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AN ASSESSMENT OF IMPACT OF CRUDE OIL EXPLOITATION ON SOILS CHARACTERISTICS IN PARTS OF OGONI REGION, RIVERS STATE, NIGERIA

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ABSTRACT

The study aimed at examining the impact of crude oil exploitation on the soils environment of Ogoni region also made recommendations on the current social and environmental problems. Composite soil samples were collected at two depths: 0-15cm (surface soils) and 15-30cm (subsurface soils) along different positions of landscape in the four study area. Samples were analysed in the laboratory within 5 days of collection. ANOVA was used to confirm that both soil chemical and physical properties significantly vary in the study locations. The result revealed that sand, silt and clay contents significantly vary in Eleme, Tai, Khana and Gokhana .Based on the locations where the soils were sampled, the results indicate that the soils vary widely in chemical characteristics in Eleme (F-ratio=1674.16; p<0.01; F-critical=1.88); Tai, Khana and Gokhana against the theoretical value. The soils of the study area are declared contaminated by heavy metals and hydrocarbon toxicity. The study therefore recommended indigenous participatory approach strategies for sustainable crude oil exploitation in Nigerian oil-rich.

Keywords: *Soils, exploration, degradation, assessment, physico-chemical*

INTRODUCTION

Oil industry activities are inevitably associated with environmental pollution. continental shelf, which is saddled with most of the industry's installations and activities (upstream and downstream) and their associated deleterious environmental impacts. The industry operates over a thousand oil producing wells, gas plants; network of thousand kilometres of pipelines (Right of Ways, RoW) criss-crossing the Delta bearing crude oil to flow stations, terminals, and refineries. On average, one oil spill occurs every week in Nigeria. Pipelines are laid across farms, waterways and fishing grounds. Some pipes cross communities and living quarters. Approximately, 6,000 km of pipelines cover Ogoni land (Azaiki, 2003).

However, due to incessant oil spills, oil has coated the aerial roots of plants killing parts of the mangrove forest and its faunal dependence. This mangrove forest, which serves as habitat for fish and molluscs as well as a source of raw materials for communities in Ogoni, has been ravaged by oil pollution. The land can no longer support the subsistent life of the Ogoni community. Typical of this example, is the abundant mangrove vegetation in Ogoni community of Bodo where the livelihood of the local people was previously sustained through farming and fishing. They also gathered mangrove wood for building and for local energy and fuel. Today, most of the youths and women have become jobless since their local economic support system is no longer sustainable. Gas had been flared for 24 hours daily for 40 years in close proximity to human habitation in nineteen oil locations (Abii and Nwosu, 2009). This has been done without regard to the negative impacts of such activities on the people and the environment.

STUDY AREA

The Ogonis are indigenous ethnic minority group in Rivers State in the Niger Delta region of Nigeria (figure 1). Ogoni has an area of 1046.4 square km, which liesbetween longitude 7°2 00 E and 7°18 30 E and latitude 4°18 30 N and 4°31 00 N. Ogoni is bounded in the north by Oyigbo LGA; west by Okrika LGA; south by Ogu/Bolo, Bonny, Andoni and Opobo/Nkoro LGAs; and in the east by Akwa Ibom State, naturally separated by Imo River (figure 2) (Akpogomeh, 2001). The Ogoni people live in the coastal plain terraces northeast of the Niger Delta. Ogoni region is divided into four Local Government Areas, viz: Tai, Eleme, Gokana and Khana, and into six regions/clans in the Delta: Ken - Khana, Baabe, Bori, Tai, Gokana, and Eleme. The region, located within the coastal and rainforest belt, is characterized by mangrove swamp forests and rich rainforest vegetation that the Ogoni people depend on (Amanyie, 2001).

Ogonis have a population of 831,726 people and reside in the northeast area of the Delta. It is made up of four Local Government Areas including: Tai with a population of 117,797 people; Eleme comprising of 190,884 people; Gokana with 228,828 people; and Khana with a population of 294,217 (NPC, 2006). This is however estimated at 954,871 by 2011, using the 2.8% national annual growth rate.

