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Evaluation of Heavy Metals Concentrations in Selected Exposed Food Stuff Consumed in Port Harcourt Nigeria

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Abstract: *The concentrations of lead, cadmium, chromium copper, zinc and iron in vegetables (pumpkin and bitter leaf) and garri at some locations in Port Harcourt were determined using Perkin Elmer AS 3100 Atomic Absorption Spectrophotometer. The results showed that in pumpkin the highest mean concentration was 911.3l6ppm Fe and the least concentration was <0.00lppm Cr; in bitter leaf the highest mean concentration was 1233.210ppm Zn and the least mean concentration was <0.001ppm Cr; in garri the highest mean concentration was 31.060ppm Fe while the least concentration was 0.001ppm in Pb, Cd and Cr .The highest mean concentration was 260.815ppm Fe and the least mean concentration was <0.001ppm Cr. The highest mean concentrations of the metals were 9.350ppm Pb in washed bitter leaf at Ozuboko, 0.700ppm Cd in pumpkin at Abuloma, 4.550ppm Cr in pumpkin at Abuloma, 16.575ppm Cu in pumpkin at Ozuboko, 1236.900ppm Zn in unwashed bitter leaf at Amadi-ama and 299.250ppm Fe in Pumpkin at Ozuboko. Statistical analysis showed no significant difference (p>0.05) between the metal concentrations in washed and unwashed bitter leaf, red and white garri and the locations. The concentrations of Cr, Zn, Fe and Pb exceeded their standard limits recommended by WHO and FAO/EU in few sites but below the limits in others and therefore do not portend serious risk to the consumers in the locality. It was recommended that heavy metals concentrations in exposed food stuff should be regularly monitored to avoid adverse effects.*

Keywords: *Food stuff, Heavy metals, Pumpkin, Bitter leaf, Garri, Nigeria*

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I. Introduction

The growing interest in heavy metal content in the environment (Land water and air) and the measurement of contamination levels in public food items commonly used or consumed in our environment has received wide attention. This may be connected to the minamata bay incident of an outbreak of water born mercury poisoning in Japan in 1953 (Moore and Moore, 1976 cited in Ubong and Gobo, 2001). Toxicological and environmental studies have prompted interest in the determination of toxic elements in food.

The ingestion of food as an obvious means of exposure to metals, not only because many metals are natural components of food stuffs but also because of environmental contamination and contamination during processing (Waqar, 2006). However, it is pertinent to note that trace metals could be divided into essential and non-essential elements to human system. Several elements like, Iron (Fe), Copper (Cu), Zinc (Zn), Cobalt (Co), Manganese (Mn) etc are known to be essential nutrients (Ubong and Gobo, 2001). The non essential trace metals, whose presence in the human body can cause deleterious effect on health include Arsenic (As), Cadmium (Cd), Lead (Pb), Mercury (Hg), Aluminum (Al), etc. (Schauss, 2003). Whether a metal is essential or not, exposure above a threshold level is dangerous (Ubong and Gobo, 2001).

Furthermore, although trace metals are natural components of the environment and agricultural farm lands which are located within areas where there is oil spills, spent crankcase-engine oil and automobile exhausts, trace metals are also added to the soil. This habit may be contributing significantly to the load of trace metals in the crops grown in such sites. Odoemena and Akpabio (1997), reported high accumulation of heavy metals in pasture grass growing along traffic high ways and industrial layout in Akwa Ibom State. Crop plants are very sensitive to nigh concentrations of heavy metals of which copper, nickel: and cobalt have been indicated as most toxic (Wilber, 1991).

Heavy metals like Mercury (Hg), Arsenic (As), Lead (Pb), and Cadmium (Cd) as well as essential nutrient metals like Iron (Fe), Zinc (Zn), Copper (Cu), are present in the soil and in natural water and atmosphere (air) in various forms and these may become contaminants of food and feeding stuffs (Akaninwor, *et. al.* 2006). It is important to know that human beings are exposed to heavy elements in soil through the food chain transfer and by direct ingestion of soil particles. Documented cases of acute trace metal toxicities in humans due to elevated soil trace metal concentrations are rare or nonexistent. Documented cases of adverse health effects due to chronic food chain exposure are more numerous. For instance, Japanese farmers suffered from cadmium toxicity after long term consumption of cadmium enriched rice (lsirimah, 2000). Dietary studies of people living down wind from old Zn and Pb smelter sites have shown that persons could by consuming some of their home grown vegetables, meat and milk ingest at least 50% more lead (Pb), and cadmium (Cd), than if comparable food items had been consumed from a control area (Isirimah, 2000). The auditing and monitoring of metals in the environment (soil, water and of foods) are fast becoming an essential aspect of pollution studies, particularly in industrialized areas (Akaninwor *et. al*., 2006).

Despite several studies on trace metal analysis in food stuff for public health monitoring, and the maintenance of relatively low level in consumable food stuff, much has not been done on common food stuff affordable to both the poor and rich of our society. Effort is therefore geared towards looking at food stuff locally processed in our environment. These include Garri (ground and fried cassava) and vegetables such as pumpkin (*Telfairia Occidentalis*) and Bitter leaves (*Vernonia amygdalina*). In this study heavy metals such as lead, Iron, Cadmium, Copper, Chromium and Zinc have been determined in the above named food items.

Table 1. Identification and Geographical Positions of the Sampling Locations

Site	Sub-sites	Elevation(ft)	North	East
Abuloma	A	85	05° 07′ 44.8″	006° 59′ 28.7″
	B	85	05° 07′ 44.8″	006° 59′ 28.7″
Ozuboko	A	51	04° 46′ 37.6″	007° 02′ 29.6″
	B	33	04° 46′ 25.7″	007° 02′ 38.9″
Tere-ama	A	32	04° 47′ 10.3″	007° 02′ 11.3″
	B	45	04° 47′ 11.0″	007° 02′ 10.6″
Amadi-ama	A	23	04° 47′ 44.9″	007° 01′ 30.8″
	B	15	04° 47′ 44.7″	007° 01′ 30.9″

As a consequence of its known toxicity as well as the serious contamination of foods that occurs from time to time during commercial handling and processing most countries monitor the levels of toxic elements in foods. The joint experts committee (FAO/WHO) on food additives has suggested a provisional tolerable intake of 400-500pg Cd per week for man. The quantity of Hg to be tolerated in human food is 0.3mg per week and for Pb a weekly intake of 3mg is allowed (Waqar, 2006). The report further assert that the maximum concentration of Pb which is permitted in prepared foods specifically intended for babies or young children is 200µg/kg (FAO/WHO, 1993). Cunningham and Saigo, (1997) asserted that many metals such as mercury, lead, cadmium and nickel are highly toxic. Levels in the microgram range so little that cannot be seen or tasted can be fatal because metals are highly persistent; they accumulate in food chains and have a cumulative effect in humans.

