Evaluation of Heavy Metals and Health Risk Index in *Amaranthus hybridus* L. Vegetable Grown in Selected Farms in Ibadan, Nigeria

***O.O. FAYINMINNU AND J.M. ADEKUNLE – JIMOH**
Department of Crop Protection and Environmental Biology,
University of Ibadan, Ibadan, Nigeria.
Corresponding Author
E-mail: olorijkb2008@gmail.com

Abstract

Heavy metals have been mostly evaluated in terms of farm site types and locations, but have not been related to the depth of ill-health they pose to the populace. However, there is inadequate information on human health risk index associated with the consumption of heavy metal contaminated vegetables. This study was conducted to evaluate the heavy metals; Pb, Cd, Cr, Cu, Zn and health risk associated with the consumption of *Amaranthus hybridus* vegetables in different farm sites. Four selected vegetable farms: Mokola, Ojoo, Olorunda Aba and Agbon-Ile in Ibadan, Nigeria were used during rainy and dry seasons for eight weeks, respectively while Soil from Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria was used to plant the control in the Screen house (control site) of the Department of crop Protection and Environmental Biology. Data collected were analysed using descriptive statistics. The results indicated that heavy metal concentrations in those farm sites were higher in water, soil and vegetables (root and shoot) when compared with the control during dry and rainy seasons. Irrigation water obtained from all the four farms except control had a highly significant amount of Pb concentrations ranging between 96.83 – 116.90mg/L and lower Cd 0.06- 0.12mg/L, while the heavy metals were not detected in the control during both seasons. Results from the soil analysis revealed significantly highest concentration of Pb (128.36mg/kg), while Cd had lower concentration value of 0.40mg/kg and the control had the lowest value (0.12mg/kg) of Pb. Heavy metals detected in vegetables grown in Ojoo farm were significantly higher than those found in other farms including the control. The concentrations of heavy metals in vegetable root samples from all the farms followed the same trend Zn>Cu>Cr>Pb>Cd in both seasons, respectively. The human Health Risk Index (HRI) values were <1 in the vegetable samples (root and shoot) from Agbon-ile, Mokola and Olorunda-Aba in both seasons. However, the HRI was >1 for Pb and Zn (ranged from 1.15-8.32) at Ojoo farm site during the dry and rainy seasons. This study showed that the proximity of Ojoo vegetable farm to heavy traffic road appeared to be the major contributory factor to its high heavy metal accumulation which resulted to high Health Risk Index.

Introduction

Industrial and anthropogenic activities have made heavy metals ubiquitous in the environment, and humans are exposed to them in various ways (Wilson and Pyatt, 2007). Heavy metals such as Fe, Cu, Zn, and Ni are essential for proper functioning of the biological systems in plants and their deficiencies or excesses could lead to disruption of cells (Ward, 1995; Uwah, 2009). However, contamination of heavy metals in the ecosystem through water, soil, air and agricultural produce (and their consumption by humans) have been a great concern of health issues. Sources of heavy metal contamination in

Keywords: Heavy metals, *Amaranthus hybridus* L., Irrigation water, Health Risk Index, Vegetable farm sites.

food chains are mainly from agricultural inputs such as fertilisers, pesticides (especially insecticides), organic manures and composts which may usually contain a wide variation of heavy metals as impurities (Singh, 2001 and Nicholson *et al.,* 2003).

Vegetables are known to be the cheapest and readily available source of important proteins, vitamins, minerals, essential amino acids, iron, calcium and other nutritional requirements (Aletor and Adeogun, 1995). They also form a major component of most Nigerian and other African dishes where the daily diet is dominated by starchy staple foods. Lokeshwari and Chandrappa, (2006) reported that vegetables take up heavy metals in growth media such as soil, air and nutrient solutions by the roots or foliage. Humans could be at risk of adverse health effects from consuming edible vegetables cultivated, especially on heavy metals contaminated farmlands or abandoned dump site. This may lead to human exposure to high toxic levels of heavy metals thereby resulting in health risks from consuming such vegetables (Xu and Thornton 1985; Nirmal *et al*., 2007). Heavy metal toxicities have been reported to cause neurological disorders, central nervous system destruction, cancers of various body organs (ATSDR, 1999; 2000) and severe mental retardation in children (Udedi, 2003) .

Largerwerff and Specht (1970) established that, there are always high toxic levels of heavy metals in plants grown closely to high traffic areas. Studies conducted in Nigeria by Onianwa and Ajayi (1987); Ogunyemi *et al*. (2003); Okunola *et al.* (2008) have shown that edible vegetables take up heavy metals especially those grown along road sides in urban areas. Contamination of edible vegetables with Cd, Cu and Ni had been reported from industrial and residential areas of Lagos State, Nigeria (Yusuf *et al*., 2003). Heavy metal concentrations in vegetables grown on dumped site and those grown in urban and peri-urban gardens in Ibadan metropolis, showed high levels of Pb and Cd (Ogunyemi *et al*., 2003). Higher accumulation of heavy metals were also found in vegetables and fruits grown in industrialised and urban areas than those in rural areas as reported by Radwan and Salama, (2006), and Fytianos *et al*. (2001). These may be due to the run- off from agrochemicals, industrial and transportation emissions released as atmospheric pollution in form of metal containing aerosols. These aerosols when deposited on the leaves can be absorbed into the plant system (Afshin and Masoud, 2008; Yusuf and Oluwole, 2009 and Suruchi and Pankaj, 2011), and thus affect food quality and safety (Muchuweti *et al*., 2006).

