# EVALUATION OF HEALTH EFFECT OF SOME SELECTED HEAVY METALS IN MAIZE CULTIVATED IN KATSINA STATE, NORTH WEST NIGERIA

---


**ABSTRACT**

This study was conducted to determine the heavy metals concentration in maize cultivated in Katsina state Nigeria. The objectives were mainly to detect the presence of heavy metals in the cultivated maize in the study area, compare the concentration of heavy metals in samples in relation to the permissible limits specified by WHO/FAO/USEPA Standards and asses the health risks to the local consumers. Samples of cultivated maize were collected in the year 2017 from the selected areas. Analysis for the concentration of these heavy metals; Cr, Cd, Fe, Ni, Mn, Pb and Zn was conducted by the use of AAS (by Atomic Absorption Spectrophotometry) method. The health risks to the local inhabitants from the consumption of the samples were evaluated based on the Target Hazard Quotient (THQ). The possibility of cancer risks in the samples through the intake of carcinogenic heavy metals was estimated using the Incremental Lifetime Cancer Risk (ILCR). Results from this study have shown that with the exception of the heavy metal Pb the concentration values of Cr, Cd, Fe, Mn and Zn in the samples were generally lower than the USEPA, WHO/FAO maximum permissive limits. The results have also indicated that the estimated daily intake of the heavy metals was lower than the tolerable daily intake limit set by the USEPA in all samples. The risk level of Target Hazard Quotient (THQ < 1) was observed for all the evaluated heavy metals for both adults and children.. The THQ for the samples was in the decreasing order Zn>Pb>Fe>Cr>Cd, for all the samples respectively. All the studied samples showed the hazard index (HI < 1) with highest in the sample from Dabai and lowest in the sample from Funtua. In adults the ILCR for Cd violated the threshold risk limit ($>10^{-4}$) in all the studied samples, while the ILCR for Pb reached the moderate risk limit ($>10^{-3}$) except for the sample from Kafur which is above the limit ($>10^{-2}$). In children ILCR for Cd in all samples and Pb for samples from Birchi, Katsina and Malunfashi has reached the moderate risk limit ($>10^{-3}$) while the ILCR for Pb in samples from Dabai, Funtua and Kafur is above the limit ($>10^{-2}$). The trend of risk for developing cancer as a result of consuming the studied maize samples showed: Kafur> Dabai > Funtua> Malunfashi > Katsina. Cumulative cancer risk (∑ILCR) in adults of all the studied maize samples reached the moderate risk limit ($>10^{-3}$) except for sample from Kafur which is above the moderate risk limit ($>10^{-2}$). While the cumulative cancer risk (∑ILCR) in children of all the studied maize samples is above the moderate risk limit ($>10^{-2}$) except for sample from Katsina which is within the moderate risk limit ($>10^{-3}$). Among all the studied samples maize sample from Kafur has the highest chances of cancer risks (ILCR $1.297980 \times 10^{-2}$ in adults, $1.510018 \times 10^{-2}$ in children) and sample from Katsina has the lowest chances of cancer risk (ILCR $1.68603093 \times 10^{-3}$ in adults, $7.775840 \times 10^{-3}$ in children). The study suggests that consumption of the studied maize samples in Katsina state is of public health concern as they may contribute to the population cancer burden.



*Keywords: Maize, Heavy metals, Katsina, health risk index, toxicity.*


## 1. INTRODUCTION

Cereal grains are the staple food of the people of the tropics providing them with about 75% of their total caloric intake and 67% of their total protein intake (1). They are rich in Carbohydrate, trace elements, vitamins, oil and protein (2). However, cereal protein is low in lysine (3; 4). Cereal crops are mostly grown in temperate and tropical regions of the world and provide more food energy worldwide than any other type of crop (5).

