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Risk Assessment and the Translocation of Heavy Metals to Some Edible Vegetables in an Oil Palm Mill Site in Okada Community, Edo State, Nigeria

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Abstract

Environmental damage caused by agricultural waste owing to increased agricultural activities is a problem of global concern. Following estimated data, up to 40% of the oil palm waste (biomass) including the Oil Palm Shell (OPS), oil palm Empty Fruit Bunch (EFB), Pressed Fruit Fibre (PFF), Oil Palm Trunks (OPT), Oil Palm Leaves (OPL) and palm oil mill effluent generated from Oil Palm Mill Sites (OPMS) in Okada Community in Edo State, Nigeria, are incinerated as part of the waste management procedures to reduce the physical nuisance they create, or a large portion of the POME is allowed to run off into adjourning rivers and vegetation in the processing sites. This study investigates the source and levels of heavy metals concentration in soil samples and in two commonly consumed vegetables grown in the study area; *Amarantus hybridus* and *Talinum triangulate*. Concentrations of Heavy metals present in soil sample assessed were 0.01, 0.54, 0.05, 0.01, 2.1, 0.10, and 11.5 for Pd, Cu, Cd, Cr, Zn, Ni, Fe respectively. The vegetables were found to bio accumulate most of the heavy metals although at less than the WHO/FAO, FEPA and E.U. standard limits. Vegetable samples Fe levels exceeded the permissible limit of 0.3 mg/kg for vegetable samples. Low concentrations of heavy metals might be due to the short duration that these palm oil mill sites are situated in a location before they are relocated to other sites owing to poor waste management. This important source of livelihood and sustenance for the Okada people is presently posing as environmental nuisance, destroying agricultural land and having effect on soil and plants owing to poor waste management practice.

Keywords: Oil Palm Mill Sites; Environmental damage; Agricultural waste; Heavy metals; Amarantus hybridus and Talinum triangulate

Introduction

Okada town; the headquarters of Ovia North East local government Area which sits on latitude 6.7348800 and longitude 5.3944700 stands out as a rich green vegetation. The People of Okada and its neighboring communities are majorly trade-oriented and peasant farmers; who make use of their vast agricultural lands growing both arable and cash crops for their subsistence needs and for income. In Okada; Edo State; Nigeria; Oil palm is the most economically important plant and a large population of the women and youths are involved in the processing of the Oil Palm Fruits (OPF) into Palm Oil (PO) in out-numbered local Oil Palm Mill Sites (OPMS) settlements. They sell off the cracked kernels meant to be processed into Palm Kernel Oil (PKO) and the Palm Kernel Shell (PKS) at very low prices to traders in bigger cities while allowing a huge amount of these biomass materials to cause public nuisance creating huge hip of garbage; polluting and degrading the environment [1, 2]. All metals with atomic mass heavier than 50 are scientifically regarded as heavy metals [3-5]. Theoretically; heavy metals are not usually specified and a list comprising of 19 elements (Cr; Mn; Fe; Co; Ni; Cu; Zn; Ga; Ge; Mo; Cd; Sn; Sb; Te; W; Hg; Tl; Pb; and Bi) is often cited

Heavy metals are known hazardous contaminants in food; translocating into the food chain through the ecosystem caused by various human activities in our environment and posing as potential risk to humans [1, 6-9]. Proper waste management and waste disposal is still far-fetched in the sub-urban and urban areas in the Nigerian State with the area under review not left out from the menace [10]. Policies aimed at minimizing waste generation are totally lacking or not enforced in Okada region so artisanal oil palm millers are not regulated by policies to be responsive towards the proper disposal of the waste generated Ebong; Such waste management concerns include heaps of uncontrolled garbage; roadsides and oil palm mill sites littered with refuse; streams blocked with rubbish; all constituting a health hazard to residents [8]. Open dumps are a source of various environmental and health hazards and also ruins the aesthetic quality of the land [11] (Figure 1).

Figure 1: Oil palm mill Study Site in Okada, Edo State, Nigeria (Photo by Erifeta G.O).

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Research focus on the misuse and abuse of arable land; assessing the environmental impact of such mismanagement of earth's resources and possible contamination of edible vegetables grown around such installation is a public health concern [12]. As the present study area is free from serious industrial pollution; the major sources of heavy metal contamination might be due to the use of locally assembled fossil fuel enabled machines for the purpose of milling.

