



Assessment of Selected Heavy Metals Levels and Its Associated Health Risk of Commonly consumed Vegetable in Awe Town, in Oyo State



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ABSTRACT

Vegetables are considered as one of the most important dietary source of nutrient but becomes deleterious to human as well as animals as it accumulates toxic metals in their tissue when grown on contaminated soil. This present study was carried out to determine the levels of selected heavy metal in vegetables collected from a farmland in Awe, Oyo state so as to determine the health risk associated with their consumption in adults using daily intake metal (DIM), target hazard quotients (THQ) and incremental life cancer risk (ILCR) indices.

Amaranthus viridis, *Celosia argentea*, *Basella alba*, *Malinum triangulare*, *Corchorus olitorius*, *Telferia occidentalis*, *Amarantus*, *Murraya koenigii*, *Taraxacum* and *Ipomoea aquatic* were collected from a vegetable farmland closely located to a pharmaceutical industry in Awe, Oyo state. Their leaves were cleaned and digested freshly with mixture of 12 mL HNO₃ and 4 mL HCl (aqua regia in 3:1). The digests were analysed for copper (Cu), lead (Pb), chromium (Cr), cadmium (Cd) and zinc (Zn) using atomic absorption spectrophotometer (AAS) model Buck Scientifics 210VGP.

The results of this study showed ranging concentrations of lead to be (0.701 to 0.464 mg/kg), zinc (0.53 to 0.15 mg/kg), Cr (0.24 to 0.04 mg/kg), copper (0.23 to 0.03 mg/kg) and cadmium (0.05 to 0.01 mg/kg) for the studied vegetables samples.

The concentration of cadmium and lead in *Corchorus olitorius* (0.41&0.701 mg/kg) and *Ipomoea aquatic* (0.41&0.652 mg/kg) exceeded FAO/WHO (2019) permissible limit while *Amaranthus viridis*, *Celosia argentea* concentration of cadmium (0.35&0.49 mg/kg) and *Amarantus spp* concentration of lead (0.464 mg/kg) also exceeded the permissible level of FAO and WHO standard. The daily plant metal intake for copper and lead exceeded the recommended tolerable limit of daily intake metals. The ILCR values for Cu, Zn and Pb exceeded the threshold value (CR > 10⁻⁴). The THQ evaluated for all the studied metals were greater than one (THQ > 1) except for Cu, Cd and Zn. It can be inferred from the result of this study that continuous consumption of the investigated vegetables by the exposed population can make them susceptible to developing diseases associated with the selected heavy metal contamination.

INTRODUCTION

Heavy metals and metalloids are the natural and structural part of the earth crust with a density greater than 5g/cm³. Many of them are environmental persistent and non-degradable contaminants. Initially they are deposited on the soil surface, then absorbed by the apoplast of plant roots and further distributed and accumulated into their edible and non-edible parts, posing an imminent danger to the food chain (Alsafran *et al.*, 2021). Some heavy metals are bio-accumulative in nature in various plant parts, resulting in poor growth of plants (Girisha and Ragavendra, 2006) and pose great danger to the various elements of the food chain in any given environment. Heavy metals such as copper (Cu), zinc (Zn), chromium (Cr), Cadmium (Cd) and Lead (Pb) are essential in plant nutrition, however many heavy metals do not play a significant role in the plant's physiology (Okoronkwo *et al.*, 2005). Plants cultivated in polluted environments can accumulate these toxic metals at a high concentration causing serious risks to human health when consumed. Heavy metals are usually absorbed by plants through their growth media (air, soil, nutrients, to mention a few); plants take up the metals through their roots or foliage (Okoronkwo *et al.*, 2005). The Commission of the European Communities and the Codex Alimentarius Commission (2001) set the Maximum Limit (ML) for Cadmium as 0.2 mg/kg for leafy vegetables and fresh herbs, 0.1 mg/kg for stem and root vegetables and 0.05 mg/kg for the remaining ungrouped vegetables. For lead, both organizations set the ML of 0.3 mg/kg for brassicas, leafy vegetables and herbs, and 0.1 mg/kg for all remaining vegetables. (Kachenko and Singh, 2006).

SCOPE OF STUDY

The scope of this study covered 10 vegetable samples (*Amaranthus viridis*, *Celosia argentea*, *Basella alba*, *Talinum triangulare*, *Corchorus olitorius*, *Telferia occidentalis*, *Amarantus spp*, *Murraya koenigii*, *Taraxacum*, *Ipomoea aquatic*) from a vegetable farmland close to a pharmaceutical industry in Awe, Oyo state. Analysis was then be carried out in the analytical laboratory for heavy metals level.

JUSTIFICATION

Considering the potential toxicity, recalcitrant nature and cumulative behaviour of heavy metals, the frequency of vegetables consumption, its safety and health concerns, more research work was still needed to be done on all species of vegetables grown and consumed in industrial areas of Nigeria. Thus, this study was designed to assess the health risk associated with level of some heavy metals present in selected vegetable species in a vegetable farmland close to a pharmaceutical industry in Awe, Oyo state, and also to assess the potential health risk associated with their daily intake.

MATERIALS AND METHOD

Research Design: The study was focused on analyzing vegetable samples for heavy metals contamination from selected farmlands in Awe closely located to a pharmaceutical industry, using the result to calculate the daily intake metal (DIM), target hazard quotient (THQ) and increment life cancer risk (ILCR) indices and hence assess the potential health risk.