Several studies on food items in industrialize (polluted) areas show high level of trace rneta1 while it is low in unpolluted areas. Hart *et al*, (2005) reported lead concentration range from 2.4µg/g to 8.6µg/g for pumpkin (*Telfairia Occiclentalis*) grown in highly industrialized areas like Trans-Amadi and oil polluted environment in Rivers State (eg. Ebocha and Aghada-Alu). The report also showed a high increase in the Pb level of food crops like Okro, Cassava and Cocoyam. The report further stated that these results effect higher concentration of metals in crops from the industrialized locations with the green vegetables, particularly pumpkin leaves, having the highest uptake. These findings give cause for concern, particularly as trace metals are bio-accumulative in the system and portend a serious health risk to man and animals. Gbaruko and Friday (2007) in their report, showed a high level of Pb in the leaves of bitter leaf (*Vernonia amygdalina*). Pb content in the bitter leaf was 0.41 ± 0.02 µg/g in oil and industrialised (polluted) areas. This level they say is far beyond the tolerable level of 0.001µg/g set by WHO and is of great public health concern. Ideriah (1996) studied the lead concentrations in food crops found along roadsides and reported that some stations exceeded the natural limit of 0.05- 3ppm. The report also showed that the crops lead concentrations were very low compared to the threshold limit of 12-20ppm.

II. Materials and Methods

Location of the Study Area

The study area is located in Port Harcourt City Local Government Area of Rivers State, Nigeria. Rivers State is located in the Niger Delta in the south- south Geopolitical region. The Port Harcourt city lies approximately between longitudes 07^{o} 01′ East and latitude 4^{O} 5′ North on an elevation of 20 meters (60 feet above sea level). However, the location of the study area is the Port Harcourt East of the metropolis comprising Abuloma, Ozuboko, Tere-Ama and Amadi-Ama.

The study area consists of residential areas, markets and vegetable farms. It also experiences high vehicular traffic and is very close to the Trans-Amadi Industrial area (Table 1 and Fig. 1.1).

Site Selection

Four sampling locations were chosen within the Port Harcourt East of the Port Harcourt Local Government Area in Rivers State, Nigeria. The sampling stations were Abuloma, Ozuboko, Tere-Ama and Arnadi-Ama. Two sub-sites were chosen from each station. The locations, lie between longitude 06^o 59′- 07^o 02′ E and latitude 04^o 46′- 05^o 07′ N (Fig. 1.1).

Sample Collection

The food items used for the study were commonly consumed staple foods and vegetables. The food items include: Garri (ground and fried cassava) and vegetables namely pumpkin leaves (*Telfairia Occidentalis*) and Bitter leaf (*Vernonia Amygdalina*). Two samples of pumpkin, four samples of bitter leaf and garri were collected from the subsites at the four locations in the study areas. A total of eight (8), sixteen (16) and ten (10) samples were collected from each site. Garri was procured from the market. The vegetable samples (pumpkin and bitter leaf) were obtained from the nearby farms and also bought from the market within the study area.

Sample Preparation

After collection, the harvested samples were washed with tap water and rinsed thoroughly with distilled water and then transported in cellophane bags to the Institute of Pollution Studies laboratory. The edible leaves of pumpkin (*Telfairia Occidentalis*) and bitter leaf (*Vernonia amygdalina*), were collected using stainless steel knife. The leaves were then dried to .constant weight in an oven at 105^oC. The dried samples were pulverized to fine powder using the laboratory mill. The milled sample was stored separately in labeled and airtight plastic containers and preserved in desiccators until required for analyses. The garri samples were dried in oven, milled into fine powder and. sieved through a mesh of 1mm diameter and stored in airtight plastic container.

Laboratory Analyses

The prepared samples were digested and analyzed for the heavy metals content using Perkin Elmer AS 3100 Atomic Absorption Spectrophotometer. 2.0g each of powdered samples was weighed into a 50ml beaker. This is predigested with 10ml of nitric acid with 2ml of perchloric acid. The entire content was heated to a temperature of 125°C for 2 hours. The digest was filtered with whatman filter paper into a 50ml standard flask. Two 5ml portions of distilled water were used to rinse the beaker and the content filtered into the 50ml flask. The filtrate was allowed to cool to room temperature before dilution was made to the 50ml mark with distilled water.

