PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOILS AFFECTED BY OIL SPILLAGE IN IHUGBOGO COMMUNITY, AHOADA EAST, SOUTHERN NIGERIA

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Abstract

The research work was carried out in Ihugbogo community Ahoada East, Southern Nigeria to investigate the physical and chemical characteristics of soils affected by oil spillage. The study location was identified along an oil pipeline track belonging to TOTAL E&P Nig. that cuts across major farmlands in the area. A transect survey sampling technique was used in this research work. The three major locations investigated designated as Location A, B and C had experienced oil spill in 1995, 2002 and 2007 respectively. Three profile pits were sunk in the following oil spilled locations in Ihugbogo at some intervals apart. The bulk density was highest in location A (1.61 g/cm^3), followed by location C (1.55 g/cm^3) while the lowest occurred at location B (1.43 g/cm^3). Silt – clay ratio were high when critical limits were considered suggesting young soils in all investigated soils. The exchangeable cations were dominated by acidity suggesting that the oil spillage in the area has greatly depleted the basic cations leading to the soils being higher in Al saturation (49.0, 59.0 and 51.0 5 %) and lower in base saturation (35.0, 24.0 and 44.25 %) in locations A, B and C respectively. This situation therefore indicates that crops planted in these soils will experience growth retardation; poor stem development and wilting.

Keywords: Oil Spillage, Soil nutrients, Soil Characteristics, Soil contamination.

Introduction

Contamination of soils by oil spill is a wide spread of environmental problem that requires cleaning up of the contaminated site. Oil may affect soils in two ways; it may penetrate into the soil, where it directly affects the plant root system, microbial population and oxygen content. Crude oil in soil makes the soil condition unsatisfactory for plant growth. Oil spill affects plants by creating condition which makes essential nutrient like nitrogen and oxygen needed for plant growth unavailable to them (Adam and Duncan, 2002). Due to reduction in the available plant nutrient or rise in toxic levels of certain element such as iron and zinc (Udo and Fayemi,1975), plants are highly susceptible to oil exposure and this kills them within a few weeks to several months. The general increase of heavy metal content in the soil has been largely caused by crude oil spillage (Anoliefo *et. al.*, 1995). Plant root can absorb heavy metal in the soil most especially where there is contamination (Jardao *et. al.*, 2006). When these heavy metals are taken up by plant roots, it results in chlorosis, weak plant growth, yield reduction, reduced nutrient uptake, disorders in plant metabolism and reduced ability to fix molecular nitrogen leguminous plant (Guala *et. al.*, 2010). The uptake of these heavy metals by plants and accumulation in the food chain is a serious threat to both animal and human health (Sprynskyy *et. al.*, 2007). The presence of heavy metal in human body is toxic and they accumulate in the soft tissues. High level ingestion of toxic metals has undesirable effect on human which becomes obvious only after several years of exposure to it (khan *et. al.*, 2008). Oil spill have degraded most agricultural land in the state and have turn hitherto productive areas into waste land with increasing soil infertility due to the destruction of soil micro organism, and dwindling agricultural productivity. Farmers have been forced to abandon their land, to seek nonexistent alternative means of livelihood. Aquatic lives have also being destroyed with the pollution of traditional fishing ground exacerbating hunger and poverty in fishing communities. Many researchers have reported a lower rate of germination in petroleum or its derivative contaminated soil (Vevrek and Campbell., 2002). Petroleum hydrocarbon may form a film on the seed, preventing the entry of oxygen and water (Adam *et al.*, 2002) and toxic hydrocarbon molecule could inhibit the activities of amylase and starch phophorlylase and thereby consisting of small molecules and those that are water soluble are more phototoxic for the germination. The main objective of the study is to evaluate the effect of oil spillage on the physical and chemical properties of soil in Ahoada East, Southern Nigeria.

STUDY AREA

Location

Ahoada is located on the Latitude 5^o 07’ 01” and 5^o 4’ 26” N and Longitude 6^o 39’ 12” and 6^o65’ 01” E. Elevation is below 100m above the sea level. The rainfall distribution is seasonal, rain occurs, on the average, every month of the year, but with varying duration. It is characterized by high rainfall, which decreases from south to north. Total annual rainfall ranges from 2,700mm to 3,500mm in the region. The maximum monthly temperature ranges from 28^0C to 33^0C, while the mean minimum monthly temperatures are in the range of 17^0C to 24^0C. The hottest months are February to April. The difference between the dry season and the wet season temperature is only about 2^0C. Relative humidity is high (91 – 94%) throughout the year and decreases slightly in the dry season.