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MATERIALS AND METHODS

Composite soil samples were collected using soil auger at two depths: 0-15cm (surface soils) and 15-30cm (subsurface soils) along different locations of the landscape in the four study locations spanning Khana (Bono Ogoi, Okloma, Bolem, Kporghor and Sim luekon); Gokana (K-Dere, Biara, Yeghe, Barako and Kiani); Eleme (Akpajo, Ejaka, Ogali, Agbonchia and Onne); and Tai Local Government Areas (Okwale, Luuku, Kpanĝ, Bere and Kani) within the Ogoni region, Rivers State (figure 3). The soil samples collected were air-dried (room temperature), ground with wooden roller and sieved via 2mm mesh. Particle size distribution was determined by Bouyoucos hydrometer method (Gee and Bauder, 1986) using sodium hexa-metaphosphate as a dispersant and the textural classes determined using the textural triangle chart.

Soil pH was determined using the method of IITA (1979). The method of Walkley and Black (1934) was used in the determination of organic carbon. Available phosphorus was determined using Bray and Kurtz (1945) No. 1 method. Total nitrogen was determined by the micro-Kjeldahl digestion method. Exchangeable bases (Ca, Mg K and Na) were extracted with neutral IM NH_4 OAc, pH 7.0; the potassium and sodium in the extract was by flame photometry while calcium and magnesium was by Versenate EDTA titration method (IITA, 1979). Cation exchange capacity (CEC) was obtained by the summation of exchangeable bases. Heavy metal contents of the soils were extracted by digestion of the samples with a mixture of concentrated HNO_3 and HCl and their concentrations determined by Atomic Absorption

