DETERMINATION OF HEAVY METALS IN SELECTED VEGETABLES, ALONG LANDZUN RIVER OF BIDA, NIGER STATE, NIGERIA

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Abstract

The concentrations of heavy metals in selected vegetables along Landzun River of Bida, Niger State were determined in order to establish the levels of their contamination. The Vegetables samples (African Spinach, Jute mallow and Pumpkin) were collected from Bangaie-Bantuwa and Nasarafu-Edogifu along Landzun River (from upper, middle and down streams) and were analyzed for Cd, Cr, Mn, Ni and Pb using Atomic Absorption Spectrophotometer (AAS). The highest concentration of Cd (0.493±0.6mg/kg) was found in Pumpkin. This was higher than the permissible limit of 0.2mg/kg. Pumpkin leaves also recorded the highest concentration of Ni (1.33±0.03mg/kg), while Spinach had the highest concentration of Pb. With the exception of Cr and Pb, the contents of Mn, Cd and Ni were high in most of the samples analyzed when compared to the WHO/FAO standard hence may posed health challenge to the consumer. The concentrations of the metals were generally in the order Mn>Pb>Ni>Cd>Cr.

Key Words: Concentrations Vegetables, Heavy metal, Contamination, Spectrophotometer

1. Introduction

Vegetables are essential part of human's diets (Mercola, 2014). In addition to their possible source of important nutrients, they constitute important functional food components by contributing protein, vitamins, iron and calcium to human diet (Shobhana *et al.*, 2016). Sewage effluents apart from being a source of nutrient for plants also result to increase in the concentration of heavy metals in soil and passage of these metals along the food chain (Tasrina *et al.*, 2015). Plants and vegetables generally take in trace elements from contaminated soils and waste water used for irrigating as well as from deposits on different parts of the plants exposed to air from polluted environment (Hajeb, *et al.*, 2014). The leafy vegetables grown in heavy metals contaminated soils accumulate higher amounts of metals than those grown in uncontaminated soils because they absorb these metals through their root from the contaminated soil (Pathak, *et al.*, 2013). The uptake and accumulation of mineral nutrients by plants may usually follow two main paths i.e., through the roots and folia surface (Lugwisha and Othman, 2016). Uptake of trace metals from the soil is affected by several factors which include soil pH, plant growth stages, types of species, fertilizers and soil (Opajobe, *et al.*, 2011).

Heavy metal refers to any metallic element that has comparatively high density and is toxic even at low concentration. It is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 5g/cm³ (Abimbola *et al.*, 2015). Heavy metals include Cadmium (Cd), Zinc (Zn), Mercury (Hg), Arsenic (As), Silver (Ag), Lead (Pb) Chromium (Cr), Copper (Cu), Iron (Fe) and Platinum group elements (Zhang, *et al.*, 2012). Heavy metals are not easily biodegradable and consequently can be accumulated in human vital organs and tissues resulting to various degrees of illness based on the level of exposures (Salawu *et al.*, 2015). Several heavy metals have been reported in edible plants consumed in different parts of the world. Among the heavy metals cadmium, mercury, arsenic and lead pose more challenges to human health on exposure (Echem, 2014).

The high consumption of vegetables from Landzun River bank of Bida area and their vast application in industries has prompted the need for the constant monitoring of the heavy metals present in them to ensure they are not beyond permissible limit for consumption. Although studies have been conducted to assess the safety level of vegetables in different plâces around irrigation source, there is dearth of information from the River bank of Bida. Since some of these metals even at low concentrations can cause serious toxic effects in organisms, it is paramount to continually determine their levels in vegetables that are intended for human consumption from the view of public health. Thus, the aim of this study is to assess the level of heavy metal in selected Vegetable Plants along Bangaie-Bantuwa and Edogifu-Nasasrafu river Landzum of Bida local government, Niger State.

2. Materials and Methods

2.1 Study Area

River Landzun is located in Bida. Bida is the second largest city in Niger State, it is located Southwest of Minna, the Capital of the State. Niger State is located between latitudes 8Â°20'N and 11Â°30'N and longitude 3Â°30'E and 7Â°20'E. The state is bordered to the North by Zamfara State, to the Northwest by Kebbi State, to the South by Kogi State, to Southwest by Kwara State; while Kaduna State and the Federal Capital Territory border the state to the Northeast and Southeast, respectively (Ogbebor *et al.,* 2015).

