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Differences in Particle Size Distribution of Soils of Northern Niger Delta of Nigeria as Affected by Crude Oil Pollution

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Abstract: *We conducted a study in particle size distribution of soils affected by crude oil spillage in Izombe, northern Niger Delta of Nigeria in 2009. Profile pits were aligned using the transect soil Survey Technique across 3 sampling units; heavily polluted (HP), moderately polluted (MP) and non-polluted (NP). Soil profile pits were dug, described and samples collected in line with the FAO procedure. Soil samples were subjected to laboratory analysis and soil data analyzed using descriptive statistics. Results showed variations in some soil physical properties as affected by crude oil pollution. Particle size distribution showed little to moderate variation (CV = 0-49%) except clay content that gave high variation (MP). Sand increased in the soils studied. Silt and clay decreased more in the polluted soils than in unpolluted soils studied. Soil structure and consistency in topsoils varied from the soils in subsoils. Root abundance decreased towards polluted soils. Further studies should be carried out to include more parameters with more intensive sampling for use in bio-remediation and in owner-manage farms.*

Keyword: *Pollution, Soil Consistency, Spillage, Soil structure*

1. INTRODUCTION

Soil is a vital natural resource whose relevance covers both agricultural and non-agricultural uses (Zinck, 1990). Variations in soils properties could be attributed to the nature of parent materials (Ibanga, 2006). Soil physical properties influencesthe occurrence and growth of many plant species as well as the movement over and through soil of water and its dissolved nutrients and chemical pollutions (Brady and Weil, 2002).

Certain factors including anthropogenic activities influence soil properties to an appreciable level (Ihem et al, 2010). However, good soil structure is important for a sustainable crop production on agricultural soils because of its influence on water holding capacity, workability, resistance to erosion, nutrients availability and general crop performance (Piccolo and Mbagwu, 1999). Mbagwu and Obi (2003) reported sealing, crushing, nutrient depletion and loss of soil organic matter resulting from soil erosion and these negative changes in soil properties lowers crop yield. Crude oil pollution alters soil properties, which affects the overall capacity of soils to allow optimum growth and development of crops (Onweremadu and Duruigbo, 2007). Crude oil spillage affects land, water, animals, plants and climate change. Crude oil spillage in the soil reduces sediment porosity and gaseous exchange that in turn may have a negative effect on the physiological function of plants (Amadi et al., 1996). Oil spills on the surface of the land usually sink into the soil through the soil pores thereby blocking the pores and leads to a marked reduction of water percolation, possibly due to increased bulk density. Oil spillage results in the volatilization of plant nutrients from the epipedon, evaporation of soil moisture, disintegration of the structure, soil aggregates and texture (Foth, 1984). The impact of oil spills have been experienced in Nigeria and its occurrence is at alarming rate. Crude oil spillage has caused pollution and destroyed several hectares of agricultural soils and aquatic environments. Similarly, reduction in crop yield, declined land productivity and depressed farm income in soil spill farmlands had been observed (Inoni et al., 2006). Oil spillage has been observed to have a direct impact on soil physical properties including soil texture. Similar studies have been conducted in this region with few scholars (Aiyesanmi, 2005, Onweremadu et al., 2007) who studied the effects of heavy metals in automobile soils but with limited information on the influence of crude oil pollution on physical properties of soils. This study therefore investigated the effects of crude oil pollution on some physical properties of soils of northern Niger Delta region of Nigeria.

2. MATERIALS AND METHODS

The study was conducted at farmlands at oil exploration sites at Izombe, northern Niger Delta of Nigeria. The site lies between latitudes $5^0 29^1$ and $5^0 41$'N and longitudes $6^0 37^1$ and $6^0 47^1$E of the equator with an elevation 100 meters above sea level. The major parent material in the study area is coastal plain sands. Theclimate is humid tropical, having a mean annual rainfall of 2500mmand a mean annual temperature range of 25-28^{0}C. Rainforest is the dominant vegetation of the area. The main socio-economic activity of the study site is arable farming and oil exploration activities.

Land preparation of the area is mostly slash-burn system and conventional tillage system of farming.