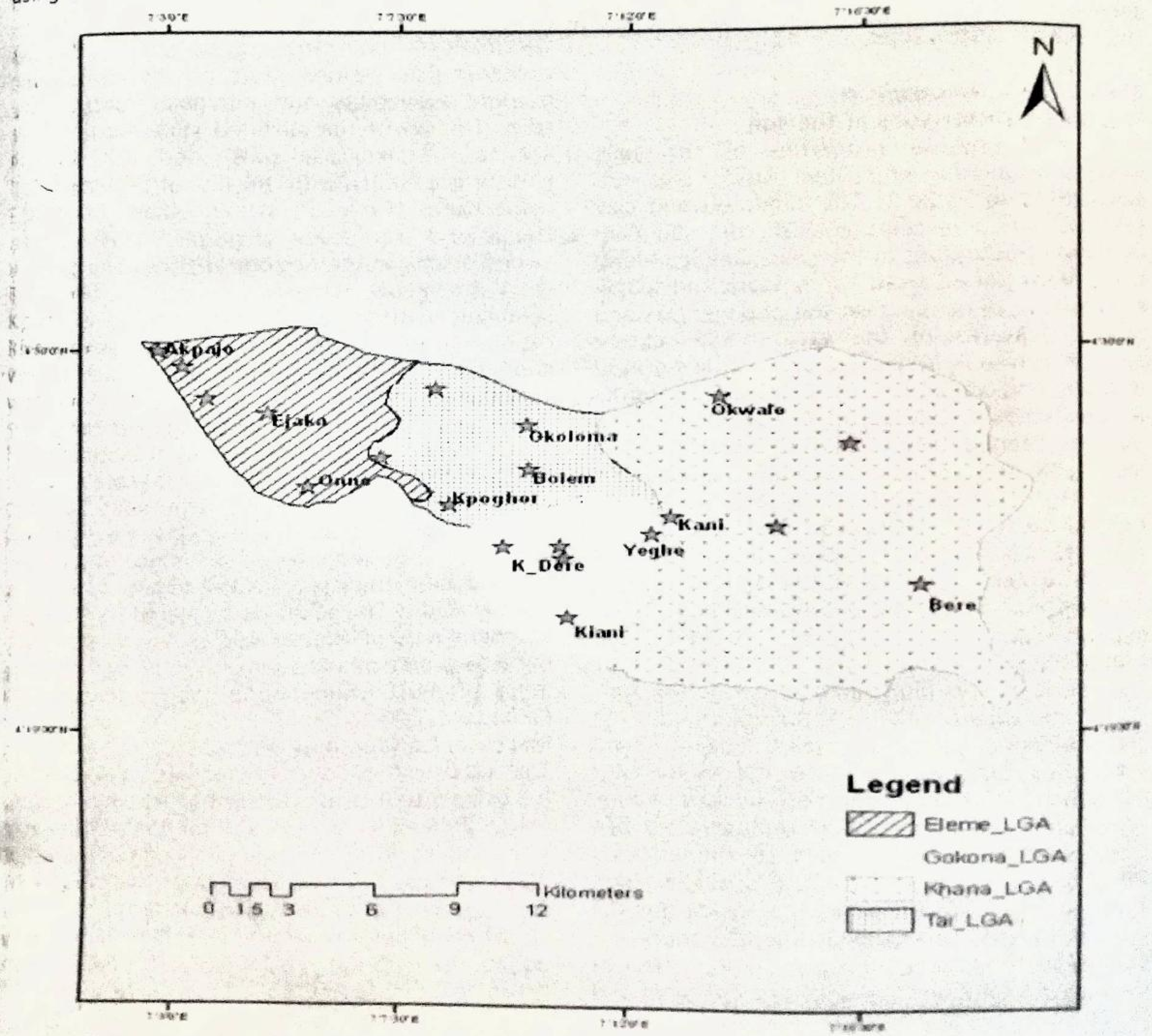

FIG 1: Ogoni region showing soil sampled locations.

Scanned by TapScanner

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Spectrophotometry (AAS) using "Buck Scientific 200A" by flame atomization (Barnhisel and Bertsch,
1982). Total hydrocarbon (THC) was determined by extracting the soil with carbon tetrachloride and measuring the total hydrocarbon content calorimetrically at 420nm using spectronic 20 (IITA, 1979).

Hypotheses

H_0: Soil physico-chemical properties do not significantly vary in the study locations.

H_1: Soil physico-chemical properties significantly vary in the study locations.

Estimates in variation of soil physical characteristics (sand, silt, and clay contents) were analysed using analysis of variance (ANOVA) for the four different sites across the study locations. Thus, ANOVA was adopted to determine if variation occurs in sand, silt and clay contents across sites.

RESULTS AND DISCUSSION

Physical characteristics of the soil

The physical properties of the soils sampled from the prescribed study area are summarized in Table 1. The sand, silt and clay fractions varied in texture along the sampling locations. The texture of the soils sampled along the stations varied from sandy loam and loamy sand texture depending on the pedogenesis and edaphic features of the area. Soil texture determines water intake, storage capacity, ease of tillage and amount of aeration influencing its fertility capability and status (FPDD, 1990). Sand fractions ranged from 67.28 to 77.01% with a mean value of 82.80% (surface soils) and between 64.92 to 76.11% with a mean of 68.74% (subsurface soils); Silt from 12.90 to 28.46% and 13.20 to 29.24% with means of 20.23% and 21.78% respectively; clay contents from 1.90 to 14.90% and 2.54 to 24.62% with means of 7.19% and 9.48% respectively for surface and subsurface soil samples collected from the study area (Table 1) This high sand content of the soils is characterized by sand formed on unconsolidated coastal plain sand and sandstones. Since sandy soil is not fit for crop production, the presence of oil-spill which significantly increased the percentage sand has adverse effect on the fertility of the affected soils. This is as a result of a probable high drainage of oil into the lower horizon of the soil causing aeration problem as the air pores get blocked with oil, which prevent the easy flow of nutrients to the soil. The soils are characterized as coarse-textured with a high proportion of sand fraction exceeding 70%. Such soils lack adsorptive capacity for basic plant nutrients and water. Consequently, such soils have weak surface aggregation and are vulnerable to erosion (FPDD, 1990).

Chemical characteristics of the soil

The chemical properties of the soils under study are summarized in Table 2 in relation to the sampling stations. Basically, results obtained from laboratory analyses were compared with acceptable conditions under which crops can thrive in the study area (IITA, 1979). It is discussed under the following nutrient concentrations:

