THE EFFECTS OF CRUDE OIL SPILLAGE ON FARMLAND IN GOKANA LOCAL GOVERNMENT AREA OF RIVERS STATE

[1]DIGHA OPAMINOLA N., [2]AMBAH B. & [3]JACOB, ESTHER .N.

[1] Department of Geography and Planning
Abia State University Uturu Abia State, **NIGERIA**

[2] Department of Agriculture
Isaac Jasper Boro College of Education Sagbama
Bayelsa State, **NIGERIA**

[3] Department of Geography and Environmental Science
University of Calabar, Calabar. **NIGERIA**
Email of Corresponding Author: dighaopaminola@yahoo.com

ABSTRACT

This work focused on investigation of the effects of crude oil spillage on farmland in Gokana Local Government Area of River state in Nigeria. The study was carried out in selected communities Kpoi, Biara, B-dere and K-dere. Soil samples were collected from each of the sampled locations comprising of the soil polluted and non-oil polluted soil following a reconnaissance survey from different soil deths; 0-15cm (surface) and 15-30cm (sub-surface). Total soil samples collect was 16. Heavy metals (Fe, Mn, Cr, and Zn) and THC, TOC, TOM, NO_3, pH, EC, and moisture content analysis of the contaminated and non-contaminated soils were determined using Atomic absorption spectrophometer, pH meter, walkey-black wet oxidation and the results of the 4 samples areas were compared with recommended standards. Evidence of THC, TOC, TOM, NO_3-N, pH, EC was analyzed using the descriptive statistics and the independent "t'' –test distribution was used to compare the difference in the heavy metals concentration and total hydrocarbon content across the sampled areas. The T-distribution statistics shows a high variability of heavy metals and others element in the oil polluted and non-oil polluted soils. These high values mean that $Kpoi_1$, $Biara_1$, K-$dere_1$ and B-$dere_1$, are affected with crude oil spillage compared with $Kpoi_2$, $Biara_2$, K-$dere_2$, and B-$dere_2$. The result therefore, implies low soil fertility, growth reduction as a result of change processes in plant growing on heavy metals polluted soils, which in turn implies low agricultural productivity and reduced livelihood in the affected areas. Recommendation are also made for quick and sustained intervention which is required to completely reclaim the affected area (soil) in order to appease the communities with the hope of living in a clean environment.

Keywords: Effects, Crude Oil, Spillage and Farmland.

1.0 INTRODUCTION

Over the years, crude oil has had profound impacts on the world's civilization than any single natural resource in recorded history. Nigeria is one of the leading oil-producing countries in Africa. It is the second largest oil producing nation in Africa and is ranked the eight leading producer in the world. Since her first export in 1956, the commodity has become the center piece of Nigeria's foreign exchange. Interestingly, all of Nigeria's oil and gas resources come from its Niger Delta region, occupied by a mosaic of indigenous nationalities (Baghebo, 2000).

Oil production has contributed to play a dominant role in its economy and has also served as a source of energy to run the nation's economy. Industries cannot function properly without the use of refined petroleum (Baghebo, 2012). Easy and faster means of transportation would have been impossible without pipelines, even the production of other necessities of man would have been impossible if crude oil was not discovered and exploited. The march of progress would be retarded and life itself would be unbearable if the world is deprived of oil that is why oil has become the concern of government, a vital ingredient of their politics and diplomatic strategies, yet behind this deification of oil, very few is said about its impact on the environment (Ashaye, 1978).

Oil spills have a significant impact on the natural resources upon which many poor Niger Delta communities depend. Drinking water is polluted, fishing, and farming are significantly impacted, and ecosystems are degraded. Oil spills significant affect the health and food security of rural people living near the facilities. Additionally, oil spills and associated impacts of oil and gas operations have impacted the biodiversity and environmental integrity of the Niger Delta (Nwilo and Badejo, 2005b).

The soil supplies the essential mineral nutrient for proper plant growth. These nutrients include both the macro and the micro nutrient. The macro nutrients are used in the greatest amount by plant and they are the ones readily available for plants productions. Plants germinate, develop and grow in soil medium where water, air and nutrient resources supply plants for healthy growth for productive and profitable agriculture. Frequent crude oil spillage on farmlands, and the consequent fouling effect in all forms of life, renders the soil (especially the biologically active surface layer) toxic and unproductive. The oil reduces the soils fertility such that the most of the essentials nutrients are no longer available for plant and crop utilization (Abii and Nwosu, 2009).

Oil spillage on farmlands is as a result of crude oil exploitation, the soil (receptor) is soak up by the oil like sponges and prevents the lenticels of crops to absorb oxygen – hence oxygen starvation (Oyedejii *et al*, 2012).

However, the crop withers and dies in large numbers thereby leaving the land barren and unproductive. Recent studies have shown that oil spills lower soil fertility and cause poor growth of plants. As the spill occurs, oil contaminated farmlands may become anaerobic and reducing conditions can result in increased solubility of iron (fe) and manganese (mn) to the extent that these potentially photo-toxic elements are absorbed by roots/plant. High oil concentration on soil not only reduces the amount of water and oxygen available for plant growth, but also interferes with soil-plant – water relationships through direct physical contact (coating of root tissues) thereby adversely affecting plant growth (Abii and Nwosu, 2008).

The Ogoni region of Rivers State suffers the dilapidating effects of crude oil pollution which has destroyed most farmlands and reduced the amount of crop yield. It is averred that these spills create unsatisfactory conditions for plants growth due to insufficient aeration of the soil and the increase in the concentration of heavy metals as these oil penetrates the pore spaces on soil following any spill. (Oyem, 2013).