2.2 Sample Collection and Preparation

Three different species of vegetable were used for this study. The specie includes Africa Spinach (*Amaranthus hybridus*), Jute mallow (*Corchurus olitorious*) and Pumpkin (*Telfara occidentalis*). The African Spinach and Jute mallow were collected from Bangai – Bantuwa (B-B) while Pumpkin (*Telfara occidentalis*) was collected from Edogifu–Nasarafu (E-N) Landzun river banks areas of Bida from upper ($B\text{-}B_1$ or $E\text{-}N_1$), middle ($B\text{-}B_2$ or $E\text{-}N_2$) and down ($B\text{-}B_3$ or $E\text{-}N_3$) streams. The samples were collected in June, 2015 and labeled in a polythene bags. The vegetables were washed with distilled water to remove any possible foliar contaminants, such as pesticides, fertilizers, dust and mud. The freshly collected samples were dried at room temperature. Each sample was separated into leaves and stems and the leaves were then grinded into finely particles using wooden mortar and pestle and sieved for wet digestion.

2.3 Method of Digestion and Analysis of Metals

2.0 g of the sieved impoverished samples was weighed into 50cm^3 beakers. 12cm^3 of HNO_3 and $HClO_4$ (3:1) were then added. The digestion was performed at a temperature of about 120^{0}C for two and half hours. After cooling, the digested solution was filtered and made up to mark with distilled water. The metals concentrations were determined using Atomic absorption spectrophotometer (AA240FS model). Each of the samples from different spot was analyzed in triplicates to obtain a representative result and the data reported in mg/kg.

2.4 Quality Control

All chemicals and reagents used in the experiments were of analytical grade and purchased from Merck (Darmstadt, Germany). All glassware used for digestion and preservation of the digested samples were washed with a solution of 10% of nitric acid followed by washing with double deionized water.

2.5 Data Analysis

The results obtained were subjected to statistical analysis by Analysis of variance (ANOVA) using SPSS 16 software. Mean values were analyzed by the Duncan's test.

3. Results and Discussion

Table1: Heavy Metal Concentrations in Jute Mallow (mg/kg)

Metals	$B\text{-}B_1$	$B\text{-}B_2$	$B\text{-}B_3$	Maximum limit FAO/WHO (2012)

Cd	0.153±0.006[a]	0.183±0.042[a]	0.117±0.081[a]	0.2
Cr	0.183±0.190[a]	ND	ND	2.3
Mn	4.500±1.817[b]	5.160±2.917[c]	3.55±0.385[a]	-
Ni	0.723±0.150[b]	0.577±0.117[a]	0.920±0.098[c]	0.2
Pb	3.713±0.227[a]	3.437±0.515[a]	3.020±0.599[a]	5.0

Results are expressed as mean ± standard deviation. Values with the same superscript on the same row do not differ significantly at $P<0.05$.

Key: B-B_1: Bangaie-bantuwa (upper area); B-B_2; Bangaie-bantuwa (middle area) and Bangaie-bantuwa (down areas); ND- Not Detected

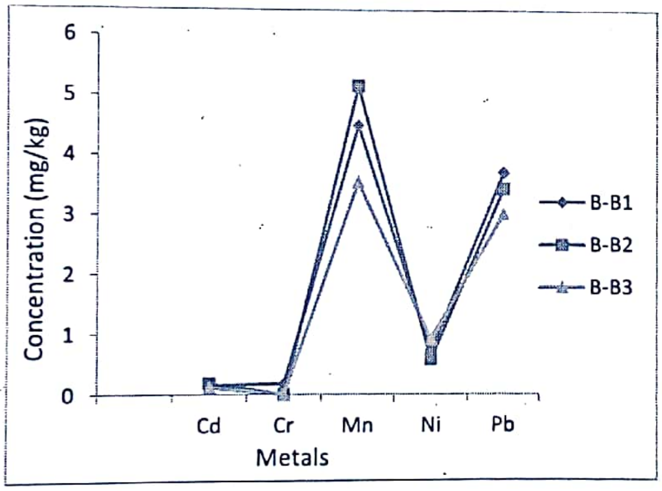

Fig. 1: Heavy Metal Concentrations in Jute Mallow (mg/kg)

