

# ECONOMIC EFFECTS OF CRUDE OIL SPILLAGES ON CROP FARMS IN RIVERS STATE, NIGERIA

T. P. OJIMBA

(Received 8 June 2010; Revision Accepted 14 March 2011)

## ABSTRACT

This article focused on economic effects of crude oil spillages on crop farms in Rivers State, Nigeria. The objectives of the study were to calculate the areas of crop farms spilled by crude oil and estimate the corresponding economic losses. Data for the study were collected using a multistage sampling procedure. A total of 170 questionnaires were distributed among crop farmers in selected 17 local government areas of Rivers State, out of which 169 questionnaires were retrieved and retained for data analysis. Total area of crop farms spilled was 548.09 ha, of which about 80% were accounted for by heavy and medium oil spillages. About 83% of the economic losses (\$148, 925.19) incurred by farmers were also accountable to heavy and medium oil spillages, while mean value lost per hectare of a crop farm affected was \$307.15. Therefore, the study concluded that oil spillages reduced areas of farmland available for cropping, thereby causing serious economic losses in form of income and output, accruable to the crop farmers in the state. To ameliorate these difficulties faced by crop farmers in Rivers State, it was recommended that comprehensive scientific rehabilitating programme and diversification of sources of income for farmers is embarked upon through effective extension and rural education programmes.

**KEYWORDS:** Crude oil spillages; environmental impact; economic losses on crop farmers; Rivers State; Nigeria.

## 1.0. INTRODUCTION

The knowledge of crude oil spill behaviour is of the utmost importance for the evaluation and risk assessment of mineral oil contamination and its effects (Seitinger, et al., 1994). An oil spill can affect the environment in numerous ways. The magnitude of the impact could be dependent on the type of accident (blowouts, explosions, pipeline ruptures), the region of the spill and the clean up and control techniques (Fisher and Sublette, 2005; Ogbu, 2008; Katusiime, 2009).

Advanced technology notwithstanding, accident in the form of blow-outs of production well and pipeline leaks have continued to occur in the Niger Delta region of Nigeria destroying farmland, crops, fish, and other wildlife (such as snails, mushrooms, and non-woody resources), thereby causing hardship to the subsistent farmers in the area (Edwin-Wosu and Kinako, 2004; Agbogidi, et al., 2005; Daniel-Kalio and Tih, 2006; Akaninwor and Okeke, 2006; Osuji and Ozioma, 2007). Also seriously contaminated are streams, ponds, rivers and lakes, which serve as sources of drinking water (Essien and Antai, 2005; Abu and Chikere, 2006; Cohen, 2008; Anugwom and Anugwom, 2009; Chikere, et al. 2009; Essien and Antai, 2009).

The exploitation of natural gas deposits of the Niger Delta region of Nigeria had not been economically viable until recently. As a result, much of it has been burnt-off to allow access to the underlying oil (NDDC, 2006; Platform, 2006). The burning gas (flares) produces gases such as nitrogen oxide and sulphur dioxide which are released into the air. These air-borne pollutants are highly toxic, and the growth of plants (especially crops) was particularly inhibited by the hot sooty emissions (Edwin-Wosu and Kinako, 2004; Cohen, 2008; Udoetok and Osuji, 2008).

Accidents could also occur due possibly to vandalization of the pipelines leading to enormous loss of crude oil and/or refined petroleum products (Onwuka, 2005; Platform, 2006; Cohen, 2008; Ogbu, 2008). Crude oil spillages in this article will include oil spillages in heavy, medium, and light degrees of occurrences on farmland in Rivers State of Nigeria.

