Impacts and Management of Oil Spill Pollution along the Nigerian Coastal Areas

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Abstract

Nigeria has a coastline of approximately 853km facing the Atlantic Ocean. This coastline lies between latitude 4^o 10' to 6^o 20' N and longitude 2^o 45' to 8^o 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. In 1956, Royal Dutch Shell discovered crude oil at Oloibiri, a village in the Niger Delta, and commercial production began in 1958. Today, there are about 606 oil fields in the Niger Delta, of which 360 are on-shore and 246 offshore. Nigeria is now the largest oil producer in Africa and the sixth largest in the world, *averaging 2.7 million barrels per day (bbl/d) in 2006. Nigeria's proven oil reserved is 35.2 billion barrels. Nigeria's economy is heavily dependent on earnings from the oil sector, which provides 20% of GDP, 95% of foreign exchange earnings, and about 65% of budgetary revenues. Since the discovery of oil in Nigeria in 1956, the country has been suffering the negative environmental consequences of oil exploration and exploitation. Between 1976 and 1996 a total of 4647 incidents resulted in the spill of approximately 2,369,470 barrels of oil into the environment. In addition, between 1997 and 2001, Nigeria also recorded a total number of 2,097 oil spill incidents. 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. Several oil spill management policy and efforts are in place to reduce the menace of oil spill incidents in the country. Some of these policies and efforts were made by the Federal Government, Non governmental agencies and oil firms in the country. The use of oil trajectory and fate models is also incorporated in oil spill management policy in the country. We have developed a new oil spill trajectory model. The results from a hypothetical simulation with the model from a point around OPL 250 located about 150km off the Nigerian coastline shows that the simulated oil spill for wet season reached the shore (around Penington River) after 104hours (about 4.5 days). Also during the dry season, the results from the model indicate that the oil spill reached the shore (at the entrance of Benin River) after 162hours (6.5days).*

1. INTRODUCTION

Nigeria is bordered to the North by the Republics of Niger and Chad, to the West by the Republic of Benin, to the East by the Republic of Cameroon and to the South by the Atlantic Ocean (Dublin Green et al, 1999). Nigeria has a coastline of approximately 853km facing the Atlantic Ocean. This coastline lies between latitude 4^o 10' to 6^o 20'N and longitude 2^o 45' to 8^o 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. Figure 1 below is the Map of the Nigerian Coastal Areas.