Table 1 and figure 1 show the mean concentrations of heavy metals in Jute Mallows. The concentration of Cadmium ranged from 0.117±0.08 to 0.153±0.006mg/kg. Values for Cadmium obtained for Jute were not significantly different among the different areas at $p<0.05$. The upper stream has the least cadmium content. The range of values obtained for Cd is lower when compared to permissible limit of 0.2mg/kg documented in FAO/WHO, 2012. The content of Cd obtained is within the range of 0-2.4 mg/kg reported by Mutune *et al.*, 2013 in a similar study. Cr was only found in the Upper stream were its concentration was 0.183±0.19mg/kg and lower than the allowed limit of 2.30mg/kg. It is also less than 1.50mg/kg reported by Abimbola *et al.*, 2015. The concentration of Mn among the different areas differed significantly. The lowest concentration of Mn was 3.55mg/kg while highest was 5.160mg/kg; these were obtained at Downstream and Middle stream respectively. Nickel differed significantly among the different areas. The range of Nickel content was from 0.577±0.12 to 0.920±0.10mg/kg. The concentration of Nickel is higher than the recommended standard of 0.2mg/kg recorded by FAO/WHO 2012. The highest and lowest concentrations of Pb in Jute Mallow were 3.713±0.227 and 3.020±0.599 mg/kg respectively. This is lower than the permissible level of 5.0 mg/kg. From table 1, it is clear that only chromium contamination in the Jute Mallow is observed as the concentration of the other metals are below their permissible limit of contamination. The high values of some of these metals is closely associated to the water absorb by the vegetables which might also show a high content of these metals. High concentration of Chromium in diet has deleterious effect to humans; it attacks DNA, proteins, and membrane lipids, thereby disrupting cellular integrity and functions (Naz, *et al.*, 2015).

Table 2: Heavy Metal Concentrations in Spinach (mg/kg)

Metals	B-B1	B-B2	B-B3	Maximum limit FAO/WHO(2012)
Cd	0.133±0.0153[a]	0.197±0.021[b]	0.177±0.252[b]	0.2
Cr	ND	0.687±0.597[ab]	1.243±0.616[b]	2.3
Mn	8.523±1.392[b]	3.160±0.496[a]	3.343±0.461[a]	-
Ni	0.810±0.210[a]	0.753±0.106[a]	0.773±0.138[a]	0.2
Pb	3.960±0.269[a]	3.613±0.370[a]	3.600±0.118[a]	5.0

Results are expressed as mean ± standard deviation. Values with the same superscript on the same row do not differ significantly at P<0.05.

Key: B-B1-3 -Bangaie-bantuwa (upper, middle and down streams) and ND: Not Detected

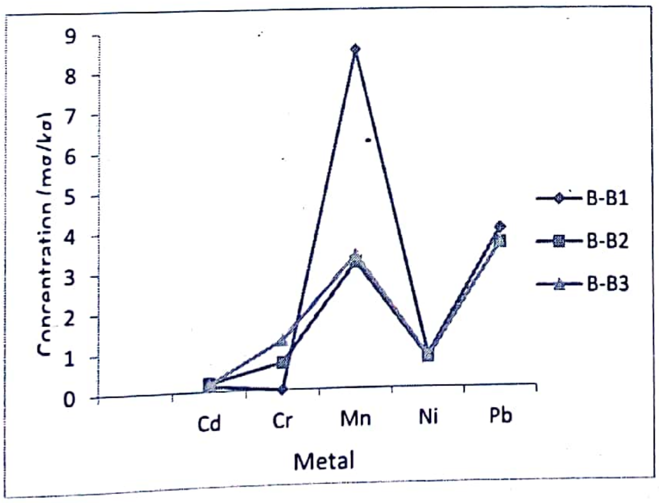

Fig. 2: Heavy Metal Concentrations in mg/kg of Spinach

From table 2 and fig. 2, the concentration of Cd in all the areas was lower than the permissible limit of 0.2mg/kg. The highest concentration of Cd was 0.197mg/kg which was at the middle stream. The value obtained for Cd in this study is higher than 0.03 µg/g obtained by Lugwisha and Othman, 2016 in a similar study on cabbage. Cr was not detected at the upstream. The highest value recorded for Cr in Spinach was 1.24mg/kg. The value obtained in this study is comparable to 0-1.2 mg/kg documented by Mutune *et al.*, 2015 in his study on heavy metals in vegetables. There was a significant difference in the concentration of Mn in Spinach between the Upper and the other two areas. The highest concentration of Mn was 8.523±1.392 mg/kg while the lowest in Spinach was 3.160±0.496mg/kg. The concentration of Mn in the Spinach at upper stream was significantly higher than all others. The consumption of these vegetables may cause poisoning of the central nervous system and manganic pneumonia. The contents of Ni obtained in this study were generally lower than the permissible limit of 0.2mg/kg documented by WHO/FAO (2012). Pb contents in the Spinach were not significantly different at P<0.05. The values obtained were all below the tolerable limit.

Table 3: Heavy Metal Concentrations in mg/kg of Pumpkin

Metals	**$E\text{-}N_1$**	**$E\text{-}N_2$**	**$E\text{-}N_3$**	**Maximum limit WHO/FAO(2012)**
Cd	0.073 ± 0.006^{a}	0.087 ± 0.015^{a}	0.493 ± 0.611^{b}	0.2
Cr	ND	ND	0.0015 ± 0.023^{a}	2.3
Mn	15.230 ± 1.796^{a}	32.333 ± 1.974^{c}	17.660 ± 2.266^{ab}	-
Ni	0.920 ± 0.050^{a}	1.133 ± 0.038^{b}	0.990 ± 0.087^{a}	0.2
Pb	2.960 ± 0.171^{a}	2.830 ± 0.154^{a}	3.303 ± 0.072^{b}	5.0

Results are expressed as mean ± standard deviation. Values with the same superscript on the same row do not differ significantly at P<0.05.

