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HEALTH RISK ASSESSMENT OF HEAVY METALS IN LEAVES OF SOME EDIBLE VEGETABLES IN BAUCHI AND SOIL IN BAUCHI METROPOLIS

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Abstract: *Health risk index of these heavy metals Cd, Cr, Fe, Zn and Pb have been determined on two vegetables sample (Amaranthuscaudatus and Hibiscus cannabinus), around Gombe road in Bauchi metropolis. The level of the heavy metals in the soil where the vegetables grown were determined. Analysis of the soil and the vegetables samples revealed that, the mean conc. Of the Cd, Cr, Fe, Zn and Pb in Amaranthuscaudatus were, 0.00, 19.4, 275, 12.5 and 0.00 mg/kg, in Hibiscus cannabinus were 0.5, 8.5, 275, 1.5 and 0.00 mg/kg and in the soil were 1.0, 144, 2000, 38 and 14.5mg/kg respectively. All the values obtained were below the permissible limit recommended by WHO/FAO. Only Cd in Hibiscus cannabinus exceeded the maximum permissible limit and it has to be monitored in order to prevent Cd disease outbreak.*

Keyword: Heavy Metal, DDI, DIM HRI THQ and Bauchi
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INTRODUCTION

Heavy metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities, and humans are exposed to them through various pathways (Wilson and Pyatt 2007). Wastewater irrigation, solid waste disposal and sludge application are the major sources of soil contamination with heavy metals, and increase metal uptake by vegetable grown on such contaminated soil is often observed.

In general, wastewater contains substantial amount of beneficial nutrients and toxic heavy metals which are creating opportunities and problems for Agricultural production (Sajjad *et al.,* 2009). Wastewater may contain various heavy metals including Zn, Cu, Pb, Mn, Ni, Cr, Cd, depending upon the type of activities it is associated with. Heavy metals are generally not removed even after the treatment of wastewater at sewage treatment plants, and this cause risk of heavy metal contamination of the soil and the subsequently to the vegetable. (Fytianos *et al*, 2001). Intake of heavy metals through the food chain by human population has been widely reported throughout the world (Muchuweti *et al*., 2006). Due to the non-biodegradable and persistent nature, heavy metals are accumulated in vital organs in the human body such as the kidneys, bones and liver and are associated with numerous serious health disorders (Duruibe *et al*., 2007). Individual metals exhibit specific signs of their toxicity. Lead, As, Hg, Zn, Cu and Al poisoning have been implicated with gastrointestinal (GI) disorders, diarrhea, stomatitis, tremor, hemoglobinuria causing a rust-red colour to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia (McCluggage, 1991). The nature of effects can be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic (European Union, 2002). Vegetables, cereals and milk are major components of human diet, being source of essential nutrients, antioxidants and metabolites in food items. In the present study, the concentrations of heavy metals in locally produced vegetables, cereals and milk were quantified throughout a year at a suburban area of Varanasi city of India, where treated and untreated wastewater has been used as a source of irrigation water for about 20 years. The contamination levels in soil and vegetable/cereal crops were evaluated with respect to the prescribed safe limits of different heavy metals set under national and international norms. Milk is not directly contaminated by wastewater irrigation, but provides insight into the food chain transfer of heavy metals from fodder grass to the milk of animals. A number of standard measures were used to assess the health risks associated with the measured levels of heavy metal contamination at the study sites.

STUDY AREA

A very large farmland is chosen for the experiment along Gombe road in Bauchi in order to achieve the goal of the work. Gombe road is one of the major sources of vegetables in Bauchi and is a place where most of the sewage sludge is disposed. Therefore investigation has to be carried out on the contaminated soil and the vegetables grown on such contaminated soil.

MATERIALS AND METHODS

All the reagents that will be used are of analytical grade, chemicals and all the glassware, containers and tools will be washed with liquid detergent first, rinsed with 20%($^{v}/_{v}$) nitric acid and finally rinsed with distilled water. The container, and glassware will kept in Oven until needed. Distilled water will be used through out the work.

SAMPLE COLLECTION

The samples were collected at Gombe road, Bauchi state. They were randomly collected within the farmland. Polyethane bags were used to keep the samples fresh before taking them to laboratory for analysis. Two vegetables samples were collected; *Amaranthuscaudatus* and *Hibiscus cannabinus*. The same soil was collected from the same farm land, it was randomly collected at a depth of 15cm from the surface soil. All the samples were air dried, grinded, passed through 2mm sieve and packaged in a cleaned container properly labeled.

