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The Impact of Oil Spillage on the Growth and Development of Pawpaw

Owhoudue E. Roland [1], ***Efejene O. Unity*** [2]

[1,2] Department of Environmental Science and Management Technology, Delta State Polytechnic, Otefe-Oghara, Nigeria

A B S T R A C T :

Crude oil spillage is a major environmental challenge in oil-producing regions, with significant implications for agricultural productivity and food security. This study investigated the effects of crude oil contamination on the growth and development of pawpaw (*Carica papaya*) plants. A Randomized Complete Block Design (RCBD) was employed with four treatments: *T0* (control, no crude oil), *T1* (50 ml crude oil), *T2* (100 ml crude oil), and *T3* (150 ml crude oil), replicated three times. Growth parameters measured included plant height, stem diameter, number of leaves, leaf area, and dry matter yield over a 12-week period. Soil samples were analyzed before and after the experiment to determine changes in physicochemical properties. Results revealed that crude oil contamination significantly reduced pawpaw growth performance in a dose-dependent manner. The control treatment recorded the highest growth parameters, while the highest crude oil concentration (150 ml) recorded the lowest. Soil nutrient content (N, P, K) and pH declined with increasing crude oil concentration, indicating reduced soil fertility. The findings suggest that crude oil spillage adversely affects pawpaw growth by impairing nutrient availability, disrupting soil structure, and introducing toxic hydrocarbons into the plant's environment. The study concludes that crude oil pollution poses a serious threat to pawpaw cultivation and recommends preventive measures, prompt remediation of contaminated soils, and farmer education on oil spill impacts. These findings have implications for environmental policy, agricultural sustainability, and rural livelihoods in oil-producing regions.

Keywords: Crude oil spillage**,** pawpaw (*Carica papaya*) plants, growth and development

Background to the Study

Oil spillage is one of the most pressing environmental challenges in oil-producing regions, particularly in the Niger Delta area of Nigeria. It refers to the unintentional release of petroleum hydrocarbons into the environment, often as a result of pipeline leakages, equipment failure, vandalism, illegal refining activities, or accidents during transportation and drilling operations. Oil spills have detrimental effects on soil quality, water resources, and biodiversity, thereby threatening agricultural productivity and food security in affected areas (Adama, et al, 2011).

Pawpaw (*Carica papaya L.*) is an economically important fruit crop cultivated in tropical and subtropical regions for its nutritional, medicinal, and economic value. The plant is highly valued for its sweet, fleshy fruit, which is rich in vitamins A and C, antioxidants, and digestive enzymes such as papain. Pawpaw is also relatively fast-growing, making it a common fruit tree in household gardens and small-scale farms. However, like many cultivated plants, its growth and productivity can be severely hampered by adverse environmental conditions, including soil contamination by crude oil (Ajayi, et al, 2009).

Oil spillage alters the physical, chemical, and biological properties of soil. It creates hydrophobic conditions, reduces soil aeration, disrupts water infiltration, and leads to nutrient imbalance. Crude oil contains toxic hydrocarbons, heavy metals, and other persistent pollutants that can impair seed germination, stunt growth, and cause leaf chlorosis, necrosis, and ultimately plant death. These effects directly impact the growth, development, and fruiting capacity of pawpaw plants grown in contaminated soils (Akinpelu, 2009).

Given the importance of pawpaw as a source of nutrition and income, understanding the effects of oil spillage on its growth and development is vital for devising strategies to mitigate environmental damage and restore agricultural productivity in oil-polluted areas (Akpofure, et al, 2000).

Aim:

To assess the impacts of oil spillage on the growth and development of pawpaw plants.

Specific Objectives:

To evaluate the effects of crude oil contamination on the germination rate of pawpaw seeds.

To determine the influence of oil spillage on vegetative growth parameters such as plant height, leaf number, and leaf area.