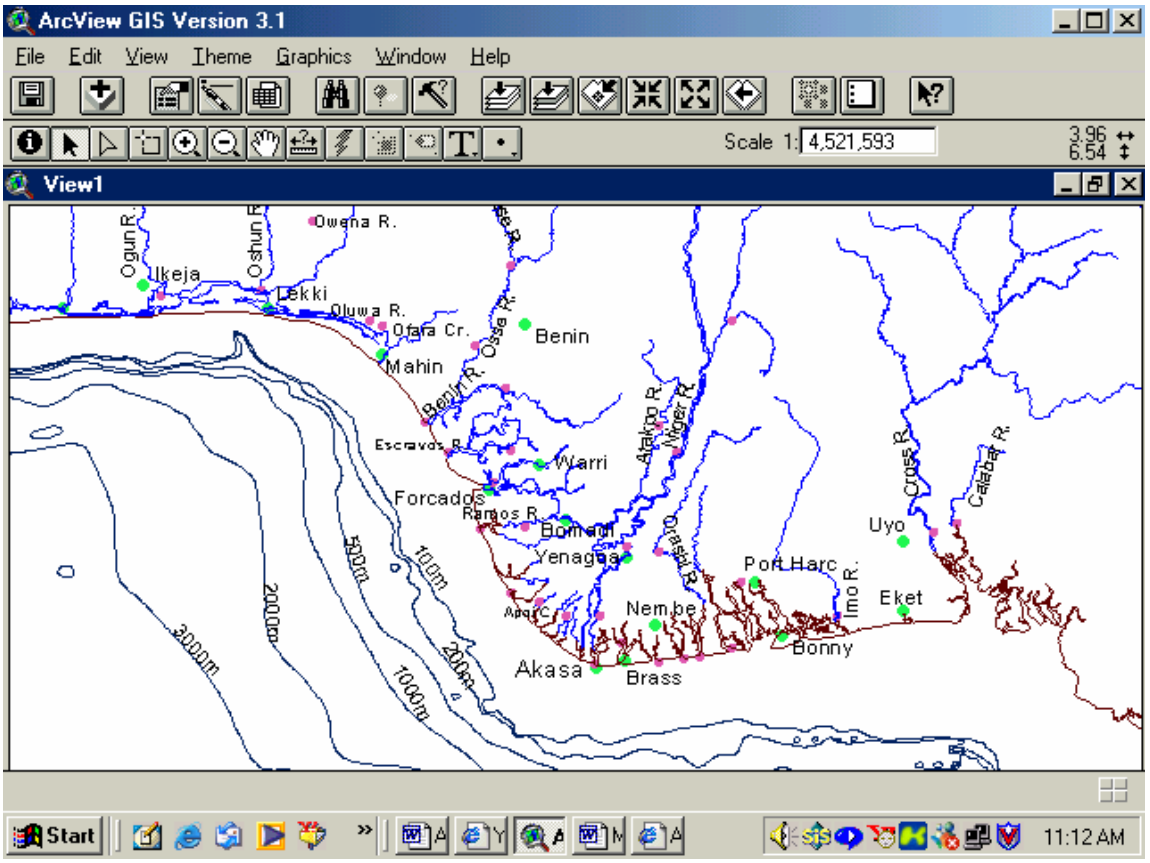

Figure 1: Map of Nigerian Coastal Areas

1.1 Climate of Nigeria's Coastal Areas

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). Nigeria's total land and water area is 923,768 sq km, with the area of the land being 910,768 sq km while that of water is 13,000 sq km (CIA World Fact Book, 2005).

The Nigerian coastal zone experiences a tropical climate consisting of rainy season (April to November) and dry season (December to March). High temperatures and humidity as well as marked wet and dry seasons characterize the Nigerian climate. The coastal areas have an annual rainfall ranging between 1, 500 and 4,000 mm (Kuruk, 2004).

The Nigerian coastal area experiences mainly the south westerlies which are onshore and confined generally to azimuths of 215^{o}-266^{o} with velocities of 2-5m/s. During the rainy season, wind speed increases to about 10m/s especially during heavy rainfalls and thunderstorms.

Temperatures in the coastal areas are moderated by the cloud cover and by the generally damp air. However, mean monthly temperature vary between 24^{o} C and 32^{o} C throughout the year.

The surface water of the Nigerian coast is basically warm with temperature generally greater than 24^{o}C. Sea surface temperatures show double peaked cycles, which match quantitatively the cycle of solar heights. Between October and May, Sea surface temperatures range from 27^{o}-28^{o}C, while during the rainy season of June to October, the range is between 24^{o} and 25^{o}C. (Dublin Green et al, 1999). The surface water is typically oceanic surface water of the Gulf of Guinea with salinity generally less than 35.00%. (Dublin Green et al, 1999).

1.2 Hydrology of Nigeria

The hydrology of Nigeria is dominated by two great river systems, the Niger-Benue and the Chad systems. With the exception of a few rivers that empty directly into the Atlantic Ocean, all other flowing waters ultimately find their way into the Chad basin or down the lower Niger to the sea. (Kuruk, 2004).

The inland water system includes thirteen lakes and reservoirs with a surface area of between 4000 hectares and 550,000 hectares, and has a total surface area of 853,600 hectares, which represents about one percent of the total area of Nigeria. They include lakes Chad, Kainji, Jebba, Shiroro, Goronyo, Tiga, Chalawa Gorge, Dadin Kowa, Kiri, Bakolori, Lower Anambra, Zobe and Oyan. With the exception of Lake Chad, all the lakes are man-made (Kuruk, 2004).

