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Full Length Research Paper

A Study on the Bioaccumulation of Trace Metals in Vegetables Cultivated near Refuse and Effluent Dumpsites along Rumude-Doubeli Bye-pass in Yola North, Adamawa State

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***Amaranthus* spp, *Hibiscus sabdariffa and Lactuca sativa* grown around refuse and effluent site were analysed for five (5) heavy metals viz: cadmium (Cd), copper (Cu), manganese (Mn), lead (Pb) and zinc (Zn) by atomic absorption spectrophotometric method. Analysis of the results showed that the concentration of the analysed metals ranged from 10.00 – 16.67 mg/kg cadmium, 30.02 – 43.33 mg/kg copper, 40.82 – 70.50mg/kg manganese, 5.02 – 8.80 mg/kg lead and 29.16 – 30.00 mg/kg zinc. Data showed that metal uptake differences by the vegetables are attributed to plant differences in tolerance to heavy metals and vegetable species. The cadmium and lead concentrations in all the vegetable samples were more than the maximum permitted concentrations proposed by FAO/WHO while manganese, copper and zinc concentrations were below the maximum permitted concentrations. But with increase in vegetable consumption by the community, the situation could worsen in the future due to the high level of cadmium and lead accumulation which have damaging effect on both plants and animals. However, the regular monitoring of concentration levels of these metals from refuse and effluents, in vegetables and in other food materials is essential to prevent excessive build-up of these metals in the food chain.**

Keywords: Heavy metals, effluents, concentration, lead, vegetables, bioaccumulation.

INTRODUCTION

Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins, minerals and trace element (Abdola and Chmtelnicka, 1990).

Heavy metals are defined as those metals with densities greater than 5g cm^{-3}. Heavy metals are commonly referred to as trace metals. One of the anthropogenic sources of metals in surface water includes domestic waste and garbage. Therefore the metals find their way leaches into the soil where plants may be bioconcentrated in the food chain. The result is that some plants may represent a serious hazard if consumed as food (Miroslay and Vladimir, 1998). Soil is

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considered as the upper part of the earth crust that supports plant growth (Ndiokwere, 2003). Heavy metals are persistent contaminants of soils coastal waters and sediments. They can affect both the yield of crops and their composition (Rashad, and Shalaby, 2007).

Heavy metals like Cu, Co, Zn, Fe, and Mn at low concentrations are essential metals for enzymatic activity and many biological processes. Other metals such as Cd and Hg have no known essential role in the body of living organisms and are toxic even at low concentrations. The essential metals also become toxic at high concentration (Jonathan and Maina, 2009).

Before the technological age, environmental pollution was due to naturally occurring phenomena such as bush burning, volcanic eruption and very little from human activities. Owing to the increase in technological innovations, a lot of chemicals are emitted into the environment both in urban and rural areas. These chemicals cause hazards to man and his environment, causing pollution. They are often accumulated in significant increasing concentrations in estuaries, seas, soil and food. The soil is a key component of the terrestrial ecosystem. Being essential for agriculture therefore, contamination of the environment by heavy metals is a serious development affecting soil (Heaton, 1986). Contamination of the soil where plants are grown leads to contamination of plants and animals who feed on them and invariably the health of the human person is at risk of being affected (Willis and Saviry,1995; Kakulu, et al., 1987; Alloway, 1990; Alloway and Ayres,1993; Tuzen, 2003).

Trace metals are metals in extremely small quantities that reside in or are present in animals and plants cells or tissues. They are a necessary part of good nutrition, although they can be or are toxic if ingested in excess quantities. Trace metals are depleted through the expenditure of energy by a living organism. They are replenished in animals by eating plants, and in plants they are replenished by or through the uptake of nutrients from the soil in which the plants grow.

Toxic metals bio-accumulate in the body via the food chain. Toxic heavy metals may affect germination, young or old trees stem growth, leaf formation, root growth, flowering, fruiting, plant growth rate and biomes photosynthesis, transpiration, mineral nutrition and secondary metabolism. Chemicals come and go but rarely disappear completely from our ecosystem. Effective management of contaminants in the environments is a complex and challenging problem with worldwide ramifications. Heavy metals are emitted into the atmosphere in variety of strong points and large diffuse sources, thus one of the most powerful emission source is garbage (Alloway and Ayres, 1993)

Amaranthus spp belongs to the family; Amaranthaceae. *Amaranthus* spp is also known as Spinach or green leaf.