Most of the Ogoni soil where these spills occur suffers from loss of soil fertility through loss of soil organic matter, leaching of nutrients, loss of the nutrient – laden topsoil, changes in soil – pH, reduction in caution exchange capacity, Stalinization, water logging and other forms of soil degradation are major problems associated with agricultural productivity on the Ogoni soil. Soil fertility loss and declining crop yield among others are found to be indirect source of pressure on natural resources and community structure especially among the Ogoni rural poor (Pyagbara, 2007). Jike (1987), argued rather trenchantly that although oil companies have contributed minimally to the country development. In Gokana, oil spills have posed a major threat to the environment, which has led to total annihilation of the ecosystem. Thus life in this area is becoming increasingly unbearable due to the ugly effects of oil spill (Oyem, 2001). Oil spillages have rendered vast stretches of indigenous farmlands useless.

The research focuses on examining the effects of crude oil spillage on farmlands in the Gokana of Rivers State. It aims at knowing the extent of pollution by comparing with data collected from virgin areas (uncontaminated soil) and the polluted sites comparing the results with recommended standards. The study also will proffer possible remedies for the effective remediation of polluted sites in the Gokana local L.G.A of Rivers State.

2.0 OBJECTIVES OF THE STUDY

This research aims at examining the effects of crude oil spillage on farmlands in Gokana local government area. The objectives include:
(1) To assess the fertility of soils in the study area.
(2) To examine the effects of crude oil spillage on farmlands.
(3) To suggest remedies/measures towards solving the problem of crude oil spillage.

3.0 RESEARCH HYPOTHESIS

1) **H_0:** There is no statistically significant difference between heavy metals concentration in soils from the polluted sites and the control site.
H_1: There is a statistically significant difference between heavy metals concentration in soils from the polluted sites and the control site.
2) **H_0:** There is no significant difference between soil fertility parameters in the crude oil spill area and the control site.
H_1: There is a significant difference between soil fertility parameters in the crude oil spill area and the control site.

4.0 LOCATION AND EXTEND OF THE STUDY AREA

Gokana is located longitude 7^0 20^{11} to 7^0 35" east of the green wish meridian and latitude 4^0 50" north of the equator (see figure 1). It is situated on the gulf of Guinea east of Port Harcourt about fifty four (54) kilometers distance from Port Harcourt. It is bounded on the north by Tai and Khama communities, at the East by Andoni, West by the Bolo people of Okirika Kingdom and at the south by the Ibani (bonny) and Attanic Ocean. Geological, the study area consist of the Benin, Agbada and Akata formations (Okonny, 2002). The area is blessed with fertile alluvium soil and with maze of rivers as well as creeks. It is a product of both fluvial and marine sediments built-up since the upper cretaceous period some 50 million years ago.

The study area enjoys two main seasons, the wet and the dry seasons. The wet or rainy season in April to October with the peak in the months of July and September. Gokana experiences an average annual rainfall of about 250cm, with an average temperature of 28^0C. The dry seasons set in by November with the tropical dust leaden harmattan wind between December to February. This is followed by the south west trade wind (monsoon wind) which crosses the area with violent storms from March to April destroying economic trees, crops and blowing fragile roofs (Oyegun and Ologunorisa, 2002). The vegetation comprises of the beach ridges zone Occupy by mangroves on the tidal and by swamp trees, palms and shrubs on the sandy ridges. The salt-water zone is mostly vegetated by red mangroves (Rhizophora Mangle) (Gaskin Albert Ayolangha and Bernord Achinike Ouegbu). The freshwater zone which is vegetated by forest tree. Species and oil palm. Lastly the mangroves swamp forest or the tidal swamps are located between the beach ridges and the freshwater alluvial zone.

By and large, according the 2006 national census result in Nigeria, Gokana is made up of 301, 828 people.

