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EFFECT OF CRUDE OIL POLLUTION ON SOIL PROPERTIES AND PERFORMANCE OF MAIZE (*Zea mays* L.) IN COASTAL PLAIN SAND SOUTH EASTERN NIGERIA.

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ABSTRACT
The Study was conducted at the Research Green House of Akwa Ibom State University, Obio Campus to assess the effect of crude oil level on soil properties and the performance of maize. The soils were respectively polluted to 2%, 5% and 10% levels with bony light crude oil of relative density of 0.835kglm at 25°. Unpolluted soil was also included to serve as control. The experiment was replicated three (3) times and completely randomized and was arranged in the green house and then allowed to settled for seven days, after which three maize seeds were planted per bag and thinned to two after plants emergence. The experiment was allowed for twenty eight days (28), and was then sampled and analysed. The result shows that non-polluted soils were dominated by sand fraction (89%) in the study area. The pH was 5.6 while electrical conductivity was 0.2dsm^{-1}, Exchangeable acidity (1.90), Effective Cation Exchange capacity (ECEC) (10.71cmol) and Base saturation (82.26%). The experiment also show that there was a significant differentce in sand, silt and clay fractions of the soil while soil texture remained the same as observed prior to the study. The soil pH increased with increase in crude oil level. Values of electrical conductivity were generally low. Crude oil contamination lead to decrease in calcium content; values were higher in the polluted soil than on control level. Polluted soil increase the number of maize leaves while there was a reduction in leaf area with increasing level of crude oil. There was no significant difference in maize plant height at 4 weeks and on maize stem girth.

INTRODUCTION
Crude oil exploration and exploitation has posed a lot of environmental hazard, despite the numerous advantages accruing from the petroleum industries. Crude oil is a complex mixture of hydrocarbons that form from the partial decomposition of biogenic materials (Overton *et al.,* 1994). It is constituted from thousands of compounds which are separated into saturates, aromatic, resins and asphaltenes. Saturates, especially those of smaller molecular weight, are readily biodegraded. Aromatics with one, two or three aromatics rings are also efficiently biodegradable; however, those with four or more aromatic rings are quite resistant to biodegradation. The asphaltenes and resin fractions contain higher molecular weight compounds whose chemical structures have not yet known (Harayana and Lio, 1999).

Contamination and eventual pollution of the environment are the primary negative impacts of crude oil exploration and exploitation. According to Nwankwo and Ifeadi (1988) crude oil spills may result from equipment failure, and malfunctioning, age and overloading of equipment, corrosive or abrasion of machine parts; and vandalization of pipelines, drill cuttings, drilling mud and fluids used for stimulating crude oil production. Chemicals, injected into them to control corrosion to assist the separation of crude oil from water, etc. Released into the environment in the course of crude oil production operations are also source of pollution. Incidental crude oil spills could also be as a result of improper disposal of petroleum products as well as wrong handling during transportation and marketing (Odu, 1972). Effect of crude oil spill on the environment not withstanding natural ecosystem has been subjected to series of disturbance by man, over population and industrialization have contributed in various ways to the deterioration of the environment upon which humanity is completely dependent for life.

Prolonged exposure of crude oil will lead to evaporation of the lighter crude oils and increases in the density and viscosity of the remaining oil (Okpokwasili and Amanchukwu, 1998). There are serious environmental and social problems associated with crude oil. According to Awobayo (1981), between 1978 and 1980, there were 734 cases of oil spills in Nigeria. Oil spills are destructive to both vegetables and animals in the environment; not only because of their contact toxicity, but also because crude oils in the environment reduces oxygen tension and increases anaerobic conditions both of which are harmful to plants roots and animals (Bossert and Bartha, 1984). Crude oil spill could cause heavy metals concentration in the soil to increase and cause crop raised to have elevated concentration of heavy metals (Laker, 1999). These heavy metals that find their way into food chain through plant uptake are hazardous to human health. Also, soil quality is affected through changes in soil pH, air, temperature, soluble nutrients and disruption of the metabolic processes of soil micro-organisms. Okpokwasili and Amanchukwu, (1998) observed that soil micro-organisms are very important, that a sudden change in soil condition as a result of pollution will adversely alter the mineralization of organic carbon, nitrogen, sulphur and phosphorus for the growth of higher plants and animals. Micro-organisms are essential in soil food web in conservation either through storage of nutrients in living organisms or control of movement of nutrients in the soils. It also increase water holding capacity of the soil, decrease in mineralization due to death of soil micro-organisms because to toxic chemicals, retard growth of nitrifies, as a result in ammonia accumulation. It adversely affects productivity of soil and reduction in available plant nutrients (Amadi and Dickson, 1993). Amund *et al.* (1993) reported that the occurrence of crude oil pollution on land is of major concern as it could result in introduction of heavy metals that cannot be broken down to non-toxic forms. Amund *et al.* (1993), however stated that the severity of crude oil pollution on soil physical and chemical properties depend on the type of pollutant, the amount of pollutant involved, type of habitat, sensitivity of affected organisms, topography of the land and adequacy of response (Odu, 1980).

