**ASIAN J NAT PROD BIOCHEM**
Volume 21, Number 1, June 2023
Pages: 6-12

P-ISSN: 2775-4189
E-ISSN: 2775-4197
DOI: 10.13057/biofar/f210102

# Risk assessment of heavy metal content in yam tubers locally produced in selected local government areas of Taraba State, Nigeria

**OTITOJU FRANCIS OLAWALE[1], MOSES ADONDUA ABAH[1,♥], OZIOMA PRINCE EMMANUEL[1], GRACE TAIWO OTITOJU[2], AJIDUKU LEYOA ABERSHI[1], DADA FOLASHADE TEMITOPE[3], ASOGWA EMEKA ANDREW[3], SAAD ABDULKADIR[4], AMSA JOHN[1]**

[1]Department of Biochemistry, Faculty of Pure and Applied Sciences, Federal University Wukari. Ibi road, 670102, PMB 1020, Taraba State, Nigeria. Tel: +234-7064945026, ♥email: M.abah@fuwukari.edu.ng

[2]Department of Food Science and Technology, Faculty of Pure and Applied Sciences, Federal University Wukari. Ibi road, 670102, PMB 1020, Taraba State, Nigeria

[3]Department of Biotechnology, Faculty of Science, Nigerian Defence Academy. PMB 2109, Kaduna State, Nigeria

[4]Department of Biochemistry, Faculty of Pure and Applied Sciences, Kwara State Polytechnic. PMB 1375, Ilorin, Kwara State, Nigeria

Manuscript received: 21 December 2022. Revision accepted: 2 March 2023.

**Abstract.** *Olawale OF, Abah MA, Emmanuel OP, Otitoju GT, Abershi AL, Temitope DF, Andrew AE, 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 J Nat Prod Biochem 21: 6-12.* Yam is one of the most cultivated tubers in northern Nigeria. The increasing yam consumption and pest attack on the crop have led to increased use of fertilizers and pesticides during the cultivation process to prevent and control pest attacks. This study aims to determine the concentration of several heavy metals (Hg, Cr, Cd, Pb, and As) in locally produced yam samples harvested from Jalingo, Takum, Mutum Biyu, Wukari and Zing Local Government Area (LGA) of Taraba state as well assessing the Total Cancer Risk and Hazard Quotient associated with consuming the analyzed yam samples. The samples were collected in duplicates from five LGAs of Taraba state (Jalingo, Takum, Mutum Biyu, Wukari, and Zing). They were washed, peeled, and dried before being analyzed for heavy metal content using the method of Nitric acid-hydrochloric acid digestion (APHA 3030 f. 2018) by Atomic Absorption Spectroscopy (AAS). The data were analyzed using ANOVA ($P<0.05$). The results showed that Hg and As values were below the permissible limit recommended by WHO, with values ranging from 0.02-0.05 mg/kg. Cadmium content was significantly high, ranging from 8.00-14.00 mg/kg. Chromium content from Zing LGA was higher than in other locations, ranging from 100.00 to 103.00 mg/kg. The risk assessment analysis revealed that chromium and arsenic had the highest and lowest hazard quotient values of 37.32 and 0.00180, respectively, for yam samples cultivated in Jalingo LGA. The highest TCR value was obtained in chromium ($3.2\times10^{-3}$) and the lowest in the lead ($1.23\times10^{-8}$). High levels of heavy metals present in yam samples could be due to excessive use of pesticides or fertilizers during cultivation, burning of plastics and rubbers, deposition from mountains, and other anthropogenic activities. The results of this study are expected to gain public awareness that consuming locally produced yam from LGAs contaminated with heavy metals is at risk of heavy metal toxicity, such as renal, neural, and respiratory disorders, among others.

**Keywords:** Bioaccumulation, cancer estimation, carcinogenesis, heavy metals, risk assessment, toxicity

## INTRODUCTION

Food shortages are becoming a major problem in most Nigerian states. It could be due to increasing crop damage by pests leading to a poor crop yield (Fu et al. 2008). Therefore, to solve this problem, farmers have resorted to applying pesticides and fertilizers during cultivation to control the activities of pests and increase crop yield, respectively (Cao et al. 2010; Abah et al. 2021). Unfortunately, the use of pesticides and fertilizers on crops has been associated with the release of heavy metals such as Cadmium (Cd), Chromium (Cr), Arsenic (As), Lead (Pb), Nickel (Ni), and Stannum (Sn) (Olawale et al. 2022). Consumption of food contaminated with heavy metals seriously affects the health and economic status of the population (Asha et al. 2010; Tchounwou et al. 2012). Heavy metal contamination could originate from several sources, such as rocks, industrial wastes, and chemicals deposited into the soil (Seepersaud et al. 2018). In addition, heavy metals may enter soils from different natural and anthropogenic (human activities) sources, including industrial or domestic wastewater, application of pesticides and inorganic fertilizers, storm runoff, leaching from landfills, shipping and harbor activities, geological weathering of the earth's crust and atmospheric deposition. Rapid industrialization also resulted in the discharge of potentially toxic trace metals such as mercury, cadmium, copper, chromium, and nickel into the marine environment (Sawidis et al. 2001).

