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The Effect of Remediation of Crude Oil Contaminated Land on Agricultural Resources in Umuechem in Etche Local Government Area of Rivers State, Nigeria

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Abstract

Contamination is the release of hazardous materials into the environment; which could be in the form of: waste, petroleum hydrocarbons and other unwanted materials. The release of these hazardous materials could affect soil nutrients and aggravate biodiversity loss. When the soil nutrient is impacted, it negatively affects its crop yield and production capabilities. Once there is contamination of the environment, remediation becomes necessary. This paper examines the effects of remediation of crude oil contaminated land on agricultural resources in Umuechem in Etche Local Government Area of Rivers State, Nigeria. Purposive sampling technique and a survey research design was adopted with the use of structured questionnaires administered on a sample size of sixty two (62) persons whose farmlands and other agricultural resources were contaminated and thereafter remediated. The sample size was made up of fifty four (54) literate and eight (8) illiterate persons. The questionnaire was interpreted in native language to the illiterate persons by either their children or any other relative. The data obtained from the survey were analysed using descriptive statistics such as tables and statistical package for social sciences (SPSS).The findings obtained indicated that

there was a post-remediation low-crop-yield and recommended that remediation consultants should adopt techniques capable of completely removing contaminants from the environment.

Keywords: Contamination, Remediation, Agricultural resources, Crop yield, Hydrocarbon

1. Introduction

The soil is a critical resource in the cultivation of crops and when it's composition is altered, it impacts on its productivity. Alteration of the composition of the soil could be done through the release of hazardous substances. Hazardous materials permeating into the soil could adversely affect soil nutrients and as such, render soil unproductive.

These hazardous substances could be in the form of petroleum by-products, solid wastes and other naturally occurring contaminants. The release of these harmful substances could arise from historic or current activities including, but not limited to: disposal or handling of waste, mismanagement of the production process and poor handling of storage facilities for petroleum products. Contamination may occur in the topsoil, water bodies and underneath the topsoil through leakages from pipes conveying petroleum products and may affect agricultural resources such as land, trees and crops including underground water.

Land could be used for several purposes such as: construction of shelters, construction of access roads, grazing for livestock, cultivation of crops as well as extraction of crude oil and other mineral resources. All these activities may be of significant negative effect on land and other agricultural resources depending on the type of use or manner of utilization. Once land is contaminated, remediation becomes necessary. Remediation entails the procedure by which contaminants are rid from land in order to restore it. Crude oil contamination has been a major source of contamination in the Niger Delta region of Nigeria, arising from the prevalence of oil production activities. Crude oil is a natural resource, if properly harnessed, is supposed to improve the well-being of the community where it is extracted, but the reverse has become the case. According to Ertel and Ugochukwu (2008), communities hosting crude oil related facilities such as pipelines, well heads and flow-stations have experienced the concomitant effects of crude oil exploration and exploitation which have depleted fish habitats, livelihoods and ecosystems. Contamination occasioned by crude oil spill has also led to the extinction of some crops and made some sea foods endangered species. Several researches had shown a relationship between crude oil contamination and low agricultural crop yield on one side and the health of the people on the other side. Land as a factor of production is a key ingredient for wealth creation and it's contamination have caused it's diminution in value and have impoverished the people. Since the discovery of crude oil in commercial quantities in Nigeria in 1956 and the subsequent pollution of the environment; there have been agitations by affected communities on the need to effectively restore the environment by means of remediation. These calls by the communities have not often yielded the desired result as prospecting and exploration companies turn deaf ears and blind eyes to their fervent request. The attendant impacts of crude oil contamination on land and ecosystem is much to be desired. The unwillingness of the polluters to quickly respond to oil spill have become a bane on land and other agricultural resources. Furthermore, oil spill have

devastated the land to the extent that it has given rise to the stigmatization of the affected land.

The whole essence of undertaking a remediation process is to remove pollutants from the affected media**,** but the essence seem to be defeated, hence crop yield has continually being in the decline; making the reality of remediation embarked upon in line with international best practices to be in the realm of speculation. The stigma associated with contaminated land remains unresolved. This phenomenon have continued to resonate worries among land owners and other stakeholders in the land management sub-sector. As a reason of the foregoing, the above stakeholders have questioned the technical expertise of the remediation consultants occasioned by the ineffectiveness of the remediation process. Some land owners have concluded that the ineffectiveness of the process was as a result of the remediation consultants not adhering to international best practices which have led to the continuous decline in crop yield after remediation.

