The rectilinear or reversing type, illustrated by currents in most inland bodies of water.
c. The hydraulic type, illustrated by the currents in straights connecting two independent tidal bodies of water.

A hydrodynamic model could be used for estimating tidal amplitude and phase.

### 4.3 Waves

Wind blowing over the water surface generates surface waves (or wind waves). Although waves look as if they move horizontally through water, they are actually the vertical movement of water (USGS et al, 1998). The size of a wave depends upon the force of the wind (magnitude), the length of time the wind blows (duration), and the amount of open water over which the wind can blow (fetch).

### 4.4 Longshore Currents

Although waves tend to become parallel with the coast as a result of refraction, they usually break at a slight angle to the shore, with the result that a littoral or longshore current is induced and is effective in moving a mass of water slowly along the coast.

Longshore drift is the prevalent sediment transport mechanism along the Nigerian coastline and is basically within the nearshore zone (1-5m water depth). The longshore currents have a main effect within the first few kilometres offshore. Velocities of longshore current as estimated by Allen (1965) ranged from $0.22ms^{-1}$ to $1.0ms^{-1}$. Longshore current velocities range between 18 and 41 cm/s during ebb tides.

There are three main longshore drift directions along the Nigerian Coastline. These directions are:

i. The west-east littoral drift along the western coastline.
ii. The littoral drift off the north western flank of the Niger Delta.
iii. The west-east littoral drift between Akasa point and the Calabar estuary.

### 4.5 Spreading

When there is an oil spill on water, spreading immediately takes place. The gaseous and liquid components evaporate. Some get

dissolved in water and even oxidize, and yet some undergo bacterial changes and eventually sink to the bottom by gravitational action. The soil is then contaminated with a gross effect upon the terrestrial life. As the evaporation of the volatile lower molecular weight components affect aerial life, so the dissolution of the less volatile components with the resulting emulsified water, affects aquatic life (Akpofure et al, 2000). Once Oil is released on water, the process of spreading takes place immediately. This process stands to be the most significant. Some forces influence the lateral spreading of oil on even calm water. These forces include:

(a.) Gravitational force which brings about decrease in film thickness.

(b.) Surface tension and inertial forces.

The force of gravity is found to be proportional to the film thickness, the gradient thickness and the density difference between the oil and water. The surface tension causes co-efficient of spreading which gives the difference between air/oil and oil/water surface tensions. This force that is independent of the film thickness is the dominant process gotten in the final phase of spreading.

The inertia of the oil body and the oil/water friction causes retardation on the surface tension. The inertia of a specific oil slick, which is a function of the density and thickness, readily diminishes alongside spreading. Another factor that affects spreading is water temperature (Akpofure et al, 2000).

The spreading of an oil slick is one of the most important processes in the early stage of the oil slick transformation, because of the influence of the surface area of the oil slick on weathering processes such as evaporation and dissolution. The balance between gravitational, viscous and surface tension forces determines the spreading of an oil slick. The spreading of an oil slick passes through three phases. In the beginning phase, the gravity and inertia forces are balanced. In the intermediate phase the gravity forces are balanced by viscous force. In the final phase, the surface tension force is balanced by viscous force.

Fay considered an oil slick to pass through three phases of spreading. Immediately after the spill, the oil slick is rather thick. Therefore, in the first phase, gravity and inertia forces dominate the spreading process with gravity being the accelerating force and inertia the retarding force. As time progresses, the oil slick becomes thin and inertia forces become relatively unimportant. In the second phase the gravity and viscous forces dominate the spreading with viscous force being the retarding one. As the slick gets thinner, interfacial tension forces become important. A third phase is reached in which interfacial tension and viscous forces dominate the spreading (Reddy and Brunet, 1997)

## 5.0 MANAGEMENT OF OIL SPILLS

A number of laws already exist in the Nigerian oil industry. Most of these laws provide the framework for oil exploration and exploitation. However, only some of these laws provide guidelines on the issues of pollution (Salu, 1999). According to the Federal Environmental Protection Agency, Lagos Nigeria, the following relevant national laws and international agreements are in effect:

a. Endangered Species Decree Cap 108 LFN 1990.

b. Federal Environmental protection Agency Act Cap 131 LFN 1990.

c. Harmful Waste Cap 165 LFN 1990.

d. Petroleum (Drilling and Production) Regulations, 1969.

e. Mineral Oil (Safety) Regulations, 1963.

f. International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971

g. Convention on the Prevention of Marine pollution Damage, 1972

h. African Convention on the Conservation of Nature and Natural Resources,1968

i. International Convention on the Establishment of an International Fund for the Compensation for Oil Pollution Damage, 1971.