Tubers such as yam, potatoes, cassava, 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). Several African countries have long used yam as a food source and traditional medicine. Yam is composed of starch with small amounts of sugars, cellulose, proteins, lipids, and minerals and plays an essential role in ensuring food security and livelihood (Flora et al. 2016). Tubers like yam could be marketed as fresh or processed products such as powdered, pounded, or direct boiling (Lanre-Iyanda and Adekunle

2012). Furthermore, plants that grow in contaminated soil absorb heavy metals and other pollutants and accumulate them in their tubers since they cannot metabolize them completely (Valko et al. 2005). The ability of yam to absorb heavy metals is affected by several factors such as soil pH, metal solubility, conductivity, the soil type, amount of the metal (s) in the soil or air, its nature, and the form of chemicals used on the farm such as the type of the fertilizer (Ellen et al. 1990; Rani et al. 2014). Different plants have different capacities and abilities to absorb heavy metals depending on their metabolism, leading to uneven plant distributions of the metals. Higher consumption of contaminated foods leads to various illnesses due to toxicity (Tchounwou et al. 2004). Exposure to these heavy metals, such as cadmium (Cd), lead (Pb), zinc (Zn), arsenic (As), and copper (Cu), is hazardous to human health (Benavides et al. 2005). Cadmium and copper are harmful to the environment, and their accumulation in farmlands used for yam cultivation could result in the contaminated product (De Mattias Sartori et al. 2004). These heavy metals have a long half-life, non-biodegradable, depleted nutrients, and soluble in water. Lead poisoning could cause physiological and morphological changes in microalgae. In addition, several heavy metals also cause toxicity-related mutagenesis and carcinogenesis (Tchounwou et al. 2004).

Long-term heavy metals exposure to plants accumulates, while animals consume many. Heavy metal accumulation in animals or crops is difficult to decontaminate or excrete even by disposing of metal-contaminated agricultural soils for safer food production (Hudson 2021). Heavy metals estimation and analysis could be used to analyze environmental pollution and information on the risk of contaminated agricultural products (Sirot et al. 2009). Due to the harsh economic situation, the number of farmers who cultivate yam has been increasing recently in Taraba state. Using fertilizers to boost soil fertility has become a primary source of soil contamination; hence, this research aims to determine the heavy metal content in yam samples locally produced in some selected Local Government Areas of Taraba state.

## MATERIALS AND METHODS

### Study area

This research was conducted in Taraba State, Nigeria (Figure 1), at a Longitude of 7.9994° N and latitude of 10.7740° E from December 2021 to March 2022. The geographical coordinates of the five Local Government Areas in this study were: Wukari (7.9303° N; 9.8125° E), Takum (7.2577° N, 9.9745° E), Jalingo (8.8929° N, 11.3771°E), Zing (8.9952°N, 11.7467°E), and Mutum Biyu (8.6450°N, 10.7718°E).

### Sample collection

Two tubers of white yam were collected from each location of five Local Government Areas of Taraba state that commonly produced yam (Jalingo, Takum, Mutum Biyu, Wukari, and Zing) were treated as individual treatment. Samples were sent to the laboratory in January 2022 and stored at room temperature before analysis.

