

Health Risk Assessment of some Heavy Metal contents of *Hibiscus sabdariffa* (Roselle) and *Spinacia oleracea* (Spinach) grown in Bargu, Shani L.G.A., Borno State, Nigeria.

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ABSTRACT

This study aimed to assess the health risk associated with heavy metal content in commonly consumed vegetables, specifically *Spinacia oleracea* (spinach) and *Hibiscus sabdariffa* (roselle), within the study area. An Atomic Absorption Spectrophotometer (AAS), model VGP210Buck Scientific, was utilized to determine the concentrations of heavy metals (Cd, Cr, Cu, Pb, and Zn) in both the vegetables and soil samples. The assessment included calculating Transfer Factor (TF), Daily Dietary Intake (DDI), Daily Intake of Metal (DIM), Health Risk Index (HRI), and Target Hazard Quotient (THQ). The AAS analysis revealed the following concentrations in *Spinacia oleracea*: Pb (2.72 mg/Kg), Zn (2.19 mg/Kg), Cr (1.88 mg/Kg), and Cu (0.48 mg/Kg), with Cd not detected. For *Hibiscus sabdariffa*, the values were: Pb (2.01 mg/Kg), Zn (1.51 mg/Kg), and Cu (0.48 mg/Kg), while Cd and Cr were not detected. Soil samples from *Spinacia oleracea* showed Pb (1.6 mg/Kg), Cu (0.48 mg/Kg), and Zn (0.01 mg/Kg), with no detection of Cd and Cr. Soil samples from *Hibiscus sabdariffa* showed Pb (2.36 mg/Kg), Zn (0.73 mg/Kg), and Cu (0.48 mg/Kg), with no detection of Cd and Cr. The THQ values for Lead (Pb) were 6.00 for *Spinacia oleracea* and 4.43 for *Hibiscus sabdariffa*, indicating a high health risk. Other heavy metals had THQ values less than 1, suggesting no immediate health risk. However, continuous consumption of these vegetables could lead to bioaccumulation, thereby posing a potential health risk over time.

Keywords: *Sabdariffa*, roselle, *spinacia* and heavy metal

INTRODUCTION

Heavy metals are metals whose densities are above 5g/cm^3 [1]. They exist in nature at trace levels [2]. However, anthropogenic activities accelerate nature's slowly occurring geochemical cycle of metals which cause most soil environments to have accumulated one or more of the heavy metals above defined background values [3]. High concentration of heavy metals in the environment can be detrimental to a variety of living systems. Heavy metals in contaminated soil from anthropogenic sources tend to be more mobile, than the heavy metal contamination from natural sources. [4]. The fate of a heavy metal in soil depends significantly on the chemical form and speciation of the metal. Once heavy metals are adsorbed in the soil by initial fast reactions (minutes, hours), slow adsorption reactions occurs (days, years) resulting in the redistribution

into different chemical forms with varying bioavailability, mobility, and toxicity [5]. This distribution is believed to be controlled by reactions of heavy metals in soils such as mineral precipitation, dissolution, ion exchange, adsorption, desorption; complex formation, biological immobilization, mobilization and plant uptake [6]. According to [7], the most common heavy metals found at contaminated sites, in order of abundance are; $\text{Pb} > \text{Cr} > \text{As} > \text{Zn} > \text{Cd} > \text{Cu} > \text{Hg}$. Excessive ingestion of these metals by human beings can cause poisoning, cancer, nervous system damage and ultimately death [8]. The toxicity of heavy metals is due to their ability to bind to oxygen, nitrogen, and Sulphur groups in proteins, resulting in alterations of enzymatic activities. Organs/systems affected and the severity of the toxicity vary with the particular

heavy metal involved, the chronicity, extent of the exposure, and the age of the individual [9]. Vegetables are common diet taken by populations throughout the world, being sources of essential nutrients, antioxidants and buffering agents [10]. In Africa, vegetables form the major component of most of the dishes, more especially in the Northeast Nigeria where among the commonest are *Spinacia oleracea* and *Hibiscus sabdariffa*. A comparative study of the nutritional and elemental composition of the two species have showed both species of vegetables contain reasonable percentage of nutrients [11]. Some vegetables are known to contain heavy metals at wide range of concentrations [12]. This is because vegetables are good absorbers of metals hence absorb both essential and toxic elements [13].