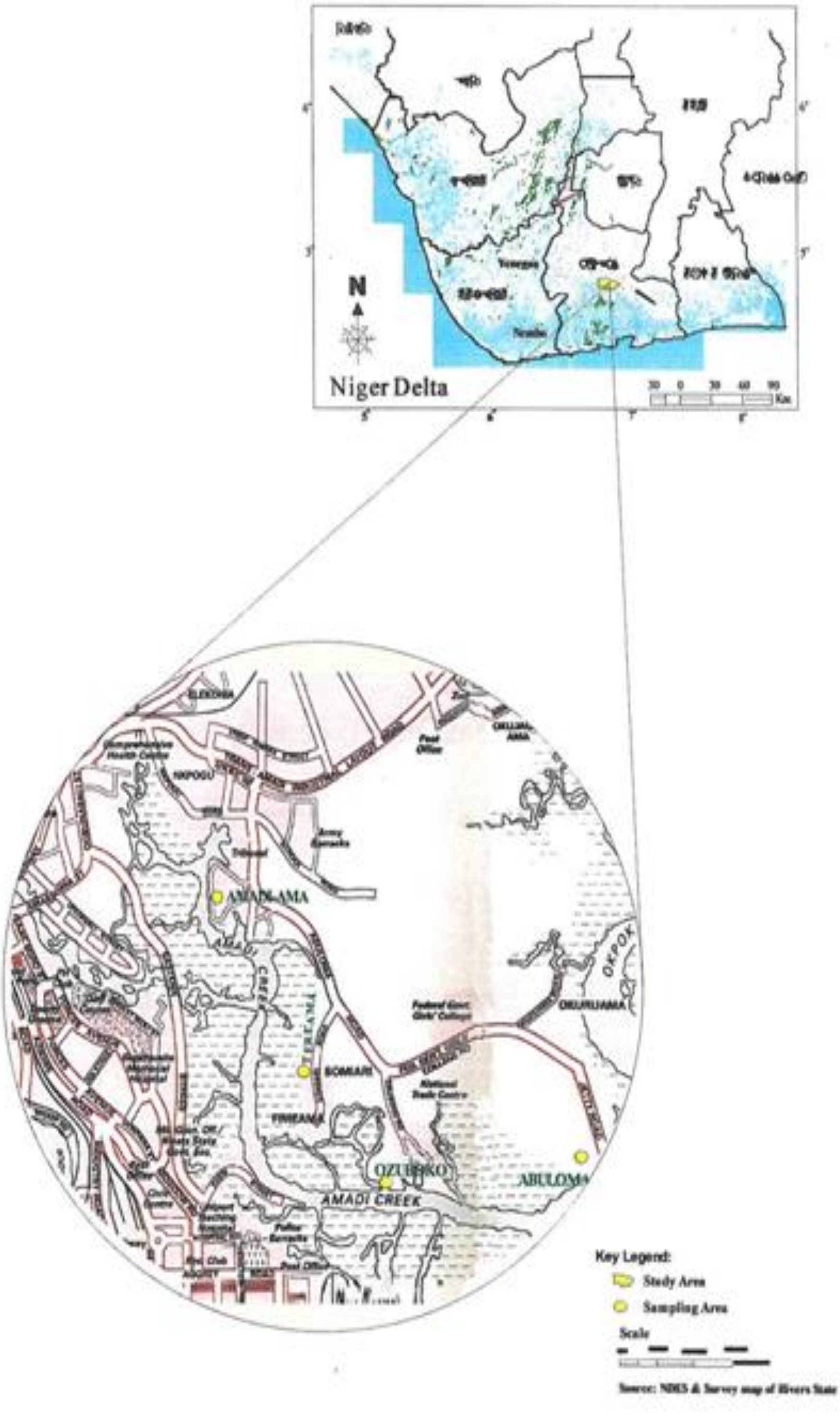

Fig. 1.1: Map of Niger Delta showing Rivers State and the Study Area

III. Results And Discussion

Results

The results of the analyses of trace metals in food and vegetable samples in the various study locations are presented in Tables 2 and 3 and Figs. 2 - 7.

LEAD

Pumpkin Leaf

The mean concentrations of Pb in pumpkin ranged from 2.063ppm at Ozuboko to 4.850ppm at Amadi-ama with a general mean of 3.913 ± 0.25ppm at all the sites. The concentrations of Pb at various stations were within the recommended limit of 12 - 20ppm. Table 2 shows the detailed concentrations at all individual sites studied and also revealed that Abuloma site 1 had the highest concentration of Pb (6.200ppm). Statistical analysis indicates that Pb concentrations within the stations were highly correlated (r = 0.9838) but with no significant difference (p>0.05) between them. Similarly, the concentrations of Pb (6.200ppm) at Abuloma were higher than the concentration of Pb (5.100ppm) at Tere-ama. Statistical analysis showed high positive correction (r = 0.9936) but with no significant difference (p>0.05) between them.

Bitter Leaf

Table 2 and Fig. 2 showed bitter leaf lead concentrations in washed bitter leaf ranged between 1.285ppm at Abuloma and 7.525ppm at Ozuboko with overall mean of 4.259 ± 0.00ppm. The unwashed bitter leaf ranged between 3.900ppm at Ozuboko and 6.430ppm at Amadi-ama with overall mean of 5.316 ± 0.00ppm. The concentrations of Pb in all the bitter leaf samples were below the standard limits (12 - 20mg/g) in food reported by Ideriah *et al* (2006). The concentrations of Pb in washed bitter leaf ranged from 1.1 50ppm at Abuloma to 9.350ppm at Tere-ama with overall mean of 4.259 ± 0.50ppm.

Garri

Lead concentrations in white garri ranged between 0.001ppm and 0.607ppm at Tere-ama with overall mean of 0.152 ± 0.25ppm. The lead concentration in red garri ranged from 0.751ppm at Abuloma to 1 .451 ppm at Tere-ama (Table 2 and Fig. 4) with overall mean of 1.078 ± 0.28ppm. The detailed Pb concentrations in white garri ranging from <0.001ppm at Abuloma and Ozuboko to 0.7l3pprn at Tere-ama with a mean of 0.152 ± 0.25ppm while Pb concentrations in red garri ranged between <0.001ppm at Abuloma and 1 .650ppm at Tere-ama with overall mean of 1.078 ± 0.28ppm. There are differences in the Pb concentrations between white and red garri.

Table 2. Mean Concentrations (ppm) of Heavy Metals at the Study Locations

Parameters	Abuloma				
		Bitter Leaf		Garri	
	Pumpkin	Washed	Unwashed	White	Red
Lead (Pb)	4.088	1.285	4.533	0.001	0.751
Cadmium (Cd)	0.463	0.176	0.602	0.001	0.001
Chromium (Cr)	3.638	0.001	4.038	0.001	0.001
Copper (Cu)	10.875	7.638	11.25	1.063	1.125
Zinc (Zn)	39.5	894.5	1204.5	13.663	13.488
Iron (Fe)	126.75	63.73	189.85	12.489	16.525

Parameters	Ozuboko				
	Pumpkin	Bitter Leaf		Garri	
		Washed	Unwashed	White	Red
Lead (Pb)	2.063	7.525	3.9	0.001	1.328
Cadmium (Cd)	0.15	0.235	0.001	0.001	0.001
Chromium (Cr)	0.738	0.001	0.001	0.001	0.001
Copper (Cu)	12.738	8.505	11.905	1.125	0.879
Zinc (Zn)	247.628	111.165	152.9	7.788	7.471
Iron (Fe)	211.376	72.785	163.035	14.15	19.903

Parameters	Tere-Ama				
	Pumpkin	Bitter Leaf		Garri	
		Washed	Unwashed	White	Red
Lead (Pb)	4.65	3.575	6.4	0.607	1.45
Cadmium (Cd)	0.05	0.001	0.314	0.001	0.001
Chromium (Cr)	0.001	0.001	0.001	0.001	0.001
Copper (Cu)	11.75	5.633	7.108	0.57	0.82
Zinc (Zn)	51.385	1135	198	5.317	8.818
Iron (Fe)	124	61.701	85.702	18.921	24.447

Parameters	Amadi-Ama		
		Bitter Leaf	Garri

	Pumpkin	Washed	Unwas hed	White	Red
Lead (Pb)	4.85	4.65	6.43	0.001	0.784
Cadmium (Cd)	0.001	3.091	0.001	0.001	0.026
Chromium (Cr)	0.051	0.001	0.688	0.001	0.001
Copper (Cu)	13.95	10.376	12.148	0.885	1.678
Zinc (Zn)	49.2	178.575	1233.21	6.853	6.944
Iron (Fe)	138.25	103.836	113.587	31.06	19.441

Table 3. Correlation Matrix of Sites and Heavy Metals

	ABSite 1	ABSite 2	OZSite 1	OZSite 2	TESite 1	TESite 2	AM Site 1	AMSite 2
ABSite 1	1							
ABSite 2	0.9822	1						
OZSite 1	0.9919	0.9971	1					
OZSite 2	0.9975	0.9732	0.9835	1				
TESite 1	0.9888	0.9977	0.9997	0.9792	1			
TESite 2	0.9718	0.9975	0.9937	0.9589	0.9960	1		
AMSite 1	0.9786	0.9984	0.9954	0.9691	0.9969	0.9980	1	
AMSite 2	0.9943	0.9961	0.9996	0.9879	0.9989	0.9911 •	0.9944	1

