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Determination of some heavy metals in selected edible vegetables grown along River Yedzaram in Uba area Adamawa State, Nigeria

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The levels of some heavy metals were investigated in selected edible potions of the vegetables; *Amarathus caudatus* (Spinach) and *Hibiscus sabdariffa* (Rosella) are grown in Uba area along the Yedzaram River in North Eastern Adamawa State, Nigeria. All samples were randomly collected from two different gardens. The levels of the heavy metals, (Cu, Fe, Cd, Cr and Zn) were analyzed using Atomic Absorption Spectrophotometer (AAS) (BUK 210 model). In all the samples analyzed, Cd and Cr were not detected. The levels of heavy metals in Farm A for *H. sabdariffa* leaves ranges from Cu (30.00 ± 0.15 mg/kg to 31.00 ± 0.18 mg/kg), Fe (37.39 ± 0.02 mg/kg to 48.47 ± 0.10 mg/kg), Zn (13.00 ± 0.01 mg/kg to 25.50 ± 0.48 mg/kg), respectively. In Spinach, the results ranged from Cu (34.33 ± 0.42 mg/kg to 34.50 ± 0.05 mg/kg), Fe (31.72 ± 0.71 mg/kg to 43.33 ± 0.02 mg/kg), Zn (21.17 ± 0.14 mg/kg to 10.83 ± 0.17 mg/kg), respectively. The data were analyzed with t-test and analysis of variance (ANOVA). There were significant differences ($p < 0.05$) between the levels of the heavy metals in the vegetables obtained from Farms A and B. The order of the metal contamination in the vegetables was Fe > Cu > Zn in Farm A and Cu> Fe> Zn in Farm B. The elevated levels of metals in vegetables in the two gardens could be attributed to excessive usage of fertilizers and other agro - chemicals and of course the environmental factors of the areas. The results were however lower than the published threshold values considered toxic for mature plant tissue, except Fe which has higher values. The consumption of these vegetables as food may not pose possible health hazards to human at the time of the study.

Key words: Heavy metals**,** *Amarathus caudatus*, *Hibiscus sabdariffa*, Uba area, fertilizers.

INTRODUCTION

Vegetable is a plant or part of a plant used as food, typically as accompany to meat or fish, such as cabbage, potato, carrot or beans (Ihekoroye and Ngoddy, 1985). Eating vegetables regularly in diet can have many health

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benefits by reducing many health related diseases and used to convert the fats and carbohydrates into energy (Milk, 2012). Eating vegetables is one of the most important pathways for the human body to absorbed dietary mineral, necessary for its healthy developmentbut unfortunately harmful element such as heavy metals which may lead to intoxication and with prolong accumulation are being found in these vegetables (Elsevier, 2008).

However, heavy metals concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities such as agricultural practices, industrial activities and waste disposal methods (Ndiokwere and Ezeh, 1990; Usman and Ayodele, 2002; Uwah et al., 2009). Contamination and subsequent pollution of the environment by heavy metals have become a global concern due to their distribution and multiple effects on the ecosystem (Nriagu, 1990). Heavy metals are present in agricultural soils at low levels. Due to their cumulative behaviours and toxicity, they have potential, hazardous effect not only on plants but on human health (Das *et al.,* 1997). Distributions of heavy metals in plants depend upon availability and concentration of heavy metals as well as particular plant species (Punz and Seighardt, 1993). Many researchers have shown that some common vegetables are capable of accumulating high levels of metals from the soil (Xiong, 1998; Uwah et al., 2009). Certain species of Brassica (cabbage) are hyper-accumulators of heavy metals in their edible tissues (Xiong, 1998). Many people could be at risk of adverse health effects from consuming common vegetable cultivated in contaminated soil (Nirmal et al., 2007).

The populations mostly affected by heavy metals toxicity are pregnant women or very young children (Boon and Soltanpour, 1992). Neurological disorders, central nervous system (CNS) destruction and cancers of various body organs are some of the report of heavy metals poisoning (Agency for Toxic Substance and the Disease Registry (ATSDR) 1999a, b: 2000). Low birth weight and severe mental retardation of newly born children have been reported in some cases where pregnant women ingest toxic amount of heavy metal through direct or indirect means (Mahaffey et al., 1981).

