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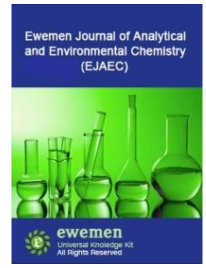

Full Length Research

DETERMINATION OF HEAVY METALS AND IONS IN VEGETABLE SAMPLES FROM WAWAH AND YIMIR- DHALANG AGRICULTURAL AREAS, KWAYA KUSAR LOCAL GOVERNMENT, BORNO STATE

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ABSTRACT

Vegetables grown on contaminated soil could take up and accumulate heavy metals and other ions at concentrations that are toxic to humans. Farmers in Kwaya Kusar Local Government Area of Borno State, Nigeria use large quantity of fertilizer in attempt to improving crop yield, which could be a source of metal contamination to the soils of the area. In this study, the levels of heavy metals were analyzed in selected vegetables grown in Kwaya Kusar, using Atomic Absorption Spectrophotometer (AAS). Results showed that Fe concentration was highest in all the samples analyzed with values ranging from 1.507 to11.650 µg/g. Cu, Co and Cr also indicated values ranging from 0.277 to 3.423 µg/g, 0.243 to 4.379 µg/g and 0.556 to 3.923 µg/g, respectively. In all samples analyzed, Pb showed the least concentration of 0.169 µg/g. The result also showed high concentration of cations and anions with Na^+ level ranging from 9.982 to 18.374 µg/g, K^+ from 11.331 to 35.474 µg/g , Ca^{2+} from 2.877 to 17.255 µg/g , NO_3^- from 1.397 to 7.909 µg/g , and SO_4^{2-} from 7.994 to 21.405. Daily intake of the metals through these vegetables was found to be above the recommended levels of 0.1-0.2 µg g^{-1} Cr, 0.3 µg g^{-1} Fe, 0.1 µg g^{-1} Pb, 0.1 µg g^{-1} Cu, 0.1 µg g^{-1} Zn, 0.1 µg g^{-1} Ni, 0.02 µg g^{-1} Cd and 0.3 µg g^{-1} Mn proposed by FAO/WHO. Thus, the high values of these metals in the vegetable samples could put the consumers of these vegetables at health risk.

Key Words: Heavy metals, vegetables, contamination, Kwaya Kusar, Bornu State.

INTRODUCTION

Heavy metals and ions are potential environmental contaminants with the capability of causing human health problems when consumed in excess through food or drink. They are given special attention throughout the world due to their toxic effects even at very low concentrations (Das, 1990). Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity had been reported (Jarup, 2003). Several reports have also confirmed that heavy metal can adversely affect metal and neurological functions as well as induced impairment in endocrine and immune system (Majolagbe *et al.,* 2011). Metal bioaccumulation is a major route through which increased levels of the pollutants are transferred across food chain/web creating public health concerns wherever man is involved in the food chain (Ambedkar *et al.,* 2011). The presence of heavy metals such as Pb and Cd in the environment has been a source of worry to environmentalists, government agencies and health practitioners due to their health implications and being non-essential elements of no benefit to human (Adebayo *et al.,* 2011). As trace elements, some heavy metals e.g. copper, selenium and zinc are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning (Cambra *et al.,* 1999).

Vegetable easily accumulate heavy metals and ions compare to grain and other plant materials, and high consumption of this vegetables could lead to toxic level of metals which could pose high health risk, hence the need to routinely analyzed the vegetable to ascertain wither they are contaminated or not. The major source of entry for heavy metals is through roots and leaves absorbing the chemicals from contaminated soil, water and air (Zurera *et al.,* 1989). Prolonged exposure to heavy metals such as cadmium, copper, lead, nickel and zinc can cause deleterious health effects in humans (Reilly, 1991). Heavy metal contamination may also occur due to irrigation with contaminated water, the addition of chemical fertilizers and metal-based pesticides, industrial emissions, harvesting process, storage and/or sale. These metals, due to their cumulative behaviour and toxicity have potential hazardous effects not only on plants but also on human health (Onianwa *et al.,* 2001; Konofal *et al.,* 2004; Kocak *et al.,* 2005; Audu and Lawal, 2005). For instance, Pb toxicity causes reduction in the haemoglobin synthesis, disturbance in the functioning of kidney, joints, reproductive and cardiovascular systems and chronic damage to the central and peripheral nervous systems (Ogwuegbu and Muhanga, 2005).

