EVALUATION OF ON-SHORE OIL SPILL REMEDIATION OPERATIONS IN PORT HARCOURT, NIGERIA

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Abstract

Most oil producing regions in the world today are experiencing serious hydrocarbon spillages on land and water. The problem is more prevalent in developing countries where greater premium is always placed on the oil money than on the environment and the inhabitants of oil producing regions. The study is an attempt to unravel the effectiveness of clean-up exercises undertaken by oil companies each time oil spillage occurs. The results show that two years after the programme the efficiency level of the remediation exercise is very low as evidenced by the heavy presence of microbiological accumulation in the soil. Thus, there is need for more thoroughness in the clean-up exercise. Monitoring agencies should also be more efficient while respective oil companies need to be more responsive so as to avert the attendant violent protests from the affected communities.

Keywords: Oil spillage, environmental degradation, oil-spill remediation, Niger-Delta Region, sustainable environmental management.

Introduction

Undoubtedly, crude oil provides ingredients for thousands of products, which are daily used throughout the world today. It has become the mainstay of the economy of all the oil ï producing nations of the world. Particularly in Nigeria, the economy is solely reliant on oil production as more than 95% of the revenue generated comes from the oil sector alone.

The Niger ï Delta region in Nigeria is the home of the nationôs hydrocarbon and consequently all the oil production activities take place there. It is also here that the incessant problems of oil spillage and associated environmental degradation are very acute. The operation of the oil industry has, over the years, become very vast covering both onshore and offshore fields. The incidence of oil spillage in the Niger-Delta region has increased over the

years from only one in 1970 to about 5332 oil spills in 2004. This has led to the spillage of more than 2.8 million barrels of crude oil into the nationôs land and marine ecosystems.

Unfortunately the oil multinational companies who are involved in oil production activities in the region have not done much to control the rate in which land degradation takes place because of oil spillages. Although it is one of the stated policies of Shell Petroleum Development Company (SPDC) to ñendeavour to limit any adverse effect on the physical environment in which its activities are carried outò (SPDC Bulletin), there has not been enough pragmatic and conscious effort to operationalize this policy. Incidentally too, the Federal Government of Nigeria has equally expressed its concern for the oil-producing environment by enacting the Polluter Pays Principle (PPP) Act in 1990. This principle places liability of environmental clean-up squarely on the shoulders of the polluter of such environment. Curiously, this seem to be a lame-duck legislation because it appears the omnibus multinational oil corporations in partnership with some unscrupulous government agencies collude to pursue their profit and corrupt motives at the expense of the residentsô lives and property, environmental decay, and the near total dislocation of the indigenous economy (Udoh, 2003)

In spite of governmentôs effort at curbing the incessant degradation of the environment in the Niger-Delta region, there seems to be an increase in oil spillage and neglect by the oil companies operating in the area. For example, the Rumuola SPDC blow-out which took place in 1988 was not treated for more than five years. Recently, the Elelenwo oil spillage which took place in 1999 was only cleaned up after two years, precisely in 2001. There was another spilage in Rupokwu in May 2004 which is yet to be cleaned up at the time of writing this paper. The effect of this apparent neglect by offending oil companies is one of the reasons for the rise in agitations by the youths in these communities since they believe it is a deliberate action. Infact, the Rupokwu oil spill resulted in the youths of this community laying siege on the Shell Petroleum Development Company (SPDC), disrupting operations for some days. (Udoh, 2003).

From the foregoing, the apparent neglect, slow and sometimes late response to oil spill clean-up exercises can be attributed to the non-challant attitude of multinational oil corporations who are more interested in making huge profits and transferring same to their home countries. Equally, it can also be blamed on the Nigerian government who enacted the appropriate legislation without ensuring its compliance. This raises a number of questions. In the light of the global emphasis on sustainable environmental development, can a development programme that threatens the existence of any region be said to be sustainable? Or should greater emphasis be on the enormous revenue generated from oil production at the expense of the environment and its inhabitants? These are ethical and moral issues that need to be addressed both nationally and globally.

The interest of this paper on oil remediation in oil producing environments is due to the fact that oil spillage is on the increase particularly in the Elelenwo District of Port Harcourt in Rivers State, Nigeria. The inability of oil companies to clean up oil-polluted sites should attract the attention and action of both government, the oil companies themselves, researchers, environmental activists, non-governmental organizations (NGOs), and the academia. It is against this backdrop that this paper is interested in probing into the level and effectiveness of on-shore oil spillage remediation in Port-Harcourt in particular and the Niger Delta region in general.

