TOTAL PETROLEUM HYDROCARBON IN THE TIDAL SEDIMENTS ALONG THE BODO COASTLINE, GOKANA, BY RIVERS STATE.

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Abstracts

This study assessed the extent of total petroleum hydrocarbon in the tidal sediment of Bodo coastline area in Gokana, Rivers state. The study revealed that there are 6km length of coastline in Bodo city. A sample frame of 30 was developed for the study by dividing the 6km coastline at 200 metres interval. The researchers take a purposive sample size of 5 which were randomly selected with the aid of table of random numbers. The study made use of a true experimental design. After laboratory analysis of samples the data were analysed with the use of one sample chi square test a 95% probability level and the hypothesis was also tested .The result of the study revealed that there are significant level of TPH in the tidal sediment of Bodo coastline in Gokana local Government area in Rivers state .The study conclude by recommending that there should be thorough cleanup.

Keywords: TPH, Coastline, Bodo-City, hydrocarbon, clean-up.

Introduction

Sammy (2004) observed that 780 million litres of oil entered the sea every month either as a result of accidental spills or vandalization of pipelines. However, this is part of the experience in the Niger delta where crude oil production is a daily activity. Jenny (2014) noted that during the spill process, 41% of the oil evaporate, melts or disperse through natural process, 33% of the spilled oil captured chemically spread, burned or skimmed during remediation process and 26% remained as a potential threat. In other words, the remediation process may likely remove all potential hydrocarbon in the soil.

Furthermore, the spill of oil in the water bodies which may either be caused by anthropogenic activities or natural process over time interact with sediments which are hazardous to the living components of the water including the water chemistry at large. The crude oil is an heterogeneous mixture of hydrocarbons and other compounds (Head, 2003). However, crude oil spills in water or soil ecosystem alters its chemistry

over time. These have resulted to the pollution of many ecosystem across the globe. As reported by Egwu (2012) oil spills from industries has increased to about 80% between 1976 and 2008.

Podlesokova, Nemelek and Vacha (1997) have noted in the Russian landscape the effect of crude oil on vegetation. They observed that when crude oil came in contact with the soil that the changing soil anaerobic conditions poisoned roots of plants, thereby leading to wilting and death of the affected vegetation. In the same vein, Oku (2001) noted that changing soil chemical content can alter niche biodiversity, macro nutrient loss and cation exchange capacity of impacted soil. It should be observed that plants communities are exposed to changing soil chemistry since plants have been noted widely in the literature to be sensitive to prevailing soil conditions (Bertha and Bossert, 1984; Waugh, 1995 and Hesse, 1997).

Furthermore, studies in the post bioremediation work have disclosed that vegetation succession occur after pre spillage conditions return. In essence, the return of normal soil chemistry after bio-degraders work to effectively digest petroleum hydrocarbon on impacted sites, bring about recolonization of site vegetation (Udo and Fayemi, 1975; Ptritchard and Costa, 1991).

Every anthropogenic activities has a cost implication for the biophysical environment (Enger and Smith, 2008:44). There was the application of the concept of environmental economics and utilization in explaining the dynamics of resource exploitation which have vital implication on the biophysical environment. That is, there are some effects of likely biodiversity loss, plants and animal extinction, air pollution, water pollution, acid rain, degradation of the quality of land and many others as the different implications of resource exploitation in the Niger Delta region. Nevertheless, some of the biophysical environmental costs are different to have access to in monetary form. Environmental economists have attempted to quantify air pollution, biodiversity loss or the loss of aesthetics or recreational opportunity offered by nature but are overwhelmed by the difficulty involved (Enger and Smith, 2008).

Studies have shown that there are different biophysical environmental lost to oil pollution. Some researchers have admitted the cost of lost opportunities which is attributed to non-usage as a result of the destruction of the beautiful value of the biophysical environment (Narayanan, 2007; Enger and Smith, 2008). Miller (2008) thus, advocates the development of natural resources that supports forms of economic growth that meet the fundamental needs of the present generations of human beings and without preventing other species from meeting their fundamental needs. This will discourage environmentally harmful and unsustainable forms of all activities.