2.1. Field Studies

We carried out the study in a transect soil survey technique aligned to the major land units in the field. A profile pit closest to the polluted site was assigned heavily polluted, followed by a moderately polluted site, which was 20 meters away from the heavily polluted site and a control profile pit, 2 Km away from the polluted site referred to as unpolluted pit. The profile pits were described according to FAO (1990). Soil samples were collected from the bottommost horizon upwards based on horizon differentiation. A total of twelve (12) soil samples were collected, air-dried, sieved using a 2-mm sieve, preparatory for laboratory analysis.

2.2. Laboratory Analysis

Soil data were subjected to means and coefficient of variation. Variability was ranked according to the procedure of Aweto (1982).

Particle size distribution was estimated by hydrometer method (Gee and Or, 2002). Texture class was determined with the textural triangle chart. Silt-clay ratio was estimated by dividing the values of percentage silt by that of clay counterparts.

3. RESULTS AND DISCUSSION

The results of morphological properties are shown in Table 1. Morphological differences were shown in the soils of the studied site. Soils were browner in polluted soils than in unpolluted soils. Generally the soils were deep (>100cm), well drained and with cleared horizons differentiation. Deep pedons with distincthorizonation is a clear indication of pronounced weathering that had taken place in the soil according to Onweremadu et al., (2005). Similar soil structures were also observed in the epipedons but varied with subsoil horizons.

Table 1. *Soil Morphological Properties*

Horizons	Depth (cm)	MunselColour Matrix (Moist)	Soil Structure	Consistence	Drainage	Roots
			Profile 1 (Heavily Polluted)			
Ap	0-21	10YR $^3/_2$	1 fgr	Very Friable	WD	Few
AB	21-42	10YR $^3/_6$	1 fgr	Very Friable	WD	Very few
Bt_1	42-80	10YR $^3/_1$	2 Co sbk	Firm	WD	Very few
Bt_2	80-132	10YR $^3/_3$	2 Co sbk	Firm	WD	Nil
			Profile 2 (Moderately Polluted)			
Ap	0-18	10YR $^2/_1$	2 fgr	Very Friable	WD	Few
AB	18-34	10YR $^3/_3$	2fCr	Very Friable	WD	Few
Bt_1	34-60	10YR $^2/_1$	2 Co sbk	Firm	WD	Few
Bt_2	60-118	10YR $^{2.5}/_2$	2 Co sbk	Very Firm	PD	Nil
Profile 3 (Non-Polluted)						
Ap	0-22	10YR $^6/_2$	1fgr	Very Friable	WD	Abundant
AB	22-38	10YR $^6/_8$	2f abk	Very Friable	WD	Many
Bt_1	38-74	10YR $^7/_6$	2 Co sbk	Firm	WD	Very few
Bt_2	74-145	10YR $^3/_8$	2 Co sbk	Very Firm	PD	Nil

1 = Weak, 2 = Moderate, F = Fine, gr = granular, cr = crumb, Co = Coarse,
abk = angular blocky, sbk = angular blocky,WD = Well drained, PD = poorly drained.