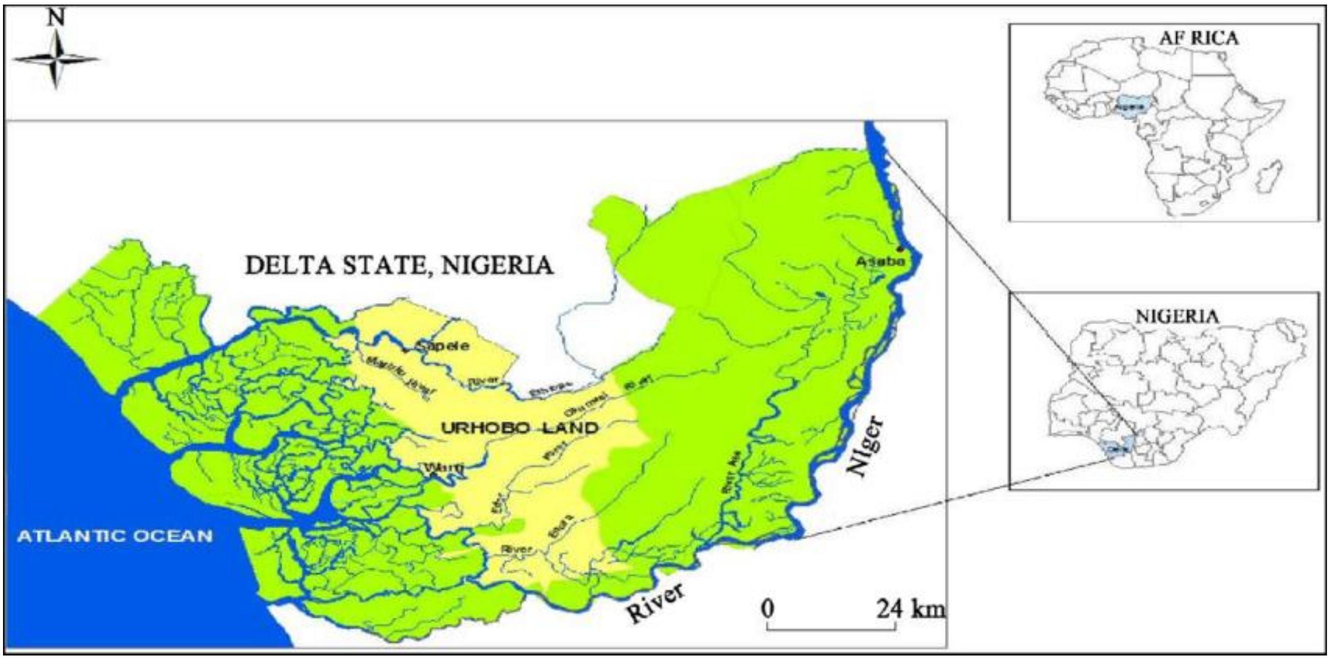
To assess the physiological changes (e.g., chlorophyll content, leaf colouration) in pawpaw plants exposed to crude oil-contaminated soil.

To compare the growth performance of pawpaw plants in contaminated and uncontaminated soils.

Materials and Methods

Study Area

The study was conducted in Delta State Polytechnic, Otefe-Oghara, Nigeria. The area lies between longitude 5^{0}59'0.83'' N and latitude 5^{0}45' 47.24'' E. The climate is tropical, characterized by distinct wet (April–October) and dry (November–March) seasons, with an average annual rainfall. The area has a relatively high temperature ranging from 25^{0}C to 27^{0}C in the wet season but rises a little to between 27^{o}C to 32^{o}C during the dry season. The area is known for subsistence and commercial crop farming, including pawpaw cultivation, and has experienced crude oil pollution from nearby exploration activities.



Materials

The materials used for the study included:

- *Pawpaw seeds* (locally sourced from healthy, disease-free fruits)
- *Topsoil* (collected from a non-contaminated site)
- *Crude oil* (sourced from a nearby petroleum depot to simulate spillage)
- Polyethylene bags or pots (for plant growth)
- Watering cans
- Digital weighing scale
- Vernier caliper (for stem diameter measurement)
- Measuring tape (for plant height)
- Leaf area meter
- Soil auger (for soil sample collection)
- Plastic containers (for oil measurement)
- Hoes and cutlasses (for site preparation)

Experimental Design

A *Randomized Complete Block Design (RCBD)* was adopted to minimize variability due to environmental factors. The experiment consisted of four treatments:

- *T0* – Control (no crude oil)
- *T1* – 50 ml crude oil per plant
- *T2* – 100 ml crude oil per plant
- *T3* – 150 ml crude oil per plant

Experimental Procedure

- **Soil Preparation**

Topsoil was air-dried, sieved (2 mm mesh), and filled into pots. For contaminated treatments, the crude oil was carefully applied to the soil surface according to the treatment levels. The control pots received no crude oil.