In recent times, economic hardship has led many people into urban and peri-urban farming especially vegetable production which brings income within a very short period of time. In lieu of this, this study was targeted at vegetable farms that supply vegetables to some major markets in Ibadan. These farms are in close proximity to the urban and rural areas, they have access to hand-dug well/stream for irrigation and the farmers rely majorly on fertilisers and farm-yard manures to enhance vegetable yield. Consumption of such produce may pose certain health risks to the consumers. In line with Onianwa and Ajayi (1987); Ogunyemi *et al*. (2003); Nicholson *et al. (*2003) and Okunola *et al.* (2008), there are possibilities of heavy metal uptake by the vegetables from traffic emissions and the soil amendments. Therefore, the quality and safety of vegetables from these farms are of major concern. Several works have been published on heavy metals in vegetables; however there is little information on the health risk index assessment in edible vegetables in Nigeria. This study therefore, evaluated the health risk index of *Amaranthus hybridus* L. from selected farms in determining the safety or health risk to the populace associated with the consumption of such vegetables.

Materials and Methods

Sample sites

This study was carried out between January and June 2013. Four local government areas (LGAs) in Ibadan, Oyo State: Ibadan North, Ido, Akinyele and Lagelu reputed for growing and supplying vegetables to major markets in Ibadan were purposively selected. Samples were collected from Mokola (Long.3.88E and Lat.7.42N), Agbon-ile (Long.3.82E and Lat.7.46N), Ojoo (Long.3.95E and Lat.7.46N) and Olorunda-Aba (Long.3.98E and Lat.7.49N) each located in the respective LGAs. One farm site was selected from each location. Each farm site, was divided into three equal parts using line transect. Three samples were collected randomly from each part. Soil samples collected from the Teaching and Research Farm, University of Ibadan were used to plant the control in the screen house of the Department of Crop Protection and Environmental Biology, University of Ibadan. Each of the farm sites had a reliable water source which varied from hand dug dam by a stream to properly dug well for irrigation purpose. Sample collection was done during the dry and rainy seasons of vegetable cropping. Samples collected were vegetables, water and soil.

Sample collection

From each of the farms, 250 ml of water, 500 g of soil and 500 g of vegetable were collected fortnightly at three and five Weeks After Sowing (3 WAS and 5 WAS) from three different points. These fortnightly collected samples were bulked to form a 750 ml, 1.5 kg and 1.5 kg composite of water, soil and vegetable, respectively. The water collected at the two different times was analysed separately to get the mean, while the bulked soil and the bulked vegetable (whole plant) at 3 WAS and 5 WAS were further bulked to make a representative composite for soil and vegetable, respectively. Samples used for the chemical analysis were obtained from this composite. This was done for both rainy and dry seasons.Water sample was collected in clean plastic bottles, from hand dug dam by a stream or a properly dug well in the different farms during dry and rainy seasons. Tap water used to irrigate the control was also collected. Soil sample collection was randomly done at a depth of 0-15 cm using a soil Dutch auger. It was collected from the same spot where the vegetable plant samples were carefully uprooted. The soil samples collected from each farm were bulked and thoroughly mixed separately to form a composite and were kept in polythene bags and labeled properly.

Amaranthus hybridus samples were harvested fortnightly at three Weeks After Sowing (3 WAS) and five (5 WAS) from the five farm sites during the harvesting period of late dry (February-March) and rainy seasons (May – June), respectively. The vegetables were uprooted carefully by hand and washed thoroughly with tap water to remove soil particles. They were separated into shoot and root samples, kept in separate paper envelopes and properly labeled.

Water Analysis: 3ml of concentrated nitric acid (HNO_3) was added to each water sample to preserve till analysis was carried out on the third day. Analysis for heavy metals in the preserved water was carried out by taking 100 ml of each sample from the farms. This was heated in a beaker with 5 ml conc. HNO_3 and $HClO_4$ was added. The mixture was made up to 25 ml with distilled water for heavy metals (Pb, Cd, Cr, Zn and Cu) and analysis carried out through Atomic Absorption Spectrometer (AAS), (AOAC, 2005).

Soil Analysis: The composite soil samples were air-dried in the Laboratory at 27± **2** °C for twenty-one days and sieved with 0.5 mm sieve. A 0.5 g sample was taken from each composite sample and digested using acid mixture concentrated HNO_3 and $HClO_4$ (4:1 by volume) made up to 25 ml with distilled water for heavy metals (Pb, Cd, Cr, Zn and Cu) and analysis carried out through AAS using the method described by AOAC, (2005).

Vegetable Analysis: The samples were left to air dry at room temperature (27± 2 °C) for twenty-one days and were ground. A 0.5 g quantity was weighed from each sample, digested in a mixture of concentrated HNO_3 and $HClO_4$ (4:1 by volume) and made up to mark (25 ml) with distilled water for heavy metals using the method described by AOAC, (2005). The digested samples were analysed for Pb, Cd, Cr, Zn and Cu using the AAS. Risk of intake of metal-contaminated vegetables to human health was characterised by Hazard Quotient (HQ).