Maize is a cereal grain. It is a monocious herbaceous annual crop, cultivated across the globe and it provides a staple food for a greater proportion of the world population. It requires 100°C minimum temperature for germination, and the growth point is below the soil surface. It also requires adequate soil moisture (for at least 2 ½ months) and a fertile, well-drained, loamy soil ranging in pH from 5.7 to 7.0. Since there is insufficient information on the levels of crude oil pollution and their disastrous level on soil physical and chemical properties, it is therefore necessary that this experiment was conducted to determine the effect of different levels of crude oil treatment on some soil physical and chemical properties and performance of maize within the study area.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at the research Green House of the Akwa Ibom State University, Obio Akpa Campus, Akwa Ibom State which is located on latitudes 04° 57/N and 05° 57/N and longitudes 007° 45/ and 008° 45/E (with the use of geographical positioning system). The climate of the area is humid tropical region, characterised by two season, rain and dry season with high heavy amount of rainfall, sometimes accompanied by high velocity of wind and dry season with high intensity of sunlight. Rainfall is bimodal with peak in June and September (Ukpong, 1992).

Planting Materials / Source of Crude Oil

The materials used for the experiment was maize seed (*Zea mays*), (Varity ZPB-SRW 644 – 31). Seed purity was 98% (18 ÷ 20 x 100). The crude oil used as pollutant for the experiment was obtained from Exon mobile flow station at

Mkpanak in Ibeno Local Government Area. It was the fresh Bonny light crude oil with relative density (specific gravity) of about 0.835kg/m.

Treatment and Field Layout

Seventy two (72) kilograms of top soil (0-15cm) was excavated from the Akwa Ibom State University teaching and research farm for the experiment. The soil was taken to the Green House, harmonized, divided into four (4) 18kg each and respectively polluted to 2%, 5% and 10% (w/w) with bonny light crude oil of relative density (specific gravity) of 0.835kglm at 25°, the 18kg soil of each pollution level was amended with 2000/ha, unamended soil was also included as control. Six (6) kilogram of each polluted level were replicated three (3) times, completely randomised, arranged in a greenhouse and allowed to settle for seven (7) days. Three (3) maize seeds were planted per bag and thinned to two (2) seedlings seven days after plant emergence. The experiment was allowed to grow for twenty eight (28) days. Thereafter, the plants were manually and gently uprooted from each bags for the determination of moisture content, Ash, crude protein and carbohydrates.

Determination of Moisture Content

The moisture dish was accurately weighted.

Approximately 1.0g of the samples was added and then reweighed. It was then kept in vacuum oven-dried for five hours. The dish washer was removed from the over, cooled and reweighed. This was repeated until a constant weight was obtained.

Determination of Ash Content

5g of sample was accurately weighted in to a crucible and dried in oven at 100°C for 8 hours until white colour was obtained. The crucible was removed from desiccators and weighted soon after cooling.