Vegetables and Soil Sample Analysis

Ground vegetable and soil samples of 2.0g each was weighted and placed into a conical flask previously washed with acid and distilled water. 4ml of perchloric acid, 25ml conc. HNO_3 and 2ml conc. H_2SO_4 were added under fume hood. The content was mixed gently at low medium heat on a hot plate under fume hood. Heating continued until dense white fumes disappear, the mixture was allowed to cool and then 40ml De-ionized water was added and boiled for a minute under the same hot plate. The solution was allowed to cool then filtered for atomic absorption spectrometry (Perkin-Elmer Corp, 1968)

Transfer Factor

Transfer factor can be calculated using Sajjad*et al.*, (2009) method who defined it as the relative tendency of a metal to be accumulated by a particular species of plant this is dependent on the pH and the nature of the plant it self.

$$T.F. = \frac{Conc\ of\ metal\ in\ edible\ part}{conc\ of\ metal\ in\ the\ soil}$$

Daily Intake of Metal (DIM)

The DIM will be calculated to averagely estimate the daily metal loading into the body system of the specified body weight of a consumer. This will inform the phyto-availability of metal the DIM in this study will be calculated based on the formula proposed by Sajjad*et al.*, (2009)

$$DIM = \frac{C_{conc\ metal} \times C_{factor} \times D_{food\ intake}}{B\ W_{average\ body\ weight}}$$

Where: C = heavy metals conc. in plant (Mg/kg)
C = conversion factor
D = Daily intake of vegetables

The conversion factor of 0.085 is to convert fresh vegetable weights to dry weight (Sajjad*et al.*, 2009) while average body weight to be used is 65kg for this study.

Daily Dietary Intake (DDI)

The DDI of metals expresses the dietary availability of metals in a particular food. The DDI therefore differs from later in the sense that it gives approximate available metals in a food and essential in the risk assessment of metals.

The DDI of metal will be determined by the following formula:

$$\text{DDI} = \frac{X \times Y \times Z}{B}$$

Where X = metal in vegetable

Y = Dry weight of the vegetable

Z = approximate daily intake

B = average body weight in this study will be 65kg

RESULTS AND DISCUSSION

This section of the chapter deals with the presentation of the results obtained from the health risk index of heavy metals (Cd, Cr, Fe, Zn and Pb) in *Amaranthuscaudatus, Hibiscus cannabinus* and the soil where these vegetables were grown. Using Atomic absorption spectrophotometer technique (AAS), analysis of the results obtained and interpretation of the results of the concentration of the heavy metals obtained in the vegetables and the soil sample by comparing them with the critical concentration of the heavy metals forward by the world health organization (WHO) 2007.

Table 1.0 Showing the AAS Result Obtained for the Vegetables and the Soil Sample from Gombe Road Bauchi

HM	*Amaranthuscaudatus* Conc. (mg/kg)	*Hibiscus cannabinus* Conc. (mg/kg)	Soil Conc. (mg/kg)
Cd	0.00	0.5	1.0
Cr	19.0	8.5	144
Fe	275	275	2000
Zn	12.5	1.5	38
Pb	0.00	0.00	14.5

The result showed that, in the *Amaranthuscaudatus,* Fe has the highest value (275mg/kg), Cd and Pb have the lowest or no value (0.00 mg/kg). In the *Hibiscus cannabinus* Fe still has the highest value (275 mg/kg) and Pb has the lowest or no value (0.00 mg/kg) while in the soil Fe also has the highest value (2000 mg/kg) and Cd has the lowest value (1.00 mg/kg) as shown in table 2. The trend in the plant is Fe>Cr>Zn>Cd>Pb and trend in the soil is is Fe>Cr>Zn>Pb>Cd. The variation of the heavy metals in the plant and the soil is due to the differences in the sources of the metals. Some of the metals are already present in the plant and the soil will contribute to the metal bioavailability. The total metal concentration of plant in this study was contribution of the plants part.

Table 2.0 Comparative Heavy Metals Concentration (Mg/Kg) in Soil Samples with Similar Work Reported in the Literature and the Maximum Permissible Limits in some Countries.

HM	Conc. In SOIL (mg/kg)	Wu yaoGuo 2010 (mg/kg)	Great Bratain (mg/kg) *	USEPA (pmm)**
Cd	1.0	0.55	3	3
Cr	144	44.72	50	400
Fe	2000	ND	NA	NL
Zn	38	118.06	300	200
Pb	14.50	216.96	400	300

*Maximum permissible limit of metals (mg/kg) in soil in Great Britain

** Maximum permissible limit of metals (ppm) in soil by USEPA

ND: Not determine

NA: Not analyzed

NL: No limit

The comparative heavy metals of soil (mg/kg) presented in (table 3) above showed a significant difference from the one reported in the literature by Wu *et al*,. (2007).The result in this study is less than the Britain and Japan standard permissible limit of metals in the soil of these countries with the exception of Cr. Cd is greater than Japan standard permissible limit but less than the Britain permissible limits. These toxic heavy metals have to be monitored to prevent further outbreak of their diseases.