Nigerian vernacular names include Alaiyahu (Hausa), Inine (Igbo) and Efo tete (Yoruba).

Amaranthus spp is usually a short-lived annual vegetable, up to 1m in height. The stems are erect, often thick and fleshy, sometimes grooved. The leaves are variable in shape, green and purple, normally alternate, petiolate and entire, tips often obtuse. The nutritional content of the leaves of various species of *Amaranthus* varies, but in general, the leaves of plants of most species contain high level of vitamin A, calcium and potassium. The fresh leaf contain 85% water; 5.0% protein, 0.7% fat, 5.0% carbohydrate and 1.5% fibre (Tindall, 1986). The oxalic acid content of various species of *Amaranthus* have been investigated by several research workers and a review of this subject has also been given by Grubben (1976).

Hibiscus sabdariffa belongs to the family of malvaceae. Common names include Roselle and Sorrel. Nigerian vernacular name of *Hibiscus sabdariffa* include Yakuwa (Hausa), Isapa (Yoruba) and Arire (Igbo).

Hibiscus sabdariffa is an erect branched woody annual herb, up to 3m in height. It has vigorous main or tap root. The stem is red or green, branching. The leaves are alternate, petiole 2-10cm long, lower leaves often ovate, upper leaves 3-5-loped, palmate, 7-15cm in length. The young shoots and leaves are eaten either raw or as a cooked vegetable; also the swollen calyces of the flowers are also used in the preparation of beverages and jellies. The calyces are often dried and store for use during the dry season. The nutritional values of the leaves are as follows: 85% water, 3.3% protein, 0.3% fat, 9.0% carbohydrate, and 1.6% fibre. The leaves contain calcium, phosphorus, iron and some vitamins such as ascorbic acid, niacin and riboflavin. The calyces contain 86% water, 1.6% protein, 0.1% fat, 11% carbohydrate and 2.5% fibre. The calyces also contain the mineral and vitamin as that in the leaves but in different percentages (Tindall, 1986).

Lactuca sativa belongs to the family of Asteraceae. *Lactuca sativa* also known as lettuce. Nigerian vernacular names of *Lactuca sativa* include: Ihe-asa (Igbo), salat (Hausa) and Eweba (Yoruba).

Lactuca sativa is grown for local consumption in the tropics. It is cultivated by market gardeners near towns. *Lactuca sativa* is grown for its leaves, which are usually eaten fresh. The dried leaves of the European type are used for the manufacture of the drug *Lactucarium*. when the plant flowers, the leaves become bitter and are no more fit for consumption. The fresh leaf contain the following nutrient: water 94.3%, protein 1.2%, fat 0.2%, carbohydrate 2.9%, fibre 0.7%, ash 0.7%. The leaf is rich in vitamin A and E; and also Ca, P, Na, Mg and K. *Lactuca sativa* is an annual herb with thick lactiferous leaves. The tap root develops quickly; it is slender at the early stage but later thickens and grows down to 1.5m. The stem at first is short and the leaves are arranged spirally. The shape and size of leaves vary according to

