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Effect of Crude Oil Pollution on Soil and Proximate Composition of Cassava from Owaza in Ukwa West Local Government Area of Abia State, Nigeria

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ABSTRACT: This work investigated the level of Total Hydrocarbon Content (THC), trace metals, physicochemical properties of the soil sample of Owaza shell location farmland and the level of proximate composition of cassava tubers from the same farmland so that proper evaluation could be reached following standard procedures. The result of the physicochemical analysis revealed that the pH of the polluted soil sample were slightly acidic than the control and the bulk density increased above 1.6 g/cm^3 that tend to restrict root growth. The THC and the trace metal level in both soil and cassava samples from the polluted farmland increased, which could be deleterious to living organism including man within affected communities. The proximate composition of the cassava sample from the polluted soil sample was also affected as the calorific value decreased (251.60 ± 0.01 kcal) to compare to that from unpolluted sample (330.96 ± 0.04 kcal). The effect of crude oil pollution on soil and plants could amount to whole lots of devastating consequences ranging from low soil fertility which implies low agricultural productivity, reduced source of livelihood, and increase in medical complication within host communities. Proper remediation process would be necessary in affected communities so that normalcy could be restored.

KEYWORDS: Crude oil exploration, Pollution, Trace Metals, Total Hydrocarbon (THC), Owaza Shell location.

1 INTRODUCTION

Over the years, Nigeria had witnessed an increasing rate of oil exploration in order to meet the needs of its teeming population. These explorations take place predominantly in south-south and the south-easthern part of Nigeria where crude oil deposits are found in quantum. Osuji and Achugasim, [1] reported that nearly all of Nigerian crude is produced from this region that is dotted with over 210 oil fields, 160 flow station cris-crossed by more than 12,000 km of old flow lines. However, this no doubt in recent time had left devastating consequences on the ecological habitat, directly obstructing the food chain with indelible health complications occasioned by oil spillage from the mega station and from broken or vandalized pipelines. For instance, an average of 122 spills per year was reported between 1970 and 1982 and an average of 1080 spills per year between 2000 and 2004 [1].

Analytical procedures commonly used to assess contamination of petroleum products are by determination of hydrocarbon fractions, total hydrocarbon and heavy metal contents [2]. The heavy metals and hydrocarbon belong to types of toxic substances that have adverse effects on health. Environment Canada, [3] reported that heavy metals might adversely affect specific tissues, reproduction and development. This may also cause anemia, nervous system disorders and depressed immune systems, resulting in mortality and effects on population levels [3]. Whereas, hydrocarbon contamination exerts adverse effect on soil condition such as higher acidity, reduced C, N, P and exchangeable cations availability, and depressed microbial activity [2], it totally leads to decreased production of food crops.

For instance, Abii and Nwosu, [4] studied two oil spill affected areas (Ogali and Agonchia) while an unaffected area (Aleto) all in Eleme LGA, Rivers State was used as control. The results showed that there was a significant decrease in the Ca, K, P, as well as a significant increase in the sand fraction and Na content of the oil spill affected soils when compared with the non affected soil. The results further showed that oil-spill had adversely affected the nutrient level and fertility states of Eleme soil [4]. However, this study was designed for the purpose of determining the level of total hydrocarbon content (THC), mineral composition (iron (Fe), zinc (Zn), nickel (Ni), cadmium (Cd), lead (Pb) and copper (Cu)), physicochemical properties of the soil sample of Owaza shell location farmland and the level of proximate composition of cassava tubers from the same farmland so that proper evaluation and conclusion can be reached.

2 Materials and Methods

2.1 Site Description

The study site is around the vicinity of Imo River-2 flow station at Owaza in Abia State of Nigeria (Fig. 1 and 2), located East of Nkali and North of Isimiri flow stations in the Niger Delta Basin where oil spill do occur, which is most times caused by valve failure like the one that occurred in September 20, 2003 at the relief pit behind the flow station (Fig 3) and covered over five hectares of arable land. It was estimated at that time that about 30,000 barrels which is approximately 4.8 million litres of crude oil were released.