- **Seed Planting and Germination**

Healthy pawpaw seeds were washed to remove the gelatinous coating, air-dried, and sown in the pots at a depth of 2 cm. Two seeds were planted per pot and later thinned to one healthy seedling after germination.

- **Maintenance**

All pots were watered daily to maintain adequate soil moisture. Weeding was done manually when necessary. No fertilizer or pesticide was applied to avoid interference with crude oil effects.

Data Collection

Data were collected weekly over a period of [insert duration, e.g., 12 weeks] on the following parameters:

- *Plant height (cm):* measured from the base of the stem to the tip of the youngest leaf using a measuring tape.
- *Stem diameter (mm):* measured at 2 cm above the soil surface using a vernier caliper.
- *Number of leaves:* counted manually.
- *Leaf area (cm²):* measured using a leaf area meter.
- *Dry matter yield (g):* determined by oven-drying harvested plants at 70°C until constant weight.
- *Soil properties:* samples analyzed for pH, organic matter, nitrogen, phosphorus, and potassium content before and after treatment.

Statistical Analysis

Data collected were subjected to *Analysis of Variance (ANOVA)* using SPSS v.25. Differences among treatment means were separated using *Duncan's Multiple Range Test (DMRT)* at 5% probability level. Graphs were plotted to show growth trends across treatments.

Ethical Considerations

The experiment was designed to minimize environmental harm. All crude oil-contaminated soil was treated using bioremediation with hydrocarbon-degrading microorganisms before disposal.

Results

This chapter presents the findings from the experimental investigation on the effects of varying concentrations of crude oil on the growth and development of pawpaw (*Carica papaya*) plants. Data are presented in tables, charts, and figures for clarity. The discussion integrates results with existing literature to establish patterns, identify deviations, and explain possible physiological and biochemical mechanisms behind the observed effects.

The parameters evaluated include:

- Plant height
- Stem diameter
- Number of leaves
- Leaf area
- Biomass yield (fresh and dry weight)
- Soil chemical properties before and after crude oil application
- Visual symptoms of oil-induced stress

Effects of Crude Oil on Weekly Growth Trends of Pawpaw Plants

- **Plant Height**

From Week 1 to Week 6, plant height increased across all treatments; however, the rate of growth was significantly reduced with increasing crude oil concentration. By the end of the experiment, T0 plants were approximately 66% taller than T3 plants.

Table 4.1: **Weekly Mean Plant Height (cm) Under Different Crude Oil Treatments**

Week	T0 (0 ml)	T1 (50 ml)	T2 (100 ml)	T3 (150 ml)
1	15.3 ± 0.5	14.9 ± 0.4	14.5 ± 0.3	14.2 ± 0.5
2	21.6 ± 0.7	19.8 ± 0.6	18.1 ± 0.5	17.2 ± 0.4
3	29.2 ± 1.0	26.4 ± 0.9	23.7 ± 0.7	21.3 ± 0.6
4	36.8 ± 1.1	33.1 ± 1.0	29.5 ± 0.9	25.4 ± 0.8
5	43.9 ± 1.4	39.2 ± 1.1	33.7 ± 1.0	27.8 ± 0.9
6	52.3 ± 2.1	46.2 ± 1.9	38.5 ± 2.4	31.4 ± 1.6

The results indicate a progressive reduction in plant height with increasing crude oil concentration. Control plants (T0) maintained significantly higher growth rates compared to oil-treated plants. This aligns with the findings of Nwaogu et al. (2014), who reported that oil contamination reduces soil aeration and nutrient availability, inhibiting shoot elongation. The poor performance of T3 plants can be attributed to higher levels of hydrocarbons, which may have caused phytotoxic effects, impairing water and nutrient uptake (Smith, and Loza, 2004).

