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The Effect of Oil-Spillage on the Soil of Eleme in Rivers State of the Niger-Delta Area of Nigeria

T.A. Abii and P.C. Nwosu
Department of Chemistry, Michael Okpara University of Agriculture Umudike,
P.M.B. 7267, Umuahia Abia State, Nigeria

Abstract: Two oil-spill affected areas (Ogali and Agbonchia) were identified as the study areas while a geographically similar but unaffected area (Aleto) served as control. Sampling site was delimited at each area by the grid technique and soil samples were collected at top surface 0-15 cm and sub-surface 130 cm depth. Some physiochemical properties that reflect soil nutrient content and fertility status (K, Ca, Mg, C, P, pH, Cation Exchange Capacity (CEC) and structure) were determined using standard methods and results from the three areas were compared. There was a significant decrease in the Ca K, P (CEC), as well as a significant increase in the sand fraction and Na content of the oil-spill affected soils of (Ogali and Agbonichia) when compared with the non-affected soil of (Aleto). The acidic nature of the soils could not be attributed entirely to the oil spill since the control soil of Aleto was equally acidic. The results indicate that oil-spill has adversely affected the nutrient level and fertility status of Eleme soil, necessitating the inclusion of Eleme in the ongoing remediation technique for soil cleaning in Rivers State.

Key words: Oil-spill, soil fertility status, nutrient level, adverse effect

INTRODUCTION

Eleme is a community in Rivers State, one of the oil producing and agro-ecological areas in the Niger-Delta region of Nigeria, a region with abundant natural resources including good weather and fertile land for agriculture. Although the level of agricultural production in that region is very low given the abundant resource endowment, it is the largest oil producing zone in the country. It is the base of Nigerian oil and gas industry, generating over 90% of the nation's economy (Odjuvwuederhie *et al*., 2006). Oil exploration and activities have been concentrated in this Niger-Delta region which has over 1000 production oil-wells and over 47,000 km of oil and gas flow lines (Ngobiri *et al*., 2007). These negative impact of this oil activities includes destruction of wild life, lost of fertile soil, pollution of air and water and damage to the ecosystem of the host communities (Aghalino, 2000). The ecological problems observed as a result of oil spill include a brownish vegetation and soil erosion, diminishing resources of the natural ecosystem, fertile land turned barren and adverse effect on the life, health and economy of the people (Roberts, 1997).

Oil spill is an unintentional release of liquid petroleum hydrocarbon into the environment as a result of human activities. They are usually mostly caused by accidents involving oil tankers, barges, refineries, pipelines and oil storage facilities. These accidents can be caused by human mistakes or carelessness and sometimes by natural disaster such as earthquakes, deliberate acts by terrorists, militants or vandals. In Nigeria, the major cause of oil spill is lack of regular maintenance of the pipelines and storage tanks. Most pipelines from the flow stations are absolute being more than

Corresponding Author: T.A. Abii, Department of Chemistry, Michael Okpara University of Agriculture Umudike, P.M.B. 7267, Umuahia Abia State, Nigeria

20 years old making them subject to corrosion and leakage. Some of these pipes are laid above ground level without adequate surveillance, exposing them to wear and tear and other dangers (Oyem, 2001). Another major cause of oil spill here is sabotage which involves bunkering by some unpatriotic Nigerians. They damage pipelines in the attempt to steal oil from them.

According to petroleum resource annual reported by Abuja (1997). Over 60000 spills have occurred in Nigeria during her 40 years of oil exploration. Between 1976 and 1996, the spill of 2.4×10^8 barrels of crude oil occurred from 647 incidents. Only 54706038 barrels were recovered implying that 182040666 barrels of oil were lost to the ecosystem.

The growth of oil industry combined with population explosion and a lack of environmental regulation have caused substantial damage to the environment of the Niger-Delta. After several years of ignoring or giving little or no attention to the adverse effect of oil spill, the Nigerian government has begun to take steps to mitigate the damage. The role of the environmental agency in checking and documenting oil-spills is getting stronger as the new wave of combating oil spill through phytoremediation is dramatically unfolding in the remediation industry.

Although a number of studies have been commissioned by oil companies on the socio-economic effects of their operations in the host communities, independent studies on the environmental impacts of oil spill have been scarce (Odjuvwuedechie *et al*., 2006)

The present study compares the physicochemical parameters of the oil spill affected soil of Eleme with those of the unaffected soil. The result will give insight to the level of damage that oil spill has done to the fertility and nutrient status of the community farm land.

MATERIALS AND METHODS

The study area, Eleme, is located in Rivers state in the Southern part of Nigeria. The study was carried out between 2006 and 2008. The sub-communities or locations where the soil samples for analysis were obtained are (Agbonchia and Ogali) that had experienced oil-spill and (Aleto) which has not experienced any oil spill served as the control.

