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ASSESSMENT OF HEAVY METAL CONCENTRATION IN FOOD CROPS GROWN AROUND ETELEBOU OIL FLOW STATION IN BAYELSA STATE, NIGERIA

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ABSTRACT

Previous studies have shown the effects of crude oil extraction on "environmental mediums" and "environment mediums" but few attempts have been made to study the effect of this activity on locally grown food crops in the Niger Delta Region of Nigeria, where oil activities have developed over the past fifty years. This study aimed at assessing the concentration levels of some heavy metals in tuber crops grown in farmlands around Etelebou oil flow station in Bayelsa State. Three samples of each of the three tuber crops, namely cocoyam (Xanthosoma mataffa), cassava (Manihot essulenta) and plantain (Musa sapientum) from the oil polluted farmland were collected, prepared, digested and analyzed in the laboratory with the aid of Atomic Absorption Spectrophotometer. Results obtained showed that the concentration levels of the heavy metals analyzed (Fe, Zn, Cr, Cu, and Pb) in these food crops were found to be relatively high and gradually accumulating over time, higher than the background values (controls). Of particular concern was the bioaccumulation of Pb in cassava (2.0mgIkg) and plantain (1.94mgIkg). These findings are indicative of potential health hazards faced by the indigenous population who feed on these crops. There is need to closely monitor the great danger posed by the bioaccumulation of these trace heavy metals on the health of the "population" animals and plants in the area.

KEY WORDS: flow station, food, crops, heavy metals, oil, pollutants.

INTRODUCTION

The Niger Delta Region, the world's largest wetland accounts for 7.5 percent of the total landmass of Nigeria (Ugbomeh and Atubi, 2010). With an estimated population of about 22 million, the region's oil resources account for 90 percent of the nation's export earnings. The region aso house over 600 oil fields, 5284 on and off-shore oil wells, 10 export terminals, 272 flow stations, 4 refineries and a Liquefied Natural Gas (LNG) project, with an estimated oil reserve of 30 billion barrels (Lubeck et al 2007). Petroleum activities have brought prosperity, better living conditions and general economic development to Nigeria (Okpara, 2004, Evoh, 2002). Unfortunately, the Niger Delta Region, and over the years, has witnessed massive oil-based environmental degradation and soil fertility loss (Nwuche and Ugorji, 2010, Akwiwu, 2002), agricultural decline (Duru, 2005; Otitoloju and Udosen, 2004), oil spillage and gas flare (Ezebuiro, 2004), fisheries decline and depletion of biodiversity (Daniel-Kalio and Braide, 2004, Ikelegbe 2004). Oil spills have also been observed to cause the death of plants (Osuji and Ezebuiro, 2006; Ufot et al 2003), and have been linked with blood contamination of people working at impacted sites (Mckelvey et al 2007). One of the greatest problems associated with oil pollution is the constant exposure to high concentration of heavy metals from oil (Osuji et al, 2004; Nkwocha and Duru 2010). Several studies in China, South Korea and USA have shown that heavy metals from mining activities widely contaminated nearby sources of drinking water (Beaumont et al 2008; Zhang and Li, 1987), food crops (Satarung and Moore, 2004), and drastically affected the health of vulnerable population including children (Fielder et al, 2003; Martha et al, 2001). It has also been widely documented that the consumption of food crops contaminated with heavy metals may lead to serious systemic health problems in the body of the affected persons (Jarup 2003; Jarup and Alfven,2004; Griggs, 2004). Heavy metal contamination of agricultural soils and crops in the vicinity of mining areas has been regarded as a major environmental concern (Kalili et el 2011; Costa, 2006; Liu et al 2005a; Luo et al, 2003). Despite these findings, few studies in Nigeria have attempted to examine the effect of crude oil from the numerous oil flow stations on the food crops planted around them. The aim of this study was to assess the concentration levels of heavy metals in food crops grown around an oil flow station in the heart of the Niger Delta Region. This will help to provide baseline information on the level of risks faced by the indigenous population where these crops are grown and widely consumed.

