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Health Risk Assessment of Heavy Metals in Samples of some Edible Vegetable Leaves sold in Samaru Market

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ABSTRACT

The present study was conducted to determine the concentration of heavy metals in some selected vegetables bought in Samaru market, Sabon Gari Local Government Area, Kaduna State Nigeria. Essential and non-essential heavy metals such as Cd, Cr, Fe, Zn, Pb, and Ni were investigated in Ugu leaf (Fluted pumpkin), *Amaranthus caudatus*, and *Hibiscus cannabitus* leaves by using Atomic Absorption Spectrometry (AAS). Plants leaves showed different metal mean concentrations concentration in the range of: Cd, Cr, Fe, Zn, Pb and Ni in Fluted pumpkin (*Telfairia occidentalis*) were: 0.060, 18.170, 275.670, 12.830, 0.040, and 0.050; in *Amaranthus caudatus* were, 0.080, 5.000, 128.000, 8.670, 0.040 and 0.900 mg/kg; in *Hibiscus cannabitus* were 1.100, 8.670, 278.670, 1.530, 0.530 and 0.050 mg/kg and in the soil were 0.060, 18.170, 275.670, 1.530, 0.040 and 0.900 mg/kg respectively. Other heavy metals were present in low quantity. The purpose of this study was to identify each type of metal associated with a given vegetable contaminated by environmental pollution and also to highlight the toxic heavy metals present in these vegetables. Health risk index (HRI) of these heavy metals have been determined on three common edible vegetable samples, only Fe in all the plants analysed exceeded the maximum permissible limit and it has to be monitored in order to prevent high Fe concentration related diseases/ailments. Most of the heavy metals concentrations values obtained were below the permissible limit recommended by WHO/FAO.

Keyword: Heavy metal, AAS, Health risk index, WHO, *Telfairia occidentalis*

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 are grown on such contaminated soil is often observed. In general, wastewater contains a substantial amount of beneficial nutrients and toxic heavy metals which are creating opportunities and problems for Agricultural production (Khan *et al.*, 2009).

Wastewater may contain various heavy metals including Zn, Cu, Pb, Mn, Ni, Cr, Cd, Fe, 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 then subsequently to the vegetable (Fytianos *et al.*, 2001). Intake of heavy metals through the food chain by the 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 (Singh *et al.*, 2010a). 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 (Singh *et al.*, 2010).

Vegetables, cereals, and milk are major components of the human diet, being a source of essential nutrients, antioxidants, and metabolites in food items. In the present study, the concentrations of heavy metals in irrigation soil and produced vegetables from such soils were quantified at a suburban area of Samaru market, Sabon Gari Kaduna, where untreated wastewater from Ahmadu Bello University Dam and its adjoining tributaries have been used as a source of irrigation water for many generations. The contamination levels in soil and vegetable were evaluated with respect to the prescribed safe limits of different heavy metals set under national and international norms. 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 which include HQ: Hazard quotient, DIM: Daily intake of metal, HRI: Health risk index and TF: Transfer factor.

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Study Area

A very large area along the tributaries and bank of Ahmadu Bello University Dam are chosen for the experiment where different types of vegetables are grown that eventually got transported to Samaru market where they are being sold to the populace in exchange for money (cash). Ahmadu Bello University dam bank and its adjoining tributaries are one of the major sources of farmed vegetables in Samaru market and are places where most of the sewage sludge is been disposed, especially that coming from the university community. Therefore, the foregoing suggests that investigation needs to be carried out on the contaminated soil and the vegetables grown on such soil.

MATERIALS AND METHOD

All the reagents used were of analytical grade, chemicals, and all the glassware, containers and tools were washed with liquid detergent first, rinsed with 20 %($^{v}/_{v}$) nitric acid and finally rinsed with deionised water. The container and glassware were kept in Oven until needed. Deionised water was used throughout the work.

Soil and Vegetable Samples Collection

The vegetable samples were collected at seven (7) different spots (as shown in figure: 5.0) within the market place with thorough investigation and interrogation of the sellers to ascertain they were all brought from the same farmland which happens to be the location where the soil was sampled. Polyethylene bags were used to keep the samples fresh before taking them to the laboratory for analysis. Three vegetables samples were collected which include; Fluted pumpkin (*Telfairia occidentalis*), *Amaranthus caudatus*, and *Hibiscus cannabitus.* Soils were collected from the same farmland where these vegetables were grown; it was randomly collected using combination of random sampling techniques at five different locations within the irrigation farmland and at the end the collected soil samples were homogenized then subjected to coning and quartering techniques in order to get a representative soil samples that will be scientifically significant for the heavy metal analysis. All soil sampling was carried out at a depth of 15 cm from the surface soil using soil auger. All the samples were air dried, ground, passed through 2mm sieve and packaged in a cleaned container that was properly labeled.

Ashing of Plant Samples

About 5.0 g of air-dried, ground and sieved plant samples of the different vegetables were weighed into porcelain crucible and ashed into a constant weight in a muffle furnace at a temperature of 550 °C. About 20 cm^3 of 0.1M HNO_3 ANALAR grade was added to the ashed sample in a beaker and boiled for a few minutes on a hot plate. After the appearance of white fumes, the digest was allowed to cool, then filtered through No. 1 Whatman filter paper into 100 cm^3 volumetric flask and made up to the mark with the 0.1M HNO_3. Blank (without the sample) was prepared using the same procedure. Both the samples and the blank were aspirated into the flame of the AAS for the determination of the metals. Absorbance values were recorded and the corresponding concentrations from the calibration curve plotted were determined and presented in mg/kg dry weight (Akubugwo *et al.,* 2007;Goswami, 2019).

