MSI Journal of
Multidisciplinary Research (MSIJMR)

Health Risk Assessment of Heavy Metals in Yam and Sweet Potatoes in Wukari

Augustina Achimugu[1*], Alfred Rimamsiwe[2], Moshud kasimu Musa[3], Aboche F. Edwin[4]

[1*,2,3,4]Faculty of physical sciences, Department of pure and Applied physics, Federal university of Wukari

*** Correspondence:** Augustina Achimugu

The authors declare that no funding was received for this work.

OPEN ACCESS

Received: 20-December-2025

Accepted: 24-January-2026

Published: 29-January-2026

This article is published in the **MSI Journal of Multidisciplinary Research (MSIJMR) ISSN 3049-0669 (Online)**

The journal is managed and published by MSI Publishers.

Volume: 3, Issue: 1 (January-2026)

ABSTRACT: The health risk assessment of heavy metals in some selected tuber crops (yam and sweet potatoes) was carried out in Wukari. Yam and Sweet potatoes tubers in Wukari and have been serving as stable food and so were also major sources of income. This study was aimed at assessing the concentration of some heavy metals (Pb, Cd,Cr,Cu, Zn and Ni) in some randomly selected selected tubers (yam and sweet potatoes) as well as the health risk in Wukari Local Government Area of Taraba State. The samples were collected from 6 different randomly selected site in Wukari namely; (Mechanic village (A), Sukundi road area (B), Jalingo road area (C), Ibi road area (D) Kente Road area (E) and Rafin kada road area (F)). The samples were washed, peeled, dried, pulverized and analyzed for heavy metal content using the Atomic Absorption Spectrophotometer. The results for the soil samples revealed that the mean values of Pb (108.9 mg/kg), Cd (2.21 mg/kg), Zn (112.8 mg/kg) and Ni (46.12 mg/kg) were above the WHO permissible limit of (85, 0.8, 50 and 35) mg/kg respectively while Cr (0.28 mg/kg) and Cu (12.21 mg/kg) were below the WHO permissible limit of 100 mg/kg and 36.00 mg/kg respectively. Similarly, the heavy metals in the tuber crops also have Pb (7.4- 57.5 mg/kg), Cd (0.2 – 1.9 mg/kg), Zn (20.0 - 40.0 mg/kg) and Ni (0 – 50) above the

WHO permissible limit of (2, 0.02, 0.6 and 10 mg/kg respectively), while Cr (0.1-0.4 mg/kg) was below the permissible limit of (1.3 mg/kg) and Cu (0-10 mg/kg) was within the permissible limit of 10 mg/kg for yam and sweet potatoes. The risk assessment analysis revealed that Pb and Cr had the highest and lowest HQ values; 49.30 and 0.11 for yam tubers, 39.25 and 0.13 for sweet potatoes. The highest cancer risk was obtained in Cd (5.1×10-2) and lowest in Cr (1.7 ×10-4). The results of this study are expected to gain public aware ness that consuming locally produced tuber crops from sites contaminated with heavy metals can lead to heavy metal toxicity, leading to liver damage, neural, and respiratory disorders, among others.

Keywords: *heavy metals, Atomic Absorption Spectroscopy, Sweet Potato, Yam.*

Introduction

Heavy metals are natural constituents of several ecosystems. Nevertheless, the escalation of human activities has resulted in modified biochemical equilibrium and elevated concentrations of heavy metals in the atmosphere, hydrosphere, and lithosphere, reaching levels that pose detrimental effects on both flora and fauna. Heavy metals possess hazardous properties and are widely present in the environment. They exhibit non-biodegradable features, rendering them resistant to natural degradation processes, hence it accumulate in food crops and pose a significant risk to human health.

Tubers such as yam, sweet potatoes and others are good food sources in Africa and other countries worldwide. Production of tubers provides employment, food supply, and food security (Yerima et al. 2020). Many African countries have long used yam and sweet potatoes as a source of food and traditional medicine; these tubers are rich sources of nutrients, including vitamins, minerals and antioxidant and play an essential role in ensuring food security and livelihood (Flora et al. 2016), they can also accumulate toxic metals (heavy metals) like lead, cadmium, copper, nickel and zinc from contaminated soil and water. Consumption of food crops contaminated with heavy metals can lead to a range of problem such as cancer, reproductive disorder, and liver inflammation and so on. According to (Sharma *et al.*, 2014) exposure to high levels of heavy metals, including mercury and lead, has the potential to cause significant consequences, including but not limited to stomach colic pain, bloody diarrhea, and kidney failure (Sharma *et al*., 2014). Additionally, studies have demonstrated that the presence of heavy metals in the human body can lead to several adverse health effects, including gastrointestinal and kidney dysfunction, disorders of the nervous system, skin lesions, vascular damage, impaired immune system function, birth defects, and the development of malignancies, among other conditions. According to a recent study conducted by Adda *et al*. (2021), Taraba state has been identified as the state with the greatest prevalence of liver diseases. This finding is attributed to the presence of toxins, specifically heavy metals, within the body (Adda *et al*., 2021). The potential risk to human and animal health arises from the accumulation of harmful heavy metals in consumable food crops. Hence this research aims to assess the levels of heavy metals in the food crops.