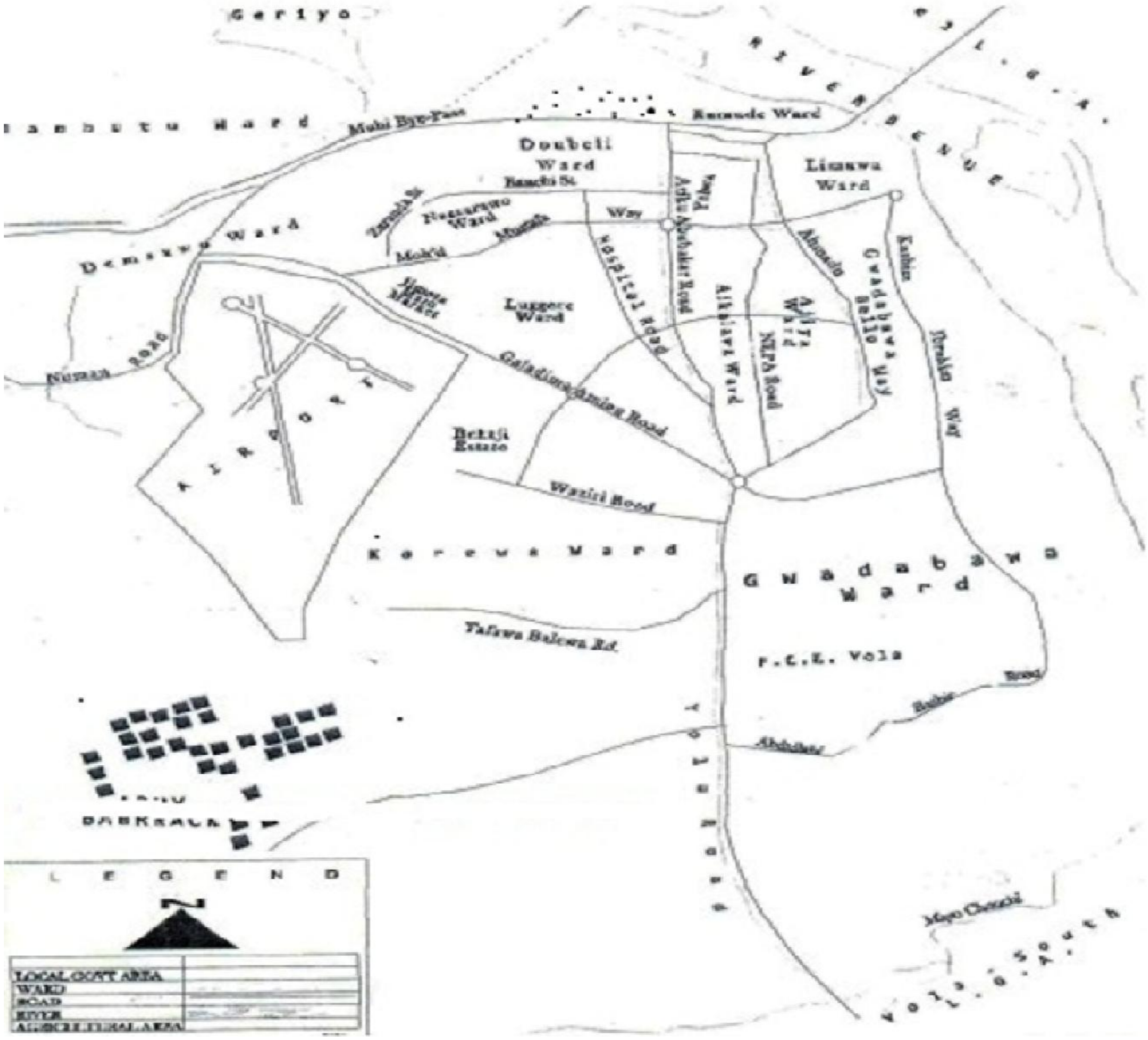

Figure1. Map of Jimeta showing sampling site.

Cultivar. Some form "head", like Cabbage, while others are loose-leaf types. This latter type grows faster. Flowers are few, all ligulate and hermaphrodite, pale yellow, exerted above the involucres (Udoh et al., 2005). In recent years consumption of these vegetables is increasing gradually, particularly among the urban community due to increased awareness on food value.

This study was carried out to investigate the extent to which refuse and effluents affect the concentration as well as the accumulation of some trace metals in leafy vegetables (*Amaranthus* spp, *Hibiscus sabdariffa* and *Lactuca sativa*). Since the uptakes of these trace metals by the leafy vegetables is an avenue of their entry into the human food chain with harmful effects on health.

MATERIALS AND METHODS

Study area

The area of this research is situated in Rumude-Doubeli bye-pass, Jimeta municipal in Yola-North local government area. It lies between latitude 09^{0} 28^{I}N and longitude $12^{0}47^{I}$E. Jimeta is the headquarter of Yola-North local government area located in Adamawa

Table 1. Heavy metal concentration of vegetable sample (mg/kg).

Sample	Cd	Cu	Mn	Pb	Zn
Amaranthus spp	15.83	43.33	69.12	8.40	29.50
Hibiscus Sabdariffa	16.67	33.33	40.82	8.80	30.00
Lactuca sativa	10.00	30.11	70.50	5.02	29.12
WHO-ML	0.10	73.00	500.00	0.30	100.00

state, Nigeria. Jimeta is bounded to the south by Yola-south Local Government Area and to the north by Girei Local Government Area. It has precipitation ranges from 600-750 mm per Annum and an altitude of 136m above sea level. Jimeta covers a total area of about 109km^2 with estimated population of 248148. Jimeta is the administrative and commercial center of the state and ever since the creation of the state it has been experiencing rural-urban drift. Due to this rural-urban drift, infrastructures lag behind the population growth. This growth has also affected the land use pattern. From this perspective, the area under study is used as the general dumpsite in the urban. It is also from this area that vegetables consumed wiithin the municipal are being cultivated to feed at least 60% of the entire population.