Digestion of Soil Samples

About 2 g of each soil sample was weighed into a separate, clean, dry and labeled 100cm^3 beaker. To each beaker 5cm^3 of water was added and then 5cm^3 conc. HNO_3. Each slurry was mixed with the bare glass end of a different stirring rod and each beaker was covered with a non-ribbed watch glass, placed concave up. All the samples were heated together on one hotplate until they were refluxing (that is until vapour is condensing on the bottom of the watch glass and dripping back down into the beaker), and were kept at reflux for 10 min, while stirring a few times. The samples were removed from the hotplate and allowed to cool until they can be safely handled. Another 5cm^3 of conc. HNO_3 was added to each, the watch glasses were replaced, and refluxed for another 10 min. The samples were again allowed to cool enough to handle, then 5cm^3 of conc. HCl was added and then 10 cm^3 of water. The watch glass cover was replaced and refluxed for 15 min, stirring occasionally. Finally, each solution was filtered through No.1 filter paper into a 100cm^3 volumetric flask and was made to the mark. Blank was prepared using the same procedure. Both the samples and the blank were separately aspirated into the flame of the AAS for the determination of the metals. Absorbance values were recorded and the corresponding concentrations from the calibration curve plotted were obtained by interpolation and presented in mg/kg dry weight (Mielke *et al.,* 1999; Yarnell & Abascal, 2006).

Statistical Analysis

Values were represented as mean ± standard deviation (SD) and stark charts were plotted using Microsoft Excel computer software package (Microsoft corp., 2016 version). To test the impact of metals emanating from the polluted soils on analysed vegetable quality, Statistical Package for Social Scientists (SPSS) version 16.0 for Windows was used. A significant difference was tested at 95 % confidence level ($P<0.05$). All the analyses were conducted in triplicates and expressed as mean data ±SD (standard deviation) (Duncan, 1955).

Instrumental Procedure

The standard stock solutions (1000 ppm) were diluted to obtain working standard solutions ranging from 1 ppb to 15 ppb and stored at 4°C. The calibration curves were plotted between measured absorbance and concentration. The prepared samples were immediately analyzed using atomic absorption spectrophotometer (AAS, Agilent 280FS AA) equipped with graphite tube atomizer (GTA 120). The instrument was operated in GTA mode, the argon gas flow was 3 L/min and the temperature parameters were followed as recommended by the instrument manufacturer. Optimized operating parameters of various heavy metals are listed in Table 5.0. All analyses were run in batches, which included standards (for calibration curves), reagent blanks and plant samples. The heavy metal concentrations were expressed in parts per million (ppm) with respect to the dry weight of the plant materials. All the samples were analyzed in triplicates and the result averaged.

Assessments of the Health Risks Associated with the Measured Levels of Heavy Metal Contamination

Transfer Factor

Transfer factor can be calculated using Khan *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 itself.

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

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 were calculated based on the formula proposed by Khan *et al.*, (2009).

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

Where: $C_{concmetal}$ = heavy metals conc. in plant (Mg/kg)

C_{factor} = conversion factor

$D_{foodintake}$ = Daily intake of vegetables

$BW_{average\ body\ weight}$ = average body weight

The conversion factor of 0.085 is to convert fresh vegetable weights to dry weight (Khan *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 DAILY INTAKE OF METAL in the sense that it gives approximately available metals in a portion of food and essential in the risk assessment of metals.

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

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

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

Health Risk Index (HRI)

By using Daily Intake of Metals (DIM) and reference oral dose (RƒD), we obtain the health risk index. The following formula is used for the calculation of HRI.

$$HRI = {}^{DIM}\!/_{RfD}$$

If the value of HRI is less than one (1) then the exposed population is said to be safe.

Hazard Quotient (HQ)

The risk to human health by the intake of metal contaminated vegetables was characterized using a hazard quotient (HQ). This is a ratio of determined dose to the reference dose (RƒD). The population will pose no risk if the ratio is less than one (1) and if the ratio is equal to or greater than one (1) then the population will experience health risk. This risk assessment method has been used by researchers and proven to be valid and true. The following equation is used;

$$HQ = {}^{[W_{plant}] \times [M_{plant}]}\!/_{RfD \times Bo}$$

Where; $[W_{plant}]$ is the daily intake of vegetables (kg per day)

$[M_{plant}]$ is the concentration of metal in the vegetable ($mgkg^{-1}$)

RfD is the oral reference dose for the metal ($mgkg^{-1}$ of body weight per day), and B_o is the human body mass (kg). The values of RfD for heavy metals were taken from the Integrated Risk Information System (Rattan *et al.*, 2005) and Department of Environment, Food and Rural Affairs (ul Islam *et al.*, 2007).

RESULT AND DISCUSSION

The results of the heavy metal analysis using AAS and interpretation of the results obtained both in analysed soil and vegetables by comparing with standards as proposed by the World Health Organization (Balkhair and Ashraf, 2016) are presented in the tables below. The results obtained show that in the fluted pumpkin (*Telfairia occidentalis*), Fe has the highest concentration (275.670 $mgkg^{-1}$) of all the heavy metals analysed from the vegetables, this is as expected because of the various anthropogenic activities involving metal scrap that is taken place along the tributaries that link the Ahmadu Bello University Dam, anthropogenic activities such as metal welding, black smiting, mechanic workshop that do consciously or unconsciously discharge their waste into the water body. Iron is an essential element that facilitates the oxidation of carbohydrates, protein, and fat to control body weight. Excess iron in the human body system is associated with symptoms of dizziness, nausea and vomiting, diarrhea, joints pain, shock, and liver damage. Iron toxicity has also adverse effects on various metabolic functions and cardiovascular system (Martin and Griswold, 2009). Whereas, Pb concentration is the lowest (0.040 $mgkg^{-1}$).