MATERIALS AND METHOD

Materials and reagents

Beakers (100cm³), Conical flasks, Funnel, Whatman No. 1 filter paper, Measuring cylinders Stirrer, Sterilized Sample bottles, Masking tape, Hot plate, Pestle & mortar, Oven, Hoe, Knife, Weighing balance and Atomic Absorption spectrophotometer

Studies have shown that, there is positive correlation between heavy metal contents of vegetables and that of the soil where they are grown [14], as well as deposit on the surface of vegetables [15]. This study was aimed at assessing the health risk status of heavy metal contents of commonly consumed vegetables (*Spinacia oleracea* and *Hibiscus sabdariffa*) in the study area. This was achieved through analysis of the vegetable samples and their respective soil samples for the heavy metals of interest (Cd, Cr, Cu, Pb and Zn). Mathematical tools were used to calculate; Transfer Factor (TF), Daily Dietary Intake (DDI), Daily Intake of Metal (DIM), Health Risk Index (HRI), Target Hazard Quotient (THQ)

(AAS)[VGP210Buck Scientific]. Concentrated Nitric acid (HNO₃), Concentrated Perchloric acid (HClO₄), Concentrated Hydrochloric acid (HCl) and Distilled water.

Sample collection

Samples of edible vegetables (*Spinacia oleracea* and *Hibiscus sabdariffa*) were randomly collected from a farm in Bargu. The soil samples were collected from the same farm land where the vegetables were

collected at a depth of 15cm from the surface of the soil [16]. The samples were packaged in cleaned containers and properly labeled.

Sample Preparation

The two vegetable samples collected were washed with clean tap water first to remove the soil particles adhered to the vegetables and then followed by double washing with distilled water. The roots were cut off, the leaves and the stems of the *Spinacia oleracea* were chopped into small pieces, and the leaves of the *Hibiscus sabdariffa* were plucked from the stem and were chopped separately [12]. The

samples of the vegetables were dried at 150°C in an oven until it was ready for grinding. Both vegetable samples and soil samples were ground using wooden pestle and mortar and sieved with 2mm sieve to obtain fine powder. Representative samples were obtained through cone and quartering [17], samples were then labeled into different containers for identification.

Sample digestion

Three gram (3.0g) of each of the samples were weighed and poured into separate beakers. 15ml of tri acids mixture (HNO₃, HClO₄ and HCl) in the ratio of 5:1:1 were added to each sample in the beaker and was stirred continuously for some minutes. The mixture was then heated at 80°C until

a transparent solution was obtained [12]. The solution was then cooled and filtered using whatman No.1 filter paper and the filtrate was maintained to 50ml with distilled water which was then poured in sample bottles and taken for analysis.

Atomic absorption spectrophotometer (AAS) analysis

Concentrations of the heavy metals of interest (Cd, Cr, Cu, Pb and Zn) in the filtrate of the digested plant samples and soil samples were determined by using an atomic absorption spectrophotometer

vgp210 buck scientific model. Calibration of the AAS instrument was done with standard solutions of the respective heavy metals of interest and blanks as outlined by [18].

CALCULATION OF THE PARAMETERS

Mathematical models outlined by [12], were used in calculating the test parameters (TF, DDI, DIM, HRI and THQ) viz:

Transfer Factor (TF)

The transfer factor is an index of the ability of the vegetable to accumulate a particular metal with respect to its concentration in the soil substrate which was calculated for each metal species as follows:

$$TF = \frac{\text{metal concentration in plant tissue}}{\text{metal concentration in soil}}$$

Daily Food Intake

Daily food intake was calculated using the formula;

$$D_{\text{food intake}} (\text{Kg/day/person}) = \frac{\left\{ \frac{DI + 2WI + WI}{1 + 3.5 + 7} \right\}}{25}$$

Where DI = Once daily Intake
2WI = Twice a week intake
WI = Weekly Intake

Daily Intake of Metal (DIM)

The daily intake of metal (DIM) was determined using the equation

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

Where;

C_{metal} = the heavy metal concentration in vegetable (mg/kg),
 C_{factor} = conversion factor (A factor of 0.085 used to convert the fresh to dry weight of vegetables.