The study location, Wawah and Yimir-dhalang in Kwaya Kusar Local Government area located in the southern part of Borno State Nigeria. Kwaya Kusar has a total land area of 732 km^2 and a population of 56,500 at the 2006 census. The farmers in the location rely heavily on fertilizers and pesticides in their agrarian practices, which could be potential sources of heavy metals accumulation in soil, vegetable, and water bodies such as stream located within the area.

MATERIALS AND METHODS

Materials

All reagent used were of analytical standards and according to equipment specification.

Methods

Sample collection

Three vegetable samples, Spinach (*Amaranthus caudatus* L.), Sorrel (*Rumex acetosa* L.), Okra (*Abelmoschus esculentus* (L.) Moench) were collected as a whole (comprising of stem, leave and root) in six different farms each in Wawah and Yimmir-dhalang. The samples were wrapped in a plain paper bag, labeled and transported to Chemistry Research Laboratory University of Maiduguri. Sampling was done at least four times from each sampling location for each vegetable. The samples were collected from June to September, 2014.

Preparation and digestion of samples for heavy metal analysis

Vegetables samples collected were thoroughly washed with water, cut and separated into different parts (root, stem and leave) and dried in an oven at 80^oC for 72 hours. The dried samples were crushed in a mortar and the resulting powder was digested by weighing 1.0 g of the dried grounded sample into 250 mL beaker. 20 mL of HNO_3 was added and heated on a hot plate until no brown fumes was giving off. 10 mL of H_2O_2 was added in small portions to avoid any possible overflow leading to loss of material and the heating continue until the volume was reduced. 10 mL of HCl was finally added and evaporated to dryness. The mixture was cooled and then filtered through a Whatman No. 41 filter paper into a 100 mL volumetric flask and made up to mark with distilled water (USEPA 3050b).

Sample analysis

Determination of Heavy Metals

The digested vegetable samples were prepared and analyzed using Atomic Absorption Spectroscopy (Perkin Elmer Analyst 200). Heavy metals analyzed were manganese (Mn), cupper (Cu), chromium (Cr), cadmium (Cd), cobalt (Co), zinc (Zn), nickel (Ni), iron (Fe) and lead (Pb).

Determination of cations and anions

For the determination of nitrate, fresh vegetable samples were prepared by chopping each sample into smaller sizes. A known amount (1 g) of the chopped sample was transferred into 100 mL flask and soaked in 50 mL of distilled water. The flask was capped and shaken for 30 minutes and filtered into a 100 mL volumetric flask, and made up to mark with distilled water (Radojevic and Bashkin, 1999). Nitrate (NO_3^-) was determined by spectrophotometry using standard cadmium reduction method 3649 – SC (Lamotte, 2000).

For sulphate determination, 5ml of magnesium nitrate solutions were added to each of the ground and sieved samples in the crucibles. These were then heated to 180°C on a hot plate. The heating process was allowed to continue until the colour of the samples changed from brown to yellow (AOAC, 1994, 1998). The samples were then transferred to the furnace at a temperature of 500°C for four hours. Magnesium nitrate was added to prevent loss of sulphur. The contents of each crucible were carefully transferred to different evaporating basins. 10 mL of concentrated HCl were added to each of them and covered with watch glasses. They were boiled on a steam bath for 3 minutes. On cooling, 10 mL of distilled water were added to each of the basins and the contents of each were filtered into 50 mL volumetric flasks and the volumes made up to marks with distilled water (Radojevic and Bashkin, 1999). Sulphate (SO_4^{2-}) was determined using Smart spectrophotometer model 2000.

Sodium (Na^+), potassium (K^+) and calcium (Ca^{2+}) were determined by analyzing the digest from sulphate determination using UV Smart spectrophotometer.

