Global Scientific JOURNALS

GSJ: Volume 9, Issue 1, January 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

ASSESSMENT OF TRACE METALS ACCUMULATION IN THREE LEAFY VEGETABLES (*Telfaira occidentalis*, *Amaranthus viridis*, and *Pterocarpus erinaceus*) DURING THE WET SEASON IN ENUGU STATE

By

G.I. Ameh; A.O. Onah; C.D. Nwani and E.N. Anumudu

Department of Applied Biology and Biotechnology, Enugu State University of Science and Technology

Department of Zoology and Environmental Biology, University of Nigeria, Nsukka

Federal College of Education, Eha-amufu

ABSTRACT

Bioaccumulation of trace metals (Mn, Ni, Cr, Co, Zn and Fe) in vegetable samples (*Telfairia occidentalis, Amaranthus viridis* and *Pterocarpus erinaceus*) from three senatorial zones in Enugu state (Enugu north, Enugu west and Enugu east) were investigated during wet the season period. The samples were collected fresh in May, June and July. Prior to analysis, each of the collected samples were dried at room temperature, pulverized using a ball mill and stored at room temperature. They were digested using wet digestion method and individual metals analyzed using atomic absorption spectrophotometer. The results of the findings revealed that the rate of accumulation of trace metals in the vegetable samples were in the following decreasing order Fe > Zn >Mn> Cr > Co > Cd. *Amaranthus viridis* had the highest accumulation of heavy metals while *P. erinaceus* had the least. Enugu East senatorial zone had the highest accumulation of Mn and Co in all the vegetable samples while Enugu West senatorial zone showed the highest accumulation of Cd, Cr, Zn and Fe in all the vegetable samples. Enugu north senatorial zone had the least level of trace metals accumulation in the three vegetable samples.

KEYWORDS: Bioaccumulation, trace metals, *Telfairia occidentalis, Amaranthus viridis,Pterocarpus erinaceus*, Wet season

INTRODUCTION

The nutritional composition of most vegetables has been characterized and are generally reported to be rich in micronutrients especially beta carotene, zinc, and iron (Flyman and Afolayan, 2006). Fluted pumpkin occurs in the forest zone of West and Central Africa, most frequently in Benin, Nigeria and Cameroon, the tender shoots, succulent leaves and immature seeds are cooked and consumed as a vegetable (Odiaka&Schippers, 2004). In tropical Africa *Amaranthusviridis* is also a widespread and common weed. It is occasionally cultivated (e.g. in Nigeria, Gabon and DR Congo) (Jansen, 2004). The health benefits of consuming vegetables can be diminished by trace metals contamination. Trace metal contaminants can result in kidney and liver damage, stomach upset and ulcers, skin rashes, lung cancer, weakened immune system, alteration of genetic material and respiratory problem (Monali, 2012).

Trace metals are extremely persistent in the environment. Vegetables take up these metals and accumulate them in their edible and non-edible parts at quantities high enough to cause clinical problems to both animals and human beings. Trace metals such as Cr, Mn, Zn, Cu, and Fe are considered essential components of biological activities in the body, however, in excess are reported to cause problem to human (Lokeshwari and Chandrappa, 2006). On the other hand, Pb, Ni, and As have no important functions in human body rather they play toxic role to living organism, hence are considered as toxic elements (Lokeshwari and Chandrappa, 2006).

Accumulation of trace metals in an agricultural environment has direct consequences for man and the ecosystem. The most significant problem associated with trace metals in the environment apart from accumulation through the food chain and persistence in nature is their toxicity. Vegetables, being one of the majorly consumed foods have also been recognized as good bio-accumulators of organic and inorganic pollutants. They also act as bio-indicators of trace metal levels in the environment, and can be used to evaluate the health of the ecosystems. While vegetables are consumed for body nourishment, trace metals composition in these food materials remains a challenge. To assess the bioaccumulation of trace metals in the tissues of three leafy vegetables (*Telfaira occidentalis*, *Amaranthus viridis*, and *Pterocarpus erinaceus*) from three senatorial zones in Enugu state is therefore very necessary.