Heavy metals like Fe, Cu, Zn, and Ni, are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders (Ward, 2005; Uwah et al., 2009). Industrial, urban wastes and agricultural application and also mining activities results in an increased concentration of heavy metals in both soil and plant. Heavy metals pollute both soil and plant and so it is necessary to examine the state of the polluted soil and plant and establish what influence heavy metals have on both. Heavy metals have great significance due to their toxicity and accumulative behaviour or and are not biodegradable (Shinggu et al., 2007). Surface soil may act as carriers and possible source of pollution, since the mobility of these metals is such that remain in upper layers without regard to soil type.

Moreover, these metals are not permanently fixed and can be released by changes in climatic or environmental condition such as rainfall (Nriagu and Pacyna, 1990). The main sources of roadside contaminants are the deposition of aerosol particles which are adhesive in nature. But in the urban environment, these particles originate mainly from road traffic, welding, emission from industries, construction activities and flaking of paint (Radojavice and Bashkin, 1999).

The use of polluted water in the immediate surroundings of big cities for growing of vegetables is a common practice in Nigeria. Although this water is considered a rich source of organic matter and plant nutrients, it also contains sufficient amount of soluble salts and metal like Fe, Mn, Cu, Zn, Pb, Ni, Sn, Hg, Cr, As and Al. When such water is used for irrigation of crops for a long period, these heavy metals may accumulate in soil and may be toxic to the plants and also cause deterioration of soil (Kirkham, 1983; Uwah, 2009).

Heavy metals contamination and pollution of environment has become a global concern, due to their distribution and multiple effects on the ecosystem, waste waters are highly use in agricultural irrigation and long-term usage of these waste waters on agricultural lands often results in the build-up of elevated levels of heavy metals in soils (Rattan et al., 2001). Crops usually cultivated on the metals contaminated soils accumulate these metals in excessive quantities are enough to cause clinical problems both to animal and human beings consuming these metals rich plants.

The study is aimed at investigating the levels of some heavy metals such as (Cu, Cd, Fe, Cr and Zn) in edible portions of spinach *(Amarathus caudatus)* and Rosella leaves *(Hibiscus sabdariffa),* cultivated along River Yedzaram in Uba area. Extrapolate the results and ascertained the suitability or otherwise of the vegetables for human consumptions.

This was carried out by analyzing spectrophotometrically the levels of the metals in the vegetable samples.

MATERIALS AND METHODS

Analytical reagent (AnalaR) grade chemicals and distilled water were used throughout the study. All glassware and plastic containers used in this work were washed with detergent solution followed by 20% (v/v) nitric acid and then rinsed with tap water and finally with distilled water.

Study area

Uba region geographically is located in the North-Eastern part of Borno State and Adamawa State, in North-eastern Nigeria. Its geographical coordinates are 10° 27' North and 13° 17' East of the Greenwich meridian. Uba region occupies land area of 2,362 km^2 and a population of 138,091 (Wandeo, 2005).

Table 1. Concentrations of some heavy metals in Spinach and Rosella from Farm A (mg/kg).

Vegetables/Sampling sites	Cd	Cr	Cu	Fe	Zn
Rosella (*Hibiscus sabdariffa*)					
Location 1	ND	ND	31.00 ± 0.18	48.67 ± 0.1	13.00 ± 0.01
Location 2	ND	ND	30.00 ± 15.00	37.39 ± 0.02	25.50 ± 0.48
Spinach (*Amaranthus caudatus*)					
Location 1	ND	ND	34.33 ± 0.42	43.33 ± 0.02	10.83 ± 0.17
Location 2	ND	ND	34.50 ± 0.05	31.72 ± 0.71	21.17 ± 0.14
WHO/FAO			20 - 100	10 -18	3 - 20
NAFDAC			0 - 40	10 - 20	0 - 50

All values represent mean ± standard deviation of triplicate determination. **ND =** Not detected**, WHO** (1996) **=** World Health organization, **NAFDAC** = National Agency for Food and Drug Administration and control.

