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Assessment of Zn, Cu and Pb Contamination in Soils and Vegetables from Some Farmlands in Lagos Metropolis, Lagos, Nigeria

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Abstract. The contamination of leafy vegetables with heavy metals poses a serious threat to humans but little attention has been given to such studies in Nigeria. Investigated in this study are the levels of concentration of three heavy metals; Zn, Cu and Pb in some leafy vegetables viz., cockscomb (*Celosia argentea*), african spinach (*Amarathus viridis*), , jute plant (*Corchorus olitorus*) and lettuce (*Lactuca capensis*) from four farmlands designated as Idi - araba, Isolo, Owode - Onirin and Badore in Lagos Metropolis. The concentrations of Cu, Zn and Pb in the leaves, stems and roots of cockscomb, african spinach, jute plant and lettuce were found to be 1.542 – 0.125, 88.417 – 17.700, 7.568 – 0.028; 1.633 – 0.125, 82.417 – 18.250, 16.334 – 0.083; 1.583 – 0.028, 17.542 – 8.243, 10.833 – 0.167; 0.046 – 0.235, 0.00, 0.456 – 0.342 mg kg^{-1} respectively. The concentrations of Pb of the leaves of vegetables at Isolo, *Corchorus olitorus* at Idi – araba, *Celosia argentea* and *Lactuca capensis* at Badore were above the recommended maximum acceptable limits by WHO Expert Committee on Food Additives. The Zn and Cu contents of leaves of all vegetables are below the recommended limits in the four farmlands. The estimated daily intake of Cu, Zn and Pb through the consumption of *Celosia argentea*, *Amarathus viridis* and *Corchorus olitorus* are below the provisional tolerable daily intake of heavy metals established by FAO/WHO. This study shows that the vegetables obtained directly from the study sites may not constitute a health hazard for consumers.

Keywords: Heavy metals, vegetables, organic wastes, fertile

Introduction

Vegetables are vital to human diet as they contain essential nutrients such as carbohydrate, proteins, vitamins and trace elements which are vital to human existence as a result of their role in metabolism [Itanna, 2002]. Heavy metals like Fe, Cu, Zn and Ni are important for proper functioning of biological systems including vegetables, the deficiency or excess of which could lead to a number of disorders and several studies have confirmed the uptake of heavy metals from soil by plants [Mohamed *et al.* 2003; Sharma *et al.* 2007; Yusuf *et al.* 2003].

Heavy metals at very low amounts are part of chemical components of soil and the levels are readily increased by natural and human activities including usage of manure, fertilizers, sewage sludge and pesticides. (Aiwonegbe and Ikhuoria, 2007). In addition to heavy metal uptake by vegetables from soil, atmospheric deposition of the same from industrial processess and vehicle emission are common sources of elevated heavy metal concentration in vegetables especially in urban cities like Lagos. Nicolas et al. (2008) have attributed increased levels of heavy metals in leafy vegetables to atmospheric depositions.

The availability of arable land for farming are increasingly being limited by rapid urbanization and industrialisation in most cities in the developing countries. It is estimated that half of the world's population now lives in towns or cities and over 54% of the African population will be living in urban areas by the year 2025 (Nabulo et al., 2008). Lagos, the commercial nerve centre of Nigeria presents a typical case of the most industrialized areas of Nigeria, hosting over 60% of the industries in the nation within its relatively small landed area (Odunaiya, 2002). The rate of population growth is about 300,000 persons per annum with a population density of about 3,746 persons per square kilometer.

The high rate of unemployment has led to the usage of hazardous places such as dumpsites, road verges and banks of drainage channels for agricultural cultivation in Lagos metropolis. The poor groups are mostly involved in vegetable farming in the hazardous sites and the produce are retailed at major markets.

Food crops and vegetables grown in these areas are readily consumed by both low and high income earners with no regard for the health implications.

Heavy metals in the environment are a health hazard due to their persistence, bioaccumulation and toxicity to plants, animals and human beings (Sharmal et. al., 2007). Heavy metal accumulation due to regular intake of food from hazardous environment could pose a serious health risk to Lagos urban communities. It is therefore imperative that regular investigations be carried out to assess the levels of heavy metals in common vgetables grown in Lagos metropolis.

The study is aimed at determining the levels of heavy metal accumulation in vegetables as well as the metal contamination of soils from some vegetable farmlands along road verges and dumpsites in Lagos metropolis with the view of assessing the health impacts of the consumption of these vegetables on the local community.