Key: $E\text{-}N_{1\text{-}3}$Edogifu-Nasarafu areas (upper, middle and down)

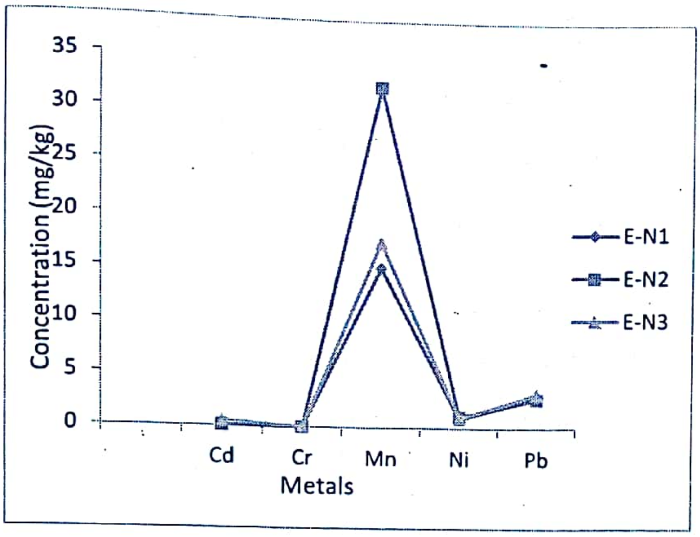

Fig. 3: Heavy Metal Concentrations in mg/kg of Pumpkin

The concentrations of trace metals in Pumpkin are shown in table 3. The highest concentration of Cd (0.493±0.611mg/kg) was at down area. The concentration at this area is significantly higher than others at $p<0.05$. The concentration of Cd obtained in this study is less than 0.1mg/kg reported by Tasrina *et al.*, 2015 in a similar study and 0.76± 0.2 reported by Lami, *et al.*, 2015. It is however above the permissible limit of 0.2mg/kg recorded in WHO standard above. Cr in pumkin was also detected at the samples from the Down area were the value recorded was 0.0015±0.02mg/kg. The result obtained for Cr is lower than the range of 8.5-21.0 reported by Akpan *et al*, 2015 in their study on Pumpkin leaves. The highest and lowest concentrations of Mn in the Pumpkin were 32.333±1.97 and 15.230±1.79mg/kg respectively. This is comparable to the findings of Akpan *et al.*, 2015. The values for Mn among the three areas were significantly different. Ni contents in the pumpkin were relatively higher when compared to the allowed limit of 0.2mg/kg. The highest concentration of Ni was 0.990±0.087 mg/kg, which is almost five times the permissible limit based on WHO/FAO, 2012. A number a researcher also reported also reported that consumption of heavy metals contaminated vegetables can pose serious health (Heidarieh, *et al.*, 2013). The high levels of these metals in the water might be attributed to, apart from the natural sources, the indiscriminate discharge of wastes from nearby mechanic workshops, which could be from motor battery of Ni–Cd base, car paints, car panel beating wastes and solder for soldering car components as well as run-off from roadside car-wash sites. The highest concentration of Pb recorded in Pumpkin was 3.303±0.072 mg/kg. The concentration of Pb from this study is higher when compared to 0.119 mg/kg to 1.596 mg/kg reported by Tasrina *et al.*, 2015. It is also higher when compared to 0.005mg/kg in pumpkin reported by Otitoju *et al*, 2012. As well as 0.613 ± 0.0009mg/kg reported by Salawu *et al.*, 2015. The order of trace metal content in the Pumpkin (Mn>Pb>Ni>Cd>Cr) is similar to the findings by Lami *et al.*, 2013 in a similar study.

4. Conclusion

The findings from this study show different levels of heavy metals concentrations in vegetables studied. With the exception of Cr and Pb whose concentrations in some of the samples being below their approved standard limit, the concentration of the other metals determined were higher than the WHO/FAO (2012) recommended limit in vegetables, which implies that they could pose health threat to man. Generally, the increasing trend for the levels of heavy metals analyzed in the samples from this study are the order of Mn>Pb>Ni>Cd>Cr. However, the findings suggest that further work should be conducted on metals uptake by other species of vegetables and to continually monitor the concentrations of these metals in vegetables from water ways so as to ensure that they are within the permissible limit for human consumption.

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