The quality of water is degraded when some foreign substances like radiological, biological, organic and inorganic substances are introduced into the water bodies (Nanayanan, 2007:145). Within the context of the study as well as the analysis, it should be observed that the presence of organic hydrocarbon resulting from spillage processes in the aquatic environment within the coast of Niger Delta has gone a long way in affecting water quality. It is recorded in the literature of the problem that transportation, removing oil from one tank to another as well as vandalization resulted to spills thus affect the aquatic biodiversity and water quality. In this regards, Dhameja (2006) noted that crude slick tire on the water surface affects its biological oxygen demand, pH and chemical oxygen demand which changes water quality moderating its biodiversity and creating a very big problem for the affected rural communities.

Oil spills destroys water quality thus affect beaches, flora and fauna, seashore and also vast marine life (Narayanan, 2007:162).

In a nutshell, it could be noted that crude oil spills have done ample effects on our environment. Most importantly as it spills into our water bodies, it impacts sediments and over time penetrates into the ground causing degradation as well as contaminating groundwater bodies as a result of the sediments formed during the process. This therefore, calls for immediate assessment of the emerging hydrocarbon content of impacted coastline sediment

Related Literature

Oyegun (1984) and Oku (1997) have observed disruption of vegetation in the urbanization process within the drainage basin; whereas Pickering and Owen (1994) noted the disastrous impact of agriculture on niche vegetal index, IPS (1984), Ekweozor (1985), Dhamanja (2006) and Enger and Smith (2008) have admitted the indispensable function of resource exploitation in biodiversity changes of every aspect of the environment. The historic Alaskan Spills as well as the Shell, Forcados tank farm failure including hundreds of thousands of minor and major oil spills experiences has shown a ecological ruin on the biophysical environment is so alarming thus affects air, soil and water quality, biodiversity and humans.

He further observed that biomagnifications mostly occur when a predator eats contaminated prey from such marine ecosystem (Narayanan, 2007). Research again has also proven that anaerobic conditions of fresh water affect dissolved oxygen (DO) thereby affecting the biological oxygen demand (NDES, 1997).

It is noted that when there is a spill, it affects the vegetation of the affected sites (Enger and Smith, 2008). That is, there is a severe decay or even death of existing vegetation in most sites during the spill as a result of the change in conditions imposed by oil slick. Podlisokova, Nemelek and Vacha (1997) further opined that the slick conditions coupled with increase anaerobic conditions have not provided enough condition for plant growth. Thus, deduced that the rising site become bare empty of existing vegetation which earlier colonise the sites.

Inspite of this, the death or vegetal depletion on polluted site can result to high rate of overland flow and the tool of sediment had generated from exposed surface becomes an instrument in River transport and channel adjustment mechanism.

Geomorphic studies have admitted the process-response mechanism on exposed or bare surfaces. The erosion processes of wind erosion decorate the literature of sediment generation and movement by wind. Assertion of it, is observed over thousands of kilometers away even in the Niger Delta in the Dry Season.

In the same vein, the activity of glaciations on exposed surfaces is more real in sediment transport. However, the exposed and material depleted surfaces of oil spillage sites can never be an exceptional case to the geomorphic principles of sediment generation and transport. As Oyegun (1984) quoted Horton (1945) opined that overland flow is responsible for the generation of sediment through erosion. He propounded that at a critical distance down slope from the drainage divide, where the depth of the sheet of water in overland flow is sufficient to generate shear stress component that can overcome the resistance of soil particles to transportation, sheet erosion occurs. Oku (2003) in his work noted that the turbidity of rivers in Niger Delta have heavy pressure of suspended particles in the wet seasons; thus the dirty colour of the various streams. Again, the morphometric adjustment is caused by transported

sediments which the river carries as a fraction load. However, the removal of vegetation by oil spill is a process-response mechanism. Worthy of note is the fact that this study shall provide an opportunity to ascertain the extent of the effect of oil spillage on sediment generation and transport on channel morphology.

