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Seasonal Variations in Trace Metals Contents of Some Vegetables Grown on Irrigated Farmlands along the Bank of River Benue within Makurdi Metropolis

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Abstract
The seasonal variation in trace metals contents of *Telfairia occidentalis* (Fluted pumpkin), *Amaranthus hybridus* (Spinach) and *Abelmoschus esculentus* (Okra) were assessed in other to determine the impact of human activities at the river bank. The results of the study indicate mean level of zinc to range between (2.67-0.53) mgkg^{-1} *Talfairia occidentalis,* (0.65-0.27)mgkg^{-1} *Amarantus hybridus* and (0.24-0.44 mgkg^{-1} for the first season, while in the second season, a range of (0.65-0.2) mgkg^{-1}, (4.21- 0.19) mgkg^{-1} and 0.03-0.34 mgkg^{-1} for *T.occidentalis, A. hybridus* and *A. esculentus* was obtained respectively. The average levels of lead for the two seasons was found to range between 0.08 - 0.26 mgkg^{-1} and 0.01- 0.16 mgkg^{-1} for *T. occidentalis,* 0.04-0.14 mgkg^{-1} and 0.11- 0.27 mgkg^{-1} for *A. hybridus* and 0.09 – 0.18 mgkg^{-1} and 0.06 – 0.17 mgkg^{-1} for *A. esculentus*. The level cadmium in *T. occidentalis, A. hybridus* and *A. esculentus* was found to range between 0.01 - 0.20 mgkg^{-1} and 0.02 - 0.13 mgkg^{-1}, 0.04-0.11 mgkg^{-1} and 0.06 - 0.14 mgkg^{-1}, and 0.7 - 0.17 mgkg^{-1} and 0.04 - 0.15 mgkg^{-1} for the first and second seasons respectively. Copper levels were observed to be between 0.02- 0.10 mgkg^{-1} and 0.01- 0.07 mgkg^{-1} in *T. occidentalis*, *A. hybridus,* 0.02 - 0.07 mgkg^{-1} and 0.02 - 0.17 mgkg^{-1}, While *A. esculentus* had 0.07 - 0.12 mgkg^{-1} and 0.08 - 0.26 mgkg^{-1} for first and second seasons respectively. Chromium levels in the three vegetables was found to be between results in *T. occidentalis* (0.06-0.14 mgkg^{-1}), *A. hybridus* (0.02-0.44 mgkg^{-1}), *A. esculentus* (0.2-0.40 mgkg^{-1}) during the first season, while in the second dry season, Chromium content of the vegetable varied as followed, *T. occidentalis* (0.01-0.02mgKg^{-1}), *A. hybridus* (0.03-0.07mgkg^{-1}), *A. esculentus* (0.01-04 mgkg^{-1}). There was significant difference ($p<0.05$) in chromium content of the plants. The result of the study revealed that the three vegetables were not harshly contaminated; hence the values obtained were far below the permissible levels accepted by the WHO/FAO. The implication is that farming activities at the river bank have not impacted sternly on the surrounding environment.
Keyword: Heavy Metals, Vegetables, Farms, irrigation, Makurdi,

1.0 Introduction

Trace metals are inorganic substances that are essential for life but required only in small or minute quantities. They occur in human and animals tissues in small amounts. Examples of trace metals include; include Cu, Fe, Zn, Cr, Cd, etc. Trace metals enter the body through food, air or absorption through the skin when they come in contact with human in agriculture and in manufacturing industries or residential settings. Industrial exposure accounts for a more common routs of exposure by adults, while ingestion is most common route for exposure in children.

Though trace metals are required by the body in minute quantities they may become toxic at levels above threshold values. As a result, prolong exposure through the consumption of vegetables and other food crops contaminated by the metals could lead to disruption of numerous biochemical processes in the human body which will consequently lead to health threats to entire food chain.

Studies have shown that trace metals are one of the most serious pollutants in our natural environment due to their toxicity, persistence in the environment and bioaccumulation. According to Karen (2005), Heavy metals in natural waters and their corresponding sediments have become a significant topic of concern for scientists and engineers in various fields associated with water quality, as well as a concern of the general public.