AB = Abuloma OZ = Ozuboko TE = Tere-ama AM = Amadi-ama

all stations	*Pb*	*Cd*	*Cr*	*Cu*	*Zn*	*Fe*
Pb	1					
Cd	0.2308	1				
Cr	0.2009	0.9390	1			
Cu	-0.7096	0.5991	-0.5523	1		
Zn	-0.1812	0.5540	-0.5639	0.5280	1	
Fe	-0.5798	0.0216	-0.1648	0.4817	0.4853	1

Cadmium

Pumpkin Leaf

The mean concentrations of Cd are shown in Tables 2 and 3. Fig. 3 shows the variations in the concentrations of Cd across the various locations. The Cd concentrations in pumpkin ranged between 0.001ppm at Amadiama and 0.463ppm at Abuloma with a mean of 0.166 ± 0.05ppm. The concentrations of Cd ranged from noT detectable level at Tere-ama to 0.700ppm at Abuloma with overall mean of 0.166 ± 0.05ppm. The concentrations of cadmium were generally higher in Abuloma and Ozuboko than Tere-ama.

Bitter Leaf

Cadmium concentrations in washed bitter leaf ranged from 0.001ppm at Tere-ama to 3091ppm at Amadi-ama with a mean of 0.188 ± 0.05ppm while unwashed bitter leaf ranged from 0.001ppm to 0.0607ppm with a mean of 0.229 ± 0.05ppm. (Table 2) The concentrations of Cd in unwashed bitter leaf at Amadi-ama were below detection limit of 0.001ppm. Unwashed bitter leaf showed highest Cd concentration of 0.653ppm and the least value of <0.001ppm. (Table 2 and Fig. 3).

Garri

The results in Fig. 4 showed that Cd concentrations in white garri were 0.001ppm at all the locations while red garri ranged from 0.001ppm at most of the locations to 0.06ppm at Amadi-ama with overall mean of 0.001 ± 0.000ppm. Cd was not detected in red garri at Abuloma site 1 and in white garri at Tere-ama sites 1 and 2.

Chromium

Pumpkin Leaf

Fig 4 showed the mean concentrations of chromium at the various sites. The results revealed that chromium concentrations in pumpkin ranged ranged between 0.001ppm at Tere-ama and 3.638ppm at Abuloma with a mean of 1.107 ± 0.2ppm. The results further showed that chromium concentration in pumpkin at Abuloma (3.638ppm), Ozuboko (0.73 8ppm) and Amadi-ama (0.051ppm) locations exceeded the recommended standard limit of 0.001ppm (WHO, 1992).

Bitter Leaf

The range of Cr concentrations in unwashed bitter leaf was between 0.001ppm at Ozuboko and Tere-ama and 4.038ppm at Abuloma with a mean of 0.229 ± 0.05 ppm. The washed bitter leaf had Cr concentration of 0.001ppm at all the locations. However, the unwashed bitter leaf had Cr concentrations at Abuloma (4.038ppm) and Amadi-ama (0.688ppm) above the recommended limit of 0.001ppm by (WHO, 1992).

Garri

Chromium concentrations in garri at all the sites were below the detectable limit (<0.001ppm) of the instrument. Fig. 4 showed that both the white and red garri are very low in Cr concentrations.

Copper

Pumpkin Leaf

The mean concentrations of Cu ranged from 10.825ppm at Abuloma to 13.950ppm at Arnadi-ama with a mean of 12.328 ± 2.150ppm. Fig. 5 showed Cu mean concentration of 13.950ppm which is the highest at the study area. The results revealed that Cu concentrations in pumpkin of 10.875pprn at Abulonia, 12.738ppm at Ozuboko, 11.750ppm at Tere-ama and 13.950ppm at Amadi-ama were slightly above the recommended limit of 1-10mg/kg per day (WHO, 1992).

Bitter Leaf

Table 2 and Figure 5 showed the mean concentrations of Cu in washed bitter leaf ranged from 5.633ppm at Tere-ama to 10.376ppm with a mean of 8.038 ± 3.0ppm while the unwashed bitter leaf ranged between 7.108ppm at Tere-ama and 12.142ppm at Amadi-ama. The concentrations in washed bitter leaf (10.5 l6ppm) at Tere-ama; 11.700ppm in unwashed at Abuloma and 10.800ppm in unwashed bitter leaf at Ozuboko were slightly above the recommended WHO/FAO Standard limits of 1 - 10mg/g/day.

Garri

The results showed that the mean concentrations of copper ranged between 0.57ppm at Tere-ama and 1.063ppm at Abuloma with overall mean of 0.849 ± 0.15ppm in white garri while red garri showed Cu concentrations ranging from 0.820ppm at Tere-ama to l.678ppm at Amadi-ama with overall mean of 1.133 ± 0.00ppm. The results also revealed that red garri had higher concentrations of Cu than the white garri at all the locations.

ZINC

Pumpkin Leaf

The mean concentrations of Zinc in pumpkin leaf ranged between 39.500ppm at Abuloma and 51.385ppm at Tere-ama with a mean of 46.920 ± 1.15pprn in all the sites studied. The results revealed that all the sites had zinc concentrations slightly above dietary allowance of 3.0 – 10.0mg/g/day for children and 15.0 – 25mg/g/day for adult (Anthony *et.. al.*, 1999).

Biter Leaf

In all the locations, the mean concentrations of zinc in bitter leaf ranged between 111.165ppm at Ozuboko and 1135.000ppm at Tere-ama with overall mean of 581.056 ± 12.50ppm. The unwashed bitter leaf had zinc concentration ranging between 152.900ppm at Ozuboko and 1233.210ppm at Amadi-ama with a mean of 697.396 ± 10.25ppm at all the locations. The results further revealed that Ozuboko had the lowest concentration of zinc than other locations in both washed and unwashed bitter leaf. The zinc concentrations at Abuloma and Amadi-ama for unwashed and Abulloma and Tere-ama for washed bitter leaf were above the toxicity range of 100 – 400mg/kg (Abdullahi *et. al*., 2007).

Garri

Garri showed lower concentration of zinc than any other food samples. Zinc concentrations in white and red garri are shown in Table 2 and Fig. 6. The zinc concentrations in white garri ranged between 5.3l7ppm at Tere-ama and 13.663ppm at Abuloma with overall mean of 8.406 ± 2.0ppm. The mean concentrations of zinc in red garri ranged from 6.944ppm at Amadi-ama to 13.488ppm at Abuloma with overall mean of 9.180 ± 2.0ppm. The concentrations of zinc in garri were generally below the WHO and FAO limits. Furthermore, statistical analysis showed that at all locations, there was high correlation ($r = 0.98526$) with no significant difference ($p > 0.05$) between them in their metal content.