Assessment of Health Risk Index

According to Integrated Risk Information System (IRIS, 2003) Health Risk Index (HRI) is evaluated based on Daily Intake of Metals (DIM) which calculates as

$$DIM = C_{metal} \times C_{factor} \times D_{food\ intake} / B_{average\ weight}$$

(Rattan *et al*., 2005) (1)

Where:

C_{metal}, C_{factor}, $D_{food\ intake}$ and $B_{average\ weight}$ represent the heavy metal concentrations in plants (mg/kg), conversion factor, daily intake of vegetables and average body weight, respectively. The conversion factor of 0.085 was used to convert fresh vegetable weight to dry weight as described by Rattan *et al*. (2005). The average daily vegetable intake for adults was considered to be 0.250 kg/person/day according to Chubike *et al*. (2013) while the average adult body weight was considered to be 60 kg according to FAO/WHO (1999).

Determination of Health Risk Index (HRI)

Health Risk Index was obtained by determining Daily Intake of Metals (DIM) and Oral Reference Dose (RfD) using the expression

$$HRI = \frac{DIM}{RfD} \quad (2)$$

The Oral reference doses (RfD) for the heavy metals were considered to be $1x10^{-3}$, 1.5, $4x10^{-2}$, $3.5x10^{-3}$ and 0.3 mg/kg/day for Cd, Cr, Cu, Pb and Zn, respectively according to US-EPA, (IRIS 2006).

If the value of HRI is less than 1, the exposed population is said to be safe and if the ratio is equal to or greater than 1, the population will experience health risk (IRIS, 2003).

Quality Assurance

Analytical grade reagents were used for all analysis. All reagents were standardised against primary standards to confirm their actual concentrations. All glasswares and plastic containers used were soaked in 10% HNO_3 solution overnight (Onianwa, 2001) and rinsed thoroughly with distilled water before use.

Statistical analysis

Data from the chemical analyses were analysed using descriptive statistics. Results were presented as mean ± standard error of the mean (SEM).

Results

Table 1 shows that results obtained during the dry and rainy seasons in all the farms had significant differences at (p=0.05). In both seasons, the highest levels of all heavy metal concentrations in water samples (Table 1) were recorded from samples collected at Ojoo farm site over that of other farm sites in the order Pb> Zn > Cu > Cr > Cd . Samples from Mokola farm site had lower heavy metal concentrations in the order Zn > Cr > Cu >Pb> Cd. The water sample from Ojo indicated highest level of Pb (96.8 mg/L and 117 mg/L) at Ojoo farm site while samples from Mokola had 0.12 mg/L and 0.28 mg/L during dry and rainy seasons, respectively. The highest values obtained for Cd were 1.73 mg/L and 2.55 mg/L in samples from Ojoo. However, heavy metals were not detectable in water samples from the control site.

The soil samples in dry and rainy seasons had the highest levels of all heavy metals (Table 2) in Ojoo farm site. Lead (Pb) had the highest concentration (128.4 mg/kg) in dry season while Cr had the highest concentration (99.4 mg/kg) in rainy season in the order Cr > Zn > Cu > Cd >Pb. Cadmium (0.40mg/kg and 0.45mg/kg) and Pb (1.37mg/kg and 1.70mg/kg) concentrations from Agbon-ile farm site were the lowest amongst the sites for dry and rainy seasons, respectively. The soil samples from Ojoo had highest concentration of Pb (128mg/kg) and lowest concentration of Cd (3.31mg/kg) while that of Agbon-ile had highest concentration Cr (33.3mg/kg) and lowest concentration of Cd (0.40mg/kg) for both seasons. The control however, had the lowest concentration of heavy metal (0.12mg/kg).

Table 1: Mean values of heavy metal concentrations (mg/L) in water samples for irrigation of *Amaranthus hybridus* L. in selected farms in Ibadan, Nigeria

Treatment	Cadmium		Chromium		Copper		Lead		Zinc	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Control	ND	ND	0.01±0.001	0.01±0.001	0.01±0.001	0.01±0.001	ND	ND	0.11±0.01	0.11±0.01
Mokola	0.1±0.01	0.06±0.01	13.4±0.13	11.2±0.24	11.9±0.10	9.64±0.18	0.36±0.03	0.28±0.01	24.5±0.27	23.3±0.14
Ojoo	2.55±0.04	1.73±0.02	56.3±3.37	38.7±0.34	47.4±0.33	44.3±1.74	117±0.33	96.8±0.57	92.5±0.34	78.7±1.40
Agbon-ile	0.36±0.01	0.26±0.01	17.4±0.11	15.3±0.17	17.9±0.24	16.4±0.57	1.55±0.03	1.35±0.02	42.2±0.33	42.9±2.43
Olorunda-Aba	0.33±0.01	0.17±0.01	15.7±0.12	13.4±0.12	18.2±0.18	13.4±0.26	0.63±0.02	0.52±0.03	36.3±0.16	34.6±1.44
*FAO/WHO (2001)	0.01	0.01	0.1	0.1	0.2	0.2	5.0	5.0	2.0	2.0

Table 2: Mean values of heavy metal concentrations (mg/kg) in soil samples of *Amaranthus hybridus* L. in selected farms in Ibadan, Nigeria