Location Coordinates of Study area

Location	Long.	Lat.	Elevation (m)
ILA	6^o 65’’	5^o 19’’	60
ILB	6^o 54’’	5^o 23’’	60
ILC	6^o 60’’	5^o 11’’	61

ILA, B and C: Ihugbogo locations A, B and C

Socio-economic Activities

About 50 percent of the active labour force engages in one form of agricultural activity or another in which about 30 percent are women. The predominant food crops in the area are yam, cassava, plantain, maize, cocoyam, and vegetable. The dominant trees are Mahogany (Angio spp), Obeche (Protobullas spp) and Iroko (cassia spp).

Field Work

A reconnaissance study was carried out and the study location identified in Ihugbogo community along an oil pipeline track that cuts across major farmlands in the area. The three major locations investigated designated as Location A, B and C had experienced spillage in 1995, 2002 and 2007 respectively. Three profile pits were sunk in the following oil spilled location in Ihugbogo at some intervals apart. The morphological properties such as texture, structure, boundary and roots were determined. Soil samples were collected according to colour difference along the horizon in the profile pits respectively. The profile pits were described using the procedure outlined by the FAO (1983). Soil sample collected were air dried and sieved using a 2mm sieve.

Laboratory Analysis

The following soil properties were determined by standard routine laboratory methods as follows: The particle size distribution was determined by hydrometer method according to the procedures of (Gee and Or, 2002), Bulk density was measured by core method (Grossman and Reinsch, 2002). Porosity was computed from bulk density and particle density. Soil p^H was determined potentiometrically in 1:25 soil liquid ratio (Hendershot *et al.*, 1993). Organic carbon was determined using method described by (Nelson and Sommers, 1982) and the result of organic carbon was multiplied by 1.724 to determine the organic matter content. Total available phosphorus was determined using Bray II method (Olsen and Sommers, 1982).Total Nitrogen was determined using kjeidal digestion and technicon/Auts analyzer method. Exchangeable base was determined by extraction of ammonia acetate (NH_4O_{AC}) of pH 7.0 known as extractant in determining calcium, magnesium while sodium and potassium was determined using flame photometer. The exchangeable acidity was determined using extraction of exchangeable H^+ and $Al^{3+}$with KCl and titrated as outlined by (Mclaren et al., 1994). The effective cation capacity was estimated by the summation of all the exchangeable base and acidity.

Statistical Analysis

Coefficient of variation (C.V) ranked as follows: low variation ≤ 15%, moderate variation > 15≤36%. High variation >35% will be used to estimate the degree of variability of soil properties (Wilding et al., 1994).

Results and Discussion

The morphological characteristics of soils of Ihugbogo as revealed in Tables 1, indicated that Locations A and C, had their structure ranged from crumbs at the uppermost horizon to blocky and sub angular blocky at the lower horizons. Also there were few mottles, many roots at the uppermost horizons and few roots down the horizons. In Location B however (Table 1), structure ranged from crumby at the surface horizon to prismatic at the subsurface horizons. Root abundance ranged from many to very few down the horizons. At this location, mottles ranged from very few to many. Since mottles distribution in soils is determined by the redoximorphic characteristics of such soil. It therefore follows that reduction and oxidation reaction in these soils have been affected by the oil spillage that occurred in these soils. However, mottles ranged from few to very many in Ihugbogo location B soils indicating that a better oxidation and reduction reactions may be taking place at this location. The duration, intensity and age of spillage could be a factor in the mottling behavior of soils being investigated.