### 1.1. The Problem of the Study

As with many other benefits of civilization in this current technical age, there are two sides of the equation of exploration and refining oil – the benefits and the consequences (loss) which in this case is the environmental impact of the oil industry on agricultural production. This view was strongly supported by Pearce, et al., (1991) and Odu (1983). Pearce, et al., (1991) stated that an improvement in environmental quality is also an economic improvement if it increases social satisfaction or welfare. A benefit is any gain in welfare (or satisfaction or utility). A cost is any loss in welfare. We are here concerned then with the measurement of the costs of reductions in environmental quality as it affects agriculture by the oil industry, whether it be oil spillage, hazards in the form of heat, light, noise or acquisition of farmlands. Therefore, it would be a better state of affairs if it is taken for granted that the disturbance of the environment (as it affects agriculture), is a fact we must live with in Rivers State as long as Nigeria prospects for oil and gas, and derive the benefits thereof (Ojimba, 2006).

In order to resolve to live with the problems of crude oil pollution and make the best out of it, it is necessary to carryout detailed studies to assess and properly understand (in economic terms) the effects crude oil spillages have on agricultural production in

particular and the environment in general, in as far as it affects the economic status of the Rivers State farmers. With distortion in the major livelihood activities of the people in Rivers State due to crude oil spillages, the question this article asks is what is the value of economic losses which the crude oil spillages on crop farms had caused the farmers in Rivers State.

### 1.2. The Justification of the Study

There is paucity of scientific data on economic losses due to crude oil spillages on crop farms in Rivers State. Ojimba (2005) did a comparison study of crop production in crude oil polluted and non-polluted farms in Rivers State, Nigeria. His results show that average peasant farm size cultivated in the non-polluted crop farms which was 1.60 ha was higher than an average peasant farm size in crude oil polluted crop farms (1.45 ha). This reduction in the area of farm size cultivated, reduced the total quantity of crop output and hence the farm income realized by farmers from crude oil polluted farms when compared to the non-polluted farms. This led to his conclusion that crude oil pollution had detrimental effects on crop production.

Ojimba (2007) investigated the effect of farm size and crude oil pollution on the poverty level of the farmers in Rivers State of Nigeria. The results of his investigation show that there was more poverty experienced in crude oil polluted crop farms households. Therefore, he concluded that crude oil pollution impoverished crop farmers in the state.

There are literatures on the general effects of oil pollution on agriculture (Otton, et al., 2005; Fisher and Sublette, 2005; Bader, 2006). There are literatures that had touched on the effects of crude oil pollution in Nigerian agriculture (Agbogidi, et al., 2005; Daniel-Kalio and Tih, 2006; Chikere and Chijioke-Osuji, 2006; Chikere, et al., 2009; Anugwom and Anugwom, 2009; Tanee and Akonye, 2009). None of these studies mentioned above had researched on the current topic: economic effects of crude oil spillages on crop farms in Rivers State of Nigeria, therefore the need and justification for the study.

### 1.3. The Objectives of the Study

The main objective of this article is to estimate the effects of crude oil spillages on crop farms in Rivers State of Nigeria. The specific objectives are to:

- (i) Calculate the area of crop farms polluted by crude oil spillages in Rivers State.
- (ii) Estimate the economic losses due to crude oil spillages on crop farms in the state; and
- (iii) Make policy recommendations that will ameliorate the negative effects of crude oil spillages on crop farms in Rivers State of Nigeria.

## 2.0. LITERATURE REVIEW

Chikere, et al., (2009) performed experiments in which Bonny light crude oil was spilled with three treatments of different fertilizers (NPK, urea and poultry droppings) with periodic tilling in a tropical soil undergoing bioremediation as a result of the crude oil spillage in Niger Delta region of Nigeria. Onwuka (2005) reported that in Nigeria, environmental problems are severe, particularly in the Niger Delta region. The author stated that the crude oil activities damaged the fertility of

the soil, and destroys wildlife and the breeding ground for marine fishes because of the toxicity of oil and gas. The various government programmes aimed at ameliorating the plight of the farmers have failed due to inefficiency and corruption. Consequently, the indigenous people (mainly farmers) are impoverished, with attendant increase in environmental abuse occasioned by their struggle for survival.