Treatment	Cadmium		Chromium		Copper		Lead		Zinc	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Control	ND	ND	0.21±0.01	2.21±0.01	1.65±0.02	1.65±0.02	0.12±0.01	0.12±0.01	2.96±0.02	2.96±0.02
Mokola	2.65±0.01	1.15±0.01	41.4±2.00	38.3±2.44	29.8±1.99	24.6±2.03	3.45±0.33	2.64±0.01	34.2±1.87	31.4±2.04
Ojoo	5.74±0.30	3.31±0.11	99.4±1.77	97.3±2.21	48.7±4.67	46.3±3.19	1.34±5.66	128±4.66	82.4±2.12	86.3±2.03
Agbon-ile	0.45±0.03	0.40±0.02	33.3±1.11	29.7±1.77	15.3±1.07	13.7±1.73	1.70±0.09	1.37±0.01	21.9±1.19	19.3±0.47
Olorunda-Aba	0.64±0.03	0.61±0.01	35.3±1.03	31.3±2.33	22.2±1.41	19.2±1.45	1.65±0.02	1.46±0.01	23.3±1.12	20.4±1.63
*EU (2001)	3	3	150	150	140	140	300	300	60	60

ND = Not Detectable, ± = Standard Error
*Values refer to Maximum Limit of World Health Organisation/European Union

Table 3: Mean values of heavy metal concentrations (mg/kg) in shoot samples of *Amaranthus hybridus* L. in selected farms in Ibadan, Nigeria

Treatment	Cadmium		Chromium		Copper		Lead		Zinc	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Control	0.02±0.01	0.02±0.01	1.43±0.01	1.43±0.01	0.24±0.01	0.24±0.01	0.11±0.01	0.11±0.01	0.47±0.01	0.47±0.01
Mokola	0.23±0.01	0.15±0.01	1.96±0.02	1.56±0.01	1.90±0.24	1.42±0.01	0.87±0.01	0.47±0.03	8.13±0.45	4.97±0.06
Ojoo	0.86±0.01	0.75±0.01	11.7±0.27	9.31±0.20	12.5±0.58	9.42±0.16	3.32±0.003	2.37±0.01	29.2±2.40	27.1±1.37
Agbon-ile	0.38±0.003	0.29±0.01	4.20±0.11	3.05±0.01	5.36±0.29	2.74±0.11	0.96±0.003	0.83±0.01	12.4±0.57	9.41±0.26
Olorunda-Aba	0.06±0.003	0.04±0.01	1.10±0.01	0.91±0.02	1.76±0.003	1.31±0.02	0.15±0.003	0.07±0.01	4.81±0.24	2.23±0.13
*FAO/WHO (2001)	0.2	0.2	2.3	2.3	73.3	73.3	0.3	0.3	99.4	99.4

The highest concentration of heavy metal present in the shoot of *Amaranthus hybridus* samples collected across all the selected farm sites in dry and rainy seasons was Zn (Table 3). Results of vegetable sample collected from Ojoo farm was in the order Zn > Cu > Cr >Pb> Cd with the same trend observed at Olorunda. The concentration of Zn obtained in vegetables across the four farm sites for dry and rainy seasons ranged between 27.1 mg/kg and 29.2 mg/kg at Ojoo, 2.23 mg/kg and 4.81 mg/kg at Olorunda, while the control site had 0.47mg/kg in both dry and rainy seasons, respectively. Cadmium concentrations (0.75 mg/kg and 0.86 mg/kg) in vegetable at Ojoo were the highest values obtained from the shoot part during the dry and rainy seasons, respectively. However, Cd had lower concentrations (0.04 mg/kg and 0.06 mg/kg) at Olorunda, while the control had the lowest concentrations (0.02 mg/kg) of Cd in the shoot for both seasons.

The results of heavy metal concentrations in the *A. hybridus* vegetable root samples (Table 4) followed the same trend as in the shoot for dry and rainy seasons. Samples from Ojoo farm had the highest levels of Zn (33.4 mg/kg and 38.2 mg/kg) while lower concentrations (0.15 mg/kg and 5.67 mg/kg) at Olorunda Aba were found in the root during dry and rainy seasons, respectively. The control however, had the lowest concentrations 0.73 mg/kg of Zn in the root for both seasons.

The Health Risk Index (HRI) of the five heavy metal concentration in *Amaranthus hybridus*

Table 4: Mean values of heavy metal concentrations (mg/kg) in root samples of *Amaranthus hybridus* L. in selected farms in Ibadan, Nigeria

Treatment	Cadmium		Chromium		Copper		Lead		Zinc	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Control	0.04±0.01	0.04±0.01	0.23±0.003	0.23±0.003	0.27±0.01	0.27±0.01	0.13±0.01	0.13±0.01	0.73±0.01	0.73±0.01
Mokola	0.68±0.04	0.35±0.34	4.68±0.01	3.05±0.01	5.35±0.22	3.20±0.01	2.59±0.06	1.31±0.01	11.4±1.06	9.20±0.52
Ojoo	1.33±0.01	1.13±0.01	13.4±0.69	11.3±0.45	15.5±0.57	13.4±0.66	8.22±0.06	5.64±0.18	38.2±1.76	33.4±1.74
Agbon-ile	0.97±0.001	0.53±0.01	6.23±0.16	4.47±0.24	7.55±0.33	6.37±0.24	3.97±0.05	2.09±0.01	15.4±1.45	11.7±0.57
Olorunda-Aba	0.29±0.01	0.15±0.01	1.45±0.08	1.11±0.14	4.63±0.26	2.95±0.01	0.62±0.01	0.41±0.01	5.67±0.10	3.52±0.01
*FAO/WHO (2001)	0.2	0.2	2.3	2.3	73.3	73.3	0.3	0.3	99.4	99.4