Table 1: Morphological Properties of the Studied Soils

IHUGBOGO LOCATION A

HORIZON	STRUCTURE	HORIZON BOUNDARY	ROOT	MOTTLES
1	Crumby	Abrupt	Many	______
2	Crumby	Wavy	Few	Very few
3	Blocky & sub angular	Abrupt	Few	______
4	Blocky & sub angular		Few	_______

IHUGBOGO LOCATION B

HORIZON	STRUCTURE	HORIZON BOUNDARY	ROOT	MOTTLES
1	Crumby	Abrupt	Many	______
2	Blocky & sub angular	Gradual	______	Very few
3	Blocky & sub angular	Gradual	Few	Few
4	Prismatic		Very few	Many

IHUGBOGO LOCATION C

HORIZON	STRUCTURE	HORIZON BOUNDARY	ROOT	MOTTLES
1	Crumby	Abrupt	Many	______
2	Crumby	Wavey	Few	Very few
3	Blocky & sub angular	Abrupt	Few	______
4	Block & sub angular	_______	Few	_______

Table 2: Soil physical properties of the site

Sample	Horiz Depth	Sand (%)	Silt (%)	Clay (%)	SCR	BD (g/cm3)	TC(%)
Ihugbogo location A							
A	0-18	66.96	19.28	13.76	1.401	1.51	SL
AB	18-35	66.96	27.28	5.76	4.736	1.64	SL
B	35-58	70.96	21.28	7.76	2.740	1.61	SL
BC	58-107	86.96	7.28	5.76	1.263	1.68	LS
Mean		72.96	18.78	8.26	2.534	1.61	
variance		1585.21	70.33	14.33			
SD		39.81	8.39	3.79			
CV %		10.85	44.66	45.83	17.25	7.06	
Ihugbogo location B							
A	0-19	58.96	13.28	13.76	0.96	1.40	SCL
AB	19-43	55.96	30.28	27.76	1.09	1.49	SL
B	43-75	52.96	23.28	23.76	0.97	1.41	SCL
BC	75-121	50.96	27.28	21.76	1.25	1.42	SCL
Mean		54.71	23.53	21.76	1.06	1.43	
variance		12.25	54.92	34.67			
SD		3.50	7.41	5.89			
CV %		6.40	31.49	27.06	24.65	5.98	
Ihugbogo location C							
A	0 - 20	82.96	9.28	8.76	1.06	1.52	SL
AB	2 -37	81.96	10.28	7.76	1.32	1.54	LS
B	37 – 68	78.96	9.28	10.76	0.86	1.56	SL
BC	68 – 109	78.96	7.28	11.76	0.61	1.55	SL
Mean		80.96	9.03	9.76	0.96	1.55	
variance		8.00	6.67	0.20			
SD		2.83	2.58	0.44			
CV %		3.49	31.18	22.93	28.23	5.56	

LS= loamy soil, SL= sandy loam, SCL= sandy clay loam

The results of physical properties are as shown in Table 2. Sandiness increased in location A while it decreased in locations B and C. Mean sand was 72.96, 54.71 and 80.96% in locations A, B and C respectively. Silt distribution increased from horizon A to AB and then decreased in down the profile at location A. However, silt increased first in all locations and then decreased subsequently. The mean silt in locations A, B and C were 18.78, 23.53 and 9.03% respectively. Clay had no particular trend in their distributions within the horizons although there were more clay contents near the surface at locations A and B while it increased down the profile at location C. Mean clay contents were 8.26, 21.76 and 9.76% at locations A, B and C respectively. Silt-clay ratio had no particular trend in their distributions across the horizons. Silt –clay ratio can be said to be high in the investigated soils especially at location A where mean SCR scored 2.534, followed by location B (1.06) while Location C scored 0.96. The high silt – clay content of these soils suggests that soils under investigation are young soils. The values of the silt – clay ratio of the soils were 2.534, 1.06 and 0.96 in locations A, B and C an indication that the soils are not old soils derived from old parent materials and is of intense degree of weathering; as old soils usually have silt – clay ratio less than 0.15, with low degree of weathering (Eze, 2014).

Bulk density increased down the profile in all investigated soils and was higher at location A where mean bulk density was 1.61 g/cm3, followed by location C which had 1.55 g/cm3 while pedon B location scored 1.43g/cm3. This invariably suggests a higher pore spaces at the surface horizons of soils. Oil spillage tends to block the pore spaces in the soils resulting to the death of soil microbes due to lack of oxygen. This situation reduces mineralization of organic substances. High pore spaces recorded in the surface horizons may be attributed to loosening of soil materials during puddling/cultivation of soil as well as the decreasing effects of oil spillage down the horizons on the studied soils.