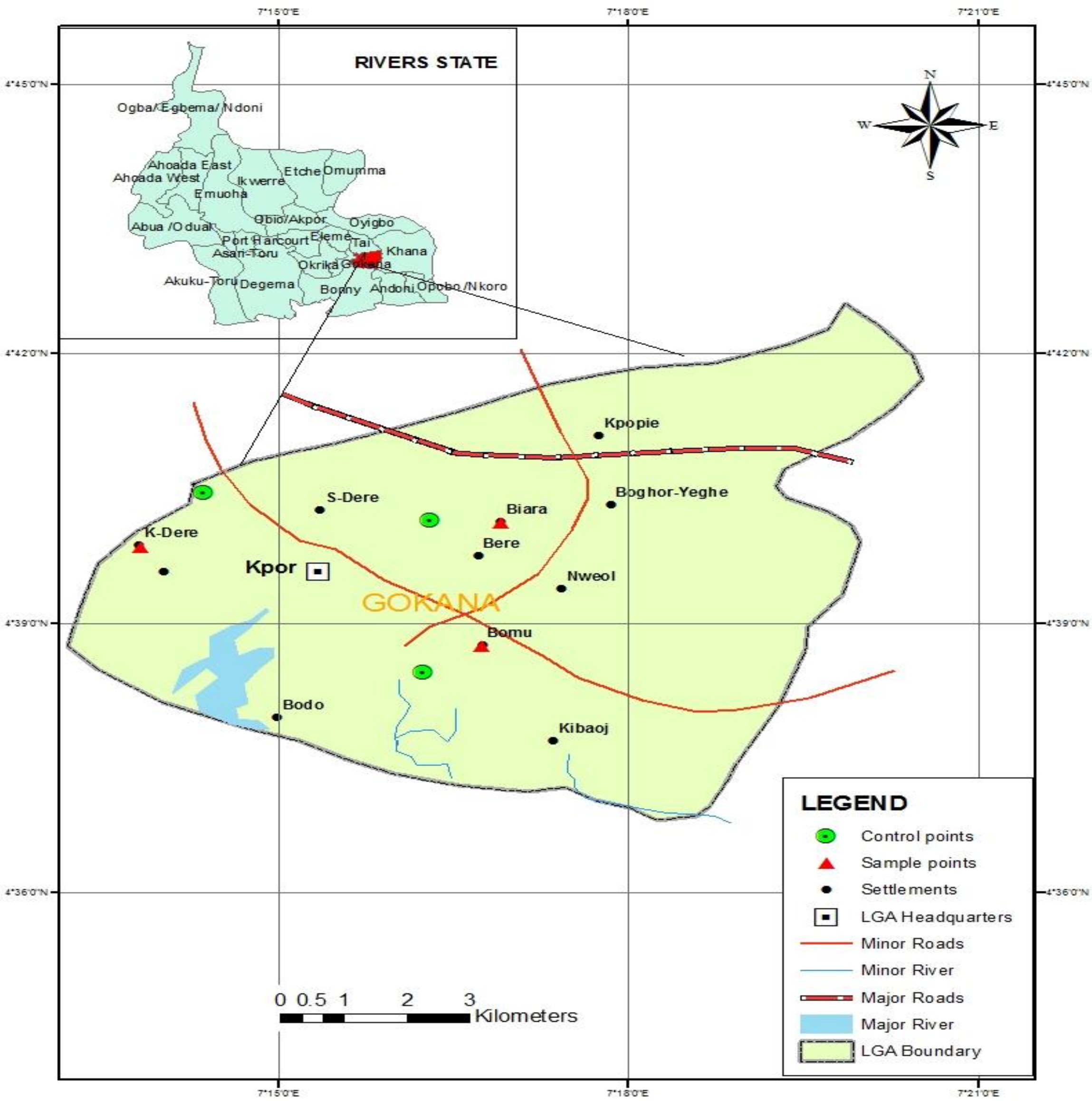

Fig. 1: Gokana L.G.A showing sampling location

5.0 MATERIALS AND METHODS

The type of data needed for this research work includes; Data on the total hydrocarbon content (THC), Total Organic Carbon (TOC) and Total Organic Matter (TOM), Heavy metals, soil PH, electrical conductivity, moisture content-Nitrogen (NO_3-N) content on Crude oil polluted soils. Data on non-oil polluted or spilled soil (control). Data on the comparison of the soil quality status with recommended standards. The Gokana LGA was simple randomly selected due to the fact it has the highest spilled sites. The area was selected with a view of sampling areas that has been impacted with crude oil spills.

Currently there are seven spilled sites in the areas which includes; Biara, K-dere, B-dere, Bomu, Kpoi, Goi and Mogho. Knowledge on spill polluted soils at the study area was achieved through the information obtained from the key informant. Soil samples were collected at two soil depths 0-15cm and 15-30cm using a soil auger. The selected sites includes; Biara, B-dere, K-dere and Kpoi. The four soil samples were collected from each of the four different sample locations with the control sample from a non-oil spilled soil, thereby bringing the sample size to 16. The soil samples collected from each polluted point was put in a sterile polyethylene receptacle, sealed, labeled and taken to the laboratory for analysis.

The use of descriptive statistics mean, standard deviation, coefficient of variability was employed to summarize the data. The data is presented in form of tables and bar charts in the accompanying chapter. The T-test distribution statistics was also employed to test the differences in heavy metals concentration and total hydrocarbon content (THC) across the sampled areas, while the World Health Organization (WHO) quality standard and Nigerian Environmental Guidelines and standard of the petroleum industries in Nigeria soil quality standard was used to compare the level or effect of crude oil spillage of the study areas.

6.0 RESULTS AND DISCUSSION

The results of total hydrocarbon content (THC), total organic compound (TOC), total organic matter (TOM), nitrate-nitrogen content (NO_3-N) pH-value, electrical conductivity (EC), moisture content and heavy metals in the crude oil polluted and non-polluted soils. Descriptive statistics was adopted in summarizing the data obtained from the laboratory analysis of THC, TOC, TOM, NO_3-N, pH, EC, moisture content and heavy metals across the sampled areas as seen in the table below: moreso, the independent t-test distribution was used to compare the difference across the sampled, areas. The use of soil quality standard for the concentration of the various components was equally employed to compare the concentration of the considered elements, THC, TOC, TOM, pH, NO_3-N, EC, and moisture content with the permissible limits of the concentration.

Table 1: Concentration of heavy metals on oil spilled soils

Location	Depth	Cr	Fe	Zn	Mn
Kpoi	0-15cm	5.20	636	59.73	37.65
	15-30cm	5.10	524	60.19	37.80
Kdere	0-15cm	4.30	636	58.89	26.35
	15-30cm	4.40	644	58.82	36.95
Biara	0-15cm	5.20	652	62.53	26.55
	15-30cm	5.10	605	62.77	26.45
Bdere	0-15cm	4.00	592	60.20	26.30
	15-30cm	4.10	426	60.19	27.60

Source: Laboratory results of sampled soils (2015)

Descriptive statistical mean ($\overline{X}$), standard deviation (S-D) and coefficient of variability (C-V) were used to summarize the data in the above table, which is presented in table and bar chart below.