Similarly, in the *Hibiscus cannabitus* Fe also has the highest concentration value of 278.670 mg/kg^{-1} of the analysed heavy metals, whereas Ni has the least concentration value of 0.050 $mgkg^{-1}$; the high concentration of Fe recorded in this plant is also associated with reasons given for fluted pumpkin (*Telfairia occidentalis*). More so, in *Amaranthus caudates.* Fe also has the highest concentration value of 128.000 $mgkg^{-1}$ while Pb has the least value of 0.040 $mgkg^{-1}$, the same reasons can be adduced for these high concentrations of iron as in fluted pumpkin (*Telfairia occidentalis*) as presented in Tables: 3.0a, 3.0b & 3.0c respectively. However, the concentration of heavy metals in the irrigation soil was also analyzed, and it was found that Fe also has the highest concentration value of 275.670 $mgkg^{-1}$, this is not surprising for it is this high concentration of Fe in the irrigation soil that accounts for the higher concentration of same heavy metal in the vegetable samples analysed. Whereas Pb has the least concentration value of 0.040 $mgkg^{-1}$ which was also clearly shown from the various low concentration of Pb recorded in the analysed vegetable samples as presented in Tables: 3.0a, 3.0b & 3.0c respectively. Although concentrations of other heavy metals in the analysed vegetable were below the toxic limits, their accumulation over a period of time can cause serious adverse health effects associated with the presence of such metal when ingested. Lead, for instance, is the most frequently occurring and stable heavy metal in nature. It is highly hazardous for plants, animals, and micro-organisms. Continuous application of fertilizers, fuel combustion, and sewage sludge are the major reasons leading to an escalation in lead pollution. It is a non-essential element that can be introduced to human by inhalation, ingestion or cutaneous absorption. It is a serious cumulative body poison. Levels of lead beyond the permissible limits or long term use of these contaminated plants could lead to toxicity characterized by colic, anaemia, chronic nephritis, headache, convulsions, brain damage, and central nervous system disorders (Goering *et al.,* 1995; Tong *et al.,* 2000). Similarly, Zinc is an essential element required for normal body growth, proper thyroid function, blood clotting, and DNA synthesis. Though there is little information about its toxicity, consumption of Zinc beyond the permissible limit may result in a toxic effect on the immune system and reduced copper level in the body (Waheed and Fatima, 2013). Though toxic, Nickel absorption by the body is reported to be very low. The most common toxic effect of nickel is lung cancer, nickel itch especially on wet or moist skin and blockage of nasal cavities (Wei *et al.,* 2015). The most common ailment arising from Nickel is allergic dermatitis known as nickel itch, which usually occurs when the skin is moist, furthermore Nickel has been identified as a suspected carcinogen and adversely affects lungs and nasal cavities. Although Nickel is required in minute quantity for the body as it is mostly present in the pancreas and hence plays an important role in the production of insulin. Its deficiency results in the disorder of the liver (Pendias, 1992). Nickel was recognized as an allergen of the year in 2008 by the American Contact Dermatitis Society and its minimal risk level was set to 0.2 $\mu g/m^3$ for inhalation during 15 - 364 days, however, no limit has been set for foodstuffs and herbs (Bhat*et al.*, 2010). In the present experiment, less than 1.50 $mgkg^{-1}$ nickel content was found in all the analysed vegetable samples. Nickel is a constituent of the enzyme urease and small quantities are essential for some plant species (Shen *et al.*, 1993); It is an essential micronutrient, which is required by urease for hydrolyzing urea. High concentrations may be toxic to plants. Extremely high concentrations of nickel have left some farmland unsuitable for growing crops. Its toxic effects have been frequently reported, such as inhibition of the mitotic activity of *Cajanuscajan*, reduction in the germination of cabbage and adverse effects on fruit yield and quality of wheat. High intake of chromium is reported to have a toxic effect, causing a skin rash, kidney and liver damage, cancer of the lungs and nose irritations (Jiang *et al.,* 2008). Chromium contamination is caused by tanneries, paper, paint and steel industries; and sewage sludge applications along with alloys in motor vehicles. Chromium is essential in carbohydrate metabolism. It also functions in protein and cholesterol biosynthesis. It is an important element required for the maintenance of normal glucose metabolism. The function of chromium is directly related to the function of insulin, which plays a very important role in diabetes mellitus. Chromium is found in the pancreas, which produces insulin (Ano and Ubochi, 2008; Zetić *et al.,* 2001). The toxic effects of chromium intake are skin rash, nose irritations, bleeds, stomach upset, kidney and liver damage and lung cancer. Chromium deficiency is characterized by disturbance in glucose lipids and protein metabolism (Rai *et al.,* 2005; Shanker *et al.*, 2005). In the present investigation, all the samples possessed chromium content within said permissible Canadian limits defined by the world Health Organisation (Sarma *et al.,* 2012). Cadmium is a non-essential trace element with uncertain direct functions in both plants and humans and responsible for several cases of poisoning through food. Recently, it is gaining more attention due to a wide occurrence in water, soil, milk, dietary and herbal medicinal products (Bauddh *et al.,* 2016). Small quantities of cadmium cause adverse changes in the arteries of the human kidney leading to kidney failure. It accumulates in the human body, replaces zinc biochemically and causes hypertension, liver and kidney damage. Cadmium poisoning causes a disease called Itai-Itai characterised by softening of bones, anaemia, renal failure and ultimately death (Järup *et al.,* 1998). The maximum allowable limit for cadmium in raw herbs is 0.3 ppm as per Ayurvedic Pharmacopoeia of India (Mensah *et al.,* 2009).