The map of jimeta showing the sampling site is shown on Figure 1.

Sample collection, preparation and determination

Amaranthus spp, *Hibiscus sabdariffa* and *Lactuca sativa* leaves were collected from the farm in the month of February, 2012 where garbage's and effluents were dumped. These samples were immediately sent to Botany Department, Federal University of Technology, Yola, for identification. The samples were thoroughly washed and air-dried at room temperature and pounded into fine powder (Simon, 1979). 10 g of the fine powder from each site were ashed in the muffle furnace for 3 hrs at 650^{o}c. About 1.0g of each of the ashed samples were further digested with concentrated nitric acid and perchloric acids and the digest made up to 50ml with nitric acid (Iornumbe and Onah, 2008). These solutions were analyzed for Pb, Cu, Zn, Mn, Cd, as described for the plant materials using Buck Scientific Atomic Absorption Spectrophotometer 205. Guide lines for maximum limit (ML) of metals in vegetables were adopted from FAO-WHO (Table 1).

RESULTS AND DISCUSSION

Concentrations of some of the trace metals found in vegetables were summarized in Table 1. From the results obtained, the three samples *Amaranthus* spp, *Hibiscus sabdariffa* and *Lactuca sativa* all contain the investigated trace metals which are Cadmium, Copper, Lead, Manganese and Zinc. This is a step in evaluating and testing of edible grades of vegetable across the state. Lead which is toxic and hazardous to man was found to be within the range of 5.02 to 8.80 mg/kg in the samples. Cadmium had its lowest concentration of 10.00 mg/kg in *Lactuca sativa* and highest concentration of 16.67 mg/kg in *Hibiscus sabdariffa*. Zinc occurred in all the samples investigated in varying concentrations, with the highest concentrations of 30.00 mg/kg detected in *Hibiscus sabdariffa*. While the lowest concentration of 29.12 mg/kg was detected in *Lactuca sativa*. Manganese was found to be the highest in concentration as it ranged from 40.82–70.50 mg/kg. Copper was found to be high in *Amaranthus* spp (43.33 mg/kg) and low in *Lactuca sativa* (30.11 mg/kg). Comparison of the metal concentrations in vegetables with the guidelines for vegetables proposed by FAO/WHO showed that zinc, manganese and copper concentrations are below the guidelines for vegetables but cadmium and lead concentrations are above the maximum permitted level proposed by FAO/ WHO guidelines.

Data showed that in all the vegetables, the highest concentrations of cadmium and lead accumulation are in *Hibiscus sabdariffa.* On the whole, all vegetables that were studied in this study, were contaminated by cadmium and lead and they were toxic to consumer.

The introduction of lead into the food chain may affect human health and thus, studies concerning lead accumulation in vegetables have increasing importance (Coutate, 1992) so also cadmium. Furthermore, consumption of heavy metals-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho-social behavior, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora et al., 2008)

CONCLUSION

From the results obtained, it is seen that the study area is an inhabitant of heavy metals, like Copper, Manganese, Lead, Zinc and Cadmium. As much as these metals are good in maintaining a balance health, condition their tendencies of being toxic have given rise to this research. This research is meant to stand as a guide to other researchers, nutritionists, and agriculturists who seek information on the level of trace metals in crops grown in the study area and also give anyone who has the opportunity of laying hands on this research the knowledge of the effects associated with the intake of these vegetables.

Perhaps the most important conclusion that may be drawn from this study, is that since vegetables tend to absorb and accumulate cadmium and lead then the vegetables should not be cultivated in that area or the government should set up an environmental protection committee in the area to stop refuse dumping in the area. The author strongly recommends that people living in this area should not eat large quantities of these vegetables harvested from this area, so as to avoid excess accumulation of heavy metals in the body. Thus regular monitoring of these toxic metals from the refuse and effluents dumpsite, in vegetables and other food materials is essential, to prevent their excessive build-up in the food chain.

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