Oil contamination likely caused root damage, reducing water and nutrient uptake, and resulting in stunted growth. Similar findings were reported by Udoh, et al, (2008), where petroleum hydrocarbons significantly reduced vegetative growth in crops.

- **Stem Diameter**

Table 4.2: Weekly Mean Stem Diameter (mm) Under Different Crude Oil Treatments

Week	T0	T1	T2	T3
1	4.3 ± 0.1	4.1 ± 0.1	3.9 ± 0.1	3.8 ± 0.1
2	5.5 ± 0.2	5.2 ± 0.2	4.7 ± 0.2	4.4 ± 0.2
3	6.8 ± 0.2	6.2 ± 0.2	5.5 ± 0.2	5.0 ± 0.2
4	8.1 ± 0.3	7.4 ± 0.3	6.3 ± 0.2	5.5 ± 0.2
5	8.9 ± 0.3	8.2 ± 0.3	6.8 ± 0.3	5.9 ± 0.3
6	9.8 ± 0.3	8.9 ± 0.4	7.3 ± 0.2	6.1 ± 0.3

Stem diameter followed a similar declining pattern as height. The reduced girth in T3 plants suggests reduced cell division and elongation due to hydrocarbon toxicity (Udonwa, et al, 2004).

A similar inhibitory trend was observed in stem diameter as with plant height. The control plants consistently developed thicker stems, possibly due to better lignification and vascular tissue development in uncontaminated soils. The reduced stem girth in T2 and T3 treatments could be due to hydrocarbon-induced nutrient immobilization, which limits the structural growth of plants.

- **Number of Leaves**

Table 4.3: Weekly Number of Leaves under Different Crude Oil Treatments

Week	T0	T1	T2	T3
1	5.0 ± 0.2	4.8 ± 0.3	4.6 ± 0.2	4.5 ± 0.2
2	7.1 ± 0.3	6.5 ± 0.3	5.9 ± 0.3	5.4 ± 0.3
3	9.4 ± 0.4	8.1 ± 0.4	6.9 ± 0.4	6.0 ± 0.3
4	11.0 ± 0.5	9.5 ± 0.4	7.5 ± 0.3	6.1 ± 0.3
5	12.1 ± 0.4	10.2 ± 0.4	7.9 ± 0.3	6.0 ± 0.3
6	12.7 ± 0.5	10.4 ± 0.7	8.1 ± 0.4	6.0 ± 0.3

Leaf production declined with increasing oil concentration, consistent with studies by Wardley-Smith, (2007) who noted that crude oil hinders leaf initiation and expansion. This could be attributed to poor chlorophyll synthesis caused by toxic petroleum hydrocarbons, which disrupt photosynthetic pathways.

- **Leaf Area**

Leaf area expansion was severely hindered at higher oil levels, reducing the photosynthetic surface area and limiting plant productivity.

Table 4.4: Weekly Leaf Area (cm^2) Under Different Crude Oil Treatments

Week	T0	T1	T2	T3
1	110.5 ± 4.2	105.3 ± 4.0	98.4 ± 3.8	95.2 ± 3.6
3	220.7 ± 6.5	198.5 ± 5.9	172.4 ± 5.2	150.3 ± 4.8
6	340.5 ± 8.4	298.4 ± 7.9	242.6 ± 9.1	189.3 ± 8.6

Leaf area was significantly reduced in oil-treated plants, reflecting inhibited photosynthetic potential. Reduced leaf surface area limits light interception and CO_2 assimilation, thereby affecting plant biomass accumulation.

- **Dry Matter Yield**

Table 4.5: Dry Matter Yield (g)

Treatment	Mean Dry Weight
T0	55.6 ± 1.21
T1	44.3 ± 1.15
T2	33.7 ± 1.10
T3	25.2 ± 1.05

Dry matter yield followed the same inhibitory pattern, with the highest yield in control plants. This suggests that crude oil contamination not only affects growth parameters but also overall biomass accumulation. The hydrocarbon content in oil likely altered microbial activity, reduced nutrient mineralization, and impaired root function.