samples (root and shoot) for dry and rainy seasons differs significantly. The root samples for both seasons revealed that Cd, Cr, and Cu recorded significantly reduced HRI < 1 in all the farm sites. The Pb and Zn in the root samples however, had HRI > 1 in samples from Ojoo, Agbon-ile and Mokola farm sites in both seasons (Figs 1 and 2). The vegetable shoot samples in dry and rainy seasons had HRI <1 from Olorunda, Agbon-ile and Mokola farm sites while, samples from Ojoo farm site gave HRI>1 in Pb and Zn (Figs 3 and 4). Results from the control showed HRI<1 for all heavy metals.

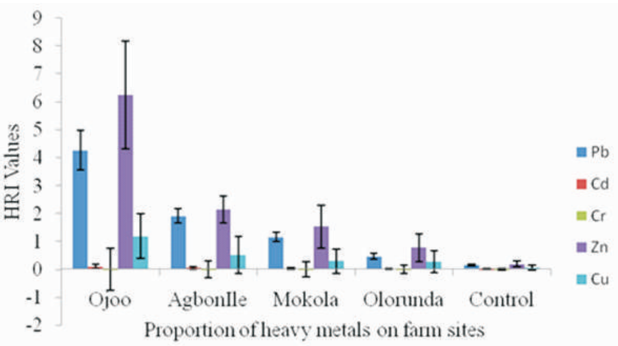

Figure 1: Health Risk Index (HRI) of *A. hybridus* roots from plants grown in selected farms of Ibadan, Nigeria during the dry season

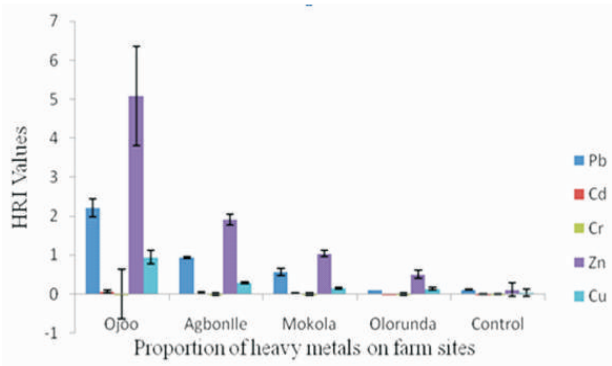

Figure 3: Health Risk Index (HRI) of *A. hybridus* shoots from plants grown in selected farms of Ibadan, Nigeria during the dry season

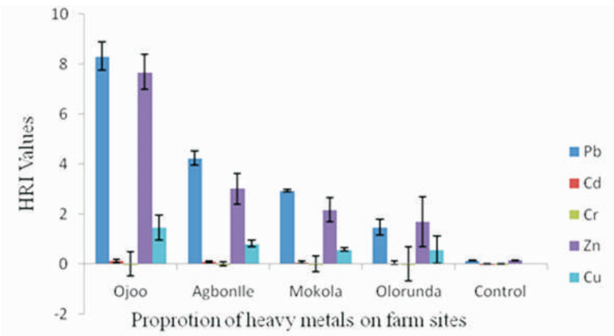

Figure 2: Health Risk Index (HRI) of *A. hybridus* roots from plants grown in selected farms of Ibadan, Nigeria during the rainy season

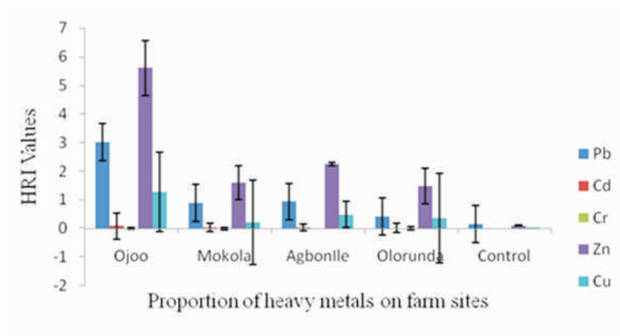

Figure 4: Health Risk Index (HRI) of *A. hybridus* shoots from plants grown in selected farms of Ibadan, Nigeria during the rainy season

Discussion

Irrigation water is believed to be one of the sources of heavy metals present in vegetable samples from the farm sites used in this study. Heavy metals such as Pb, Zn, Cu, Cr and Cd concentrations in irrigation water samples in this study during the rainy and dry seasons were above the recommendations of FAO/WHO (2001). Comparatively, the results showed that, the heavy metal concentrations in water samples during the rainy season were higher than that of dry season. This is in line with the findings of Idoko *et al.* (2012) which showed that metals like lead and copper recorded higher concentration in the wet season. High concentrations of some of the metals observed in the wet season samples could be an indication that the soluble forms of the metals are either present in the environment or produced after some chemical reactions have occurred (Idoko *et al.*, 2012). This could also be due to the run-off of heavy metals into the water reservoirs during the rainy season. The high concentration of heavy metals in the irrigation water may have contributed to its absorption by vegetables.