The trends in the concentration of heavy metals in the analysed vegetable samples are as follow: Fe > Cr > Zn > Cd > Ni > Pb. The variation of the heavy metals noticed in the plant and the soil might be due to the differences in the sources of the metals. Some of the metals are already present in the plant and the soil will only contribute to the metal bioavailability. The total concentration of heavy metals analysed from the plants is solely from the plants' parts.

The comparison in the concentration of heavy metals as presented in Table 1.0 above showed a significant difference from a work reported in the literature by Wu *et al.,* 2010 from previous studies. All concentrations of these heavy metals analysed in the irrigation soil were less than Britain and Japan standard permissible limit or heavy metals in the soil of these countries. These toxic heavy metals must be monitored to prevent further exposure to man through the food chain, to ameliorate the lethal effect of diseases associated with these heavy metals.

More so, results of heavy metal analysis obtained in this studies were also compared with similar previous work done as reported by Kachenko & Singh, 2006 which shows that most values obtained in this study were lower and also lower than the maximum permissible limit of the Indian standard as reported by Shaheen *et al.,* 2016 in previous studies carried out. Except that for Fe which were higher than the value of both Indian and WHO/FAO standard limits (Shaheen *et al.,* 2016). Analysis of variance results as presented in the Table 7.0: since F $>F_{critical}$ it shows that there is statistical significant difference between the heavy metals concentration from the three different analysed vegetables; whereas the p value is less than 0.05 ($p<0.05$) which shows that there is statistical significance difference between the heavy metals concentrations present in the three analysed vegetables, which implies that the null hypothesis which states that there is no significant difference between heavy metals concentrations in the three analysed vegetable samples and that in the soil sample is thus rejected and the alternate hypothesis accepted. To this end, correlation analysis carried out between the heavy metals concentrations in the soil and the three analysed vegetables as presented in the Table 6.0: shows that there is a strong positive correlation ($r \approx +1.00$) between the heavy metals concentrations in soil: vs in Fluted Pumpkin; *Hibiscus Cannabitus*; and *Amaranthus Caudatus*. Fluted Pumpkin: vs *Hibiscus Cannabitus*; *Amaranthus Caudatus* and *Hibiscus Cannabitus* vs *Amaranthus Caudatus*. This shows that they are all from a common source of pollution which are the pollutants present in the analysed irrigation soil. Assessment of Health Risks Association with the Measured Levels of Heavy Metal Contamination. Transfer Factor (TF): Transfer factor was used to understand the extent of risk and associated hazard due to the transfer of heavy metals from the soil into the plants and its subsequent accumulation, using the relation according to (Akubugwo *et al.*, 2007).

$TF = {C_p}/{C_s}$ Where: Cp = concentration of metal in the plant, Cs = metal concentration in the soil sample. 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 indicated by the transfer factor as presented in Table: 3a, 3b & 3c and Figure 1.0. The transfer factor is a function of different factors such as soil, soil pH, soil organic matter, metal availability, and soil particle size. Results of the transfer factor indicated that Cd in *Hibiscus cannabitus* has the highest TF value (28.330), Thus making *Hibiscus cannabitus* a good hyperaccumulator for the metal Cd. The concentrations of heavy metals follow the following trend Cd > Pb > Zn > Cr > Cd > Fe. This could be attributed to the high retention of the metals in the soil. In a related work by Singh *et al.*, 2010b reported high TF for heavy metals through leafy vegetables. The TF value of unity, indicated that the concentration of the metal in the plant was equal to that of the soil while the TF value greater than unity indicates a higher concentration of the metal in the plants than in the soil which means plant uptake of this metal at the sites was not restricted by pH or other parameters (Amusan *et al.*, 2005). Daily Intake of Metal (DIM): The DIM which is a function of body weight and metal intake in vegetable, iron (Fe) has the highest concentration of 12.755 $mgkg^{-1}$ in *Hibiscus cannabitus*, followed by Fe (12.617) $mgkg^{-1}$ in fluted pumpkin (*Telfairia occidentalis*). The concentrations of heavy metals follow the trend Fe > Cr > Zn > Cd > Ni > Pb. Similarly, *Amaranthus caudatus* is found to have the least DIM value of 5.859 $mgkg^{-1}$ for Fe. Health Risk Index (HRI): More so results of health risk index for the analysed heavy metals in fluted pumpkin (*Telfairia occidentalis*), *Hibiscus cannabitus* and *Amaranthus caudatus* is as presented in Tables 3.0a, 3.0b and 3.0c respectively. The results showed that the order of HRI in fluted pumpkin (*Telfairia occidentalis*) is Fe > Cr > Zn > Cd =Pb =Ni; Similarly, in *Hibiscus cannabitus* the order is Fe > Cr > Ni > Cd > Zn > Pb and in *Amaranthus caudatus* the order is Fe > Cd = Zn > Cr > Pb > Ni. This implies that the inhabitants are highly exposed to health risk associated with these toxic heavy metals they consumed in the analysed vegetables in that order. Hazard Quotient (HQ): Moreover, the Hazard Quotient (HQ) for the analysed heavy metals as presented in Table 3.0a, 3.0b and 3.0c showed that virtually all the HQ values were less than one (1) for the analysed heavy metals, this implies that the consumers of these vegetable are not exposed to a risk due to high concentrations of these metals, with the exception of Fe that has values greater than one in all the three analysed vegetable which implies that inhabitant of that location and consumers of the analysed vegetable are exposed to high risk of ailment associated with high concentrations of Fe such as symptoms of dizziness, nausea and vomiting, diarrhea, joints pain, shock, and liver damage.