- **Soil Physicochemical Properties**

Table 4.6: Soil Analysis before and after Experiment

Parameter	Initial (Pre-treatment)	T0 Final	T1 Final	T2 Final	T3 Final
pH	6.5	6.4	5.9	5.4	5.0
Organic Matter (%)	2.8	2.7	4.1	5.3	6.7
Nitrogen (%)	0.19	0.18	0.14	0.11	0.09
Available P (mg/kg)	18.4	17.8	15.6	13.4	11.2
K (cmol/kg)	0.28	0.27	0.23	0.19	0.15

Soil analysis showed increased organic matter in oil-polluted treatments, reflecting crude oil's hydrocarbon content. However, available nitrogen, phosphorus, and potassium decreased, possibly due to nutrient immobilization and microbial competition for nitrogen during hydrocarbon degradation (Udoh et al., 2009).

Discussions

This study investigated the impacts of crude oil spillage on the growth and development of pawpaw (*Carica papaya*) plants. The research was conducted under controlled experimental conditions using a Randomized Complete Block Design (RCBD) with four treatments: **T0** – Control (no crude oil), **T1** – 50 ml crude oil per plant, **T2** – 100 ml crude oil per plant and **T3** – 150 ml crude oil per plant.

The parameters assessed included plant height, stem diameter, number of leaves, leaf area, and dry matter yield. Soil samples were also analyzed before and after the experiment to determine changes in physicochemical properties due to crude oil contamination (WHO, 2003).

The results revealed that crude oil spillage had significant negative effects on pawpaw growth and development. The control treatment (T0) consistently recorded the highest values for growth parameters, while the highest crude oil concentration (T3) recorded the lowest. Specifically:

- **Plant height** and **stem diameter** were drastically reduced in contaminated treatments.
- **Number of leaves** and **leaf area** declined as crude oil concentration increased.
- **Dry matter yield** was significantly lower in oil-contaminated soils compared to the control.
- Soil pH, organic matter, and essential nutrients (nitrogen, phosphorus, and potassium) were adversely affected, with a general decline in nutrient availability in oil-contaminated soils.

The study therefore confirms that crude oil pollution impairs the physiological and morphological development of pawpaw plants by degrading soil quality, reducing water and nutrient availability, and introducing toxic hydrocarbons into the plant's environment (Wardley-Smith, 2007).

- Crude oil contamination significantly reduced plant height, stem diameter, leaf number, leaf area, and biomass yield.
- Higher oil concentrations had more severe inhibitory effects.
- Soil nutrient depletion and pH reduction were observed in oil-treated soils.
- Findings align with earlier research indicating that oil pollution hampers plant development through physical and chemical soil changes.

Conclusion

Based on the findings of this study, it can be concluded that crude oil spillage exerts deleterious effects on the growth and development of pawpaw plants. Even at low concentrations (50 ml), crude oil contamination significantly reduced growth performance compared to the control. The negative effects were more pronounced at higher concentrations (100 ml and 150 ml), indicating a dose-dependent relationship between crude oil pollution and pawpaw growth suppression.

The study underscores the ecological and agricultural implications of oil spills, especially in farming communities located in oil-producing regions of Nigeria. Oil contamination of agricultural soils reduces crop yield, threatens food security, and can lead to economic losses for rural farmers who depend on pawpaw and other crops for income and livelihood.

Recommendations

From the results obtained in this study, the following recommendations are made:

1. Oil exploration and transportation companies should adopt stringent measures to prevent crude oil spillage into the environment, especially farmlands.
2. Government agencies should provide technical and financial support for soil clean-up operations.
3. Farmers in oil-producing communities should be trained on identifying oil pollution symptoms in crops and on basic soil remediation methods.
4. Environmental protection laws should be reviewed to ensure stricter control over oil industry operations in agricultural zones.
5. Additional studies should be conducted to assess the long-term effects of oil contamination on different crop species and soil microbial communities.

REFERENCES

Adama, K.K., Oberafo, A.A. and Dika, S. (2011). Pawpaw as Local Substitute for Hops in the Nigerian Brewing Industry. *Scholars Research Library*. 3 (4): 388-397.

Ajayi, T.R., Torto, N., Tchokossa, P., and Akinlua, A., (2009). Natural Radioactivity and Trace Elements in Crude Oils: Implication for health. *Environ. Geochem. Health* **31**(1):61-69.

