Influence of Environmental Pollution on Soil Types and Properties in The Niger Delta Area of Akwa Ibom State, Nigeria

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Abstract: A field soil survey and laboratory studies were carried out to examine the influence of crude oil and industrial wastes pollution on soil profile development and characteristics in Ikot Abasi, Niger Delta area of Akwa Ibom State, Nigeria. Nine soil profiles, three each, in oil affected site (OAS), industrial waste affected site (IWAS) and non-contaminated (control) site (NCS), respectively, were studied. Soil samples were collected and analyzed in the laboratory for some physical and chemical properties. The result of soil classification following the USDA Soil Taxonomy and correlated with the World Reference Base for Soil Resources (WRB) showed that all the three pedons from the control (NCS) were highly weathered and matured soils (Ultisols). Of the three pedons from the OAS, two (66.7%) were matured while one (33.3%) was young soil (Inceptisol/Cambisol). Similarly, of the three pedons from the IWAS, one (33.3%) was matured (Ultisols/Acrisols) while two pedons (66.7%) were young soils (Inceptisols/Cambisols). This indicates that environmental pollution can retard soil formation and profile development resulting in relatively young soils. Furthermore, analysis of variance (ANOVA), showed that soils of OAS were significantly ($P < 0.05$) different from those of IWAS and NCS in 12(52.2%) and seven (30.4%), respectively, of the 23 soil properties considered. Also, soils of IWAS were significantly different from those of the NCS in six (26.1%) of the soil properties. The result further showed that oil pollution significantly increased soil total hydrocarbon (THC) and lead (Pb) contents as well as organic matter content (OM), available phosphorous (P) exchangeable potassium (K), micronutrients (Fe, Zn, Cu, Mn) and lowered exchangeable acidity (EA). Industrial wastes also increased soil exchangeable calcium (Ca) and K and effective cation exchange capacity (ECEC) and lowered EA. Therefore, appropriate remediation and land management practices can ameliorate the harmful effects of these pollution activities while the essential nutrients and positive influences imparted to the soil during the pollution are harnessed to improve the land/soil qualities and characteristics.

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1. Introduction:

Soils have strong relationships with food security, rural poverty, maintenance of environmental quality and promotion of plants, animals and human health. Agronomists, plant breeders, plant pathologists, ecologists, foresters, livestock specialists and others depend on soil for the proper management of their resources. Soil is one of the most important items in world development issues.

Soil is the basis of agricultural and of natural plant communities. Thus, the thin layer of soil covering the surface of the earth represents the difference between survival and extinction for most land-based life (Doran et al., 1996). However, inventories of soil productive capacity indicate human-induced degradation on nearly 40% of the world's agricultural land as a result of soil erosion, atmospheric pollution, extensive soil cultivation, over-grazing, land clearing, salinization, and desertification (Oldeman, 1994). Indeed, degradation and loss of productive agricultural land is one of our most pressing ecological concerns, rivaled only by human caused environmental problems like global climate change, depletion of the protective ozone layer and serious declines in biodiversity (Lal, 1998).

Environmental pollution through oil spills and industrial effluent can cause serious damages to both terrestrial and aquatic ecosystems and destruction of forest and farmland through deforestation and burning. These effects can be further modified by erosional and depositional processes. All these may severely affect the characteristics and management of agricultural soils (Dambo, 2000).

Ikot Abasi in Akwa Ibom State is a major oil producing area in the Niger Delta area of Nigeria. It has both on-shore and off-shore fields, as well as large deposit of gas (Udo et al., 2001). The area has been affected by crude oil spillages of serious magnitude. Furthermore, the disposal of solid and liquid industrial wastes also constitutes another source of environmental pollution in the area. Some previous studies (Udo et al., 2001; Worgu, 2000; Andrade et al., 2004; Chukwu, 2014), have shown that soil pollution has had serious environmental effects on soils, forests and water bodies in host communities in the Niger Delta. It alters both the chemical and physical properties of soil and degrades soil fertility (Udoh and Chukwu, 2014).