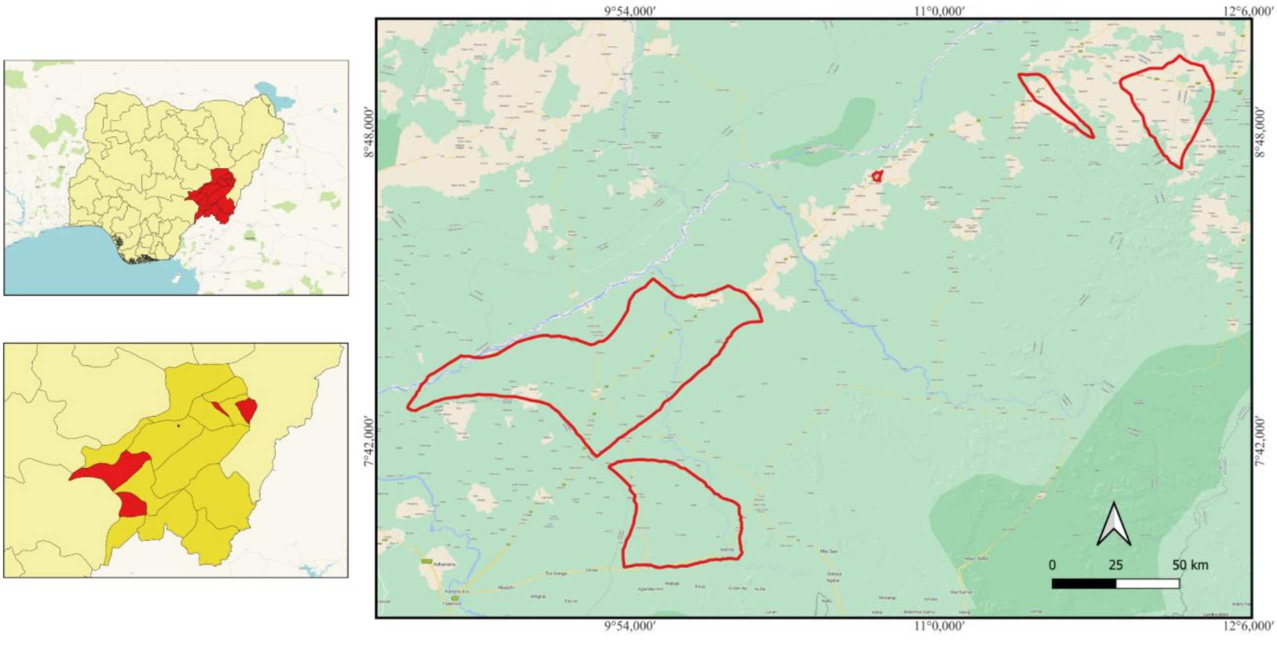


**Figure 1.** Yam-producing area in Local Government Areas of Taraba State, Nigeria indicated by red color

**Sample collection**

Two tubers of white yam were collected from each location of five Local Government Areas of Taraba state that commonly produce yam (Jalingo, Takum, Mutum Biyu, Wukari, and Zing) and were treated as individual treatment. Samples were sent to the laboratory in January 2022 and stored at room temperature before analysis.

**Sample preparation**

The samples were thoroughly washed with distilled water to remove surface dirt, dust, and other deposits which may cause contamination and then peeled. The samples were rewashed thoroughly with distilled water to remove contamination. The cleaned samples were cut into smaller pieces to speed up the drying process. The samples were air-dried for three days and ground using a pestle and mortar. They were again washed and allowed to dry. They were placed into well-labeled envelopes for further analysis. The samples were labeled in the order shown below:

Takum farms 1 and 2 as TK1 and TK2, respectively
Mutum Biyu farm 1 and 2 as MB1 and MB2, respectively
Zing farms 1 and 2 as ZG1 and ZG2, respectively
Jalingo farms 1 and 2 as JL1 and JL2, respectively
Wukari farms 1 and 2 as WK1 and WK2, respectively

**Sample digestion**

Sample digestion was performed using the method by Okoli et al. (2022). Five (5) mL of a well-mixed acid appropriate for the heavy metals of interest was transferred to a flask. In a fume cupboard, 3 mL of concentrated $HNO_3$ was added to the flask, covered with a ribbed watch glass, and then placed on a heating mantle, and the mixture was cautiously evaporated to less than 5 mL. The mixture was cooled, and the flask walls were rinsed. The glass was washed with metal-free water, and then 5 mL of concentrated $HNO_3$ was added and covered with a no-ribbed watch glass. The flask was put into the heating mantle. The heating continued until digestion was complete. Additional heating for 15 mins was done to dissolve any precipitate. The mixture was cooled down, and the flask walls were washed with distilled water. Insoluble materials were filtered, and the filtrate was transferred to a 100 mL volumetric flask and then mixed thoroughly.

**AAS sample analysis**

Heavy metal concentrations in the digested samples were determined using a Shimadzu Atomic Absorption Spectrophotometer (AAS-model 6650F with the appropriate lamps installed. Heavy metal concentration was quantified from calibration curves using the individual metal standards. The heavy metals analyzed were: Lead (Pb), Chromium (Cr), Mercury (Hg), Arsenic (As), and Cadmium (Cd).

**Hazard quotient estimation**

The Hazard quotient model assessed the risk of consuming yam-contaminated heavy metals in five Local Government Areas. The hazard quotient is the ratio of the potential exposure to a substance and the level of no adverse effects. The Estimated Daily Intake (EDI) was calculated using the equation described by Mai (2006).

$$\text{Hazard Quotient} = \frac{Estimated\ Daily\ Intake\ (EDI)}{Acceptable\ Daily\ Intake\ (ADI)}$$

A hazard quotient less than or equal to one indicates negligible hazard, while a hazard quotient greater than one indicates hazard possibility.

$$\text{EDI} = \frac{\text{(concentration of heavy metal as mg/ kg) x (daily intake of food in kg/person)}}{\text{Adult body weight (60 kg)}}$$

**Target cancer risk analysis**

The target cancer risk formula by Juan et al. (2010) was used to calculate the possibility of consumers having cancer after consuming yams contaminated with heavy metals in the five Local Government Areas.

$$TR = \frac{EFr \times EDtot \times YI \times MCS \times CPSo \times 10\text{-}3}{BWa \times ATc}$$

Where:
EFr = Exposure frequency (350 days/years)
EDtot = Exposure duration, total (30 years)
YI = Yam ingestion, gram per day (1 gram) × 1000 mg/kg
MCS = Metal concentration
BWa = Adult (65 kg)
CPSo = Carcinogenic potency slope, oral (1 mg/kg/day)
ATc = Averaging time, carcinogens (25,550 days)

*Reference doses for the following heavy metals as recommended by WHO/FAO are as follows: Lead 0.004 ( mg/kg, Arseni; 0.01 ( mg/kg), Chromium 0.003 ( mg/kg), Cadmium 0.001 and Mercury 0.001 ( mg/kg).