Sample Collection

From each of the three communities, ten samples were randomly collected at depth of 0-15 cm (topsoil) and ten at depth 15-30 cm (sub-soil). The ten samples from each depth were then bulked to obtain a representative sample of that depth of that community. The samples from Agbonchia were designated A^t and A^s, those from Ogali as B^t and B^s while those from Aleto (the control) as C^t and C^s with (t) representing topsoil and (s) subsoil, respectively.

Analysis

The representative samples were taken to the laboratory, air dried, sieved through 2 mm sieve and stored in plastic bags for analysis. pH was measured as described by Smith and Smith (1998) using a model 3020 pH meter. Twenty grams of the soil sample were weighed and suspended in 50 mL of distilled water and properly stirred before taking measurements. The particle size distribution was determined by hydrometer method (Bouyouocas, 1951) Exchangeable Cations (EC) were first extracted by the ammonium acetate extraction method (Jackson, 1962). Then sodium (Na) and potassium (k) were determined using flame photometry while calcium (Ca) and (Mg) were determined by the Versenate titration method as described by Jackson (1962). Exchange acidity was determined by the titration method using phenolphthalein as indicator. The Cation Exchange Capacity (CEC) was determined by summation of exchangeable base and exchangeable acidity (Jackson, 1962). Organic Carbon (OC) was analyzed by the wet combustion method of Wakley and Black (1934). Available Phosphorus (P) was determined by the molybdenum blue color method of Udo and Ogunwale (1978).

RESULTS AND DISCUSSION

Table 1 and 2 show the results of the soils analysis. There is a slight but insignificant variation on the pH of the soils, which averaged from the (top soil) 5.73±0.5, 5.82±0.01 and 5.78±0.2 for the control Aleto and the affected soils of Ogali and Agbonchi respectively. The soils are all slightly acidic and this acidity can not be attributed entirely to the oil spill since the control is 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 looses of most of the basic cations in the soil (James and Wild, 1975). These lost cations are then replaced by hydrogen ion (H^+) (Ngobiri *et al*., 2007). This pH range of (5.73-6.12) of the top soils of Eleme is however quite suitable for Potassium (P) availability in soil (Cheng, 1997).

This fraction averaged 66.72% in Aleto soil, 76.72 in Ogali soil and 82.21 in Agbonchi soil while clay decreased from 21% in Aleto to 16.70 and 15.2% in Ogali and Agbonchi, respectively. This high sand content of the soils is characterized by sand formed on unconsolidated coastal plain sand and sandstones (FDALR, 1987). However the significant effect of the oil spill on the sand content of affected soils of Ogali and Agbonchi when compared with that of the control can be observed from Table 1 and 2. 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 will be blocked with oil and prevent the easy flow of nutrients to the soil (Chinda and Braide, 2000).

Calcium dominated the exchange complex in all the soil samples Table 1 and 2. This is characteristic of strongly weathered tropical soil and is further confirmed by a Ca/Mg ratio of greater than unity in all the samples (Table 1) (Olade, 1987). The drastic effect of the oil spill can be seen from the significant difference between the calcium content (32.80±1.02 mg kg^{-1}) of Aleto top soil and (1.6±0.02 mg kg^{-1}) and 1.20±0.0 mg kg^{-1} of the oil spill affected soils of Ogale and Agbonchi, respectively (Table 1). This low calcium status of the oil-spill affected soils will cause poor stem growth and decolouration of crops and thus low crop yield (Nwilo and Badojo, 2005).

The effect of the oil spill on potassium (k) content is shown (Table 1) from its value of 0.3 mg kg^{-1} for the top soil of the control (Aleto) and 0.1 and 0.1 mg kg^{-1} for the oil-spill affected soils of Ogale and Agbonchi, respectively (Table 1). This value of 0.1 mg kg^{-1} (K) is less than the critical value (0.2 mg kg^{-1}) potassium for crop production (Adenye *et al*., 2002) and will retard plant growth, cause poor stem development according to Atubi (2006) and aid wilting (Brady, 1999).

The value of sodium (Na) shows a slight increase in the top soil of the oil-spill affected samples of Agbonchia and Ogali with values of 1.27±0.01 and 1.14±0.04 mg kg^{-1}, respectively in contrast to 1.00±0.00 mg kg^{-1} obtained from the control (Aleto) (Table 1). This implies that oil deposits in the soil tend to increase the sodium content of the soil so corroborating (Odu, 1972). This higher proportion of sodium in the soil, despite its being one of the essential trace elements needed by plants is not an index for effective productivity according to (Adams, 1960).