IRON

Pumpkin

The mean concentrations of Fe ranged from l24.000ppm at Tere-ama to 260.81 5ppm at Amadi-ama with overall mean of 150.094 ± 5.l2ppm across the locations. The mean concentration of 200ppm at Ozuboko exceeded the recommended dose for man. (Abdullahi *et al.*, 2007).

Bitter leaf

The Fe mean concentrations in washed bitter leaf ranged from 61.701ppm at Tere-ama to 103.836pprn with overall mean of 75.508 ± 4.00ppm at all the locations while the unwashed bitter leaf showed mean concentrations of Fe ranging from 85.701ppm at Tere-ama to 189.850ppm at Abuloma with overall mean value of 138.042 ± 5.25ppm. The results revealed that Fe concentrations in unwashed bitter leaf were higher than washed bitter leaf in all the locations. The results obtained in were below the recommended dose (200ppm) for man by Abdullahi *et.. al.* (2007), FAO (1993) and WHO/EU (1999).

Garri

The results revealed that the mean concentration of Fe in white garri ranged between 12.489ppm at Abuloma and 31.060ppm at Amadi-ama with overall mean of 19.155 ± 0.72ppm. The mean concentrations of Fe in red garri ranged from 16.525ppm at Abuloma to 24.447ppm at Tere-ama. The observed results showed that the mean concentrations of Fe in red garri were higher than that in white garri except at Amadi-ama. The Fe concentrations at Tere -ama and Amadi-ama in both white and red garri at Ozuboko exceeded the maximum recommended dietary allowance of 18mg/kg Fe/day (Wayne and Dale, 1989; Akaninwor *et.. al.*., 2006).

IV. Discussion

LEAD

Pumpkin

The significantly high concentrations of lead measured in pumpkin are attributed to the extent of accumulation of Pb in the environment resulting from automobile emissions as well as the species in use. This observation is in agreement with the report of Salami and Non (2002) who found that water lettuce accumulate Pb than did water lily. There are differences between the metal concentrations across the stations. These differences in concentrations could be due to the source of the pumpkin, fertilizers and variations in vehicular traffic that discharge dust particles into the environment. Study done in Awa Ibom on pumpkin leaf grown in soil within the vicinity of a paint industry has shown lead concentrations of 0.034 and 0.086mg/100g (Udosen, 1994). Ideriah and Braide (2006) reported concentration of 41.5 ± 16.65mg/g in vegetation along roadsides in Port Harcourt, Nigeria. The study also showed a least concentration of 1.2mg/g in pumpkin.

In order to determine the level of pollution, the results obtained were compared with plants threshold limit and natural concentration. In the present study, the recommended threshold limits (12 – 20mg/kg) and natural concentrations (0.05 – 3.00mg/g) of lead in plants which was reported by Ideriah (1996) were exceeded especially in the pumpkin. Similarly, the variations in the concentrations of lead in the various food vegetables could be because plants differ in their uptake and sensitivity to lead - a factor which depends on certain soil conditions and roots morphology (Hemphill, 1997 and Hart *et. al*., 2005).

Bitter Leaf

The bitter leaf shows the same pattern of consistent increase in Pb concentrations in unwashed bitter leaf at all the locations. The unwashed bitter leaf were observed to have higher Pb concentrations than the washed bitter leaf at all the locations except at Ozuboko site 2.This may be as a result of the handling procedure during the washing process of the bitter leaf and the farm where it was harvested. Although there are differences in concentration between the washed and unwashed bitter leaf, statistical analysis showed high positive correlation ($r = 0.9966$) with no significant difference ($p > 0.05$) between them. The Pb concentration in bitter leaf throughout the locations were within the recommended threshold limit (12 – 20mg/g) reported by Ideriah and Braide (2006). Similarly, considering a dietary intake of 1.5 µg/day as WHO safe standard, it may not cause any health hazard to the populace.

Garri

Garri is processed food and its metal content tend to be lower than the other food items. The concentrations of Pb in white garri were below the detectable limit of 0.001ppm. This is in agreement with the report of Akaninwor *et. al.* (2006) on trace metal levels in raw and heat processed food. The difference observed between white and red garri may be as a result of the addition of palm oil used in reducing the effect of cyanide in garri.

Cadmium

Pumpkin

The concentrations of Cd at Arnadi-ama were below detectable limit of 0.001ppm which could mean low contamination at that location. Moharned *et. al.* (2006) proposed weekly intake of Cd from rice to be 4.04mg/kg body weight which accounts for more than 57% of total Cd intake. The Cadmium level obtained in this study is low compared to the value reported by Mohamed *et al.*, (2006). This was possible because there is no known oil installation and industries that release the metal to increase the load in the environment. The Cd content in this study further suggests lesser extend of Cadmium pollution at the sample locations. The Cd concentrations are below the toxicity range of 1 – 30mg/kg (Abdullahi *et.. al.,* 2007).

Bitter Leaf

The concentrations of Cd unwashed bitter leaf at Amadi-ama were below the detectable limit of 0.001ppm. Considering the dietary intake of 1.5µg/day as WHO safe standard, the study area may not be at risk but bioaccumulation of the trace metal overtime may be deleterious on health. The presence of Cd in nature and entrance to human food chain causes serious damage in kidneys, lungs, bones and also anemia and sometimes hypertension (Afshar *et. al.,* 2000 and Mohamed *et. al.,* 2006). Cadmium may enter food chain via bitter leaf, even unpolluted areas may contain Cadmium because fertilizers that are used in farms, had amounts of Cd (Mohamed *et. al.,* 2006). This may account for the concentrations obtained for washed and unwashed bitter leaf in this study.

Garri

Cadmium was not detected in red garri at Abuloma and in white garri at Tere-ama. However, Cd concentrations at other locations were below the detectable limit of 0.001ppm except at Amadi-ama for red garri. Akininwor *et. al*. (2006) reported that the level of Cd in heat processed foods (garri) from oil producing areas and Abakaliki, a non-oil producing area were below detectable limit except at Nembe (0.21ppm ± 0.01). The results in this study are in agreement with the report of Akaninwor *et. al.* (2006). This means that the only observed level of Cd, 0.026ppm at Amadi-ama may be as a result of the Cadmium status of the farms in the area. However, across the locations, there may not be any risk of cadmium poisoning as a result of consumption of garri since the Cadmium concentration are below the WHO Safe Standard of 1.5iµg/day (0.002ppm).

CHROMIUM

Pumpkin Leaf

The level of Chromium at Abuloma and Ozuboko were above the recommended tolerable limit of 0.001µg/g (0.0001ppm) recommended by WHO (1992). In all the locations increase in the metal concentrations showed the following trend: Abulolma> Ozuboko > Amadi-ama> Tere-ama. Although there are no Federal Environmental Protection Agency (FEPA) standards in Nigeria for food and vegetables, the results in this study (Cr < 0.001ppm) at Tere-ama and Amadi-ama are not deleterious to health. For locations where the Chromium concentrations are high, it is expected that bioaccurnulation would take place over time and may be dangerous to health.