As regards to the marine environment, pollution or contamination of coastal areas by crude oil arising from offshore spills mostly take place in the shore between the high water and the low water (intertidal) area where the washout of dissolved nutrients can be extremely rapid (Lee and Levy. 1987) and (Wrenn 1997). Slow release and oleophobic formulation have been developed to maintain nutrients in content with oil. Tagger, Bianchi, Julland, Lepetit and Ronx (1983) and Boufadel, Swidan and Venosa (1997) posited that some of these depend on dissolution of the nutrient into the aqueous phase before they can be used by hydrocarbon degraders. Thus, plan of appropriate oil remediation strategies and nutrient recovery system needs a comprehension of the movement of dissolved nutrients in the high water and low water zone (intertidal).

This is very important to note that movement across the porous matrix of a marine beach is driven by the addition of tides, waves and flow of fresh water from coastal aquifers. In the same vein, tide influences cause the groundwater elevation in the beach and the resulting hydraulic gradients to vary rapidly. Hence, wave processes influence groundwater flow through two main mechanisms.

Boufadel, Swidan and Venosa (1997) firstly, opined that, when it is ahead of the tide, most of the water infiltrates virtually via the sand above the water and flows horizontally when it reaches the water table. Again, waves can as well influence the movement of groundwater in the submerged zones of beaches through a pumping structure that is enhanced by differences in head between wave trough-crest (Venosa, et al. and Wrenn, et al. 1997).

Niger Delta is the oil producing area of the country. It is noted recently that all spills in this region have escalated to serious dimensions due to pipeline vandalization and activities in the oil industry such as oil exploration, transportation, discharge from tankers (Jenny, 2014). This has affected most water bodies in this region which are polluted with different hydrocarbon fractions.

Egwu (2012) reported that the oil industry spills have led to loss of many lives destruction of arable farmlands fishing grounds, recreational facilities, cultural areas and polluted waters. These have significant concern in the long term effect of acute and chronic contaminations, having capacities to cause diseases for decades or more of such spills (Kaku Professional Engineers Limited, Nigeria, 2012). The most disturbing aspect of this is that Nigerian oil industry is dependent on foreign experts, international oil companies and other foreign organisations to a large extent for spill management (Oku, 2014). The above can never add local content value in terms of transfer of technology as well as development (Egwu, 2012). Hence, the need for urgent or immediate development of cost-effective technique for cleaning oil that will be based on cheap agro by-product raw materials found readily within the marine environment.

According to Jude, Edith, Ajibola and Okibe (2018) x-ray the impact of chemically modified natural fibre has a very high sorption capacity of oil from water which is time and concentration dependent. Similarly, Oku (2001) on oil spills and macro nutrient loss index, his study unveils that of non impacted sites, the level of macro nutrient loss was higher than that

on impacted sites which point to the fact that the changing biogeochemical synthesis of oil impacted sites have vital implication for nutrient availability for purposeful agricultural productivity.

In a nutshell, the process of oil spills has become a global concern as a result of its impacts on agricultural produce, tourism, economic activities, value of landscape including the contamination of water body or sources of portable water. Thus, it could be concluded that oil spills has a lot of effects on the biogeochemical synthesis as well as the aesthetic or the physical environment of the Niger Delta and even the water body since the commercial exploration of crude oil in Nigeria stated in the late 1950's.

Based on this, it could be observed that Jude, et al. (2018) worked on the treatment of crude oil contaminated water with chemically modified natural fibre while Oku (2001) experimented on the Bioremediation of Nigeria, light crude oil using attenuation processes with hibiscus cannabis and NPK (20:20:10) but they have not worked on the assessment of the extent of total petroleum hydrocarbon in Bodo coastline area in Bodo. Therefore, it is based on this lacuna that the researcher chooses to carry out this research work on the assessment of the extent of total petroleum hydrocarbon in tidal sediment of Bodo coastline in Gokana Local Government Area.

However, it could be observed that over the years, there has been increase in the spill of oil due to aging facilities, exploration and production, vandalisation and transportation. The unfolding processes have actually caused a lot of contaminations as a result of the spills.