This study revealed that, all the heavy metal concentrations in the soil samples were within the FAO/WHO (2001) permissible levels; although higher concentrations in the soil samples were observed when compared with the vegetable. The heavy metals in soils might have been absorbed by the vegetable samples in form of soil solution and thus increased the concentrations in the plant tissues. This might be attributed to the root which seems not to act as a barrier to the translocation of the heavy metals. It is also an indication that some portion of the soil heavy metals is taken up by the vegetables due to the selective permeability function of the root to heavy metals. This is in accordance with the findings of Davies and White (1981). Variations in Pb concentration were shown in the soil samples from Ojoo farm site during the dry and rainy seasons. During rainy season, the concentration of Pb in the soil might have been reduced by dilution effect of rain or due to the runoff/erosion of heavy metals, while highly concentrated at the top soil surface during the dry season (Oluyemi *et al*., 2008).

The shoot (edible part) and root of *Amaranthus hybridus* L. from Mokola, Ojoo and Agbon-ile were contaminated with heavy metals (Pb, Cd and Cr) which exceeded the WHO/FAO (2001) permissible limits for vegetables. *Amaranthus hybridus* being a leafy vegetable tended to show higher concentrations of these metal ions due to its higher translocation rate in which metals could be transferred from root to stem (shoot). This is similar to the findings that leafy vegetables have high capacity to accumulate heavy metals such as Cd and Pb (Dosunmu *et al*., 2003; Ghosh *et al*., 2012). The nearness of the farm sites to the high traffic roads with vehicular emissions and commercial activities probably explains higher level of heavy metal such as Pb in the vegetable samples from Ojoo and Mokola. The vegetable samples (the edible part) might have been exposed to the deposition of atmospheric pollutants such as air dust and emissions from traffic loads which could have increased the heavy metal in the vegetables. Also higher level of Pb in the vegetable samples could have been as a result of accumulation of tetra-ethyl vapor and salts (primary sources of Pb) from vehicular emissions into the vegetable edible part (shoot) as reported by Nasralla and Alli (1985). This is in agreement with the findings of Dosunmu *et al*. (2003); Ogunyemi *et al*. (2003) and Okunola *et al*. (2008) that automobiles are a major source of heavy metals in the soil and vegetation along urban roadsides in Nigeria.

Agbon-ile farm site is in a sparsely populated area but the vegetable samples contained relatively high levels of heavy metals (Pb and Cd). This is probably so because the farm is located within a valley bottom. The high values observed in the vegetable samples could be associated with the various anthropogenic sources of the heavy metals containing waste materials that might have been indiscriminately dumped/deposited through flooding and run-off into the valley bottom. This result agrees with the findings of Oguntola (2002) and Oluwatosin *et al*. (2010) which showed that vegetables cultivated in the valley bottom soils at Institute of Agricultural Research and Training in Ibadan and in other parts of southwestern, Nigeria contained high concentrations of Pb and Cd which were high enough to pose health problems.

The Health Risk Index values for vegetable root samples were <1 for Pb and Zn in samples collected from Ojoo, Olorunda Aba, Agbon-ile, Mokola and University of Ibadan farm sites during dry and rainy seasons. The shoot samples indicated HRI<1 in all the farm sites in both seasons with the exception of Ojoo farm site having Pb and Zn >1 for HRI. The intake of heavy metals (Pb and Zn) depends on both their concentrations in edible portions of vegetables and the associated consumption data. These indicate that there is relative presence of human health risks (IRIS, 2003) associated with the ingestion vegetables (*A. hybridus*) from the selected farm sites especially Ojoo. The HRIs for Pb and Zn in vegetable samples from Ojoo imply that the population consuming the vegetable may experience health risk (IRIS, 2003) in the near future. This may lead to chronic toxic effects on humans after several years of exposure as reported by Bahemuka and Mubofu, (1999) and Ikeda *et al.* (2000).

Conclusion and Recommendation

In this study, the concentrations of the heavy metals in the vegetables were high especially Cd, Cr and Pb from the four farm sites Mokola, Ojoo, Olorunda Aba and Agbon-ile with the exception of the control site (Screen house) in the University of Ibadan. Exposures of the vegetable samples to heavy metals contamination may be through irrigation water, vehicular exhaust while on farm and on display for sales in the markets. This therefore, increases the human health risks associated with the consumption of such vegetables. The Health Risk Index <1 does not imply a total health risk free condition for the consumers of vegetables from those farm sites. The public (farmers and consumers) should be enlightened on the health risks associated with the consumption of vegetables cultivated close to the major and high roads as well as in valley bottom soils and should also be mindful of the sources of irrigation water.

Acknowledgements

The authors acknowledge all the vegetable growers in all the selected farm sites: Mokola, Ojoo, Olorunda Aba, Agbon-ile and Teaching and Research Farm, University of Ibadan for the permission to collect samples from their plots.

References

Afshin Maleki and Masoud Alasv and Zarasv and (2008). Heavy metals in selected edible vegetables and estimation of their daily intake in Sanandaj. *Iran Southeast Asian Journal of Tropical Medicine and Public Health* 39 (2):335- 340.

Aletor V.A. and Adeogun O.A. (1995). Nutrient and antinutrient components of some tropical leafy vegetables. *Food Chemistry* 53: 375-379.