Bitter Leaf

The highest mean concentration of chromium (4.03 8ppm) was obtained at Abuloma for unwashed bitter leaf. This level of Chromium exceeded the tolerable limit of 0.001µg/g (0.0001ppm) recommended by WHO, (1992). All the washed bitter leaf in all the locations are less than 0.001ppm which imply that the concentrations are below the detectable limits. It is expected that the metal burden on the health of the population in the study area especially Ozuboko and Tere-arna are at minimal risk. Furthermore, the Cr content in bitter leaf obtained in this study compared favourable with the Chromium level of 0.061 ± 0.02µg/g reported by Gbaruko *et al.,* (2007) for bitter leaf. The t-test analysis in this study showed that the metal concentrations in bitter leaf were highly correlated (r = 0.9834) but not significantly different (p> 0.05) for the various sites. The leaves of bitter leaf and pumpkin are used for the preparation of soup that is consumed by man, since they are washed before usage and their Cr levels are below the WHO Standards. Chromium, Nickel and Zinc are beneficial to man at lower levels since they are integral parts of important physiological compounds in certain enzymes, where it is essential for their activity (Gbaruko *et. al.,* 2007).

Garri

Chromium was not detected in both white and red garri at Abuloma while in other locations the concentrations were less than 0.001ppm. This implies that the environment and the cassava species used in producing the garri may not have been contaminated. Furthermore, cooking and frying may have led to considerable reduction of chromium in garri. This observation is similar to earlier report that boiling of food (e.g. yarn, cocoyam) resulted in the removal of free amino acid and a considerable reduction in the amount of minerals (Akaninwor *et. al..* 2006). The people are therefore not at risk as a result of consuming the food items.

COPPER

Pumpkin Leaf

High concentrations of Cu in pumpkin which is above the recommended dietary allowance of 1.5 – 3.0mg/gCu/day (Akaninwor *et. al.,* 2006) were observed. WHO (1996) reported that although copper is an essential element, it is toxic and the minimum limit for intake was set from 1 to 10mg/g/day. The results revealed the presence of environmental pollution, particularly in the areas of increased industrial activities. The pollutants may have come not only from soil concentration but also from aerial deposition as observed by Hart *et. al.* (2005) and Pilegaard and Johnson (1984). The study area is however close to Trans-Amadi industrial area and therefore, its activities may have likely influenced the concentrations of copper.

Bitter Leaf

The study showed that Cu concentrations were higher in some sites than 6.917 – 9.833mg/kg in onion samples reported by Abdulliahi *et. al..*, (2008). The reason for these observations may be from environmental sources such as household waste and heavy duty vehicles used to convey sand along the areas as well as industrial activities in Trans-Amadi industrial area. This study, therefore confirms the presence of environmental pollution. Although Cu is an essential element, bio-accumulation may result in adverse effects on humans.

Garri

Garri showed the least concentration of Copper among the food items. White garri was lower in concentration of Cu than red garri. Akaninwor *et. al.* (2006) in their study of trace metals level in raw and heat processed staple foods, reported that Copper levels of heat processed foods in all the locations studied have less Cu as a result of loss of mineral to cooking water. The slightly elevated Cu in red garri without a' corresponding intake of dietary zinc may result in accumulation of Cu in the liver which may lead to Wilson's disease and may also result to liver necrosis (Akaninwor *et. al.*, 2006). Akaninwor *et. al.* (2006) reported mean levels of Cu as 1.03 ± 10.14 - 2.83 ± 0.14ppm. In this study, the mean concentrations of Cu are within recommended safe dietary limit of 1.5 – 3.00mg/g/Cu/day (1.5 – 3.00ppm). Within the various locations, Cu concentrations are lower and therefore do not pose any deleterious problems to the society. It was also observed from statistical analysis that the metals are highly correlated but there was no significant difference ($p .> 0.05$) between them.

ZINC

Pumpkin Leaf

The results obtained are very high compared with the range of 136.tg/g (0.0ppm) to 232 µg/g (0.12ppm) in pumpkin leaves reported by Hart *et. al.* (2005) around polluted site. This implies that the Zn concentration in pumpkin likely show appreciable burden on the consumers within the various locations. However, the result is below the toxic dose for man, 150 – 600mg/kg recommended by WHO/EU (1999) and 0.2mg/kg recommended by Abdullahi *et. al.* (2007). Salami *et al.* (2002) reported that leaf contains high concentration of Zinc than the bark and soil. This could be because the element is required in the photosynthetic process in the leaf. It is essential to plants as it forms metallo enzyme complexes.

Abdullahi *et. al.* (2008) reported that Zn concentration in onion leaf ranged from 4.000 – 5.667mg/kg which were above the concentration obtained in this study. It is however difficult to say if the zinc level were a measure of the contents of the soils on which the pumpkin was initially cultivated (Faboya, 2000). There were narrow variations in the zinc concentrations across the sites despite the fact that they are located along the same geographical zone. This may be as a result of the fact that some locations may be at the downwind direction resulting in the deposition of particulate dust likely to be contaminated with zinc.

Bitter Leaf

The concentrations of zinc were considered very high. Although no definite emission source of zinc was seen, the variations and high concentrations may imply that the general human activities like burning of refuse and welding within the area may have contributed to the zinc levels. Similarly, the high level of zinc in all the sites could be partly be due to pretreatment of farm with fertilizers and manures which might have increased the mineral content of the soil and hence the farm produce (Faboya, 2000). The zinc concentrations in the samples are all above the guideline limits of FAO/WHO and WHO/EU (0.3mg/kg and 0.2mg/kg respectively). This could prove detrimental to health within the study area. Salami et al. (2002) reported that excess toxic element (Zn) in the soil through a process of bioaccumulation and the food chain can produce adverse effects in man leading to sickness or organ malfunction.

Garri

In this study, garri showed lower concentrations of zinc than in other food samples. The variations in concentrations of zinc between red and white garri may be attributed to the processing and exposure to the environment, since the food item is mostly displayed in the open space close to the road. Dust particles may likely contribute to the metal load measured. Similarly, the oil added to make the red garri may also be a contributing factor. However, the result obtained in this study are within the maximum recommended dietary allowance of 10 – l5mg/g/Zn/day (Akaninwor *et al.*, 2006, Wayne and Dale, 1981) hence there is no overload of the metal in the population that may lead to gastroenteritis and abdominal pains which have been reported as consequential cause of human Zinc overload (Akaninwor *et. al.*, 2006 and Macre *et. al.*, 1993).