Table 1: Comparison of Heavy Metals Concentration (mg/kg) in Soil Samples with similar work Reported in the Literature and the Maximum Permissible Limits in Some Countries

Heavy Metals	Conc. in Soil (mg/kg)	Wu yao Guo, 2010 (mg/kg)	Great Britain (mg/kg)*	USEPA (mg/kg)**
Cd	0.060	0.550	3.000	3.000
Cr	18.170	44.720	50.000	400.000
Fe	275.670	ND	NA	NL
Zn	1.530	118.060	300.000	200.000
Pb	0.040	216.960	400.000	300.000
Ni	5-500	5.0	4.0	75-150

*Maximum permissible limit of metals (mg/kg) in the soil in Great Britain
** Maximum permissible limit of metals (ppm) in soil by USEPA (1985) ND: Not determine, NA: Not analyzed, NL: No limit

Table 2: Comparison between Heavy Metals Conc. (mg/kg) in Vegetable Samples with Maximum Permissible Limit in Some Countries and WHO/FAO/India

Heavy Metals	*Amaranthus caudatus* Conc. (mg/kg)	*Hibiscus cannabitus* Conc. (mg/kg)	Fluted pumpkin (*Telfairia occidentalis*) Conc. (mg/kg)	Indian Standard (Conc. Mg/kg)	Anthony Bahot, 2005	**WHO/ FAO
Cd	0.08±0.01	1.10±0.10	0.06±0.01	1.5	0.361	0.2
Cr	5.00±1.00	8.67±0.21	18.17±0.76	20	ND	NA
Fe	128.00±6.08	278.67±2.08	275.67±2.08	NA	ND	5
Zn	8.67±0.29	1.53±0.56	12.83±0.21	50	54	60
Pb	0.04±0.02	0.53±0.06	0.04±0.01	2.5	4.31	5
Ni	0.90±0.10	0.05±0.01	0.05±0.01	1.5	ND	NL

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

Table 3a: Different parameters for Fluted pumpkin (*Telfairia occidentalis*)

Heavy Metals	Conc. In irrigation Soil (mg/kg)	Conc. In vegetable (mg/kg)	HQ	DIM	HRI	TF
Cd	0.060	0.060	0.001	0.275	0.001	1.000
Cr	18.170	18.170	0.280	0.832	0.280	1.000
Fe	275.670	275.670	4.241	12.617	4.241	1.000
Zn	1.530	12.830	0.197	0.587	0.197	8.390
Pb	0.040	0.040	0.001	0.183	0.001	1.000
Ni	0.900	0.050	0.001	0.229	0.001	0.060

Table 3b: Different parameters for *Hibiscus Cannabitus*

Heavy Metals	Conc. In irrigation Soil (mg/kg)	Conc. In vegetable (mg/kg)	HQ	DIM	HRI	TF
Cd	0.060	1.100	0.017	0.050	0.001	18.33
Cr	18.170	8.670	0.133	0.397	0.006	0.480
Fe	275.670	278.670	4.287	12.755	0.196	1.000
Zn	1.530	1.530	0.024	0.070	0.001	1.000
Pb	0.040	0.530	0.008	0.024	0.000	13.25
Ni	0.900	0.050	0.001	0.229	0.004	0.060

Table 3c: Different parameters for *Amaranthus Caudatus*

Heavy Metals	Conc. In irrigation Soil (mg/kg)	Conc. In vegetable (mg/kg)	HQ	DIM	HRI	TF
Cd	0.060	0.080	0.001	0.366	0.006	1.330
Cr	18.170	5.000	0.077	0.229	0.004	0.280
Fe	275.670	128.000	1.969	5.859	0.090	0.460
Zn	1.530	8.670	0.133	0.397	0.006	5.670
Pb	0.040	0.040	0.001	0.183	0.003	1.000
Ni	0.900	0.900	0.014	0.041	0.001	1.000

HQ: Hazard quotient, DIM: Daily intake of metal, HRI: Health risk index, TF: Transfer factor

Table 4.0: A A S Results Obtained for the Vegetables and the Soil Sample from Some Selected Sales Points in Samaru Market

Heavy Metals	Fluted pumpkin (*Telfairia occidentalis*) Conc. (mg/kg)	*Hibiscus Cannabinus* Conc. (mg/kg)	*Amaranthus caudatus* conc. (mg/kg)	Irrigation Soil Conc. (mg/kg)
Cd	0.06±0.01	1.10±0.10	0.08±0.01	0.060
Cr	18.17±0.76	8.67±0.21	5.00±1.00	18.170
Fe	275.67±2.08	278.67±2.08	128.00±6.08	275.670
Zn	12.83±0.21	1.53±0.56	8.67±0.29	1.530
Pb	0.04±0.01	0.53±0.06	0.04±0.02	0.040
Ni	0.05±0.01	0.05±0.01	0.90±0.10	0.900

Table 5: Operating Parameters for the Instrument (AAS)

Serial number	Heavy metals	Wavelength (nm)	Intensity Lamp (mA)	Slit width (nm)
1	Cd	228.8	8	0.7
2	Cr	357.9	10	0.2
3	Fe	248.3	3	3.0
4	Zn	213.9	3	5.0
5	Pb	283.3	10	0.7
6	Ni	232.0	10	0.2