Materials and Methods

Fresh vegetable samples were randomly harvested between May and June 2009 from the four sampling sites; Idiaraba, Isolo, Owode onirin and Badore.

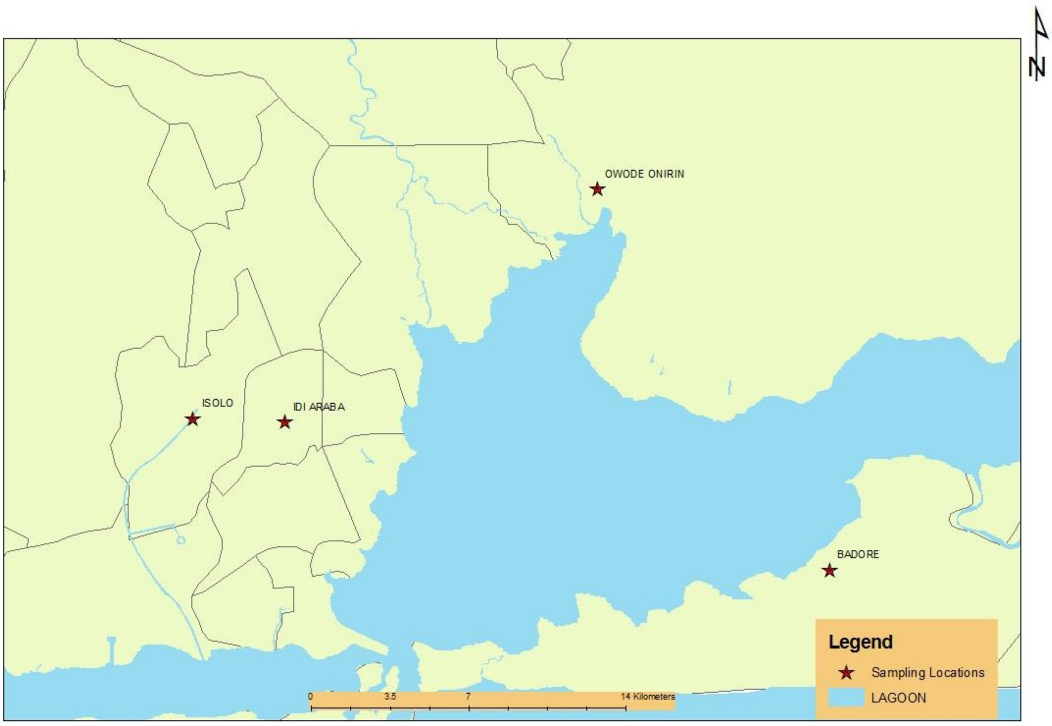

Figure 1. Sampling sites; (A) Idiaraba; (B) Isolo; (C) Owode onirin; (D) Badore

Table 1: List of Leafy Vegetables and Locations of Farmlands

Sampling area	Location	Common name	Scientific name
(A) Idi-Araba	N06^{o}31.7008^{1}	Cockscomb	Celosia argentea
	E003^{o}21.237^{1}	African spinach	Amaranthus hybrides
		Jute plant	Corchorus olitorius
(B) Isolo	N06^{o}31.724^{1}	Cockscomb	Celosia argentea
	E003^{o}19.057^{1}	African Spinash	Amaranthus sativa
		Jute plant	Corchorus olitorius
(C) Owode Onirin	N06^{o}37.134^{1}	Cockscomb	Celosia argentea
	E003^{o}28.375^{1}	Jute plant	Corchorus olitorius
(D) Badore		Cockscomb	Celosia argentea
	N06^{o}28.427^{1}	African Spinash	Amaranthus hybrides
	E003^{o}34.510^{1}	Jute plant	Corchorus olitorius

The plants were washed under tap water and then distilled water. Individual plants were separated into root, stem and leaves. The samples were dried at 80^{o}C for 72 h, cooled and ground. 1.25 g of each sample was placed in 250 ml conical flask and digested with HNO_3. The digests were filtered and made up to the mark in 50 ml volumetric flask with deionised water. The resultant supernatant was analysed for Zn, Cu and Pb using flame atomic absorption spectrophotometer. Soil samples were collected from a depth of 10 cm from each sampling sites and air dried. The samples were ground to a fine powder in a mortal. A sample of 1.250 g of the soil was digested in aqua regia: a mixture of 25% of HNO_3, and 75% OF HCl. The digested soil was then filtered and the filtrate made up to the mark in 50ml standard flask with deionised water. The resulting solution was analyzed for Zn, Cu, Pb and Cd using flame atomic absorption spectrophotometer, Perkin Elmer A Anayst 200 model.