In this study; we looked into the concentration of different metals in both soil and in two commonly consumed vegetables grown around the oil mill sites and evaluated their contamination status in line with international standard guidelines.

Materials and Methods

Sampling site

Soils and vegetable *(Amarantus hybridus* and *Talinum triangulate)* samples were randomly collected from an Oil palm Mill site in Okada; Edo State; Nigeria (Figure 1) using hand trowel that had been pre-cleaned with concentrated nitric acid in order to prevent heavy metal contamination prior to analysis.

Plant collection

Random sampling technique was employed to collect the vegetable samples of African spinach; "Green" *(Amaranthus hybridus)* and waterleaf *(Talinum triangulare)* from an Oil Palm Mill Site in Okada; Edo state; Nigeria to obtain composite samples. The leaves of vegetable samples were separated from the whole plants with the aid of a stainless-steel knife and labelled.

Sample preparation

The vegetable samples; *Amarantus hybridus* and *Talinum triangulate* were air dried for 3days and then oven dried at 1050C; then ground into powder; a mixture of acid (aqua ragia) HNO3 and HCL; in the ratio of 3:1 was freshly prepared. 1g of the sample was weighed into a digestion bottle. 10ml mixture of the acid was measured into the bottle containing the sample. The mixture was then placed on a hot plate and heated slowly until the solution was clear. It cooled and filtered into a 100ml volumetric flask and made up to mark. The solution was used for Atomic Absorption Spectrum (AAS) analysis.

Atomic Absorption Spectrum (AAS) analysis

The BUCK Scientific VGA 210 AAS was used for analysis: The method used was the air-acetylene gas Flame Atomic Absorption Spectrophotometer (FAAS). 10ml of the test samples were aspirated using specific lamps that correspond to the metal being analyzed. The individual concentration of the samples was read off as displayed in mg/l.

Results and Discussion

The results obtained from the analyzed data to determine the concentrations of heavy metals in sample soil and vegetables are as presented in Table 3 and Table 7 Results indicated that sample soil contained heavy metals concentrations that were lower than the permissible levels when compared with several internationally set standard thresholds as presented in Table 1.0 to 2.0. It was found that the individual concentrations of Pd; Cu; Cd; Cr; Zn; Ni; Fe mean values were low in all sample soils when compared to various internationally acceptable limits and this could be indicative of low heavy metal exposure route. *Amarantus hybridus* and *Talinum triangulate* are commonly grown for food around most artisanal settlements of oil palm mill sites and these plants get to flourish well around such locations. The two locally grown vegetables at the sample oil palm mill sites also showed concentrations of heavy metals Table 5 and Table 6 that were below the desirable limits in plants as specified by WHO/FAO; FEPA and E.U. Standards. This is indicative of a low overall heavy metal pollution both in sample sites investigated. This is expected since bioaccumulation of heavy metals is strongly related to the concentrations of the elements in the soil. This can be understandably interpreted since exposure routes to these sites are limited. Typically; plants only take up heavy metals from soil solution. There are no industrial installations at the locations under neither review nor other verifiable sources of exposure. The only deducible source of heavy metals pollution could be as a result of uncontrolled use of fertilizers; pesticides and herbicides in farms where these oil palms are grown can be attributed to the heavy metals concentration in sample soils and vegetables analyzed. The low concentrations of heavy metals observed in both vegetables scientifically may not have any negative clinical effect on consumers since the reference limits; (Table 1 and 2) have been certified by FAO/WHO; FEPA and E.U Standards as safe levels. (Table 1-3 figure 3; table 4; figure 4; Table 5; Figure 5; Table 6; Figure 6; Table 7; Figure 7).

Table 1: WHO permissible limits for heavy metals in plant and soil.

Elements	*Standard value in soil	***Permissible value in plant
	(mg/kg)	(mg/kg)
Cadmium (Cd)	0.8	0.02
Zinc (Zn)	50	0.6
Cupper (Cu)	36	10
Chromium (Cr)	100	1.3
Pb	85	2
Ni	35	10
Specified concentration indicates desirable maximum levels of elements in unpolluted soils. Source: Denneman C (1996) and WHO (1996).		