Sample collection: Fresh sample of ten (10) commonly consumed vegetables was collected from a selected farm land, awe closely located to a pharmaceutical Industry with coordinate 7.8259777°N and 3.95331°E. The samples was properly tagged in polythene bags and was taken to the herbarium of Botany Department, University of Ibadan for identification.

Acid Digestion: Exactly 1.0g of each sample was weighed and placed in digestion flask followed by the mixture of 12mL HNO₃ and 4mL HCl (aqua regia in 3:1) was added to the sample for digestion. The mixture was heated gently in the digestion block until brown fumes disappeared, it was then be allowed to cool for 15 minutes. The resulting mixture was filtered using Whatman No. 42 filter paper. Then 5mL of the filtrate was be put into 50mL volumetric flask and topped to the mark with distilled water. The final solution was transferred into the acid cleaned plastic bottle, sealed, labelled and stored in a deep freezer.

AAS Analysis: The operating parameters for the AAS (Shimadzu AA-6300) equipment was set according to the manufacturer's specifications. The Air-C₂H₂ flame was used to analyze all the metals.

The detection limit was set at ≤0.01000 ppm, repeatability ≤ 2.00%, and stability ≤ 6.0% (Crouch *et al.*, 2014).

HEALTH RISK ASSESSMENT

Risk of intake of metal-contaminated vegetables to human health was characterized by Target Hazard Quotient (THQ). This is a ratio of determined dose to the reference dose (R_D). The population will pose no risk if the ratio is less than 1 and if the ratio is equal or greater than 1 then population will experience health risk.

This risk assessment method has been used by researchers (Sridhara *et al.*, 2008) and proved to be valid and true. The following equation is used;

The daily intake of metals (DIM) was calculated to averagely estimate the daily metal loading into the body system of a specified body weight of a consumer.

This will inform the relative phyto-availability of metal. This does not take into cognizance the possible metabolic ejection of the metals but can easily tell the possible ingestion rate of a particular metal. The estimated daily intake of metal in this study was calculated based on the formula below:

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

Where;

C_{metal} = heavy metals conc. in plants (mg/kg) metal

C_{factor} = conversion factor

$D_{\text{food intake}}$ = daily intake of vegetables.

Average weight used will be 65g in this study.

Increment Life Cancer Risk (ILCR)
The ILCR was calculated using the formula below:
 $ILCR = CDI \times CSF$
Where CDI is the cancer risk index and CSF is the cancer slope factor.

$$CDI = \frac{C \times DIM \times F \times ED}{BW \times AT}$$

where F is the exposure frequency (350 days/year); ED is the exposure duration (54 years, equivalent to the average lifetime of the Nigerian population); C is the metal concentration in the edible parts of vegetables (mg/kg) (USEPA IRIS, 2006); BW is the average body weight (65kg for adults' vegetable consumer in South western Nigeria); and AT is the average exposure time for non-carcinogens (ED x 365 days/year). If the ILCR value is greater than 10⁻⁴, the exposure is likely to cause obvious adverse effects.

$$THQ = \frac{[W_{\text{plant}}] \times [M_{\text{plant}}]}{R_D \times B}$$

Where $[W_{\text{plant}}]$ is the dry weight of contaminated plant material consumed (mgd⁻¹), $[M_{\text{plant}}]$ is the plant concentration of metal in vegetables (mg kg⁻¹), R_D is the food reference dose for the metal (mgd⁻¹) and B is the body mass (kg).

The values of R_D for heavy metals were taken from Integrated Risk Information System (Abdollahif *et al.*, 2009) and Department of Environment, Food and Rural Affairs (DEFRA, 2009).

CONTRIBUTION TO THE UN SUSTAINABLE DEVELOPMENT GOALS

The excessive entry into food chain of these metals leads to increased susceptibility and exposure to metal poisoning of the exposed local population. Leading to a number of serious health problems resulting from the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defences and a high prevalence of upper gastrointestinal cancer among all other related diseases. This study contribute to the UN sustainable development goal 3 target 3.9 "substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. The concentration of heavy metals in vegetables of the study area and its health-related risks be regularly monitored to avoid metal build up in the body, whose detrimental impact becomes apparently only after several years of exposure.

CONCLUSION

Generally, the heavy metals concentrations in the studied vegetables were all below the permissible limit of WHO/FAO (2019) except Cd and Pb. The levels of metals discovered in some vegetables indicated obvious contamination of samples by heavy metals as shown by DIM, THQ and ILCR. The individual hazard quotient values were all below 1 except Pb, Cd and Cr that suggested an acceptable level of non-carcinogenic adverse risk. Only Pb had the highest value above permissible maximum tolerable daily intake (PMTDI) among other metals in water spinach. The cancer risk (ILCR) values for Cu, Cd and Pb exceeded the threshold value ILCR > 10⁻⁴, these metals may pose potential cancer risk to the exposed population via continuous consumption of the studied vegetable samples while ILCR values for Cr and Zn were found to be less than the threshold value (ILCR > 10⁻⁴), indicating that the population in the studied area are not at any cancer risk due to Cr and Zn exposure from vegetable samples consumption.

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