MATERIALS AND METHODS

Study Area

The study was conducted in October 2010, at two different sites of cultivated lands in Etelebou, Yenagoa Local Government Area (LGA) of Bayelsa State. The area marks the geological boundary of the formation and the meander belts of the Upper Deltaic Plains of the Niger Delta Region (Osuji and Onojake, 2004). This area falls within the tropical climate characterized by rainy and dry seasons; lies between Longitude 5^0E and 8^0E and Latitude 4^0N and 6^0N (Opafunson 2007), with a rural population made up of peasant farmers who also engage in fishing, hunting and gathering with few commercial activities. This community counts these oil flow stations, surrounded by farmlands where crops such as plantain, cocoyam, cassava, pumpkin, melon etc are planted all year round. These crops are heavily consumed by the local population who depend on them as their major staples.

Data Collection

This study was a follow-up of an exhaustive research carried out in April 2011 to assess the impact of oil from the same oil flow station on the surrounding soil quality using ASTM method (2007). Data and results obtained from this research formed part of this study. The results were essentially used as a reference material for soil data at the polluted and control sites. In our study, two sampling site locations that corresponded with this earlier study, were used. Site A was the impacted site made up of the farm land surrounding the oil flow station, on which different food crops were planted. Three major food crops were selected for the study, namely, cassava, plantain and cocoyam. Aside constituting as major food crops for the local people, these crops can easily bioaccumulate heavy metals from the soil (Osuji et al, 2004). Site B, on the other hand, is located at about 900m from Site A with relatively no petroleum activity but was also cultivated with the same food crops. Site B therefore served as the control site. The trace heavy metals analyzed include Pb, Fe, Cu, Cr, and Zn. These metals represent some of the normal constituents of oil in varying proportions (NRC, 1985). From these two sites, three samples of each of the three food crops were randomly collected, washed with clean water, peeled, sliced and dried in an oven at 70^0C for a period of 72h. The specimens were then cooled to ambient temperature, milled and sieved through a mesh of 1mm diameter. The prepared specimens were then digested slowly on an electrothermal heater for about 20mins, then cooled and filtered through a 541 Whatman filter paper into a volumetric flask. The residual acid concentration of the digested samples were brought to 1% v/v after digestion. The digested samples were then analyzed for trace heavy metals using the Atomic Absorption Spectrophotometer Model 451. The instrument was calibrated using standard solutions of Pb, Fe, Cu, Cr and Zn. The absorbance obtained were used in calculating the concentration levels of the metals in different samples of the food crops. Analyses were carried out at the UNIDO Laboratory, Owerri.

Statistical Analysis

In the primary analysis, univariate statistics (mean, SD) were used to present the concentration levels of contaminants in the samples. The values obtained from these samples were subjected to further analysis using logistic regression. As the levels of contamination may vary among sites, non-parametric methods were used to assess variations in relation to sample characteristics. One-way analysis of variance (ANOVA) was used to examine the statistically significant differences in concentration levels of trace metals in the food crops on the assumption that oil pollution affected the crops grown at the two sites equally. Results were given with 95% confidence intervals (CIs). Significant heterogeneity was defined as a chi-square test of p-value <0.1. All analyses was performed using SPSS version 17.0 for windows (SPSS; Chicago, IL; USA). All significant testing were two sided.

TABLE 1: Concentration of Zn, Pb, Cu, Fe and Cr in Mg/Kg in Soil Samples, where T represents Topsoil and B represents bottom soil