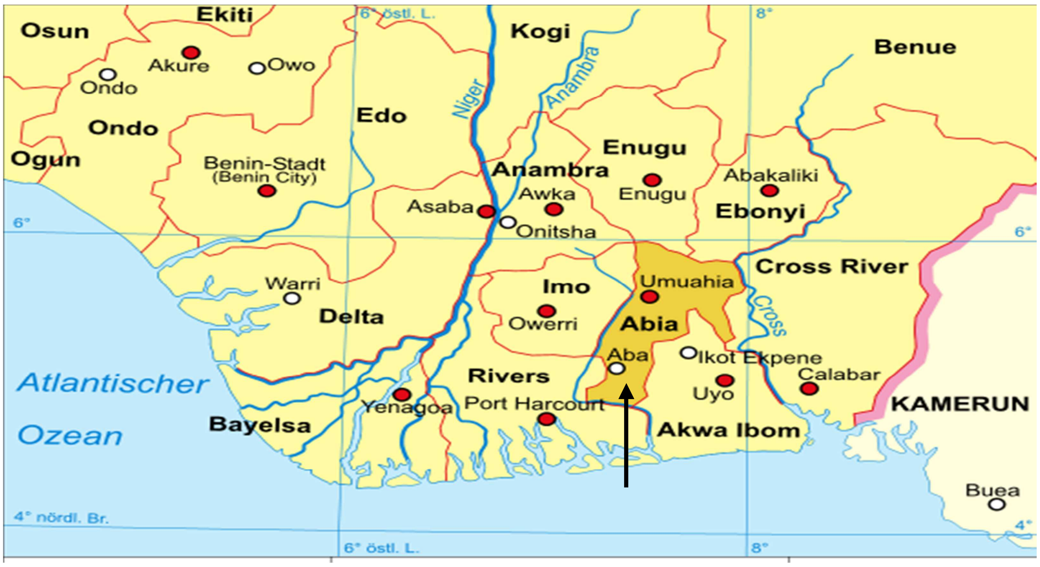

Fig. 1: A cross-section of the Map of Nigeria Showing Abia State, Nigeria [5]

Fig. 2: A Map Showing Owaza and its Environs [6]

Fig. 3: An oil polluted land within the environment of Shell Petroleum Development company oil flow station at Owaza in Ukwa West Local Government Area of Abia State, Nigeria

2.2 SAMPLE COLLECTION

Soil samples were collected in triplicate using a hand soil auger from crude oil polluted farmland at Owaza, Shell location just at the spot where plant material were harvested, first by removing litter from the soil surface and then excavating the soil at a depth of 0-15cm (top surface) and 15-30cm (sub-surface depths). The samples were wrapped and labelled promptly with aluminium foil, and taken to the laboratory for analysis. Soil sample were also collected from unpolluted site in triplicate.

The cassava tubers (Fig. 4) were harvested from the crude oil polluted environment in triplicate and the control gotten from the unpolluted farmland and were labelled and taken to the laboratory for proximate analysis.

Fig. 4: Cassava samples used

2.3 SAMPLE PREPARATION

The soil sample for analysis was oven dried, crushed and sieved to remove debris. The dried samples were grounded in a mortar and pestle to avoid heavy metal contamination, sieved and stored appropriately at room temperature for analysis. The cassava samples were hand-peeled and washed in distilled water after which it was sliced into smaller parts with a knife and dried, grounded and separately store in an appropriately labelled 100ml beakers and covered with aluminium foil.

2.4 DETERMINATION OF PHYSICOCHEMICAL PROPERTIES OF SOIL

The pH of the soil samples was determined as described by Ebere *et al*., [7]. Two grams (2 g) of phosphate powdered buffer was dissolved in 200 mL of sterile distilled water, and used to standardise a pH meter at pH 7.0. The reference electrode was aseptically dipped into 50 mL aliquots containing 1g of each sample. The pH meter was read off and the reference electrode subsequently washed with distilled water.

Bulk density was determined by the very common method of measuring simply by collecting a known volume of soil using a metal ring pressed into the soil (intact core), and determining the weight after drying [8]. Bulk density is usually expressed in mega grams per cubic metre (Mg/m^3) but the numerically equivalent units of g/cm^3 and t/m^3 are also used (1 Mg/m^3 = 1 g/cm^3 = 1 t/m^3) [9].

$$\boldsymbol{Bulk\ density\ (g/(cm)^3\ ) = \frac{Dry\ soil\ weight\ (g)}{Soil\ volume\ (cm^3)}}$$

