GROWTH COMPARISON OF FOUR ARABLE CROPS ON THE POLLUTED AND UNPOLLUTED SOILS OF BODO CITY IN OGONI LAND RIVER STATE, NIGERIA

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ABSTRACT

The aim of this research was to ascertain the effects of crude oil spill on agricultural soil and plant growth. The soil samples were collected from cultivated area that is not affected by spill and crude oil polluted site both in Bodo city in Gokana Local Government Area of River State and were taken to Campus II Delta State University, Abraka, Delta State. Four selected vital crops were sown on these soils to determine the plant growth response due to the presence of crude oil contamination. The unpolluted soil was used as a control as compared to the polluted one. The parameters analyzed were soil moisture content, pH, Electrical conductivity (E.C), total hydrocarbon content (THC), total organic carbon (TOC), total nitrogen, phosphorus, zinc, lead, cadmium, nickel, chromium, sand, silt and clay. The study revealed that there were adverse effects of crude oil pollution on soil nutrients, fertility as well as plant growth and production. It was also observed that the polluted agricultural land had high concentration of zinc, lead, cadmium and Chromium that are above the limit set in the National Standard for heavy metal pollution on soil. The people's livelihood as well as their food security is a function of the healthy state of the soil for plant production for sustainability. Therefore, it is recommended that the UNEP Environmental Assessment Report on Ogoni land should be implemented with immediate effect to ameliorate the native effects of crude oil spill on vital food crops of the Ogoni people.

Key word: Polluted soil, unpolluted soil, soil pollution, plant growth.

INTRODUCTION

Environmental pollution is a common hazard in the Niger Delta Region. It is largely due to crude oil exploration and exploitation in the area. This environmental pollution resulting from the crude oil drilling has put so many food crops at considerable risk. The crude oil contamination has serious damage on the physiological, anatomical and growth performance of plants, soil components and aquatic ecosystems. Sustainable use of agricultural soil on which plants depend is absolutely necessary for agricultural productivity. Soil pollution by crude oil and other petroleum products are presently a menance in Nigeria (Oyedeji et al., 2012).

Contamination of soils by oil is also worrisome because such environmental pollutants (including trace metals, organics and radio nuclides) rarely occur alone and sources contributing to their contamination often contain a mixture of contaminants (Salbu et al., 2005).

Basic soils have higher concentrations of calcium, magnesium, and sodium carbonates. The pH of soil varies significantly in thin soil zones. These variations in pH are due to differences in both macro and micro ecosystems. The microbial population near root surfaces is an example of such an ecosystem. The most common heavy metals found at contaminated sites, in order of abundance are Pb, Cr, As, Zn, Cd, Cu, and Hg (USEPA, 1996). Those metals are important since they are capable of decreasing crop production due to the risk of bioaccumulation and biomagnification in the food chain. Once in the soil, heavy metals are adsorbed by initial fast reactions (minutes, hours), followed by slow adsorption reactions (days, years) and are, therefore, redistributed into different chemical forms with varying bioavailability, mobility, and toxicity (Shiowatana et al., 2001; Buekers, 2007).

Based on the environmental consequences of crude oil spillage and the economic importance of plant, the study was aimed at determining the impacts of crude oil on some physico-chemical parameters of polluted soil, and the growth of plants, in Ogoni land.

MATERIALS AND METHODS

Description of study area

Bodo community lies on the coastal low land of the Niger Delta, and in the southern part of Gokana Local Government Area of Rivers State and is located between latitude 4°36’N and Longitude 7°21’E of the equator (Taneen, 2005).

Planting method

Plastic bowls were obtained from the Botany Planting Garden of the Delta State University, Abraka, Nigeria. The plastics were washed with detergent and rinsed with clean water which was later dried using sun light; finally, it was also rinsed again with sterile water and dried to ensure that there was no microbe present. They were also perforated at the bottom to allow water drainage; thereafter, about 3 kg of soil for both polluted and unpolluted were measured into the bowl after which plant viability test was carried out using seed flotation method. The viable seeds of *Capsicum annum*, *Lycopersicum esculentum*, *Telfaira occidentalis* and *Amaranthus* sp. were planted with about 5-6 seedlings per hole after being carefully selected. Sprouting of the seeds began 3-5 days after planting and at about 2 weeks of planting the seedlings, measurement of the plants heights began. This was done for 9 days preceding the last day of the measurement after it was observed that the experimental plants on the polluted soil were not visible but those on the unpolluted were still visible but not measurable.

Physio-chemical and heavy metal content analysis

Physio-chemical parameters of the soil samples were carried out in the Chemistry Lab. of Delta State University, Campus II.