References to Caps, volumes and pages are as in the laws of the Federation of Nigeria. Some of the acts and regulations on pollution given by (Oshineye, 2000) are given below:

i. **The Mineral Oil (Safety) Regulations 1963**, that deals with safe discharge of inflammable gases and provide penalties for contravention and non-compliance.

ii. **Petroleum Regulations 1967** that prohibit discharge or escape of petroleum into waters within harbour area and make provisions for precautions in the conveyance of petroleum and rules for safe operation of pipelines.

iii. **Petroleum Drilling and Production Regulation 1969** that requires licence holders to take all practical precautions, including the provision of up-to-date equipment approved by the appropriate authority to prevent pollution of inland waters, river water courses, the territorial waters of Nigeria or the high seas by oil or other fluids or substances.

iv. **Oil in Navigable Waters Act 1968** that prohibits discharge of oil or any mixture containing oil into the territorial or navigable inland waters.

v. **Oil Terminal Dues Act 1969** that prohibits oil discharge to area of the continental shelf within which any oil terminal is situated.

vi. **Petroleum Refining Regulations 1974**, which deals, among other things, with construction requirements for oil storage tanks to minimise damage from leakage.

vii. **Associated Gas Re-Injection Act 1979** that provides for the utilisation of gas produced in association with oil and for the re-injection of such associated gas not utilised in an industrial project. This is to discourage gas flaring. The Government has raised the penalty for

gas flaring and this increase was due to the government's determination to protect the environment and ensure the optimal and functional use of Nigeria's gas resources.

viii. **Oil Pipeline Act 1956** (as amended by Oil pipelines Act 1965) which prevents the pollution of land or any waters.

The Federal Environmental Protection Agency (FEPA), which was recently made part of the Ministry of the Environment is legally vested with the responsibility of protecting and sustaining the Nigerian environment through formulation and implementation of regulatory frameworks. The National Policy on the Environment comprises one of the instruments developed by the agency to carry out its tasks. The document describes guidelines and strategies for achieving the policy goal of sustainable development (Ntukekpo, 1996).

Due to increasing awareness in preventing and controlling spills in Nigeria, the Clean Nigeria Associates (C.N.A.) was formed in November 1981. The C.N.A. is a consortium of eleven oil companies operating in Nigeria, including N.N.P.C. The primary purpose of establishing the C.N.A is to maintain a capability to combat spills of liquid hydrocarbons or pollutants in general. The Environmental Impact Assessment (EIA) decree No 86 of 1992 was promulgated to protect and sustain our ecosystem. The law makes EIA compulsory for any major project that may have adverse effects on the environment (Ntukekpo, 1996; Olagoke, 1996).

The Decree was to control activities that have environmental impact on the host communities, facilitates the promotion and implementation of policy, encourage information exchange. It sought to assess the likely or potential environmental impacts of proposed activities, including their direct or indirect, cumulative, short term and long term effects, and to identify the measures available to mitigate adverse environmental impacts of proposed activities, and assessment of those measures. The guidelines made provisions for offshore operations, safety measures, liability and compensation (Ozekhome, 2001).

As part of an environmental baseline studies project for the Nigerian National Petroleum Corporation (NNPC), sixty coastal and two hundred riverine/estuarine stations were studied in 1984 and 1985. Data gathered at these stations were used in describing regional and site-specific shoreline types. The outer coastline of Nigeria was divided into five broad categories, and within these categories, the shoreline has been divided into Environmental Sensitive Index (ESI) shoreline types. In addition, an ESI scale was developed and applied for the tidally influenced Bonny/New Calabar mouth and estuary.

The Nigerian federal government has indicated that it is no longer willing to tolerate oil companies absolving themselves of their responsibility to reduce pollution. The Federal Government has noted that future drilling rights will be "closely determined by" companies' environmental compliance, in addition to their submission of an environmental impact assessment for the proposed site.