The relative high bulk density of the investigated soils, especially at location A may be due to soil compaction as a result of oil spillage. The increasing trend of bulk density in the investigated soils corroborates with those of Onweremadu *et al*., (2007) and Chikezie *et al*., (2009)

Akamigbo, (1999) reported that low soil organic matter was responsible for increased bulk density in cultivated soils of Southeastern Nigeria. Ahukaemere and Akpan (2013) suggest that there could be the possibility of migrating clay filling up the pore spaces in the horizons of illuviation may account for the high bulk density values in the sub-surface horizons. Moreover, frequent cultivation of land made the soil loose and ultimately contributed for the low density in these layers. Results on bulk density were less than the critical limits for root restriction (1.75 – 1.85 g/cm^3) (soil survey staff, 1996) indicating the potential of the soil to support arable crop production. The soils textural class of the investigated soils indicated that location A ranged from sandy loam to loamy sand, location B had sandy clay loam as it dominant texture while location C had a dominant sandy loam texture.

The chemical properties of soils of Ihugbogo soils are as shown in Tables 3. Soil pH as measured in KCl was high in Locations A, B and C and their means were 4.86, 4.89 and 4.86 respectively. Organic matter decreased down the profile in all investigated pedons of soils of Ihugbogo and means were distribution was highest in location A (2.86%) followed by location C (1.93%) while the lowest organic matter was found in location B (1.3%). Also total nitrogen (TN) decreased down the profile in all investigated soils. Total N had means of 0.15, 0.07 and 0.1% in locations A, B and C respectively.

Table 3: Chemical Properties of the site

Ihugbogo Location A

sample	pH (H_20)	pH (KCL)	OC (%)	OM (%)	TN (%)	Av.P (mg/kg)	Ca^{2+}	Mg^{2+}	K^+	Na^+	Al^{3+}	H^+	TEA	TEB	ECEC	BS (%)	Al. Sat (%)
							←				Cmol/kg				→		
A	5.39	4.83	1.88	3.24	0.16	7.07	0.40	0.14	0.04	0.08	1.12	0.36	1.48	0.67	2.15	31	52
AB	5.95	5.21	1.34	2.31	0.12	3.79	0.08	0.27	0.02	0.13	1.56	0.24	1.80	0.49	2.29	22	68
B	5.02	4.98	1.78	3.07	0.16	5.20	0.08	0.08	0.04	0.11	1.72	0.96	2.68	0.32	3.00	11	57
BC	4.89	4.43	1.64	2.83	0.14	5.54	2.88	4.13	0.04	0.12	1.84	0.44	2.28	7.17	9.45	76	19
MEAN	5.31	4.86	1.66	2.86	0.15	5.40	0.86	1.16	0.04	0.11	1.56	0.50	2.06	2.16	4.22	35	49
VARIANCE	0.23	0.11	0.16	0.16	0.00	1.81	1.84	3.94	0.00	0.00	0.10	0.10	0.28	11.16	12.28	08	
SD	0.47	0.33	0.41	0.40	0.02	1.35	1.36	1.98	0.02	0.04	0.31	0.32	0.50	3.34	3.50	0.29	
CV (%)	8.85	6.75	24.45	14.2	13.3	24.94	157.5	171.	50.0	32.7	20.19	20.16	25.6	154.6	83.05	81.1	27.2