Soil pH

Soil pH is fundamental to the understanding of soil systems, because it is an indicator of many reactions in the soils. It shows whether the soil is acidic, neutral or basic and provides useful information on the availability of the exchangeable cations. Soil pH controls plant nutrient availability and microbial reactions in soils. The pH of the air-dried soils ranged from 4.2 to 5.8 (surface soils) and 4.2 to 5.6 (subsurface soils) with means of 5.0 and 5.3 respectively (Table 2) within Khana, Gokana, Eleme and Tai study locations. This depicts strong acidity in the ecological zone. The project environment is strongly acidic across the sampling stations due to the leaching of basic cations from the soil *solum*. Such acidic soil condition can induce phosphate fixation and consequently reduce the ability of microbes to fix atmospheric nitrogen. The strong acid condition indicates that certain elements such as Zinc, Iron, Manganese and Aluminium are available in soils of the study environment. The soils are all slightly acidic and this acidity cannot be attributed entirely to the oil spill since other non-oil producing areas such as Yeghe and Kpong are equally acidic. The acidity is typical of the soils of southern part of Nigeria and is ascribed to the excessive precipitation which leads to leaching loose of most of the basic cations in the soil (Ekundayo, 2004).

Electrical Conductivity (EC)

The electrical conductivity values varied from 0.025 to 0.049 dSm^{-1} (surface soils) while 0.026 to 0.500dSm^{-1} were recorded for the subsurface soil samples in all the sampling stations (Table 2). This range of values indicates that the soils are non-saline as all the values along the stations are below 4dSm^{-1} (Miller and Donahue, 1995) and do not exceed the critical value of 2dSm^{-1} for sensitive crop species (FAO, 1974). These results suggest that the soils do not have salinity problem.

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Table 1: Physical properties of the soil in Ogoni region, Rivers State.

Para-meter (%)	KHANA LGA Surface soils Range Mean	KHANA LGA Sub-surface Range Mean	GOKANA LGA Surface soils Range Mean	GOKANA LGA Sub-surface Range Mean	ELEME LGA Surface soils Range Mean	ELEME LGA Sub-surface Range Mean	TAI LGA Surface soils Range Mean	TAI LGA Sub-surface Range Mean
Sand	69.11-73.37 79.18	67.24-69.97 72.20	72.22-75.62 79.99	70.06-71.20 72.26	67.28- 71.96 79.01	62.18- 68.41 76.11	66.11- 72.35 77.71	62.79- 67.09 70.42
Silt	18.10- 20.08 22.76	19.84- 21.24 24.04	18.13- 18.69 20.11	15.28- 18.58 26.26	12.90- 20.98 28.46	13.20- 22.02 29.29	14.18- 17.81 20.12	16.02- 20.89 26.10
Clay	1.63- 6.55 9.77	7.65- 8.78 9.98	1.75- 5.69 7.67	1.48- 8.22 14.66	1.90- 27.42 14.90	2.54-9.57 24.62	7.43- 9.84 13.77	5.13-12.02 17.71
Textural class	Loamy sand	Sandy loam	Sandy loam	Loam sandy	Sandy loam	Loam sandy	Loam sandy	Sandy loam

(Field work, 2010)