Table 2: Descriptive statistics of heavy metals in surface and sub-surface oil spilled oil

Heavy metals	Depth	$\overline{X}$	S.D	C.V (%)
Chromium (cr)	Surface	4.68	0.53	11.32
	Sub-surface	4.68	0.44	9.40
Iron (Fe)	Surface	635.75	27.02	4.25
	Sub-surface	547.75	83.54	15.20
Manganese	Surface	29.21	4.87	16.67
	Sub-surface	32.20	5.20	16.15
Zinc (Zn)	Surface	60.34	1.35	2.24
	Sub-surface	60.49	1.43	2.36

Table 3: WHO standard for heavy metals in agricultural soils

Parameters	Target value (mg/kg)
Chromium (Cr)	1.5
Iron (Fe)	20
Zinc (Zn)	11
Manganese (Mn)	11

Source: WHO standard, 1998

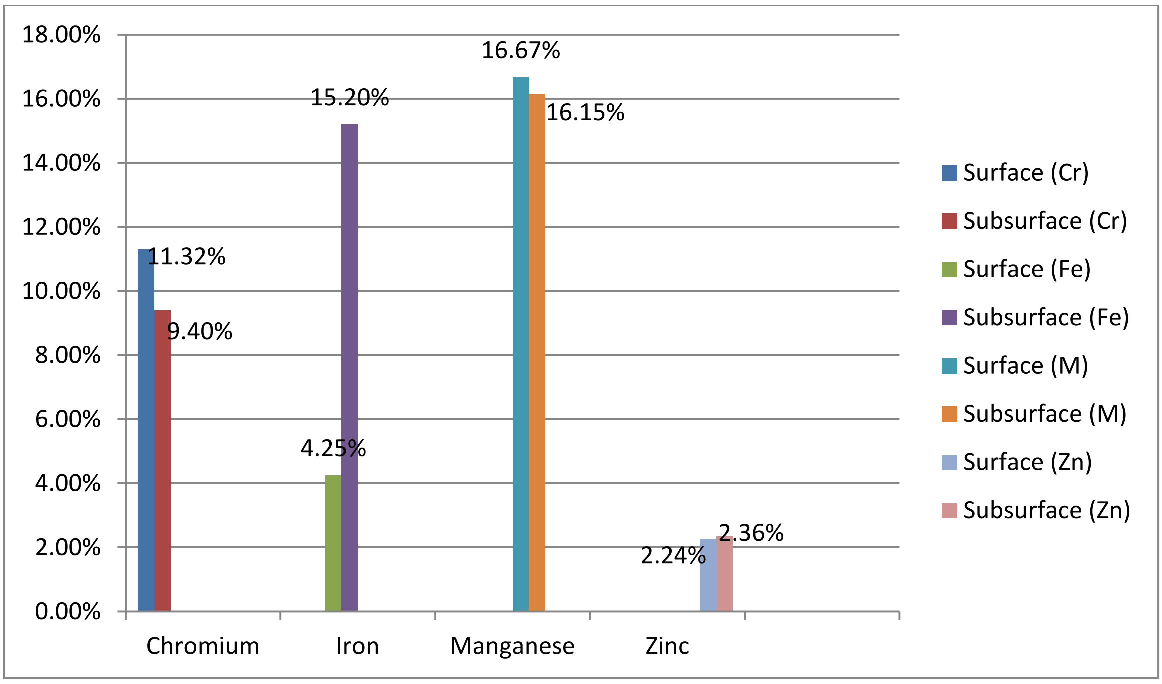

Fig.2: The coefficient of variability of heavy metals of polluted surface and sub-surface soils

Table 4 below shows that total hydrocarbon content in the soil spilled polluted soils as obtained from the laboratory analysis of the sampled soils.

Table 4: Total hydrocarbon content (THC) in oil spilled soils

Location	Depth	THC
Kpoi	0-15cm 15-30cm	85512 40541
Kdere	0-15cm 15-30cm	69515 40275
Biara	0-15cm 15-30cm	68217 35192
Bdere	0-15cm 15-30cm	48764 18576

Source: laboratory result of sample soil (2015)

Table 5: Shows the summary of the laboratory result for total hydrocarbon content (THC)

Variable	Depth	$\overline{X}$ – value	S.D $(X-\overline{X})^2$	C.V (%)
T.H.C	Surface	68002.0	425.80	0.63
	Sub-surface	33645.5	7575.83	22.52

7.0 Comparing the data with recommended standard

The data in table 4 above was subjected to the environmental guidelines and standard of the petroleum industries in Nigeria (EGASPIN), issued in 1992 and was handed by the federal government's department of petroleum resources (DPR). The standard is currently the minimum operating requirement for oil industry in Nigeria as shown in the table 6.

Table 6: EGASPIN standard for petroleum industries in Nigeria

Parameter	Target values mg/kg	Intervention value mg/kg
THC	50	5000

Source: EGASPIN (1991).

Note: Target values are soil quality needs for sustainability. They are the soil qualities required for the full restoration of the soil functionality for animal and plant life. The target values therefore indicate the soil quality levels ultimately aimed at agricultural productivity.

Intervention values shows the quality for which the functionality of the soil for human, animal and plant life is threatened when being seriously impaired.

As observed in table 6, the mean value exceeds the permissible limits set out by EGASPIN (mean value for surface soils was 68002 while that of the sub-surface soils was 33645.5). This therefore implies that the soil is heavily impacted with THC, thereby threatening the functionality of the soil for plant productivity, as it prevents the lenticels absorb oxygen resulting to oxygen starvation and this will lead to crop being withered and died in large number oxygen resulting to numbers. This will eventually leave the soil barren and unproductive.