AOAC (2005).Official method of analysis. Association of Analytical Chemists. Washington DC. 15th ed. 11-14.

ATSDR (1999).Toxicological Profile for Cadmium and Nickel. Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services, Public Health Service, 205-93-0606.

ATSDR (2000).Toxicological Profile for Arsenic. Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services, Public Health Service, 205-1999-00024.

Bahemuka, T. E. and Mubofu, E.B. (1999).Heavy metals in edible green vegetables grown along the sites of the Sinza and Msinbazi Rivers in Dares Sallam Tanzania. *Food Chemistry* 66: 63 -66.

Bi, X., Feng, X., Yang, Y., Qiu, G., Li, G., Li, F., Liu, T., Fu, Z., Jin, Z. (2006). Environmental contamination of heavy metals from zinc smelting areas in Hezhang County, western Guizhou, China. *Environment International* 31:778-783.

Chubike N. E., Okaka, J.C. and Okoli, E.C. (2013). Evaluation of Vegetable Consumption in South Eastern Nigeria. *International Journal of Nutrition and Metabolism* 5(4): 57-60.

Cui, Y.J., Zhu, Y.G. Zhai, R. Huang, Y. Qui, Y. and Ling, J. (2005). Exposure to metal mixtures and human health impacts in a contaminated area in Nanning, China. *Environment International* 31:784-790.

Davies, B.E. and White, H.M. (1981).Trace element in vegetables grown on soils contaminated b y base metal mining. *Journal of Plant Nutrition* 3:387–396.

Demirezen, D. and Akysoy, A. (2006). Heavy metal levels in vegetables in Turkey are within safe limits for Cu, Zn, Ni and exceeded for Cd and Pb. *Journal of Food Quality* 29:252-265.

Dosumu, O.O., Salami, N. and Adekola, F.A. (2003). Comparative study of trace element levels in some local vegetable varieties and irrigation waters from different locations in Ilorin, Nigeria. *Bulletin of Chemical Society of Ethiopia* 17(1): 107-112.

FAO/WHO (1999).Joint expert of Food Additives, "Summary and Conclusions" in proceedings of the 53rd Meeting of Joint FAO/WHO Expert Committee on Food Additives and Contaminants. Joint FAO/WHO Food Standards Programme, ALINORM 01/12A:1-289.

FAO/WHO Joint Food and Agricultural Organisation/World Health Organisation (2001). Food standards programme codex committee on contaminants in foods, fifth session pp 64-89.

Fytianos, K., Katsianis, G. Triantafyllou, P. and Zachariadis, G. (2001). Accumulation of heavy metals in vegetables grown in an industrial area in relation to soil. *Bulletin of Environmental Contaminant Toxicology* 67: 423-430.

Ghosh, A.K., Bhatt, M.A. and Agrawal, H.P. (2012). Effect of long-term application of treated sewage water on heavy metal accumulation in vegetables grown in Northern India. *Environmental Monitoring and Assessment* 184: 1025-1036.

Idoko, O.M., Ologunorisa, T.E. and Okoya A.A. (2012).Temporal variability of Heavy Metals concentration in Rural Groundwater of Benue state, Middle Belt, Nigeria. *Journal of Sustainable Development* 5(2): 1-15.

Ikeda, M., Zhang, Z.W. Shimbo, S. Watanabe, T. Nakatsuka, H. Moon, C. and Matsuda, S. (2002). Heavy metal content of vegetables irrigated with mixture of wastewater and sewage sludge in Zimbabwe: implications for human health. *Agriculture, Ecosystem and Environment* 112: 41- 48.

IRIS, Integrated Risk Information System (2003). U.S Environmental Protection Agency 2002: A review of the Reference Dose and Reference Concentration Processes 192pp.

Itanna, F. (2002).Metals in leafy vegetables grown in Addis Ababa and toxicological implications. *Ethiopian Journal of Health Development* 6:295.

Khan, S., Cao, Q.Y.Z. Huang, Y.Z. and Zhu, Y.G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. *Environmental Pollution* 125(3): 686-692.

Largerwerff, J. U. and Speecht, A.W. (1970). Contamination of roadside and vegetation with Cd, Ni, Pb, Zn, *Environmental Science Technology 4:* 583-586.

Lokeshwari H, Chandrappa, G.T. (2006). Impact of heavy metal contamination of Bellandur Lake on soil and cultivated vegetation. *Current Science* 91(5): 622-627.

Muchuweti, M., Birkett, J.W., Chinyanga, E., Zvauya, R., Scrimshaw, M.D., Lester, J.N. (2006). Heavy metal content of vegetables irrigated with mixture of wastewater and sewage sludge in Zimbabwe: implications for human health. *Agriculture, Ecosystem and Environment* 112:41-48.

Naser, H.M., Sultana, S. Mahmud, N.U. Gomes, R. and Noor, S. (2011). Heavy metal levels in vegetables with growth stage and plant species variations. *Bangladesh Journal of Agricultural Resources* 36(4): 563-574.

Nasralla, M.N. and Alli, E.A. (1985). Lead accumulation in edible portion of crops grown near Egyptian Traffic roads. *Agriculture Ecosystem Environment* 13:73-82.

Nicholson, F.A., Smith, S.R. Alloway, B.J. Carlon-Smith, C. and Chambers, B.J. (2003). An inventory of heavy metals inputs to agricultural soil in England and Wales. *Science Total Environment* 311, 205-219.