$D_{\text{food intake}}$ = the average daily vegetable intake for 25 people (male and female) which was calculated to be 0.54kg/person/day and an average body mass of 25 inhabitants of Bargu were measured to be 61.2kg which represents the average mass per person.

Daily Dietary Intake (DDI)

The daily dietary intake of metals expresses the dietary availability of metals in a particular food.

The daily dietary intake of metal was determined by using the 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

Health Risk Index (HRI)

The Health Risk Index of heavy metal due to consumption of contaminated vegetable is defined as a quotient between the estimated exposure to daily

metal intake (DIM) from soil through food chain and reference dose (RfDo). Hence;

$$HRI = \frac{DIM}{RfDo}$$

Where, DIM represents the daily intake of metals
RfDo represents reference oral dose. RfDo values

for Pb, Cr, Cd, Cu and Zn are; 0.004, 1.5, 0.001, 0.04 and 0.30 (mg/kg/bw/day), respectively.

Target Hazard Quotient (THQ)

This is defined as the ratio of the body intake dose of a metal to the reference dose. The THQ was calculated by using the formula:

$$THQ = \frac{D_{\text{food intake}} \times C_{\text{metal}}}{RfDo \times BW_{\text{average}}}$$

Where; $D_{\text{food intake}}$ = daily intake of vegetables (kg/day)
 C_{metals} = heavy metal concentration in vegetable.
RfDo = represent reference oral dose for metal (mg/kg/person/day).

BW_{average} = average body weight.

- If the $THQ \geq 1$ there will be potential health risk.
- If the $THQ < 1$ there will be no potential health risk.

RESULTS AND DISCUSSION

The results showed Spinach have higher concentration of heavy metals than Roselle; Cd was not detected in both vegetables; however, Cr was

detected in spinach only. Pb had higher concentration values while Cu had equal values in both the vegetable samples (fig.1)

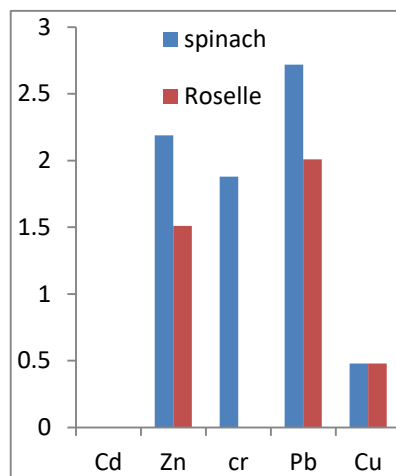


Fig.1: Concentration of heavy metals (mg/Kg) vegetable samples

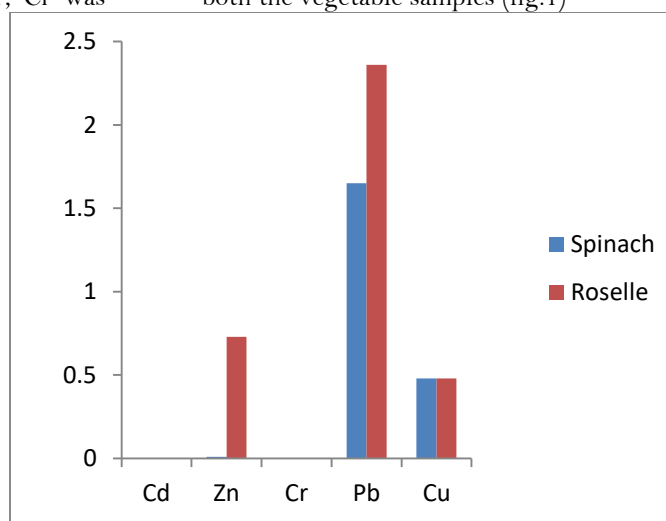


Fig.2: Concentration of heavy metals (mg/Kg) in soil samples

The concentration of Cd, Zn, Cr, Pb and Cu for the soil samples is (fig. 2), indicates that Roselle soil had higher concentration than the Spinach soil. Cd and Cr were not detected, while Cu had the same value of 0.48mg/kg in both the soil samples. The order of heavy metals concentration in the soil sample for Spinach was Pb>Cu>Zn>Cd=Cr, while for Roselle was Pb>Zn>Cu>Cd=Cr. For daily intake of metals DIM, Pb intake was the highest in both Spinach and