Katusiime (2009) in her report on Niger Delta said that leaking pipelines running through villages, farms, creeks and rivers are a major source of pollution. Farmland polluted by oil is rarely rehabilitated thereby causing economic ruin. Platform (2006) in its report on oil pollution in the Niger Delta stated that between 1976 and 1998, over 2.5 million barrels of oil have been spilt into the environment and that these spillages are a regular feature of life in the Niger Delta. They are rarely dealt with promptly. In some cases, minor leaks are left for months, resulting in major pollution. Platform (2006) went on to say that there is no clean up operation in the Niger Delta worth mentioning. No one knows exactly how much oil has been spilt, how much land is polluted, how many people are affected, what species are threatened, what the economic or environmental costs have been. This article will calculate the areas of crop farms affected by crude oil spillages and try to estimate the economic values of crops lost due to the various degrees of oil spillages in Rivers State of Nigeria.

Cohen (2008) reported that the residents of the Niger Delta sub-region have been expressing deep grievances for over two decades. Their air has been polluted by the flaring gas associated with crude oil pollution. Their wetlands, streams and farmland have been polluted by oil spills and pipelines leaks. Cohen (2008) further reported that the residents of Niger Delta have seen virtually no benefits from oil revenues coming to Nigeria via the Federal Government and that the people remain among the poorest in the country.

In some of the earlier studies conducted in Rivers State, Nigeria, Mubana (1978) determined the magnitude of the negative effects of crude petroleum exploration and production on the output levels on traditional farms in parts of Rivers State, concentrating on only four villages. He observed that on heavily polluted farms both crop plants and trees were extinct. Osuji (1998) also conducted a post-impact survey of oil spill affected sites at Ogbodo and Eneka in Rivers State of Nigeria. The survey conducted 15 months after the oil spillage revealed that the oil affected plots had fewer plant covers when compared with the unaffected plots. Each of these studies showed that oil concentration in the soil has adverse effects on performance of crops. However, none of these citations entailed detailed estimates of areas affected and economic analysis of crude oil spillages.

## 3.0. DATA

This study was conducted in Rivers State of Nigeria where oil production and exploration activities is spread throughout the 23 local government areas of the state. Data were collected from both the primary and secondary sources. The primary data were collected through personal interviews and observations with the crop farmers, and structured questionnaires distributed among such crop farmers farming in crude oil polluted farmland in the state.

A multistage sampling technique was used to obtain data for the study. The first stage involved the selection of seventeen (17) local government areas (LGAs), out of the existing 23 LGAs in the state. This selection was based on the fact that these 17 LGAs were more crop farming inclined than others. The LGAs include: Abua/Odual, Ahoada East, Ahoada West, Andoni, Asaritoru, Degema, Eleme, Emohua, Etche, Gokana, Ikwerre, Khana, Obio/Akpor, Ogba/Egbema/Ndoni, Omuma, Oyigbo and Tai LGAs.

The second stage involved the stratification of farmland in an affected LGA into sampling units namely crude oil heavily spilled, medium and light degrees of spillages on crop farms. The third stage involved the random sampling of ten (10) crop farmers whose farmland were affected by the different degrees of spillages. A total of 170 questionnaires were distributed among crop farmers in the seventeen LGAs selected, out of which 169 questionnaires were retrieved and retained as suitable for data analysis.

#### 4.0. RESULT ANALYSIS AND DISCUSSIONS

The results were analyzed based on the set objectives of calculating the areas of farmland polluted by crude oil spillages, and estimating the economic losses incurred due to the different degrees of crude oil spillages on the crop farms in Rivers State.

#### 4.1. Area of Farmland Polluted by Crude Oil Spillages

The area of farmland affected by various degrees of crude oil spillages in Rivers State during the period of survey in 2003 is shown on Table 1. The survey identified three categories of degrees of crude oil spillages, which usually occur on crop farms in the state. These are heavy crude oil spillages (in which all crops are destroyed), medium oil spillages (in which almost all crops are destroyed on the affected farms), and light oil spillages (in which some crops were destroyed). These findings conform with the findings of the earlier studies of Mubana (1978); and Osuji, (1998); and also with the more recent findings of Fisher and Sublette (2005).