**Data analysis**

The variations in the level of heavy metals in the yam samples were analyzed using Analysis of Variance (ANOVA). Statistical test was performed at $p<0.05$ level of significance with the result reported as Mean ± SD.

## RESULTS AND DISCUSSION

**Heavy metal concentration and risk assessment of yam**

Table 1 shows the heavy metal concentration in yam samples cultivated in Jalingo LGA, and the order of these heavy metal concentrations is presented as follows: Cr>Cd>Pb>Hg>As. The risk assessment analysis revealed that chromium and arsenic had the highest and lowest hazard quotient values of 37.32 and 0.00180, respectively. The highest TCR value was obtained in chromium ($3.2\times10^{-3}$) and the lowest in the lead ($1.23\times10^{-8}$).

The level of heavy metal concentration in yam samples cultivated in Takum LGA shows in Table 1. The order of these heavy metal concentrations is presented as follows:

Cr>Cd>Pb>Hg>As. The risk assessment analysis revealed that chromium and arsenic had the highest and the lowest hazard quotient of 51.064 and 0.00180, respectively. In addition, the highest TCR value was obtained in chromium ($4.4\times10^{-3}$) and the lowest in the lead ($5.1\times10^{-9}$).

The level of heavy metal concentration in yam samples cultivated in Mutum Biyu LGA shows in Table 1. The order of these heavy metal concentrations is as follows: Cr>Cd>Pb>Hg>As. The risk assessment analysis revealed that chromium and arsenic had the highest and the lowest hazard quotient of 40.645 and 0.00180, respectively. The highest TCR value was obtained in chromium ($3.5\times10^{-3}$) and the lowest in the lead ($1.17\times10^{-8}$).

The level of heavy metal concentration in yam samples cultivated in Wukari LGA LGA shows in Table 1. The order of these heavy metal concentrations is as follows: Cr>Cd>Pb>Hg>As. The risk assessment analysis revealed that chromium and arsenic had the highest and the lowest hazard quotient of 56.0328 and 0.00300, respectively. The highest TCR value was obtained in chromium ($4.83\times10^{-3}$) and the lowest in the lead ($6.4\times10^{-9}$).

Table 1 also shows the level of heavy metal concentration in yam samples cultivated in Zing LGA. The order of these heavy metal concentrations is as follows: Cr>Cd>Pb>Hg=As. The risk assessment analysis revealed that chromium and arsenic had the highest and the lowest hazard quotient of 62.4430 and 0.00370, respectively. In addition, the highest TCR value was obtained in chromium ($5.38\times10^{-3}$) and the lowest in the lead ($9.5\times10^{-9}$).

**Table 1.** Heavy metal concentration and risk assessment of yam samples cultivated in Taraba State, Nigeria

| Parameter | Concentration (ppm) | WHO limit ( mg/kg) | Risk assessment parameters | | | Target cancer risk |
|---|---|---|---|---|---|---|
| | | | EDI | ADI | HQ | TCR |
| Jalingo | | | | | | |
| Hg | 0.02 ± 0.00 | 0.10 | 0.000030 | 0.001 | 0.03700 | - |
| As | 0.01 ± 0.00 | 0.22 | 0.000018 | 0.010 | 0.00180 | $1.88\times10^{-8}$ |
| Pb | 1.15 ± 0.03 | 0.30 | 0.00210 | 0.004 | 0.53000 | $1.23\times10^{-8}$ |
| Cd | 9.87 ± 0.06 | 0.20 | 0.01810 | 0.001 | 18.0950 | $7.9\times10^{-5}$ |
| Cr | 61.08 ± 0.12 | 0.05 | 0.11198 | 0.003 | 37.3200 | $3.2\times10^{-3}$ |
| Takum | | | | | | |
| Hg | 0.03 ± 0.02 | 0.10 | 0.000055 | 0.001 | 0.05500 | - |
| As | 0.01 ± 0.00 | 0.22 | 0.000018 | 0.010 | 0.00180 | $1.88\times10^{-8}$ |
| Pb | 0.48 ± 0.04 | 0.30 | 0.000880 | 0.004 | 0.22000 | $5.1\times10^{-9}$ |
| Cd | 11.69 ± 0.05 | 0.20 | 0.021430 | 0.001 | 21.43170 | $2.4\times10^{-5}$ |
| Cr | 83.56 ± 0.62 | 0.05 | 0.153190 | 0.003 | 51.06400 | $4.4\times10^{-3}$ |
| Mutum Biyu | | | | | | |
| Hg | 0.02 ± 0.00 | 0.10 | 0.000037 | 0.001 | 0.03700 | - |
| As | 0.01 ± 0.00 | 0.22 | 0.000018 | 0.010 | 0.00180 | $1.88\times10^{-8}$ |
| Pb | 1.10 ± 0.04 | 0.30 | 0.002017 | 0.004 | 0.50400 | $1.17\times10^{-8}$ |
| Cd | 10.37 ± 0.14 | 0.20 | 0.019000 | 0.001 | 19.01170 | $8.19\times10^{-5}$ |
| Cr | 66.51 ± 0.00 | 0.05 | 0.121940 | 0.003 | 40.64500 | $3.5\times10^{-3}$ |
| Wukari | | | | | | |
| Hg | 0.04 ± 0.00 | 0.10 | 0.000073 | 0.001 | 0.07330 | - |
| As | 0.02 ± 0.00 | 0.22 | 0.000037 | 0.010 | 0.00300 | $1.88\times10^{-8}$ |
| Pb | 0.60 ± 0.02 | 0.30 | 0.001100 | 0.004 | 0.27500 | $6.4\times10^{-9}$ |
| Cd | 12.45 ± 0.12 | 0.20 | 0.022830 | 0.001 | 22.8250 | $9.8\times10^{-5}$ |
| Cr | 91.69 ± 0.07 | 0.05 | 0.168100 | 0.003 | 56.0328 | $4.83\times10^{-3}$ |
| Zing | | | | | | |
| Hg | 0.02 ± 0.00 | 0.10 | 0.000037 | 0.001 | 0.03700 | - |
| As | 0.02 ± 0.00 | 0.22 | 0.000037 | 0.010 | 0.00370 | $1.88\times10^{-8}$ |
| Pb | 0.89 ± 0.05 | 0.30 | 0.001630 | 0.004 | 0.40791 | $9.5\times10^{-9}$ |
| Cd | 13.80 ± 0.11 | 0.20 | 0.025300 | 0.001 | 25.3000 | $1.09\times10^{-4}$ |
| Cr | 102.18 ± 0.26 | 0.05 | 0.187330 | 0.003 | 62.4430 | $5.38\times10^{-3}$ |