The aim of this present study was to assess the influence environmental (crude oil and industrial wastes) pollution on soil types (in terms of profile development) and soil (physical and chemical) properties in Ikot Abasi, Niger Delta Area, Akwa Ibom State, Nigeria.

2. Materials and Methods:

2.1. Description of the Study Area:

The area of this study was Ikot Abasi Local Government Area in Akwa Ibom State, Nigeria. It is located in the extreme south western part of the State in the Niger Delta and situates between latitudes 4°28' and 4°43'N and longitudes 7°30' and 7°50'E.

The area has a humid tropical climate characterized by heavy rainfall with mean annual rainfall of about 4000mm and mean annual temperature of about 27°C. Relative humidity is above 80% almost throughout the year with high cloud covers resulting in low incipient solar radiation. The geological material includes quaternary deposits (which give rise to alluvial plains and beach ridge sands) and the tertiary coastal plain sands (Udo et al., 2001).

2.2. Field Work:

Three sites were identified using free survey. The sites were: oil affected site (OAS), where major crude oil spillage occurred five years ago; industrial waste affected site (IWAS), where a manufacturing company used as waste dump site, and non-contaminated site (NCS), an area free from major environmental pollution as a control. Three profile pits were sited in each study location to represent the land type under investigation. Each of the nine profile pits was described following the FAO, (2006) guidelines for profile description. Soil samples were collected according to the observed genetic horizons of all the pits, for laboratory analysis.

2.3. Laboratory Analysis:

The physical and chemical analyses carried out on the soil samples included the following: particle size distribution – determined by the hydrometer method according to the procedure of Gee and Or (2002). Saturated hydraulic conductivity was determined using constant head permeameter as described by Klute (1986), while bulk density was by the method of Grossman and Reinsch (2002). Soil pH was determined using pH meter and read at a soil: water ratio of 1:2.5. Available phosphorus (P) was determined by Bray P-1 extractant as described by Udo et al., (2009). Exchangeable acidity (H+ and Al3+) was extracted with INKCl and titrated against 0.05M NaOH. Organic carbon was determined by Walkley and Black wet digestion method (Nelson and Sommers, 1982), while total nitrogen (N) was estimated from organic carbon. Exchangeable bases were extracted with neutral ammonium acetate (at pH 7), K+ and Na+ contents were read with the aid of flame photometer, while Ca2+ and Mg2+ were determined by EDTA complexiometric titration method (Jacson, 1965). Effective cation exchange capacity (ECEC) was determined by the summation of exchangeable acidity and exchangeable bases (Soil Survey Staff, 2010). Base saturation was calculated as the percentage of ECEC occupied by Ca, Mg, Na and K. Heavy metals/ micronutrients (Cd, Pb, Cu, Mn, Fe, Zn) were determined using total elementary analysis of perchloric and nitric acid digestion and read using atomic absorption spectrophotometer (AAS). Total petroleum hydrocarbon (TPH) was extracted with xylene and measured using AAS as described by Osuji and Nwoye (2007).

2.4. Soil Classification:

From the result of the field morphological properties and laboratory analysis, the nine pedons were classified according to the USDA Soil Taxonomy system (Soil Survey Staff, 2010) and the World Reference Base for Soil Resources (FAO, 2006). Pedons were placed in a particular order based on the presence or absence of diagnostic horizons. The differentiae used in defining the suborder were the presence or absence of properties associated with wetness (Soil Moisture Regime). In the great group category, the classification was based largely, on the presence or absence of horizon features and their arrangement. At the subgroup category, soils were placed in a particular class based on whether they represent the central concepts of the great group, intergrades or transitional forms.

2.5. Statistical Analysis:

Statistical analysis carried out included: descriptive statistics (mean, minimum and maximum values), analysis of variance (ANOVA), to compare the differences in soil characteristics among the different pollution sites (OAS, IWAS and NCS (control), (SAS Institute, 1996).