Sampling and sample treatment

The samples analyzed include *H. Sabdariffa* (Spinach) and *A. caudatus* (Rosella) leaves. Samples were collected from May to September, 2012 from two different Farms (A and B) along the River Yedzaram Uba area. Edible portions of the fresh samples of *A. caudatus* (Rosella) and *H. sabdariffa* (Spinach) were randomly collected (handpicked) from two different vegetable Farms (A and B), which supply most of the vegetables consumed in Uba. The samples were wrapped in big brown envelopes and labeled. Only fresh vegetables in good conditions were collected in order to produce good quality dried product (Audu and Lawal, 2005). A total of 10 samples each of *A. caudatus* and *H. sabdariffa* from each of the vegetable farms along River Yadzaram in Uba were collected. Samples from each of the two farms were pooled together to obtained two homogenous samples.

In the laboratory, vegetable samples were washed with tape water and thereafter with distilled water and the water was allowed to drip out and were then sliced into smaller portion and then dried in an oven at 80°C for hours (AOAC, 2000). At the end of the drying, the oven turned off and left overnight to enable the sample cool to room temperature. Each sample was grounded into a fine powder, sieved and finally stored in a 250 cm^3 screw capped plastic jar appropriately labeled (AOAC, 2000).

Digestion procedure

1.0 g of each powdered leaves samples were weighed out into Kjeldahl digestion flask mixed with 10 cm^3 of concentrated sulphuric acid, concentrated perchloric acid and concentrated nitric acid in the ratio 1: 2: 20 by volume respectively and left to stand overnight. Thereafter, the flask was heated at 70°C for 40 min and then, the heat was increased to 120°C. The mixture turned black after a while (Jeffery et al., 1989). The digestion was completed when the solution became clear and white fumes appeared. The digest was diluted with 20 cm^3 of distilled water and boiled for 15 min. This was then allowed to cool, transferred into 100 cm^3 volumetric flasks and diluted to the mark with distilled water. The sample solution was then filtered through a filter paper into a screw capped polyethylene bottle.

Determination of heavy metals

Levels of Cd, Cu, Fe, Zn and Cr in the vegetable samples were determined using Buck 210 model Atomic absorption spectrophotometer (AAS) equipped with an air-acetylene burner and hollow cathode lamps. Working standards were also prepared by further dilution of 1000 ppm stock solution of each of the metals and a calibration curve was constructed by plotting absorbance versus concentration. By interpolation, the concentrations of the metals in sample digests were determined. The mean values of six determinations per sample were recorded.

Statistical analysis

All analysis was performed in triplicates. Results were expressed by mean of ± SD. Statistical significance was established using one way analysis of variance (ANOVA). Means were separated according to Duncan's multiple range analysis ($p < 0.05$) using software SPSS 16.0.

RESULTS AND DISCUSSION

The levels of heavy metals (Cu, Cd, Cr, Fe and Zn) in Rosella (*H. sabdariffa*) and Spinach (*A. caudatus*) are as shown in Tables 1 and 2 of Farm A and B. In Rosella (*H. sabdariffa*), obtained from Farm A, the metal levels were: Cu, 30.00 ± 0.15 mg/kg to 31.00 ± 0.18 mg/kg; Fe, 37.39 ± 0.02 mg/kg to 48.67 ± 0.10 mg/kg and Zn, 13.00 ± 0.01 mg/kg to 25.50 ± 0.48 mg/kg. In those obtained from Farm B, the metal levels were: Cu, 31.33 ± 0.25 mg/kg to 33.83 ± 0.03 mg/kg; Fe, 25.06 ± 0.22 mg/kg to 28.47 ± 0.09 mg/kg and Zn, 7.33 ± 0.02 mg/kg. In Spinach (*A. caudatus*) obtained from Farm A, the metal levels were: Cu, 34.33 ± 0.42 mg/kg to 34.50 ± 0.05 mg/kg; Fe, 31.72 ± 0.71 mg/kg to 43.33 ± 0.02 mg/kg and Zn, 10.83 ± 0.17 mg/kg to 21.17 ± 0.14mg/kg. In those obtained from Farm B, the metal levels were: Cu, 35.03 ± 0.50 mg/kg to 38.00 ± 0.10 mg/kg; Fe, 28.47 ± 0.09 mg/kg and Zn, 10.50 ± 0.09 mg/kg to 25.00 ± 0.44 mg/kg. In both Farms A and B chromium and cadmium were not detected. The analysis revealed that Spinach contained higher concentration of copper than Rosella. Although, the maximum values recorded in both the vegetables are within the National Agency for Food and Drug Administration and control's (NAFDAC) maximum tolerable Cu concentration of 40 mg/kg in fresh vegetables. On the other hand, the results