Note: USEPA (2014). *Results are expressed in mean ± standard deviation of duplicate samples. EDI: Estimated Daily Intake, ADI: Acceptable Daily Intake, HQ: Hazard Quotient, TCR: Target Cancer Risk

## Discussion

This study determined heavy metal concentration in yam samples harvested from five selected Local Government Areas (Jalingo, Takum, Mutum Biyu, Wukari, and Zing). Table 1 shows the heavy metal concentration, risk assessment, and cancer risk estimation of heavy metals in yam samples harvested from the Jalingo Local Government Area. The order of heavy metal concentration from highest to lowest is as follows: Cr>Cd>Pb>Hg>As. Chromium had the highest concentration (61.08 ± 0.12), while arsenic had the lowest concentration (0.01 ± 0.00). Chromium concentration in the yam sample from Jalingo exceeded the permissible limit recommended by WHO (0.05 mg/kg). The previous study by Oyatayo et al. (2015) showed the Cr concentration in water samples from Gashaka Gumti Park was 0.08 mg/kg. The high chromium concentration in this study could result from improper waste disposals such as leather, textile, and other industrial chemicals around the yam cultivation area. Consumption of yam originating from the Jalingo local Government Area may result in chromium toxicity. Chromium in the cells is reduced by hydrogen peroxide ($H_2O_2$), Glutathione (GSH) reductase, and ascorbic acid to produce reactive intermediates. Any of these states of chromium can attack DNA, proteins, and membrane lipids by forming reactive oxygen species such as $O_2^-$, $H_2O_2$, $^-OH$, and $OH_2$, which may cause lung cancer and respiratory tract irritation (Zhema et al. 2022).

Lead exposure could result from exposure to chemicals such as paints, lead batteries, smelters, and oxides used in producing paint, pigments, and Pb sheets as the primary external source of lead in the food chain (Oancea et al. 2005). Lead concentration in yam samples harvested from Jalingo exceeded the recommended WHO value of 1.0. Stankovic et al. (2014) showed lead concentration in some medicinal plants grown in Jalingo low-lands ranged from 0.00 to 0.06 mg/kg. The differences with the results of this study may be due to the differences in metal bioaccumulation by different plant species and their ability to detoxify them. Lead can inhibit or mimic the actions of calcium and interact with proteins (Okoli et al. 2022). Lead binds to sulfhydryl and amide groups of enzymes, altering their configuration and diminishing their activities that can cause anemia, weakness, and kidney or brain damage (Wang and Sun 2013). Mercury and arsenic concentration were lower than 0.05 mg/kg; this concentration was below WHO permissible limit. However, they can bioaccumulate due to the overuse of chemical pesticides, fertilizers, and other sources of mercury and arsenic, thus inducing toxicity such as renal and neurological disorders. Arsenic can also bioaccumulate, interfering with the activities of mitochondrial enzymes and the uncoupling of oxidative phosphorylation (Okoli et al. 2022).

The risk assessment and cancer risk estimation calculated for samples harvested from Jalingo revealed that chromium had the highest hazard quotient (37.3), above 1, with a TCR value of $3.2\times10^{-3}$. These values indicated an increased cancer risk from consuming yam tubers contaminated with Cr. It also reveals that a significant amount of chromium was released from various sources into the environment.