Determination of Crude Protein

The crude protein was determined using micro kjeldhal digestion

Crude protein (%) = A – B) x 1.4007 x 100

Weight (g) of sample A = volume (ml) std HCL x normality of std HCL

B = volume (ml) std NaOH x normality of std NaOH

Determination of total carbohydrate

Total carbohydrates = 100 – (% lipid + % ash + % moisture + % protein)

Soil Sample / Laboratory Analysis

Composite soil samples 0 - 15cm depths were randomly collected before and at the end of the study from teaching and research farm in Akwa Ibom State University, Obio Akpa Campus. Bulk samples were air-dried at room temperature, crushed and sieved through 2mm sieve and analysed for the following parameters:- Soil pH was determined in water with glass electrodes in 1:2.5 water ratio (Udo and Ogunwale, 1978); Organic matter as outlined by Udo and Ogunwale, (1978). Total Nitrogen was determined by macro-kieldahl digestion; Available phosphorus was determined using Bray P-1 method by Page *et al.,* (1982) and Sparks (1996); Electrical conductivity (EC) was measured with electrical conductivity meter. Exchangeable bases were determined using IN ammonium acetate (NH_4 OAC) extraction method (exchangeable sodium and potassium in the solution was read using the flame photometer while exchangeable Calcium and magnesium was determined using atomic absorption spectrometer). Effective contain exchange capacity (ECEC) was computed as:

ECEC = Ca + Mg + K + Na + EA

Where,

EA = Exchangeable acidity

Ca = Calcium

Mg = Magnesium

K = Potassium

N = Sodium

Statistical Analysis

The data obtained were statistically analyzed using LSD (Least significant difference) at 0.05% level of significant after analysis of variance test.

RESULTS AND DISCUSSION

Some Physico-Chemical Properties of the Soil before the experiment

Result of soil properties before the treatment are presented in Table 1., indicated that soil particles were dominated by sand fraction (89%), while silt and clay fractions recorded 4.1% and 6.9%, respectively. Soil pH was moderately acidic (5.6,) reflecting the acid sands parent materials from which the soils of the area were derived. Electrical conductivity (EC) was low in the area (0.2 dsm^{-1}), an indication that the soils are non - saline. Organic carbon content was moderate (1.23%), total N was (0.17%) and available P was high

(25.00mg kg^{-2}), Exchangeable Ca, Mg, K and Na were 5.64, 2.67, 034 and 0.16 $cmolkg^{-1}$, respectively. Based on the classification, the concentration of Ca, Mg and K were in the acceptable limits for crop production while K was low. Exchangeable acidity was 1.9 $cmolkg^{-1}$, ECE was 10.71 cmolkg, while base saturation was high (82.26%). The soil was fairly fertile and adequate for arable crop production.

Table 1: some Physico-chemical Properties of the Soil before the experiment.

Sand (%)	89.0
Silt (%)	4.1
Clay (%)	6.9
pH	5.6
EC (dSM^{-1})	0.2
OC(%)	1:23
TN($\%^{1}$)	0.17
Av.P (mg kg^{-1})	25.00
Ca ($cmol^{-1}$)	5.64
Mg (cmol kg^{-1})	2.67
K ($cmol^{-1}$)	0.34
Na ($cmolkg^{-1}$)	0.16
EA(cmol kg^{-1})	1.9
ECEC ($cmol^{-1}$)	10.71
BS(%)	82,26

EC - Electrical conductivity, Oc - Organic carbon, Ca - Calcium, Mg - Magnesium, k - Potassium, Na – Sodium, ECEC – Effective cation exchange capacity, TN - Total nitrogen, Av. p - Available Phosphorus, EA - Exchangeable acidity, BS - Base saturation

The result of the effect of crude oil treatment on some physicochemical properties of the soil revealed that, there was no significant difference in sand, silt and clay fractions of the soil and consequently, soil texture remained the same as the observed prior to the study (Table 2).; there were no significant interactive effects of crude oil levels on soil texture. The non- significant effect of oil of crude treatment can be attributed to the fact that soil texture, which is defined by the content of sand, silt and Clay, is an inherent soil property which cannot be altered by soil management. The pH of the soil in control (0%) and that of the pre- study soils were both moderately acidic (Table 2). However, high soil pH value of 6.48, 6.71, and 6.75 were observed in soil that

receives 2%, 5% and 10% crude oil treatment respectively. Though the value seemed to increase with increase in crude oil level, there was no significant difference among the treatments. The result of previous studies showed that crude oil raised soil pH (Wang *et. al.,* 2009) were in line with the result of this study. The higher pH values in crude oil-polluted soils, might be attributed to the fact that oil pollution in soil has been shown to be associated with the accumulation of exchangeable capacity (ECEC) (Benka-Coker and Ekudayo, 1995; Ekudayo and Obuekwe, 1997.
The interaction of crude oil levels did not also show significant effect on soil pH (Tabie 2).