IRON

Pumpkin Leaf

The result obtained in this study showed that iron concentrations are well below the 651 µg/g in pumpkin leaf recorded by Hart *et. al.* (2005) in oil polluted sites. The high concentration of Fe in pumpkin might be due to the participation of the green vegetable in the synthesis of ferrodoxin, an, attitude which makes them useful sources of Iron (Hart *et. al.*, 2005). Abdullahi *et. al.* (2007) reported that the toxic doses of Iron to plants are 10 – 200mg/kg (10 – 200ppm) while it is 200mg/kg in man. However, the levels of the trace metals obtained in this study fall within the range reported in the literature and below the toxic doses. The populace therefore, may not expect a lethal dose of the metals within the locations.

Bitter Leaf

The level of iron in bitter leaf was not as high as that in pumpkin leaves which were significantly higher in iron content as reported by Davidson *et. al.*, (1979) and Hart *et. al.*, (2005). Iron in bitter leaf showed that unwashed bitter leaf had higher concentration of Fe than washed bitter leaf. This observation is similar to other food items analyzed in this study.

Garri

Macre, *et. al.* (1993) reported that processing of foods may contribute to increase in concentration of iron naturally present in the food stuff. This assertion may be observed in the iron content observed in white and red garri at Tere-ama and Amadi-ama. The Fe concentrations in white and red garri at Abuloma and Ozuboko are within the maximum recommended dietary allowance of 18mg/kg/Fe/day. From the results in this study, the population is not likely to experience any Fe burden in their health but for the locations whose concentrations are slightly above the maximum recommended dietary allowance may result in accumulation of the metal over time.

V. Conclusion

The results .of this study indicate that most of the samples were found within the allowed limits of FAO/WHO, and WHO/EU of the metals analyzed. However, metals like Fe, Zn, Cu, and Pb at some sites were above the tolerable limits, but do not portend any risk at the moment.

Although the essential elements are beneficial to man and plants, when found in excessive amounts well above the levels normally found in food, can prove detrimental to health. This is more so when they exist in commonly consumed food crops, particularly the green vegetables and garri which are consumed by all household in the locality.

These levels of trace metals in some samples could result from contamination of the processing procedure, exposure to dust particles due to industrial activities around Trans-Amadi and high vehicular activities around the area.

Therefore, people that consume these food items will be conscious of what they consume and also serve as essential to frame guidelines and standards for trace metals in these foodstuffs by Federal Environmental Protection Agency (FEPA).

VI. Recommendations

Based on the results of this study the following recommendations are made.

1. Further studies and constant determination of trace metals content in consumable food stuff within our locality.
2. The Federal Environmental protection Agency to provide standards of these trace metals in food stuffs like garri, bitter leaf and pumpkin.