The concentrations of different heavy metals, risk assessment, and cancer risk estimation in yam samples harvested from Takum LGA, Taraba State, are presented in Table 1. Chromium had the highest concentration (50.0 mg/kg) of other heavy metals estimated in the yam samples, which exceeded the WHO recommended value. The HQ and TCR values of chromium were 51.10 and $4.4\times10^{-3}$, respectively, indicating a high cancer risk. The high chromium concentration in the yam samples could be due to activities like the incineration of municipal waste, such as plastics and batteries, by the inhabitants of the LGA.

The concentration of cadmium, HQ, and TCR values were 11.69 ± 0.05 mg/kg, 21.43, and $2.4\times10^{-5}$, respectively. A previous study by Adachu et al. (2015) showed that lead and cadmium concentrations were within the range of 0.00-0.03 mg/kg in herbal decoction and beverages locally produced in Wukari. The cadmium concentration differed from the findings of Maxwell et al. (2015), that Cd concentration in dust particles along Jalingo road was 0.002 mg/kg. Cadmium causes toxicity, such as cell proliferation, lung damage, and apoptosis. These activities interact with the DNA repair mechanism, generate the reaction of oxygen species (ROS), and induce apoptosis (Wang and Sun 2013).

The level of mercury and arsenic in yam samples harvested from Takum LGA were significantly less than 0.05 mg/kg. It suggests that mercury and arsenic pollution is less in this location. The low concentrations of Hg and As reduce the risk of mercury and arsenic toxicity, such as reactions with protein sulfhydryl groups to inactivate dihydrolipoyl dehydrogenase and thiolase enzymes. It produces inhibited pyruvate oxidation and beta-oxidation of fatty acids (De Mattias Sartori et al. 2004). Ezeonu et al. (2022) reported that lead and mercury concentration in dust particles along federal high roads in Taraba state was 0.00015 mg/kg. Lead interferes with intracellular calcium cycling, altering the ability of organelle to release molecules from the stores, such as endoplasmic reticulum and mitochondria (Sirot et al. 2009).

Yam samples harvested from Mutum Biyu LGA of Taraba state had mercury and arsenic concentrations lower than the permissible values of WHO (0.10 mg/kg). Lower concentrations of Hg and As could be due to reduced burning of fossils and petroleum pollution, which are the major sources of mercury in plants. A study by Aremu et al. (2017) showed mercury and arsenic concentrations in groundwater in Wukari were low (0.0002 mg/kg and 0.003 mg/kg, respectively). The health implication of arsenic bioaccumulation includes lung and skin cancers due to free radicals attacking DNA and proteins (Hudson 2021).

Yam samples harvested from Wukari LGA had a high chromium concentration (91.69 mg/kg), followed by cadmium (12.45 mg/kg), significantly above the WHO permissible levels of 0.05 mg/kg and 0.20 mg/kg, respectively. The HQ values of chromium and cadmium were 56.0 and 22.8, respectively, while the TCR values were $4.83\times10^{-3}$ and $9.8\times10^{-5}$, respectively, indicating a high cancer risk to predisposed consumers of contaminated samples. Yerima et al. (2020) study on soil samples around the Mechanic Village, LGA Wukari, showed a high cadmium concentration (1.33 mg/kg). Increased oil pollution from petroleum and other gases in garages, lubricants, and dumping of spare parts, metals, and plastic scraps has contributed to a high concentration of these metals in the harvested yam samples (Zhema et al. 2022). Cadmium is a toxic metal that causes chromosomal aberrations, sister chromatid exchange, DNA strand breaks, and DNA- protein crosslinks in cell lines (Sirot et al. 2009). As a result, cadmium causes mutations and chromosomal deletions leading to lung damage and gastrointestinal and neurological disorders. In addition, contaminated chromium in foods can cause an attack on DNA, proteins, and membrane lipids, disrupting cellular integrity and functions (Sirot et al. 2009).

The result of heavy metal concentration, risk assessment, and TCR in yam samples harvested from Zing LGA is presented in Table 1. Yam samples from Zing LGA contained high concentrations of chromium and cadmium with HQ of 62.4 and 25.3, respectively, and TCR of $5.38\times10^{-3}$ and $1.09\times10^{-}4$, respectively. These results indicate a high risk of cancer to predisposed consumers. The high concentration of Cr and Cd in yam samples from Zing LGA could be due to weathering rocks and waterfalls from the mountains in Zing LGA, as a source of cadmium and chromium to the food chain (Hudson 2021)., This result differed from the report of Achadu et al. (2015) that heavy metal concentrations in soil samples from Wukari LGA. High Cr consumption has adverse health effects, such as kidney damage (renal tubular damage). Cr (VI) can pass through cell membranes and be reduced intracellularly to reactive intermediates that can react with cellular molecules leading to upper abdominal pain, edema, pulmonary congestion, nose irritation, and skin irritations (Yerima et al. 2020).