Table 2: Mean concentrations of Heavy metals in soil and plants following FEPA, E.U and FAO/WHO guidelines (Threshold Values).

Heavy Metals	FEPA Threshold for Heavy metals in soil m/kg	E.U. Standards for Heavy Metals in Soils (ppm).	WHO/FAO Safe limit for Heavy Metals in Vegetables (mg/kg.	E.U Standards for Heavy Metals in vegetables (ppm).
Lead (Pd)	1.6	300	0.3	0.3
Cadmium (Cd)	Not Specified	3	0.2	0.2
Zinc (Zn)	300-400	-	99.4	-
Cromium (Cr)	Not specified	150	1.3	0.3
Cupper (Cu)	70-80	140	-	-
Iron (Fe)	400	-	-	-
Note: Dash (-) means standard was not determined.				

Table 3: Heavy metals distribution in sample soil.

Heavy metals	Soil
	(mg/Kg)
Lead (Pb)	0.01
Copper (Cu)	0.54
Cadmium (Cd)	0.05
Chromium (Cr)	0.01
Zinc (Zn)	2.1
Nickel (Ni)	0.1
Iron (Fe)	11.5

Figure 2: Oil Palm Mill study site at Okada, Edo State, Nigeria (Photo by Erifeta G.O).

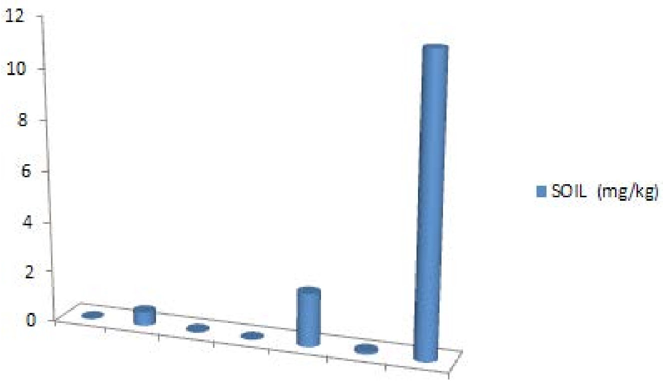

Figure 3: Shows Heavy metals distribution in sample soil.

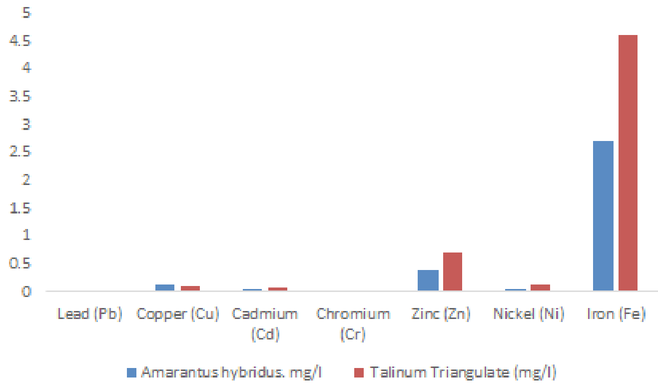

Figure 4: Heavy metal concentration in African Spinach "GREEN" (Amaranths hybridus) and water leaf (Talinum Triangulate).

Table 4: Heavy metal concentration in African Spinach "GREEN" (Amaranths hybridus) and water leaf (Talinum triangulate) samples.

Heavy metals	Amarantus hybridus. mg/l	Talinum triangulate (mg/l)
Lead (Pb)	0	0
Copper (Cu)	0.13	0.12
Cadmium (Cd)	0.04	0.07
Chromium (Cr)	0	0
Zinc (Zn)	0.4	0.7
Nickel (Ni)	0.05	0.13
Iron (Fe)	2.7	4.6

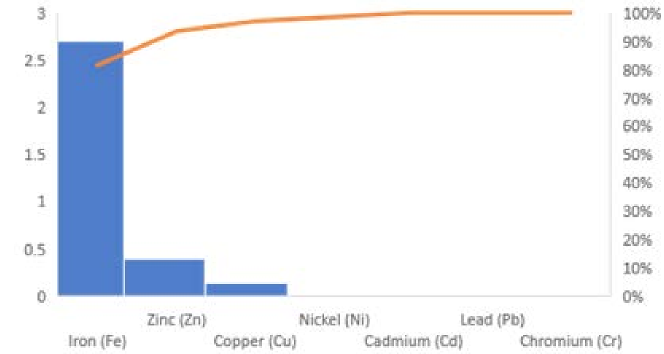

Figure 5: Heavy metals present in Amaranths hybridus Samples.