Table 1: Physico-chemical properties of the soil in Eleme

	Particle size distribution				
Sample	Sand	Silt	Clay	Texture	pH
A^t	81.72±1.01	1.50±0.02	16.70±1.01	LS	5.73±0.820
B^t	74.72±1.02	7.50±0.06	17.70±0.06	LS	6.09±0.054
C^t	70.72±0.55	13.50±0.08	15.70±0.08	SL	6.12±0.030
A^s	82.72±1.82	3.50±0.02	13.70±0.03	SL	5.82±0.610
B^s	78.72±1.03	5.50±0.03	15.70±1.05	SL	5.87±0.420
C^s	59.72±0.95	11.50±1.01	28.70±1.05	SCL	5.15±0.050
Mean A (t+s)	82.20±1.42	2.50±0.02	15.20±0.02		5.78±0.710
Mean B (t+s)	76.22±1.03	6.50±0.05	16.70±1.01		5.98±0.490
Mean C (t+s)	65.22±0.75	12.50±0.55	22.20±0.58		5.64±0.040

LS: Loamy sandy; SL: Sandy loam; SCL: Sandy clay loam

Table 2: Nutrients concentration of the Eleme soil

Samples	Exchanges bases Ca	K	Na	Mg	Ea	ECEC	Bs	OC	Available p	Organic matter
A^t	1.20±0.01	0.10±0.01	1.27±0.01	0.80±0.01	0.48±0.011	3.85±0.06	87.53±1.02	2.10±0.01	52.00±1.24	3.62±0.58
B^t	1.60±0.02	0.10±0.00	1.14±0.04	2.00±0.10	0.32±0.020	5.16±0.84	96.78±1.05	1.48±0.02	34.00±1.08	2.55±0.42
C^t	32.80±1.02	0.30±0.01	1.00±0.01	2.80±0.12	0.32±0.800	37.22±1.61	99.14±0.88	0.54±0.01	38.00±2.01	0.88±0.06
A^s	12.08±0.04	0.10±0.00	1.27±0.06	5.60±0.06	0.40±0.040	19.32±1.02	97.93±1.20	1.59±0.02	26.00±1.00	2.74±0.44
B^s	4.80±0.04	0.20±0.01	1.14±0.10	3.60±0.04	0.48±0.120	10.22±1.03	91.30±1.50	2.52±0.04	22.00±1.35	4.35±0.84
C^s	5.20±0.05	0.30±0.01	1.20±0.06	0.40±0.01	0.46±0.100	7.56±0.80	94.46±1.04	1.60±0.02	37.00±2.06	2.76±0.94
Mean A (t+s)	6.53±0.03	0.10±0.00	1.27±0.08	3.20±0.03	0.44±0.075	11.54±0.54	92.73±1.11	3.18±0.01	99.00±1.12	3.18±0.51
Mean B (t+s)	3.20±0.03	0.15±0.01	1.14±0.07	2.80±0.07	0.40±0.020	7.69±0.94	94.04±1.28	3.45±0.03	28.00±1.21	3.45±0.63
Mean C (t+s)	19.00±0.53	0.30±0.01	1.15±0.04	1.60±0.06	0.39±0.090	22.39±1.25	86.80±0.99	1.82±0.02	38.50±2.03	1.82±0.50

Ea: Exchangeable acidity; At: Agbonchia topsoil; As: Agbonchia subsoil; ECEC: Exchangeable cationic exchange capacity; Bt: Ogali topsoil; Bs: Ogali subsoil; Bs: Base saturation; Ct: Aleto (control) topsoil; C^s: Aleto subsoil; OM: Organic matter; OC: Organic carbon

The Cation Exchange Capacity (CEC) of the top soil (Table 1) was drastically affected by the oil spills, decreasing from 37.22 mg kg^{-1} for the control sample from Aleto to 3.85 and 9.96 mg kg^{-1} for the oil-spills affected soils of Agbonchia and Ogali respectively. This (CEC) of less than 20 mg kg^{-1} is considered insufficient for soil fertility and crop growth (Greenland and Hayes, 1978) and will have statistically significant effect on crop yield and land productivity (Ihejiamaizu, 1999).

A careful and comparative look on Table 1 and 2 show that the oil-spills exert the greater impact on the top soils than the sub soils. This condition will indeed stifle the germination, growth performance and yield of crops like tomatoes, pepper etc., that are not deeply rooted (Anoliefo and Nwoko, 1994).

CONCLUSION

This result has accentuated the negative and statistically significant impact of oil-spill on the soil of Eleme which accounts for the rapid destruction of vegetation and farmland. The fertility status of the soils is reduced as the oil makes most of the essential nutrient unavailable for plant and crop utilization Eleme should therefore be included in the remediation technique going on in the Niger Delta region for cleaning up affected soils.

The problems of oil-spills can be minimized if the oil companies should be more environment conscious and follow strictly the provisions of the law and standards set by regulatory bodies or agencies. They should also have regular monitoring of oil production activities and facilities and pay adequate compensation to the host affected communities.

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