3. Results and Discussion:

3.1. Influence of Environmental Pollution on Soil Profile Development and Classification in the Study Area:

Each of the three study sites, namely, oil affected site (OAS), industrial waste affected site (IWAS) and non-contaminated site (NCS), was represented by three pedons, respectively. Some profile characteristics of soils in the three study sites (OAS, IWAS and NCS) are presented in Tables 1, 2 and 3, respectively, while the classification of soils in the three study sites is presented in Table 4.

The nine pedons (three from each study site) were classified following the criteria outlined in the USDA Soil Taxonomy (Soil Survey Staff, 2010) and correlated with the World Reference Base (WRB) for Soil Resources (FAO, 2006) system. The nine pedons were classified into order, suborder, great group and subgroup on the basis of diagnostic horizons, the properties of the soils that reflect the nature of the soil environment and the dominant pedogenic processes that are responsible for the soil formation (Soil Survey Staff, 2010; Ajiboye and Ogunwale 2010; Udoh et al., 2013).

From the result of the field study of profile pits and laboratory analyses of soil samples, it was observed that soils in the study area have high sand content which generally decreases with profile depth, irrespective of the study site. The results in Tables 1, 2 and 3, show that based on the stage of profile development, profiles 1 and 2 of the OAS (Table 1), profile 2 of the IWAS (Table 2) and all the 3 profiles of NCS (Table 3) showed evidence of argillic (Bt) horizon which placed these pedons in the Ultisols order (Soil Survey Staff, 2010). Although they all have high base saturation (>35%), which should have qualified them as Alfisols, previous workers, Kang and Juo (1980), and Enwezor et al. (1981) have described soils in this area as “Low Activity Clay” (LAC) soils due to their low ECEC, hence they are placed in the Ultisols order. On the other hand, profiles 3 of OAS, 1 and 3 of IWAS did not show enough evidence of the argillic or kandic horizon but had moderate weathering with features of cambic B horizon, hence they were classified as Inceptisols (Soil Survey Staff, 2010).

All the Ultisols correlated with Acrisols while the Inceptisols correlated with Cambisols of the World Reference Base for Soil Resources (IUSS/INRB,2007). All the freely drained Ultisols (under Udic moisture regime), pedons 1, 2,5,7,8,9 (Table 4), were classified as Udults whereas Inceptisols under similar conditions were classified as Udepts (pedons 3) at the suborder category (Table 4). Similarly, Inceptisols under poor drainage conditions (seasonally flooded) were classified as Aquepts at the suborder level (pedons 4 and 6, Table 4).

Furthermore, all the Udults, pedons 1 and 2 (OAS), 5 (IWAS) and 7,8, and 9 (NCS) (Table 4), were placed in the Paleudult great group because of the minimal decrease in clay content with increasing depth in addition to the absence of a densic or lithic contact within 150cm depth (Soil Survey Staff, 2010). One of the Paleudults (Pedon 9 from NCS; Table 4), with a loamy argillic horizon (Table 3, profile 3), qualified as Typic Paleudult at the subgroup category. The remaining four Paleudults, two each, from the OAS and NCS, respectively, all qualified as Arenic Paleudults at the subgroup category (Table 4), because they have sandy textures extending from the mineral soil surface to the top of an argillic horizon (Tables 1 and 3) (Soil Survey Staff, 2010).

Also, further classification of the Inceptisols placed the freely drained pedon (Udept) from OAS, in the Dystrudept pedon (Udept) from OAS, in the Dystrudept great group because of the acidic reaction in the profile. It also qualified as Typic Dystrudept at the subgroup level, being freely drained, acidic and deep profile (Soil Survey Staff, 2010). The two wet Inceptisols (Aquepts, from IWAS; Table 4) qualified as Endoaquepts at the great group category due to their fluctuating ground water level. Also, because of the relatively high chroma in some horizons, the two Endoquepts qualified as Aeric Endoaquepts at the subgroup category.