Materials and Method

The materials used in this research work are: 12 tuber crops samples (6 yam tubers, and 6 sweet potato tubers) from 6 farmland. The chemicals used for the analysis of heavy metal content are concentrated HNO_3, concentrated HCl, and distilled water. Other equipment includes sample bottles, reagent bottles, measuring cylinder, volumetric flask, funnel, hoe, cutlass, ruler, nylon, sample bottle mortar and pestle, beakers, and drying oven was used in this analysis. Atomic absorption spectrophotometer (UNICAM 929) is used for the determination of metals.

Study Area

The research was conducted in the Wukari local government area of Taraba state. The geographical coordinates of the location are 9°47`E longitude and 7°51`N latitude, in the southern region of Taraba State, Nigeria. Agricultural practices in Wukari and its surrounding areas are conducted on a significant scale. The cultivation of various crops such as rice, yam, maize, millets, cassava, and sweet potatoes is prevalent, resulting in a consistent availability of these key agricultural products throughout the year. Figure 1 depicts the geographical representation of the designated study area.

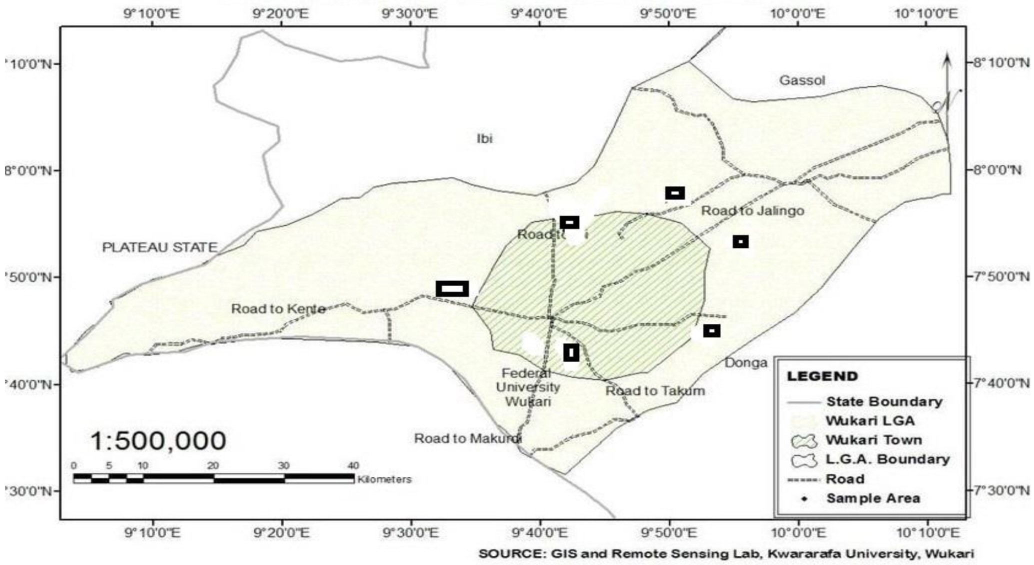

Figure 1: Map of the Study Area **(**Ejike *et al.,* 2020)

Sample Collection

Six sampling locations, namely STA (mechanic village), STB (Sukundi road area), STC (Jalingo road area), STD (Ibi road area), STE (kente road area), and STF (Rafin kada road area), were selected in a randomized manner, taking into consideration the level of human-induced activities in the area, such as garbage disposal and mechanic workshops. The collection plant samples occured concurrently during the optimal harvest period in October. Tuber crops, namely Yam (Dioscorea rotundata), and Sweet Potato (Ipomea Botatas), were obtained from agricultural fields located in the vicinity of the designated sites.

Plant Samples Preparation/ Pretreatment

Samples were peeled and washed three times with distilled water and allowed to dry at room temperature for one week and then oven dried to constant weight at 65 ^{o}C for 48 hours using Memmert drying oven. The dried samples were homogenized (ground to powder) using laboratory ceramic mortar and pestle. The homogenized samples were sieved with 2 mm sieve to obtain fine particle size for easy digestion.

AAS sample analysis

Heavy metal concentrations in the digested samples were determined using UNICAM 929 Atomic Absorption Spectrophotometer (AAS). Heavy metal concentration was quantified from calibration curves using the individual metal standards. The heavy metals analyzed were: Lead (Pb), Chromium (Cr), Cadmium (Cd), copper (Cu), Nickel (Ni) and Zinc (Zn)

3.2.6. Potential Health Risk Assessment

For the assessment of health risks through consumption of tubers (yam, and sweet potatoes) produced by the local inhabitants the estimated daily intake (EDI), the hazard quotient (HQ), total hazard quotient (THQ), and the cancer risk (CR) were estimated using equations 1,2,3 and 4 respectively

Estimated Daily Intake (EDI) via ingestion

The result could be obtained using Equation (1) below.