Remediation has been an essential technique to remove the presence of crude oil contamination from land and other affected media. However, responses to an oil spill varies largely depending on some indispensable factors such as the type of contamination and if human beings or animals are at risk (David & Joel, 2013). The researchers went further to assert that the effect of contamination is not limited to its effects on the ecosystem but goes a long way to induce poverty, displace population in the affected area, reduces production capacity of plants as well as affects the profit level of business or commercial entities.

This study ultimately focused on the effects of remediation of contaminated land on agricultural resources in Umuechem in Etche Local Government Area, Rivers State, Nigeria.

1.1 Aim and Objectives of the Study

The aim of the study is to examine the effect of remediation of crude oil contaminated land on agricultural resources in Umuechem in Etche Local Government Area, Rivers State, Nigeria.

The objectives are as follows:

1. To identify agricultural resources in Umuechem
2. To establish the level of crop yield before oil spill
3. To establish the level of crop yield after remediation

2. Literature Review

The total reliance of the Nigerian economy since post independence Nigeria, on the extraction of crude oil has put pressure on various environmental components on oil producing areas of Nigeria (Ite, Ibok, Ite & Petters, 2013). According to the researchers, this pressure arose from the indiscriminate discharge of crude oil and its by-products on land and water bodies. Akujuru (2014) opined that different schools of thought have defined contamination differently; meaning that there is no specific acceptable definition of the term, hence none of the definitions should be seen to be incorrect, but the context will determine how comprehensive or otherwise the definition could be. The contamination of water bodies

and land of Niger Delta has become prevalence and had got international attention (UNEP, 2011). It is as a result of the preponderance of oil contamination incidences in Niger Delta and it's concomitant effect on the ecosystem of the region which was not given utmost attention by the polluter and the federal government of Nigeria, has led to agitations by affected communities that gave rise to the UNEP report on the comprehensive cleanup and restoration of the Ogoni environment. In that report, it was unravelled that oil contamination has devastated the Ogoni environment and as such has affected the livelihood of fishermen and farmers who depends on water bodies and land respectively for their economic well-being. According to Oteh and Eze (2012), contamination is the release of hazardous substances into the environment which alters the chemical condition of the environment. These substances could be in the form of; waste, petroleum products and other unwanted materials. The release of those hazardous materials devastates the environment (Kumar, Okonkwo & Taylor, 2015).Hazardous substances could be of great risk to the health of human beings, property or the ecosystem due to their physical and chemical components that make them up (Ordinioha & Brisibe, 2013). These hazardous materials could be categorised into the following: compressed gases including inflammable gases, oxidizing substances, toxic materials, radioactive materials and corrosive substances.

Aaron (2005) opined that there have been over 7000 cases of oil contamination that had been reported since the inception of oil production activities in Nigeria. The research went further to assert that over 240,000 barrel of crude oil are spilled per annum in the Niger Delta. The Niger Delta environment has a complex and rigorous pipeline system crisscrossing the region and large volume of petroleum and it by-products have been spilled through the pipeline and failure of storage systems; these failures could be due to defects of materials, erosion and pipeline corrosion (Kadafa, 2012). Adebayo and Dada (2008) identified and ranked the following as the major causes of crude oil contamination in an ascending order: vandalisation by unpatriotic citizens, external corrosion, corrosionas a result of hydrocarbon induce cracking, mechanical impact and failure due to equipment. Kadafa (2012) attributed most crude oil contamination to wilful vandalism of pipelines by unpatriotic citizens. Oil facilities vandalism when viewed from national security perspective portend a threat to national peace and security. Their studies established three dimensions to vandalism of pipeline as a source of oil contamination as follows: oil terrorism, pipeline vandalism/fuel scooping and oil bunkering. Crude oil contamination happens both on land and sea. When it happens on land, it impacts the soil (land), crops and trees whereas when it happens on the water, it affects aquatic lives, mangrove forests and the entire aquatic ecosystem.