The Lagos lagoon is one of several lagoon systems in the West African sub region and most extensive. The lagoon is part of the barrier lagoon coasts of Nigeria. The water is shallow and covers an area of about 208km^2 (Ekundayo and Akpata, 1978). The lagoon is fed mainly by the rivers of Ogun, Shasha, Oshun, Agboyi and Majidun; the Ogudu creeks and waters of Epe and Lekki lagoons. The Lagoon empties into the Atlantic Ocean via Lagos harbour. The southern margin of the Lagos Lagoon is bounded by the Five Cowrie Creek, the eastern margin by the Palavar Islands and its northern border by Ikorodu. The lagoon is 40 – 64km long and has two arms; one connects the Lekki Lagoon while the other leads northward into the hinterland (Allen, 1965). The lagoon is shallow with depths of 1.5 – 3m (Ibe, 1988), and made up of muddy and sandy bottom. Its bottom relief is negligible.

Deltas and estuaries, with their saline wetlands have a total surface area of 858,000 hectares, while freshwaters cover about 3,221,500 hectares. Other water bodies, including small reservoirs, fish ponds and miscellaneous wetlands suitable for rice cultivation cover about 4,108,000 hectares (Kuruk, 2004).

The entire Gulf of Guinea is highly stratified with a thin surface layer of warm fresh tropical water (Longhurst 1964). The stratification of the upper water column along the Gulf of Guinea is generally very strong except in areas subject to upwelling events.

1.3 Geology of Nigeria's Coast

The Nigerian coastal geology is basically sedimentary and is dominated by the geology of arcuate Niger delta. The Niger delta is composed of an overall classic sequence which reaches a maximum thickness of 9-12 kilometers (lbe 1988). The Nigerian continental shelf is narrow

in the west (less than 30km) but relatively broad off the Niger Delta and the eastern flank where it measures 45-80 km in width. The shelf is interrupted by several submarine canyons which include Avon, Mahin and Calabar Canyons

1.4 Geomorphological Units of Nigerian Coastal Areas

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 geomorphology of the Lagos Lagoon is classified under the Barrier-Lagoon Complex, which extends for about 250km from the Nigerian/Benin Republic border to Ajumo village. The Complex consists of narrow beach ridges, which are aligned parallel to the coast. The beach sediments varied from medium to coarse-grained sand.

1.5 Vegetation of Nigeria's Coastal Areas

The vegetation of the Nigerian coastal area is characterised by mangrove forests, brackish swamp forests and rain forests. The country's extensive mangrove ecosystem, a great proportion of which lies within the Niger Delta and found mainly in the Rivers, Delta, Cross River, Akwa lbom, Lagos and Ondo states, is estimated to cover between 500,000 and 885,000 hectares. Freshwaters start at the northern limit of the mangrove ecosystems and extend to the Sahelian region (Kuruk, 2004).

1.6 Oil Exploration and Exploitation

In 1956, Shell British Petroleum (now Royal Dutch Shell) discovered crude oil at Oloibiri, a village in the Niger Delta, and commercial production began in 1958. Today, there are 606 oil fields in the Niger Delta, of which 360 are on-shore and 246 off-shore. (Nigeria Country Analysis Brief, 2005). Nigeria is now the largest oil producer in Africa and the sixth largest in the world, averaging 2.7 million barrels per day (bbl/d) in 2006. Nigeria's economy is heavily dependent on earnings from the oil sector, which provides 20% of GDP, 95% of foreign exchange earnings, and about 65% of budgetary revenues (CIA World Fact Book, 2005).