Results and Discussion

The concentrations of metals in soils from different sites are presented in Table 2 while Tables 3 – 5 depict the concentrations of metals in the leaves, stems and roots of Lettuce (*Lectuca sativa*), Soko (*Celosia argentea*), Tete (*Amaranthus hybrides*) and Ewedu (*Corchorus Olitorius*) respectively.

Table 2: Heavy metal contents for soils in various farmlands

Farmlands	Cu(mg/kg)	Zn(mg/kg)	Pb(mg/kg)
Idi-araba	11.025±0.345	63.833±2.376	17.083±0.952
Isolo	14.037±1.028	109.670±9.220	29.911±1.881
Owode Onirin	10.350±1.213	77.416±3.781	15.833±1.124
Badore	6.190 ± 0.518	65.500±2.582	12.666±1.543

Table 3: Heavy metal contents in leaves of vegetables from Idi araba, Isolo, Owode onirin and Badore farmlands (mg/kg).

		Cu	Zn	Pb
	Celosia argentea	0.367±0.005	22.321± 0.170	0.028± 0.002
Idi -araba	*Amaranthus hybrides*	0.125±0 013	18.250± 0.056	0.083± 0.003
	Corchorus Olitorius	0.245±0.003	31.141± 0.408	0.483± 0.017
	Celosia argentea	0.275±0.006	31.358± 0.215	0.325± 0.009
Isolo	*Amaranthus hybrides*	0.158±0.008	24.383± 0.179	0.614± 0.036
	Corchorus Olitorius	0.028±0.001	42.500± 0.386	0.826± 0.044
Owode Onirin	*Celosia argentea*	1.200±0.006	36.275± 0.284	0.768± 0.005
	Corchorus Olitorius	1.058±0.008	45.223± 0.362	0.167± 0.004
	Celosia argentea	1.158±0.004	17.70± 0.042	0.256± 0.008
Badore	*Amaranthus hybrides*	1.283±0.007	24.334± 0.022	0.133± 0.002
	Corchorus Olitorius	1.342±0.011	18.243± 0.056	0.342± 0.002
	Lectuca sativa	0.235±0.034	ND	0.456± 0.004

Table 4: Heavy metal contents in stems of vegetables from Idi araba, Isolo, Owode onirin and Badore farmlands (mg/kg).

		Cu	Zn	Pb
Idi -araba	*Celosia argentea*	0.650 ± 0.041	48.456± 0.221	0.058± 0.003
	Amaranthus hybrides	0.350 ± 0.022	59.600 ± 0.316	0.266± 0.002
	Corchorus Olitorius	0.575 ± 0.006	36.435 ± 0.211	0.642± 0.005
Isolo	*Celosia argentea*	0.292 ± 0.004	75.233 ± 0.544	0.345± 0.007
	Amaranthus hybrides	0.383 ± 0.016	79.600 ±0.640	0.825± 0.014
	Corchorus Olitorius	0.142± 0.002	55.000 ± 0.392	1.124± 0.014
Owode Onirin	*Celosia argentea*	1.383± 0.012	40.475 ± 0.326	0.292± 0.006
	Corchorus Olitorius	1.267± 0.006	61.224 ± 0.511	0.367± 0.003
Badore	*Celosia argentea*	1.317 ± 0.014	59.352 ± 0.375	0.058± 0.003
	Amaranthus hybrides	1.525 ± 0.009	61.448 ± 0.255	0.350± 0.007
	Corchorus Olitorius	1.500 ± 0.006	30.002 ± 0.233	1.565± 0.015
	Lectuca sativa	0.946 ± 0.033	ND	0.623± 0.008

TABLE 5: Heavy metal contents in roots of vegetables from Idi araba, Isolo, Owode onirin and Badore farmlands (mg/kg).