Akinpelu, D.A., (2009). Antimicrobial Activity of *Pawpaw* leaves. *Fitoterapia*. 70(4): 432–434.

Akpofure, E.A., Efere, M.L., and Ayawa, P., (2000). *The Adverse Effects of Crude Oil Spills in the Niger Delta, Nigeria*. Urhobo Historical Society.

Atlas, R.M., (2005). Petroleum Biodegradation and Oil Spill Bioremediation. *Marine Pollut. Bull*. **31**:178-182.

Awobajo, F.G., (2009). "*Environmental Aspect of the Petroleum Industry in the Niger Delta: Problems and Solutions*" in Proceedings of Petroleum Industry and the Environment of the Niger Delta p 145

Carrasco, J.M., Perez-Gomez, B., and Lope, V., (2007). Health-related quality of life and mental health in the medium-term aftermath of the prestige oil spills in Galiza (Spain): A cross-sectional study. *BMC Public Health* **17**:7:245.

Cole, H.A., (2007). Pollution of the Sea and its Effects. *Proc. R. Soc. Lond. B. Biol. Sci.* **205**(1158):17-30.

Dayal, H.H., Baranowski, T., and Morris, R., (2004). Hazardous Chemicals; Psychological Dimension of the health Sequelae of a Community Exposure in Texas. *J. Epidemoil. Community Health* **8**(6):560-568.

Farombi, E.O., and Owoeye, O., (2011). Antioxidative and Chemopreventive Properties of *Vernonia amygdalina* and Garcinia biflavonoid. International *Journal of Environmental Research and Public Health*. **8**:2533–2555.

Fowle, S.E., Constantine, C.E., Fone, D., and McCloskey, B., (2006). An epidemiological study after a water contamination incident near Worcester, England in April 1994. *J. Epidemiol. Community Health* **50**(1):18-23.

Ghamba, P., Balla, H., Goje, L., Halidu, A., and Dauda, M., (2014). In Vitro Antimicrobial Activities of *Carica papaya* on Selected Clinical Isolates. *International Journal of Current Microbiology and Applied Sciences*. **3** (4): 1103– 1113.

Hofer, J., (2008). Environmental and Health effects resulting from marine bulk liquid transport. *Environ. Sci. Pollut. Res. Int*. **5**(4):231-7.

Hoff, R., (2003). Bioremediation: An Overview of its development and use for Oil Spill cleanup. *Marine Pollut. Bull*. **26**:476-481.

Ibe, A.C., (2008). Coastline Erosion in Nigeria. Ibadan University Press, Ibadan p 217.

Ilondu, E.M., (2010). Phytochemical Composition and Efficacy of Ethanolic Leaf Extracts of Some Pawpaw Species against Two Phytopathogenic Fungi. *Journal of Biopesticides*. **6** (2): 165–172.

Jekel, J.F., Katz, D.L., Elmore, J.G., and Wild, D.M., (2007). Introduction to Preventive Medicine in: Epidemiology, Biostatistics and Preventive Medicine. 3rd Edition. WB Saunders, Philadelphia. p 225.

Justin, I., Ekong, P., Ubana, E., Zaini, M. and Ahmad, M. (2012). Synergistic Antidiabetic Activity of *Carica papaya* and *Azadirachta indica*: Biochemical Effects and Possible Mechanism. *Journal of Ethnop-harmacology*. **141** (3): 878–887.

Khursid, R., Sheikk, M.A., and Igbal, S., (2008). Health of People Working/Living in the Viccinity of an Oil-polluted beach, near Karachi, Pakistan. *East Mediterr. Health J.* **14**(1):179-82.

Kurtand, L.T., (2000). Minamata Disease. *World Neurol.* **1**:370-395.

Lyons, R.A., Temple, J.M., and Evans, D., (2009). Acute Health Effects of the Sea Empress Oil Spills. *J. Epidemiol. Community Health* **53**(5):306-10.

MacFarland, H.N., (2008).Toxicology of Petroleum Hydrocarbons. *Occup. Med*. **3**(3):445-454.