Nigeria's state-held refineries (Port Harcourt I and II, Warri, and Kaduna) have a combined capacity of 438,750 bbl/d, but problems including sabotage, fire, poor management and lack of regular maintenance contribute to a low current capacity of around 214,000 bbl/d, according to World Markets Research Center. Plans for several small, independently-owned refineries are also being developed, with the Nigerian government planning for three new refineries to come onstream by 2008. *(*Nigeria Country Analysis Brief, 2005*)*

1.6.1 Oil and Gas Reserves in Nigerian Coastal Areas

Oil and Gas Journal (2005) estimates Nigeria's proven oil reserved at 35.2 billion barrels. The Nigerian government plans to expand its proven reserves to 40 billion barrels by 2010. In February 2005, Nigeria announced the award of five oil blocks in the Joint Development Zone (JDZ), shared by Nigeria and neighboring Sao Tome and Principe (STP). The JDZ reportedly holds reserves of 11 billion barrels and could potentially yield up to 3 million bbl/d in the next 2-3 years. Development is also occurring in the waters surrounding the

JDZ. (Nigeria Country Analysis Brief, 2005). Oil and Gas Journal (2005) further stated that Nigeria has an estimated 176 trillion cubic feet (Tcf) of proven natural gas reserves, giving the country one of the top ten natural gas endowments in the world and the largest endowment in Africa.

1.6.2 Oil Spill Incidents in Nigeria

Oil spill incidents have occurred in various parts and at different times along our coast. 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. Nigeria's largest spill was an offshore well-blow out in January 1980 when an estimated 200,000 barrels of oil (8.4million US gallons) spilled into the Atlantic Ocean from an oil industry facility and that damaged 340 hectares of mangrove (Nwilo and Badejo, 2005).

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. A total of 549,060 barrels of oil representing 23.17% of the total oil spilt into the environment was recovered. 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.

Available records for the period of 1976 to 1996 indicate that approximately 6%, 25%, and 69% respectively, of total oil spilled in the Niger Delta area, were in land, swamp and offshore environments. Also, between 1997 and 2001, Nigeria recorded a total number of 2,097 oil spill incidents.

Thousands of barrels of oil have been spilt into the environment through our oil pipelines and tanks in the country. This spillage is as a result of our lack of regular maintenance of the pipelines and storage tanks. Some of these facilities have been in use for decades without replacement. 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. SPDC claimed in 1996 that sabotage accounted for more than 60 percent of all oil spilled at its facilities in Nigeria, stating that the percentage has increased over the years both because the number of sabotage incidents has increased and because spills due to corrosion have decreased with programs to replace oil pipelines (SPDC, 1996).

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.

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.

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, Nigeria lost about $4 billion in oil revenues in 2000 due to the activities of vandals on our oil installations. The government estimates that as much as 300,000 bbl/d of Nigerian crude is illegally bunkered (freighted) out of the country.

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.

2. IMPACTS OF OIL SPILL INCIDENTS ON NIGERIAN COASTAL AREAS

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

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).

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 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.

Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment has caused significant tension between the people living in the region and the multinational oil companies operating there. It is only in the past decade that environmental groups, the Federal Government, and the foreign oil companies operating in the Niger Delta began to take steps to mitigate the impacts. Large areas of the mangrove ecosystem have also been destroyed. The mangrove forest was in the past a major source of wood for the indigenous people. In some places it is no longer in a healthy state to sustain this use (Nwilo &Badejo 2005).

The Idoho oil spill traveled all the way from Akwa Ibom state to Lagos state dispersing oil through the coastal states, up to the Lagos coast. This culminated in the presence of sheen of oil on the coastal areas of Cross river state, Akwa Ibom state, Rivers state, Bayelsa state, Delta state, Ondo state and Lagos state.

In many villages near oil installations, even when there has been no recent spill, an oily sheen can be seen on the water, which in fresh water areas is usually the same water that the people living there use for drinking and washing. In April 1997, samples taken from water used for drinking and washing by local villagers were analyzed in the U.S. A sample from Luawii, in Ogoni, where there had been no oil production for four years, had 18 ppm of hydrocarbons in the water, 360 times the level allowed in drinking water in the European Union (E.U.). A sample from Ukpeleide, Ikwerre, contained 34 ppm, 680 times the E.U. standard.