		Cu	Zn	Pb
Idi -araba	*Celosia argentea*	0.942± 0.008	52.567± 0.368	6.258± 0.038
	Amaranthus hybrides	0.475± 0.010	41.392± 0.169	16.334± 0.088
	Corchorus Olitorius	0.875± 0.007	38.089± 0.086	10.833± 0.102
Isolo	*Celosia argentea*	1.292± 0.067	88.417± 0.398	7.568± 0.028
	Amaranthus hybrides	0.733± 0.006	82.583± 0.512	9.000± 0.013
	Corchorus Olitorius	1.050± 0.003	71.542± 0.298	8.417± 0.059
Owode Onirin	*Celosia argentea*	1.578± 0.005	522.233± 1.578	0.397± 0.007
	Corchorus Olitorius	1.317± 0.008	45.784± 0.193	0.588± 0.004
Badore	*Celosia argentea*	1.542± 0.010	61.631± 0.412	0.458± 0.027
	Amaranthus hybrides	1.633± 0 .021	43.892± 0.212	0.550± 0.030
	Corchorus Olitorius	1.583± 0.012	54.017± 0.153	0.742± 0.003
	Lectuca sativa	0.413± 0.003	ND	0.342± 0.009

The heavy metal contents in the soils ranged 6.190 to 11.025mg/kg Cu; 63.833 to 109.070 mg/kg Zn and 12.667 to 29.916 mg/kg Pb. Significant differences were observed in heavy metals concentrations in soils of the farmlands ($P<0.05$, DF = 3, ANOVA). The wide variation of heavy metal contents in soil samples can be attributed to different activities that prevail in or around locations. Isolo soil was the most contaminated by Pb and Ni followed by Owode Onirin and Idi-araba. The least contaminated soil was that of Badore. Isolo farm occupy part of an abadoned dump site where solid wastes ranging from metal scraps, batteries, industrial, hospital and domestic wastes were once indiscriminatory disposed. Badore on the other hand is a new upcoming town with minimal industrialization, it is therefore, not out of place for there to be low level of heavy metals in the soil from Badore farmland compared with the other farmlands.

The levels of metal contents of soils from Idi- Araba and Owode Onirin are comparable, Idi-Araba location is in a densely populated environment and quite close to a busy major road while Owode Onirin farmland is close to huge metal scrape deposit used in metallic fabrications. The maximum allowable limits in soils recommended by Kabata – Pendias and Pendias [1992] are 100 mg/kg for Cu and Pb and 300 mg/kg for Zn. The levels of Zn, Cu and Pb in the farmlands fall within the normal range and the results are similar to those obtained by Ogunsola et al. [2003] in the determination of lead of soil and plant grown around a textile industry at Ikorodu, Lagos. The results obtained by Adewuyi et al.[2010] for heavy metal concentrations in soils of some dumpsites in Lagos are slightly higher than the results from this study but are also within the normal range in mineral soil environment.

Elevated concentrations of heavy metals are common occurence in the soils located close to industrial areas. Kachenko and Singh [2005] investigated the heavy metal contamination in soil and vegetable samples at four vegetable growing regions in New South Wales, Australia and obtained elevated concentrations of Cu, Pb, Cd and Zn in the regions around smelters. An eleveted level of Cu was also recorded by Gundermann and Hutchinson [1995] with a 2 km radius in a Ni – Cu smelter in North America. The moderate levels of contamination of soils by heavy metals in some soils in Nigeria can be attributed to the level of industrialization of the country.

Table 3 depicts the mean concentrations of metals in the edible parts of vegetable samples. The heavy metal contents ranged 0.028 to 1.342 mg/kg Cu; 0.00 to 45.223 mg/kg Zn and 0.028 to 0.826 mg/kg Pb. The wide variations of the levels of metal contents in different vegetable species as well as that in different locations is a reflection of the selectivity of the plants for metals, the levels of heavy metal contamination of the soils and soil characteristics such as pH and organic matter.

The levels of copper in the leaves of vegetable samples ranged from 0.275 – 1.58 mg/kg with a mean concentration of 0.750 in *Celosia argentea*; 0.125 – 1.283 mg/kg with a mean concentration of 0.522 in *Amaranthus hybrides* and 0.028 – 1.34 with a mean concentration of 0.668 in *Corchorus Olitorius*. The Cu levels are lower than the limits recommended by FAO/WHO for consumption in vegetables. *Celosia argentea* showed the highest levels of Cu contents at Idi araba, Isolo and Owode Onirin which is a reflection of the metal contents of the soils in the farmlands. It has been shown that metal uptake by pants is closely related to their concentrations and bioavailabilities in soils [Sharmal et al., 2006]. The results obtained in the study are cmparable with the results for the concentration of Cu in spinash from farms irrigated by waste water in Kano by Lawal et al. [2011].