The result of this study agrees with earlier observations by Enwezor et al., (1990) and Udoh et al., (2011) that the most prevalent soils in Eastern Nigeria (including Akwa Ibom State) are the Ultisols, while other soil orders identified include Inceptisols and Entisols. But specifically, the result has shown that environmental pollution by crude oil and industrial wastes, with the attendant soil disturbances, may adversely affect the rate of soil development. As can be observed in this study (Table 4). All the three pedons in the NCS were Ultisols – highly weathered and matured with well-developed argillic (Bt) horizons. On the other hand, two of the pedons in the OAS and one in the IWAS were Ultisols, while one pedon from the OAS and two pedons from the IWAS were Inceptisols – relatively young soils with moderate weathering lacking argillic or kandic horizons (Soil Survey Staff, 2010; Udoh et al., 2013). This is as a result of the disturbances including remediation measures in these pollution sites which retarded the soil profile development.

Table 1: *Some profile characteristics of soils in the oil affected site (OAS)*

Horizon depth(cm)	Horizon design	Sand	Silt g/kg	Clay	TC[1]	Org.M[2] g/kg	ECEC[3] Cmol/kg	B/Sat[4] %
				Profile 1				
0 -10	Ap1	873.60	37.30	89.10	LS	23.90	8.89	87.63
10-20	Ap2	873.60	37.30	89.10	LS	13.00	4.45	88.17
20-30	BA	893.60	7.30	99.10	S	15.00	11.65	87.12
30-50	Bt	833.60	37.30	129.10	LS	17.00	10.13	75.32
50-90	C1	833.60	27.30	139.10	LS	16.00	7.21	75.03
90-200	C2	843.60	17.30	139.10	LS	12.00	15.70	93.63
Mean		709.70	27.30	114.10		16.20	10.32	84.48
				Profile 2				
0 -14	Ap	943.60	25.30	31.10	S	21.90	5.36	72.01
14-15	Bt	863.60	27.30	109.10	LS	24.50	6.70	71.64
50-100	B	843.60	27.30	129.10	LS	22.70	7.69	80.49
100-164	BC	843.60	27.30	129.10	LS	29.50	7.94	83.63
164-200	C	863.60	17.30	119.10	LS	19.80	7.68	83.07
Mean		867.60	24.90	103.50		23.60	7.07	78.17
				Profile 3				
0 -9	Ap1	833.60	27.30	139.10	LS	24.90	8.88	71.85
9 – 20	Ap2	823.60	27.30	149.10	LS	18.60	8.38	76.13
20-50	B	853.60	17.30	129.10	LS	27.90	10.69	71.94
50-100	BC	853.60	17.30	129.10	LS	13.40	6.45	84.50
100-200	C	833.60	27.30	139.10	LS	19.00	10.79	75.47
Mean		839.60	23.30	137.10		20.80	8.92	75.98

1: TC =textural class.
2: Org.M = organic matter.
3: ECEC = effective cation exchange capacity.
4: B/sat = base saturation.

Table 2: *Some profile characteristics of soils in the industrial wastes affected site (IWAS)*