Since water from the river is used for irrigation of food and vegetables crops cultivated during the dry season farming on the river bank, it is believed that, these crops may bioaccumulate trace metals and other toxic chemicals (Mohsen, 2008). Also, considering the infertility of most lands as a result of constant usage, the application of fertilizers on crops for maximum yield has remained a common practice among farmers without compunction to the health implications. According to Addisott (1991), the excessive use of nitrogenous fertilizers usually increases the acidity of the soil and consequently bioaccumulation of toxins, especially metals in the bodies of those who consume such crops.

Excessive concentrations of both essential and non-essential metals in plants may result in phytotoxicity. The toxic effect of a metal is determined more by its chemical speciation than by its concentration. Human exposure to toxic levels may have negative effects on individual organs in the body and cause either direct poisoning or various diseases. Copper and Zn are two important essential elements for plants, microorganisms, animals and humans. Cadmium on the other hand has no essential biological function and is generally toxic. The major threat to human health is chronic accumulation in the kidneys leading to kidney dysfunction. Food intake and tobacco smoking are the main routes by which Cd enters the body. Lead is not an essential element, either. It is well known to be toxic and its effects have been more extensively reviewed than the effects of other trace metals. Lead can cause serious injury to the brain, nervous system, red blood cells and kidneys.

The present study takes a look at the trace metal contents of three common vegetables; *Telfairia occidentalis* (Fluted pumpkin), *Amaranthus hybridus* (Spinach) and *Abelmoschus esculentus* (Okra) grown on the bank of the river during dry season farming**.**

2.0 Materials and Methods

2.1 *Study Area*

Makurdi the Benue State capital is located on latitude 7^{o}44'N and longitude 832'E of the Equator. It is situated in a valley in North Central Nigeria with an elevation of 100m above sea level. The River Benue divides Makurdi town into north and south Banks, which are connected by bridges. The town is situated in a valley in north central Nigeria with an elevation of 100m above sea level. The presence of the river has made it possible for irrigated farming to be done at the river bank. Various crops and vegetables are cultivated during the dry season farming. The most common of which are *Telfairia occidentalis* (Fluted pumpkin), *Amaranthus hybridus* (Spinach) and *Abelmoschus esculentus* (Okra), *Talinum triangulare* (water leaf) and *Capsicum annum* (Pepper), etc.

2.2 Collection and pretreatment of samples

Fresh samples of *Talfairia occidentalis* (Fluted pumpkin), *Amaranthus hybridus* (spinach), and *Abelmoschus esculentus* (okra) were collected from five locations [Air Force Base (AFB), Benue Brewery Limited (BBL), New Bridge (NB), Saint Joseph's Technical College (SJC) and Rice mill (RM)] all along the river bank, from farmlands where the dry season farming is practiced. They were identified by a botanist in the Department of Biological Sciences, Benue State University Makurdi. Sample collection was done for two dry seasons in 2010 and 2011 between February to March each season. The samples were first air dried to constant weight. For metal analysis, the samples were dry in an oven at 110^{o}C, ground using a mortar and pestle to fine particles before digestion. Samples for the analysis of herbicides were air-dry to constant weight before extraction.

2.3 Determination of Moisture Content of Vegetables

A crucible was dried to constant weight in oven at 105^{o}C. A known weight of the sample was placed into the crucible and dried in the oven at 105^{o}C to constant weight. The crucible and its content was cooled in a dessicator and weighed. The moisture content was calculated and expressed in percentage. Three replicate determinations were made in each case and the mean value reported.

2.4 Determination of Ash and Organic Mater Content of Vegetables

The crucible was preheated in a muffle furnace at 550^{o}c for one hour, cooled in a dessicator and weighed. 2g of the oven dried ground sample was transferred into the crucible and weighed. The crucible and its content were placed in the muffle furnace and the temperature was allowed to rise to 550^{o}C. After maintaining the temperature at 550^{o}C for twelve hours, the crucible with its residue was allowed to cool to 200^{o}C before transferring it into the dessicator to cool to room temperature and then weighed. The organic matter content was calculated by subtracting the percentage ash content from 100 (Allen *et al*, 1989). The experiment was repeated several times.