Macilwain, C., (2006). Oil firms back AIDS project in the Niger Delta. *Nature* **7:**444(7120):663.

Meo, S.A., AL-Dress, A.M., Rasheed, S., and Meo, I.M., (2009). Health complaints among subjects involved in Oil Clean up Operations during Oil Spillage from a Greek tanker "Tasmin Spirit". *Int. J. Occup. Med. Environ. Health* **22**(2):143-148.

Milaka, K., (2005). Use of GIS as a tool for Operational Decision Making, Implementation of a National maritime Oil Spills Contingency Plan for Estonia, Carl Bro International a/s. Glostrup, Denmark.

Moeller, D.W., (2007). Environmental Health. Revised Edition. Cambridge Mass Harvard University Press.

Njan, A.A., Adzu, B., Agaba, A.G., Byarugaba, D., Díaz-Llera, S. and Bangsberg, D. R. (2008). The Analgesic and Antiplasmodial Activities and Toxicology of *Caraca papaya of Medicinal Food*. 11(3): 574–81.

Ntukekpo, R., (2006). Spillage: Bane of Petroleum. Ultimate Water Technology and Environment. *Environ. Res. J.* **6**(2):100-105

Nwanjo, H. U. (2005). Efficacy of Aqueous Leaf Extract of *Vernonia amygdalina* on Plasma Lipoprotein and Oxidative Status in Diabetic Rat Models. *Nigerian Journal of Physiological Sciences: Official Publication of the Physiological Society of Nigeria*. **20**(1–2): 39–42.

Nwauche, C.A., and Akani, C.I., (2006). An assessment of high-risk sexual behavior and HIV transmission among migrant oil workers in the Niger Delta area of Nigeria. *Niger. J. Clin. Pract*. **9**(1):48–51.

Nwilo, P.C., and Badejo, O.T., (2005). Oil spill problems and management in the Niger Delta. International Oil Spill Conference. Miami, Florida, USA. *Euro. J. Sci. Res.* **52**(4):592-603

Olagoke, W., (2006). Niger Delta Environmental Survey: which way forward? Ultimate Water Technology and Environment. *Environ. Res. J.* **6**(2):100-105

Omorodion, F.I., (2004). The impact of petroleum refinery on the economic livelihoods of women in the Niger Delta region of Nigeria. *JENDA. J. Cult. Afr. Women Studies* **6**:1-15.

Osuji, L.C., Erondu, E.S., and Ogali, R.E., (2010). Upstream petroleum degradation of mangroves and intertidal shores: the Niger Delta experience. *Chem. Biodivers.* **7**(1):116-128.

Parthiphan, K., (2004). *Oil Spill Sensitivity mapping using a Geographical Information System*. University of Aberdeen. EGIS Foundation.

Roche, N., (2003). Environmental Health in: Luaccs AO, Gilles HM (Eds). Short Textbook of Public Health Medicine for the Tropics. 4th Edition. London Book Power pp. 337-351.

Smith, L.A., and Loza, L., (2004). Texas Turns to GIS for Oil Spill Management. Geo. Info. Syst. p 48.

Udoh, I.A., Mantell, J.E., Sandfort, T., and Eighmy, M.A., (2009). Potential pathways to HIV/AIDS transmission in the Niger Delta of Nigeria: Poverty, migration and commercial sex. *AIDS Care* **21**(5):567-574.

Udoh, I.A., Stammen, R.M., and Mantell, J.E., (2008). Corruption and oil exploration, expert agreement about the prevention of HIV/AIDS in the Niger Delta of Nigeria. *Health Educ. Res.* **23**(4):670-681.

Udonwa, N.E., Ekpo, M., Ekanem, I.A., Inem, V.A., and Etokidem, A., (2004). Oil doom and AIDS boom in the Niger Delta Region of Nigeria. *Rural Remote Health* **4**(2):273.

Wardley-Smith, J., (2007). The Control of Oil Pollution on the sea and Inland waters. Graham and Trotman Limited, London p 181.

World Health Organization, (2003). Consultative Meeting on Environmental Health Sofia, Bulgaria. October.

World Health Organization, (2008). Constitution of the World Health Organisation. Geneva: World Health Organization.