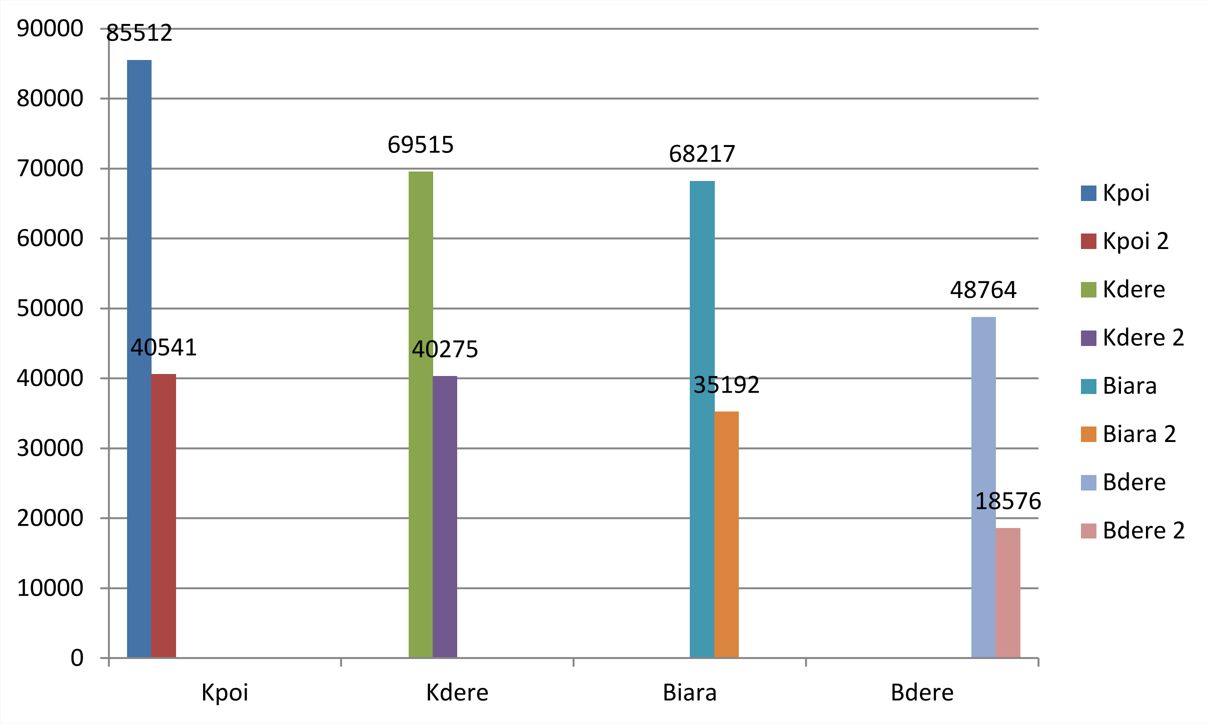

Fig. 3: Total hydrocarbon content in the oil spilled area

The table below shows the concentration of heavy metals in the control sites for both surface and sub-surface soils.

Table 7: Concentration of heavy metals control sites

Location	Depth	Cr	Fe	Zn	Mn
Kpoi	0-15cm	3.30	130.0	24.21	22.80
	15-30cm	3.20	130.1	24.12	22.40
Kdere	0-15cm	2.05	129.1	23.10	25.45
	15-30cm	2.06	128.2	22.50	25.77
Biara	0-15cm	3.20	133.0	24.16	24.40
	15-30cm	3.20	132.5	23.99	24.40
Bdere	0-15cm	1.65	129.0	23.60	24.80
	15-30cm	1.65	129.0	23.50	24.90

Source: Laboratory results of sampled soils (2015)

Descriptive statistical mean (X), standard deviation (S-D) and coefficient of variability (C-V) where used to summarize the data in table 7 as presented in the table and bar chart below.

Table 8: Descriptive statistics of heavy metals surface and sub-surface soil for the control sites

Variable	Depth	$\overline{X}$	S.D	C.V (%)
Chromium (Cr)	Surface	2.55	0.72	28.24
	Sub-surface	2.53	0.69	27.27
Iron (Fe)	Surface	130.35	1.57	1.20
	Sub-surface	129.95	1.62	1.25
Manganese	Surface	24.36	0.98	4.02
	Sub-surface	24.37	1.24	5.09
Zinc (Zn)	Surface	23.77	0.45	1.89
	Sub-surface	23.53	0.61	2.59

The total hydrocarbon content (THC) of the non-oil spilled soils for both surface and sub-surface soils as obtained from the laboratory analysis of the sampled soils is presented in the table below.

Table 9: Total hydrocarbon content in non-oil spilled soils

Location	Depth	THC
Kpoi	0-15cm 15-30cm	74 73
Kdere	0-15cm 15-30cm	75 66
Biara	0-15cm 15-30cm	100 98
Bdere	0-15cm 15-30cm	67 66

The summary of the laboratory result for heavy metals is presented in the table 9 showing the mean (X), standard deviation (S-D) and the coefficient of variability (C-V) of total hydrocarbon content (THC) in the control areas.

Table 10: Descriptive statistics of THC in the surface and sub-surface soils of the control sites

Variable	Depth	$\overline{X}$ – value	S.D	C.V (%)
T.H.C	Surface Sub-surface	45.26 45.10	0.93 1.04	8.84 9.05

8.0 Heavy metals concentration in the area

The mean values of the heavy metals concentration on oil spilled sites and control sites were compared to examine the differences that exist among them. The 't' – distribution statistics was employed to test the differences. The observed heavy metals are chromium (Cr), iron (Fe), Zinc (Zn) and manganese (Mn).

9.0 Analysis of chromium (Cr): table 10 and 11

Below show the analysis of both surface and sub-surface chromium (Cr) of the area using t-test distribution statistics.