RESULTS AND DISCUSSION

The concentration of heavy metals and ions varied among the different parts of the vegetable samples as shown in Figure 1-6. The order of concentration of the metals and ions in the samples analyzed was Fruit>leaves>stem>root. Figures 1, 2 & 3 showed the concentrations of heavy metals, while Figures 4, 5 & 6 showed the concentrations of cations and anions, in spinach, sorrel and okra, respectively. The range of concentration were: Mn; 0.242 to 3.541 µg/g, Cu; 0.277 to 3.423 µg/g, Cr; 0.556 to 3.923 µg/g, Cd; 0.305 to 6.095 µg/g, Co; 0.243 to 4.379 µg/g, Zn; 0.289 to 4.081 µg/g, Ni; 0.304 to 6.712 µg/g, Fe; 1.507 to 11.650, Pb; 0.169 to 1.186 µg/g, Na^+; 9.982 to 18.374 µg/g, K^+; 11.331 to 35.474 µg/g, Ca^{2+}; 2.877 to 17.255 µg/g, NO_3^-;1.397 to 7.909± µg/g, and SO_4^{2-} 7.994 to 21.405 µg/g.

Santimaria *et al.* (1999), reported that in vegetables organs the concentrations of heavy metals are in the order of leaf> stem> root> tuber> bulb> fruit> seed. Study by Akan *et al.* (2009), shows a similar pattern. The result of this study shows concentration in the order Fruit>leaves>stem>root. As vegetable absorbs nutrient from the soil, they also take toxic metals together which are often transported to the leaves and fruit of the vegetable. Akan *et al.* (2009), also report high concentration of heavy metals in vegetables. Some of the concentration of heavy metals in the studied vegetables were higher than the FAO/WHO guideline values of 0.1-0.2 µg/g Cr, 0.3 µg/g Fe, 0.1 µg/g Pb, 0.1 µg/g Cu, 0.1 µg/g Zn, 0.1 µg/g Ni, 0.02µg/g Cd and 0.3 µg/g Mn, as reported by Akan *et al*. (2009). The nitrate and sulphate were within permissible limits.