Table 6: Correlation Analysis between Soil and Analysed Vegetables Heavy Metal Concentrations

	Soil	Flutted Pumpkin	*Hibiscus Cannabitus*	*Amaranthus Caudatus*
Soil	1.000			
Fluted Pumpkin	0.999	1.000		
Hibiscus Cannabitus	0.999	0.999	1.000	
Amaranthus Caudatus	0.997	0.999	0.998	1.000

Table 7: Two-Factor ANOVA between Soil and Analysed Vegetables Heavy Metal Concentrations

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Cd	4.000	1.300	0.325	0.267
Cr	4.000	50.010	12.503	45.072
Fe	4.000	958.010	239.503	5527.692
Zn	4.000	24.560	6.140	31.220
Pb	4.000	0.650	0.163	0.060
Ni	4.000	1.900	0.475	0.241
Soil	6.000	296.370	49.395	12337.612
Fluted Pumpkin	6.000	306.820	51.137	12159.792
Hibiscus Cannabitus	6.000	290.550	48.425	12733.218
Amaranthus Caudatus	6.000	142.690	23.782	2618.316

Table 8: ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	185465.471	5.000	37093.094	40.379	3.521E-08	2.901
Columns	3034.440	3.000	1011.480	1.101	0.379	3.287
Error	13779.218	15.000	918.615			
Total	202279.130	23.000				

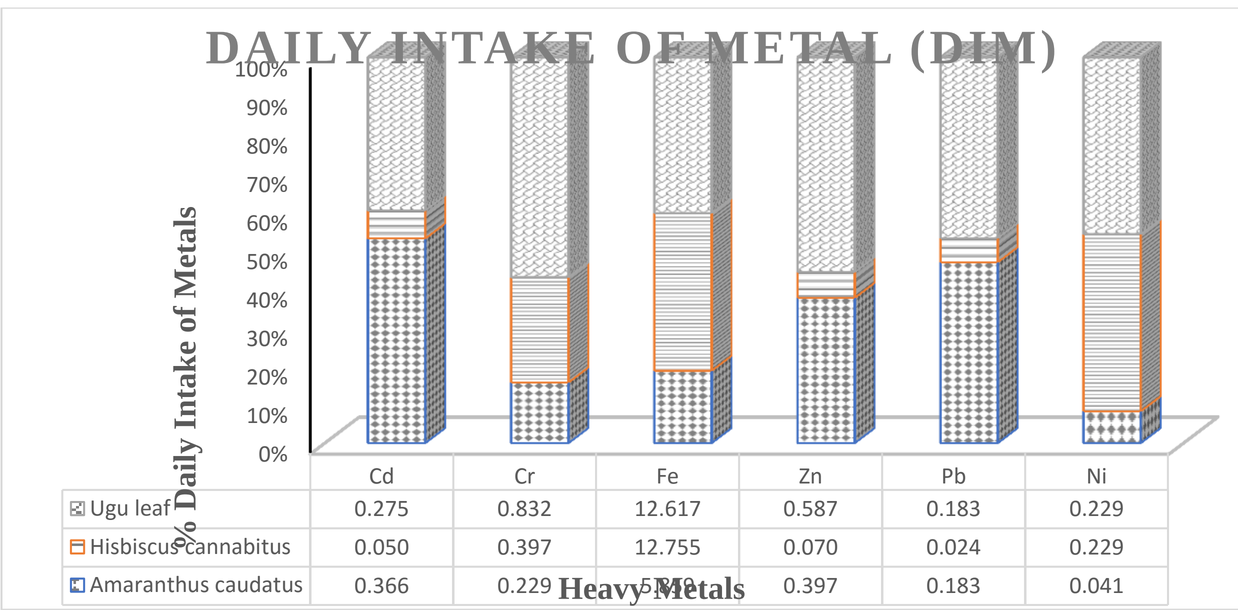

Figure 1: Index of Pollution Daily Intake of Metals (DIM)