Table 11: Analysis of surface chromium of the polluted and non-polluted soils

Group	Sample size (N)	Mean ($\overline{X}$)	Sample S.D
Polluted (X_1)	4	4.68	0.53
Control (X_2)	4	2.55	0.72

:.t = 3.80 and degree of freedom = 4 + 4 – 2 = 6

Using the t-distribution table, the degree of freedom (df) of 6 under the 0.05 significance level; t-critical or table = 1.94 while the –calculated = 3.80. This shows that t-calculated is greater than t-critical (i.e 3.80> 1.94) which implies that, there is a significant difference between the crude oil polluted and non polluted surface soils of chromium (Cr) across the study area.

Table 12: Analysis of sub-surface soil chromium (cr) of the polluted and non-polluted soils

Group	Sample size (N)	Mean $(\overline{X})$	Standard deviation S.D
Polluted (X_1)	4	4.68	0.44
Control (X_2)	4	2.53	0.69

t= 4.02
Degree of freedom (df) = 4+4-2 = 6

Using the t-distribution table, with degree of freedom (df) of 6 at 0.05 level of significance, the table t-value (2.13) is lesser than the calculated t.values (4.02). The result however implies a significant difference between the crude oil polluted and non-polluted sub-surface soils of chromium (Cr) across the study area.

10.0 Analysis of Iron (Fe) metal

Table 12 and 13 shows an analysis of both surface and surface and sub-surface iron (fe) of the study area using independent t-test.

Table 13: Surface soil analysis of iron in the polluted and non-polluted

Group	Sample size (N)	Mean $(\overline{X})$	S.D
Polluted (X_1)	4	635.75	27.02
Control (X_2)	4	130.35	1.57

:. t= 189.04
Degree of freedom (df) = 6

The calculated t-value (189.04) is greater than the table t-value (2.13). This result therefore shows that, there is variation between the crude oil polluted area and non-polluted surface soils of iron (fe) across the study area.

Table 14: Show sub-surface soil analysis of iron (fe) in polluted and control sites

Group	Sample size (N)	Mean $(\overline{X})$	S.D
Polluted (X_1)	4	549.75	83.54
Control (X_2)	4	129.95	1.62

:. t= 90.98
Degree of freedom (df) = 6

The table or critical t-value (2.13) is lesser than the calculated t-value (90-98). This implies that, there is a significant difference between the crude oil polluted and non-polluted sub-surface soils of iron (fe) across the study area.

11.0 Analysis of zinc (Zn) metal

Table 14 and 15 below shows an analysis of both surface and sub-surface zinc (Zn) of study area using t-test distribution.

Table 15: Surface analysis of zinc (Zn) metal in polluted and control sites.

Group	Sample size (N)	Mean ($\bar{X}$)	S.D
Polluted (X_1)	4	60.34	1.35
Control (X_2)	4	23.77	0.45

:. t= 54.52
Degree of freedom (df) = 6

Using the t-distribution table and the degree of freedom of 6 at a significance level of 0.05 the t-critical (2.13) is lesser than the calculated t-value (54.52). The statistical result however shows a significant variation between the crude oil polluted and non-polluted surface of zinc (zn) metal in the sample soil.

Table 16: Showing the sub-surface analysis of zinc (zn) metal in polluted and control sites

Group	Sample size (N)	Mean ($\bar{X}$)	S.D
Polluted (X_1)	4	60.49	1.43
Control (X_2)	4	23.53	0.61

:. t= 51.76
Degree of freedom (df) = 6

At 0.05 level of significance and degree of freedom of 6, the critical value of t was found to be 2.13 which is lesser than the calculated t-value (51.76). This implies variation in the polluted and non-polluted sub-surface soils of the study area.

12.0 Analysis of manganese (Mn) metal

Table 16 and 17 shows an analysis of surface and sub-surface manganese (mn) respectively of the study area and was analyzed using t-test distribution.

Table 17: Surface analysis of manganese (mn) metal in the polluted and control sites

Group	Sample size (N)	Mean ($\bar{X}$)	S.D
Polluted (X_1)	4	29.21	4.87
Control (X_2)	4	24.36	1.24

:. t = 3.92 and Degree of freedom (df) = 6

The calculated t-value is greater than the table or critical t-value which shows that, there is a significant difference between the crude oil polluted and non-polluted surface soils of manganese (Mn) metals.

Tables18: Sub-surface analysis of manganese (mn) metal of the polluted and non-polluted areas

Group	Sample size (N)	Mean ($\bar{X}$)	S.D
Polluted (X_1)	4	32.20	5.20
Control (X_2)	4	24.37	1.24

:. t= 6. 17
Degree of freedom (df) = 6

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Using the t-distribution table, the degree of freedom of 6 a t 0.05 level significance, the critical t-value is lesser than the calculated t-value (i.e. 2.13<6.17) this implies that, there is a significant differences between the crude oil polluted and non-polluted sub-surface soils of manganese (mn) metal.

The table 19 was used for the analysis of the total hydrocarbon content in the oil spilled sites and the control site using the t-test.

Table 19 shows the analysis of both polluted and non polluted surface soils which table 4.19 shows the analysis of both polluted and non-polluted sub-surface soils.

Table 19: Analysis of both polluted and non-polluted surface soils of THC

Group	**Sample size (N)**	**Mean ($\bar{X}$)**	**S.D**
Polluted (X_1)	4	68002	425.8
Control (X_2)	4	45.26	0.93

:. t = 6579.41
Degree of freedom = 6. Table t-value = 2.13

At 0.05 level of significance of t-distribution table, and at degree of freedom of 6 the critical or table t-value (2.13) is lesser than the calculated t-vale (6579.41). This shows a statistical significant difference between the polluted and non-polluted surface soils total hydrocarbon content (THC).