Data analysis

The results obtained in the physicochemical parameters were reported in mean of multiple analysis and recorded in their respective units. The results of plant growth in polluted and unpolluted soils were recorded as presence and absence of growth. Statistical tool used was Ms Excel 2010.

RESULTS

Presented in Table 1 are the physiochemical parameters of analyzed soil samples. Sample A denoted the unpolluted soil sample while sample B was the polluted soil sample. The moisture content was 28.40% for unpolluted soil sample while the polluted soil sample was 19.30%. There was a variation in the pH levels of the unpolluted and polluted which were 5.90 and 4.80; in the two samples were 431 and 510.14 us/cm. Total hydrocarbon content for unpolluted and polluted were 1.32 and 4.40%; total nitrogen contents were 8.30 and 14.62 mg/kg, respectively, and phosphorus for the two soil samples were 4.68 and 6.73 mg/kg.

The parameters for heavy metals also

Table 1. Physio-chemical parameters of the unpolluted and polluted soil samples.

Parameters	Control (unpolluted soil)	Polluted soil
Moisture %	28.40	19.30
pH	5.90	4.80
E.C (us/cm)	431.00	510.14
THC (mg/kg)	3,140	6,817
TOC (%)	1.32	4.40
Total nitrogen (mg/kg)	8.30	14.62
Phosphorus (mg/kg)	4.68	6.73
Zinc (mg/kg)	17.75	31.43
Lead (mg/kg)	0.89	4.89
Cadmiun (mg/kg)	1.06	5.16
Nickel (mg/kg)	8.35	11.43
Chromiun (mg/kg)	1.10	3.48
Sand %	91.00	88.00
Silt %	7.00	10.00
Clay %	2.00	2.00

E.C=Electrical conductivity; THC=total hydrocarbon content; TOC=total organic carbon.

showed variations between the unpolluted and polluted soil samples. Zinc was 17.75 and 31.43 mg/kg, lead was 0.89 and 4.89 mg/kg, cadmiun was 1.06 and 5.16 mg/kg, nickel was 8.35 and 11.43 mg/kg, chromin was 1.10 and 3.48 mg/kg for the unpolluted and polluted soil samples, respectively. The soil types also showed variations: sand, silt, and clay for unpolluted and polluted were 91 and 88, 7 and 10, 2 and 2% respectively.

The growth profile of the various plants (*C. annum, L. esculentum, T. occidentalis* and *Amaranthus* sp.) grown in polluted and unpolluted soils are presented in Table 2. The results show that there were observable growths on the plants grown on unpolluted soil, although they were not up to measurable stage. This could be attributed to the high level of heavy metals contents recorded in the unpolluted soil. The results obtained in the polluted soil showed that there was no growth due to the high level of crude oil contamination.

Table 2. Growth profile of plants in polluted and unpolluted soil samples.

Plants	Days after planting																	
	1		2		3		4		5		6		7		8		9	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
C. annum	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG
L esculentum	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG
T. occidentalis	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG
Amaranthus sp.	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG

A, Unpolluted soil; B, polluted soil; G, growth but not measurable; NG, no Growth.

DISCUSSION

Total hydrocarbon content (TOC)

From the data obtained (Table 2), a significant difference ($p<0.05$) between the two samples (polluted and unpolluted) in the study area the total hydrocarbon contents for the polluted and unpolluted were 6,817 and 3,140 mg/kg. A review of such existing data on the Niger Delta Environment Survey-NDES (1999) (Osuji et al., 2004), affirms that such high hydrocarbon levels affect both above–ground and subterranean flora and fauna, which are essential adjuncts in the biogeochemical cycle that affects availability of plant nutrients. The intense infusion of degradable hydrocarbon likely stimulates aerobic and anaerobic microbial metabolism as oxygen becomes limiting utilization of alternate electron acceptors produces an increasing reducing environment. In general, the essential elements required for plant growth, will be inherently low due to the high concentration of the degradable hydrocarbon.

Electrical conductivity (EC)

As salt content increases, so does electrical conductivity. The significantly higher electrical conductivity values obtained for the polluted than the unpolluted samples could be as a result of the high concentration of charged ions (cations and anions) in the oil impacted site. Anions, metallic ions and carbonic acids contribute to electrical conductivity of tropical soils. However, the generally low electrical conductivity values of the soils of the study area is an indication of the high degree of leaching of nitrate salt taking place as a result of high rainfall in the Niger Delta (Ekundayo, 1997).