Table 5: Heavy metals present in Amaranths hybridus Samples.

Heavy metals	Amarantus hybridus. mg/l
Lead (Pb)	0
Copper (Cu)	0.13
Cadmium (Cd)	0.04
Chromium (Cr)	0
Zinc (Zn)	0.4
Nickel (Ni)	0.05
Iron (Fe)	2.7

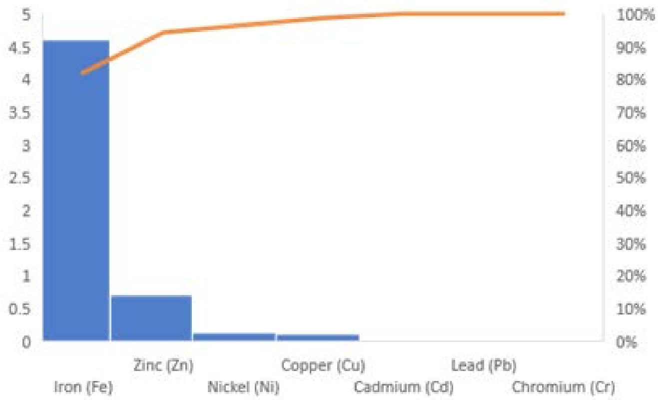

Figure 6: Heavy metal concentration in Talinum triangulate.

Table 6: Heavy metal concentration in Talinum triangulate samples.

Heavy metals	Talinum Triangulate (mg/l)
Lead (Pb)	0
Copper (Cu)	0.12
Cadmium (Cd)	0.07
Chromium (Cr)	0
Zinc (Zn)	0.7
Nickel (Ni)	0.13
Iron (Fe)	4.6

Conclusion

This study was carried out to evaluate the accumulation of heavy metals in soils and their possible translocation into edible vegetables grown in artisanal oil palm mills in Okada; Edo State; Nigeria. The results obtained clearly indicates that heavy metal contamination in sample soil was low and within the internationally permissible threshold. The study also revealed that the low concentrations in the

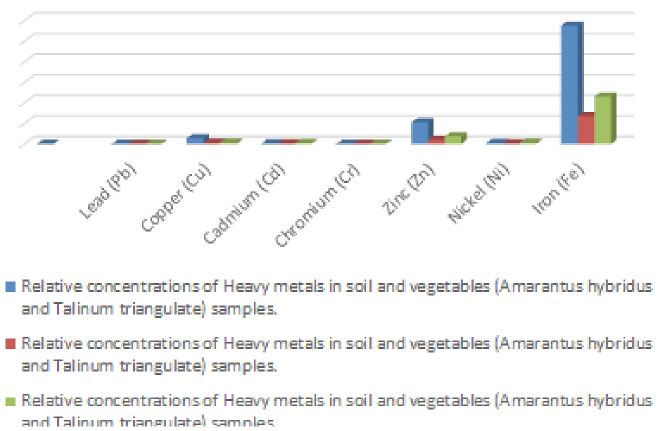

Figure 7: Relative concentration of Heavy metals in soil and vegetables (Amarantus hybridus and Talinum triangulate) samples.

Table 7: Relative concentration of Heavy metals in soil and vegetables (Amaranths hybridus and Talinum triangulate) samples.

Heavy metals	SOIL	Amarantus hybridus (mg/l)	Talinum Triangulate (mg/l)
	(mg/l)		
Lead (Pb)	0.01	0	0
Copper (Cu)	0.54	0.13	0.12
Cadmium (Cd)	0.05	0.04	0.07
Chromium (Cr)	0.01	0	0
Zinc (Zn)	2.1	0.4	0.7
Nickel (Ni)	0.1	0.05	0.13
Iron (Fe)	11.5	2.7	4.6

sample soils were in concordance with the low concentrations also observed in the two plants under investigation. It was discovered that the consumption of these vegetables grown in these milling sites may not constitute any possible health hazards/concerns to humans.

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