Table 2: Nutrient concentration of the soils in Ogoni region, Rivers State

Parameter (%)	KHANA LGA Surface soils Range Mean	KHANA LGA Sub-surface Range Mean	GOKANA LGA Surface soils Range Mean	GOKANA LGA Sub-surface Range Mean	ELEME LGA Surface soils Range Mean	ELEME LGA Sub-surface Range Mean	TAI LGA Surface soils Range Mean	TAI LGA Sub-surface Range Mean
PH	4.3-5.7 4.9	4.2-5.4 5.0	4.2-5.5 5.0	4.9-5.6 5.3	5.2-5.8 5.5	5.0-5.2 5.1	5.1-5.6 5.3	4.6-5.3 5.1
Ec (dSm	0.025- 0.037 0.044	0.040- 0.043 0.047	0.036-0.043 0.049	0.026- 0.039 0.500	0.034- 0.039 0.042	0.037- 0.038 0.040	0.035-0.040 0.040	0.033- 0.045 0.0430
Org Carbon	1.21-3.53 2.19	1.00-2.10 1.89	1.29-2.41 1.76	1.01-1.40 1.14	1.00-3.15 2.19	1.20-2.18 1.92	1.78-3.80 2.74	1.00-2.79 2.02
Tot nitrogen	0.03-0.07 0.05	0.03-0.05 0.04	0.04-0.07 0.06	0.02-0.05 0.04	0.04-0.07 0.05	0.03-0.05 0.04	0.04-0.08 0.06	0.04-0.06 0.05
Phosphorus	8-12 10	8-12 9	7-12 10	8-12 9	7-9 10	7-14 10	6-12 9	7-13 9
Calcium	1.77-3.22 2.45	2.05-3.01 2.46	1.24-2.79 2.26	1.21-2.90 2.15	0.88-1.42 1.24	0.40-1.98 1.33	0.56-3.11 1.65	0.96-2.01 1.35
Magnesium	1.44-3.62 2.59	1.20-2.65 2.08	1.40-2.80 1.83	1.00-2.96 1.45	1.90-2.43 2.15	1.84-2.38 2.20	1.79-6.24 3.21	1.09-4.11 2.13
Sodium	0.09-0.26 0.132	0.06-0.18 0.12	0.01-0.20 0.10	0.07-0.28 0.13	0.07-0.09 0.08	0.06-0.09 0.07	0.07-0.24 0.11	0.05-0.11 0.07
Potassium	1.40-3.11 2.38	1.93-3.11 2.49	1.09-2.19 1.71	1.00-1.77 1.22	1.00-2.15 1.71	0.08-2.00 1.41	1.22-2.19 1.73	1.04-2.67 1.62
Exc acidity	2.66-3.81 3.12	1.79-8.06 5.57	1.31-3.00 2.29	1.26-2.18 1.95	2.07-3.18 2.56	2.00-3.19 2.28	1.22-3.40 2.19	1.24-3.40 2.13
ECEC	9.74-1167 10.65	9.19-10.92 9.70	5.87-9.52 8.19	5.63-8.44 6.90	7.11-8.40 7.80	5.89-9.37 7.28	6.66-12.12 8.89	4.77-9.92 7.29
Base sat	65-76 10.67	63-81 76	65-81 72	63-85 71	60-73 66	64-74 68	64-90 75	55-83 70

(Field work, 2010)

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Organic Carbon and total Nitrogen contents

Carbon is an essential plant nutrient and the foundation of all life (Magddoff, 1992). Carbon compound are enzymatically oxidized to produce carbon dioxide, water, energy, and decomposer biomass. Soil organic matter contributes to soil aggregation and reduces susceptibility to erosion (Brady and Weil, 1996). The organic carbon in soils of the study area ranged from 1.00 to 3.80% and between 1.00 to 2.79% for surface and subsurface soils respectively across the prescribed stations (Table 2). Such soils are rated medium in fertility status (Holland *et al.*, 1989). The results indicate that organic carbon decreases with depth in all the stations used for this study. From the results, Tai station recorded the highest level of organic carbon contents, while the lowest content was obtained in Eleme, Tai and Khana of the ecological zone. Thus, in spite of the level of pollution, the soils can sustain crop production in the ecological zone.

Nitrogen in the form of protein is present in the protoplasm of every cell. The available form of Nitrogen in the soil is ammonium or nitrate ion. Total nitrogen varied from 0.03 to 0.08% and 0.02 to 0.06% for surface and subsurface soils respectively in all the stations sampled for this study (Table 2). This range of values is rated low when compared with the medium range of 0.10 to 0.45% (Holland *et al.*, 1989) for soils of the area under study. In a similar manner, total nitrogen decreases with depth in all the stations where the samples were collected. These locational range of values is consistent with the works of Ukaegbu and Akamigbo (2005) who reported average total percentage of 0.08 in soils of the Cross River Coastal plain sands and mean range of 0.10 to 0.14% reported by Abii and Nwosu (2009) for surface and subsurface soils of Eleme in Rivers State. Thus, there is variation in the contents of total nitrogen in this ecological zone.

Available Phosphorus and Exchangeable Cations

Phosphorus is an essential part of nucleoprotein in the cells nuclei, which control cell division and growth, and of deoxyribonucleic acid (DNA) molecules. In the study environment, available phosphorous ranged from 6 to 12mgkg^{-1} (surface soils) and between 7 to 14mgkg^{-1} for the subsurface soil samples (Table 2). Available P contents were generally moderate (i.e. polluted, but not significantly) in all the stations as values are below 15mgkg^{-1} (FPDD, 1990). This range of values is consistent with the findings of Ekundayo (2004) who reported near mean value of 10mgkg^{-1} for arable soils of South-Eastern Nigeria.