MATERIALS AND METHODS

Collection and Identification of Plant Materials

The plant samples (*Telfairia occidentalis*, *Amaranthus viridis* and *Pterocarpus erinaceus*)were collected from a market in each of the three senatorial districts (Enugu north, Enugu west, and Enugu east) of Enugu State; the samples were identified and authenticated. Voucher specimens were kept for reference purpose. The plant samples were collected three times each dry seasons in the months of May, June and July.

Sample Preparation

Leaf samples were detached from plant stem and dried at room temperature and pressure for ten days to remove all water molecules from the leafs. The dried leaf samples were milled to 250µm particle size using a domestic blender. This was meant to increase the sample surface area. The milled samples in powdery form were parked in amber specimen bottles prior to analysis.

Sample Digestion

1g of each prepared sample was weighed into a 100ml beaker. 30mls of aqua-regia (a mixture of nitric acid and hydrochloric acid in the ratio 1:3) was measured in a 100ml measuring cylinder and added into the weighed samples. 10 drops of hydrogen peroxide were added to each of the preparation to increase the complexing power of the mineral acids. The samples in beakers were placed on a digital laboratory heating mantle under fume cupboard and heated at100^{o}C until the dried leaf samples completely digest. Each digest was allowed to cool and diluted with 50ml of distilled deionised water. They were filtered into 100ml volumetric flask using whatman filter paper (125mm). The digests were made up to the 100ml mark using distilled-deionised. The wet digested solution was transferred to plastic bottles and labeled accurately. The digests were used for metal determination. The wet digesting of the leaf sample was carried out in Proda laboratory, Enugu state.

Determination of Heavy Metals

Concentrations of heavy metals in soil and plant samples were determined by atomic absorption spectrophotometer. The standard solutions of examined heavy metals were prepared by dilution of standard stock solutions (Merck AAS Solution) with deionized water.

$$\text{Metal concentration (mg/kg)} = \frac{Reading\ \ (mg/L) \times Final\ \ volume\ \ (ml)}{Initial\ \ sample\ \ weight\ (g)}$$

RESULTS

Experimental Control

The results of the experimental control of the samples of the three vegetable species are shown in Table 1. The experimental values of the sample species were less than the maximum allowed concentration (MAC) of Food and Agricultural Organization (FAO) recommended values. The concentration of Fe was highest compared to the other metals investigated. *T. occidentalis* samples had the highest Fe concentration (1.27±0.106 mg/kg). *A. viridis* sample showed the highest concentrations of Mn (0.12±0.001 mg/kg), Ni (0.05±0.000 mg/kg), Cr (0.07±0.003 mg/kg) and Zn (0.65±0.013 mg/kg). Co concentration was similar in all the three vegetable samples (0.01±0.000 mg/kg). *P. erinaceus* sample had the lowest concentrations of Ni (0.02±0.000 mg/kg), Cr (0.04±0.005 mg/kg), Zn (0.20±0.010 mg/kg) and Fe (0.20±0.012 mg/kg). Mn was not detected in *P. erinaceus* sample (Table 1).

Table 1 Experimental Sample Values and the Recommended FAO values

Parameters	*T. occidentalis* mg/kg	*A. viridis* mg/kg	*P. erinaceus* mg/kg	MAC (FAO 1985) mg/kg
Mn	0.06±0.010	0.12±0.001	0.00±0.000	-
Ni	0.04±0.000	0.05±0.000	0.02±0.000	0.20
Cr	0.06±0.005	0.07±0.003	0.04±0.005	1.00
Co	0.01±0.000	0.01±0.000	0.01±0.000	2.00
Zn	0.50±0.010	0.65±0.013	0.20±0.010	2.00
Fe	1.27±0.106	1.00±0.100	0.20±0.012	5.00

MAC-Maximum allowed concentration. Results are in mean±SD

Trace Metal Concentrations in Vegetable Samples

The concentrations of trace metals in the vegetable samples from the three senatorial zones during the month of May, June, and July, are presented in the Tables 2, 3, and 4 below.