2.5 Determination Of Total Hydrocarbon Content (THC)

The photometric method employed by Ebere *et al*., [7] was used. Aliquot of 0.1 g of the soil sample was mixed with 10 mL of carbon tetrachloride solution. This mixture was stirred and decanted using a separate funnel into a glass capped container. Clean tap water was added and shaken vigorously until all silt materials in the sample were displaced. The mixture was allowed to stand out and the carbon tetrachloride (CCl_4) phase decanted into a clean conical flask. Enough Na_2SO_4, (anhydrous), was added and shaken vigorously to remove all traces of water that may still have been present in the mixture. The resultant clear solution was spectrophotometrically analysed at 420 nm using Japan APEL PD-3000UV UV-Spectrophotometer in which carbon tetrachloride Solution was used as the blank. Hydrocarbon (oil and grease), concentration in the samples were extrapolated from a standard curve and calculated using the relationship:

$$\%\ \boldsymbol{Crude\ oil\ (ppm) = \frac{Conc. from\ graph * T.V.S.E}{Weight\ of\ sample\ (mg)}}$$

Where, T.V.S.E. is Total Volume of Solvent Extract (10 mL).

2.6 Determination Of The Heavy Metal Composition

Heavy metal composition was determined as modified from the works of Ashiq *et al*., [10]; Madukosiri and Dressman, [11] and Zeng-Yei, [12]. Two grams (2g) of the oven dried sample were digested with 12 ml of di-acid mixture (Conc. Nitric acid (HNO_3) and perchloric acid ($HCLO_4$) in the ratio 2:1) on a hot plate to a temperature of 120 ^oC for 15mins till frothing cease. After digestion, the solution was allowed to cool to a room temperature and thereafter filtered into a conical flask and was made up to 50 ml using deionised water and was stored in a 50 ml container prior to analysis. Bumping chips were added to prevent vigorous boiling during heating. The digested samples were further analyzed using the Varian Atomic Absorption Spectrophotometer (FS 240).

2.7 Proximate Analyses Of The Cassava Tuber

The proximate composition of the cassava sample was determined using the methods of the AOAC, [13]. Moisture content was determined by thermal drying (air oven) method. Ash content was determined using the furnace method. Crude protein content was estimated by the use of Kjeldahl and titration method. Crude lipid content was done using soxhlet type of the direct solvent extraction method as reported by Nwinuka *et al*., [14]. Crude fibre content was estimated by the AOAC acid and alkaline digestion methods. Total carbohydrate content was determined by Cleg Anthrone Method [15]. The Calorific values was determined using the Atwater factors of 4, 9 and 4 for protein, lipid and carbohydrate, respectively, to multiply their mean values as reported by Onyeike *et al*., [16].

2.8 Statistical Analyses And Data Processing

One-way analysis of variance (ANOVA) was conducted on each of processing methods and Least Significant Difference (LSD) test at significant level of $p < 0.05$ was performed using SPSS version 17 software for windows to compare the difference between treatment means.

3 Results and Discussion

The result of the physicochemical properties (Table 1) revealed that the pH of the polluted soil sample were slightly acidic (polluted soil (0-15) cm = 5.6, (15-30) cm = 6.4) when compared to the control (unpolluted soil (0-15) cm = 6.5, (15-30) cm = 7.2). The result suggests that the crude oil spills on the soil impacted negatively on the soil pH by lowering it and hence making un-conducive for growth and sustenance of living organisms. The bulk density of the soil was also impacted negatively as bulk density result were found to be high in the polluted soil sample (polluted soil (0-15) cm = 1.72, (15-30) cm = 1.25) when compared with the control soil (unpolluted soil (0-15) cm = 1.57, (15-30) cm = 1.12). Hunt and Gilkes [17] suggested that the critical value of bulk density for restricting root growth varied with soil type, but in general bulk densities greater than 1.6 g/cm3 tends to restrict root growth [8].

Table 1: Result of physicochemical properties of soil from the study sites

Physiochemical properties	**Polluted Soil Sample**		**Unpolluted Soil Sample**	
	Polluted (0-15) cm	Polluted soil (15- 30) cm	Control (0-15) cm	Control (15-30) cm
Ph	5.6	6.4	6.5	7.2
Bulk Density (g/cm^3)	1.72	1.25	1.57	1.12

The study indicate high level of total hydrocarbon (Table 2) from Owaza crude oil polluted farmland (polluted soil (0-15) cm = 2637, (15-30) cm = 2389) when compared to the control (unpolluted soil (0-15) cm = 1212, (15-30) cm = 1184). This however provided evidence of severe hydrocarbon contamination of the farmland. The conditions generally imply low soil fertility, which gives low agricultural product and reduces source of agricultural product and hence decreased source of livelihood in the affected areas. High levels of THC could be deleterious to health when consumed or by mere contact with the skin [11]. Some health complications resulting from toxicological problems said to have direct link with the exposure to high levels of hydrocarbons includes blood and kidney problems when inhaled, disorders of the central nervous system due to loss of myelin, and dermatitis when in contact with the skin [18].