2.5 Digestion of vegetable samples for Metal analysis

1.0 g portion of the ground sample was weighed into a 100cm^3 Kjeldhal digestion flask; 5ml of concentrated nitric acid (HNO_3) was added followed by 1ml each of concentrated sulphuric acid (H_2SO_4) and perchloric acid ($HClO_4$). The flask was heated in the fume cupboard until dense white fumes appeared at the end of the digestion. The flask was cooled and the content was diluted with distilled water and filtered into 100cm^3 volumetric flasks (Allen *et al*, 1989). The content was made up to the mark with distilled water and transferred to 120cm^3 plastic bottles and stored for heavy metal determination using Atomic absorption Spectrophotometer AA6800 (automated) SHIMADZU JANPAN.

2.6 Spiking Experiment

30 cm^3 of multi-element standard solution was drawn with graduated pipette and used to spike 0.5g of pre-digested vegetable sample weighed into a 100cm^3 Kjeldahl digestion flask; the spike and unspike samples were digested as in section 2.4 Replicates determination were done with blank digestion. The concentrations of the spiked and unspiked samples were used to calculate the percentage recovery for each metal after the atomic absorption spectrophotometeric analysis (Okunola *et al,* 2007).

3.0 Results and discussion

The moisture content of *Talfairia occidentalis, Amarantus hybridus* and *Abelmoschus esculentus* also known as or *Hibiscus esculentus* (Table1.0) was observed to be 27.66%, 25.67% and 21.67% in the first season of analysis while in the second season, the observed moisture content for the three vegetable was 17.66%, 21.66% and 11.67% respectively. There was significant difference ($p<0.05$) in moisture contents of the vegetables for the two seasons. The moisture contents of the vegetables were relatively higher in the first season than the second season; this may be attributed to the time of sample collection.

The ash content of *Talfairia occidentalis, Amarantus hybridus* and *abelmoschus esculentus* (Table1.0) was found to be 7.0%, 5.33% and 16.67% respectively in the first season of study. The second season, ash content of the three plants was found to be 7.00%, 6.64% and 15.50% for *Talfairia occidentalis, Amarantus hybridus* and *abelmoschus esculentus* respectively. There was significant difference ($p<0.05$) in ash content of the vegetable in the two seasons. The result obtained compared favourably with those reported by Kajihausa *et al* (2010) for similar vegetables.

The results of organic matter content of the vegetables (Table1.0) was observed to be 93.00%, 94.67% and 83.33% respectively for *Talfairia occidentalis, Amarantus hybridus* and *abelmoschus esculentus* in the first season. The contents of organic matter in *Talfairia occidentalis, Amarantus hybridus* and *abelmoschus esculentus* recorded in the second season was 93.00%, 93.33% and 84.50% respectively. There was no significant difference ($p<0.05$) in ash content of the vegetable in the two seasons of study. Organic matter content is the measure of the nutritional value (lipids, proteins and carbohydrates) of a plant material. The high values observed for the vegetables are indications that the vegetables are good sources of nutrients.

The result of spiking experiment (Table2.0) was found to be in the order Pb < Cd < Cr < Zn < Cu. The range of recovery of the metal was 94.85-86.52. The high percentage recovery observed is an indication of the validity of the sample treatment procedures used.

The mean level of zinc observed in *Talfairia occidentalis* (Table3.0) was found to range between (2.67-0.53) mgKg^{-1} and (0.65-0.2)mgKg^{-1} in the first and second season respectively. The zinc content of *Amarantus hybridus* (Table 4.0) ranged between (0.65-0.27)mgKg^{-1},in the first season and (4.21- 0.19) mgKg^{-1} in the second season respectively. Zinc content in *Abelmoschus esculentus* (Table 5.0) was found to range between 0.24-0.44 mgKg^{-1} and 0.03-0.34 mgKg^{-1} for the first and second dry seasons. There was significant difference ($p<0.05$) in zinc content of the three vegetables. The results indicate that, *Talfairia occidentalis* can absorbed and accumulate the zinc metal better than any of the other two vegetables, since level of zinc in *Talfairia occidentalis* was found to be highest in all cases. The presence of zinc in the soil along the bank could be from domestic waste water, and run-off from soil containing zinc which is deposited on the bank during wet season. Also organic matter can chelates inorganic sources of and increase its availability. The type of manure used by the farmers on the soil could be a possible source of zinc in the soil since in most farmers used animal dung.