The total area of respondents' crop farms spilled by the various degrees of crude oil spillages during the period of the survey in 2003 was 548.09 ha. Of these, the heavy oil spillages (in which all crops were destroyed) occurred on the largest area of 272.90 ha (49.79%). This was followed by medium oil spillages (in which almost all crops were destroyed) which occurred on 164.54 ha (30.01%) of respondents crop farms, and the light oil spillages (in which some crops were destroyed), occurred on 110.69 ha (20.20%) of respondents crop farms in Rivers State.

❖ Table 1: Area of crop farms affected by crude oil spillages in varying degrees in Rivers State, 2003.

**Table 1: Area of crop farms affected by crude oil spillages in varying degrees in Rivers State in 2003.**

Degrees of oil spillage	Total hectares spilled (ha)	Percentage	Average farm size spilled (ha)	Standard deviation (S.D) (ha)	Minimum value (ha)	Maximum value (ha)	C.V. ( %)	Ranking
Heavy Oil spillage (all crops destroyed)	272.90	49.79	3.37	1.91	0.40	10.00	56.68	1 <sup>st</sup>
Medium oil spillage (almost all crops destroyed)	164.50	30.01	2.79	1.50	0.30	10.00	53.76	2 <sup>nd</sup>
Light oil spillage (some crops destroyed)	110.69	20.20	2.09	1.21	0.20	8.00	57.89	3 <sup>rd</sup>
Total	548.09	100	-	-	-	-	-	-
Mean	182.70	-	2.75	1.54	0.30	9.33	56.11	-

Source: Field Survey, 2003.

Results on Table 1 further show that average area of respondents' farm size heavily spilled by crude oil during the period of survey was 3.37 ha, average area of farm size affected by medium oil spillage was 2.79 ha and light oil spillages occurred on an average farm size of 2.09 ha. These crude oil spillages reduced the farmland available for cropping in the state (Ojimba, 2007). This reduction in crop farms area had caused untold economic hardship to the crop farmers affected in Rivers State and this hardship is continuous (Onwuka, 2005; Platform 2006).

#### 4.2. Economic Effects of Crude Oil Spillages on Crop Farms

The estimated economic values of crops lost by surveyed crop farmers due to various degrees of crude oil spillages on crop farmland in Rivers State in 2003 are reported on Table 2. The original value of naira (local Nigerian currency) obtained during the survey was converted into United States of America dollars (US\$) using an exchange rate of ₦120 for US\$1.00 which was the prevailing exchange rate as at the time of the survey in 2003.

All crude oil spillages investigated caused a total economic loss of \$178,769.37 incurred by the crop farmers interviewed during the survey. Among these economic losses, heavy crude oil spillages on crop farms accounted for more than 57% of crops lost valued at \$102,934.21, with a mean crops value lost per heavy degree of spillage of \$1,286.68 and a mean crop value lost per hectare of crop farm of \$381.80. The medium crude oil spillage category accounted for about 25.73% of the total loss of crops by the interviewed respondents in Rivers State in 2003. This amounted to \$45,990.98 with a mean crops value lost per medium degree of spillage of \$753.95 and mean crops value lost per hectare of \$270.23. The light oil spillage accounted for about 16.69% with a total value of \$29,844.18. The mean crops value lost per degree of light oil spillage was \$563.10, with a mean crops value lost per hectare of a crop farm of \$269.42.

❖ Table 2: Estimated economic value of crops lost due to oil spillages on crop farms in Rivers State in (US\$.)