The concentrations of Zn in the leaves of vegetable samples ranged from 17.70 – 36.275 mg/kg with a mean concentration of 26.91 in *Celosia argentea*; 18.25 – 24.383 mg/kg with a mean concentration of 22.32 in *Amaranthus hybrides* and 18.243 – 45.223 with a mean concentration of 34.33 in *Corchorus Olitorius*. The Zn levels are lower than the limits recommended by FAO/WHO for consumption in vegetables. *Corchorus Olitorius* showed the highest level of Zn contents in all the farms except Badore where the level was slightly lower than that of *Amaranthus hybrides*. This can be attributed to the level of Zn in Badore soil as well as the nature of the soil and the absorption capacity of the plant which are subject to numerous environmental and human factors.

Pb, which has been implicated in many diseases, especially of the cardiovascular, renal, nervous and skeletal systems [Jarup, 2003] is of serious concern. The levels of Pb in the leaves of vegetable samples ranged from 0.028 – 0.768 mg/kg with a mean concentration of 0.344 in *Celosia argentea*; 0.083 – 0.614 mg/kg with a mean concentration of 0.276 in *Amaranthus hybrides* and 0.167 – 0.826 with a mean concentration of 0.455 in *Corchorus Olitorius*. The levels of Pb in *Celosia argentea* in the vegetables of Isolo and Owode Onirin locations exceeded the FAO/WHO-codex standard of 0.3mg/kg while that of Badore has the value of 0.256$\pm$0.008 which is slightly lower than the recommended limit. It is worthy of note that the soils of Isolo and Owode Onirin have elevated levels of Pb contents. The result from this study conforms with earlier reports of correlation between the levels of heavy metals in soils and the plants grown on the soils [Adewuyi et al., 2010, Adeniyi, 1996].

The levels of the metals, Cu, Zn and Pb in stems and roots of the studied as presented in Tables 4 and 5 show coorrelation with the levels of the metals in the soils. The order of heavy metal distribution in the vegetable plants is root > stem > leaves in all the farmlands. This order shows that the ground parts of the plants effectively accumulated heavy metal pollutants from soil, with the lowest concentrations transported to the leaves.

Estimation of daily intake of heavy metals.

Exposure of consumers to health risks are usually expressed as provisional tolerable daily intake (PTDI) which is the limit of heavy metal intake based on the body weight of an average adult (60 kg body weight). The reference values established by FAO/WHO (1999) for Cu, Zn and Pb are 3 mg, 60 mg and 214 µg for Cu, Zn and Pb respectively. The total mean concentration of heavy metals in

Celosia argentea, Amaranthus hybrides and *Corchorus Olitorius* in all the farmlands are presented in Table 6.

Table 6. Mean concentrations of heavy metals in vegetable leaves from all farmlands

	Cu (mg/kg)	Zn (mg/kg)	Pb (mg/kg)
Celosia argentea	0.750	26.910	0.344
Amaranthus hybrides	0.522	22.320	0.276
Corchorus Olitorius	0.668	34.330	0.455

If a daily intake of 80 g of each type of fresh vegetable is assumed to be consumed by an adult (60 kg body weight), the corresponding dry weights for *Celosia argentea, Amaranthus hybrides* and *Corchorus Olitorius* are 8.01 g, 7.36 g and 8.34 g. The estimated daily intake of the metals based on the mean concentrations in Table 6 are given in Table 7.

Table 7. Estimated daily intake of metals

	Cu (mg/kg)	Zn (mg/kg)	Pb (mg/kg)
Celosia argentea	6 μg	215 μg	2.61 μg
Amaranthus hybrides	4.06 μg	164 μg	2.03 μg
Corchorus Olitorius	5.57 μg	286 μg	3.79 μg
PTDI (WHO)	3 mg	60 mg	214 μg

The estimated daily intake of Cu, Zn and Pb in this study are lower than that recommended by the FAO/WHO for heavy metal intake based on an average adult (60 kg body weight). The results indicate that the daily intake of Cu, Zn and Pb through the vegetables obtained directly from the study areas may not constitute health hazard for consumers.

Conclusion

The finding in the present study shows that the levels of Cu, Zn and Pb in the farmlands fall below the maximum allowable limits in soils. The level of Pb in vegetables exceeded the FAO/WHO-codex standard of 0.3mg/kg. The vegetables are also contaminated with Cu and Zn but with levels below the FAO/WHO – codex standard. However, the estimated daily intake of the metals through the consumption of vegetables are below the provisional tolerable daily intake (PTDI) which is the limit of heavy metal intake based on the body weight of an average adult (60 kg body weight).

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