In conclusion, analyzing heavy metal content in food samples commonly consumed in a particular location is important in ensuring human health. Elevated levels of heavy metals in foodstuffs pose a high risk to health and a potential cause of cancer due to their bioaccumulation. Cadmium and Chromium concentration in these sampling sites has exceeded the WHO permissible limit with a hazard quotient. It reveals a high risk of toxicity and carcinogenic due to increased environmental pollution. Sources of environmental pollution could be waste disposals, incinerations, and burning of tires, plastics, rubbers, and scrapes from mechanic sites to reduce the contamination of agricultural lands used to produce yam. Daily consumption of foods with high levels of heavy metals will accumulate, resulting in different toxic effects such as cancers, renal failures, neurological disturbances, respiratory tract infections, and even high intoxication deaths. The continuous consumption of foods contaminated with mercury and arsenic at low concentrations results in their accumulation in the body since heavy metals have a long half-life, are soluble in water, and pass through the cell membrane.

## ACKNOWLEDGEMENTS

We thank all who were involved in this study.

## REFERENCES


Abah MA, Otitoju O, Okoli EC, Ozioma PE, Bando DC, Zephaniah HS. 2021. Determination of selected pesticide residues in leafy vegetables (*Amaranthus spinosus*) consumed in Donga, Taraba State. Intl J Biochem Bioinform Biotechnol Stud 6 (2): 9-16. DOI: 10.37745/ijbbbs.15.

Achadu OJ, Goler EE, Ayejuyo OO, Olaoye OO, Ochimana OI. 2015. Assessment of heavy metals (Pb, Cd, Zn, and Cu) concentrations in soils along a major highway in Wukari, North Eastern Nigeria. J Biol Environ Sci 6 (2): 1-7.

Aremu MO, Oko OJ, Andrew C. 2017. Groundwater and river quality assessment for some heavy metals and physicochemical parameters in Wukari town, Taraba State, Nigeria. Intl J Sci 6 (05): 73-80. DOI: 10.18483/ijSci.1298.

Asha PS, Krishnakumar PK, Kaladharan P, Prema D, Diwakar K, Valsala KK, Bhat GS. 2010. Heavy metal concentration in sea water, sediment, and bivalves off Tuticorin. J Mar Biol Assoc India 52 (1): 48-54. DOI: 10.7718/ijec.v11i1.806.

Benavides MP, Gallego SM, Tomaro ML. 2005. Cadmium toxicity in plants. Braz J Plant Physiol 17 (1): 2134. DOI: 10.1590//s1677 04202005000100003.

Cao H, Chen J, Zhang J, Zhang H, Qiao L, Men Y. 2010. Heavy metals in rice and garden vegetables and their potential health risks to inhabitants in the vicinity of an industrial zone in Jiangsu, China. J Environ Sci 22 (11): 1792-1799. DOI: 10.1016/S1001-0742(09)60321-1.

De Mattias Sartori IA, Ribeiro RF, Francischone CE, de Mattos MDGC. 2004. In vitro comparative analysis of the fit of gold alloy or commercially pure titanium implant supported prostheses before and after electroerosion. J Prosthet Dent 92 (2): 132-138. DOI: 10.1016/jprosdent.2004.04.001.

Ellen G, van Loon JW, Tolsma K. 1990. Heavy metals in vegetables grown in the Netherlands and in domestic and imported fruits. Zeitschrift für Lebensmittel Untersuchung und Forschung 190 (1): 34-39. DOI: 10.3923/jbs2007.943.948.

Ezeonu CS, Tatah SV, Imo C, Yakubu OE, Garba QH, Arowora K, Umaru IJ, Abah MA, Abu MS, Yohanna ER, Timothy M. 2022. Antioxidant potential of ginger extract on metals (lead, cadmium, and boron) induced oxidative stress in maize plant. Asian J Trop Biotechnol 19: 45-51. DOI: 10.13057/biotek/c190201.

Flora SJ, Flora G, Saxena G. 2006. Environmental occurrence, health effects and management of lead poisoning. In: Casas JS, Sordo J (Eds). Lead. Elsevier Science BV. DOI: 10.1016/B978-044452945-9/50004-x.

Fu J, Zhou Q, Liu J, Liu W, Wang T, Zhang Q, Jiang G. 2008. High levels of heavy metals in rice (*Oryza sativa* L.) from a typical E-waste recycling area in southeast China and its potential risk to human health. Chemosphere 71: 1269-1275. DOI: 10.1016/j.chemosphere.2007.11.065.

Hudson SS. 2021. Compound AABA form and style distinction in heavy metal. Music Theor Online 27 (1): 1-31. DOI: 10.30535/mto.27.1.5.

Juan C, Juan CM, Jordi M, Guillermina F. 2010. Determination of macrolide and lincosamide antibiotics by pressurised liquid extraction and liquid chromatography-tandem mass spectrometry in meat and milk, Food Control 21 (12): 1703-1709. DOI: 10.1016/j.foodcont.2010.05.004

Lanre-Iyanda TY, Adekunle IM. 2012. Assessment of heavy metals and their estimated daily intakes from two commonly consumed foods (Kulikuli and Robo) found in Nigeria. Afr J Food Agric Nutrit Dev 12 (3): 6156-6169. DOI: 10.18697/ajfand.51.10250.