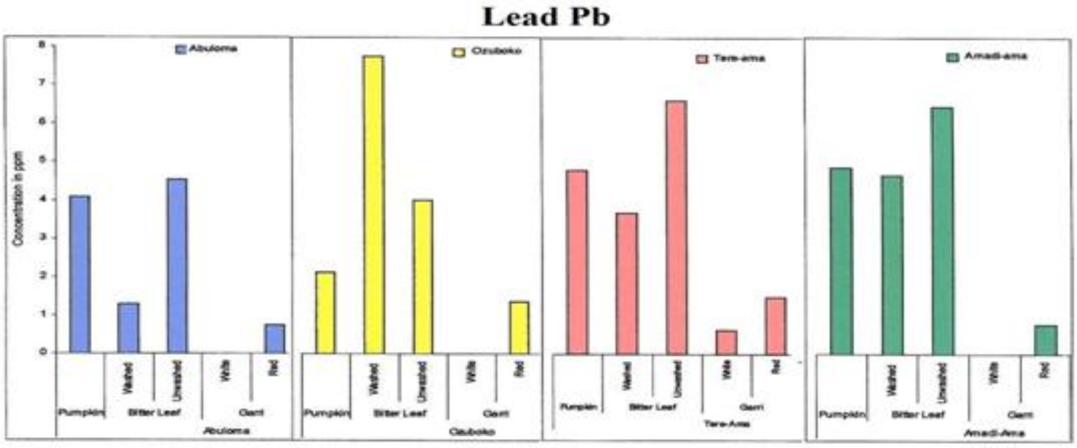

Fig.2: Variations in Concentration of Lead at the various locations

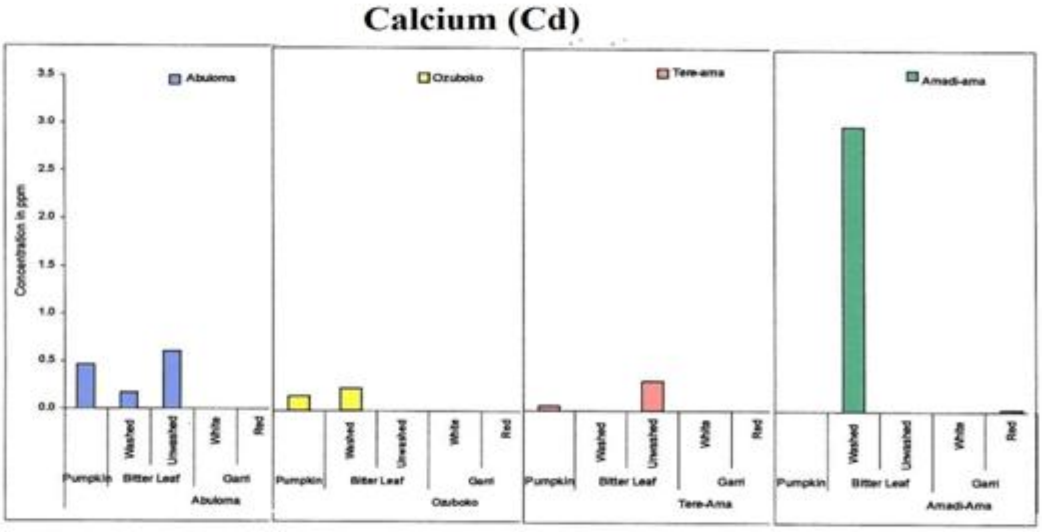

Fig.3: Variations in Concentration of Cadmium at the various locations

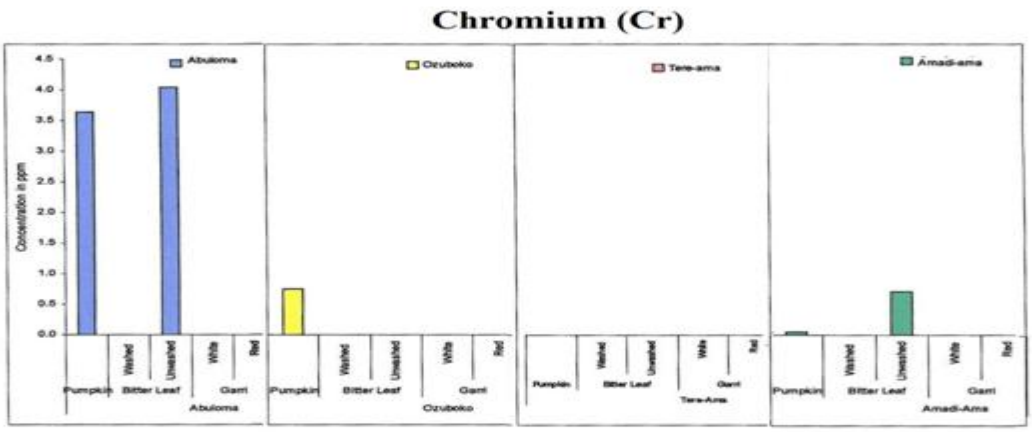

Fig.4: Variations in Concentration of Chromium at the various locations

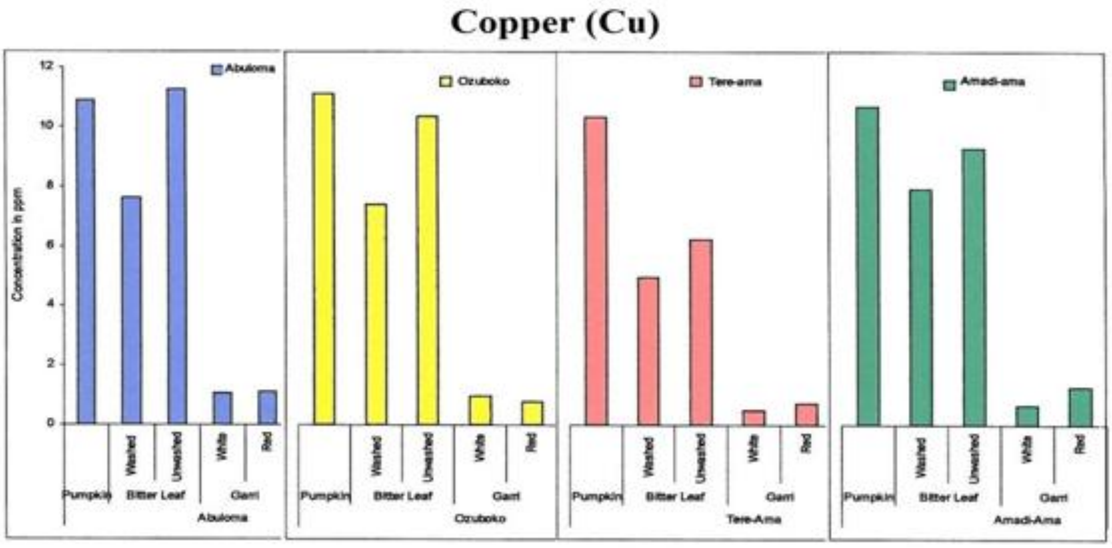

Fig.5: Variations in Concentration of Copper at the various locations

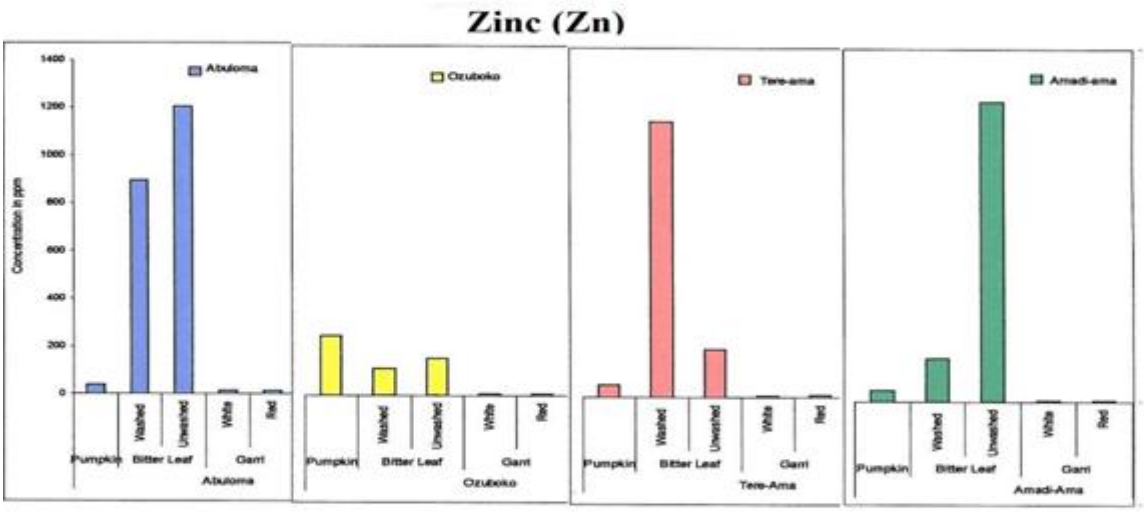

Fig. 6: Variations in Concentration of Zinc at the various locations

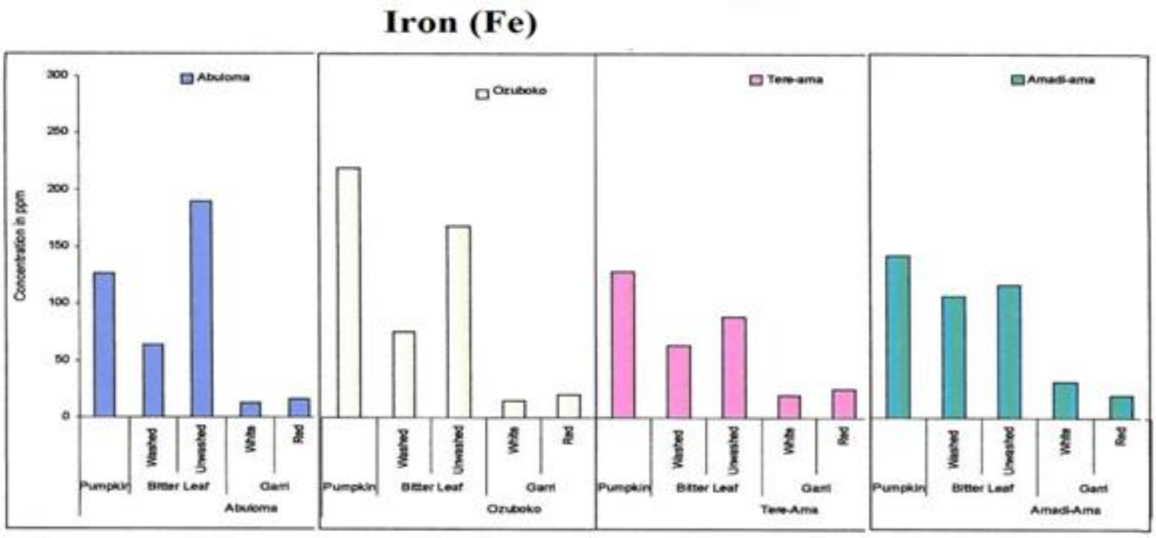

Fig. 7: Variations in Concentration of Iron at the various locations

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