Our major problem is that treatments are not properly done due to reagent use or methodology of the entire process. Hence groundwater impact as well as ecosystem experiencing diverse ecological problems are common (Oku, 2004).

Similarly, Agbayi, Ajigbola and Okigbe (2018) also observed that acetylation of natural cellulose gives a material with high sorption capacity for oil in fresh water. The oil palm empty fruit bunch (OPEFB) and the cocoa pod (CP) were acetylated under mild condition and it was observed that their sorption capacity were high.

Kriti and Subhash (2014) observed that treatment of petroleum hydrocarbon polluted environment through bioremediation technology is widely adopted and considered as one of the best technology for the treatment of petroleum contaminated environment. They further observed that bioremediation utilizes the natural ability of microorganisms to degrade the hazardous compound into simpler and non-hazardous form. In essence, the growth potential of micro decomposers in site could improve the rate of bioremediation programme.

Thuns and Todara (2003)worked on the causative factors of the extinction of some endemic species of plants and animals from the coastlines of Niger delta region and observed that the major causative factor is that of the high level of TPH along the coastlines as a result of high level of bunkering and vandalizations in the oil producing areas .

Tordi (2017) compares the level of TPH along the coastlines of Akwa Ibom and the coastlines of Rivers state and observed that the level of TPH along Rivers State coastline is higher than that of Akwa Ibom. He further added that some of the problems could be traced to negligence as well as poor maintenance culture on the part of the people and the International Oil Companies (IOC).

Furthermore, Spin and Ozil (2005) worked on the assessment of the level of illegal bunkering activities and the impact on the coastline areas in Bayelsa and observed that the

bunkering activities has adversely affected the coastline areas of Bayelsa through spills and increasing the TPH in the tidal sediment of the areas involved.

Again, Guy and Gil (2004) worked on the assessment of high level of TPH in soil and the rate of crop productivity and observed that high level of hydrocarbon in the soil impede plant growth and productivity.

It could be noted from above that different researchers have worked on TPH, done some kind of comparison between locations, carried out some treatment techniques, but to the best of our knowledge, no research has been carried out on the assessment of the extent of TPH in the tidal sediment especially in Bodo coastline area in Gokana local Government Area .Hence, the topic derive its significance and characteristic uniqueness.

Therefore, arising from the above, the questions for the current study were as follows:

- What is the impact index of crude oil in Bodo coastlines area in Gokana?
- What is the total petroleum hydrocarbon (TPH) of tidal sediments along the Bodo coastline?

Aim and Objectives

The aim of this research work is to ascertain the extent of total petroleum hydrocarbon in tidal sediment of Bodo coastline in Gokana. To achieve this, the following objectives were formulated.

- To identify the level index of crude oil in Bodo coastline area in Gokana.
- To examine the total petroleum hydrocarbon in the tidal sediments along coastline area of Bodo.

Research hypothesis

H_0: There is no significant levels of Total petroleum hydrocarbon in the tidal sediment of Bodo coastline.

H_1: There are significant levels of total petroleum hydrocarbon in the tidal sediment of Bodo coastline.

Methodology

The study employs a true experimental design. A sample frame of 30 points was developed for 6km coastline at 200 metres interval. A simple random sampling technique was used to select five sample points along the Bodo coastline area. The sample points include T. Connection, Lelasibookpo, Numuu Tegu, Numuu Bia and Numuu Kozo. From the result of the laboratory analysis , the one tail chi square was used to test the hypothesis stated at 0.05 level of significance.