Statement of Problem

Most oil producing regions in the world today are experiencing hydrocarbon spillages on land and sea. The picture is worse in developing countries. It is truism that oil spillage pollutes the environment. The oil spilled contaminates the soil, rendering it unsuitable for agricultural activities and thus making the inhabitants of the area vulnerable to food shortage, hunger and other health hazards such as malnutrition. Petroleum and its components are toxic to both human life and the environment. According to Odu (1975), toxicity depends on the type and volume of oil spilled. Nigeria basically has two types of crude: Nigerian light, which contains a high percentage of nephithermic hydrocarbon and the Nigerian medium which has a higher specific gravity and more residue boiling point about 37^0C.

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 another 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? Scholars have observed that the Niger-Delta region is within the vertex of ecological fragility. If this statement is taken into consideration, then there is absolute need to strictly examine the extent of the clean-up operations in the area. This is the essence of this paper.

Study Objectives

The following are the objectives of this study:

i) To examine the various strategies adopted in site clean-up operations in Port Harcourt.
ii) To examine the efficiency level of on-shore oil spill clean-up.
iii) To assess the extent of monitoring by Federal and State government environmental agencies.
iv) To examine the problem militating against clean up exercises in the study area.
v) To offer suggestions on ways of making on-shore oil spill remediation more efficient in oil producing areas.

Study Area

Port Harcourt is located between longitude 07^0 01ôE and 0750ôE latitude $04^0$46ôN and 04 75ôN. It is the oil capital of Nigeria and the administrative headquarters of Rivers State. The elongated and restricted nature of the dry land area of the city has a rare development making it essentially linear in form.

The city lies within the equatorial region with high rainfall and temperature. Rainfall total is about 2317mm falling heaviest in the months of July and September. The yearly mean

temperature range for the city is 30^0C. The hottest months are January, February, March, and May.

The geological segments of the city are located on the Delta plain and coastal plain terraces. There are variations in soil type in each area. The lower delta plain is covered with salt water and mangrove swamps. The costal plain terrace is not affected by tidal water but in some river valleys which extend from the creek, the tide erodes the banks. The soils consist mainly of silt, sand and loam.

Port Harcourt houses the second largest seaport in Nigeria coming only after Lagos. It is equally the industrial hob of the Niger-Delta region. Several multinational industrial complexes involved in the exploration of crude oil and other ancillary or service industries are located in Port Harcourt. Due to its metropolitan nature, the population of the city has witnessed an interesting and steady growth since it was founded in 1912 peaking at about 706,765 in 1991. The population of the city presently is put at about 2 million people. (NPC, 2006)

The traditional socio-economic activity of the indigenous population is farming and fishing. However, these have declined dramatically as a result of rapid urbanization which has led to the conversion of once arable lands to industrial and residential land uses. Today, Port Harcourt has grown into a large conglomerate of industrial, economic, political, and social base and is playing a very prominent role in the socio-economic transformation of the nation. According to the Federal Ministry of Petroleum Resources, Nigeria has about 159 oil fields and 1481 oil wells (see Niger Delta Environmental Survey, 1997). The Port Harcourt area has more than 286 oil wells which is an evidence of the high level of oil production activities taking place there. One problem associated with oil exploitation is the periodic occurrence of oil spillage which is also prevalent in Port Harcourt. The environmental consequences of oil spillage are multifaceted. It leads to the destruction of mangrove ecosystems, reduction in crop yields, decline in fish production, contamination of groundwater, imperils human health, and destroys the aesthetic value of water bodies. Generally, victims of oil spillage are denied their sources of socio-economic livelihood.

Research Design

The study adopted an exploratory and experimental method. Composite soil samples were taken at different topographical positions in the Elelenwo remediation site in Port Harcourt. The depths of soil sample at the surface ranged from 0-15cm and at the sub-surface was between 15cm-30cm. These soil samples were oil-dried, grounded with wooden roller, sieved through a 2mm mesh, labeled and packaged in polythene bags for laboratory analysis. The soils were analyzed for microbiological parameters, bacterial and fungi degraders, heavy metals and total hydrocarbon contents (THC). Additionally, three sets of questionnaires were administered to collect information from the oil company (SPDC), the oil spillage clean-up company, and the host community.

Conceptual Framework and Viewpoints From Literature

There are two basic approaches in understanding the completeness of a clean-up exercise in polluted oil sites. These are the generic approach and the trigger-concentration approach. The former involves a meticulous site ï by ï site assessment of the extent of damage. It is commonly utilized because of the ease of implementation and usefulness for initial assessment of contamination.