Table 20: Analysis of both polluted and non polluted sub-surface soils of THC

Group	**Sample size (N)**	**Mean ($\bar{X}$)**	**S.D**
Polluted (X_1)	4	33645.5	425.8
Control (X_2)	4	45.10	1.04

:. t-calculated = 3252.67
t-critical = 2.13
degree of freedom = 6

Using the t-distribution table, with degree of freedom of 6 and at 0.05 level of significance, the tabulated t-value (2.13) is lesser than the calculated t-value (3252.67). This is an indication that, there is a significant difference between the crude oil polluted sub-surface soils and the control or non-polluted sub-surface soils of total hydrocarbon content (THC).

Since the calculated t-value for all the heavy metals is greater than critical or table t-value, the null hypothesis is rejected while the alternate hypothesis is upheld.

It is a known fact that, heavy metal is present naturally in the soil but in low concentration. Crude oil spills increases the concentrations of these elements are such a quantity that are harmful to plants and crop production. The implication of this is reduction in crop yield which can lead to food insecurity in the area. Iron (fe), manganese (mn) and zinc (zn) as well as chromium (cr) as observed in the sampled areas form part of micro-nutrient needed in small quantity by plants.

The comparison of the mean values of both oil polluted soils and control soils shows an increase in the amount of heavy metals in the oil spilled areas. This is the major reason for nutrient imbalance. The high concentration of iron (fe) for instance brings about yellowing of leaves in the farmland as observed during the cause of the researchers fieldwork. Excessive accumulation of heavy metals such as chromium, iron, manganese and zinc as observed in the samples areas due to oil spillage, may not only result to soil contamination, but also affect food quality and safety. Again, it should be noted that, impacted soils can increase soil water holding capacity, decrease soil bulk density, increased soil aeration and stimulate soil microbial activities as well as root penetrability.

The analysis as shown in table 4 shows that, the mean values are above the permissible limits of the intervention value of the EGASPIN standard for soil quality. This therefore, implies that, the soils are heavily impacted with total hydrocarbon content (THC) across the oil spilled areas, thereby threatened the functionality of the soil for crop productivity as it prevents the lenticels of crops from absorbing oxygen resulting to oxygen starvation, thereby making the crops to wither and die in large numbers.

Furthermore, the high THC levels in the area affect both above-ground and sub terra near flora and fauna which are essentials in the biogeochemical cycle that affects the availability of plants nutrients. The concentration of macro-nutrients in both study and control areas are inherently very low compared to acceptable ranges recommended for agricultural soil. The concentration of the macro-nutrient is lower in oil spilled sites than the control sites. Moreso, as oxygen becomes limited, utilization of nitrate as electron acceptors will explain the dramatic differences in concentrations between the control plots and the hydrocarbon impacted areas.

There is high moisture content in the surface and sub-surface soils of oil spilled areas resulting to insufficient aeration of the soil due to the displacement of air in the soils, this leads to or encourages water logging and reduced rate of evaporation.

There is partial coating of soil surfaces by the hydrophobic hydrocarbon thereby reducing the water holding capacity in the area. This partial coast leads to a break down of soil structure and the dispersion of soil particles which reduces percolation and retention of water. Again, the soil in the area develops severe and persistent water repellency following contamination with crude oil (Osuji *et al,* 2006). High moisture content also reduces microbial activities through hindrance to the movement of air which would reduce oxygen supply. The pH of the oil-impacted soils at both surface and sub-surface are significantly lower than the background soils. The present of oil in the soils discourage the leaching of basic salts which are responsible for the rise in pH in the control; resulting to the production of organic acids by microbial metabolism. The soil has pH values lesser than 7 between 4.9 to 6.2 which affect the solubility of minerals. The soils are highly acidic and are toxic to plants nitrogen fixation and decomposition activities and hindered in the soils of the area. The electrical conductivity is the measure of ionic concentration in the soils. The electrical conductivity in the crude oil spilled soils is significantly lower than in the control soils, because organic compounds like crude oil cannot conduct electrical current very well. There is a decrease in the concentration of nitrate-nitrogen (NO_3-N) in the oil-spilled sites which brings about reduction or slow – down in the nitrification process. Oil degrading or hydrocarbon utilizing microbes such as Azobacter become more abundant while nitrifying bacteria such as Nitrosomonas become reduced in number (Odu *et al*, 1985).

The total organic matter (Tom) and total organic carbon (TOC) contents is lower in oil – spilled soils than that of the control areas. The spilled oil impaired the metabolic processes which would have facilitated the agronomic addition of organic carbon from the petroleum hydrocarbons by reducing the carbon-mineralizing capacity of the microflora (Osuji and Onojake, 2006. The present of the crude oil spill in the are has thus, resulted to two types of decomposition processes that are very significance. (The decomposition of the soil organic matter and the decomposition of the added petroleum hydrocarbons). Both decompositions are the prerogative of heterotrophic organism.

It is most likely that, the stimulation of these microbes by the presence of the spilled – oil on the site, and again that their proliferation did not adequately cope with the business of breaking down the excess carbonaceous substrate, perhaps due to various factors such as the environmental condition of weathering and climatic predispositions as well as the physico-chemical properties earlier discussed (Osuji *et al*, 2006).

Although heavy metals exist naturally in the soil, crude oil spills increase the concentrations of these elements to such amount that is harmful to both plants and crop production. The implication of this is growth reduction as a result of changes in physiological and bio-chemical processes in plants growing on heavy metals polluted soils, resulting in a reduced yield of crops production that eventually leads to food insecurity.

Excessive accumulation of heavy metals in agricultural soils through crude oil spillage may not only result to soil contamination but also affect food quality and safety. It is now known that remediation of impacted soil can increase soil water holding capacity decreased soil bulk density, increased soil aeration and root penetrability and stimulate soil microbial activities.