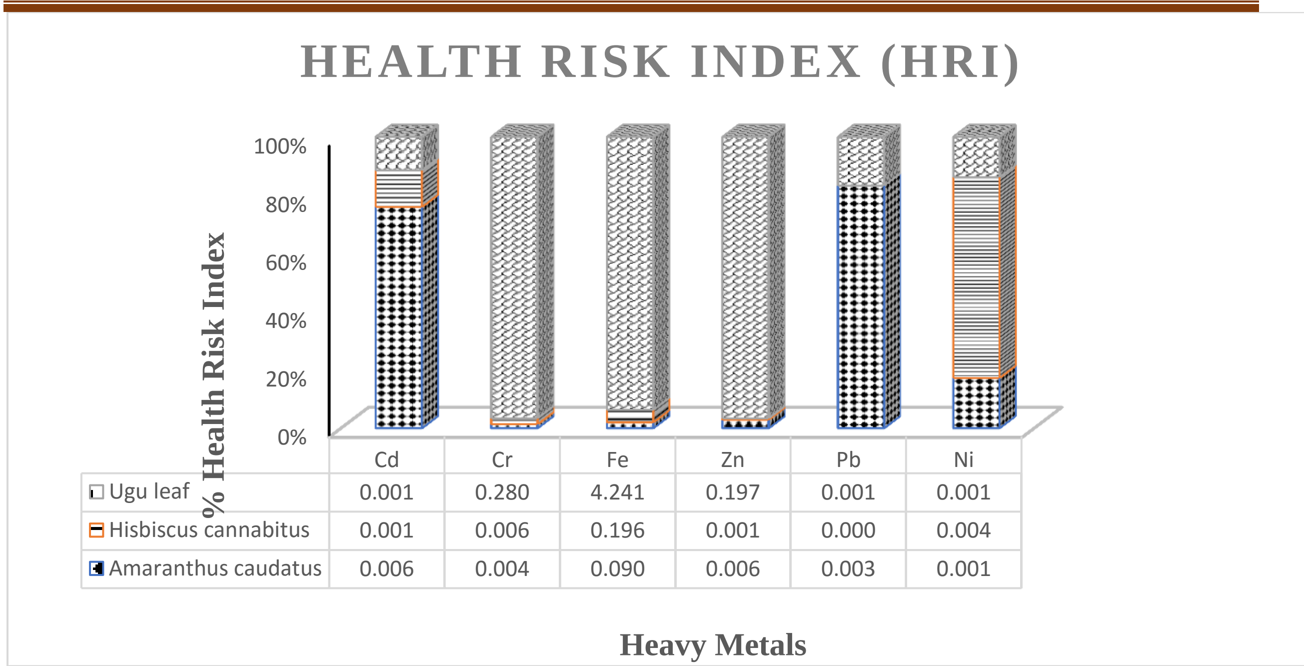

Figure 2: Index of Pollution Health Risk Index (HRI)

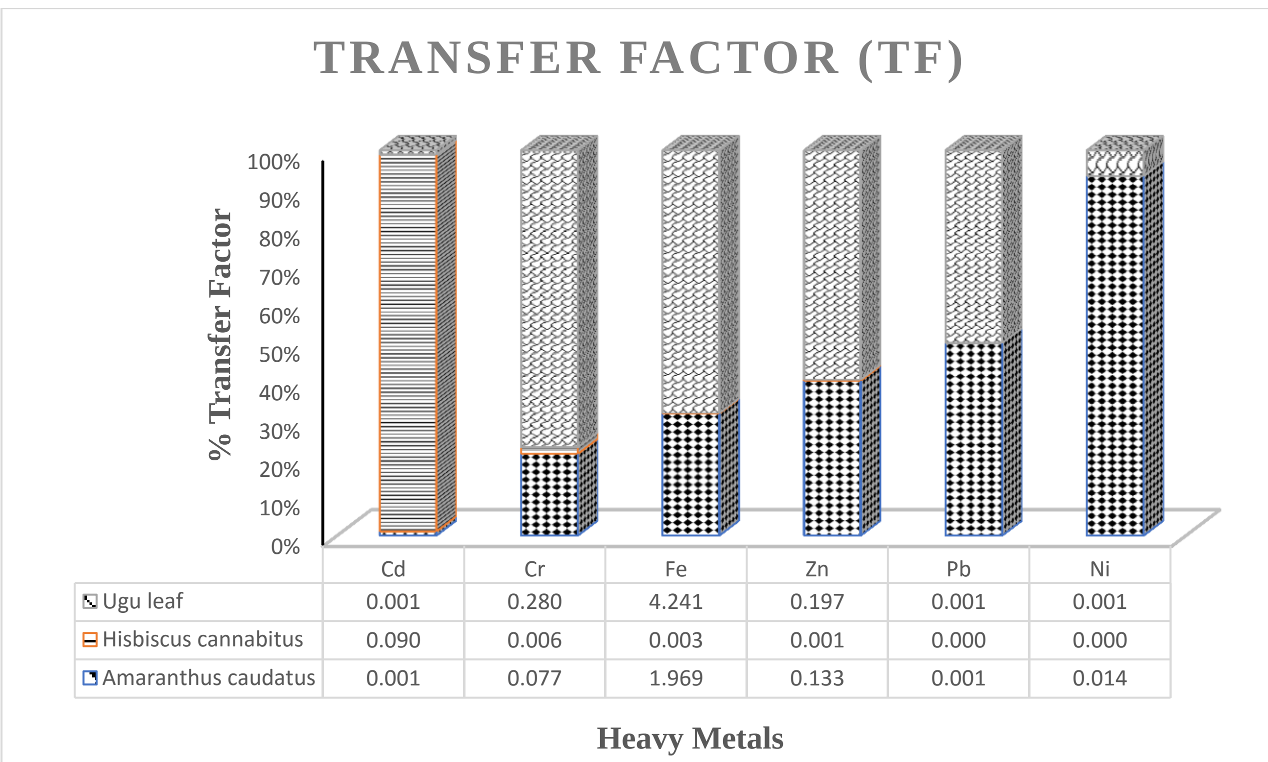

Figure 3: Index of Pollution Transfer Factor (TF)