Table1: One Tail Chi Square Analysis of TPH in Soil Sediment of Bodo Coastline Area

S/N	SAMPLE ID/LOCATION	PARAMETER (TPH) mg/kg	MEAN
1.	SS 1 (T. Connection)	2178.24	748.98
2	SS 2 (Lelasibookpo	471.75	
3.	SS 3 (Numuubia)	371. 65	
4.	SS 4 (NumuuTegu)	576. 58	
5.	SS 5 (Numuu Kozo)	131.66	

***Source**: Researcher's Field work (2019)*

TABLE 2: Summary of Chi Square Result For The Hypothesis

MEAN X	X^2 CAL.	X^2 CRITICAL	ALPHA LEVEL	RESULT / DECISION
748. 98	3976.37	9.488	0.05	There is significant H_i accepted

Decision/Result

The table value at 0.05 level of significance is 9.488 while the X^2 value which is the calculated value is 3976.37. Thus, since the x^2 calculated value is greater than the table value we rejected the null hypothesis which state that there is no significant level of TPH in Bodo Coastline area and accepted the alternate hypothesis which stated that there are significant levels of TPH in the tidal sediment of Bodo Coastline area in Gokana Local Government Area.

Discussion of Findings

From the table shown above, it could be observed that the mean level of TPH in the tidal sediment of Bodo coastline area is 748.98 indicating that its on the high side .Again, from the test conducted and from the statistics, it is shown that there is a high level of TPH in the tidal sediment of Bodo coastline area in Gokana local Government area with a statistical table value of 3976.37 which is above the critical value of 9.488 at 0.05 level of significance. This finding is in line with the earlier findings of Sammy(2004) which stated that the high rate of spills in coastal environment of the Niger Delta.

Again, in line with the above findings, Egwu (2012) noted the high incidence of crude in spill environment and sdvocated for timely response in the remediation programme by stakeholders.

Waugh (1995), NDES(1997), Oku (2001), Dhamaja (2006) and Eager and Smith (2008) noted that oil spills distort the ecological microbes through the high proferation of anaerobic decomposer as oppose to the aerobic microbes that inhibits the site prior to spillage experience which incidences of high TPH content in soil and solvents.

Again in line with the above findings Guy and Gil (2004) in their earlier research confirmed that high level of TPH in a particular soil sediment does not only affect the living components of the soil but also alter the chemical composition of the soil/water.

The earlier work of Tordi (2017) also is in line with this research work that compared the level index of TPH in the tidal sediment of AkwaIbom state coastline and that of Rivers state coastline and observed that, that of Rivers state is higher than the AkwaIbom and attributed it to high level of spills caused by illegal bunkering .Again ,this research work also aligned with the earlier work of Thuns and Todara(2003)who also observed that in Niger Delta region , the extinction of most of the endemic species of plants and animals and the contamination of water bodies is as a result of of the high level of spills especially along the coastlines resulting to high concentration of petroleum hydrocarbons. From the finding of this study and from the findings of the researchers above, it is observed that as there are high level of bunkering activities ,so there are high level of spills resulting to high level of TPH in the tidal sediment of Bodo coastline area in Gokana local Government Area in Rivers state.

Conclusion

From the results of the analysis , the study concludes that there are high level index of TPH in the tidal sediment of Bodo coastline area in Gokana local Government area and these

are caused as a result of high level of bunkering activities along the area concerned resulting to high level of spills.

Recommendation

From the findings of the study the following recommendations are made:

- There should be effective clean up to tackle the oil that has already spill into the area.
- There should be proper coating of the pipelines to avoid pipe explosion and timely maintenance of old oil facilities.
- Policies should be put in place by government to curb any form of oil spills in the area.
- The people from the affected area should be compensated with some reasonable amount of money and some basic amenities like good water and good hospital.
- All the pipelines should be properly linked up and have a control room that will be used to monitor all the pipelines

References

Agbayi, B. A., Ajigbola, A. & Okigbe, B. (2018).*Treatment of crude oil impacted freshwater using natural cellulose*. Ilorin: Koti Publisher Ltd.

Ajoku, L. I. (2006). Foundation of education research and Statistics. Port Harcourt: Pearl Publishers.

Ashton-Jones, N. (Ed) (1998). The human ecosystem of the Niger delta, Ibadan: Kraft Books Ltd.

Atlas, R. M. (1995). Bioremediation Chemical and Engineering News. April pp. 32 – 42.

Bartha, R. & Bossert, I. (1984).The fate of petroleum in soil ecosystem. In petroleum microbiology, Atlas, R. M. (ed). New York: Macmillan.