13.0 RECOMMENDATIONS

Having successfully analyzed the soil samples collected from the 4 sampled sites, in Gokana Local Government Area of River State, the study shows that the soil samples in $Kpoi_1$, $Kdere_1$, $Biara_1$ and $Bdere_1$ are highly impacted compared to the samples collected from the control of $Kpoi_2$, $Kdere_2$, $Biara_2$ and $Bdere_2$. Therefore, in order to minimize the effects of oil spills in these areas, the following recommendation are suggested:

- Prevention of illegal activities: A campaign to bring to an end illegal oil-related activities (tapping into oil wells/pipelines, transportation of crude, leakage or faulty facility, artisanal refining) should be conducted across Ogoni land. The campaign should be a joint initiative between the government of Nigeria, the oil companies, Rivers State, Government and Local Community Authorities. The campaign could also spell out training, employment and livelihood incentive that will encourage people away from participating in illegal activities.
- Oil spill response: In order to ensure that, all oil spills, regardless of the cause, are dealt with within the shortest possible time; an oil spill contingency plan (OSCP) for Ogoni land should be prepared. The plan should be communicated to the community, with particular emphasis on how any delay in reporting or responding to a spill will have disproportionate environmental consequences. In this way the communities will come to understand the response process and learn to work with the oil response agencies and vice versa.
- Application of appropriate and sufficient inorganic NPK fertilizer to restore the carbon to nutrient ratio to the optimum required to stimulate and sustain microbial activity.
- Adjustment of the soil pH to 6.0-6.5 by the addition of lime.

- Stimulation of the indigenous microbial growth by cultivating the soil to distribute the nutrients and lime and to aerate the treatment zone.
- It is important for the Nigeria government to undertake a review of laws affecting the relationship of oil companies with the host communities, which includes the land use Act, EIA decree and the petroleum production and distribution Act, as well as other relevant laws.
- Government should ensure that a mechanism will be created that will redress violations of human rights and the right to an effective remedy by a competent authority. This should include rehabilitation, reconstruction, and adequate compensation.
- The oil companies should engage in preventive measures to mitigate or minimize the risk of oil spills, like investing the adequate and regular maintenance of their oil installation and the replacing of old pipes, as well as improving the security agencies guarding their various installation (to prevent the vadalization of pipelines).
- The oil companies should be responsible for the environmental and human health impact of all their activities in the host communities.

14.0 CONCLUSION

It can be concluded that the test results obtained from the soil analysis of the soil-impacted areas shows the total hydrocarbon levels, total organic carbon, total organic matter, electrical conductivity, moisture content, pH, nitrate – nitrogen, heavy metals concentration shows a severity of contamination of the soils compared to the control sites. This condition generally implies low soil fertility, which in turn implies low agricultural productivity and reduced source of livelihood in the affected area. Using the descriptive statistics, and the t-test distribution, the result from the impacted areas shows high statistical variability, therefore the need for remedial actions.

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APPENDIX I

Laboratory result of heavy metals on spilled soils.

Sample location	Depth	Cr	Fe	Zn	Mn	Mg/kg
Kpoi	0.15cm 15.30cm	5.20 5.10	636 524	59.73 60.19	37.65 37.80	
k-dere	0.15cm 15.30cm	4.30 4.40	663 644	58.89 58.82	26.35 36.95	
Biara	0.15cm 15.30cm	5.20 5.10	652 605	62.53 62.77	26.55 26.45	
B-dere	0.15cm 15.30cm	4.00 4.10	592 426	60.20 60.19	26.30 27.60	

UMCAM 939.AAS

APPENDIX II

Laboratory result of heavy metals on control sites.

Sample location	Depth	Cr	Fe	Zn	Mn	Mg/kg
Kpoi	0.15cm 15.30cm	3.30 3.20	130.0 130.1	24.21 24.12	22.80 22.40	
k-dere	0.15cm 15.30cm	2.05 2.06	129.4 128.2	23.10 22.50	25.45 25.77	
Biara	0.15cm 15.30cm	3.20 3.20	133.0 132.5	24.16 23.99	24.40 24.40	
B-dere	0.15cm 15.30cm	1.65 1.65	129.0 129.0	23.60 23.50	24.80 24.90	

UMCAM 939.AAS

APPENDIX III

Sample location	Depth	% TOC	%TOM	EC	Mg/kg NO_3-N	Mg/kg THC	%moisture	pH
Kpoi	0.15cm 15.30cm	3.9 3.2	6.76 5.50	0.18 0.11	141 129	85512 40541	26.32 26.29	6.2 6.1
Kdere	0.15cm 15.30cm	3.6 3.2	6.19 5.20	0.16 0.24	162 148	69515 40273	24.10 32.70	6.0 5.8
Biara	0.15cm 15.30cm	3.8 3.1	6.54 5.33	0.15 0.17	161 138	68217 35192	25.90 25.20	6.2 6.0
Bdere	0.15cm 15.30cm	3.3 3.0	5.33 5.33	0.17 0.19	214 210	48764 18576	27.10 26.30	6.1 6.1
Control	0.15cm 15.30cm	2.1 1.9	3.61 3.27	0.19 0.20	392 365	526 374	22.4 22.10	5.2 4.9

UMCAM 939. AAS

APPENDIX IV


Plate 1: A barren farmland at K-dere as a result of crude oil spillage


Plate 2: A view of Bomu flow station

APPENDIX V

Plate 3: A disused wellhead in Bomu

Plate 4: Oil spilled impacted farmland in Biara

APPENDIX VI

Plate 5: NNPC Trunk Line SPILL in a farmland at K-Dere

Plate 6: An oil spill impacted farmland in Bomu

APPENDIX VII

Plate 7: Soil caked into a crust of dried crude oil in B-dere