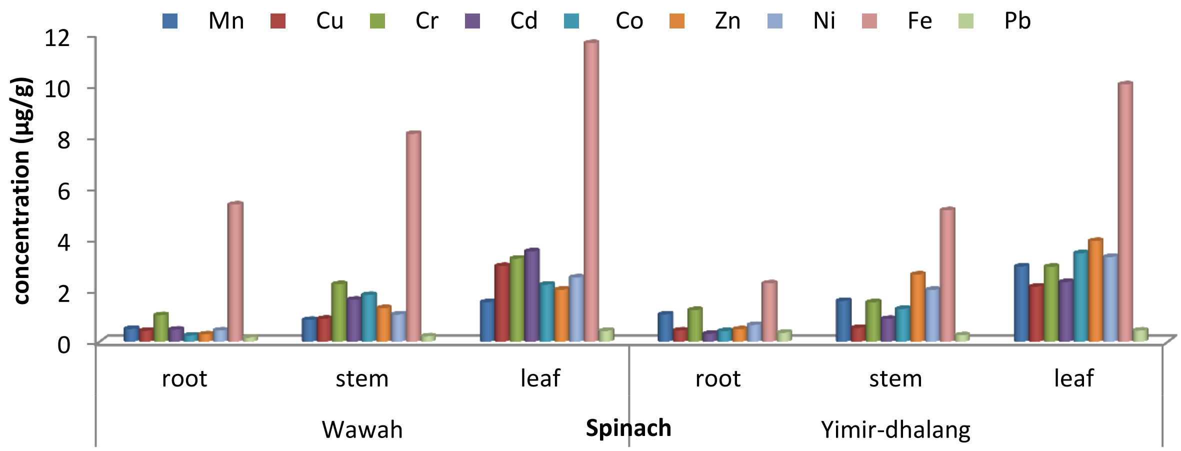

Figure 1: Mean concentration of heavy metals in Spinach samples

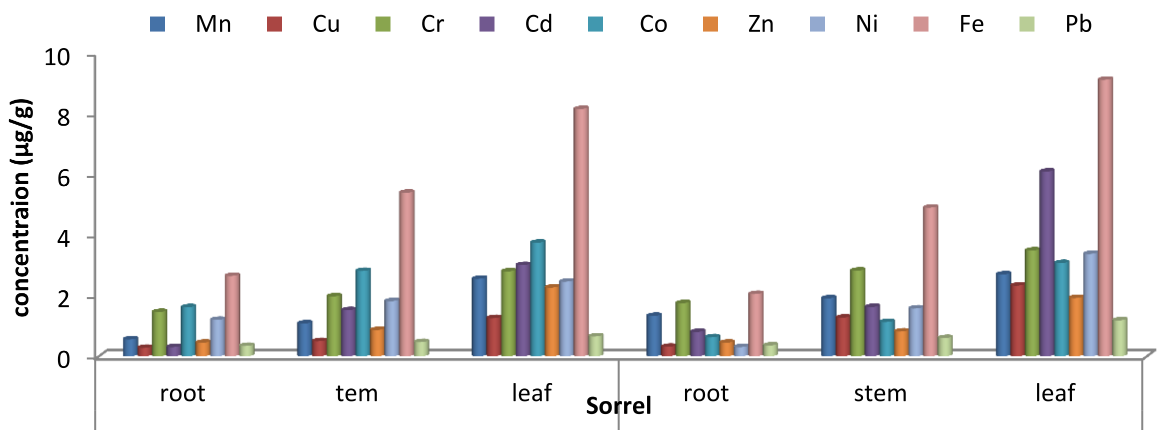

Figure 2: Mean concentration of heavy metals in Sorrel samples

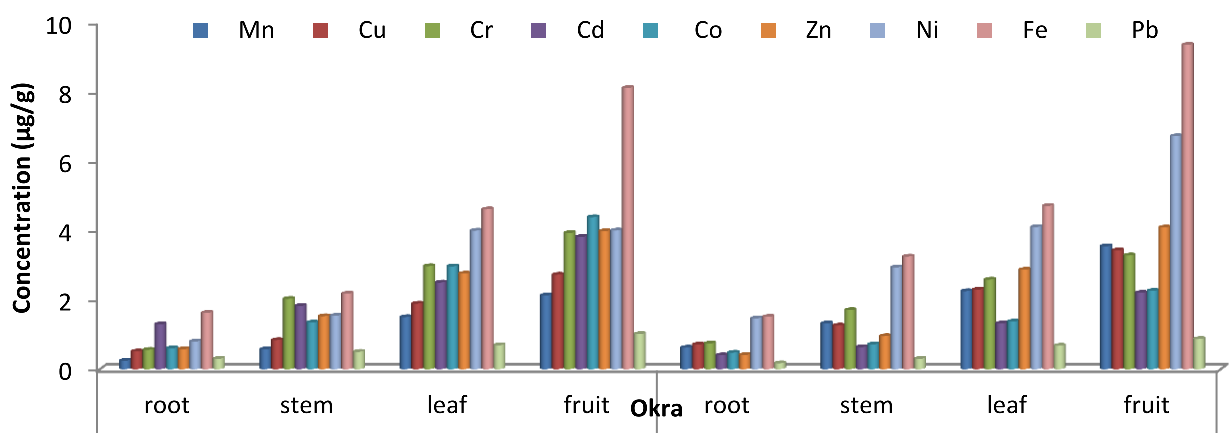

Figure 3: Mean concentration of heavy metals in Okra samples

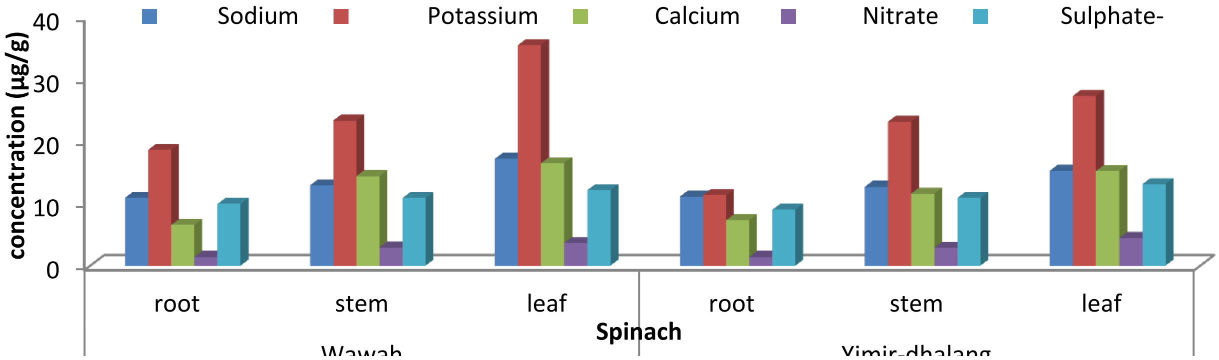

Figure 4: Mean concentration of cations and anions in Spinach samples

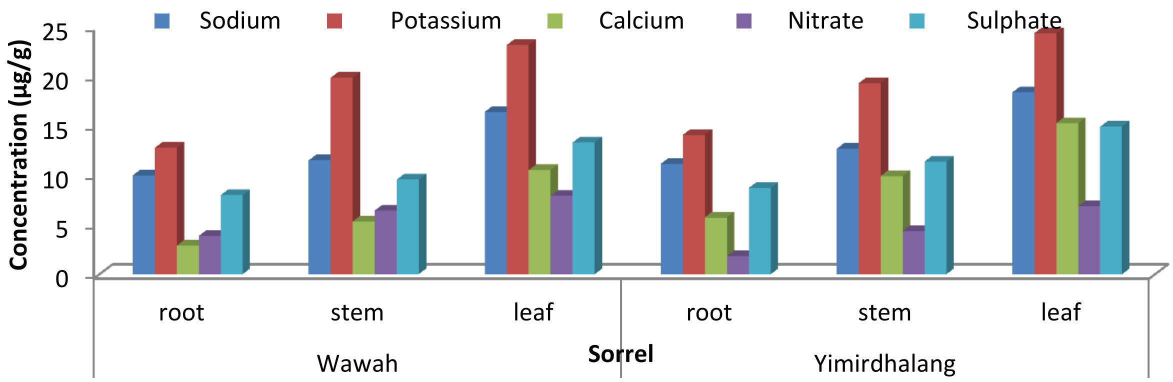

Figure 5: Mean concentration of cations and anions in Sorrel samples

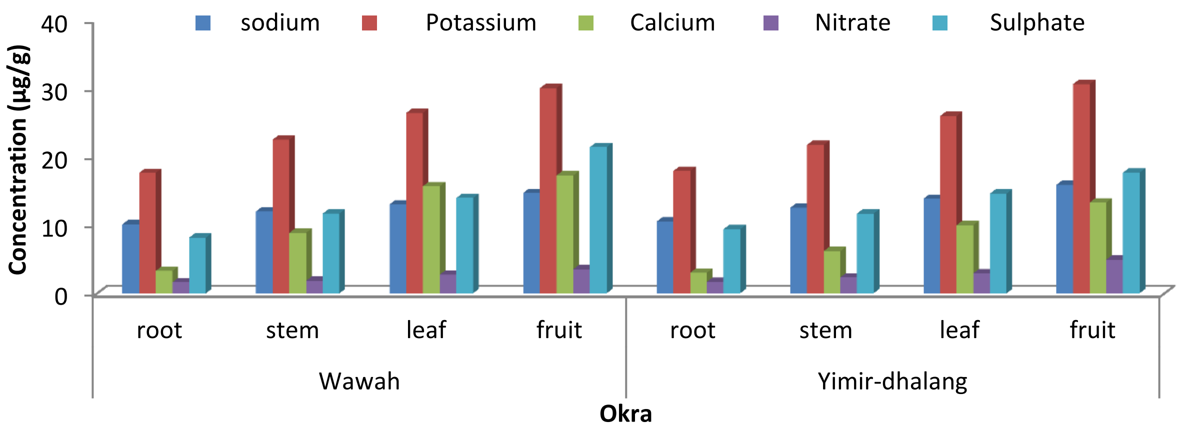

Figure 6: Mean concentration of cations and anions in Okra samples

The high concentration of heavy metals in vegetables could be attributed to high use of inorganic fertilizers, organic manure from sewage or use of industrial effluent for irrigation by some of the farmers in the study area. Result of analysis of variance (ANOVA) showed that variation between vegetable parts were statistically significant ($p<0.05$).Variation of concentration of the metals and ions analyzed could be due to difference in soil properties of the study location or activities engage in by the farmers.

CONCLUSION

The levels of heavy metals and ions in the study locations were high and continuous consumption of vegetable from this location could endanger the health of consumers hence the need for relevant authorities to checkmate and regulate practice that lead to vegetables and other plant contamination.

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