Table 3.0 Comparative Heavy Metals Conc. (mg/kg) in Vegetable Sample with Maximum Permissible Limit in Some Countries and WHO/FAO/India

HM	*Amaranthuscaudatus* Conc. (mg/kg)	*Hibiscus cannabinus* Conc. (mg/kg)	Indian standard Conc. (mg/kg)	Anthony bahot 2005 Conc. (mg/kg)	**WHO/FAO
Cd	0.00	0.50	1.50	0.361	0.2
Cr	19.0	8.50	20.0	ND	NA
Fe	275	275	NA	ND	5.0
Zn	12.5	1.50	50.0	54	60
Pb	0.00	0.00	2.5	4.31	5.0

Source: *Anita *et al.*, (2010) **WHO/FAO (2011)

The result of heavy metals (Table 4.0) in vegetable in this work were compared with similar work reported by Anthony and Balwant (2005) as this work were less than that of the compared results and in some cases higher than the maximum permissible limit of the Indian standard and WHO/FAO (2007). Example, Cd in *Hibiscus cannabinus* is higher than the maximum permissible limit when compared with WHO/FAO/Indian standard (2007). Therefore, it has to be monitored in order to prevent further outbreak of Cd sickness.

Table 4a. Different Parameters for *Amaranthuscaudatus*

HM	Conc. In soil (mg/kg)	Conc. In Vegetable (mg/kg)	HQ	DIM	HRI	TF
Cd	1.0	0.00	0.00	0.00	0.00	0.00
Cr	144	19.0	4.52	0.89	0.39	0.14
Fe	2000	275	0.35	12.59	0.30	0.14
Zn	38	12.5	0.07	0.57	0.01	0.33
Pb	14.5	0.00	0.00	0.00	0.00	0.00

HQ: Hazard quotient

DIM: Daily intake of metal

HRI: Health risk index

TF: Transfer factor

Table 4b. Different Parameters for *Hibiscus cannabinus*

HM	Conc. In soil (mg/kg)	Conc. In vegetables (mg/kg)	HQ	DIM	HRI	TF
Cd	1.0	0.5	1.346	0.023	0.115	0.5
Cr	144	8.5	1.989	0.389	0.169	0.059
Fe	2000	275	0.348	12.587	0.295	0.138
Zn	38	1.5	0.008	0.669	0.001	0.039
Pb	14.5	0.00	0.00	0.00	0.00	0.00

The availability of a metal species in its different forms to migrate from the soil through the plants part and makes itself available for consumption was represented by TF the transfer factor as seen in figure 1. The transfer factor is a function of different factors such as soil, pH, soil organic matter, metal availability and soil particle size.

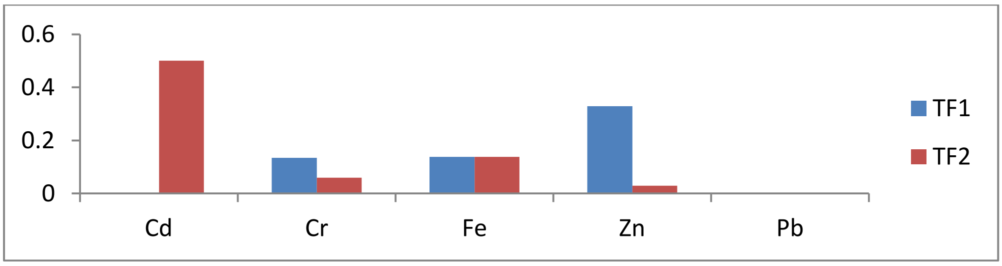

Figure1. TF for both plants

TF1: for *Amaranthuscaudatus*

TF2: for *Hibiscus cannabinus*

It is found that Zinc has the highest TF value (0.329) in the *Amaranthuscaudatus* and Cd has the highest TF value (0.5) in the *Hibiscus cannabinus*. The trends of heavy metals follows Pb>Zn. This could be attributed to the high retention of the metals in the soil. Sridthara Chary *et al.*, (2008) also reported that high TF for heavy metals through leafy vegetables. The TF does not present the risk associated with the metals in any form.