$$EDI = \frac{C \times IR \times ED \times EF}{BW \times AT} \quad (1)$$

Where C is the heavy metal concentration in the tuber crop (mg/kg), IR is the ingestion rate of tuber (kg/day), EF is the exposure frequency (day/per year), ED is the exposure duration (year), BW is the body weight of the exposed individual (kg), and AT is the time period over which the

dose is averaged (day). In this study, AT can be calculated as: AT=ED×365 day, for carcinogens ED is 55 years; and average BW is 60 kg for adults (Huang *et al.,*2015). The IR for yam is 75.15 kg/year per capita (FOS/FOA, 2006) and for sweet potatoes is 89.7kg/year/capita for Nigeria (Bergh *et al.,* 2012)

Hazard Quotient (HQ)

The non-carcinogenic hazard for a specific single metal in tuber was characterized by the hazard quotient (HQ) calculated using Eq. (2), and the non-carcinogenic hazard for multiple metals (THQ) was calculated using Eq. (3) as follows

$$HQ = \frac{EDIi}{RFDi} \quad (2)$$

$$THQ = \sum HQ = HQPb + HQCd + HQCr + HQCu + HQZn + HQNi \quad (3)$$

Where RFD = Reference Oral dose of a specific metal i. Reference doses for the following heavy metals as recommended by WHO/FAO are as follows: Lead (0.004

mg/kg), Chromium (0.003 mg/kg), Cadmium (0.001 mg/kg) (Olawale *et al.,* 2023). Cu (0.04 mg/kg), Ni (0.02 mg/kg) and Zn (0.3 mg/kg) (US EPA, 2016)

THQ is the sum of HQ for heavy metal. If the HQ and THQ are above one, it is considered likely that the exposed people will experience adverse health effects consequently, if HQ and THQ are less than one, the heavy metal is thought to be safe for human health (Li *et al*., 2014).

Carcer Risk Analysis (CR)

The cancer risk is related to the cancer slope factor (SF). The risk of a single metal can be calculated using Eq. (3.7):

$$CRi = EDIi \times SFi \qquad 4$$

Where, CR_i is the potential risk of a specific carcinogenic metal, i. The cancer slope factor SF (kg·day/mg) is 1.5 for As and 0.5 for Cr, from US EPA Integrated Risk Information System (IRIS), 0.0085 for Pb and 15 for Cd from California OEHHA Toxicity Criteria Database (Mo *et al.,* 2015). The CR_itotal is the sum of cancer risk of heavy metal i. The cancer risk could be classified as no significant health risk (CR_i or CR_itotal $< 1 \times 10^{-6}$); acceptable/tolerable ($1 \times 10^{-6} <$ Riski or Risktotal $<1 \times 10^{-4}$); or unacceptable (CR_i or CR_itotal $> 1 \times 10^{-4}$) (US EPA, 2001).

RESULTS AND DISCUSSION

The study determined the heavy metal concentration in randomly selected tuber crops (yam and sweet potatoes) from six sample sites in Wukari.

Table 1: Heavy Metal Concentration in the Tuber Crops

SAMPLES	**PARAMETERS**					
	MEAN CONCENTRATION (mg/kg)					
YAM	**Pb**	**Cd**	**Cr**	**Cu**	**Zn**	**Ni**
A	**50.10**	**1.00**	**0.30**	**10.00**	**40.00**	**20.00**
B	**57.50**	**0.20**	**0.20**	**ND**	**40.00**	**10.00**
C	**38.30**	**0.60**	**0.10**	**10.00**	**40.00**	**10.00**
D	**32.20**	**0.20**	**0.10**	**ND**	**30.00**	**20.00**

E	**31.60**	**0.80**	**0.10**	**ND**	**20.00**	**10.00**
F	**13.00**	**1.90**	**0.10**	**10.00**	**20.00**	**ND**
SWEET POTATOES						
A	**6.90**	**0.40**	**0.30**	**ND**	**30.00**	**10.00**
B	**7.40**	**0.20**	**0.10**	**ND**	**20.00**	**10.00**
C	**19.30**	**0.40**	**0.20**	**ND**	**20.00**	**30.00**
D	**32.20**	**1.30**	**0.20**	**10.00**	**20.00**	**10.00**
E	**19.80**	**0.60**	**0.10**	**ND**	**30.00**	**30.00**
F	**38.20**	**0.80**	**0.30**	**ND**	**20.00**	**20.00**
WHO/FAO(Ogundele *et al.*, 2015)	**2.00**	**0.02**	**1.30**	**10.00**	**0.60**	**10.00**

A to F represent test samples

ND = Not detected

Table 1 shows the heavy metal concentration in plant samples from the six locations. Yam sample showed a similar trend in the level of the heavy metals from the six locations as (Pb>Zn>Ni>Cu>Cd>Cr). In the case of the potato sample, sites A, B, E followed a trend in the order of Zn>Ni>Pb>Cu>Cd>Cr) while site D and E follows the order (Pb>Zn>Ni>Cu>Cd>Cr) sample C follows (Ni>Zn>Pb>Cu>Cd>Cr).