Eregha and Irughe (2009) has raised alarm that toxic materials from petroleum products is gradually permeating into the Niger Delta environment through various routes. Ajai (2010) posits that crude oil contamination have degraded the Niger Delta environment and its ecosystem, polluted sources of food, underground water; making oil contamination a major threat to the sustenance of lives and livelihood of the communities; by so doing, denying them their environmental benefits. Kadafa (2012) observed that ecosystem services such as: aquatic habitats as an abode for fishes and other aquatic lives and a complementing mangrove forest are gradually becoming depleted. Chinwe, Abiola-oloke and Jideani (2012) further

reinforced the opinion of others by alluding that the fresh water wetland and mangrove forest have been impacted by crude oil contamination, thereby making the ecosystem unsafe for biodiversity. Alruman, Standing and Paton (2015) in a research undertaken, stated that the chemical component and characteristics of crude oil have altered the soil composition and functionalities resulting in the soil being unsafe for micro enzymatic interaction. According to the trio, this chemical characteristic of crude oil which altered the soil composition has also impacted the soil nutrient cycle which resulted to unproductive soil; making it unsafe for plants development and increasing soil toxicity. In a research carried out by Umukoro (2012), it was discovered that the continuous increase in the contamination of the soil can reduce the volume of land available for crop cultivation and livestock grazing. When lands and seas are impacted by contamination, remediation becomes the only option to rid the environment of the presence of crude oil and its by-products. Wilson and Johns (1993); Lim, Lau, Von and Poh (2016) defined remediation as the process of eliminating contaminants from any contaminated environment. The presence of contaminants in the environment is seen to threaten agricultural production, hence, the sources have not be checked and controlled. Over the years there have been unsuccessful remediation efforts which have continued to engender post remediated low-crop-yield. The implication is that the remediated sites were not restored to it's pristine state. The main thrust of every remediation initiative is to restore the environment to the state it was before the contamination. Several remediation methods have been deployed in the Niger Delta to remove crude oil contamination which recorded poor results; as the techniques employed are inappropriate for the affected environment thus total recovery of the media is not achieved (Giadom, 2015). Polluter have often deployed remediation by enhanced natural attenuation (RENA) and this technique has become inappropriate for Niger Delta environment (Sam, Coulon & Prpich, 2016). Several researchers have investigated various remediation techniques and recorded different results. Hamizah, Phan, Yong & Mohd Ridzuan (2014) carried out a study on the effectiveness of oil palm empty fruit bunch and sugarcane bagasse in enhancing the bioremediation of soil contaminated with hydrocarbon. In their method of study, two bacteria strains that were previously characterized such aspseudornonasaeruginasa and acinetobacterbaumannii were used. The result recorded that the level of hydrocarbon degraded in soil amended with sugarcane bagasse and oil palm empty fruit bunch were 100% and 97% respectively. Emami, Pourbabaei and Alikhani (2014) studied the implication of the use of different nitrogen fertilizers (NO_3-N and NH_4-N) on soil contaminated with hydrocarbon. It was established in this study that the addition of NH_4-N to a contaminated soil resulted in a drastic reduction of the contaminant concentration and promoted the degree of seed germination index. Jung, Choi, Sung And park (2014) which studied the effect of red clay and processed red clay on a diesel contaminated soil proved that both types of clays can enhance the bioremediation of soil contaminated with hydrocarbon. Moreira, Oliveira, Triguis, Queiroz, Ferraira, Martins, Silva and Falcao (2013) investigated the use of Avicenniaschaueriana in the elimination of the presence of total petroleum hydrocarbon (TPH). Avicenniaschaueriana is a plant whose effectiveness was proved by this study in the reduction of the presence of total petroleum hydrocarbon. The pilot study was carried out for three months in a terrain similar to that of mangrove. After Ninety days (90), it was established that phytoremediation technique was

more effective than bioremediation in degrading hydrocarbon. Avicenniaschaueriana recorded high efficiency level in reducing the presence of total petroleum hydrocarbon (TPH).