These data on Table 2 indicate that there were severe economic losses by crop farmers interviewed during the survey due to crude oil spillages on their crop farms. The reduction in size of farmlands and the

economic loss of crops due to crude oil spillages on crop farms in Rivers State has led to loss of areas of cultivable farmland, achievable crop output and accruable net farm incomes to the farmers in the affected areas. This has led to increased poverty among the Rivers State crop farmers (Ojimba, 2006; 2007) and might be one of the reasons why the indigenes of the state are said to be one of the poorest in the country despite their oil rich environment (Cohen, 2008). Secondly, the average economic loss of \$307.15 per hectare of crop farm in the state is very significant to the economy of peasant farmers households who are believed to live on less than \$1.00 per person per day and own an average of 1.0 ha of farm cultivated annually (Lin and Lin, 2003; Adams and Page, 2005; Ojimba, 2007).

#### 5.0. SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study focused on economic effects of crude oil spillages on crop farms in Rivers State, Nigeria. The specific objectives of the study were to calculate the areas of crop farms polluted by crude oil spillages, estimate the economic losses arising from such excesses, and make policy recommendations that will ameliorate the negative effects on crop farmer.

**Table 2: Estimated economic value of crops lost due to oil spillages on crop farms in Rivers State in (US \$.)**

Degrees of oil spillage	Total crops value lost/degree of spillage (\$)	Percentage	Mean crops value lost/degree of spillage (\$)	Standard deviation (S.D) (\$)	Mean crops value lost/ha (\$)	Coefficient of variation (C.V.) (%)	Ranking
Heavy Oil Spillage (All Crops Destroyed)	102,934.21	57.58	1,286.68	910.42	381.80	70.76	1 <sup>st</sup>
Medium Oil Spillage (Almost All Crops Destroyed)	45,990.98	25.73	753.95	547.12	270.23	72.57	2 <sup>nd</sup>
Light Oil Spillage (Some Crops Destroyed)	29,844.18	16.69	563.10	423.35	269.42	75.18	3 <sup>rd</sup>
Total Crops Value Lost	178,769.37	100	2,603.73	1,880.89	921.45	72.24	-
Mean Crops Value Lost	59,589.79	-	867.91	626.96	307.15	72.24	-

Source: Field Survey, 2003.

Data for the study were collected from both primary and secondary sources.

The study which was conducted in Rivers State of Nigeria used a multistage sampling technique to obtain

data for analysis. A total of 170 questionnaires were distributed among crop farmers in the selected 17 LGAs out of which 169 questionnaires were retrieved and retained as suitable for data analysis.

Results of the analyses showed that the degree of oil spillage on crop farms were principally three, namely heavy oil spillage (where all crops were destroyed), medium oil spillage (where almost all crops were destroyed) and light oil spillage (where some crops were destroyed). The total area of crop farms spilled during the period of survey was 548.09 ha, of which about 50% of the spillage were due to heavy oil spillage, 30% of the oil spillage was caused by the medium oil spillages and the remaining 20%, was as a result of light oil spillages. These crude oil spillages reduced the farmland available for cropping in Rivers State. All crude oil spillages caused a total economic loss of \$178,769.37 incurred by the respondent crop farmers in Rivers State in 2003. About 57% of these economic losses were accountable to heavy oil spillages, with a mean crops value lost per hectare of a crop farm as \$381.80. This was followed by medium oil spillages which accounted for about 26% of the crops lost, with crops value lost per hectare of a crop farm as \$270.23.

In conclusion, the reduction in size of farmland and the economic loss of crops due to crude oil spillages on crop farms in Rivers State has led to loss of areas of cultivable farmland, achievable crop output and accruable net farm incomes to the farmers in the affected areas. This led to increased poverty among the Rivers State crop farmers.

In recommending policies that will ameliorate the negative effects of crude oil spillages on crop farms in Rivers State, this study recommends the following, that:-

- (i) Comprehensive scientific rehabilitation programmes should be implemented for unavoidable oil spilled crop farms. The rehabilitation programmes should be handled by experts in this field who are emerging strongly in the state.
- (ii) Farmers in the state who are in crude oil spillages prone areas should seek additional means of livelihood by diversifying their source of income or quit farming entirely for other economic activities that are not crude oil spillages prone, thereby allowing land to be allocated for its best alternative uses, in this case, oil and gas exploration and production, since crude oil has become the main stay of the Nigerian economy.
- (iii) There is the need to intensify the dissemination of benefits from the rehabilitation programmes and educating crop farmers on best farm practices available and what functional measures to adopt in case of unavoidable crude oil spillage on their crops farms. This could be done through extension and rural educational programme outfits existing in the state, including the Niger Delta Development Commission (NDDC).