Electrical conductivity showed no significant ($P<0.5$) difference with crude oil treatment and control (0%). However, values of electrical conductivity were generally low, depicting the non-saline nature of soil in the study area. Organic Carbon content of soils that received no crude oil treatment was significantly ($P<0.5$) lower than those of soils that receive different levels of crude oil treatment (Table 2). Soil that received crude oil treatment was statistically the same and there was no interactive effect of crude oil levels on organic carbon concentration. The high organic carbon content observed in this study corroborated with the finding (Wang et al., 2009), who reported that oil contamination significantly ($P< 0.5$) increase the organic carbon content of soils. Total nitrogen was not significantly ($P< 0.05$) affected by crude oil treatment at different levels because normally, N has not been reported to be a major component of crude oil.

Available P was significantly ($P<0.05$) higher in soil that received no crude oil treatment than in soils that received different levels of crude oil treatment (Table 2). There was no significant affect (Table 2) on the interaction of crude oil on the concentration of available P (Table 4). The result of previous study equally showed that oil contamination decreased available phosphorus concentration by various degrees (Wang *et al.,* 2009). In this study, the reason for the decrease in available P with crude oil contamination could be linked to the increase in carbon concentration, which might have affected the equilibrium of nutrient in the soil. Microbes in soils, which utilize petroleum hydrocarbon as a carbon source, could utilize considerable amounts of available phosphorus when they degrade the hydrocarbons (Jackson, 1970; Wang *et al.,* 2009). Calcium was significantly ($P<0.05$) affected by crude oil treatment with soils that received no crude oil having significantly ($P<0.05$) higher concentration of exchangeable Ca than those that do not received the interaction of crude oil treatment and did not have a significant effect on the concentration of exchangeable. Crude oil treatment reduced exchangeable Mg concentration and increased the concentration of exchangeable K and Na, though the difference obtained were not significant (Table 2). The interaction of crude oil levels did not show any significant effect on the concentrations of exchangeable Mg, Na and K. Exchangeable acidity and ECEC were significantly (P<O.05) higher in unpolluted soil. There was no significant effect on the interaction of crude oil on the concentration of exchangeable acidity and ECEC (Table 2). This indication counteracts the effect of the crude oil in the soil. Base saturation was not significantly (p0.05) affected by crude oil levels.

Table 2: Physicochemical Properties of soil affected by Different Crude Oil Rate

Soil property	0%	2%	5%	10%	LSD $^{(0.05)}$
Sand (%)	87.50	86.70	87.83	455	1.97^{NS}
Silt (%)	5.00	5.10	4.93	4.55	1.28 ^{NS}
Clay (%)	7.50	8.20	7.23	9.37	1.44 ^{NS}
Texture	ls	Ls	ls	Ls	
pH	5.57	6.48	6.71	6.75	0.21**
Ec (dSm^{-1})	0.2	0.08	0.07	0.06	0.09 ^{NS}
OC (%)	1.29	6.66	6.68	6.69	5.88**
TN (%)	0.10	0.12	0.13	0.09	0.03 ^{NS}
Av. P (mgkg^{-1})	25.53	9.16	7.59	6.55	4.72**
Ca (cmol kg^{-1})	4.98	3.77	3.82	3.21	0.62*
Mg (emol Kg^{-1})	2.12	1,82	1.73	1.64	0.46^{NS}
Na (cmol kg^{-1})	0.06	0.08	0.08	0.09	0.08^{NS}
K(cnmol kg^{-1})	0.07	0.01	0.11	0.011	0.03^{NS}
EA (cmol kg^{-1})	2.75	1.55	1.80	1.73	0.54 *
ECEC (cmol kg^{-1})	9.97	7.31	7.54	6.77	0.94*
BS(%)	72.52	79.14	76.31	7495	6.43^{NS}

Ec- Electrical Conductivity, Om -Organic matter, Tn- Total Nitrogen, AV. P-Available phosphorus, EA- Exchangeable Acidity, ECEC- effective cation exchange capacity, BS - base saturation, LSD (0.05) - Least significant different at 5% probability level, NS- not significant.