Station	Station	Zn	Pb	Cu	Fe	Cr
1	T	8.19	0.98	1.81	18.50	0.81
	B	9.00	1.67	3.01	19.30	0.91
2	T	8.30	2.33	2.30	27.10	0.51
	B	9.90	3.33	4.20	27.10	0.60
3	T	7.40	0.64	2.20	20.00	0.10
	B	8.60	0.91	4.10	22.01	0.40
4	T	8.14	1.32	2.44	20.90	0.47
	B	9.37	1.97	3.77	21.80	0.64
5	T	7.96	1.10	2.10	23.40	0.61
	B	6.30	1.43	3.43	24.70	0.78
6	T	6.89	2.22	3.30	17.10	0.21
	B	7.32	3.10	4.41	19.20	0.81
7	T	6.93	1.42	2.10	19.10	0.30
	B	9.22	2.38	3.92	20.10	1.02
8	T	7.33	2.08	2.23	16.02	0.42
	B	8.24	2.42	3.10	18.50	0.52
9	T	6.82	2.10	2.54	17.80	0.31
	B	7.12	2.70	3.81	19.20	0.77
10	T	7.10	1.85	2.46	19.60	0.48
	B	8.34	2.90	3.27	20.40	0.93
Control	T	1.40	0.03	1.20	14.40	0.002
Site	B	1.60	0.04	2.34	15.10	0.003

TABLE 2: Minimum and Maximum Concentration of Heavy Metal in Food Crops in Mg/Kg

		Minimum	Maximum
Zn	Cocoyam	5.30	7.70
	Cassava	6.94	8.25
	Plantain fruit	4.81	6.41
Fe	Cocoyam	6.30	8.40
	Cassava	8.30	9.80
	Plantain fruit	9.42	10.55
Cu	Cocoyam	2.40	3.10
	Cassava	2.81	3.22
	Plantain fruit	2.10	2.93
Pb	Cocoyam	1.73	2.00
	Cassava	1.94	2.41
	Plantain fruit	1.20	1.92
Cr	Cocoyam	.33	.54
	Cassava	.41	.71
	Plantain fruit	.42	.62

RESULTS AND DISCUSSION

It was well established in the previous study that soil sampling carried out in the vicinity of the oil flow station showed significant build-up of metal concentration in the soils of the farmlands up to 500 meters from the station (Agbalaje, 2010). Fig. 1 shows the mean concentration values of these trace metals in the top (0-15cm depth) and bottom (15-30cm) depth) soils. Higher values were recorded at the bottom soils. For example, Zn recorded a value of 7.50mg/kg on top soil and 8.34mg/kg at the bottom soil; Pb 1.60mg/kg at top soil and 2.28mg/kg at bottom soil, while Cr recorded the least mean values of 0.42mg/kg on top soil and 0.73mg/kg at bottom soil. Table 2 clearly shows the minimum and maximum values of these contaminants in the samples of the food crops. The minimum concentration level of Zn was recorded in plantain (4.81mg/kg) while the maximum concentration level was recorded in cassava (8.25mg/kg). For Fe, the minimum level was recorded in cocoyam (6.30mg/kg) while the maximum was found in plantain (10.55mg/kg). The least concentration of Cu was recorded in plantain (2.10mg/kg) as the maximum concentration level was found in cassava (3.22mg/kg). As for Pb, the minimum value was recorded in plantain (1.20mg/kg) while the maximum concentration level was observed in cassava (2.41mg/kg). The least values of all these trace metals were recorded on Cr with minimum concentration level found in cocoyam (0.33mg/kg) and the maximum in cassava (0.71mg/kg). All these values were obtained from samples of food crops grown at Site A, the impacted site. The samples collected from Site B, (control), recorded concentration levels of these trace metals below detectable limits as shown in Tables 2 and 3.

TABLE 3: Concentration of Zn, Pb, Cu Fe and Cr in Cocoyam, Cassava and Plantain in Mg/Kg

Element		Cocoyam	Cassava	Plantain
Zn	S_1	7.70	8.25	6.410
	S_2	6.24	7.28	5.320
	S_3	5.30	6.94	4.810
Fe	S_1	7.60	9.80	10.55
	S_2	8.40	8.40	9.70
	S_3	6.30	8.30	9.42
Cu	S_1	3.10	3.22	2.93
	S_2	2.40	3.21	2.76
	S_3	2.60	2.81	2.10
Pb	S_1	2.00	2.41	1.92
	S_2	1.73	2.00	1.20
	S_3	1.81	1.94	1.74
Cr	S_1	0.54	0.71	0.62
	S_2	0.33	0.63	0.42
	S_3	0.41	0.41	0.58
Control		0.001	0.003	0.006