Zinc is essential for many plant functions; e.g. it aid in the production of auxins, activates enzymes in protein synthesis, and is involved in the regulation and consumption of sugars. Zinc is necessary in the formation of starch and proper development of the roots. It influenced the rate of seeds and stalks maturation, it also aid in the formation of chlorophyll and carbohydrates. The presence of adequate amounts of zinc in the tissue enables the plant to withstand lower air temperatures.

Reported symptoms of zinc toxicity in plant is associated with chlorotic and necrotic leaf tips, interveinal chlorosis in new leaves, retarded growth of the entire plant, and injured roots which resembles barbed wire. However, excessive Zn availability or uptake could cause the deficiencies of other nutrients such as phosphorus. High levels of zinc can interrupt the activity in soils microorganisms leading to breakdown in of organic matter content of the soil.

The average levels of lead in *Talfairia occidentalis,* for the two seasons (Table 3.0) was found to range between 0.08 - 0.26 $mgkg^{-1}$ and 0.01- 0.16 $mgkg^{-1}$ respectively. In *Amarantus hybridus,* the mean lead level recorded (Table 4.0) ranged between 0.04-0.14 $mgkg^{-1}$ and 0.11- 0.27 $mgkg^{-1}$ for the first and second seasons respectively. While 0.09 – 0.18$mgkg^{-1}$ and 0.06 – 0.17$mgkg^{-1}$ were found as average range of lead in *Abelmoschus esculentus* for the first and second dry season respectively. The results indicate that *A. hybridus* had the ability to absorb lead than the other two vegetable, since it has the highest content (0.27$mgkg^{-1}$) of the lead at RM, although this amount is far lower that the 5.0$mgkg^{-1}$ set as the maximum permissible limit by the WHO. There was significant difference ($p<0.05$) in lead content of the vegetables Automobile – exhaust, ashes, batteries, cables, pigments, plumbing materials, gasoline, solder and steel products are the common sources of lead in the environment. The use of rice milling machines at the rice mill could be the responsible the high amount of lead in the vegetables cultivated in this area. Other sources in which lead could be found in food materials includes disposal of food packaging materials, glassware, ceramic products, and pesticides. Mohsen *et al* (2008), reported that lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bone, intestines, kidney, reproductive and nervous systems. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behaviour disorders. Symptoms of lead toxicity include; abdominal pain, confusion, headache, anemia, irritability, and in severe cases seizures, coma and death.

In Table 3.0, the mean cadmium content of *T. occidentalis* was found to range between 0.01 - 0.20$mgkg^{-1}$ and 0.02 - 0.13 $mgkg^{-1}$ for the first and second dry season, while Table 4.0 indicate the results of Cd content of *A. hybridus* to range between 0.04-0.11 $mgkg^{-1}$ during the first dry season and 0.06 - 0.14 in the second dry season respectively. Cadmium content of *Abelmoschus esculentus* was found to range between 0.7 - 0.17 $mgkg^{-1}$ and 0.04 - 0.15 $mgkg^{-1}$ (Table 5.0) during the first and second season respectively. The results show *Abelmoschus esculentus* to absorbed cadmium more than the other two plants, although, the highest valued (0.17 $mgkg^{-1}$) recorded is lower than the maximum permissible value (0.20 $mgkg^{-1}$) accepted by the WHO. Statistical analysis of variance using ANOVA indicate significant difference ($p<0.05$) in cadmium content of the vegetables. The presence of cadmium in the vegetables could be as a result of the deposition of cadmium containing materials like plates, jewelries, stained glass, cigarette filters, battery works, exhaust pipe etc on the bank through run off waters during wet season. The result obtained compared favourable with the results reported by Muhammad *et al* (2008) for similar vegetable. Bernharh *et al,* (2006), reported that exposure to high levels of cadmium in humans will result in long-lasting impairment of lung function; while chronic exposure may result in a build-up of cadmium in the kidneys that can cause kidney disease, including proteinuria, a decrease in glomerular filtration rate, and an increased frequency of kidney stone formation.