Moisture content

It was found from Table 1 that the moisture content in the unpolluted by oil spill from the data obtained was 28.40% while the polluted soil sample having 19.30% of water content retained lesser water. Low soil water contents of the crude oil contaminated soil could be due to reduced soil moisture recharge caused by hydrophobic nature of crude oil contaminated soil (Abii and Nwosu, 2009).

pH

There was a slight variation of the pH of the polluted and unpolluted soil. The pH of the polluted soil was 4.80 while that of the unpolluted was 5.9. The acidity recorded in this study in the polluted soil is grossly in agreement with previous reports by researchers who have done similar research works in the Niger Delta area (Abii and Nwosu, 2009).

Soil texture

The soil texture for both polluted soil samples recorded are 88.00% for sand, 88.00% for silt, 2.00% for clay while unpolluted soil samples are 91.00% for sand, 7% for silt, 2% for clay. The result shows that the soil texture for polluted is lower than unpolluted soils in terms of sand and silt, but for clay there was no difference. This also revealed that crude oil can affect the sand and silt content of soil.

Total nitrogen

The result of the total nitrogen obtained showed variation which means that the polluted soil sample has the higher values of 14.62 mg/kg while the unpolluted has a lower value of 8.30 mg/kg. The increase of total nitrogen in crude oil spilled areas may be due to the fixation of atmospheric nitrogen by the microorganisms which assimilated the hydrocarbons (Arao ***et al.,*** 2010).

Total phosphorus

Phosphorus was found to be higher in the crude oil affected areas than the unaffected areas. The polluted area had a value of 6.73 mg/kg while the unpolluted area was 4.68 mg/kg. Available phosphorous increased in natural gas polluted soil and increased with oil contamination (Alloway, 1995).

Total organic carbon

Percentage of organic carbon in the crude oil contaminated area was found to be higher than unaffected areas. It was found to be 4.40 and 1.32% respectively. This increase was attributable to the carbon from the spilled crude oil. Increase of organic carbon is directly proportional to the increase of crude oil addition to the soil (Egbe, 2010).

Heavy metals (Cd, Cr, Pb, Zn and Ni)

The concentration of cadmium (Cd) in the soil samples ranged between 5.16 and 1.06 mg/kg. The highest value (5.16 mg/kg) was obtained from the crude oil polluted soil and the lowest value (1.06 mg/kg) was obtained from unpolluted soil. The higher concentration of Cd in this soil can be attributed to activity of oil exploration because the background Cd level in soils should not exceed 0.5 mg/kg (John, 1992). The presence of chromium within the soil at 3.48 mg/kg for polluted and 1.10mg/kg for unpolluted soil samples show the influence of crude oil spill in both soils. However, the concentration of chromium in both soils exceeded the contamination level as shown in Table 1. This was in line with the findings of Ofunne (1993). Lead concentration in the soil profile of the study area ranges from 0.89 to 4.89 mg/kg as shown in Table 1. The highest concentration (4.89 mg/kg) was found in the polluted soil crude oil sample while the lowest concentration (0.89 mg/kg) was obtained in the unpolluted soil. This finding correlates with that of Holmgreen et al. (1993) finding of 0.01 to 2.7mg/kg of lead concentration in soils.

The concentration of zinc in the polluted and unpolluted soil samples show variation. The polluted soil showed a higher concentration of 31.43 mg/kg, while the unpolluted showed a lower concentration of 17.75 mg/kg. Zinc though a heavy metal is also micronutrient (Alvarez-Benedi and Munoz-Carpena, 2005). As a micronutrient, it has been indicated to be beneficial to both plants and animals (Alloway, 1995). It has however been observed that if Zn exceeds certain limits in soils it becomes toxic to biota (Alvarez-Benedi and Munoz-Carpena, 2005; Ogundiran and Afolabi, 2008). Just like the other heavy metals, nickel is also very toxic. The result obtained shows that the concentration of nickel in the polluted soil is higher that the unpolluted soil. The implication of this is that nickel can cause delay in oil biodegradation by micro-organisms (Franco et al., 2010). The plant used as an indicator for the study were visible but not measurable in the unpolluted soil, while in the polluted soil the plants were not visible; this showed how crude oil can cause damage to plants when spilled into agricultural soil.

CONCLUSION

Cadmium, chromium, zinc, nickel and lead concentration were higher within the polluted soil samples. The unpolluted soil samples also had high level of heavy metal concentration than the maximum allowable limit, which showed unpolluted soil sample in Ogoni land is also polluted with heavy metals. The people’s livelihood as well as their food security is a function of the healthy state of the soil for plant production for sustainability. Therefore, it is recommended that the UNEP Environmental Assessment Report on Ogoni land should be implemented with immediate effect to ameliorate the native effects of crude oil spill on vital food crops of the Ogoni people.

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