The result of multiple regression analysis showed that concentration levels of these heavy metals in the food crops were significantly high and are associated with three variables, namely, crop species (cassava recorded higher levels of concentration of these contaminants than other crops, $p = 0.023$, partial correlation = 0.351), increasing age of crops ($p=0.017$, partial correlation = 0.412) and soil type (sandy clay soil at a distance from the polluted site recorded higher than sandy loam close to the project site $p = 0.011$, partial correlation = 0.372) (Table 4). These three variables explained 71 percent of the total variance, but most importantly they could be explained by the high concentration levels of the trace metals recorded in the soils of site A, the polluted site. The high values of the trace elements recorded in the food crops sampled at site A could be attributed to the high concentration levels of these contaminants in the soils of the farmland where these crops are grown. The only source of these elements was the different oil related activities going on at the flow station which constantly released oily substances that found their way into the surrounding soils and consequently contaminated the food crops. Also, the low concentration values of these trace metals at site B, located at 900m from the polluted fields is an indicator that petroleum activities at site A were responsible for the pollution of the food crops around this site. It was observed that the values of Pb and Zn recorded in cassava and plantain were higher than the values recorded in the corresponding soil samples indicating hyper-accumulation in these crops. Plantain and cassava tubers can serve as bioindicators of soil pollution as recorded in this study. Of serious concern is the high concentration levels of Pb observed especially in cassava sampled in site A which exceeded WHO maximum acceptable limits for foods. There is risk of lead poisoning from cassava harvested from the oil polluted farmlands around Etelebou flow station and many other oil stations scattered throughout the Niger Delta Region. Garri is a common product from cassava tubers widely consumed by the local population and constitutes a major ingredient in the local staple. It is well established that exposure to high levels of Pb may cause kidney damage leading to renal failure (Laura et al 2009; Colgan 2003). Such high concentrations of Pb in cassava in particular, and other trace heavy metals in general, may particularly affect vulnerable populations including children (Wang and Zhang, 2006; Canfield et al 2003) and all exposed adults (Saraiva et al, 2007; Weisskopf et al, 2007; Vahter et al, 2007; Fiedler et al, 2003). The dual and dangerous arguments posited by Moffat and Linden (1995) that *only areas that are directly affected by oil activities exhibit long-term environmental effect*, and therefore, *the general impact of oil pollution on human health in the Niger Delta may not be significant* do not hold water in this context. Also, Onwubiko (2011) in a recent research in Ogoni land concluded that:

while soil and water characteristics show evidence of variations attributable to influence of petroleum activities in the oil producing communities, studies did not show that people's economic and social life had been completely affected adversely.

The problems (tears, blood, and deaths) characterizing these areas arise more from information mismanagements, selfishness, and sentiment on all sides rather than from scientifically proven deterioration of the environment. Agitations coming from the people are based more on psychological impulses rather than on concrete scientific facts, even if there were any.

Conclusions arising from these studies and others of this genre, covertly sponsored by Multi-National Oil Companies (MNOCs) operating in the Niger Delta Region, are proffered to diffuse tension among the aggrieved stakeholders in the affected areas and are completely at variance with many empirical scientific research findings in the area. The fact is that most of these rural communities heavily affected by oil and oil related activities in the Niger Delta still remain the food baskets of the population in the region. As more people, especially those living in the urban areas depend on the agricultural products from these rural communities for their living, they are more and more exposed to contamination of these trace metals including lead, both in the short term and in the long term.