Table 2. Concentration of some heavy metals in Spinach and Rosella from Farm B (mg/kg)

Vegetables/Sampling sites	Cd	Cr	Cu	Fe	Zn
Rosella (*Hibiscus Sabdariffa*)					
Location 1	ND	ND	31.33 ± 0.25	28.47 ± 0.09	7.33 ± 0.02
Location 2	ND	ND	33.83 ± 0.03	25.06 ± 0.22	7.33 ± 0.02
Spinach (*Amaranthus caudatus*)					
Location 1	ND	ND	38.00 ± 0.10	28.47 ± 0.09	25.00 ± 0.44
Location 2	ND	ND	35.03 ± 0.50	28.47 ± 0.09	10.50 ± 0.09
WHO/FAO			20 - 100	10 - 18	3 - 20
NAFDAC			0 - 40	10 - 20	0 - 50

All values represent mean ± standard deviation of triplicate determination. **ND** = Not detected**, WHO** (1996) = World Health organization**, NAFDAC** = National Agency for Food and Drug Administration and control.

were also lower than the published threshold values for mature plant tissue, except Fe with higher level.

The published threshold values are: As, 5 to 10 mg/kg; Fe, 10 to 20 mg/kg; Cu, 20 to 100 mg/kg; Pb, 30 to 300 mg/kg and Zn, 100 to 400 mg/kg (Kabata-Pendias and Pendias, 1984). The critical values or values regarded as excessive are: Zn, >50 – 100 µg/g; Mn, >1000 – 4000 µg/g; Fe, >200 - 500 µg/g; Cu, >7 – 20 µg/g; Pb, >4 – 30 µg/g and Cd, >1 – 3 µg/g; depending on the plants (vegetables) in question (EC–UN/ECE, 1995). The order of the metals contamination in the vegetables was Fe > Cu > Zn in farm A and Cu > Fe > Zn in Farm B.

Statistical test of significance using the Student t-test and ANOVA, showed significant differences ($p < 0.05$) between the levels of the heavy metals in vegetables obtained from the sample sites in Farm A and those from Farm B, with exception of Cu which showed no significant differences ($p > 0.05$). The elevated level of Fe in vegetables in the two gardens could be attributed to excessive usage of fertilizers and other agro-chemicals, as well as the use of waste water in irrigating the soil and of course, the environmental factors in the areas (Uwah et al., 2011). Similarly, the elevated levels of the metals in the vegetables obtained in Farms A and B could be due to possible pollution as a result of the vast agricultural activities going on in the area, and downstream deposition of fertilizers and other agro- chemicals as the Yedzaram River flows into the area. The consumption of these vegetables as food may not pose possible health hazards to human at the time of the study.

Conclusion

Considering the health risk's encountered in diets as a result of high levels of heavy metals in vegetables, the maximum allowable levels of these metals in vegetables should not exceed levels that reflect good agricultural practices. Farmers should be educated on the problems associated with excessive usage of fertilizers and other chemicals, as well as irrigating the crops with waste and all sorts of polluted water and the needs to grow crops with safe levels of heavy metals.

The vegetables contained variable levels of heavy metals (Cd, Cr, Cu, Fe, and Zn), with the exception of those of Fe, the metals levels were lower than the published threshold values considered toxic for mature plant tissue. Similarly, the levels of some of the metals were lower that the established critical limits causing toxicity in plants.

Agronomic practices such as application of fertilizers and use of waste water can affect bioavailability and crop accumulations of heavy metals.

Consumption of these vegetables as food may not constitute possible health hazards to humans at the time of the study.

The results obtained in this study would go a long way in providing a baseline data for the assessment of the distribution of these metals in Spinach (*A. caudatus*) and rosella (*H. sabdariffa*) grown in Uba area in Adamawa State. Further, studies will be carried out on the concentration of the heavy metals in soil of the studied areas.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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