Charles, P. A. (2012). Oil spills and their corresponding treatment techniques in Nigeria. Lagos Kenny Publishers Limited.

Dhameja, S. K. (2006). Society and environment. Delhi: Kataria and Sons Publishers.

Egwu, S. A. (2012). Oil spill control and management. *Pet Technology Development Journal*, 1:1 – 6.

Ekweozor, I. K. E. (1985). A baseline survey for the monitoring of oil pollution in the Bonny Estuary Nigeria. Unpublished M. Phil. Thesis, Rivers State University of Science and Technology.

Enger, E. D. & Smith, B. F. (2008). Environmental Science: A Study of Interrelationships, Boston: McGraw-Hill.

Etuk, A. (2008). The use of bioremediation through attenuation process to improve on soil aeration. Port Harcourt: Charles Publishers Ltd.

Famiran, A. & Ojo, O. (1980). Man's physical environment. Ibadan: Heinemann.

Gibson, D. T. & G. S. Saler (1992). Scientific Foundation of Bioremediation: Current Status and Future Needs. American Academy of Microbiology, Washington, D. C.

Guy, E. and Gil, A.(2004).The effects of TPH on soil sediment and crop productivity. Timons publishers ltd ,Port Harcourt.

Head, I. M., Jones, D. M. & Larter, S. R. (2003).Biological activities in the deep subsurface and the origin of heavy oil. *Nature*, 426: 344 – 352.

Hesse, P. R. (1997). A textbook of soil chemical analysis. London: Murray.

Horton (1945).Soil pollution index as a parameter for poor crop yield.Unpublished M.Sc. Thesis, Rivers State University. Port Harcourt.

IPS (1984). Soil pollution and effects on soil microbes.Tiden Publishers Limited.

Jenny, B. (2014). Hydrocarbon Remediation Processes. *Africa J. Biotech*, 2(5), 104 – 108.

John, A. (2010). Research methodology in contemporary era. Port Harcourt: Kelly's Publisher.

John, B. (2011). Population and sample size in research work: Its challenges. Port Harcourt: Peters Publishers Ltd.

Jude, B. L. (2008). The black liquid gold in Niger Delta region.Werkershim: Mangrave Publisher.

Jude, C. O., Edith, B. A., Ajibola, V. O., Okibe, F. G. (2018). Treatment of crude oil contaminated water with chemically modified natural fibre. Lafia, Nigeria. Journal of Science, 6:43-55.

Kaku Professional Engineers Limited (2012). Oil spill conference Nigeria, 106/110 Lewis Street (5th Floor), Lagos, Nigeria, 10 – 11 September, 2012.

Kiele, A. (2015). Oil spills in Bodo coastline area: Its challenges on the ecosystem. Port Harcourt: John Publishers Ltd.

Kriti, A. & Subhash, A. B. (2014). The use of bioremediation in the treatment of petroleum hydrocarbon polluted sites. Jalingo: Tina's Publishers Ltd.

Lee, K. & Levy, E. M. (1987). Proc. 1987 International oil spill conference, American Petroleum Institute. Washington, D.C.

Lee, K., G. H., Tremblay, J. Gamthier, S. E. Cobanli & N. Griffin (1997). Bioaugmentation and biostimulation: A paradox between laboratory and field result. Pp. 697 – 705 in proceedings, 1997 International Oil Spill Conference. American Petroleum Institute. Washington, D. C.

Miller, G. T. & Spoolman, S. (2008). Environmental science.California Brooks/Cole.

Narayanan, P. (2007). Environmental pollution: principles, analysis and control. New Delhi: CBS Publishers.

Nwosu, A. B. (2006). The place of research design in contemporary studies. Port Harcourt: Skales Publishers Ltd.

NDES (1997). Niger Delta Environmental Survey Report.

Oko, A. L. (2008). Associated problems of hydrocarbon contaminations in Nigeria. Lagos, Stronger Publishers Limited.