Metal Concentration in Vegetables for the Month of May

The mean concentrations of Mn in *A. viridis* samples were higher than the levels of Mn in *T. occidentalis* and *P. erinaceus* samples; *P. erinaceus* samples had the least levels of Mn in all the three senatorial zones (Table 5). ANOVA at 95% across the column showed no significant difference in the different concentrations of Mn in *T. occidentalis* samples from the three senatorial zones. The mean concentrations of Mn in *A. viridis* samples from Enugu north and west senatorial zones varied significantly with samples from Enugu east senatorial zone. Similar to *T. occidentalis*, there was no significant difference in the mean concentrations of Mn in *P. erinaceus*from all the three senatorial zones. Ni had the highest detection level in *A. viridis*samples from all three senatorial zones. *T. occidentalis* samples have mean Ni concentration slightly below *A. viridis* samples but above *P. erinaceus* samples. All mean concentrations of Ni in all three samples from the three senatorial zones were below FAO maximum allowed concentration. Samples from Enugu west senatorial zone had the highest abundance of Ni. ANOVA at 95% across the column showed no significant difference the levels of Ni in *A. viridis* and *P. erinaceus* samples from the three senatorial zones, while *T. occidentalis* samples from Enugu north senatorial zone varied significantly from samples from Enugu west and east senatorial zones. Similar concentrations of Cr were observed in *T. occidentalis* and *A. viridis*samples from Enugu west and east senatorial zones, while *A. viridis* samples from Enugu north senatorial zones have higher Cr levels than *T. occidentalis*. *P. erinaceus* samples had the least levels of Cr from all three senatorial zones. There was no significant difference in the different levels of Cr in *A. viridis*and *P. erinaceus*samples from the three senatorial zones. While *T. occidentalis*samples from Enugu west and east senatorial zones showed significant difference in their levels of Cr with samples from Enugu north

Co level was highest in *P. erinaceus* samples from Enugu north and west senatorial zones (both were 0.02mg/kg) while for Enugu east senatorial zone, *A. viridis* samples and *P. erinaceus* samples had the same level of Co (0.03mg/kg). *T. occidentalis* samples from all the three senatorial zones had the least levels of Co. There was no significant difference in the level of cobalt in all vegetable samples from the three senatorial zones. The levels of Zn in *A. viridis* samples from all the three senatorial zones were higher than the other two vegetable samples. *P. erinaceus* samples had Zn levels slightly below *A. viridis* samples but above *T. occidentalis* samples, which had the least levels of Zn for all three senatorial zones. The differences in the mean concentrations of Zn in all vegetable samples from the three senatorial zones were significant. Fe levels in *T. occidentalis* samples were higher than the other two vegetable samples. *P. erinaceus*samples had the levels of Fe in all three senatorial zones except for Enugu north of which the Fe levels in *P. erinaceus*were higher than those in *A. viridis*samples. There was no significant difference in the level of Fe in *T. occidentalis* samples from the three senatorial zones. The levels of Fe in *A. viridis* and *P. erinaceus*samples from Enugu north and Enugu east senatorial zones varied significantly with samples from Enugu west senatorial zone.

Table 2 Trace Metal Concentrations in the Vegetable Samples from the three Senatorial Zones of Enugu State for the month of May