Following the major Texaco spill of 1980, it was reported that 180 people died in one community as a result of the pollution. On several occasions, people interviewed by Human Rights Watch said that spills in their area had made people sick who drank the water, especially children.

3. MANAGEMENT OF OIL SPILL IN NIGERIA

Several laws and policies have been taken in managing oil spill incidents at the international and national levels. These laws and policies are given in the following sections:

3.1 Oil Pollution Act (OPA) of 1990

The Oil Pollution Act of 1990 (OPA 1990) is responsible for many of the nation's improvements in oil spill prevention and response. OPA 1990 provides guidance for government and industry on oil spill prevention, mitigation, cleanup and liability. The majority of OPA 1990 provisions were targeted at reducing the number of spills followed by reducing the quantity of oil spilled. OPA 1990 also created a comprehensive scheme to ensure that sufficient financial resources are available to clean up a spill and to compensate persons damaged by a spill. It also ensures that the federal response system is adequately prepared to manage the impacts of oil spills that do occur; and mandates that industry implement prevention and preparedness measures. The OPA also mandates that tankers and inland oil facilities develop individual response plans. Furthermore the OPA also mandates enhancements to the national response system, and development of Area Contingency Plans.

3.2 National Oil Spill Detection and Response Agency (NOSDRA)

A National Oil Spill Detection and Response Agency (NOSDRA) has been approved by the Federal Executive Council of Nigeria. The Ministry of Environment, which initiated the Agency, has also forwarded to the Federal Executive Council for approval, the reviewed draft National Oil Spill Contingency Plan (NOSCP) which the Agency would manage (Alexandra Gas and Oil Connections, 2006)

The establishment of the contingency plan and the agency was in compliance with the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC90) to which Nigeria is a signatory. The draft bill on the NOSDRA has been forwarded to the National Assembly for deliberation and enactment into law (Alexandra Gas and Oil Connections, 2006).

Apart from intensifying efforts towards compliance monitoring and enforcement of oil and gas regulations and standards, the ministry is also mounting pressure on the oil and gas operators for a gas flare-out. Effort is also being made, according to the sources, to ensure the use of environmental-friendly drilling fluid and mud systems (Alexandra Gas and Oil Connections, 2006)

3.3 The Niger Delta Development Commission (NDDC)

To reduce the rate of oil incidents along the Nigerian Coast particularly as a result of vandalisation, the Federal Government through an act of the National Assembly in 2000 passed into law the Niger Delta Development Commission. (NDDC). The Act among other things, established a Commission to carry out among other things the following tasks:

a. Cause the Niger-Delta area to be surveyed in order to ascertain measures, which are necessary to promote its physical and socio-economic development;
b. Prepare plans and schemes designed to promote the physical development of the Niger-Delta area;
c. Identify factors inhibiting the development of the Niger-Delta and assist the member states in the formation and implementation of policies to ensure sound and efficient management of the resources of the Niger-Delta;
d. Assess and report on any project funded or carried out in the Niger-Delta area by oil and gas producing companies and any other company including non-governmental organisations and ensure that funds released for such projects are properly utilised;
e. Tackle ecological and environmental problems that arise from the exploration of oil in the Niger-Delta area.
f. Liaise with the various oil mineral and gas prospecting and producing companies on all matters of pollution prevention and control.

Essentially, items (e) and (f) deal with issues pertaining to oil exploration and production and the NNDC act is a strategic way of dealing with all forms of pollution from these activities in the Niger Delta.

3.4 Petroleum Related Laws and Regulations

Part of the means of managing the environment is to have in place the necessary laws, regulations and guidelines. 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.