Copper levels were observed to range between 0.02- 0.10 $mgkg^{-1}$ and 0.01- 0.07 $mgkg^{-1}$ in *T. occidentalis* during first and second dry season respectively (Table 3.0). In *A. hybridus,* a range of 0.02 - 0.07 $mgkg^{-1}$ and 0.02 - 0.17 $mgkg^{-1}$ (Table 4.0) was recorded for the first and second seasons respectively. Whereas, in *A. esculentus*
(Table 5.0), 0.07 - 0.12 $mgkg^{-1}$ and 0.08 - 0.26 $mgkg^{-1}$ was obtained during the first and second period of analysis respectively. There was significant difference ($p<0.05$) in copper content of the plants. Copper was not detected in some sampled sites. Again, the highest level of copper was found in *A. esculentus*, this implies that *A. esculentus* had the ability to absorbed Cu metal than *T. occidentalis* and *A. hybridus.* The values obtained compared favourable

with those reported by Afshin *et al* (2008), while Chipo *et al* (2011) reported slightly higher values, the difference could be due to environmental factors. Copper is an essential element widely distributed and always present in food, animal livers, which are the major contributor to dietary copper exposure. It is necessary for normal biological activities of amino-oxides and tyrosinase enzymes. Tyrosinase is required for the catalytic conversion of tyrosine tomelanin, the vital pigment located beneath the skin, which protects the skin from dangerous radiation. A daily dietary intake of 2 to 3 mg of copper is recommended for human adults. Ingestion of 15-75mg of copper causes gastrointestinal disorders. Excessive intake of copper may cause heamolysis, hepatotoxic and nephrotoxic effects. Continuous ingestion of copper from food may induce chronic copper poisoning in man (Durdana *et al*, 2007).

Chromium levels in the three vegetables (Table 3.0, 4.0 and 5.0) was found to range between results in *T. occidentalis* (0.06-0.14 $mgkg^{-1}$), *A. hybridus* (0.02-0.44 $mgkg^{-1}$), *A. esculentus* (0.2-0.40 $mgkg^{-1}$) during the first season of analysis, while during the second dry season, Chromium content of the vegetable was found as followed, *T. occidentalis* (0.01-0.02$mgKg^{-1}$), *A. hybridus* (0.03-0.07$mgkg^{-1}$), *A. esculentus* (0.01-04 $mgkg^{-1}$). There was significant difference ($p<0.05$) in chromium content of the plants. The result compared favourable with those reported by Jianmin *et al* (2012), although, Abii (2012) reported higher chromium content for similar plants; the difference could be environmental factors. Chromium in its trivalent form (Cr^{3+}) can be found naturally in various food products. It is an essential micronutrient need for carbohydrate and fat metabolism, increases the biological action of insulin. Chromium is known to help to maintain the blood glucose level and in activation of several enzymes that are necessary for carrying out various metabolic processes.
Its deficiency is associated with insulin resistance. Exposure to chromium in its hexavalent form (Cr^{6+}) could lead to some health threats; hence the hexavalent form of chromium is highly toxic. In this form it is known to damage genetic materials in the body (Ningthoujam, 2012).

Tables 6.0 and 7.0 show the correlation of metals absorbed by *T. occidentalis* in the different sample sites for the first and second seasons respectively. The correlation coefficient (r) values were found to range between 0.999 – 0.959 and 0.994 - 0.015 for first and second seasons respectively. The results indicate positive correlations for the two seasons except the correlation of Cr with Cd in the second season which was negative. The results also show significant difference ($p<0.01$) whereas there was no significant difference at $p<0.05$. The strongly positive correlation of the trace metals is an indication that they are from a common origin.

Tables 8.0 and 9.0 show the correlation of metals levels in *A. hybridus* with correlation coefficient (r) values ranging between 0.984 – 0.678 and 0.948 – 0.225 for first and second seasons respectively. The results indicate strongly positive correlations for the two seasons except for the correlation of Cr with Cd in the second season which was negative. The results also show significant difference ($p<0.01$) in the levels of Cd/Pb, Cu/Cd and Cr/Cd, similarly, significant difference exit at ($p<0.05$) in the content of the metals in the vegetable in both seasons.