Location	Samples	Trace metals (mg/kg)					
		Mn	**Ni**	**Cr**	**Co**	**Zn**	**Fe**
Enugu north	*T. occidentalis*	$0.12{\pm}0.010^{a}$	$0.07{\pm}0.003^{a}$	$0.09{\pm}0.004^{bc}$	$0.01{\pm}0.000^{a}$	$0.42{\pm}0.014^{ac}$	$2.81{\pm}0.102^{a}$
	A. viridis	$0.24{\pm}0.020^{abc}$	$0.09{\pm}0.005^{abc}$	$0.11{\pm}0.003^{b}$	$0.01{\pm}0.000^{b}$	$0.66{\pm}0.015^{ab}$	$2.47{\pm}0.110^{bc}$
	P. erinaceus	$0.04{\pm}0.005^{bc}$	$0.05{\pm}0.004^{ac}$	$0.05{\pm}0.005^{abc}$	$0.02{\pm}0.0005^{c}$	$0.42{\pm}0.014^{bc}$	$2.22{\pm}0.100^{bc}$
Enugu west	*T. occidentalis*	$0.15{\pm}0.010^{a}$	$0.11{\pm}0.007^{ab}$	$0.13{\pm}0.004^{abc}$	$0.01{\pm}0.014^{ac}$	$0.37{\pm}0.039^{a}$	$2.65{\pm}0.019^{a}$
	A. viridis	$0.25{\pm}0.013^{abc}$	$0.13{\pm}0.010^{abc}$	$0.13{\pm}0.0005^{b}$	$0.02{\pm}0.0005^{b}$	$0.44{\pm}0.014^{abc}$	$2.10{\pm}0.052^{b}$
	P. erinaceus	$0.05{\pm}0.002^{bc}$	$0.07{\pm}0.005^{ac}$	$0.07{\pm}0.005^{abc}$	$0.02{\pm}0.0005^{c}$	$0.43{\pm}0.013^{abc}$	$1.94{\pm}0.140^{c}$
Enugu east	*T. occidentalis*	$0.16{\pm}0.004^{a}$	$0.11{\pm}0.007^{ab}$	$0.12{\pm}0.005^{abc}$	$0.01{\pm}0.000^{a}$	$0.34{\pm}0.012^{ab}$	$2.59{\pm}0.060^{a}$
	A. viridis	$0.31{\pm}0.010^{bc}$	$0.12{\pm}0.005^{abc}$	$0.12{\pm}0.003^{b}$	$0.03{\pm}0.001^{b}$	$0.39{\pm}0.015^{bc}$	$2.28{\pm}0.030^{bc}$
	P. erinaceus	$0.05{\pm}0.010^{bc}$	$0.06{\pm}0.005^{ac}$	$0.06{\pm}0.004^{abc}$	$0.03{\pm}0.001^{c}$	$0.46{\pm}0.014^{c}$	$2.41{\pm}0.080^{bc}$

MAC (FAO 1985)		-	0.20	1.00	2.00	2.00	5.00

MAC-Maximum allowed concentration. Results are in mean±SD. Similar letters in a column are not significantly different at 0.05 level of significance

Metal Concentration in Vegetables for the Month of June

The levels of Mn in the vegetable samples were higher in *A. viridis* samples from the three senatorial zones and least in *P. erinaceus* samples. ANOVA at 95% showed no significant difference in the levels of Mn in *T. occidentalis* and *P. erinaceus* samples from all the three senatorial zones. The levels of Mn in *A. viridis* samples from the three senatorial zones varied from one another (Table 6). Ni concentrations were below FAO maximum allowed concentration for all vegetable samples from the three senatorial zones. Ni detection was highest in *A. viridis* samples from Enugu west and east senatorial zone; \and the same concentration of Ni was observed in *T. occidentalis* and *A. viridis* samples from Enugu north senatorial zone. *P. erinaceus* samples have the least mean concentration of Ni for all the three senatorial zones. Co detection was higher in *A. viridis* samples from Enugu north and west senatorial zones than the other vegetable samples. For Enugu east senatorial zone, equal level of Co was observed in *T. occidentalis* and *A. viridis* samples. *P. erinaceus* samples had the least levels of Co for all the three senatorial zones. There was no significant difference in the different levels of Co observed in *A.viridis* and *P. erinaceus* samples from the three senatorial zones. The levels of Co detected in *T. occidentalis* samples from Enugu west and east senatorial zones varied significantly from samples for Enugu north senatorial zone.