The trigger concentration model involves the determination of two extreme boundary levels or values namely the threshold value which defines the boundary below which no remedial action is necessary for the site under consideration and, the action value that defines concentration values which when equaled or exceeded, remedial work is considered practically unavoidable. However, when concentration levels lie between the threshold and action values, there is need to consider whether remedial action is required for the purpose. Trigger concentration based approach and other generic guidelines for environmental components provide rationally consistent guidelines on the likely need for remediation without the very substantial technical demands and cost assessment. According to experts, the environmental components for such remediation include oil, groundwater, surface water and human health. Environmental quality objectives and their related environmental quality standards (EQS) are frequently used to set trigger levels and clean-up criteria for contaminated land. Interestingly, this approach forms the basis of clean-up standards and permissible levels in Europe, America, and Nigeria.

The literature on soil spill clean-up is vast. Only a synopsis is presented here. According to Shell Petroleum Development Company report (2000), on risk perspective of crude oil, the main chemicals of concern are benzene and some poly-aromatics hydrocarbons (PAHs), which are carcinogens. Several ecotoxiological studies on crude oil have shown that when these hazardous compounds migrate into the food chain through bio-accumulation, ground water contamination and ingestion of edible ecological resources, it could constitute a great threat to human health (Olusi, 1981). With respect to agricultural activities oil spillage is potently inimical. It reduces soil fertility and this results in poor quality and decreased output. On their part, the Constitutional Right Project (1991) avers that oil spillage is the most controversial of all the impacts of oil exploration and that the extent of damage to the environment is determined by what, where, how much, as well as how long it remains uncleaned. In addition, Imevbore and Adeyemi (1979) have found out that where soils are heavily contaminated by oil, plants shed their leaves and eventually die. This point is valid because it is common knowledge that oil exerts its influence on plants through the process of biomulsification.

There are several strategies which have over the years been evolved for oil clean-up operations but for the purpose of this study only two will be reviewed. These include the Environmental Sensitivity Index (ESI), mapping and the Environmental Site Assessment (ESA). Environmental Sensitivity Index (ESI) was developed by the RPI International Inc and its use dates back to the Torrey Canyon oil spill of 1967. It is useful for the identification of sensitive and aesthetic features when responding to spills and other environmental incidents. Importantly, it is the tool currently used to tackle the problem of oil spillage in the Gulf region. According to Nduaguba (1991), Environmental Sensitivity Index (ESI) is a management tool for combating or controlling man-made and/or accidental environmental disaster such as spillage. It is also used in Nigeria although this has not been standardized.

The Environmental Site Assessment (ESA) strategy is used to determine the existence and extent of contaminants in a site. It makes use of sampling techniques to characterize the extent of contamination or provide the baseline of soil and groundwater conditions. In this approach, the history of the site is required to identify the potential source of crude oil contamination, the use of the siteôs pervious permits, waste disposal licenses, and surrounding land use (Ofunne and Ogamba, 1998).

In Nigeria, there are unarguably over 2000 crude oil contaminated sites in the Niger Delta region. Oil companies operating in the country are expected to open a register of all contaminated sites for possible remediation. Commendably, oil companies have devised various strategies to combat oil spill. Descalzi (1999) has categorized these strategies into three tiers;

> Tier 1: Localized spills up to 2000 barrels on land, near onshore and offshore environments. It involves spills which can be coordinated in the field by personnel, and equipment from the operational base office. Response time for such spills should be about three hours with a crisis period of one week. Tier 2: Involves spills of between 2000 and 10,000 barrels. It involves the mobilization of members from the Clean Nigeria Association (CAN) and the response time is 12 hours and a crisis period of two weeks. Tier 3: Involving spills greater than 10,000 barrels. It may require the invitation of assistance from overseas agencies such as Oil Spill Response Limited (OSRL) in Southampton. This response should be 48 hours and a crisis period of 4 weeks.

According to Descalzi (1991), responding effectively to spills is a product of experience and the provision of resources and materials.

The aim of oil spill cleanï up programmes should involve salvaging the oil spilled and avoiding further pollution (Imevbore and Adeyemi, 1981). Oil remediation exercises follow a sequence of events which Descalzi (1991) has summarized to include containment, environmental assessment identification survey, enhanced engineering, oil spill trajectory modeling, washing techniques to remove stranded oil, etc. Broadly, the techniques of oil spill clean-up can be classified into absorption, manual recovery, chemical recovery, and nature clearing (microbes).