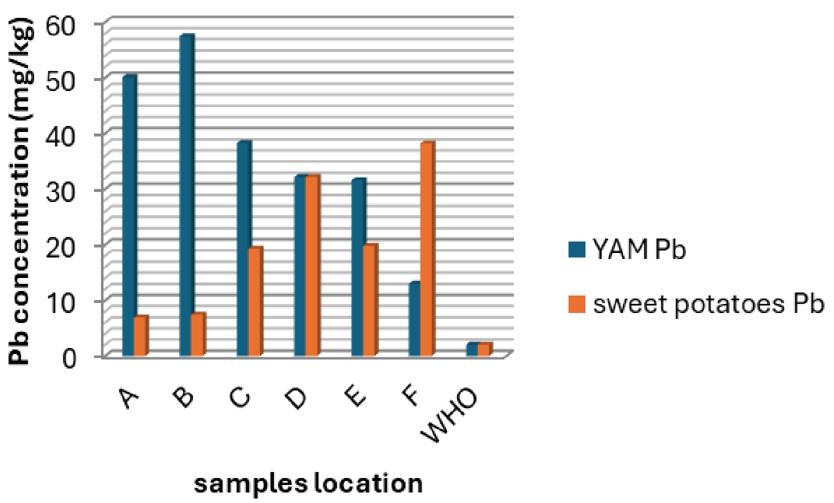

Fig 2: Pb concentration in plant

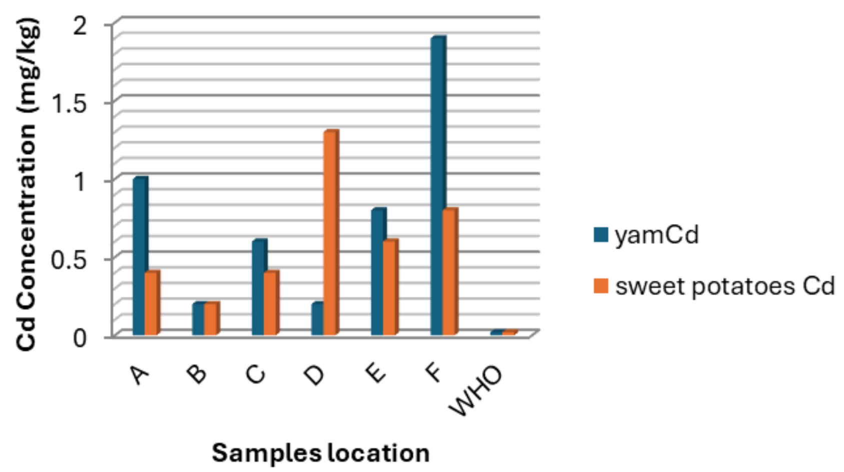

Fig 3: Cd concentarion in plant

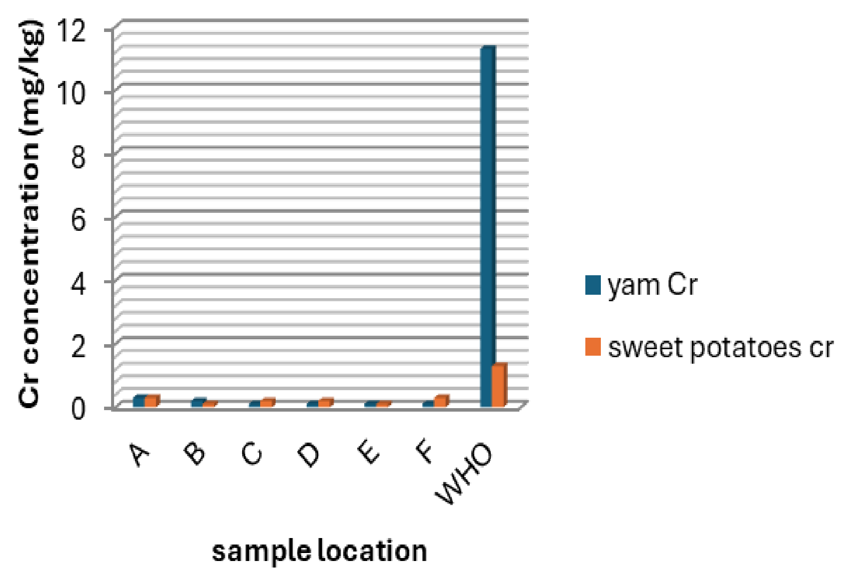

Fig 4: Cr concentration in plant

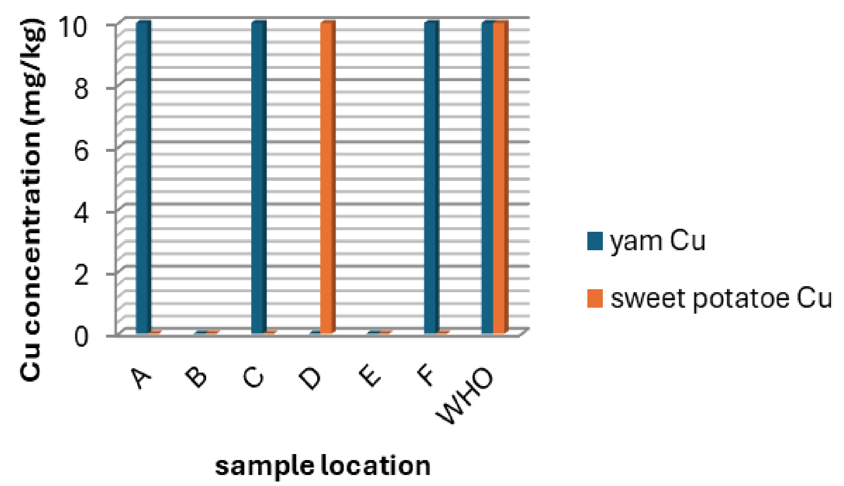

Fig 5: Cu concentration in plant

Fig 6: Zn concentration in plant

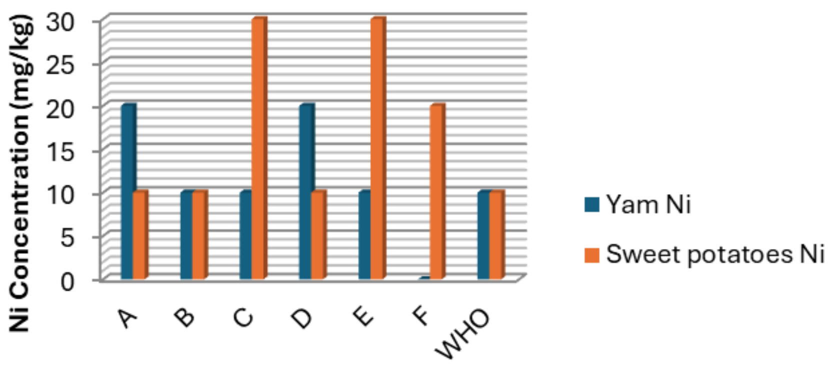

Fig 7: Ni concentration in plant

Table 2: Estimated Daily Intake (EDI), Hazard Quotient (HQ), and Cancer Risk (CR) of Heavy Metals in tubers (yam and sweet potatoes) for adults

ARAMETER & LOCATION	YAM			SWEET POTATOES		
A	EDI	HQ	CR	EDI	HQ	CR
Pb	0.1719	42.9796	0.0015	0.0283	7.0725	0.0002
Cd	0.0034	6.8630	0.0515	0.0016	3.2800	0.0246
Cr	0.0010	0.3432	0.0005	0.0012	0.4100	0.0006
Cu	0.0343	0.8579	ND	ND	ND	ND
Zn	0.1373	0.4575	ND	0.1230	0.4100	ND

Ni	**0.0686**	**3.4315**	**ND**	**0.0410**	**2.0500**	**ND**
B						
Pb	**0.1973**	**49.3279**	**0.0017**	**0.0303**	**7.5850**	**0.0003**
Cd	**0.0007**	**1.3726**	**0.0103**	**0.0008**	**1.6400**	**0.0123**
Cr	**0.0007**	**0.2288**	**0.0003**	**0.0004**	**0.1367**	**0.0002**
Cu	**ND**	**ND**	**ND**	**ND**	**ND`**	**ND**
Zn	**0.1373**	**0.4575**	**ND**	**0.0820**	**0.2733**	**ND**
Ni	**0.0343**	**1.7158**	**ND**	**0.0410**	**2.0500**	**ND**