Table 2: Total hydrocarbon content of the soil and cassava sample (mg/100g)

THC content	**Polluted Soil Sample**		**Unpolluted Soil Sample**	
	(0-15) cm	(15- 30) cm	(0-15) cm	(15-30) cm
THC of soil sample	2637	2389	1212	1184
	Polluted cassava sample		Unpolluted cassava sample	
THC of cassava sample	9302.30		3900.70	

The observable increase in total hydrocarbon content (THC) of the cassava sample (Table 2) from the crude oil polluted environment may be attributed to the high content of carbon in the oil polluted soil (9302 mg/100g) to compare with the non-oil polluted environment (3900.70 mg/100g). The observation was in accordance with the findings of Ekundayo and Obiekwe, [19] who noted increase in organic carbon content of crops from oil polluted farmland in southern Nigeria. The aftermath of the increase in total hydrocarbon content is the increase in the level of heavy metals such as Lead, Nickel, Cadmium etc., which when found in soil, water bodies, air etc. causes hazardous effects due to its carcinogenic and mutagenic effect on humans. The result from the atomic absorption spectroscopic analysis indicated that trace metals (Fe, Zn, Ni, Pb, Cd and Cu) level from crude oil polluted soil (0-15 cm) was significantly higher than the trace metal level in the depth of (15-30 cm) as well far higher when compared to the control (Table 3). It is on record that Pb causes emotional changes, insomnia, neuromuscular changes, headaches [20].

Table 3: Result of the Mineral Composition of the Soil Sample (mg/kg)

Minerals	**Polluted Sample**		**Unpolluted Sample**	
	(0-15) cm	**(15-30) cm**	**(0-15) cm**	**(15-30) cm**
Fe	40.50±0.01	36.18±0.25	22.10±0.03	11.15±0.01
Zn	1.80±0.01	1.02±0.01	0.80±0.00	0.35±0.03
Ni	0.16±0.01	0.10±0.01	0.12±0.04	0.11±0.02
Cd	0.01±0.00	0.01±0.01	0.01±0.00	ND
Pb	3.69±0.01	2.20±0.01	0.85±0.00	0.22±0.02
Cu	0.72±0.01	0.43±0.01	0.25±0.01	0.10±0.03

Values were presented as Mean ± standard deviation of triplicate determination at p≤0.05. (ND = Not determined).

Also, Madukosiri and Dressman, [11] affirmed that Lead (Pb) is known to be widely distributed as metallic lead, inorganic and organometallic compounds. Most known toxic organo-metallic Pb compound is tetraethyl lead, used as an octane-boosting gasoline additive. Lead in this form has high affinity for lipid and for sulphydryl groups of many proteins. Evidence showed that Pb, at toxic levels could inhibit the activity of the enzyme, carbonic anhydrase - which functions in carbon dioxide transport by the blood. Also Pb can inhibit the synthesis of haemoglobin by blocking the ferrochelatase reaction. In the nervous system, Pb as well as mercury and cadmium can act as inhibitors of action potential, by antagonizing the specific calcium dependent process required for the release of the neurotransmitter from the presynaptic nerve terminus [21].

The result of the proximate composition of the cassava sample (Table 4) revealed that the moisture content was higher in sample from oil polluted environment (33.64 ± 0.04 %) than that from non-oil polluted environment (15.85 ± 0.02 %) (Fig. 5). This indicates that cassava sample from non-oil polluted environment can be stored for a longer time due to its low water activity than the one from oil polluted environment. The ash content was higher in oil polluted environment (2.01 ± 0.01 %) than the non-oil polluted environment (1.24 ± 0.02 %). Crude oil pollution increases the mineral elements in the sample from oil polluted environment. Increase in mineral content of plant grown in crude oil polluted environment above recommended standard may be deleterious to health of the population depending on the plant for food. The lipid content of the sample from oil polluted environment (1.85 ± 0.03 %) was significantly ($p<0.05$) higher than that from non-oil polluted environment (0.68 ± 0.02 %).