## REFERENCES

- Abu, G.O. and Chikere, B.O., 2006. Cell surface properties of hydrocarbon utilizing bacteria isolates from Port Harcourt marine environment. *Nigerian J. Microbiology*. 20: 809-816.
- Adams, R.H. and Page, J., 2005. Do international migration and remittance reduce poverty in developing countries? *World Development*. 33(10): 1645-1669.
- Agbogidi, M.O., Nweke, U.F. and Eshegbeyi, O.F., 2005. Effects of soil pollution by crude oil on seedling growth of *Leucaena Leucecephala* (LAM) De Witt. *Global J. Pure and Applied Sciences*. 11(4): 453 – 456.
- Akaninwhor, J.O. and Okeke, E.A., 2006. Effects of diets contaminated with crude petroleum products (Bonnylight and Forcados) on enzyme activity of *Wistar albina* rats. *Global J. Pure and Applied Sciences*. 12(4): 501 – 504.
- Anugwom, E.E. and Anugwom, K.N., 2009. The other side of civil society story: Women, oil and the Niger Delta environmental struggle. [www.springerlink.com/index/13K7J8318242540.pdf](http://www.springerlink.com/index/13K7J8318242540.pdf).- *Geo Journal Springer*. \_\_\_\_ (Accessed 14/09/2009).
- Bader, D., 2006. Ecuador rainforest and its devastation by oil production: Ecuador rainforest home to one of the worst cases of oil pollution ever. [www.tropical-rainforest-animals.com/Ecuador-rainforest.html](http://www.tropical-rainforest-animals.com/Ecuador-rainforest.html). (Accessed 14/08/2009).
- Chikere, B.O. and Chijoke – Osuji, O., 2006. Microbial diversity and physiochemical properties of a crude oil polluted soil. *Nigerian J. Microbiology*. 20: 1039 – 1046.
- Chikere, B., Okpokwasili, G.C. and Chikere, B.O., 2009. Bacteria diversity in a tropical crude oil polluted soil undergoing bioremediation. *African J. Biotechnology*. 8 (11): 2535 - 2540.
- Cohen, H., 2008. Nigeria : A well – oiled federation. *Peace Ops. JIPO* 4(2), Sept. – October. (Accessed 14/08/2009).
- Daniel–Kalio, L.A. and Tih, A.P., 2006. Effects of nutrient supplementation and successive planting in oil-polluted soil on the performance of carica papaya L. *Global J. Pure and Applied Sciences*. 12(3): 315-318.
- Edwin–Wosu, N.L. and Kinako, P.D.S., 2004. Biomass loss as an index of pollution in various gradient of a crude oil polluted terrestrial environment. *Global J. Pure and Applied Sciences*. 10 (4): 623 – 625.
- Essien, J.P. and Antai, S.P., 2005. Negative effects of oil spillage on beach microalgae in Nigeria. *World J. of Microbiology and Biotechnology*. Springer. [www.springerlink.com](http://www.springerlink.com). (Accessed 02/07/2009).
- Essien, J.P. and Antai, S.P., 2009. Chromatium species. An emerging bio-indicator of crude oil pollution of tidal mud flats in the Niger Delta. *Environmental Monitoring and Assessment* 2009. Springer. [www.springerlink.com](http://www.springerlink.com). (Accessed 02/07/2009).
- Fisher, J.B. and Sublette, K.L., 2005. Environmental releases from exploration and production