C						
Pb	**0.1314**	**32.8567**	**0.0011**	**0.0791**	**19.7829**	**0.0007**
Cd	**0.0021**	**4.1178**	**0.0309**	**0.0016**	**3.2800**	**0.0246**
Cr	**0.0003**	**0.1144**	**0.0002**	**0.0008**	**0.2733**	**0.0004**
Cu	**ND**	**0.8579**	**ND**	**ND**	**ND**	**ND**
Zn	**ND**	**0.4575**	**ND**	**0.0820**	**0.2733**	**ND**
Ni	**ND**	**1.7158**	**ND**	**0.1230**	**6.1500**	**ND**
D						
Pb	**0.1105**	**27.6236**	**0.0009**	**0.1320**	**33.0050**	**0.0011**
Cd	**0.0007**	**1.3726**	**0.0103**	**0.0053**	**10.6600**	**0.0800**
Cr	**0.0003**	**0.1144**	**0.0002**	**0.0008**	**0.2733**	**0.0004**
Cu	**ND**	**ND**	**ND**	**0.0410**	**1.0250**	**ND**
Zn	**0.1029**	**0.3432**	**ND**	**0.0820**	**0.2733**	**ND**
Ni	**0.0686**	**3.4315**	**ND**	**0.0410**	**2.0500**	**ND**
E						
Pb	**0.1084**	**27.1089**	**0.0009**	**0.0812**	**20.2950**	**0.0007**
Cd	**0.0027**	**5.4904**	**0.0412**	**0.0025**	**4.9200**	**0.0369**
Cr	**0.0003**	**0.1144**	**0.0002**	**0.0004**	**0.1367**	**0.0002**
Cu	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Zn	**0.0686**	**0.2229**	**ND**	**0.1230**	**0.4100**	**ND**
Ni	**0.0343**	**1.7158**	**ND**	**0.1230**	**6.1500**	**ND**
F						
Pb	**0.0446**	**11.1524**	**0.0004**	**0.1570**	**39.2575**	**0.0013**