The exchangeable cations (Ca, Mg, K and Na) are positively charged ions usually absorbed by electrostatic or columbic attraction to soil surface colloids. Plants absorb it in exchangeable form (Donahue et al., 1990). The exchangeable cations for the surface soils were as follows: Ca (0.56-3.22cmolkg^{-1}); Mg (1.09-6.24cmolkg^{-1}); K (1.00-3.11cmolkg^{-1}) and Na (0.01-0.26cmolkg^{-1}). Conversely, the following values were recorded for the subsurface soils: Ca (0.40 to 3.01 cmolkg^{-1}); Mg (1.00-4.11 cmolkg^{-1}); K (0.08 to 3.11 cmolkg^{-1}) (<10.0cmolkg^{-1}) for both surface and subsurface soils. Magnesium was moderate for both seasons and Na (0.05 to 0.28 cmolkg^{-1}) (Table 2); K was considerable (>1.2cmolkg^{-1}) in both surface and subsurface soils and Na was within the permissible limits (>0.3cmolkg^{-1}) (Table 2). Thus, there is a slight locational difference among the exchangeable bases in soils of the environment. In sum, there is a low cation reserve in the soils.

Effective cation exchange capacity (ECEC)

Effective cation exchange capacity (ECEC) was very moderate in both surface and subsurface soils with range values of 5.87 to 11.67cmolkg^{-1} recorded in the surface soils compared to range values of 4.77 to 10.92cmolkg^{-1} for the subsurface soil samples (>10.0 cmolkg^{-1}).

Exchange acidity (EA)

Exchange acidity value for the surface soils (1.22 in Tai LGA to 3.81cmolkg^{-1} in Khana LGA) and subsurface soils (1.24 to 8.06 cmolkg^{-1}) were above range when compared with a medium range of 2.1 to 4.1 cmolkg^{-1} (Table 2). Albeit impact of Al^{3+} in the soil solution could be significant in terms of influencing the biochemical behaviour.

Base saturation (BS)

Base saturation ranged from 60 to 90 and 55 to 85 for surface and subsurface soil samples respectively across the prescribed stations under study (Table 2). With the mean percentage base saturation above the threshold limits in surface and subsurface soil samples, basic nutrient must have occurred in available forms in soil solution in spite of the low cation reserves across the stations. This collaborate earlier results of Abii et al (2009) on the effect of oil spillage on the soil of Eleme, Rivers State, which indicated that base saturation range of 60-85 and 50-80 for surface and subsurface respectively.

Heavy metal status

The heavy metals status in soils of the study area is summarized in Table 3. Heavy metals exist in variable oxidation states, particularly those that belong to the d-group of the periodic table, each with different reactive, toxicological, physiological and bioconcentration potential. Though some heavy metals, such as Cadium (Cd), Lead (Pb) and Zinc (Zn) are toxic in their cationic form, many others require biochemical transformation to organic metallic compounds (Donahue et al., 1990).

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Table 3: Heavy metal and total hydrocarbon contents (THC) of Ogoni soils