- operations in Oklahoma: Type, volume, causes, and prevention. *Environmental Geosciences*. 12 (2): 89 – 99.
- Katusiime, D., 2009. Like oil our environment is equally very important. African Institute for Energy Governance, Kampala, Uganda. [www.Afriego-ug.org/index.php?option=com...task...Afriego](http://www.Afriego-ug.org/index.php?option=com...task...Afriego). Newsletter Issue 1, p. 37 (Accessed 12/08/2009)
- Lin, C.T. and Lin, J.P., 2003. The impact of research led agriculture productivity growth on poverty reduction in Africa, Asia and Latin America. *World Development*. 31(2): 1959 – 1975.
- Mubana, E.C., 1978. An economic analysis of the impact of crude petroleum exploration and production on traditional agriculture in Rivers State of Nigeria. M. Phil Dissertation, Univ. Ibadan, Nigeria.
- NNDC, 2006. Niger Delta Regional Development Master Plan. Niger Delta Development Commission (NDDC), Port Harcourt, Nigeria. 258pp
- Odu, C.T. I., 1983. The oil industry and the environment. *The Nigerian Accountant*. 16 (1): 23-26; 47.
- Ogbu, A., 2008. Nigeria: Militants hit pipelines again. *This Day* (Lagos), 22<sup>nd</sup> April, 2008. World Prout Assembly. (Accessed 14/08/2009).
- Ojimba, T.P., 2005. Comparative analysis of crop production in crude oil polluted and non-polluted farmlands in Rivers State, Nigeria. *J. Vocational Education and Technology*. 2(1): 113 – 130.
- Ojimba, T.P., 2006. Crude oil pollution, crop production and farmers' welfare in Rivers State, Nigeria. Ph.D. Thesis, Univ. Ibadan, Nigeria.
- Ojimba T.P., 2007. Effect of farm size and crude oil pollution on the poverty level of the farmers in Rivers State of Nigeria. *Acta Agronomica Nigeriana*. 7 (2):108-119
- Onwuka, E.C., 2005. Oil extraction, environmental degradation and poverty in the Niger Delta region of Nigeria. A view point. *International J. Environmental Studies*. 62 (6): 655- 662.
- suji, L.C., 1998. Some environmental effect of crude oil spillage in two sites in Rivers State of Nigeria. Ph.D. Thesis, Univ. Ibadan, Nigeria.
- Osuji L.C. and Ozioma, A., 2007. Environmental degradation of polluting aromatic and aliphatic hydrocarbons. A case study. *J. Chemistry and Biodiversity*. [interscience.wiley.com](http://interscience.wiley.com). (Accessed 13/08/2009)
- Otton,, J.K., Zielinski, R.A., Smith B.D., Abbott, M.M. and Keeland, B.D., 2005. Environmental impacts of oil production on soil, bedrock, and vegetation at the U.S. Geological Survey Osage- Skiatook Petroleum Environmental Research Site A, Osage Country, Oklahoma. *Environmental Geosciences*. 12 (2): 73 - 87.
- Pearce, D.W., Markandya, A. and Barbier, E.D., 1991. *Blueprint for a Green Economy*. 5<sup>th</sup> edition, London Earthscan Publication Ltd.
- Platform, 2006. Nigeria. Oil pollution in the Niger Delta [www.carbonweb.org/showitem-asp?article=73...7...](http://www.carbonweb.org/showitem-asp?article=73...7...) (Accessed 22/08/2009).
- Seitinger, P., Baumgarbner, A. and Schindlbauer, H., 1994. The behaviour of oil spills in soils and groundwater. *National Resources and Development*. 40: 69 – 84.
- Tanee, F.B.G. and Akonye, L.A., 2009. Phytoremediation potential of *Vigna unguiculata* in a crude oil polluted tropical soil of the Niger Delta. *Global J. Pure and Applied Sciences*. 15(1). (Accessed 26/04/2010).
- Udoetok, I.A. and Osuji, L.C., 2008. Gas chromatographic fingerprinting of crude oil from Idu-Ekpeye oil spillage site in Niger Delta. *Environmental Monitoring and Assessment*. 2008. Springer. (Accessed 12/08/2009).