Cr detection in all the vegetable samples were within the range of 0.01 to 0.03 mg/kg, *P. erinaceus* samples had the highest mean concentrations of Cr (0.03mg/kg) for all three senatorial zones. There is no significant difference in the levels of Cr observed in the three vegetable samples from all the three senatorial zones. Zn levels were higher in *A. viridis* (0.53mg/kg) samples for Enugu north senatorial zones but for Enugu west and east senatorial zones, *P. erinaceus* samples have the highest mean concentration of Zn (0.45 and 0.44 mg/kg respectively). *T. occidentalis* samples have the least levels of Zn for all the senatorial zones. There is no significant difference in the levels of Zn in *T. occidentalis* and *A. viridis* samples from the three senatorial zones. The levels of Zn in *P. erinaceus* samples from Enugu west and east senatorial zones varied significantly with samples from Enugu north senatorial zones. Fe levels observed in *T. occidentalis* samples were highest compared to the other vegetable samples for the three senatorial zones. *P. erinaceus* samples have the least levels of Fe for Enugu north and east senatorial zones, while *A, viridis* samples from Enugu west senatorial zones have the least Fe mean concentration. There was no significant difference in the mean concentrations of Fe in *T. occidentalis* samples for all the three senatorial zones while the differences in the mean concentrations of Fe in *A. viridis* and *P. erinaceus* samples varied significantly from one another.

Table 3 **Trace Metal Concentrations in the Vegetable Samples from the three Senatorial Zones of Enugu State for the month of June**

Location	**Samples**	**Trace metals (mg/kg)**					
		Mn	**Ni**	**Cr**	**Co**	**Zn**	**Fe**
Enugu north	*T. occidentalis*	0.14±0.010[a]	0.09±0.005[abc]	0.09±0.004[bc]	0.01±0.000[a]	0.39±0.014[ac]	2.74±0.307[a]
	A. viridis	0.27±0.015[bc]	0.09±0.005[bc]	0.12±0.010[b]	0.02±0.0005[b]	0.53±0.105[ab]	2.35±0.131[bc]
	P. erinaceus	0.06±0.005[c]	0.06±0.003[c]	0.05±0.005[abc]	0.03±0.001[c]	0.41±0.004[abc]	2.20±0.145[bc]
Enugu west	*T. occidentalis*	0.16±0.010[a]	0.13±0.010[ab]	0.13±0.014[abc]	0.02±0.0005[a]	0.31±0.039[a]	2.62±0.619[a]

	A. viridis	0.29±0.013[c]	0.15±0.004[c]	0.14±0.015[b]	0.02±0.0005[b]	0.38±0.014[abc]	1.86±0.052[b]
	P. erinaceus	0.07±0.005[bc]	0.09±0.005[ab]	0.07±0.005[abc]	0.03±0.001[c]	0.45±0.030[bc]	1.85±0.047[c]
Enugu east	*T. occidentalis*	0.18±0.009[a]	0.12±0.003[ab]	0.13±0.005[abc]	0.02±0.0005[a]	0.30±0.012[ab]	2.53±0.560[a]
	A. viridis	0.35±0.010[abc]	0.14±0.005[c]	0.13±0.005[b]	0.02±0.0005[b]	0.33±0.015[bc]	2.03±0.130[c]
	P. erinaceus	0.07±0.010[c]	0.08±0.003[ab]	0.06±0.004[abc]	0.03±0.001[c]	0.44±0.014[bc]	2.16±0.080[abc]
MAC (FAO 1985)		-	0.20	1.00	2.00	2.00	5.00

MAC-Maximum allowed concentration. Results are in mean±SD. Similar letters in a column are not significantly different at 0.05 level of significance

Metal Concentration in Vegetables for the Month of July

The Table 7 revealed that *A. viridis* samples from the three senatorial zones had the highest Mn levels, while *P. erinaceus* samples had the least (which was within the range 0.08 to 0.10mg/kg). ANOVA at 95% across the column showed no significant difference between the mean concentrations of Mn in *T. occidentalis* samples from Enugu north and west which varies significantly with samples from Enugu east senatorial zone. This was also similar for *A. viridis* samples. *P. erinaceus* samples showed no significant difference in their mean concentrations of Mn for all the three senatorial zones. Ni mean concentration was highest in *A. viridis* samples from all the three senatorial zones and least in *P. erinaceus* samples. Equal levels of Ni were observed in *T. occidentalis* samples and *P. erinaceus* samples for Enugu east senatorial zone. The differences in the mean concentration of Ni in *A. viridis* samples from the three senatorial zones were significant. *T. occidentalis* and *P. erinaceus* samples from Enugu west and east had no significant differences in their mean concentration of Ni but varies significantly with samples from Enugu north senatorial zone.