Roselle with values of 0.00204 and 0.00151mg/Kg/person/day, followed by Zn (0.00164 and 0.00113mg/Kg/person/day). Both plants recorded a DIM value of 0.00036mg/Kg/person/day for Cu, 0mg/Kg/person/day for Cd while only Spinach had a DIM value of 0.00141mg/Kg/person/day for Cr (Fig. 4 below).

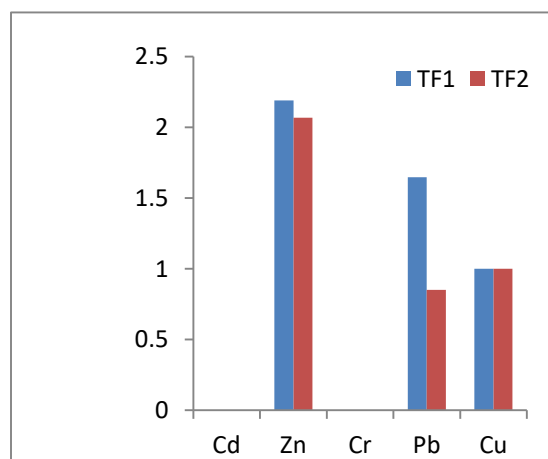


Fig.3. *S. oleracea* (TF1) and *H. sabdariffa* (TF2)

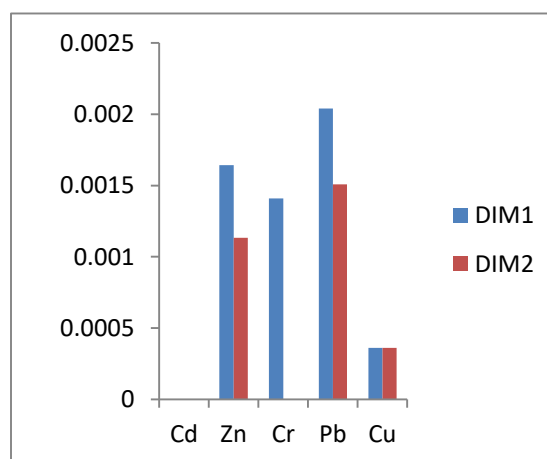


Fig. 4. *S. oleracea* DIM1 and *H. sabdariffa* DIM2

Pb has the highest DDI value in both vegetables preceded by Zn. Cd shows no DDI value for both vegetable samples while Cu shows the same value for both samples. The DDI for Cr in Spinach was higher than that

observed in Roselle. The trend for DDI in Spinach was found to be in the order Pb>Zn>Cr>Cu>Cd while that of Roselle was Pb>Zn>Cu with Cd and Cr showing zero values