Horizon depth(cm)	Horizon design	Sand	Silt g/kg	Clay	TC'	Org.M2 g/kg	ECEC3 Cmol/kg	B/Sat4 %
				Profile 1				
0 -20	Ap	923.60	27.30	49.10	S	18.00	13.50	77.78
20-35	B	870.90	44.00	85.10	LS	15.40	6.38	84.33
35-69	C1	940.90	14.00	45.10	S	15.20	10.04	91.45
69-92	C2	880.90	34.00	85.10	LS	20.90	10.07	90.07
92-143	C3	964.91	3.00	38.10	S	3.00	7.27	86.24
Mean		916.24	24.46	60.50		14.50	10.25	85.97
				Profile 2				
0 -15	Ap	920.90	24.00	55.10	S	1.60	10.19	90.19
15-58	Bt1	870.90	24.00	105.10	LS	5.10	15.34	93.48
58-106	Bt2	879.10	24.00	105.10	LS	14.20	12.07	91.71
106-180	C	860.90	44.00	95.10	LS	8.30	12.35	91.10
Mean		870.00	29.00	90.10		7.30	12.49	92.17
				Profile 3				
0 -33	Ap	890.90	14.00	95.10	LS	5.80	10.43	80.82
33 – 54	B1	879.10	15.30	105.10	LS	3.20	13.91	91.37
54-105	B2	869.10	34.00	105.10	LS	6.00	10.32	80.62
105-183	C	879.10	34.00	95.10	LS	13.00	16.03	81.29
Mean		879.55	24.32	100.10		7.00	12.67	85.52

1: TC =textural class.
2: Org.M = organic matter.
3: ECEC = effective cation exchange capacity.
4: B/sat = base saturation.

3.2. Differences Among Some Soil Properties Influenced by Environmental Pollution:

The result of statistical analysis to compare differences in some (23) soil properties among the three study sites – oil affected site (OAS), industrial waste affected site (IWAS) and the non-contaminated site (NCS) (control), is shown in Table 5.

Table 3: *Some profile characteristics of soils in the non-contaminated site (NCS)*

Horizon depth(cm)	Horizon design	Sand	Silt g/kg	Clay	TC'	Org.M2 g/kg	ECEC3 Cmol/kg	B/Sat4 %
				Profile 1				
0 -27	Ap	889.10	44.00	75.10	LS	8.0	11.56	80.10
27-67	Bt1	9.10	24.00	105.10	LS	20.5	8.42	76.25
67-107	Bt2	820.90	14.00	165.10	SL	5.4	12.04	76.74
107-152	BC	820.90	14.00	165.10	SL	7.0	9.00	66.67
152-200	C	750.90	94.00	155.10	SL	9.4	13.22	77.31
Mean		832.18	38.00	133.10		10.6	10.85	60.66
				Profile 2				
0 -26	Ap	920.90	40.00	39.10	S	14.0	11.77	74.51
26-65	Bt1	820.90	44.00	135.10	LS	5.4	10.62	71.75
65-100	Bt2	820.90	44.00	135.10	LS	30.9	8.40	64.29
100-150	BC	820.90	44.00	135.10	LS	34.9	8.50	64.71
150-200	C	810.90	4.00	185.10	LS	13.0	7.04	71.59
Mean		838.9	35.20	125.90		19.64	9.27	63.37
				Profile 3				
0 -30	Ap	900.90	44.00	55.10	S	23.9	15.96	81.20
30 – 50	Bt1	800.90	14.00	185.10	SL	12.0	13.02	92.32
50-85	Bt2	770.90	14.00	215.10	SCL	21.3	14.56	79.40
85-107	BC	770.90	14.00	215.10	SCL	13.0	10.36	71.04
107-200	C	770.90	14.00	215.10	SCL	10.4	10.82	72.27
Mean		802.90	20.00	177.10		16.12	12.94	79.25

1: TC =textural class.
2: Org.M = organic matter.
3: ECEC = effective cation exchange capacity.
4: B/sat = base saturation.

Table 4: *Classification of Soils in the Study Area*

Pedons	USDA Soil Taxonomy	FAO/WRB
	Oil affected site (OAS)	
1	Arenic Paleudults	Haplic Acrisol
2	Arenic Paleudults	Haplic Acrisol
3	Typic Dystrudepts	Haplic Cambisol
	Industrial waste affected site (IWAS)	
4	Aeric Endoaquepts	Endogleyic Cambisol
5	Arenic Paleudults	Haplic Acrisols
6	Aeric Endoaquepts	Endogleyic Cambisol
	Non-contaminated site (NCS)	
7	Arenic Paleudults	Haplic Acrisol
8	Arenic Paleudults	Haplic Acrisol
9	Typic Paleudults	Haplic Acrisol

The result shows that soils of the OAS were significantly ($p<0.05$) different from IWAS soils in 12 (52.2%) of the 23 soil properties tested. Also, the OAS soils were significantly different from the NCS soils in seven (30.43%) of the 23 soil properties. Furthermore, soils of IWAS were significantly different from those of the NCS in six (26%) of the soil properties tested.