In July 2002, the Nigerian government ordered oil companies operating in the country to comply with the Environmental Guidelines and Standards for the Oil Industry, published by the Department of Petroleum Resources (DPR), the monitoring arm of the Nigeria National Petroleum Corporation (NNPC), or risk paying a fine. The 300-page guidelines provide rules to reduce pollution and procedures for environmental monitoring.

The Nigerian government has taken action to show it is serious about enforcing environmental regulations. In March 2003, the Nigerian subsidiary of Shell was ordered to pay $1.5 billion to the Ijaw tribe for the company's actions in the state of Bayelsa over a 50-year period. A government committee that investigated Shell ruled that the company was responsible for a number of oil spills and environmental incidents, including an epidemic in 1993-1994 in which 1,400 people were killed. The government committee blamed the prevalence of cancer in the region on exposure to the company's oil spills, noting that Shell continually refused to pay compensation for these spills, and where it had, the payment was inadequate.

### 5.1 Bioremediation

Bioremediation is a technique that may be useful to remove spilled oil under certain geographic and climatic conditions. Bioremediation is a proven alternative treatment tool that can be used to treat certain aerobic oil-contaminated environments. Typically, it is used as a polishing step after conventional mechanical cleanup options have been applied. It is a relatively slow process, requiring weeks to months to effect cleanup. If done properly, it can be very cost-effective, although an in-depth economic analysis has not been conducted to date. It has the advantage that the toxic hydrocarbon compounds are destroyed rather than simply moved to another environment.

The two main approaches to oil-spill bioremediation are:

(1) *bioaugmentation,* in which oil-degrading bacteria are added to supplement the existing microbial population, and
(2) *biostimulation,* in which nutrients or other growth-limiting co-substrates are added to stimulate the growth of indigenous oil degraders.

### 5.2 Nigeria-Sat 1 Satellite

A Russian Kosmos rocket blasted off from a military base in Kazakhstan and boosted the Nigeria Sat1 payload into orbit. The satellite's launch makes Nigeria, Africa's most populous country, the continent's fourth nation with a satellite in orbit. Algeria, Egypt and South Africa also operate Earth satellites. The Nigerian satellite will join the Disaster Monitoring Constellation, an international early-warning satellite network transmitting real-time information about droughts, earthquakes, deforestation and man-made disasters observable from space. The Federal Government plans to use the $13 million satellite to also monitor email traffic. Nigeria has a very serious problem with corruption. Every day, unscrupulous individuals are siphoning millions out from our economy. Typically, money is smuggled out of the country with the aid of people overseas, particularly in America. Criminals engaged in this illegal activity take up to twenty to twenty-five million dollars at a time. The Nigeria Sat-1, an Orbit Satellite for geographical mapping, which the country launched recently would also help to check the perennial problem of oil

pipeline vandalisation, and assist in combating and managing oil spill incidents.

### 5.3 International Co-operation

Cracking down on smugglers has proved difficult, since many people accuse the federal government of pocketing much of the oil wealth, and the oil companies of plundering local resources while abandoning the Delta dwellers to pollution, poverty, unemployment and disease. To shore up the fight against oil smugglers in Nigeria, the US has donated three 56 metre (180ft) refitted World War two-era patrol oats to the navy. Another four vessels are due to be delivered by December, according to the United Nations. The Pentagon is funding each boat's refurbishment to the tune of $3.5m.

The efforts of the Federal Government with the assistance of the US are already yielding fruits. Several tankers have been intercepted by the Nigerian Navy. The tanker, African Pride, has become the latest vessel intercepted by the Nigerian Navy in the Gulf of Guinea and it is believed to be part of a fleet which aids the theft of an estimated 200,000 barrels a day from the Delta swamps. The tanker had the biggest consignment of all the 15 vessels seized since January 2002. Its crew of 18 Russians, two Romanians and two Georgians have been remanded in prison custody awaiting a court hearing.

### 5.4 Effective Management of Oil Spill Incidents in the Country

A successful combating operation to a marine oil spill is dependent on a rapid response from the time the oil spill is reported until it has been fully combated. In order to reduce the response time and qualify the decision-making process, application of Geographic Information Systems (GIS) as an operational tool has been suggested. Information on the exact position and size of the oil spill can be plotted on maps in GIS and a priority of the combat efforts and means according to the identified coastal sensitive areas can be carried out. GIS offers opportunities for integration of oil drift forecast models (prediction of wind and current influence on the oil spill) in the computer program framework (Milaka,1995).