Ihugbogo Location B

sample	pH (H_20)	pH (KCL)	OC (%)	OM (%)	TN (%)	Av.P (mg/kg)	Ca^{2+}	Mg^{2+}	K^+	Na^+	Al^{3+}	H^+	TEA	TEB	ECEC	BS (%)	Al. Sat (%)
A	5.47	4.88	1.06	1.83	0.11	2.98	0.32	1.33	0.05	0.13	1.60	0.40	2.00	1.83	3.83	48	41.8
AB	5.50	5.03	0.38	0.66	0.04	1.35	0.32	0.27	0.04	0.08	2.32	0.28	2.60	0.71	3.31	22	70.1
B	5.31	4.87	0.24	0.41	0.02	5.62	0.08	0.27	0.04	0.08	2.52	0.20	2.72	0.47	3.19	15	79.0
BC	5.15	4.77	1.34	2.31	0.12	5.15	0.17	0.13	0.03	0.05	2.04	1.76	3.80	0.39	4.19	9	48.7
MEAN	5.36	4.89	0.76	1.30	0.07	3.78	0.22	0.50	0.04	0.09	2.12	0.66	2.78	0.85	3.63	24	59.9
VARIANCE	0.03	0.01	0.28	0.83	0.00	3.94	0.01	0.31	0.00	0.00	0.16	0.54	0.56	0.45	0.22	3	
SD	0.16	0.11	0.53	0.91	0.05	1.98	0.12	0.56	0.01	0.06	0.40	0.74	0.75	0.67	0.47	0.2	
CV (%)	3.01	2.19	69.67	70.25	71.43	52.48	53.77	111.	35.3	64.8	18.80	111.	26.9	78.51	12.82	71.	14.6

Ihugbogo Location C

sample	pH (H_20)	pH (KCL)	OC (%)	OM (%)	TN (%)	Av.P (mg/kg)	Ca^{2+}	Mg^{2+}	K^+	Na^+	Al^{3+}	H^+	TEA	TEB	ECEC	BS (%)	Al. Sat (%)
A	5.31	4.60	1.42	2.45	0.12	6.60	4.16	4.80	0.04	0.06	1.16	0.04	1.20	9.06	10.26	88	11.3
AB	5.17	4.61	0.80	1.38	0.07	3.98	0.08	0.08	0.05	0.16	1.88	0.20	2.08	0.37	2.45	15	76.7
B	5.30	4.58	1.18	2.03	0.10	2.95	0.10	0.83	0.04	0.15	1.88	0.24	2.12	1.13	3.25	35	57.8
BC	6.42	5.63	1.08	1.86	0.09	5.20	0.40	0.53	0.03	0.17	1.76	0.04	1.80	1.13	2.93	39	60.0
MEAN	5.55	4.86	1.12	1.93	0.10	4.68	1.19	1.56	0.04	0.14	1.67	0.13	1.80	2.92	4.72	44.25	51.5
VARIANCE	0.34	0.27	0.07	0.20	0.00	2.48	3.96	4.76	0.00	0.00	0.12	0.01	0.18	16.87	13.74	2.45	
SD	0.58	0.52	0.26	0.44	0.02	1.57	1.99	2.18	0.01	0.05	0.34	0.10	0.42	4.11	3.71	1.56	
CV (%)	10.51	10.63	22.90	22.93	21.40	33.65	167.12	139.86	35.2	36.3	20.63	80.62	23.59	140.66	78.52	88.35	32.4

OC= organic carbon, OM= organic matter, TN= total nitrogen, TEB= total exchangeable base, TEA= total exchangeable acidity, CV= coefficient of variation, Avail. P= available phosphorus, ECEC = Effective Cation Exchange Capacity, BS= Base Saturation

Available P had no particular trend in the profiles of the investigated soils although the surface soils had higher available P compared to the distribution down the horizons especially in pedons A and C while pedon B tend to have more available P in its last two horizons. Available P was highest in location A having 5.40 mg/kg, followed by location C having 4.68 mg/kg while location B had the lowest of 3.78 mg/kg in the investigated soils. The phosphorus content of the representative pedons is generally low based on the rating for Nigerian soils (<15 mg kg-1) (Enwezor *et al.*, 1990; Adepetu, 2000). Generally, the low phosphorus content may be due to high soil acidity (Uzoho *et al*., 2004).

The P content could be attributed to strongly to moderate acidic soils (pH < 5.0) which are not conducive for the release of P. It has been reported that in acid soils, P is fixed by acidic Al (Enwenzor *et al*., 1989).