2.1 Empirical Studies

Extensive studies have not been done on the effect of remediation of contaminated land on agricultural resources in Nigeria. However, limited literature may be available to x-ray local trajectory in the remediation efficacies on contaminated land on agricultural resources in Nigeria. Notwithstanding, a couple of research highlighting the effects of remediation of contaminated land in the Niger Delta and similar terrain are discussed below. Mmom & Deekor (2010) undertook an assessment of land farming effectiveness (remediation by natural attenuation) on the elimination of petroleum hydrocarbon in the polluted soil of Niger Delta Region of Nigeria. In order to ascertain the effectiveness of the land farming technique, ten (10) polluted and remediated sites were selected. Among the selected sites were five (5) well-drained sites and another five (5) sites that are swampy in the Niger Delta. Samples from each of these sites were subjected to laboratory investigation and analysis. Percentages, regression analysis and t-test were used as statistical analytical tools. The findings indicated the maximum efficacy level of 82.24% and 50.54% in reducing TPH and PAH concentration respectively using remediation by natural attenuation. In their findings, the level of reduction of soil pollutants was faster and higher in well-drained sites than wetland soils. The overall implication of their findings was that land farming recorded a high efficacy level in degrading soil contaminants. Eni and Okpiliya (2011) have studied the effectiveness of cleanup of petroleum products in polluted environment of the Niger Delta of Nigeria. In their studies, it was unravelled that two years after the cleanup of contaminated sites by the polluters in the region; there were heavy microbiological accumulations that were found in remediated soil above acceptable level. This indicated that the level of result recorded was very poor and recommended thoroughness in the exercise of cleanup programmes.

In the studies undertaken by Koshlaf, Shahsavari, Aburto-Medina and Nagalakshmi (2016) which examined the effectiveness of bioremediation in Libyan contaminated soil revealed that petroleum hydrocarbon was degraded at 96% in soil treated with pea straw whereas natural attenuation recorded 76% reduction of petroleum products present in soil. The study was the first to establish the efficacy of the use of pea straw in removing contaminants from Libyan oil polluted environment. In similar vein, Goi, Trapido and Kulik (2009) carried out a research on the effectiveness of hydrogen peroxide on soil contaminated with hydrocarbon. In their study, it was discovered that the remediation of diesel polluted soil with hydrogen peroxide was a viable means by which contaminants could be rid of polluted sites. The application of hydrogen per oxide into a diesel contaminated soil resulted to the rapid reduction of the concentration of the contaminants. They further established that in the use of this method, greater care ought to be taken to ensure that the hydrogen peroxide does not permeate deeper into the soil aquifer.

In a related study undertaken by Ezenne, Nwoke, Ezikpe, Obalum and Ugwuishiwu (2014), it was revealed that the use of poultry droppings for the remediation of sites contaminated with petroleum hydrocarbon recorded a significant reduction of the concentration of hydrocarbon

in contaminated soil. In their method, poultry droppings which serve as an amendmentwas applied to three selected contaminated soil in southern Nigeria, soil samples were evaluated for 6weeks. It was revealed that the quantum of poultry droppings applied to each of the soil sample recorded tremendous reduction in the concentration of petroleum hydrocarbon in the affected soil.

In all the studies undertaken by both local and foreign researchers, none was able to restore contaminated land to its pristine state hence the need for this study. The study is targeted at establishing if a remediated site can be restored to its pre-contamination state.

3. Methodology

This research adopted quantitative research method and survey research design. Structured questionnaires were administered in order to elicit responses from the sample size of sixty two (62) persons whose farmland and other agricultural resources were contaminated and thereafter remediated in Umuechem Community in Etche Local Government Area of River State. The sample size comprised of fifty four (54) literate and eight (8) illiterate persons.

The content of the questionnaire were translated in native language to the illiterate respondents by either their children or any other relative. The questionnaires distributed were all retrieved from the respondents. The questions where ranked in a 5-point likert scale of: very good rated first with 5 points, good rated second with 4 points, fair rated third with 3 points, poor rated fourth with 2 points and very poor rated fifth with 1 point. With the summation of all the scaled points (5+4+3+2+1) =15. The criterion cut-off point was calculated thus: 15÷5=3, where 15 is the sum of all the rated points in the scale and 5 is the number of the rating scale. With the above calculation, the criterion cut-off point is 3. Criterion cut-off point is the least or minimum mean that is acceptable in the responses of the respondents. In other words, it is the lowest score in a research that is considered to be the benchmark average allowable in the responses of the respondents. The following are the agricultural resources identified in the study area: land, yam, plantain, maize, Okro, pepper and pumpkin.