Required information for oil spill sensitivity mapping can be depicted on a set of thematic maps using GIS even though they can in theory be depicted onto a single sheet. With the use of a GIS, however, all the relevant information or themes can be stored in the system and produced onto maps in a format that befits the needs of the day. Alternatively, modelling exercises using the GIS can be conducted to assess the adequacy of any given oil spill contingency plan (Parthiphan, 1994).

The creation of regional spill response centres along coastlines will help in managing oil spill problems (Smith and Loza, 1994). The centres will use oil spill models for combating oil spill problems. Using data collected with an airborne system to input one or several new starting point(s) into the model, will improve the accuracy of the further predictions (Sandberg, 1996). Oil spillage can also be treated or removed by natural means, mechanical systems, absorbents, burning, gelling, sinking and dispersion. Oil spillage can be removed by natural means through the process of evaporation, photochemical oxidation and dispersions (Smith 1977). Bioremediation can also be used for managing oil spill problems (Hoff, 1993; Prince, 1993). Oil spill dispersal can also be managed by using oil spill trajectory and fate models, oil booms and mops, surfactant chemicals, oil skimmers, absorbents and gels.

An effective response to a marine oil spill requires knowledge of the sensibility of the coastal zones to determine priorities of the combat activities to protect the most sensitive areas. In order to assist the decision-makers in choosing the areas of priority, coastal sensitivity maps of Nigeria including areas of ecological and socio-economic interest must be produced at small scales.

## 6.0 CONCLUSION AND RECOMMENDATIONS

### 6.1 Conclusion

Oil spill has occurred several times along the Nigerian coast as a result of upsurge in oil exploration and exploitation activities. The causes of oil spillage along our coast are corrosion of oil pipes and storage tanks, sabotage and carelessness during oil production operations. The impacts of spillage on our coastal areas are enormous. Lives have been lost, the coastal habitat and ecology have also been destroyed. There have been numerous calls and agitations for resource control by oil producing states in the country. This calls has made the Federal Government to give the states the rights to control minerals within 200m bathy lines and the coastlands.

Tides and ocean currents are the major factors responsible for oil spill movement along our coastline. Wind drift current and waves are secondary factors for moving oil spill

Oil spill dispersal can be managed by using oil spill trajectory and fate models, oil booms and mops, surfactant chemicals, oil skimmers, absorbents and gels. The oil producing companies in Nigeria formed in 1981 the Clean Nigeria Association (C.N.A.) as a contingency plan towards managing major oil spill incidents along the Nigerian coast. Establishment of regional spill response centres along our coastlines, and the use of data collected with an airborne system will help in managing oil spill problems in Nigeria.

### 6.2 Recommendations

There is a need for a better understanding of the coastal ecology so as to evaluate the significance of the impacts generated by oil spill incidents.

The Federal Government in conjunction with oil parastatals and other non-governmental agencies should create more meteorological stations near the shoreline or on the coastal waters. The meteorological stations should provide real time or predicted meteorological data of the surrounding environment. This data would serve among other things as input data into oil spill models.

Medium scale digital maps should be made from satellite images from the newly launched Nigeria Sat-1. Images from the satellite and other satellites in orbit could also be use for managing oil spill incidents in the country.

Establishment of regional spill response centres along our coastlines, and the use of data collected with an airborne system will help in managing oil spill problems in Nigeria.

Geographic Information System (GIS) could be used to identify oil spill responders and provide information about the closest resources of oil spill response equipment and personnel.

The petroleum industry should work closely with government agencies, universities and research centers and come out with management strategies for combating the menace of oil spill incidents.

More funds should be provided by all the stakeholders in the oil industry for further research in the development and use of oil spill models in the country. The adoption of the model developed in this research work and the procurement of other oil spill models would serve as a basis in carrying out more research in this area.

The creation of NDDC and the rights given to the oil producing states over oil within the states and 200m bathy line by the Federal Government would go a long way in reducing the tension in the oil rich communities. However, the Federal Government, State Governments and other non-governmental agencies should ensure that the social amenities and needed infrastructures in these communities are provided.

When a spill occurs, various governmental and non-governmental agencies should harness all available resources to reduce the impact of the oil spillage on our coastal environment.

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