In the unpolluted soils also, the structures were weak with fine crumb. The soils were very friable, firm and well-drained except in the last horizons in moderately and non-polluted soils which had poor drainage. It could be as a result of blocking of pore spaces by the crude oil leading to reduction of water percolation and breakdown of soil aggregates (soil structure) of the affected site. There were presence of plant roots in the soil samples collected except in the last horizons of the polluted soils- possibly owing to the alteration of soil properties. This finding is in agreement with the findings of Onweremadu and Duruigbo (2007), that oil spillage alters soil properties which affects the overall capacity of soils to allow optimum growth and development of crops. The variability could be due to topography, climate and land use (Esu et al., 1991). The physical properties of the studied soils is shown in Table 2. Soil texture of the site ranges from sand to sandy loam. This reflected the nature of the parent materials from which they were derived (Coastal Plain Sands). Adams et al (1999) opined that soil texture provides a useful guide to a soil potential and usually fixed for a given site. Sandiness of these soils in the studied soilssuggest easy leaching of nutrients and heavy metals (Onweremadu, 2008); it may also suggest the degree of erodibility of the soil of the area studied. Results of the finding (Table 2) showed that silt and clay particles were low. This could be attributed to the effects of pedogenic processes of translocation in which silt and clay particles were moved from the upper horizons to lower horizons. This finding is in line with that of McOliver (1980) that oil spillage results to sandy texture condition of the upper horizon of the soil by reducing the clay content and increasing silt. Increased biotoxicity occurs in soils with less clay content as clay surface are negeatively charged thereby attracting cationic heavy metals (Babel and Opiso, 2007). Similarly, loss of clay could also be as a result of reduction in the activities of the microorganisms due to the penetration of oil through the soil pores. Reduction in the biological activities of the soil tend to decrease the net-clay movement to the soil surface. Loss of clay from the soil surface layer will reduce microaggregate stability and nutrient content implying soil degradation (Lal and Steward, 1990). The silt-clay ratio (Table 2) reflect the weathering stage of parent materials (Mbagwu et al., 1985). It also reveals the erodibility potential of the soils studied. The results showed that the polluted soils are formed over parent materials that are at a more advanced stage of weathering than the parent materials on which the non-polluted soils occur. This is attributed to excessive high rainfall and temperature of the area which quickens weathering activity process. The high rainfall and temperature resulted in the deposition of high volumes of silt-clay, which were carried in from runoff (Ewa-oboho, 1993). Table 3, shows the variability in some soil physical properties of the studied soils. Results revealed that sand had little variation in both polluted and unpolluted soils. Clay particles varied highly in the polluted soils than non-polluted soils while the silt-clay ratio varied highly in moderate polluted soils with moderate variation in non-polluted soils. This could be as a result of landscape position, depositions of high volumes of silt-clay as a result of high rainfall (Ewa-oboho, 1993) as the lighter the particle, the more readily the are transported. Movement of spilled oil eroded lighter particle sizes more than heavier sand-sized particles.

Table 2. *Physical Properties of the soil in the study site*

Depth (cm)	**Horizons gkg**	**Sand** →	← **Silt**	**Clay**	**TC**	**SCR**
Profile 1 (Heavily Polluted)						
Ap	0-21	947	22	31	S	0.71
AB	21-42	907	32	61	S	0.52
Bt_1	42-80	847	62	91	Ls	0.68
Bt_2	80-132	878	77	136	SL	0.57
Mean		872.0	48.3	79.8		0.61
Profile 2 (Moderately Polluted)						
Ap	0-18	921	37	42	S	0.88
AB	18-34	902	42	56	LS	0.75
Bt_1	34-60	804	61	135	SL	0.45
Bt_2	60-118	777	57	116	SL	0.34
Mean		851.0	49.3	99.8		0.49
Profile 3 (Non-Polluted)						
Ap	0-22	871	42	87	LS	0.48
AB	22-38	792	77	131	SL	0.59
Bt_1	38-74	764	130	106	SL	1.23
Bt_2	74-145	727	87	186	SL	0.47
Mean		788.5	84.0	127.5		0.66

Table 3. *Variability in Some Physical Properties of Studied Soils*

		Sand			Silt			Clay			SCR	
Attribute	SP	MP	NP	SP	MP	NP	SP	MP	NP	SP	MP	NP
Mean	872.0	851.0	788.5	48.3	49.3	84.0	79.8	99.8	127.5	0.61	0.49	0.66
CV (%)	6.95	7.24	6.71	45.94	20.30	37.38	48.62	53.30	18.28	13.11	51.02	48.48
Ranking	LV	LV	LV	MV	MV	MV	MV	HV	LV	LV	HV	ML

SP = Several Polluted, MP = Moderately Polluted, NP = Non-Polluted

SCR = Silt-Clay ratio, CV(%) = Coefficient of variation, LV = Little variation, MV = Moderate Variation,

HV = High variation

4. CONCLUSION

Significant variations were shown in the selected physical properties of the soils studied. Crude oil spillage influenced distribution of soil particle sizes. The physical properties in an oil-polluted soils are impaired largely due to the depleting potential of crude oil as it contaminates the soil. Based on our findings, crude oil spillage has great effect on the physical environment; therefore, it becomes necessary that effective and sustainable measures be adopted to mitigate the incidence of oil spillage, reduce its effect by the use of bioremediation in soils for a productive agricultural use.

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