Specially, the result (Table 5) shows that mean sand content in IWAS (896.69g/kg) was significantly higher ($P<0.05$) than those of OAS (855.48g/kg) and NCS (824.66g/kg). The trend was as follows: IWAS > OAS > NCS. On the other hand, the clay content of the OAS (117.97g/kg) and NCS (138 g/kg) were statistically similar but both were significantly higher than that of the IWAS

(77.00g/kg). The high sand content in the study area generally, could be attributed to the nature of the soil percent materials which are beach ridge sands and coastal plain sands (Petters et al., 1989; Ibia and Udo, 2009; Udoh et al., 2013).

In terms of the chemical properties, the result in Table 5, shows that oil pollution increased the soil content of total nitrogen (N), available phosphorus (P), manganese (Mn), lead (Pb) and total hydrocarbon (THC), which were significantly ($p<0.05\%$) higher in OAS than the corresponding values in the NCS soils. Also, comparing OAS with IWAS, the values of the following six soil properties, organic matter, total N, available P, Cu, Mn and Pb, were significantly higher in OAS than in IWAS. On the other hand, soils from IWAS had significantly higher values of exchangeable Ca, Na, ECEC and exchangeable acidity (EA) than soils of the OAS.

It could be observed from the above result that oil pollution had significant influence on a wider range of soil properties than industrial waste pollution, previously workers (Baker, 1976; Amadi et al., 1993; Osuji et al., 2005; Wang et al., 2010) have equally observed that oil pollution excerted adverse effects on soil properties and plant community. Both the physical and chemical properties of the soil are affected by oil pollution. Comparing soils of the OAS with those of the control (NCS) the result (Table 5) shows that oil pollution increases soil bulk density (BD) lead content (Pb), total hydrocarbon (THC), micronutrient elements (Fe, Mn, Zn, Cu) as well as organic matter (OM), nitrogen (N), phosphorous (P) and Potassium (K). On the other hand, the result (Table 5), also shows that oil pollution depressed soil pH, exchangeable Ca and Mg, effective cation exchange capacity (ECEC) exchangeable acidity (EA) and cadmium (Cd) content.

The above result is in line with the observations of several other workers in similar studies. Ekundayo et al., (1989) had observed that oil pollution leads to build up of P in soils. Also, Kayode et al., (2009) had observed that oil pollution altered the physical and chemical properties of the soil and resulted in increased bulk density, water porosity, organic matter content and reduced soil capillarity, soil aeration, water holding capacity, soil nitrogen, phosphorus and potassium among others. The increase in soil bulk density can be attributed to the destruction of soil structure which in turn can reduce root penetrations of crops and subsequently impedes nutrient up-take from the soil.

The result of this study has also indicated that environmental pollution, although generally considered to be deleterious, may have some beneficial effect by adding some micro-and macro nutrients to the soil. However, as observed by Wang et al. (2010) and Udoh and Chukwu (2014), the level of soil contamination and impact of oil residuals on soil quality greatly depends on the length of time the oil well was in production as well as on the magnitude and frequency of occurrence of pollution.