Another technique of oil spill clean-up operation is known as bio-remediation. According to Asikong and Udofia (2005), Cunningham, et al (2003) and Onwurah (2000), bioremediation is the process by which biological agents especially micro-organisms are used to reclaim soil and water environments polluted by substances hazardous or harmful to human health and the environment. Recently, the US Environmental Protection Agency has reported that bio-remediation is a safe and effective oil removal option. In addition, Onwurah (2000) reports that the following engineering technologies such as composting, land farming, solid phase treatment, bioreactor application, land fills, genetically engineered micro-organisms (GEMs), and special nutrient application are widely used in treating oil spilled sites. To Asikong and Udofia (2005), there are three approaches for the speedy and enhanced performance of micro-organisms including bioaugmentation, biostimulation, and bio-technological protocol. Explaining further

> Bioaugmentation is the addition or introduction of foreign microbes into contaminated environment for the purpose of detoxification of toxic pollutants. Biostimulation involves the addition of appropriate microbial nutrients to a contaminated soil or water environmenté Biotechnological approach involves the genetic engineering of some micro-organisms to change their genetic components for enhanced degradation (Asikong and Udofia, 2005).

It is, however, believed that the bio-degradation rate of more recalcitrant and aromatic hydrocarbons is rapid at first but declines rather quickly (Adams and Jacksons, 1996). Biodegradation of these compounds are limited by their strong absorption potential and low solubility.

Presentation and Discussion of Results

Clean-Up Strategies in Soil Remediation

Tables 1 and 2 show the strategies and materials used in the site clean-up exercise in the affected areas. In the Elelenwo contaminated

Table 1: Strategies used in site clean-up

Method	Number	%
Manual	5	20
Chemical	-	-
Bioremediation	20	80
Total	**25**	**100**

Source: Author: Fieldwork, 2009.

Table 2: Materials used for site clean-up

Method	Number	%
Shovel	3	12
Microorganism	20	80
Others	2	8
Total	**25**	**100**

Source: Author: Fieldwork, 2009.

site clean-up exercise, 80% of the method used was bio-remediation, while the manual method accounted for 20%. In table 2, 12% of the material used was shovel, while the use of micro-organisms constituted 80%. Other materials used make up 8%. The data in table 2 confirm the information in table 1. The use of shovel in the second table validates the manual strategy shown in table 1 and this indicates the fact that the cleaning up was done more or less manually. In addition, the use of micro-cleaning up was done more or less manually. In addition, the use of micro-organisms as materials confirms that the strategy adopted was biological remediation as shown in the first table.

Level of Clean-Up Exercise

To ascertain the thoroughness of the clean-up exercise, the results of the microbiological analysis for total hetero-tropic bacteria (THB) and hydrocarbon utilizing bacteria (HUB) are presented for discussion as shown in Table 3; The soil samples for this analysis were taken two years after the remediation exercise.

Table 3: Total Hetero-Tropic Bacteria (THB) and Hydrocarbon Utilizing Bacteria (HUB) from Soil of Elelenwo Remediation Site in Port Harcourt

Sampling Code	Depth (cm)	THBCx10^3	HUB x 10^3	%HUB
SPOT A	0-15	200.36	22.41	11.18
	15-30	196.43	20.13	10.25
SPOT B	0-15	235.62	30.34	12.88
	16-30	218.54	25.44	11.65
SPOT C	0-15	181.28	20.93	11.55
	16-30	172.66	18.222	10.55
SPOT D	0-15	214.37	28.33	13.22
	16-30	203.46	26.46	13.01
SPOT E	0-15	246.93	37.93	15.14
	16-30	218.34	26.24	12.02
RANGE	Surface	181.28 ï 246.54	20.96 ï 37.39	11.18 ï 15.14
	Sub-surface	172.66 ï 218.54	18.22 ï 26.24	10.25 ï 13.01

THBC = Total Hetero-tropic Bacteria count
HUB = Hydrocarbon Utilizing Bacteria
Note: HUB > 1% indicates pollution from microbiological standpoint
Source: Lab Analysis in Canon Ball (Nig.) Ltd, Calabar:

To be sure that the level of clean-up is high, the HUB should not be more than 1.0%. However, results presented in table 3 show that the total hetero-tropic bacteria count ranged from 181.28 to 246.93 x 10^3 cfu/g for surface soils and from 172.66 to 218.54 x 10^3 cfu/g sub-surface soils. Furthermore, the hydrocarbon utilizing bacteria (HUB) varied from 20.96 x 10c cfu/g to 37.39 x 10^3 cfu/g for surface soils and between 18.33 x 10^3 cfu/g to 26.24 x 10^3 cfu/g for the sub-surface soil. The percentage of HUB also varied from 11.18% to 15.14% for surface soils and between 10.25% to 13.01% for sub-surface soils for all the spots sampled. The implication from these analyses shows that the high range of values of HUB above 1% indicate that the soils around the area are still polluted with petroleum hydrocarbon even though clean-up exercise were undertaken on these sites two years earlier. The anomalously high presence of hydrocarbon pollutants depicts a highly polluted ecosystem. This also implies that it would be difficult for plants or other forms of life to thrive well on such soils.