Cd	**0.0065**	**13.0397**	**0.0978**	**0.0033**	**6.5600**	**0.0492**
Cr	**0.0003**	**0.1144**	**0.0002**	**0.0012**	**0.4100**	**0.0006**
Cu	**0.0343**	**0.8579**	**ND**	**ND**	**ND**	**ND**
Zn	**0.0686**	**0.2288**	**ND**	**0.0820**	**0.2733**	**ND**
Ni	**ND**	**ND**	**ND**	**0.0820**	**4.1000**	**ND**

A to F represent test samples

ND = Not detected; ADI = Average daily intake; HQ = Hazard quotient; CR =cancer risk

From Table 2 the risk assessment analysis revealed that lead and chromium exhibited the highest and lowest hazard quotient values in all the six locations. Consequently, lead and chromium showed the highest and least average daily intake for yam samples while variations were observed in sweet potatoes.

Discussion

Levels of heavy metals in plants samples

From Table 1 and Figure 2 the mean concentrations of Pb in Yam and Sweet potatoes tubers varied as follows; (13.00 - 57.20) mg/kg in yam; and (6.9 – 38.20) mg/kg in sweet potatoes. The results are in line with the work of Olawale *et al.,* (2023) in Wukari who reported lower value of Pb (0.6 mg/kg) in Yam than those of this study and Enyindah, (2023) also reported a lower value of (1.83 mg/kg) for Pb in sweet potatoes in River state. Heavy metals, such as lead (Pb), exhibit toxicity even at low quantities. The study found that the lead content in tuber crops are above the permitted limits set by the WHO (2 mg/kg), thereby presenting significant health hazards to individuals who consume these food crops. Kharchoufa *et al*. (2018) have outlined that the typical manifestations of lead (Pb) poisoning encompass several symptoms such as cephalalgia, abdominal discomfort, myalgia, gastrointestinal disturbances, emesis, vertigo, and depressive symptoms. According to Onwugbuta *et al*. (2022), it has been observed that lead (Pb) has the capacity to traverse the placental barrier, resulting in detrimental effects on the developing fetal brain. This, in turn, may contribute to the emergence of autoimmunity, a condition characterized by the immune system's assault on its own cells. Consequently, individuals may experience various diseases, including but not limited to rheumatoid arthritis, kidney disorders, nervous system impairments, and circulatory system dysfunctions. The transfer factor of the metal to the tubers exhibited a notable magnitude, potentially elucidating the rationale behind the tubers' surpassing of the acceptable thresholds for lead content.

The risk assessment and cancer risks estimation calculation for all the samples shows that Pb has HQ >1, indicating that consumption of Yam and Sweet Potatoes tubers grown in the sample sites poses a potential health risk associated with ingesting excess of Pb. However the cancer risk assessment shows that yam in the entire sample site have values >1 $x10^{-4}$ indicating an increase cancer risk in consuming yam from the said site. Similarly the cancer risk for consuming sweet potatoes was also above limit of 1 x 10^{-4} in all the sample sites, indicating a high cancer risk.

The Cadmium concentration in the tuber crops (yam and sweet potatoes) from Table 1 is as follows; yam (0.2 – 1.9) mg/kg and sweet potatoes (0.2-1.3) mg/kg. The results of Cd from this study are all above the WHO permissible limit of 0.02 mg/kg in plant samples. According to Nworu *et al.,* (2018) cadmium is highly mobile element and can easily be transported through the shoots of plants and uniformly distributed throughout the affected plant. Biose *et al.,*(2020) reported a value range of (0.03 - 0.09 mg/kg) for potatoes in Benin metropolitan. Higher value of 12.45 mg/kg was reported by Olawale *et al.,* 2023 in yam tubers cultivated in mechanic village Wukari while a study by Nworu *et al.,*2018 reported a mean cadmium concentration of 0.65 mg/kg and 0.50 mg/kg in both cassava and yam tubers cultivated in Enyigba lead zinc mining site in Ebonyi state Nigeria. According to Lere *et al*., (2021) Cd is a heavy metal with high toxicity and it is a non-essential element in foods and natural waters and it accumulates principally in the kidneys and liver. According to Rahimzadeh *et al.,* (2017) and Pirhadi *et al.,* (2022) Cadmium causes mutations and chromosomal deletions leading to lung damage, gastrointestinal and neurological disorders. The HQ and CR value of cadmium as shown in Table 2 for the entire samples site are above 1 and 1 $x.10^{-4}$ respectively signifying a high cancer risk to consumer of the tubers in this sample sites.

The mean concentration of Cr in the studied tuber crops are as follows yam (0.10 – 0.30) mg/kg, and (0.10 – 0.30) mg/kg for sweet potatoes. These values were found to be below the permissible limit of 1.30 mg/kg recommended by WHO. The results obtained is higher than those of Nworu *et al.,* (2018) who reported Cr (0.01-0.09) mg/kg for both yam and cassava tubers. However, the chromium levels obtained from this study are lower than that Ahmed *et al.,*2019, in Prayagraj India who reported a value of 4.08 mg/kg in sweet potatoes grown in soil amended with solid liquid waste, and Olawale *et al.,* (2023) in Wukari where they reported a mean value of 91.69 mg/kg in yam tubers. The risk assessment and cancer risk estimation as shown from Table 2 reveals that, HQ <1 implying no health risk, CR > 1×10^{-4}(which is unacceptable limit CR limit) implying that though Cr is below permissible limit in the tuber crops but constant consumption of it can lead to cancer risk due to accumulation in the blood.