Nirmal, K.J.I., Hiren, S. and Rita, N.K. (2007). Characterization of Heavy Metals in Vegetables Using Inductive Coupled Plasma Analyzer (ICPA). *Journal of Applied Science* and *Environmental Management* 11(3): 75 -79.

Ogunyemi, S., Bamgbose, O.O. and Awodoyin, R.O. (2003).Heavy metal contamination of some leafy vegetables growing within Ibadan metropolis, South-western Nigeria. *Tropical Agricultural Research and Extension Journal.* 6(2):71-76.

Okunola, O.J., Uzairu, A. Ndukwe, G.I. and Adewusi, S.G. (2008). Assessment of Cd and Zn in road side surface soils and vegetation along some roads of Kaduna Metropolis, Nigeria. *Resource Journal of Environmental Science* 2:266-274.

Oluyemi, E.A., Feuyit, G. Oyekunle, J.A.O. and Ogunfowokan, A.O. (2008).Seasonal variations in heavy metal concentrations in soil and some selected crops at a landfill in Nigeria. *African Journal of Environmental Science and Technology* 2 (5): 89-96.

Oluwatosin, G.A., Adeoyolanu, O.D. Ojo, A.O. Are, K.S. Dauda, T.O. and Aduramigba-Modupe, V.O. (2010). Heavy Metal Uptake and Accumulation by Edible Leafy Vegetable (*Amaranthus hybridus* L.) Grown on Urban Valley Bottom Soils in Southwestern Nigeria. *Soil and Sediment Contamination* 19:1–20.

Onianwa, P.C. and S.O. Ajayi (1987). Heavy metal contents of epiphytic acrocarpous mosses within inhabited sites in southwest Nigeria. *Environment International* 13:191 -196

Onianwa, P.C. (2001). Roadside Topsoil Concentrations of Lead and other Heavy metals in Ibadan, Nigeria. *Soil Sediment Contaminants* 10 (6): 577-591.

Radwan, M. A. and Salama, K. A. (2006). Market basket survey for some heavy metals in Egyptian fruits and vegetables. *Food Chemistry Toxicology 44*: 1273-1278.

Rattan, R.K., Datta, S.P. Chhonkar, P.K. Suribabuamd, K. and Singh, A.K. (2005). Long-term impact of irrigation with sewage effluents on heavy metals content in soils, crops and groundwater- a case study. *Agriculture, Ecosystem and Environment* 109: 310-322.

Singh, B. (2001). Heavy metals in soil: sources, chemical reactions and forms'. In: D. Smith, S. Fityus and M. All-man (eds.), Geotechnics: Proceedings of the 2nd Australia and New Zealand Conference on Environmental Geotechnics, Newcastle, NSW, Australia, pp. 77-93.

Suruchi and Pankaj, K.(2011). Assessment of heavy metal contamination in different vegetables grown in and around urban areas. *Resource Journal of Environmental Toxicology* 5(3):162-179.

Udedi S.S. (2003). From Guinea Worm Scourge to Metal Toxicity in Ebonyi State, Chemistry in Nigeria as the New Millennium Unfolds, 2(2): 13–14.

US-EPA. IRIS. United States Environmental Protection Agency, Integrated Risk Information System http//www.epa.gov/iris/subst (December, 2006).

Uwah E.I., Ndahi N.P. and Ogugbuaja V.O. (2009). Study of the Levels of some Agricultural Pollutants in Soils and Water Leaf (*Talinum triangulare*) obtained in Maiduguri, Nigeria. *Journal of Applied Science* and *Environmental Sanitation* 4(2): 71–78.

Ward, N.I. (1995). Environmental Analytical Chemistry. In: Trace Elements Fifield, F.W. and

Haines, P.J. (eds.), Blackie Academic and Professional, UK, pp. 320–328.

Wang, X., Sao, T. Xang, B. Tao, S. (2005). Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. *Science of the Total Environment* 350: 28-37.

Wilson, B. and Pyatt, F.B. (2007). Heavy metal dispersion, persistence and bioaccumulation around an ancient copper mine situated in Anglesey, UK. *Ecotoxicology and Environmental Safety* 66:224-231.

Whatmuff, M.S (2002). Applying biosolids to acid soil in New South Wales: Are guidelines on soil metal limits from other countries appropriate. *Australian Journal of Soil Resources* 40:1041-1056.

Xu, J. and Thornton, I. (1985). Arsenic in garden soils and vegetable crops in Cornwall, England: implications for human health. *Environment Geochemical Health* 7(4): 131-133.

Yusuf, A.A., Arowolo, T.A. and Bamgbose, O. (2003).Cadmium. Copper and Nickel Levels in Vegetables from Industrial and Residential Areas of Lagos City, Nigeria. *Food Chemistry Toxicology* 41: 285–291.

Yusuf, K.A and Osibanjo, O. (2006). Trace metals in water and sediments from Ologe Lagoon, Southwestern Nigeria. *Pakistan Journal of Science and Industrial Resources* 49:88-96.

Yusuf, A.A and Oluwole, S. O. (2009). Heavy metal (Cu, Zn, Pb) contamination of vegetables in urban city: A case study in Lagos. *Resource Journal of Environmental Science* 30:292-298.

Blank