TABLE 4. F- 95 Confidence Interval for Mean of Heavy Metal Concentration in Food Crops

		N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound
Zn	Cocoyam	3	6.4133	1.2094	.6982	3.4091	9.4175
	Cassava	3	7.4900	.6798	.3925	5.8013	9.1787
	Plantain fruit	3	5.5133	.8173	.4719	3.4830	7.5437
	Total	9	6.4722	1.1759	.3920	5.5684	7.3761
Fe	Cocoyam	3	7.4333	1.0599	.6119	4.8005	10.0662
	Cassava	3	8.8333	.8386	.4842	6.7500	10.9167
	Plantain fruit	3	9.8900	.5885	.3398	8.4282	11.3518
	Total	9	8.7189	1.2970	.4323	7.7219	9.7159
Cu	Cocoyam	3	2.7000	.3606	.2082	1.8043	3.5957
	Cassava	3	3.0800	.2339	.1350	2.4909	3.6610
	Plantain fruit	3	2.5967	.4384	.2531	1.5075	3.6858
	Total	9	2.7922	03779	.1260	2.5017	3.0827
Pb	Cocoyam	3	1.8467	.1387	8.007E-021	.5022	2.1912
	Cassava	3	2.1167	.2558	.1477	1.4812	2.7521
	Plantain fruit	3	1.6200	.3747	.2163	.6892	2.5508
	Total	9	1.8611	.3204	.1068	1.6149	2.1074
Cr	Cocoyam	3	.4267	.1060	6.119E-02	.1634	.6900
	Cassava	3	.5833	.1553	8.969E-02	.1974	.9692
	Plantain fruit	3	.5400	.1058	6.110E-02	.2771	.8029
	Total	9	.5167	.1286	4.288E-02	.4178	.6156

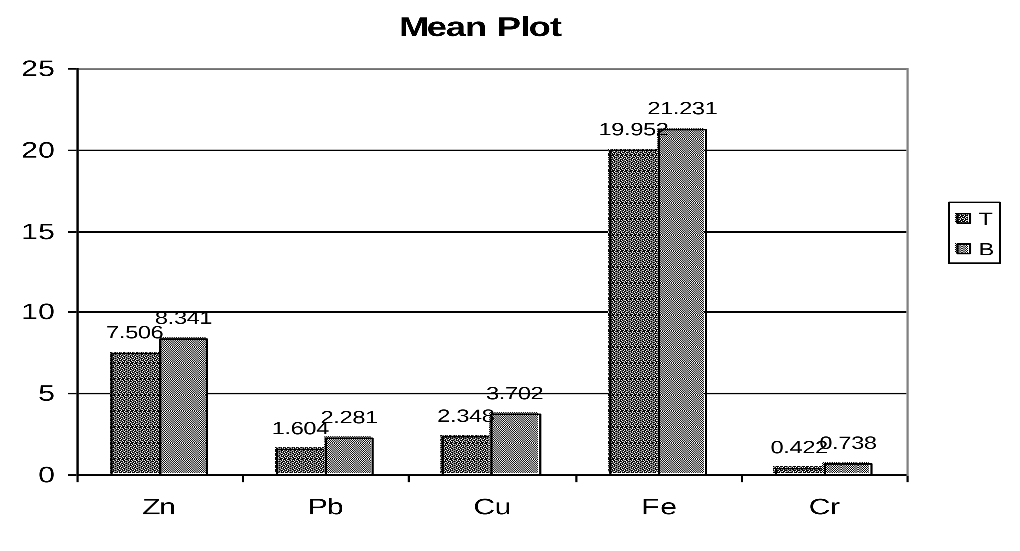

Fig.1: Mean concentration (mg/kg) of Zn, Pb, Cu, Fe and Cr in soil samples, where T represent Top soil and B bottom soil
Source: Agbalaje, 2010

CONCLUSION

This study has tried to assess the concentration levels of heavy metals in food crops grown around Etelebou oil flow station in Bayelsa State. The results of the case examined showed that oil and oil related activities at this station polluted the surrounding agricultural soils which led to the contamination of the locally grown food crops, and invariably the local food chain. The high concentration levels of the trace heavy metals identified, especially Pb, is of particular concern. As some of these trace metals bio-accumulate in human organs and tissues, they constitute potential danger to the health of all those who consume food products from these polluted areas. The results of this study are sufficiently compelling to warrant future studies in the area to obtain general and specific information on the quality of food crops grown around all oil-related facilities in the Niger Delta Region to ensure food security in the area in the years ahead.

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