Examination of exchangeable cations shows that calcium (Ca) had no particular trend although it tends to increase down the profile in location A, however, in locations B and C, Ca decreased down the profile. Mean Ca distribution in the examined pedons were 0.86, 0.22 and 1.19 Cmol/kg in locations A, B and C respectively. The Ca content of the soils were very low (<2 Cmol/kg) according to Tabi et al., 2012). Abii and Nwosu (2009) who worked on soils of the region stated that oil spillage reduces the exchangeable basic cation content of soils. The low Ca content may lead to poor stem growth and discoloration of crops and low crop yield (Awilo and Badejo, 2005). Exchangeable magnesium (Mg) had a similar trend with Ca where it increased down the profile in location A and decreased in B and C. Mg contents of these soils were low as means were 1.16, 0.50 and 1.56 Cmol/kg in A, B and C locations respectively. Potassium (K) contents of the investigated soils were the lowest at it registered 0.04 Cmol/kg in all locations of the studied soil. Also, Tabi (2012) noted that K content of any soils less that 0.1 cmol/kg is very low, while Adenye et al., (2002) puts the critical limits of K at 0.2 cmol/kg. This situation therefore suggests that crops planted in these soils will experience growth retardation; poor stem development and wilting (Atubi 2006; Brady and Weil, 1999). The Sodium (Na) contents had not particular trend of distribution in all locations with means of 0.11, 0.09 and 0.14 Cmol/kg. However, Na content of the soils being investigated were low (Tabi 2012) yet were higher in contents than Ca in location A and K in all locations. This implies that oil spillage tend to increase the Na contents of the soils as corroborating Odu (1972). Despite Na being one of the essential trace elements needed by plants, it is however not an index for effective productivity according to Abii and Nwosu (2009). Exchangeable Al dominated the studied soils and increased down the profile in virtually all locations. The means of Al distribution were 1.56, 2.12 and 1.67 Cmol/kg in locations A, B and C respectively. This high Al concentration of their overall effective cations has however led to high Al saturation in the studied soils at the expense of Exchangeable bases such as Ca and Mg which were low. With the levels of exchangeable bases, the soils lack adsorptive capacity for nutrients. The low effective CEC of these soils indicates their low capacity to retain nutrient elements, and low CEC renders soils unsuitable for intensive agriculture (Kparmwang *et al*.; 2004). The low effective CEC of the soils resulted from the effect of oil spillage on the soils of Ihugbogo community. The effective CEC had means of 4.22, 3.63 and 4.72 cmol/kg which Tabi (2012) noted to be very low as mean values were >20 cmol/kg. Also, the Effective CEC were dominated by exchangeable Al which is an acidic cation thereby leading to the preponderance of acidity in the investigated soils. The results especially the acidic nature of the soils and the deficiency of exchangeable bases indicate that the soils are generally not fertile (base saturation <50 %) (Landon, 1984; Eze 2013).

The acid nature of the soils may be due to high intensity rainfall in the area, which leaches basic cations down the profile. This is because Ihugbogo is situated in the tropical rainforest of the southern Nigeria where rainfall and other climatic factors are intense. Enwezor *et al*. (1981) stated that leaching of Ca and Mg is largely responsible for acidity development in soils. Also, it may be due to Al saturation of the exchange complex.

Table 4: Variability of Some Selected Soil Properties

	Location A		Location B		Location C	
Soil Properties	CV (%)	Rank	CV (%)	Rank	CV (%)	Rank
Sand	10.85	LV	6.40	LV	3.49	LV
Silt	44.44	HV	31.49	MV	31.18	MV
Clay	45.83	HV	27.06	MV	34.03	MV
pH (KCl	6.75	LV	2.19	LV	10.51	LV
OM	24.45	LV	70.25	HV	22.93	MV
Avail. P	24.94	MV	52.6	HV	154	HV
TEA	25.6	MV	26.9	MV	23.59	MV
TEB	154	HV	78.51	HV	140.7	HV
ECEC	83.05	HV	12.82	LV	78.35	HV

LV= low variation, MV= moderate variation, HV= high variation.

The variability of the soils properties of the investigated region as shown in Table 4 shows that sand and pH varied lowly (CV≥15%) in all the investigated soils. Silt and clay varied highly (CV >35%) in location A but moderate (CV > 15≤ 35%) in locations A and B. Organic matter varied moderately (CV > 15≤ 35%) in locations A and C and highly (CV>35%) in location B. Available P was moderate (CV > 15≤ 35%) in location A and High (CV>35%) in location C. Total exchangeable acidity (TEA) varied moderately (CV > 15≤ 35%) in all investigated locations. Total exchangeable bases (TEB) varied highly (CV>35%) in all locations while effective CEC varied highly (CV>35%) in locations A and C and lowly (CV≤15%) in location B.