Table 5: *Comparing the mean values of soil properties between the three locations, oil affected site (OAS), industrial waste affected site (IWAS) and non-contaminated site (NCS)*

Soil Properties	OAS	IWAS	NCS	Critical	Range
Sand (g/kg)	855.48b	896.69a	824.66c	26.09	27.40
Silt (g/kg)	25.30a	25.86a	37.73a	23.39	24.57
Clay (g/kg)	117.97a	77.00b	138.70a	25.43	26.71
OC (g/kg)	19.60a	9.80b	14.90ab	5.759	6.049
TN (g/kg)	0.90a	0.40b	0.60ab	2.411	2.533
Av.P (mg/kg)	15.53a	1.33b	5.44b	5.247	5.512
pH	5.53a	5.52a	5.69a	0.259	0.272
Exch.Ca (cmol/kg)	4.15b	6.50a	5.01ab	1.534	1.611
Mg (cmol/kg)	2.07a	2.84a	2.90a	1.158	1.217
K (cmol/kg)	0.84a	0.50a	0.25a	0.623	0.654
Na (cmol/kg)	0.12a	0.80b	0.12a	0.210	0.022
ECEC (cmol/kg)	8.87b	11.32a	11.01a	1.979	2.079
B.Sat (%)	79.85b	87.50a	74.68b	5.409	5.682
EA (cmol)	1.71b	1.41b	2.67a	0.494	0.519
BD (g/cm3)	2.00a	1.91a	1.85a	0.186	0.795
HC (cm/min)	0.34a	0.10b	0.21ab	0.131	0.138
Fe (mg/kg)	41.72a	15.43a	20.37a	25.40	26.63
Zn (mg/kg)	3.30a	1.74a	1.86a	2.578	2.703
Cu (mg/kg)	9.16a	10.44a	7.61a	5.536	5.806
Mn (mg/kg)	27.05a	14.88b	14.41b	6.306	6.613
Cd (mg/kg)	0.18b	0.22b	0.98a	0.535	0.5614
Pb (mg/kg)	1.35a	0.59b	0.67b	0.316	0.3312
THC (mg/kg)	146.67a	117.78b	97.78c	67.44	70.72

BD= bulk density, HC = saturated hydraulic conducivity, OC=organic carbon, TN=total nitrogen, Av.P= available phosphorus, Exch.Ca = exchangeable calcium, Exch. Mg=exchangeable magnesium, Exch. Na=exchangeable sodium, Exch. K= exchangeable potassium, ECEC = effective cation exchange capacity, Bsat=base saturation, Fe=iron, Zn=zinc, Cu=copper, Mn=manganese, Cd=cadmium, Pb=lead, THC = total hydrocarbon; a,b,c, = means with the same letter in the same row are not significantly different

4. Conclusion:

The result of this study has shown that environmental pollution by oil spillage and industrial wastes has significant effects on the land/soil quality and characteristics. Soil formation and development, as well as the physical, chemical and biological characteristics of the soils, were seriously altered. Total hydrocarbon content of soils and lead (Pb) were increased. This may have serious implications on the agricultural productivity of the land, and consequently on food security.

Nevertheless, the study also revealed that environmental pollution both by oil and industrial wastes may add some essential plant nutrient elements to the soil and bring about an improvement in the land/soil quality and characteristics. For instance, this study showed that, compared with the control (NCS), oil polluted soils had higher organic carbon (OC), total nitrogen (N), available phosphorus (P), exchangeable potassium (K), base saturation (BS), micronutrients (Fe, Zn, Cu, Mn) and lower exchangeable acidity (EA). Similarly, industrial wastes polluted soils had higher exchangeable calcium (Ca) and K, BS, effective cation exchange capacity (ECEC) and lower EA.

Therefore, a better understanding of the immediate and long term effects of pollution on the environment in areas prone to these activities is imperative. This will facilitate the development of appropriate remediation and land management practices that would ameliorate the harmful and hazardous effects, including the danger of soil nutrient imbalances and toxicity usually associated with this pollution. If properly managed, polluted land may not only be reclaimed for agricultural and other land uses, but with time, there may be marked improvement in the land/soil qualities and characteristics because of the essential nutrients and positive influences imparted to the soil during the pollution.

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