Mai S. 2006. Potential human health risks from metals (Hg, Cd, and Pb) and Polychlorinated Biphenyls (PCBs) via seafood consumption: Estimation of Target Hazard Quotients (THQs) and Toxic Equivalents (TEQs). Food Chem Toxicol 46 (8): 2782-2788. DOI: 10.1016/j.fct.2008.05.011.

Maxwell SE, Lau MY, Howard GS. 2015. Is psychology suffering from a replication crisis What does "failure to replicate really mean? Am Psychol 70 (6): 487. DOI: 10.1037/a0039400.

Oancea S, Foca N, Airinei A. 2005. Effects of heavy metals on plant growth and photosynthetic activity. Analele Ştiinţifice ale Universităţii "AL. I. CUZA1 IAŞI, Tomul I, s. Biofizică, Fizică medicală şi Fizica mediului.

Okoli EC, Abah MA, Olawale O, Yohanna ER, Zephaniah SH. 2022. Ecological risk assessment of heavy metals in fish samples from Donga River, Taraba State, Nigeria. Asian J Appl Sci 15: 24-28. DOI: 10.3923/ajaps.2022.24.28.

Olawale O, Abah MA, Grace OT, Habibu B, Okoli EC, Omajali, PU. 2022. Risk assessment of pesticide residues in water samples from river Gongola, Adamawa state, Nigeria. World J Adv Res Rev 13 (01): 424-432. DOI: 10.30574/wjarr.2022.13.1.0015.

Oyatayo KT, Songu GA, Amos GA, Ndabula C. 2015. Assessment of heavy metal concentration in hand-dug well water from selected land uses in Wukari Town, Wukari, Taraba State, Nigeria. J Geosci Environ Prot 3 (09): 1-10. DOI: 10.4236/gep.2015.39001.

Rani A, Kumar A, Lal A, Pant M. 2014. Cellular mechanisms of cadmium-induced toxicity: A review. Intl J Environ Health Res 24 (4): 378-399. DOI: 10.1007/s10811-017-1372-3.

Sawidis T, Brown MT, Zachariadis G, Sratis I. 2001. Trace metal concentrations in marine macroalgae from different biotopes in the Aegean Sea. Environ Intl 27 (1): 43-47. DOI: 10.1007/s10811-017-1372-3.

Seepersaud MA, Ramkissoon A, Seecharan S, Powder-George YL, Mohammed FK. 2018. Environmental monitoring of heavy metals and Polycyclic Aromatic Hydrocarbons (PAHs) in *Sargassum filipendula* and *Sargassum vulgare* along the eastern coastal waters of Trinidad and Tobago, West Indies. J Appl Phycol 30 (3): 2143-2154. DOI: 10.1007/s10811-017-1372-3.

Sirot V, Guérin T, Volatier JL, Leblanc JC. 2009. Dietary exposure and biomarkers of arsenic in consumers of fish and shellfish from France. Sci Total Environ 407 (6): 1875-1885. DOI: 10.1037/a0039400.

Stankovic S, Kalaba P, Stankovic AR. 2014. Biota as toxic metal indicators. Environ Chem Lett 12: 63-84. DOI: 10.1007/s10311-013-0430-6.

Tchounwou PB, Centeno JA, Patlolla AK. 2004. Arsenic toxicity, mutagenesis, and carcinogenesis–a health risk assessment and management approach. Mol Cell Biochem 255 (1): 47-55. DOI: 10.1023/b.mcbi.0000007260.32981.b9.

Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. 2012. Heavy metal toxicity and the environment. Mol Clin Environ Toxicol 101: 133-164. DOI: 10.1007/978-3-7643-8340-4_6.

USEPA [US Environmental Protection Agency]. 2014. Frame Work for Human Health Risk Assessment to inform Decision Making, EPA/100/R-14/001, Risk Assessment Forum, Office of the Science Advisor, USEPA, Washington, DC

Valko MMHCM, Morris H, Cronin MTD. 2005. Metals, toxicity, and oxidative stress. Curr Med Chem 12 (10): 1161-1208. DOI: 10.2174/0929867053764635.

Wang T, Sun H. 2013. Biosorption of heavy metals from aqueous solution by UV-mutant. Environ Sci Pollut Res Intl 20 (10): 7450-7463. DOI: 10.1007/s11356-013-1767-x.

Yerima EA, Itodo AU, Shaâ R, Wuana RA. 2020. Ecological risk assessment of mineral and heavy metals levels of soil around auto mechanic Village Wukari, Nigeria. Acad J Chem 5 (7): 81-90. DOI: 10.32861/ajc.57.81.90.

Zhema PA, Abah MA, Emochone RY, Okoli EC, Saaku SA, Habibu B. 2022. Investigation of trace metal contamination in bread baked and sold in Wukari. Glob Sci J 10 (2): 2076-2084. DOI: 10.11216/gsj.2022.02.60325.