Abstract: Health risk index of chromium (Cr), cadmium (Cd), lead (Pb), copper (Cu), and zinc (Zn) have been determined on two vegetable samples (Hibiscus cannabinus and Sesamum radiatum), grown in Bayara–Bauchi. The levels of the heavy metals in the soil where the vegetables were grown were also determined. Atomic absorption spectrometer was used to estimate as well as evaluate the level of these heavy metals in the vegetables and soil. This study include the measurement of transfer factor (TF), daily dietary intake (DDI), daily intake of metal (DIM), health risk index (HIR) and target hazard quotient (THQ). The mean concentration of Cd, Cr, Pb, Cu, and Zn in Hibiscus cannabinus were 3.05±0.01, 0.78±0.01, 0.12±0.01, 3.55±0.02 and 21.88±0.01 mg/kg, were 3.0±0.00, 0.55±0.02, ND, 0.22±0.01 and 24.17±0.00 mg/kg in Sesamum radiatum and in the soil were 2.52±0.02, 6.50±0.01, ND, 1.67±0.02 and 26.55±0.03 mg/kg, respectively. All the values obtained were below the permissible limit recommended by WHO/FAO except for Cd in both Hibiscus cannabinus and Sesamum radiatum. It is concluded that these vegetables are safe for public consumption as they do not contain the amount of heavy metals that would constitute danger of metal poisoning. The HRI and THQ ≥ 1 indicated that there is potential health risk associated with Cd. Precautionary measures should be taken to avoid bioaccumulation and biotransformation of the heavy metals.

Keywords: Heavy metals, vegetables, risk, Bayara–Bauchi.

Introduction
Vegetable plants form the major component of most African dishes providing the most needed nutritional needs of the consumers such as minerals, vitamins, iron, calcium, protein and other nutritional requirements. They also contain heavy metals at wide range of concentrations (Afshin and Mason, 2008). Heavy metals contamination of soil through anthropogenic activities is a widespread and serious problem confronting scientists and regulators throughout the world (Li et al., 2001). Heavy metals are non-biodegradable and persistent environmental contaminants which may be deposited on the surfaces and then absorbed into the tissue of vegetables. Plant take up these heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environment as well as from contaminated soil (Sharmet et al., 2008). Contamination of vegetables with heavy metals such as Pb, Cr, Cd, Mn, As, Co and Ni may be due to irrigation with contaminated water, and metal-based pesticides, industrials emissions, transportation of the harvest products, storage and or at the point of sales (Afshin and Masound, 2008). Clearly, not only the ingestion or inhalation of contaminated particles, but also the ingestion of plants produced by contaminated area is another principal factor contributing to heavy metals of exposure for population (Dudka and Miller, 1999). The poisoning effects of heavy metals are due to their interference with normal body biochemistry in normal metabolic processes (Okonkwa et al., 2011). Vegetables are and also have beneficial anti-oxidative effects. Heavy metal contamination of vegetables cannot be underestimated as these foodstuffs are important component of human diets. Prolonged consumption of contaminated vegetables may lead to the increasing accumulation of toxic metals in the liver and kidney of humans resulting in the disturbance of biochemical processes such as liver, kidney, cardio-vascular, nervous and bone disorders. Therefore there is a need to ascertain the values of these heavy metals in vegetables grown in Bayara-Bauchi. The aim and objectives of this study is to determine the level of heavy metals in Hibiscus cannabinus and Sesamum radiatum vegetables grown in Bayara – Bauchi and their, transfer factor (TF), daily dietary intake (DDI) daily intake of metal (DIM), health risk index (HIR) and target hazard quotient (THQ).

Materials and Method
Samples collection
Samples of the edible vegetables (Hibiscus cannabinus, Sesamum radiatum) were randomly collected from a farm in Bayara. The samples were taken to the laboratory and washed with clean tap water first to remove the soil particles adhered to the sample of vegetable and then followed by double washing with distilled water (Lawal and Audu, 2011). The roots were cut off, the leaves and the stem were chopped into smaller pieces. The soil sample was collected from the same farm lands where the vegetables were collected at a depth of 15 cm from the surface of the soil. The samples were packaged in cleaned containers and properly labeled. The sample of vegetables was dried at 150°C in the oven. The dried samples were ground into fine powder using mortar and pestle.

Digestion of the sample
A 3.0 g sample of vegetables (Hibiscus cannabinus and Sesamum radiatum) and the soil sample was digested with 15 ml of tri acid mixture (HNO₃, H₂SO₄ & HClO₄ in 5:1:1 ratio) at 80°C until transparent solution is obtained (Allen et al., 1986). The solution was then cooled and filtered using Whatman No. 42 filter paper and the filtrate was maintained to 50 ml with distilled water.