Effect of crude oil treatments on the growth of maize presented on Figure1 showed that the number of leaves are significantly (P<0.05) affected by crude oil level at both 2 and 4 weeks after germination (WAG). At 2 weeks after germination, the highest number of maize leaves (4.83) was obtained with 0% crude oil level, which was significantly higher than those of 2, 5 and 10 % level of treatment. At 4 weeks after germination, 0% gave the highest means number of maize leaves (6.56), followed 2% (5.46) and 5% (4.82) while 10% gave the least of number of leaves (4.30) (Figure 1). The decrease in number of maize leaves with increase in crude oil treatment was also observed by Nwankwo and Badejo (2015) and can be attributed to the fact that crude oil in soil creates unsatisfactory conditions for plant growth probably due to impaired soil aeration (De Jong, 1980). When oil comes in contact with the aerial parts of crops, they wilt and die off due to blockage of stomata, thereby inhibiting photosynthesis, transpiration and respiration (Anoliefo and Vwioki, 1994).

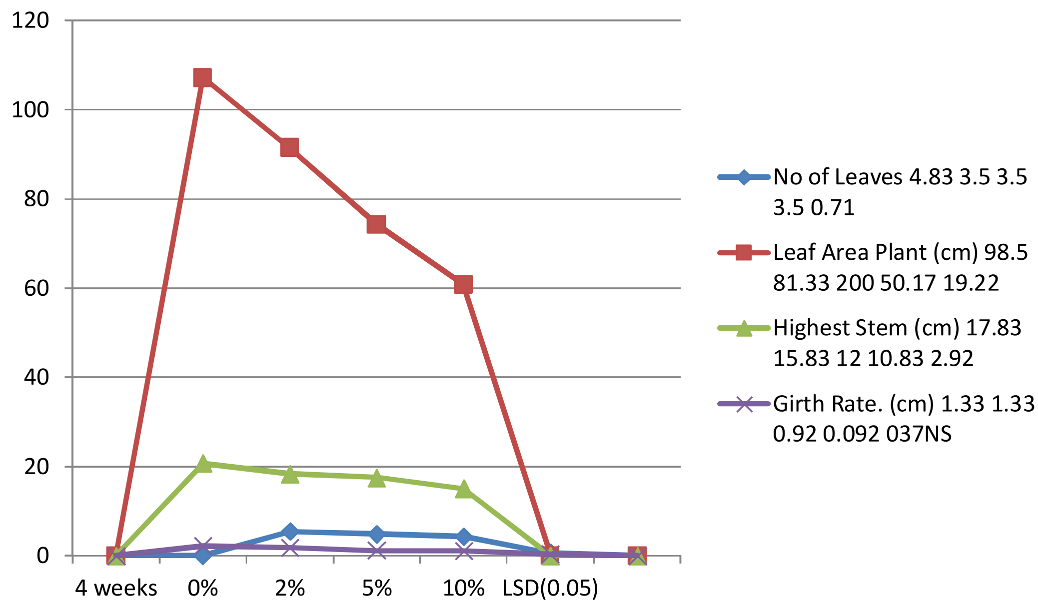

Figure 1: Effect of Crude Oil treatments on the Growth of Maize at two weeks

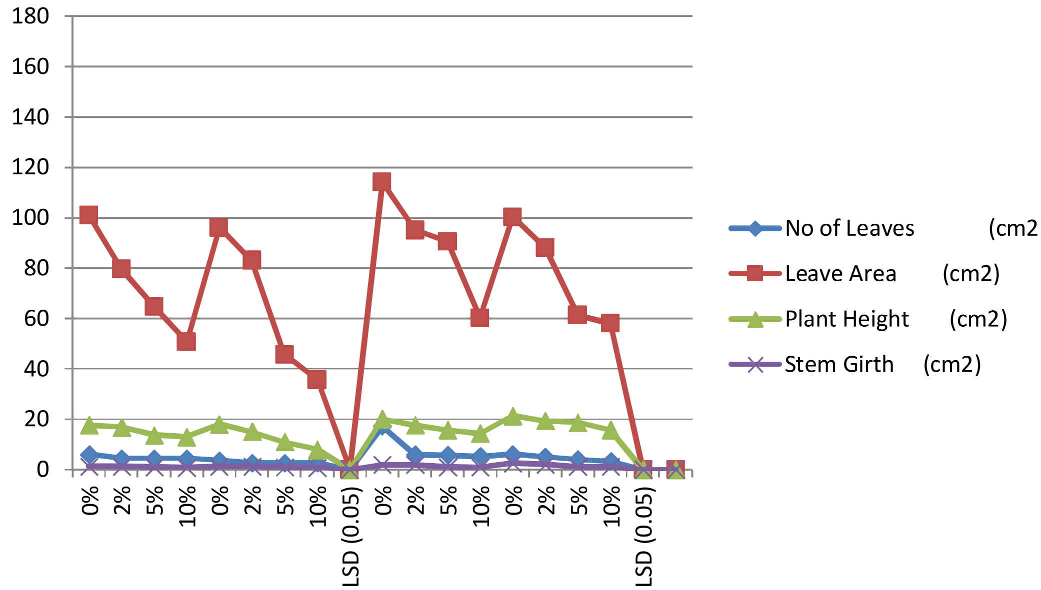

Figure 2: Effect of Crude Oil treatments on the Growth of Maize at 2 and 4 weeks

At 2 weeks after germination (Fig 1), Leaf Area of maize was significantly (P<0.05) affected by crude oil treatment with the leaf Area obtained under 0% (98.50cm) and 2% (81.33 cm), crude oil treatment being equal but significantly (P<0.5) higher than those of 5% (50.17 cm). There was a reduction in leaf area with increasing levels of crude oil treatment due to the implication of metabolic activities that bring about growth (Pezeskki and Delune, 1993). At 4 weeks after germination (Fig 1), crude oil treatment did not produce significant effect in maize leaf area at both 2 and 4 week after germination (Fig 1).