Table 4: Result of proximate composition of cassava from oil polluted and unpolluted soil

Parameters	**Proximate Composition**	
	Polluted Cassava Tuber	Unpolluted Cassava Tuber (Control)
Moisture content (%)	33.64 ± 0.04^a	15.85 ± 0.02^b
Total carbohydrate (%)	56.55 ± 0.05^b	78.65 ± 0.05^a
Lipid content (%)	1.85 ± 0.03^a	0.68 ± 0.02^b
Ash content (%)	2.01 ± 0.01^a	1.24 ± 0.02^b
Crude protein (%)	2.19 ± 0.01^b	2.56 ± 0.03^a
Fibre content (%)	3.77 ± 0.01^a	1.02 ± 0.02^b
Calorific value (kcal/100g)	251.60 ± 0.01^b	330.96 ± 0.04^a

The values above were presented as mean ± standard deviation (S.D) of triplicate determinations. Values in the same row bearing the same superscript is not significantly different at *p< 0.5*.

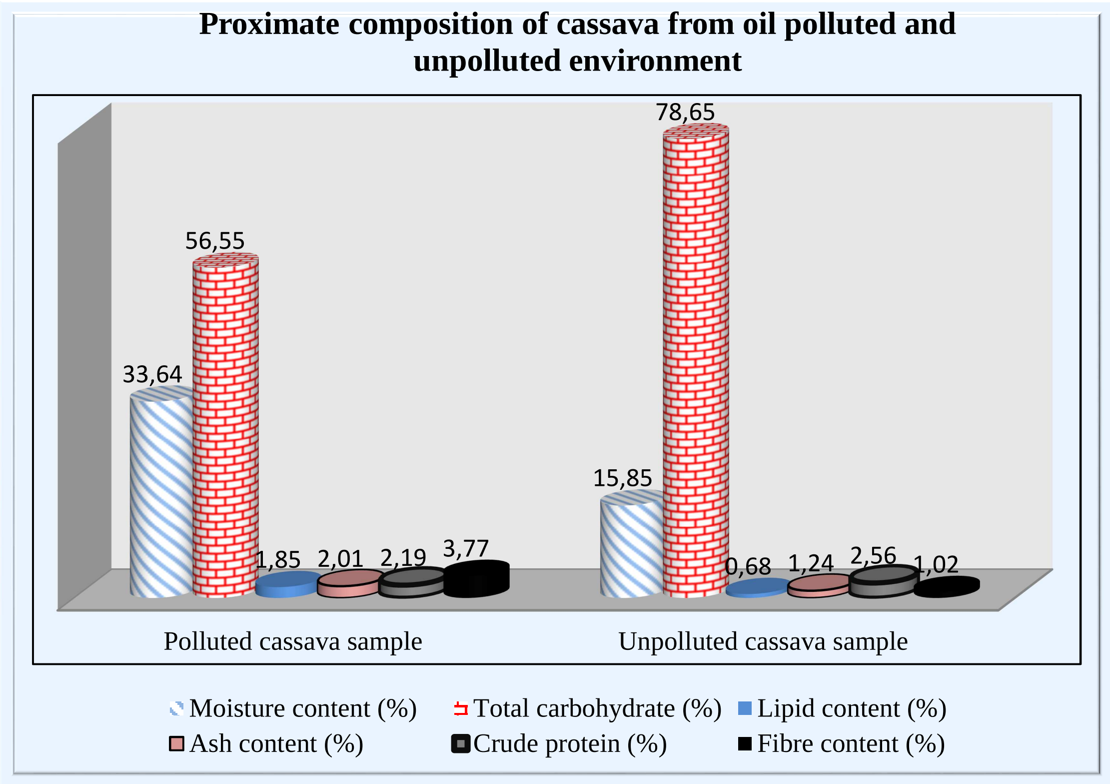

Fig. 5: Proximate composition of cassava from oil polluted and unpolluted environment

High level of fibre in the sample from oil polluted environment may help in lowering the blood sugar level and blood cholesterol, while decreasing the carbohydrate content of the plant. Increase in fibre could be as a result of adverse effect of crude oil pollution in the photosynthetic apparatus of the plant. Furthermore, the crude protein, total carbohydrate and energy value of the samples harvested from the non-oil polluted environment were higher than those from oil polluted environment. This suggests that the spill affected the productivity and yield of the cassava crop. Generally, the total carbohydrate content was higher in samples from non-oil polluted environment and this implies that samples from non-oil polluted environment will provide more energy to the body and of higher economic value than that from polluted farmland.

4 Conclusion

The effect of crude oil pollution on soil and plants could amount to whole lots of devastating consequences ranging from low soil fertility which implies low agricultural productivity, reduced source of livelihood, and increase in medical complication within host communities. Proper remediation process would be necessary in affected communities so that normalcy could be restored.

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Conflicts Of Interest

Both authors declare no conflict of interest.

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