DIM

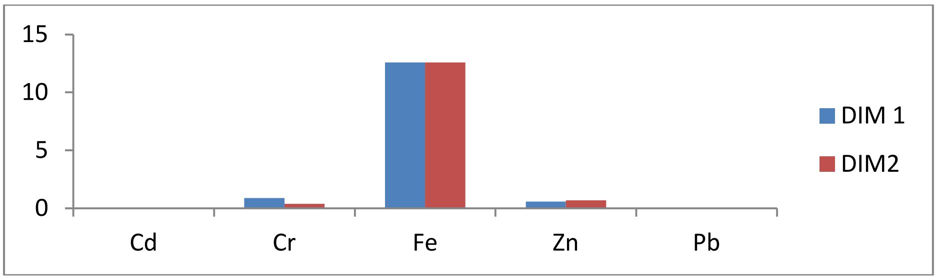

Figure2. DIM for both plants.

DIM1: for *Amaranthuscaudatus*

DIM2: for *Hibiscus cannabinus*

The DIM as a function of body weight and intake, Fe has the highest conc. (275 mg/kg) and the highest DIM (12.587) in both plants. The trend of DIM is found to be in the order of fe>Cr>Zn>Cd>Pb

HRI

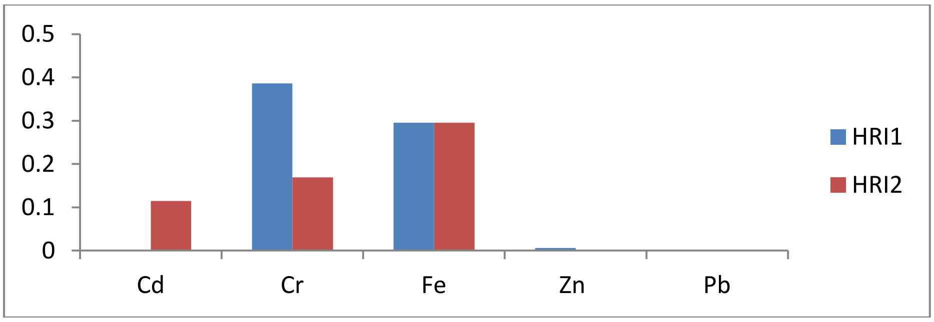

Figure 3.Health Risk Index for both plants.

HRI1: for *Amaranthuscaudatus*

HRI2: for *Hibiscus cannabinus*

Health risk index for many metals in *Amaranthuscaudatus* and *Hibiscus cannabinus*and presented in fig 3. The results showed that the order of HRI in *Amaranthuscaudatus* is Cr>Fe>Zn>Cd>Pb and in Hibiscus cannabinus Fe>Cr>Cd>Zn>Pb. This simply means that the inhabitants are highly expose health risk associated with these metals in the order Pb>Cd>Cr>Zn>Fe.

HQ

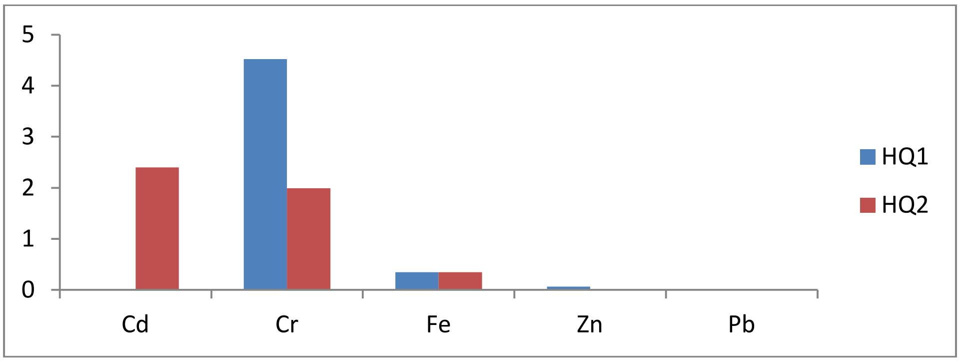

Figure4. Hazard Quotient value for heavy metals in both plants.

HQ1: for *Amaranthuscaudatus*

HQ2: for *Hibiscus cannabinus*

The HQ for Fe and Zn is less than 1. Therefore, it does not poses concern, but it values are very high in Cr and Cd as seen in figure 4. This simply means the inhabitants are highly exposed to Cr and Cd health risk to the great extents.

CONCLUSION

Based on the results obtained from the analysis using AAS technique and the analysis made by comparing the detected concentration of these heavy metals (Cd, Cr, Fe, Zn and Pb) in *Amaranthuscaudatus, Hibiscus cannabinus* and the soil sample with the recommended concentration put forward by the World health organization (WHO). It is now concluded that these vegetables are safe for public consumption as they do not contain the amount of the heavy metals that would constitute danger of metal poisoning and are not at alarming levels.

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