Data collected were presented in the tables and analysed with the use of statistical tools such as mean and standard deviation.

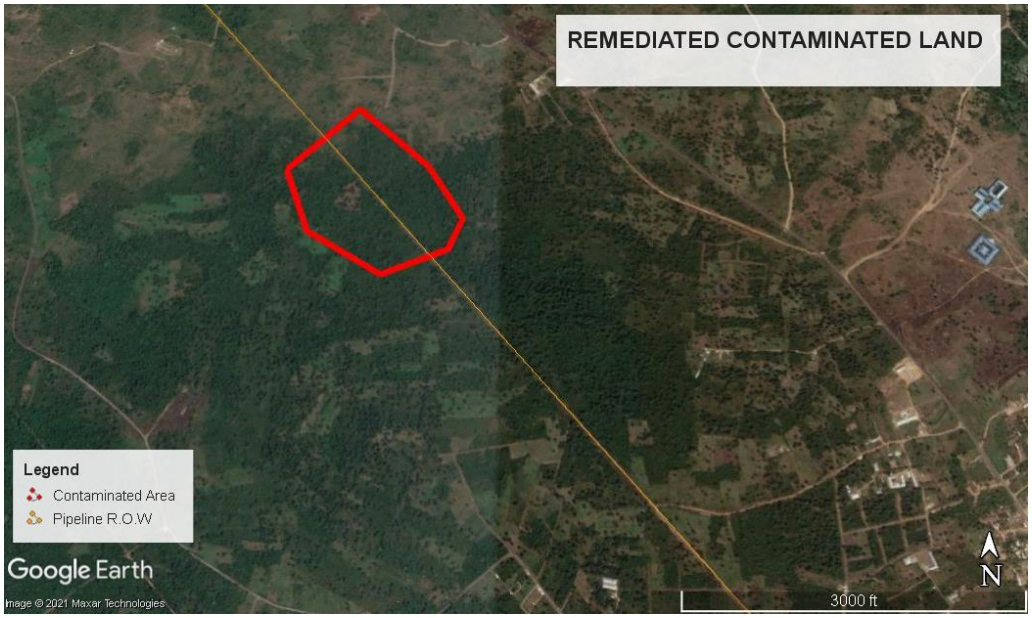

Figure 1. Satellite imagery of remediated contaminated land in Umuechem

Umuechem in Etche Local Government Area of Rivers State is an agrarian community lying and situate at the coordinate of 4.88957^0N and 7.03763^0E. It is a community with high concentration of oil and gas deposits and had been adversely impacted by oil spill devastation since the discovery of crude oil deposits in the community. Umuechem is bounded in the West by Omuwei Igwuruta in Ikwerre L.G.A, in the north by Abara community, in the East by Imo River tributary and in the South by Chokocho all in Etche L.G.A of Rivers State, Nigeria. The people are predominantly subsistent farmers and fishermen. They produce the following crops: yam, plantain, maize, okro, pepper, pumpkin, cassava, cocoyam, sugarcane among others. There is a new economic paradigm of sand mining in the community. This has turned to be a newly discovered economic life wire of the area. As an agrarian society that dwell on cultivation of land as its main livelihood, there evolved a land ownership structure where all land is owned by families and through the instrumentality of the family head and other principal members of family, portions of farmland are apportioned to family members for the purpose of cultivation. However whenever any member of the family want to erect a building, such member seeks the consent and approval of the family for a partitioning of the family land to that effect. Umuechem comprises of three distinct villages viz: Umuogo, Umunwantu and Umuoga autonomous community. The community is led by Eze Sampson Emu who is the paramount ruler of Umuechem community. The paramount ruler by virtue of his position administers the community in concert with other critical organs of the community such as: council of chiefs, youth forum, town council, community development committee and community trust committee.

4. Results and Discussion

The identified crops are contained in the table below according to their individual yield levels.