From Table 1 and Figure 5 the mean concentrations of Cu in the tuber crops range from Yam (ND -10) mg/kg, and detected only in sample D for sweet potatoes . Cu in tubers is below the maximum tolerable limit of 10 mg/kg by WHO. The results corresponded with that of Biose *et al.,* 2020 in Benin metropolitan who reported a value 0f 0.11 mg/kg for peeled potatoes and 0.19 mg/kg for unpealed potatoes. Similarly, Mongi and Chove (2020) have identified a concentration of 6.50 mg/kg of Cu in cocoyam cultivated in a wetland area of Tanzania. Furthermore, Nworu *et al*. (2018), in their study conducted at the Enyigba lead-zinc mining site in Ebonyi state Nigeria, have detected concentrations of 16 mg/kg for yam. The study observed an extremely minimal transport of copper from the soils to the tubers. One possible explanation for the reduced copper content in plants compared to soils is the limited mobility of copper inside plants, resulting in its accumulation mostly in the roots. The observed uniformity in copper concentrations across all tubers at the six investigated sites may be due to what Onwugbuta *et al*. (2022) have posited that the presence of copper in soils leads to a robust affinity for both organic matter and minerals. Consequently, due to its limited travel distance upon release, copper has a tendency to concentrate inside soil. This observation perhaps elucidates the reason behind the elevated copper concentrations in the soil, juxtaposed with the comparatively low copper content found in the tubers. The hazard quotient (HQ) value for copper, as indicated in Table 2, was less than 1 in regions where copper was identified. This finding indicates a low or negligible presence of copper in the tuber crops cultivated in Wukari, as the element was not discovered in the majority of the samples taken from various sites and crops.

Similarly concentration of Zn from Table 1 for all the plant samples range (20 – 40) mg/kg for yam and (20 – 30) mg/kg for sweet potatoes, and are above the WHO permissible limit of 0.6 mg/kg. Zinc is one of the essential elements in diets which enhance the essential functioning of the immune system. According to Mbah and Njoku (2023) it is also essential for the growth and development of the foetus, and the normal functioning of the brain cells. High concentration of Zinc in human diets is more beneficial than its deficiency. A higher value 0f 68-84 mg/kg has been reported by Nworu *et al.,* (2018) in Enyigba lead-zinc mining site in Ebonyi state Nigeria for both yam and cassava. Biose *et al*. (2021) also reported a high value of 50.65 mg/kg and 25 .05 mg/kg for yam and sweet potatoes respectively in Benin City. From Table 2, HQ<1 for Zn in all the samples sites for the various food crops. This indicate that consumption of tubers in all the sites poses no health risk from zinc, though the Zn metal is above the WHO permissible limit for plant but it has no potential health risk.

Nickel concentration in tuber crops from Table 1and Fig 7 ranges from yam (10.0 – 20.0) mg/kg, cassava (10-50) mg/kg and sweet potatoes (10 - 30) mg/kg. However the mean concentration in Ni obtained in the study is higher than the WHO permissible limit of 10.0 mg/kg. Similarly Emurotu and Onianwa (2017) reported a value range of 5.32-47.3 mg/kg in cassava. Nworu *et al.,* (2018), reported Ni levels ranging from 15-53.0 mg/kg and 15 - 46.0 mg/kg for cassava and yam tubers respectively while Biose *et al.,* 2020 reporteed 0.0 for both yam and sweet potatoes. According to Ahmad *et al.,* (2011), Ni in plants is highly mobile and is likely to accumulate in both leaves and seeds in this study the transfer ratio of nickel between the soil and tubers were significant. From Table 2 HQ>1 for Ni in all the samples sites indicating that consuming the tubers grown in the samples sites poses a potential health risk associated with ingestion of excess Ni as stated by Munir *et al.,* (2021), that intake of too large quantities of nickel by humans from plants grown on nickel rich soils has higher chances of inducing the development of cancers of the lung, nose, larynx and prostrate as well as inducing respiratory failures, birth defects and heart disorders.

Conclusion

The concentration of heavy metals in soils and tubers (yam and sweet potatoes) in Wukari were investigated and the study revealed that Pb, Cd and Ni concentration in soils and plant samples exceeded the WHO permissible limit with a high hazard. Which indicate a high toxicity and carcinogenicity. Cu concentration was not detected in most of the plant samples and was below the permissible limit in the soil, the concentration of Cr in both soils and plant samples are below the permissible limit in the entire site and its CR was also within the tolerable rate. In addition the potential controlling factors for the transfer of the metals from soils to tubers were identified, Soil to plant transfer factors revealed that the accumulation of heavy metals into the crops were moderate for the entire sample sites and crops except for Cu and Cd in site F which shows a very high transfer factor > than 1. Therefore the result from this work revealed that there is a high cancer risk for the consumers of this tuber due to excess Cd in the tubers and other non-carcinogenic health risk like liver and kidney damage, gastrointestinal disease, respiratory tract infections, etc due to excess Pb, Ni and Cd.