3.5 The Environmental Impact Assessment (EIA) decree No 86 of 1992

The Environmental Impact Assessment (EIA) decree No 86 of 1992 was promulgated to protect and sustain our ecosystem. The law makes the development of an EIA compulsory for any major project that may have adverse effects on the environment (Ntukekpo, 1996; Olagoke, 1996). 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.(Ozekhome, 2001). The carrying out of EIAs is policed by the Federal Environmental Protection Agency, and by state environmental protection agencies.

3.6 Federal and State Agencies

A number of Federal and State agencies deal with the problems of oil spill in Nigeria. The agencies include: the Department of Petroleum Resources (DPR), the Federal Ministry of Environment, the State Ministries of Environment and the National Maritime Authority.

3.7 Efforts of the Oil Companies and Non Governmental Agencies

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 Nigeria National Petroleum Corporation (NNPC). The primary purpose of establishing the C.N.A is to maintain a capability to combat spills of liquid hydrocarbons or pollutants in general (Nwilo & Badejo, 2005).

As a result of the focus on Shell's activities in Nigeria, Shell in collaboration with all the members of Oil Producers Trade Section (OPTS) of the Lagos Chambers of Commerce established the Niger Delta Environmental Survey (NDES). Shell, the OPTS and the

Rivers and Delta States governments provided the necessary funding for the activities of NDES.

The NDES was expected to provide:

a. A comprehensive description of the area, ecological zones, boundaries, and different uses of renewable and non-renewable natural resources;
b. An integrated view on the state of the environment and its relationship to local people;
c. An analysis of the causal relationships between land use, settlement patterns, industry and the environment, to provide a base line for future development planning;
d. An indicative plan for the development and management of the Niger Delta (NDES, 1996).

3.8 Oil Trajectory and Fate Models for Oil Spill Disaster Monitoring

Oil spill simulation model is used in oil response and contingency planning and as a tool in oil fate and impact assessment (Rossouw, 1998). In the event of an oil spill taking place, predictions of the slick can be supplied, provided that the necessary meteorological information is available (Rossouw, 1998). 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 (Wardley-Smith, 1977). Bioremediation can also be used for managing oil spill problems (Hoff, 1993; Prince, 1993; Atlas, 1995).

3.9 Nigerian Sat 1

The Nigerian Sat 1 Satellite has joined 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 Nigeria Sat-1, an Orbit Satellite for geographical mapping, would also help to check the perennial problem of oil pipeline vandalisation, and assist in combating and managing oil spill incidents. The Nigeria Sat-1, would help in monitoring oil spill by providing the spill position which would serve as input data into the oil spill model., It would also give the extent of coastal water and coastal areas polluted. These information are vital for quick clean up of oil impacted areas.

3.10 International Co-operation

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. United Nations has also said that United States would donate additional four vessels. 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. The Nigerian Navy has intercepted several tankers.

3.11 Geographic Information System for Managing Oil Spill Incidents

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 improve the decision-making process, application of Geographic Information Systems (GIS) as an operational tool is very essential. Information on the exact position and size of the oil spill can be plotted on maps in a GIS environment. 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, 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).

3.12 Environmental Sensitive Index (ESI) Mapping

ESI maps are basemaps that show the sensitivity of given locations or areas to a particular stress factor (such as exposure to petroleum products) on a scale of 1 to 10, 10 being most sensitive. The maps may contain physical and geomorphic features (e.g., shorelines), biological features, and socioeconomic features such as agricultural fields. Some ESI maps contain features of particular interest to oil spill planning and response, such as the recommended positions of booms or skimmers. The sensitivity of a given feature to a stress factor may be indicated by the color given the symbol or pattern used to represent it.

Standards for the development of the environmental sensitivity index maps for the coast of Nigeria have been developed by the Environmental Systems Research Institute (ESRI). These standards are used by all the oil companies to prepare ESI maps for their areas of operations in Nigeria.