Oku, H. B. (1997). Determinants of channel morphology in the urbanizing Ntawogba Basin, Port Harcourt, Nigeria. An unpublished M.Sc. Dissertation. University of Port Harcourt, Nigeria.

Oku, H. B. (2001). Bioremediation of the Bonny light crudeoil using attenuation process with hibiscus cannabis and NPK 15:15:15. An Unpublished Thesis, University of Port Harcourt, Nigeria.

Oku, H. B. (2001). Oil spillage and macro nutrient loss index.*Rivers Journal of the Social Science*, 5(1&2).

Oku, H. B. (2016a). The Niger Delta Environment. Port Harcourt: Kanissi Books.

Oku, H. B. (2016b). Processes of the human environment. Port Harcourt. Kanissi Books

Otuk, B. Y. (2008). Treatment techniques in crude oil contaminated sites. Unpublished MPhil. thesis, Rives State University, Port Harcourt.

Owen, A. U. (1994). Water pollution and treatment measures.Leko Publishers.

Oyegun, C. U. (1984). "Predicting channel morphology from sediment yield discharge and urbanization" Unpublished M.Sc. Thesis, University of Ibadan.

Podlesokova, E., Nemelek, J. & Vacha, R. (1997).Contamination of soil within the persistent organic xerobiotic. Substances in the Zech Republic in Zech Post Vyroba, 43(8), 357 – 364.

Prince, R. C. R. Stone & J. E. Lindstrom (1992). Bioremediation of oil spills with particular reference to the spill from Exxon Valdex. *Journal of Microbial Control of Pollution*, 8, 19 – 34.

Pritchard, P. H. & Costa, L. F. (1991).EPA's Alaska oil spill bioremediation project. Environmental Science and Technology, 25, pp. 115 – 130.

Sammy, A. (2004). Niger Delta Problems of 21st Century. Boca Raton: Lewis Publishers.

Skahany, G. J. & T. R. Metting (1992). Bioremediation of contaminated soil. In J. R. Metting (ed) Soil microbial Ecology: Application in Agricultural and Environmental Management. New York: Marcel Dekker Inc. pp. 483 – 513.

Skewy, A. (2003). The ecological effect of crude oil fractions: A working manual. 2nd Edition. Nairobi: Sacred Africa.

Sokubo, T. Y. (2008). Soft and contaminated sites; treatment strategies. New York.

Stud, R. C. (2004). Soil infertility and poverty rate. Port Harcourt: Nyle Publisher's Limited.

Tagger, S. A., Bianchi, M. Julliand, J. Lepetit & B. Ronx (1983).Effects of microbial seeding of crude oil in seawater in a model system. *Mar. Biol.* 78, 13 – 20.

Tamuro, A. (2008). The climatic condition of Gokana local government. Port Harcourt: Barida Publishers Ltd.

Tordi, A .A (2007). Comparison between the TPH concentration in AkwaIbom state coastlines areas and that of Rivers state coastal areas .Phils publishers ltd , Uyo.

Thuns, B. & Todara, A. (2003).The extinction of some endemic species from Niger Delta coastline areas; its causative factors. Port Harcourt: Kadilobari publishers ltd.

Udo, E. J. & Fayemi, A. A. A. (1975).The effect of oil pollution of soil on germination growth and nutrient uptake of corn. *Journal of Environmental Quality*, 4:537 – 540.

UNEP Report (2008). An environmental report of 2008 in Ogoni land.

Venosa, A. D., M. T. Swidan, B. A. Wrenn, K. L., Strohmeier, J. R., Haines, B. L. Eberhart, D. King & E. Holder (1997). "Bioremediation of an experimental oil spill on the storeline of Delaware Bay". Environmental Science and Technology. 30(5), 1764 – 1775.

Waugh, D. (1995). Geography: An integrated approach. London: Nelson.

Wrenn, B. A., Boufadel, M. C., Swidan, M. T. & Venosa, A. D. (1997). "Nutrient transport during bioremediation of crude oil contaminated beaches" in: in situ and on situ Bioremediation. Vol. 4, pp. 267 – 272. Battelle Memorial Institute Columbus, OH.