CONCLUSION

The investigated soils were very low in exchangeable bases when critical limits were considered leading to very low base saturation. Al saturation was higher than normal in the investigated soils. Among the major effects of oil spillage of Ihugbogo soils was depletion of basic cations leading to over saturation of the exchangeable sites with acidic cations. However, Na contents of the soils being investigated were low, yet higher in contents than Ca in location A and K in all locations. This implies that oil spillage tend to increase the Na contents of the soils. Despite Na being one of the essential trace elements needed by plants, it is however not an index for effective productivity. This situation therefore suggests that crops planted in these soils will experience growth retardation; poor stem development and wilting.

REFERENCE

Abii T. A and Nwosu P.C. (2009). The effect of Oil spillage on the soils of Eleme Rivers State of the Niger-Delta Area of Nigeria. *Research Journal of Environmental Sciences. 3:316 – 320.*

Adam, G and Duncan, H. J (2002): Influence of diesel fuel on the seed germination. *Environ. Pollution 120:o363-370.*

Adepetu, J. A. (2000). Interpretation of soil test data. In: Simple Soil, Water and Plant Testing Technologies for Soil Resource Management. IITA Ibadan/FAO Rome, pp. 89-97.

Ahukaemere, C.M. and Akpan, E. L.(2012). Fertility Status and Characterization of Paddy Soils of Amasiri In Ebonyi State, Southeastern Nigeria. *2012; 8 (2): 159-168 ISSN: 0794-5213 Online copy available at www.patnsukjournal.net/currentissue*

Akamigbo, F.O.R., (1999). Influence of land use on soil properties of the humid tropical agro-ecology of Southeastern Nigeria. Niger Agric J. 30: 59-76.

Aneliefo, G.O. and Vwioko, D.E(1995) Effect of spent lubrication oil on the growth of capsicum anum L. and Hycoperscion esculentum Miller. Environmental pollution,88,361-364.http://dx.doi.org/10.1016/0269-7491 (95)93451-5

Atubi A. O. and Anokala P.C. (2006). The socio-economic effects of oil spillage on Agriculture in the Niger-Delta. J. Environ. Stud.,2: 50 – 56.

Awilo C. and Badejo O. T. (2005). Management of Oil Spill Along the Nigeria Coastal Areas. First Edn., University of Lagos Press, Nigeria.

Brady N. C. and Weil R. R. (1999). The nature and properties of Soil 12th Edition Prentice Hall Inc., New Jersey, USA., Page: 785.

Chikezie, A., Eswaran, H., Asawalam, D.O., and Ano, A.O. (2009). Characterization of the benchmark soils of contrasting parent materials in Abia State, South-eastern Nigeria. Global J. of Pure and Applied Sciences 16(1) 23-29.

Enwenzor, W. O., Udo, E. J. and Sobulo, R. A. (1981). Fertility status and the productivity of the acid sands. In: Acid sand of South Eastern Nigeria, Soil Science Society of Nigeria.

Enwenzor, W. O.; Udo, E. J.; Usoroh, N. J.; Ayotade, K. A.; Adepetu, J. A.; Chude, V. O. and Udegbe, C. I. (1989). Fertilizer use and management practices for crops in Nigeria Series, 2: 63-64.

Enwezor, W.O., Ohiri, A.C., Opuwaribo, E.E, and Udo, E. J. (1990). Literature review on soil fertility investigation in Nigeria. Federal ministry of Natural Resources Lagos. Pp 36.45

Eze N. C. (2014). Soil Characterization and land Suitability Evaluation of Nnuka Farmland in Nsukka Local Government Area of Enugu State, Nigeria. An MSc. Thesis submitted to the department of soil science university of nigeria, nsukka. Univ. of Nig. Virtual Library.

Gee, G. W., and Or D. (2002). Particule size distribution: in Dane JH., Topp G.C(eds). Methods of soil analysis part 4 physical methods.soil sci. so. Am. Book series No.5 ASA and SSSA, Madison WI 2002;201-228.