The same level of Cr was observed in *T. occidentalis* and *A. viridis* samples from Enugu west and east senatorial zones (0.14mg/kg for both). *A. viridis* samples had the highest level of Cr (0.13mg/kg) for Enugu north senatorial zones slightly above *T. occidentalis* samples (0.13mg/kg). *P. erinaceus* samples had the least levels of Cr for all the three senatorial zones. ANOVA at 95% across the column showed no significant differences in the levels of Cr for all the vegetable samples from the three senatorial zones. The levels of Co observed were within the range of 0.02 to 0.03 mg/kg except for *T. occidentalis* samples from Enugu north senatorial zone which had a mean Co concentration of 0.01mg/kg. There was no significant difference in the levels of Co observed in all the three vegetable samples from the three senatorial zones. Zn had highest detection level in *P. erinaceus* samples from Enugu west and east senatorial zones while *A. viridis*samples had the highest Zn concentration for Enugu north senatorial zone. *T. occidentalis*samples from all the three senatorial zones have the least mean concentrations of zinc. The differences in the mean concentrations of Zn in *T. occidentalis* and *A. viridis*samples from the three senatorial zones were significant. The mean concentrations of Zn in *P. erinaceus* samples from Enugu west and east senatorial zones were not significant but varied significantly with samples from Enugu north senatorial zone.

The mean concentrations of Fe observed in *T. occidentalis* samples were higher than the other two vegetable samples of which *A. viridis* samples had the least mean concentration of Fe for Enugu west and east senatorial zones. There was no significant difference in the levels of Fe observed in *T. occidentalis* samples from the three senatorial zones. The levels of Fe observed in *A. viridis* samples from the three senatorial zones varied significantly from each other. The concentrations of Fe observed from *P. erinaceus* samples from Enugu north and Enugu east senatorial zones varied with the concentrations observed in samples from Enugu west senatorial zone.

Table 4 Trace Metal Concentrations in the Vegetable Samples from the three Senatorial Zones of Enugu State for the month of July

Location	Samples	Trace metals (mg/kg)					
		Mn	**Ni**	**Cr**	**Co**	**Zn**	**Fe**
Enugu north	*T. occidentalis*	0.16±0.015[a]	0.11±0.010[a]	0.12±0.004[abc]	0.01±0.000[a]	0.37±0.014[ac]	2.56±0.307[a]
	A. viridis	0.30±0.010[bc]	0.12±0.005[abc]	0.13±0.003[abc]	0.02±0.0002[b]	0.48±0.050[ab]	2.31±0.131[bc]
	P. erinaceus	0.08±0.005[c]	0.08±0.005[c]	0.05±0.005[abc]	0.02±0.0005[c]	0.38±0.004[bc]	2.14±0.145[bc]
Enugu west	*T. occidentalis*	0.16±0.010[a]	0.14±0.012[abc]	0.14±0.004[abc]	0.02±0.0005[a]	0.30±0.009[a]	2.61±0.619[a]
	A. viridis	0.31±0.013[bc]	0.18±0.010[ab]	0.14±0.015[abc]	0.03±0.002[b]	0.31±0.004[abc]	1.74±0.552[b]
	P. erinaceus	0.10±0.012[c]	0.13±0.010[ac]	0.08±0.005[abc]	0.03±0.001[c]	0.43±0.003[abc]	1.75±0.147[c]
Enugu east	*T. occidentalis*	0.19±0.014[ac]	0.12±0.008[abc]	0.14±0.015[abc]	0.02±0.0005[a]	0.28±0.012[ab]	2.48±0.560[a]
	A. viridis	0.38±0.010[abc]	0.15±0.005[ac]	0.14±0.010[abc]	0.02±0.0002[b]	0.25±0.005[bc]	1.96±0.130[c]
	P. erinaceus	0.08±0.010[c]	0.12±0.008[ac]	0.07±0.004[bc]	0.03±0.001[c]	0.44±0.004[abc]	2.12±0.080[bc]
MAC (FAO 1985)		-	0.20	1.00	2.00	2.00	5.00