3.13 Creating of Awareness

Awareness creation on the impacts of oil spill is an integral part of management programme for oil spill along the coast of Nigeria. This is being carried out by government at different levels and agencies such as the Niger Delta Development Commission (NDDC).

4. SIMULATION OF OIL SPILL ALONG THE NIGERIAN COAST

We have developed a new oil spill trajectory model. The results from a hypothetical simulation with the model from a point around OPL 250 located about 150km off the Nigerian coastline shows that the simulated oil spill for wet season reached the shore (around Penington River) after 104hours (about 4.5 days). Also during the dry season, the results from the model indicate that the oil spill reached the shore (at the entrance of Benin River) after 162hours (6.5days). Figures 2 and 3 below show the oil spill trajectories for

the wet and dry seasons respectively. It is obvious from the figures below that the season of occurrence of an oil spill is a major in determining the oil spill trajectory for an area. The wet season trajectory went east-west wise while the dry season trajectory went northwards. Areas to be affected by an oil spill to a reasonable extent depend on the period of the oil spill.

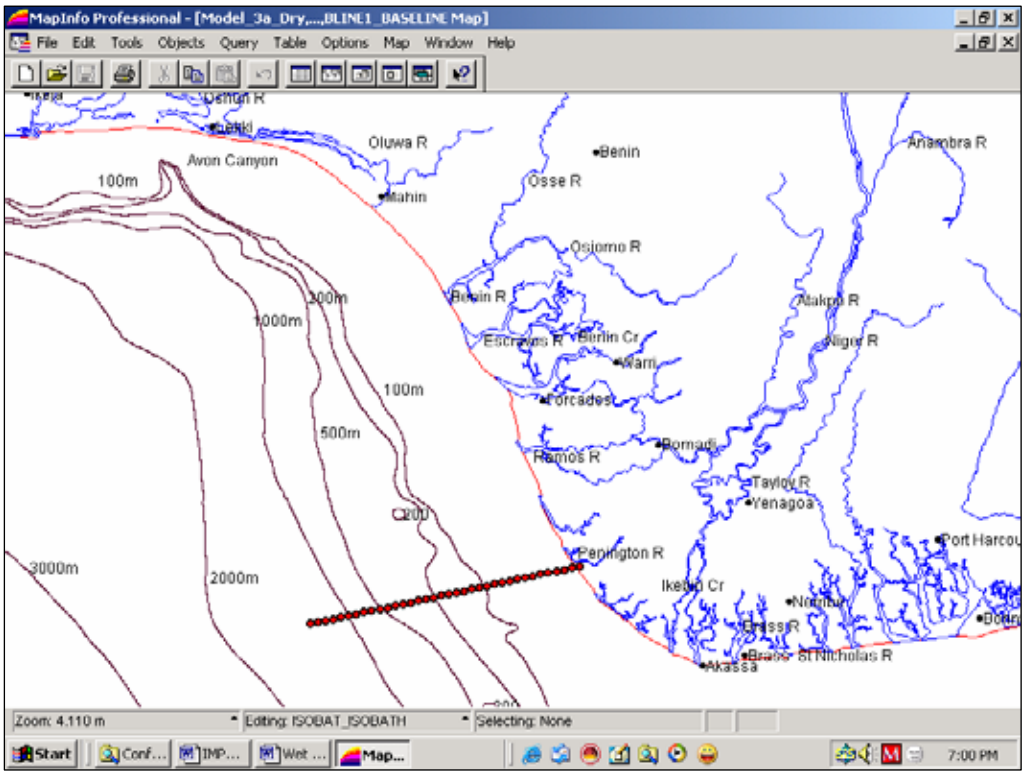

Figure 2: Oil Spill Trajectory for Wet Season on Nigerian Coastal Waters

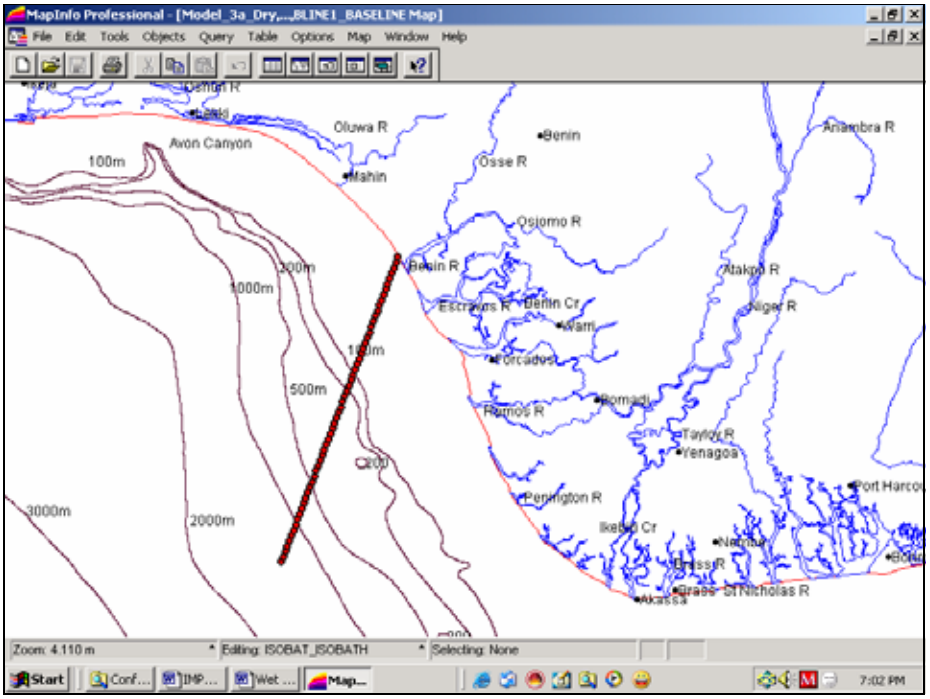

Figure 3: Oil Spill Trajectory for Dry Season on Nigerian Coastal Waters

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Since the discovery of oil in Nigeria in the 1956, the country has been suffering the negative environmental consequences of oil development. Sabotage has been a major cause of oil spillage in the country. Oil spill incidents have destroyed the coastal vegetation, polluted drinkable water and led to ethnic and regional crises in the Niger Delta. Several oil spill management policy and efforts are in place to reduce the menace of oil spill incidents in the country. Some of these policies and efforts include:

a. The formation of the National Oil Spill Detection and Response Agency (NOSDRA) by the Federal Executive Council of Nigeria.
b. The putting in place of relevant acts and regulations on oil spill pollution.
c. The passing into law of the Niger Delta Development Commission (NDDC).
d. The establishment of the Niger Delta Environmental Survey
e. The incorporating oil trajectory and fate models into oil spill management policy in the country.
f. The development of standards for the development of the environmental sensitivity index maps for the coast of Nigeria

All these efforts have assisted in detection and management of oil spills along the Nigerian coast.

Results from a hypothetical simulation with the model from a point around OPL 250 located about 150km off the Nigerian coastline shows that the simulated oil spill for wet season reached the shore (around Penington River) after 104hours (about 4.5 days). Also

during the dry season, the results from the model indicate that the oil spill reached the shore (at the entrance of Benin River) after 162hours (6.5days).

5.2 Recommendations

The Nigeria Sat-1, would help in monitoring oil spill by providing the spill position which would serve as input data into the oil spill model. It would also give the extent of coastal water and coastal areas polluted. These information are vital for quick clean up of oil impacted areas.

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.

The creation of regional spill response centres along coastlines would help in managing oil spill problems. The centres will use oil spill models for combating oil spill problems. Data collected with an airborne system could serve as inputs in the model.

The petroleum industry should work closely with government agencies, universities and research centers to combat 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 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 are provided for the oil rich communities.

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