Grossman, R.B and T.G. Reinch, (2002). Bulk density and linear extensibility in: methods of soil analysis part 4. Physical methods. Dane, J.H and G.C. Topp (eds). Soil Science Soc.Am.Book series No.5. ASA and SSA Madison,W.I, Pp: 201-228.

Guala, S.D., Vega, F.A. and Covelo, E.F. (2010) The dynamics of heavy metals in plant-soil interactions.Ecology modeling. 221,1148-1152. http://dx.doi.org/10.1016/j.ecolmodel.2010.01.003

Hendershot ,W.H., Lalande, H., Duqyette, M.(1993): soil reaction and exchangeable acidity. In: carte M.R. (ed). Soil sampling and methods of soil analysis can.sol.soil.sci.Lewis publisher London,141-145.

Jordao, c.p., Nascentes, C.c, cecon, P.R., Fontes, R.L.F. and Pereira, J.L.(2006) Heavy metal availability in soil amended with composted urban solid wastes. Environmental monitoring and Assessment, 112,309-326.

Khan, S., Cao, Q., zheng, Y.M., Huang, Y.Z and Zhu, Y.G. (2008) Health risks of heavy metals in contaminated soils and food crops irrigated with waste water In Beijing, china Environmental pollution, 152,686-692. http://dx.doi.org/10.1016/j.envepol. 2007.06.056

Kparmwang, T., V.O. Chude, B.A., Raji and A.C. Odenze 2000. Extractible micronutrient in some soils developed on sandstone and shale in the Benue valley, Nigeria. Nigeria J. Soil Resources 1:42-48.

Landon, J. R. (1984). Booker Tropical Manual. A handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Booker Agricultural International Ltd, UK.

Mclaren, C.G., Carey, P.I., Cameron, K.C. Adams, J.A. and Sedole, J.R. (1994). Effect of soil properties and contract period on the leaching of copper, chromium and arsenic through undistributed soil. Tans 15th World Congress, soil sci. 3a: 156-169.

Nelson, D.W and sommers L.E (1982). Total carbon, organic carbon and organic matter in :sparks, D.l. (Eds.), Methods of soil analysis. Part 3.SSSA Books series NO 5 SSSA Madison.

Odu C.T. (1972). Microbiology of soils contaminated with petroleum hydrocarbons. J. Environ. Microbiol., 58: 201 – 208

Olson, S. R and Sommers, L.E.(1982). Phosphorus in: Method of soil analysis. A.l. page, R. Hmiller and D.R.keeney(eds). Maidsion, W.I Americal society of agronomy.1572pp.

Onweremadu, E.U., Ndukwu, B.N., Opara, C.C and Onyia, V.N (2007). Characterization of wetland soils of Zarama, Bayelsa, State, Nigeria in relation to Fe and Mn distribution. Int. J. of Agriculture and Food Systems 1(1):80-86.

Sprnynskyy, M., Kosobucki, P., kowolkowski, T. and buszewsk, B. (2007) influence ofclinoptilolite rock on chemical speciation of selected heavy metal in sewage sludge. Journal of harzardous Materials, 149,310-316. http://dx.doi.org/10.1016/j.jhazmat.2007.04.001

Tabi F.O, Omoko M, Boukong A, Mvondo Z.A.D., Bitondo D and Fuh C. C. (2012). Evaluation of lowland rice (*Oryza sativa*) production system and management recommendations for Logone and Chari flood plain – Republic of Cameroon. Agricultural Science Research Journals Vol. 2(5); pp. 261-273.

Udo, E. J., Fayemi, A. A., 1975. The effect of oil pollution of soil on germination, growth and nutrient uptake of Corn. *J. Environ. Qual., 4: 537-540.*

Uzoho, B. U. and Oti, N. N. (2004). Phosphorus adsorption characteristics of selected Southeastern Nigeria soils. In: Proceeding of the 29th Annual conference of the Soil Science Society of Nigeria, pp. 121-131.

Vavrek, M. C. and Campbell, W. J. (2002): contribution of seed bank to fresh water wetland vegetation recovery. Louisiana applied and educational oil spill research and development program OSRADP.

Wilding L. P., Bouma, J. and Boss. D. W (1994). Impact os spatial variability on interpretative modeling. In; Bryant R.B. and R.W.. Arnold- Quantitative modeling of soil forming process. SSSA special publ. No.39:61-7