MAC-Maximum allowed concentration. Results are in mean±SD. Similar letters in a column are not significantly different at 0.05 level of significance

DISCUSSION

The present study investigated the concentrations of trace metals (Mn, Ni, Cr, Co, Zn and Fe) in three vegetable samples (*Telfairiaoccidentalis*, *Amaranthusviridis* and *Pterocarpuserinaceus*) from three senatorial zones of Enugu state (Enugu east, west and north) duringwet seasons (May, June and July). The results from the vegetable samples (*T. occidentalis, A. viridis*, and *P. erinaceus*) analysis from Enugu north, west and east senatorial zones, revealed the presence of trace metals in the three vegetable samples.There were differences in the mean concentrations of trace metals observed in the three vegetable samples. *Amaranthusviridis* showed the highest concentration of trace metals while *P. erinaceus* showed the least. *T. occidentalis* concentration of trace metals was slightly below that of *A. viridis* but above *P. erinaceus* samples (the rate of trace metals accumulation is in the order *A. viridis*>*T. occidentalis*>*P. erinaceus*). This is in line with Zheng *et al*., (2007) who reported that vegetable species differ widely in their ability to take up and accumulate heavy metals, even among cultivars and varieties within the same species.

The trace metals investigated in the present study were Mn, Ni, Cr, Co, Zn and Fe. These metals varied in their concentrations,increasing progressively during the wet season (May to July); except for Zn and Fe which decreased progressively. This lends support to Yusuf *et al*., (2003) who reported that factors influencing the concentration of heavy metals in plants include climate, environmental pollution, nature of the soil on which the plant is grown, and the degree of maturity of the plant at the time of harvesting. The rate of accumulation of trace metals in the vegetable samples were in the following decreasing order Fe > Zn >Mn> Cr > Ni > Co.

Conclusion

The results obtained in this study indicate that metal concentration in the edible vegetables from the three senatorial districts of Enugu State varied with seasons (dry and rainy seasons). Although, a number of trace metals are essential for biological systems, their deficiency symptoms are noted with depletion or removal of these metals. However, essentials heavy metals become toxic when their concentration level exceeds those required for correct nutrition.

REFERENCES

Flyman, M.V. and Afolayan, A.J. (2006). The suitability of wild vegetables for alleviating human dietary deficiencies. *South African Journal of Botany 72*: 492-497.

Food and Agriculture Organization, FAO. (1985). Water quality for irrigation for agriculture. *Irrigation Drainage Paper 29*: 1-130.

Jansen, P.C.M. (2004). *Amaranthusviridis* L. Grubben, G.J.H. & Denton, O.A. (Eds.). PROTA (Plant Resources of Tropical Africa), Netherlands. Accessed on 12/01/2020. Retrieved from https://uses.plantnet-project.org/en/Amaranthus_viridis_(PROTA)

Odiaka, N.I. &Schippers, R.R. (2004). *Telfairiaoccidentalis* Hook.f. Grubben, G.J.H. &Denton, O.A. (Eds.). PROTA (Plant Resources of Tropical Africa), Wageningen, Netherlands. Accessed on 12/01/2020. Retrieved from http://www.prota4u.org/search.asp

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 andToxicology 41*: 375-378

Zheng, N., Wang, Q.,Zhang, X., Zheng, D., Zhang, Z. and Zhang, S. (2007). Population health risk due to dietary intake of heavy metals in the industrial area of Huludao city, China. *ScienceTotal Environment 287*: 96-104.