Atomic absorption spectrophotometer analysis
The concentration of Pb, Cr, Cd, Cu and Zn in the filtrate of digested plant samples was estimated by using an atomic absorption spectrophotometer. The instrument was...
The health risk index for the locals through the weight 64.3kg RfDo represent reference oral dose. RfDo value for Pb, Cr, metal to the reference dose. The THQ can be calculated by

\[ \text{THQ} = \frac{D_{\text{food intake}} \times C_{\text{metal}}}{\text{BW}_{\text{average}}} \]

Where \( D_{\text{food intake}} \) = Daily intake of vegetables (kg/day) \( C_{\text{metal}} = \) Heavy metal concentration in vegetable, \( \text{RfDo} \) = Represent reference oral dose for metal (mg/kg bw/day) \( \text{BW}_{\text{average}} = \) average body weight 64.3 kg

- If the THQ ≥ 1 there will be potential health risk.
- If the THQ < 1 there will be no potential health risk.

**Results and Discussion**

The results obtained from the health risk index of heavy metals (Cd, Cr, Pb Cu and Zn) in *Hibiscus cannabinus*, *Sesamum radiatums* and the soil where these vegetables were grown. The availability of a metal in its different forms to migrate from the soil through the plants part and makes itself available for consumption was represented by the transfer factor as seen in Fig 1. The Daily Dietary Intake of Zinc metal in both vegetables is higher than the DDI of the other metal as shown in the Fig 2. Also, Fig. 2 indicates that the daily dietary intake (DDI) of Zn in both vegetables (*Hibiscus cannabinus* and *Sesamum radiatums*) was the highest 70.23x10^-5 and 77.59 x 10^-5 mg/person/day. The trend for DDI of *Hibiscus cannabinus* is found to be in the order Zn>Cu>Cd>Cr>Pb while in *Sesamum radiatums* is Zn>Cd>Cr>Cu>Pb

In Fig. 3, the DIM as a function of body weight and intake, Zn has the highest value of DIM of both vegetables (*Hibiscus cannabinus* and *Sesamum radiatums*) of 198.9 x 10^{-4} and 219.8 x 10^{-4} mg/kg/person/day. The trend of DIM in *Hibiscus cannabinus* was found to be in the order of Zn>Cu>Cd>Cr>Pb and Zn>Cd>Cr>Cu>Pb in *Sesamum radiatums*.
showed that Cd had the highest of HRI (2.7700) and THQ (32.64) in *Hibiscus cannabinus* and Cd still had the highest of HRI (2.7300) and THQ (32.100) in *Sesamum radiatum*. The HRI and THQ values of Cd for both vegetables were ≥1. Therefore, there is potential health risk of Cd related diseases e.g renal, prostrate and ovarian cancers. The THQ for all the metal is less than 1 except Cd in both plants. Therefore, there is potential health risk associated with Cadmium (Cd).

![Fig. 4: Health Risk Index for *Hibiscus cannabinus* and (HRI1) *Sesamum radiatum* (HRI2)](image)

![Fig. 5: Target Hazard Quotient for *Hibiscus cannabinus* (THQ1) and *Sesamum radiatum* (THQ2)](image)

The result showed that, in *Hibiscus cannabinus*, Zn has the highest value (21.88 mg/kg), while Cr (0.78 mg/kg) and Pb (0.12 mg/kg) levels were low. In the *Sesamum radiatum*, Zn value (24.17 mg/kg) was also the highest and Pb was not detected in the soil, Zn also has the highest value (26.55 mg/kg) and Cu has the lowest (1.67 mg/kg). Pb was not detected in the soil sample as shown in Table 1. The trend in the plant *Hibiscus cannabinus* was Zn>C>Cr>C>C>Pb, Zn>C>Cr>C>C>Pb in *Sesamum radiatum* and Zn>C>Cr>C>C>Pb in the soil sample. 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 may be present in the plant and the soil will also contribute to the metal bioavailability.

**Table 1:** Heavy metal concentration (mg/kg) in soil and vegetables (*Hibiscus cannabinus* and *Sesamum radiatum*)

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Soil</th>
<th><em>Hibiscus cannabinus</em></th>
<th><em>Sesamum radiatum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>2.62 ± 0.02</td>
<td>3.05 ± 0.01</td>
<td>3.00 ± 0.00</td>
</tr>
<tr>
<td>Cr</td>
<td>6.50 ± 0.01</td>
<td>0.78 ± 0.01</td>
<td>0.55 ± 0.02</td>
</tr>
<tr>
<td>Pb</td>
<td>ND</td>
<td>0.12 ± 0.01</td>
<td>ND</td>
</tr>
<tr>
<td>Cu</td>
<td>1.67 ± 0.02</td>
<td>3.55 ± 0.02</td>
<td>0.22 ± 0.01</td>
</tr>
<tr>
<td>Zn</td>
<td>26.55 ± 0.03</td>
<td>21.88 ± 0.01</td>
<td>24.17 ± 0.00</td>
</tr>
</tbody>
</table>