Agencies involved in Clean-up Monitoring

The responsibility of monitoring the extent to which oil companies comply in clean-up exercise is that of the Federal Ministry of Environment, the Department of Petroleum Resources (DPR), as well as Ministries of Environment in the respective States. Data from the field as presented in table 4 indicate that the State Ministry of Environment was more involved and interested in the monitoring programme recording a total of 58.8% of the total number of times the site was visited. This was closely followed by the SPDC 23.1%, and the Federal Ministry of Environment and Department of Petroleum Resources (DPR), 15.4% and 7.7% respectively.

Table4: Agencies involved in Monitoring Clean-up Exercise

Agency	**No. of times site is visited**	**%**
Federal Ministry of Environment	2	15.4
Dept. of Petroleum Resources (DPR)	1	7.7
SPDC	3	23.1
State Ministry of Enviornment	7	58.8
Total	**13**	**100**

Source: Authorôs Fieldwork, 2009.

The reason for the involvement and interest of the State Ministry of Environment is not far ï fetched. They are the home government who feel the greatest impact of the incessant harassments and restiveness of youths from communities ravaged by oil spills.

Factors Affecting Prompt Clean-up Exercise

There are two principal factors affecting the prompt response of oil companies in embarking on efficient clean-up exercises in the affected areas. These are red-tape or bureaucratic bottle-necks in the oil companies and community agitations/youth restiveness. Information from fieldwork shows that undue delays, nonchalant attitude on the part of the management of oil companies and bureaucracy affect the time action is taken to clean-up a spilled site. Source: Authorôs Fieldwork, 2009.

Tables: Factors Affecting Clean-Up Exercise

Factors	**Response**	**%**
Oil Company Bureaucracy	14	56
Community Agitations	11	44
Total	25	100

As shown in Table 5, this accounts for 56% of the reasons why clean-up exercises are always unduly delayed. For instance, investigations from this study show that the Elelenwo oil-spilled site was neglected for upward of three years before attention was paid to it. The issue of community protests and youth restiveness accounts for 44%. Often, partly because of the slow or no response from oil companies and partly because of the inability or unwillingness of oil companies to pay compensation, communities have often taken the laws into their lands by causing violent demonstrations sometimes resulting in loss of lives, destruction of oil installations, and stoppage of work in such oil establishments. In other instances, the community insists that they should be involved in the clean-up operations. This was the case with respect to the company which handled the Elewenwo spilled site. The company contracted by SPDC employed a large number of youths from the community to assist in the exercise.

Policy Implication

The results of the laboratory analyses show that the efficiency of the oil clean-up exercise is anything but good. They attest to the fact that several years after the remediation programmes, there were still some heavy presence of microbiological accumulation in the soil of the study area. They also underscore the need for the agencies involved in monitoring

clean-up programmes to live up to expectation. Effective monitoring is vital to ensure that the entire soil area polluted by petroleum hydrocarbon is effectively remediated to restore the soil back to its pre-polluted or pre-spilled status. In view of the foregoing, the following policy options are recommended;

i) Clean-up operations should be internalized to avoid the problem of bureaucracy which leads to unnecessary delays in the award of clean-up contracts. To be efficient, if will require oil companies to have a standing and functional clean-up unit with the latest state ï of- the art technology.

ii) 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.

iii) 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.

iv) 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 clean-up is promptly carried out, ensure the thoroughness of the exercise, and strict adherence to standards.

v) 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.

Conclusion

The problem of oil spillage is universal. The incidence of oil spills depends largely on the quality of technology used in the oil industry and the caliber of personnel employed. There is need for oil companies to be more careful in their operations in order to minimize the devastating consequences of oil spillage on the human environment. The Department of Petroleum Resources should synergize with oil companies so as to minimize the occurrence of oil spills, embark on effective clean-up operations, and ensure that communities affected are promptly and adequately compensated.

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