Para-meter (%)	KHANA LGA		GOKANA LGA		ELEME LGA		TAI LGA	
	Surface soils Range Mean	Sub-surface Range Mean	Surface soils Range Mean	Sub-surface Range Mean	Surface soils Range Mean	Sub-surface Range Mean	Surface soils Range Mean	Sub-surface Range Mean
Iron	3002.16-5259.54 8112.04	2660.26- 4242.95 6626.11	426.11-1796.35 3211.11	62.06-1606.43 3026.04	1998.19-2272.46 2671.10	1779.10-1591.982 2201.61	2429.10-4356.772 6701.04	1264.02-11594.8 4356.772
Zinc	2.16- 21.06 41.41	2.05- 27.41 56.26	11.11- 30.13 46.21	17.16- 13.30 50.26	12.80- 27.29 41.28	9.80-23.822 44.19	4.00- 10.292 26.18	3.91-8.344 21.24
Copper	1.11-4.20 1.84	0.40-4.04 1.81	1.44-8.60 3.98	1.18-6.26 2.47	1.26-3.91 2.47	1.71-2.98 2.202	0.19-2.66 1.59	1.04-2.60 1.688
Chromium	1.07-4.11 2.13	1.00-2.26 1.70	1.09-2.16 1.46	1.01-3.36 1.71	2.04-3.98 3.03	1.06-3.08 1.862	1.04-6.26 2.594	1.00-3.68 2.16
Manganese	111.20-186.42 267.11	170.20-212.47 300.62	101.24-153.80 217.19	109.00-190.83 272.69	110.26-201.67 267.18	117.80-203.058 267.18	118.28-202.2 264.98	109.00-167.862 313.20
Cadmium	1.04-2.64 2.13	1.01-2.48 1.59	1.02-2.11 1.638	1.00-2.46 1.53	1.28-3.28 2.43	1.11-2.98 1.852	1.11-3.08 2.214	0.93-2.36 1.912
Nickel	11.20-22.70 28.60	10.96-17.24 23.11	11.41-17.55 26.67	9.81- 15.18 23.03	11.28-18.27 26.34	10.00- 15.09 19.20	11.60-18.264 28.74	0.80-15.074 26.09
Lead	10.70-18.42 24.24	12.04-15.71 20.10	4.11- 11.998 21.17	2.00- 10.51 21.11	1.26-11.03 21.11	1.80-9.442 20.12	1.80-14.0 28.10	2.14-11.942 20.08
Vanadium	2.12-4.18 2.97	2.01-4.10 3.04	1.41-2.46 2.066	1.06-2.14 1.40	2.19-6.24 4.04	2.18-6.86 4.884	4.12-8.28 5.954	4.00-8.96 6.016
THC	165.18-197.91 265.11	126.70-131.47 218.71	1.77.78-232.496 276.06	100.11-170.57 204.11	103.22-161.55 264.66	99.81-150.956 220.90	219.11-259.922 301.42	107.20-192.606 218-12

(Field work, 2010)

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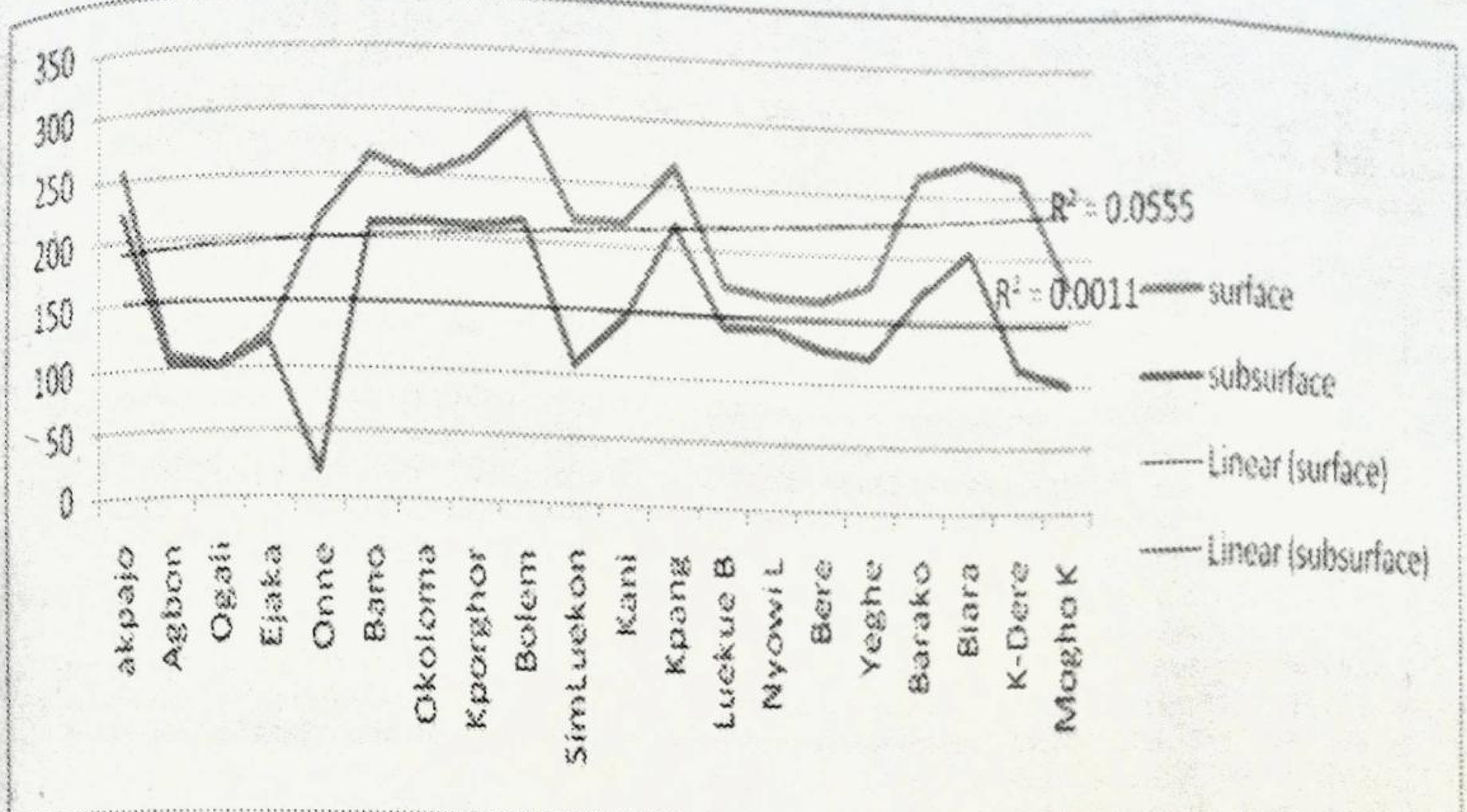