ND = Not Detected

**Table 2:** Comparative heavy metals concentration (mg/kg) in soil samples with similar work reported in the literature and the maximum permissible limits in some countries

<table>
<thead>
<tr>
<th>Heavy Metal</th>
<th>Conc. in Soil</th>
<th>Wu, 2010</th>
<th>Great Britain*</th>
<th>USEPA**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>2.62</td>
<td>0.55</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cr</td>
<td>6.50</td>
<td>44.72</td>
<td>50</td>
<td>400</td>
</tr>
<tr>
<td>Pb</td>
<td>ND</td>
<td>216.93</td>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>Cu</td>
<td>1.67</td>
<td>54.13</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Zn</td>
<td>26.55</td>
<td>118.06</td>
<td>300</td>
<td>200</td>
</tr>
</tbody>
</table>

*Maximum permissible limit of metals (mg/kg) in soil in Great Britain; ** Maximum permissible limit of metals (ppm) in soil by USEPA (1985); ND: Not determine

Comparisons of heavy metals in soil in this study and other literatures (Table 2) showed a difference from the one reported in the literature by Wu et al. (2007). The result in this study is less than the British, USEPA and Japan standard permissible limit of metals in the soil of those countries with the exception of Cd which is greater than Japan standard permissible limit but less than the Britain and USEPA permissible limits. This is a very toxic heavy metal that should be monitored to prevent further outbreak of Cd related sicknesses. It is found that Copper has the highest TF value (2.126) in the *Hibiscus cannabinus* and Cd has the highest TF value (1.145) in the *Sesamum radiatum*. Siridathra et al. (2008) reported that high TF for heavy metals through leafy vegetables. The TF does not present the risk associated with the metals in any form.

The concentration of Cd, Cr, Pb, Cu and Zn for soil and vegetables (*Hibiscus cannabinus* and *Sesamum radiatum*) is shown in Table 1. The results showed an irregular pattern of heavy metal availability. Zn has the highest in the soil (26.55 mg/kg) and in vegetables (*Hibiscus cannabinus* and *Sesamum radiatum*) 21.88 mg/kg and 24.17 mg/kg, respectively. Pb was not detected in both soil and *Sesamum radiatum* but detected in *Hibiscus cannabinus* (0.12 mg/kg). These variations of heavy metal in soil and vegetables are due to differences in the sources of the metal. Some of the soil will contribute to the metal bioavailability in the plant.

Comparisons of heavy metals in soil in this study and other literatures (Table 2) showed a difference from the one reported by Wu et al. (2010). The result of heavy metals (Table 3) in vegetables 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* and *Sesamum radiatum* was higher than the maximum permissible limit when compared with WHO/FAO (2007), Indian (2007) and Anthony Balwant (2005) standards.
Cui had the highest transfer factor (TF) value (2.126) in *Hibiscus cannabinus* while Cd was the highest (1.145) in *Sesamum radiatum*. Sridhara *et al.* (2008) reported that high TF for heavy metals for leafy vegetables. The TF does not present the risk associated with metals in any form.

The trend of the TF value was Cu>Cd>Zn>Cr>Pb in *Hibiscus cannabinus* while in *Sesamum radiatum* was Cd>Zn>Cu>Pb. Variations in TF among different vegetables may be attributed to differences in the concentration of metals in the soil and differences in element uptake by different vegetables (Cui *et al.*, 2004). In Fig. 2, the daily dietary intake (DDI) of Zn in both vegetables (*Hibiscus cannabinus* and *Sesamum radiatum*) was the highest 70.23x10^{-5} and 77.59 x 10^{-5} mg/person/day.

**Conclusion**

Based on the results obtained from the analysis using AAS technique and the analysis made by comparing the detected concentration of Cd, Cr, Pb, Cu and Zn in *Hibiscus cannabinus*, *Sesamum radiatum*and the soil sample with the recommended concentration put forward by WHO. These vegetables were safe for public consumption as they do not contain the amount of the heavy metals that would constitute danger of metal poisoning. The HRI and THQ indicate that the heavy metals are not dangerous to consumers. Only Cd in *Hibiscus cannabinus* and *Sesamum radiatum* exceeded the maximum permissible limit and has to be monitored in order to prevent Cd disease outbreak.

**References**


Uptake and Risk Assessment of Heavy Metals in Vegetables Grown in Bayara-Bauchi, Nigeria