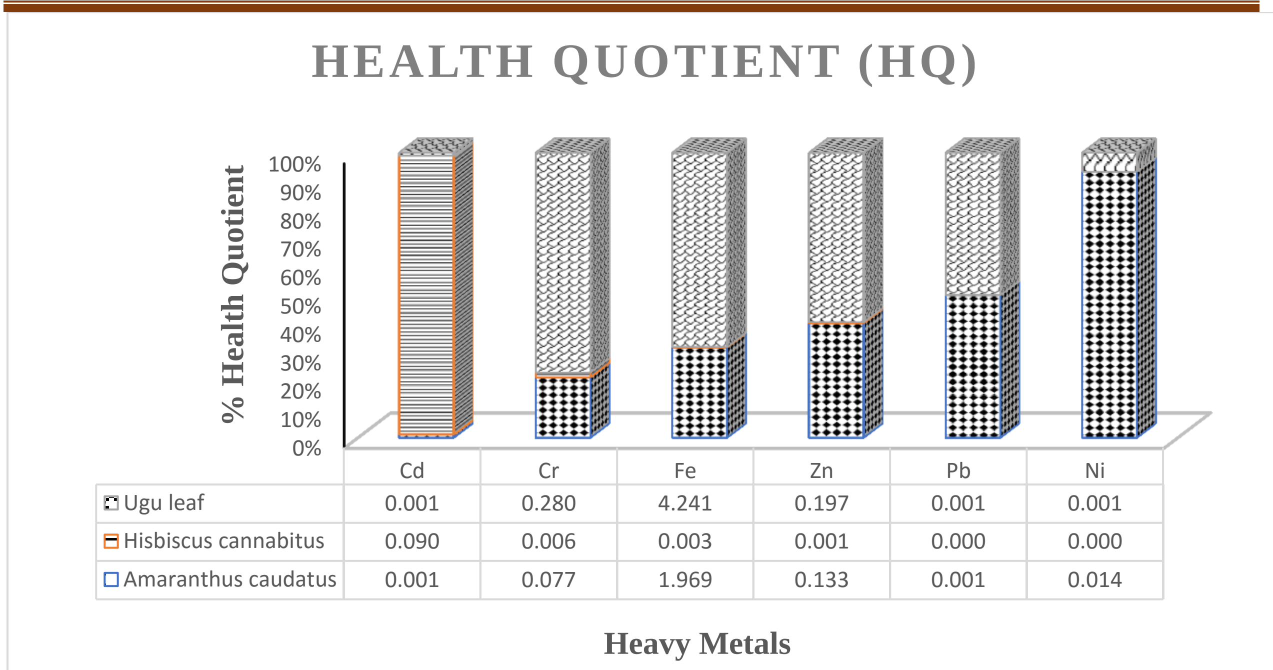

Figure 4: Index of Health Quotient (HQ)

CONCLUSION

Based on the results obtained from the AAS analysis of the following heavy metals Cd, Cr, Fe, Zn, Pb and Ni in fluted pumpkin (*Telfairia occidentalis*), *Hibiscus cannabitus* and *Amaranthus caudatus* and the soils where those vegetables were grown, it has shown that these vegetables are safe for public consumption since most of the analysed heavy metals when compared with the safe limits as put forward by the World Health Organization (WHO) were all below the limit. To this end, these heavy metals do not contain an amount of the heavy metals that would constitute a danger of metal poisoning to the final consumers of those vegetables.

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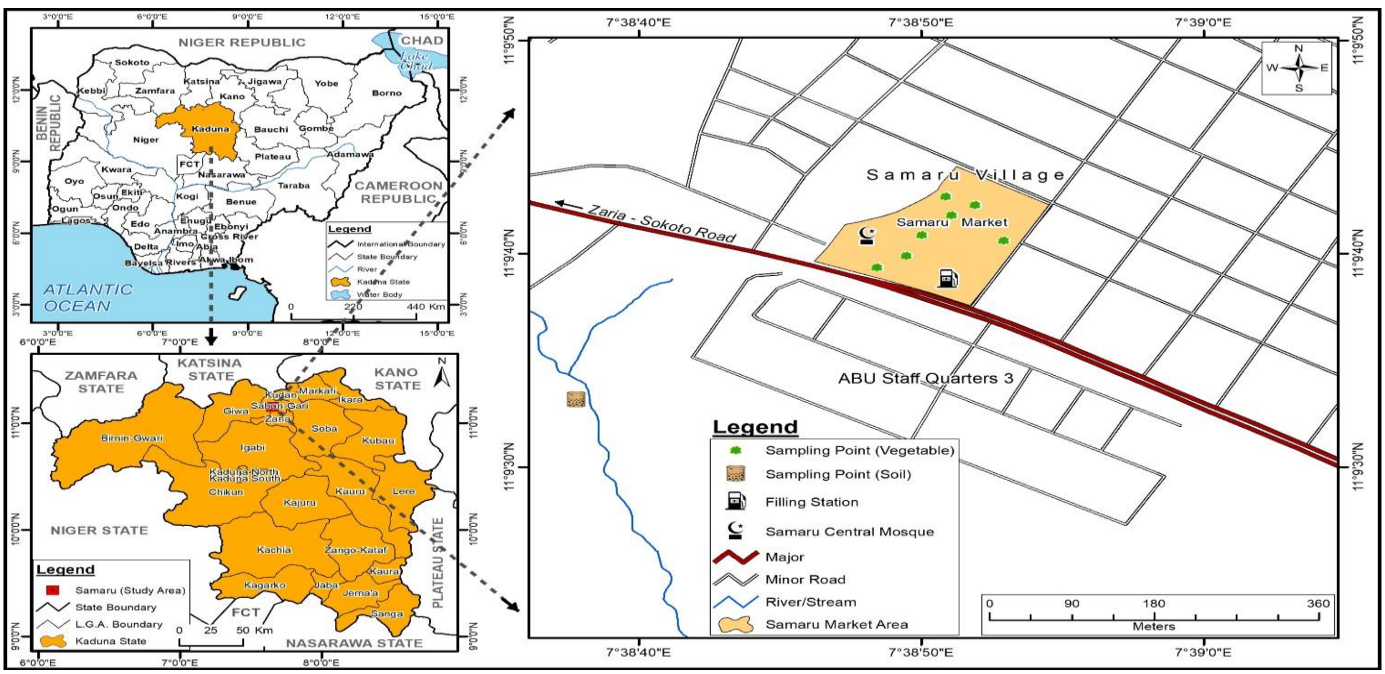

Figure 5.0: Map of Samaru-Zaria Showing Vegetables and Soil Sampling Points
Source: Map Gallery, Geography Department, ABU Zaria, 2019