Table 1. Scale of Harvest per Plot per Annum

S/N	CROP	VERY POOR	POOR	FAIR	GOOD	VERY GOOD
1	Yam	150 tubers and below	151-250 tubers	251-350 tubers	351-450 tubers	above 450 tubers
2	Plantain	19 bunches and below	20-30 bunches	31-40 bunches	41-50 bunches	above 50 bunches
3	Maize	99 cobs and below	100-140 cobs	150-210 cobs	220-290 cobs	300 cobs and above
4	Okro	Below 0.5 basket	0.5 basket	0.75 basket	1 basket	1.5 basket
5	Pepper	Below 0.5 basin	0.5 Basin	1 basin	1.5 basins	2 Basins and above
6	Pumpkin	49 leaf bunch	50-89 leaf bunch	90-149 leaf bunch	150-249 leaf bunch	250 leaf bunch and above

Source: National Agriculture Extension and Research Liaison Services (NAERLS, 2014) and Okorji (2017).

Table 1 above shows the crop yield level per plot per annum. It indicates the level at which each crop could be adjudged to yield in every cultivation/farming season. The judgement of the productivity of each crop was based on a 5-point likert scale of: very poor, poor, fair, good and very good.

Research question 1: what is the level of crop yield before oil spill?

Table 2. Shows responses on the level of crop yield before oil spill

Options	Frequency	Percentage	Mean	Standard Deviation
Very poor	0	0	4.79	0.127
Poor	0	0		
Fair	0	0		
Good	13	20.92		
Very good	49	79.03		
Total	**62**	**100**		

Source: Researcher's field survey 2019

Table 2 with **(M=4.79 SD=0.127)** indicated that 79.03% of the sample are in total agreement that the level of crop yield before the oil contamination took place was very good, meaning that crop productivity level was optimal whereas, 20.97% of respondents accepted that crop yield before the oil contamination was good. This implies that a greater percentage of respondents agreed that before oil spill that contaminated their agricultural resources, there was an optimal level of crop yield.

Research Question 2: What is the level of crop yield after remediation?

Table 3. Shows responses on the level of crop yield after remediation

Options	Frequency	Percentage	Mean	Standard Deviation
Very poor	0	0	4.14	0.325
Poor	0	0		
Fair	16	25.81		
Good	21	33.87		
Very good	25	40.32		
Total	**62**	**100**		

Source: Researcher's field survey 2019

Table 3 with **(M=4.14, SD=0.325)** indicated that 40.32% of respondents agreed that the level of crop yield after remediation was optimal, 33.87% of respondents accepted that the level of crop yield after remediation was good but not optimal, whereas 25.81% of respondents affirmed that the level of crop yield after remediation was fair. From the above analysis, it means that there was a decline in crop yield level after remediation relative to the level of crop yield before oil spill. This implies that the level of crop yield after remediation did not equate with the yield level before oil contamination.

In the various literature and empirical studies reviewed, none of the studies was able to establish where any remediation carried out restored any contaminated environment to its pre-contamination state (total cure) and this study did not establish otherwise.

In this study, it was revealed that there was a decline in the level of crop yield after remediation. The comparison between the level of crop yield before oil spill **(M=4.79 SD=0.127)** and the level of crop yield after remediation **(M=4.14, SD=0.325)** indicated a decrease in crop yield level after remediation. The result indicated that contamination was not completely removed from the affected sites hence the continuous post remediation low-crop-yield. It implies that the level of crop yield after remediation was not optimal in relation to the optimal level of crop yield obtained before the oil contamination.

5. Conclusion/Recommendation

This study established that the contamination which was the reason for the remediation was not completely removed and the affected soil was not restored to it's pristine state, meaning that total cleanup of contaminated site was not achieved.The following recommendations are suggested to ensure that the remediation of contaminated sites are carried out in such a manner that: the polluter, affected communities and government agencies have value for money.

a. Government and remediation agencies should ensure relevant techniques are adopted relative to a particular polluted terrain.

b. Polluters and remediation agencies should ensure the appointment of a remediation consultant is based on the level of expertise and experience.

c. Independent remediation consultant should be appointed to evaluate and peer-review the already concluded remediation process.

d. Government should ensure a legal framework is in place to regulate remediation and the timeline within which remediation should be carried out after oil spill.

e. Care should be taken to properly delineate a contaminated site rather than abandoning part of the affected area to be unremedied.

f. A defect liability period should be set within which remediation consultants would be held liable for the ineffectiveness of the process undertaken and certain percentage of the fee held.

g. Regulatory authorities should ensure that erring remediation consultants should be blacklisted.

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