Tables 10.0 and 11.0 show the correlation of metals levels in *A. esculentus* with correlation coefficient (r) values ranging between 0.959 - 0.296 and 0.997 – 0.00 for the first and second seasons respectively. The results indicate positive correlations for the two seasons except for the correlation of Pb/Zn, Cu/Pb in the first season and Pb/Zn in the second season were negative. There was significant difference ($p<0.01$) in the levels of Cr/Cu in the first year and Cd/Pb in the second season. Similarly, there was significant difference ($p<0.05$) in the contents of the metals in the vegetable for both seasons. The low correlation of the metal content in the vegetable was observed between Cu/Zn in the second season.

4.0 Conclusion

The results of heavy metal contents of the vegetables indicate *Talfairia occidentalis* to be more susceptible to absorption of the metals than the other two vegetables. Although, all the three vegetables were not harshly contaminated, hence the values obtained were far below the permissible levels accepted by the WHO/FAO. However, continuous accumulation of these pollutants in soil and by the plants and aquatic animals will lead to some health problems by the vulnerable population in future.

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1.0 Moisture, Ash and organic matter contents of Vegetables

	Talfairia occidentalis (fluted pumpkin)		*Amaranthus hybridus* (spinach)		*Abelmoschus esculentus* (Okra)	
	2010	2011	2010	2011	2010	2011
Moisture (%)	27.66±0.43	17.66±0.30	25.67±0.27	21.66±0.38	21.67±0.24	11.67±0.37
Ash (%)	7.00±0.19	7.00±0.94	5.33±0.69	06.64±0.35	16.67±0.12	15.50±0.71
O.M. (%)	93.00±0.19	93.00±0.439	94.67±0.64	93.33±0.34	83.33±0.12	84.50±0.71

2.0 Table Percentage (%) Recoveries of Metals from Spike Samples

Metal	Percentage(%) Recovery
Zinc	94.22±0.26
Lead	86.52±0.47
Cadmium	89.67±1.14
Copper	94.85 ±0.29
Chromium	91.43±0.45

3.0 Trace Metals contents of *Talfairia occidentalis* (fluted pumpkin) concentration ($mgkg^{-1}$)

Sites	Zn		Pb		Cd		Cu		Cr	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
AFB	2.47±0.01	0.56±0.02	0.08±0.09	0.16±0.11	0.07±0.04	ND	0.02±0.02	0.06±0.01	0.14±0.04	0.01±0.01
BBL	2.67±0.01	0.50±0.01	0.09±0.19	0.11±0.16	0.04±0.09	0.06±0.03	0.10±0.03	0.01±0.03	0.08±0.08	0.02±0.01
NB	0.53±0.01	0.07±0.01	0.11±0.03	0.16±0.17	ND	0.07±0.01	0.08±0.06	0.07±0.02	0.06±0.06	0.02±0.07
SJT	0.73±0.01	0.52±0.01	0.22±0.22	0.07±0.00	0.01±0.07	0.02±0.02	ND	0.02±0.06	0.07±0.02	0.01±0.00
RM	2.55±0.06	0.56±0.06	0.26±0.03	0.01±0.00	0.11±0.03	0.13±0.02	0.08±0.05	ND	ND	0.02±0.01
WHO	60.00		5.00		0.20		40.00		-	

Source: Aweng, *et al* (2011)

4.0 Trace Metals contents of *Amaranthus hybridus* (Spinach), concentration ($mgkg^{-1}$)

Sites	Zn		Pb		Cd		Cu		Cr	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
AFB	0.57±0.01	0.28±0.03	ND	0.18±0.09	0.11±0.05	0.14±0.01	ND	0.03±0.01	0.44±0.02	0.03±0.02
BBL	0.46±0.01	0.21±0.02	ND	0.21±0.06	0.04±0.11	0.06±0.01	ND	0.02±0.01	0.06±0.05	0.05±0.00
NB	0.65±0.01	0.19±0.02	ND	0.18±0.11	0.09±0.05	ND	0.03±0.06	0.03±0.00	0.02±0.02	0.06±0.02
SJT	0.27±0.01	0.21±0.03	0.04±0.00	0.11±0.05	0.08±0.13	0.08±0.03	0.02±0.02	0.08±0.03	0.02±0.07	0.07±0.01
RM	0.35±0.01	ND	0.14±0.09	0.27±0.15	0.08±0.07	0.07±0.04	0.07±0.06	0.17±0.04	0.04±0.00	0.03±0.00
WHO	60.00		5.00		0.20		40.00		-	