References

1. Adda, D. K., et al. (2021). Prevalence of liver diseases and heavy metal toxins in Taraba State. *[Local Health Report/Journal]*.

2. Ahmad, K., et al. (2011). Assessment of heavy metal accumulation in plants and transfer factors. *Journal of Environmental Sciences*.

3. Ahmed, S., et al. (2019). Heavy metal contamination in sweet potatoes grown in soil amended with solid liquid waste. *International Journal of Environmental Research*.

4. Balali-Mood, M., Naseri, K., Tahergorabi, Z., Khazdair, M. R., & Sadeghi, M. (2021). Toxic mechanisms of five heavy metals: Mercury, lead, chromium,

cadmium, and arsenic. *Frontiers in Pharmacology, 12*, Article 643972. https://doi.org/10.3389/fphar.2021.643972

5. Bergh, et al. (2012). *Sweet potato ingestion rates and food security in Nigeria* [Technical Report].

6. Biose, E., et al. (2020). Assessment of heavy metals in potatoes in Benin metropolitan area. *African Journal of Environmental Science and Technology*.

7. Biose, E., et al. (2021). Determination of zinc and other heavy metals in yam and sweet potatoes in Benin City. *Journal of Applied Sciences and Environmental Management*.

8. Ejike, O. M., et al. (2020). Assessment of radiation dose level in farm soils of mission quarters, Wukari, Taraba State, Nigeria. *International Research Journal of Advanced Science, 1*(2), 47–52.

9. Emurotu, J. E., & Onianwa, P. C. (2017). Bioaccumulation of heavy metals in soil and selected food crops cultivated in Kogi State, north central Nigeria. *Environmental Systems Research, 6*, Article 21. https://doi.org/10.1186/s40068-017-0098-1

10. Enyindah, F. (2023). Heavy metal concentrations in yam, cassava, and potato from Aluu market, Rivers State, Nigeria. *Journal of Environmental Health, 15*(2), 45–52.

11. Federal Office of Statistics / Food and Agriculture Organization. (2006). *Agricultural survey and yam production statistics*.

12. Flora, et al. (2016). Tubers as rich sources of nutrients and their role in food security. *International Journal of Food Science*.

13. Huang, M., et al. (2015). Health risk assessment of heavy metals in soil and food crops. *Ecotoxicology and Environmental Safety, 112*, 141–153.

14. Kharchoufa, L., et al. (2018). Toxicity and health effects of medicinal plants and lead poisoning. *Journal of Toxicology*.

15. Lere, et al. (2021). Toxicity of cadmium and its accumulation in the kidneys and liver. *Toxicology Reports*.

16. Li, Z., et al. (2014). Health risk assessment of heavy metals in commodities. *Food and Chemical Toxicology*.

17. Mbah, & Njoku. (2023). Zinc concentration in diets and its effect on fetal development. *Journal of Maternal and Child Health*.

18. Mo, et al. (2015). *Cancer slope factors for heavy metals*. California OEHHA Toxicity Criteria Database.

19. Mongi, R. J., & Chove, B. E. (2020). Heavy metals in cocoyam cultivated in wetland areas of Tanzania. *Tanzania Journal of Agricultural Sciences*.

20. Munir, et al. (2021). Health risks of nickel intake and cancer development. *Environmental Geochemistry and Health*.

21. Nworu, J. S., et al. (2018). Comparative analysis of heavy metal bioaccumulation capacities of three major yam species from mining and non-mining areas. *Journal of Chemical Society of Nigeria, 43*(1).

22. Ogundele, et al. (2015). *WHO/FAO permissible limits for heavy metals in food*.

23. Olawale, O. F., Abah, M. A., Emmanuel, O. P., Otitoju, G. T., Abershi, A. L., Temitope, D. F., Andrew, A. E., Abdulkadir, S., & John, A. (2023). Risk assessment of heavy metal content in yam tubers locally produced in selected local government areas of Taraba State, Nigeria. *Asian Journal of Natural Product Biochemistry, 21*(1), 6–12. https://doi.org/10.13057/biofar/f210102

24. Onwugbuta, et al. (2022). Lead transfer through placental barriers and copper affinity in soils. *Journal of Environmental Pathology*.

25. Pirhadi, et al. (2022). Cadmium induced chromosomal deletions and neurological disorders. *Neurotoxicology*.

26. Rahimzadeh, M. R., et al. (2017). Cadmium toxicity and health effects: A review. *Caspian Journal of Internal Medicine, 8*(3), 135–145.

27. Sharma, R. K., et al. (2014). Physiological effects of heavy metal exposure and stomach colic pain. *Journal of Environmental Biology*.

28. U.S. Environmental Protection Agency. (2001). *Risk assessment guidance for Superfund: Volume I, Human health evaluation manual*.

29. U.S. Environmental Protection Agency. (2016). *Regional screening levels (RSLs) - Generic tables*.

30. Yerima, et al. (2020). Production of tubers, employment, and food security. *Journal of Agricultural Economics and Development*.