FIG 2: Total hydrocarbon content (THC) of soils in the study area

Testing of research hypothesis

The results posit that soil physical characteristics which are relevant in understanding the genesis, their lithology and their morphological features changes with site as at (2010) in the Niger Delta significantly show wide variations based on wide variations in sand, silt and clay fractions, and probably owing to differences in parent material. Clearly, the variation in the chemical properties in all the sites sampled may be ascribed to variation in the soil parent material and the stage of pedogenetic formation. Thus, an understanding of the chemical characteristics is guided mostly by the factors outlined above.

CONCLUSION

The physical properties of the soils sampled in terms of sand, silt and clay fractions varied in texture along the sampling locations. The texture of the soils sampled along the stations varied from sandy loam and loamy sand texture depending on the pedogenesis and edaphic features of the study area. For example, Tai and Khana LGAs correspond to areas with loam sandy and sandy loam for surface and subsurface soils respectively, while Gokana and Eleme LGAs indicates sandy loam and loamy sand respectively for surface and subsurface soils. The soils are characterized as coarse-textured with a high proportion of sand fraction exceeding 70%, 22% for silt and 8% for clay fractions. Thus, the soils of the prescribed study area are declared contaminated by heavy metals and hydrocarbon toxicity, though contaminated by metals but not significant. Also taking cognizance of the sandy loam and loamy sand texture, medium in organic carbon contents, the soils have weak surface aggregation and inherently medium in fertility status.

From the result, sand, silt and clay contents significantly vary in Eleme, Tai, Khana and Gokhana as evident in the calculated F-ratios of 307.70; 606.72; 1312.31; and 1154.02 respectively against the tabulated F-ratio of 3.35 as reflected by the wide variations in sand, silt and clay fractions, and probably owing to differences in parent material. Conversely, the summary result of the soils around the Ogoni area based on the locations where the soils were sampled. The results presented indicate that the soils vary widely in chemical characteristics in Eleme (F-ratio=1674.16; $p<0.01$; F-critical=1.88); Tai (F-ratio=82.67; $p<0.01$; F-critical=1.88); Khana (F-ratio=1467.66; $p<0.01$; F-critical=1.88) and Gokhana (F-ratio=709.49; $p<0.01$; F-critical=1.88) against the theoretical value. Therefore, the alternate hypothesis that soil physico-chemical properties significantly vary in the study locations is accepted.

RECOMMENDATIONS

The oil industry has undoubtedly brought economic benefits to many people, but it has left its trail a complex mix of environmental pollution problems, study has as such, the following recommendations:

(i) There is need to ensure effective enforcement of National Environmental Standards Agency (NESA) regulation, guidelines and standards, which arises from researches and critical observation of environmental situation in the oil producing areas

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(ii) In order to protect and preserve our environment from pollution caused by petroleum related operations, a long term and comprehensive environmental monitoring programme should be instituted. The monitoring programme however should have as its basis the provision for establishment of comprehensive environmental base data in Nigeria.

(iii) Farmers should be given appropriate fertilizer to correct the soil eg Gypsum.

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