5.0 Trace Metals contents of *Amaranthus hybridus* (Spinach), concentration ($mgkg^{-1}$)

Sites	Zn		Pb		Cd		Cu		Cr	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
AFB	0.26±0.08	0.03±0.01	0.11±0.18	0.07±0.18	0.16±0.05	0.04±0.01	0.11±0.09	0.10±0.05	0.04±0.06	0.04±0.01
BBL	0.28±0.08	0.21±0.00	0.15±0.18	0.06±0.00	0.07±0.04	0.09±0.07	0.07±0.06	0.08±0.08	0.40±0.07	0.02±0.04
NB	0.44±0.00	0.34±0.02	0.09±0.87	0.09±0.06	0.09±0.09	0.12±0.04	0.08±0.07	0.13±0.02	0.07±0.15	0.02±0.00
SJT	0.24±0.12	0.24±0.02	0.18±0.02	0.08±0.09	0.17±0.08	0.11±0.06	0.12±0.11	0.16±0.03	0.08±0.00	0.01±0.00
RM	0.44±0.02	0.24±0.02	0.16±0.14	0.17±0.00	0.13±0.03	0.15±0.05	ND	0.26±0.09	0.02±0.05	0.03±0.02
WHO	60.00		5.00		0.20		40.00		-	

Table 6 Correlation of trace metals levels in *T. occidentalis* at different sample site (first season)

	Zn	Pb	Cd	Cu	Cr
Zn	1				
Pb	.999**	1			
Cd	.981**	.985**	1		
Cu	.961**	.959**	.978**	1	
Cr	.994**	.996**	.986**	.973**	1

**Correlation is significant at 0.01 or 99% confident level (2-tailed).
*Correlation is significant at 0.05 or 95% confident level (2-tailed)
Number of samples n = 5

Table7.0 Correlation of trace metals levels in *T. occidentalis* at different sample sites (second season)

	Zn	Pb	Cd	Cu	Cr
Zn	1				
Pb	.984**	1			
Cd	.147	.079	1		
Cu	.970**	.994**	.015	1	
Cr	.955 *	.952**	-.138	.963**	1

**Correlation is significant at 0.01 or 99% confident level (2-tailed)
*Correlation is significant at 0.05 or 95% confident level (2-tailed)
Number of samples n = 5

Table 8.0 Correlation of trace metals levels in *A. hybridus* at different sample sites (first season)

	Zn	Pb	Cd	Cu	Cr
Zn	1				
Pb	.696	1			
Cd	.688	.978**	1		
Cu	.678	.942*	.986**	1	
Cr	.593	.963**	.984**	.950*	1

**Correlation is significant at 0.01 or 99% confident level (2-tailed).
*Correlation is significant at 0.05 or 95% confident level (2-tailed).
Number of samples n = 5

Table 9.0 Correlation of trace metals levels in *A. hybridus* at different sample sites (second season)

	Zn	Pb	Cd	Cu	Cr
Zn	1				
Pb	.879*	1			
Cd	.742	.948*	1		
Cu	.883*	.775	.774	1	
Cr	.620	.225	-.059	.357	1

**Correlation is significant at 0.01 or 99% confident level (2-tailed).
*Correlation is significant at 0.05 or 95% confident level (2-tailed).
Number of samples n = 5

10.0 Correlation of trace metals levels in *A. esculentus* at different sample sites (first season)

	Zn	Pb	Cd	Cu	Cr
Zn	1				
Pb	-.165	1			
Cd	.874	.296	1		
Cu	.924*	-.193	.784*	1	
Cr	.935*	.108	.959**	.926*	1

**Correlation is significant at 0.01 or 99% confident level (2-tailed).
*Correlation is significant at 0.05 or 95% confident level (2-tailed).
Number of samples n = 5

Table 11.0 Correlation of trace metals levels in *A. esculentus* at different sample sites (second season)

	Zn	Pb	Cd	Cu	Cr
Zn	1				
Pb	- .349	1			
Cd	.297	.997**	1		
Cu	.000*	.932*	.943*	1	
Cr	.449	.669	.696	.880*	1

**Correlation is significant at 0.01 or 99% confident level (2-tailed).
*Correlation is significant at 0.05 or 95% confident level (2-tailed).
Number of samples n = 5