At 2 weeks after germination (Fig 1), maize plant Height was significantly (P<0.05) affected by crude oil treatment with the highest plant height obtained under 0% (17.83 cm), 2% (15.83cm), 5% (12.00cm) while that of 10% (10.83cm) had the least maize plant height at 2 weeks after germination (Fig 1), Increase of crude oil treatment reduces the stem. At 4 weeks after germination (Fig 2), there was no significant (P<0.05) effect of crude oil treatment on maize plant height. The interacted crude oil treatment did not produce significant (P<0.05) difference in maize plant height at both 2 and 4 weeks germination (Fig 1)

At 2 weeks after germination (Fig 1), Stem Girth was not significantly (P<0.05) affected by crude oil treatment but at 4 weeks after germination, it was significant affected the Stem Girth 0% (2.22cm) and 2% (1.83cm) being equal but significantly higher than those of 5% (1.12 cm) and 10% (1.07cm) at 4 weeks after germination, there was no significant (P<0.05) effect of crude oil treatment on maize Stem Girth. The interaction of crude oil treatment did not produce significant (P< 0.05) different in maize Stem Girth at both 2 and 4 weeks after germination.

CONCLUSION

Crude Oil pollution have a profound effect on soil properties and performance of maize on coastal plain sand in Akwa Ibom State. Soil pH decreased with increase in crude oil pollution. Organic carbon increase with an increase in crude oil concentration. Crude oil pollutant has effect on; Number of leaves, Leave area, and Plant height at 2 and 4 weeks after germination. Maize plants performance was comparatively better at 0 and 2% pollution levels with higher values recorded in 0% and 2% pollution levels than those of 5% and 10 % pollution levels with higher values recorded in 0% and 2% (98.50cm and 81.33cm) respectively. The result revealed that at 0% and 2% crude oil Pollution, maize can strive well than in 5% and 10% Crude oil Pollution.

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