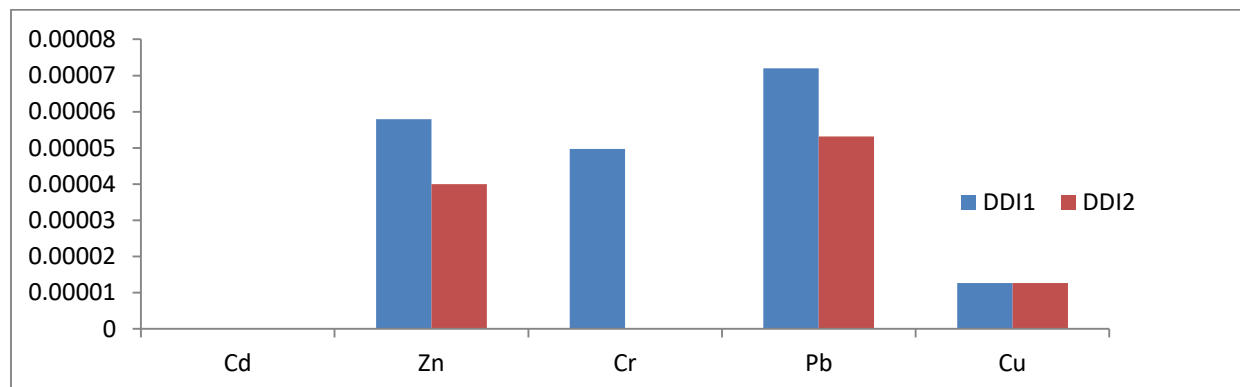


Fig.5. DDI for *S. oleracea* (DDI 1) and *H. sabdariffa* (DDI 2)

The order of HRI were; Pb>Cu>Zn>Cr>Cd and Pb>Cu>Zn>Cr=Cd for Spinach and roselle respectively (fig.6). This means that the inhabitants of Bargu are exposed to Health Risk associated with these metals, especially Pb.

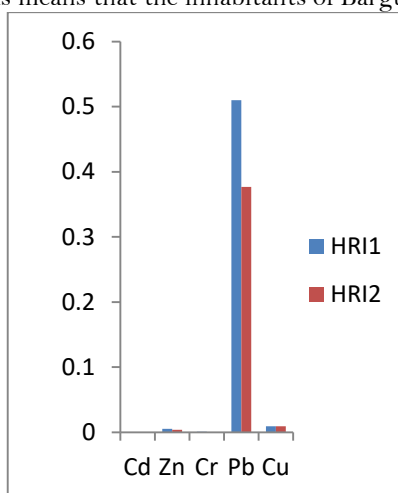


Fig. 6 HRI for *Sp. Oleracea* (THQ 1) and *H. sabdariffa* (THQ 2)

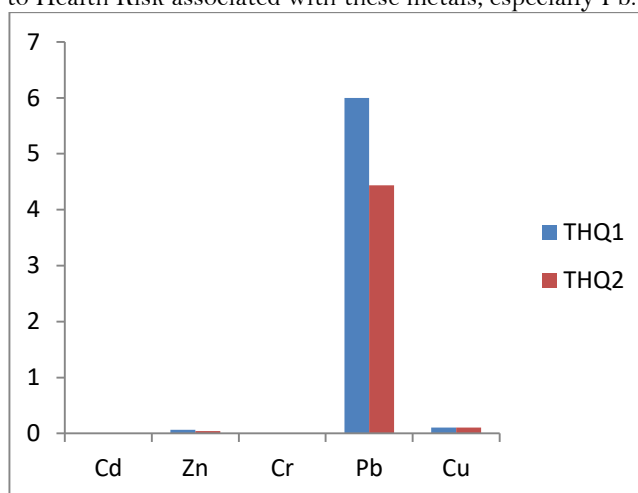


Fig. 7 THQ for *S. oleracea* (HRI 1) and *H. sabdariffa* (HRI 2)

THQ which is the ratio of body intake dose of metal to the standard reference dose of a metal. Values greater than or equal to 1 translates to high potential health risk. Fig. 7 shows that only Pb has a high potential health risk among all the heavy

metals tested. Hence the inhabitants of Bargu are at risk of suffering from diseases associated with Pb pollution which include: hyperactivity, mental retardation and other Neuro-Psychological disorders as reported by [19].

CONCLUSION

All the tested parameters were observed to be below the maximum permissible limit as standardized by WHO and FAO. From the health risk assessment of the heavy metals, only Lead (Pb) had a high health risk potential with a Target Health Quotient (THQ) value of 6.000 for Spinach and 4.434 for Roselle

respectively. All the other heavy metals tested had a THQ of less than 1 and hence poses no health risk. However, continuous ingestion of these metals from these vegetable can lead to bioaccumulation of the heavy metals hence may pose long time health risk to the consumers.

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