Heavy metals are environmental contaminants capable of causing human health problems if the excess amount is ingested through the food they are non-biodegradable and persistent, have a long biological half-lives and can be bio-accumulated through biological chains (6). Heavy metal toxicity may occur due to contamination of irrigation water, the application of fertilizer and metal based pesticides, industrial emission, harvesting process, transportation, storage or sale. Crops and vegetables grown in soils contaminated with heavy metals have greater accumulation than those grown in uncontaminated soils (7). The toxicity of heavy metals most commonly involves the brain and kidney but other manifestations can occur in some other parts of the body, for example, arsenic is clearly capable of causing cancer, hypertension can result in individuals exposed to lead and renal toxicity in individual exposed to cadmium (8). Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition. Auto repair activities are one of the major sources of increase in heavy metals concentration in Nigeria [52, 53].

Maize (Zea mays) is an important staple crop in Nigeria (9). It is one of the staple foods consumed by the teaming population of Nigeria in a large amount. Maize ranks third in the world production of cereal following wheat and rice (10). It is used as a feed for livestock and a principal raw material for many industrial products (10; 11). Of the 22 countries in the world where maize forms the highest percentage of energy in the national diet, 16 are in Africa (12).

Tuwon mascara, Masa/Waina and Danbu are among the main staple foods of the inhabitants of Katsina state prepared from maize grain. The absence of data on the heavy metals composition of this all-important cereal and the health implication of consuming foods prepared with maize with heavy metals above permissible limits necessitate this study. Data on heavy metal in the cultivated maize generated will give an insight on the level of metal contamination and by extension the impact on food safety standard and risk to consumers.

## 2. MATERIAL AND METHODS

### 2.1 STUDY AREA AND SAMPLE COLLECTION

The study was carried out during 2017 in Katsina State, Nigeria located between latitude 12015’N and longitude of 7030’E in the North West Zone of Nigeria, with an area of 24,192km2 (9,341 sq meters). Katsina State has two distinct seasons: rainy and dry. The rainy season begins in April and ends in October, while the dry season starts in November and ends in March. This study was undertaken during the dry season. The average annual rainfall, temperature, and relative humidity of Katsina State are 1,312 mm, 27.3ºC and 50.2%, respectively (13). The study was conducted within some catchment areas that cultivate maize located within 2 out of the 3 senatorial zones that constitute to make up the state (Katsina senatorial zone: Katsina; Funtua senatorial zone: Dabai, Funtua, Kafur and Malunfashi). Sampling for this work was carried out by dividing the catchment areas into five (5) locations. In each of the locations, the plot where the crops were cultivated was subdivided into twenty (20) sampling areas. Samples were collected from each of the areas and combined to form bulk sample, from which a representative sample was obtained. The samples were code-named and stored in glass bottles with tight covers to protect them from moisture and contamination. They were then stored in the refrigerator at 40C until ready for use.

### 2.2 IDENTIFICATION OF SAMPLE

The samples were identified in herbarium of the department of biology of Umaru Musa Yar’adua University Katsina.

### 2.3 SAMPLE PREPARATION

The seeds were cleaned by picking out stones and other irrelevant materials and dried at room temperature. 300g of each sample was taken and ground into a fine powder in a mortar using a pestle. The powdered samples and the remaining duplicate portions of the samples were stored as whole grains in labelled glass bottles in the refrigerator at 40c until ready for used.

### 2.4 HEAVY METALS DETERMINATION

5 g of each Sample was dried at 800C for 2 hours in a Gallenkamp hotbox oven (CHF097XX2.5) and then blended in an electric blender. 0.5 g of each sample was weighed and ashed at 5500C for 24 hours in an electric muffle furnace (Thermolyne FB131DM Fisher Scientific). The ash was diluted with 4.5 ml concentrated hydrochloric acid (HCl) and concentrated nitric acid (HN03) mixed at ratio 3:1 the diluent is left for some minutes for proper digestion in a beaker. 50

ml of distilled water was added to the diluents to make up to 100 ml in a volumetric flask. The levels of heavy metals (Pb, Zn, Ni, Cd, Cr, Mn and Fe) were determined using AA210RAP BUCK Atomic Absorption Spectrometer flame emission spectrometer filter GLA-4B Graphite furnace (East Norwalk USA), according to standard methods (14) and the results were given in (mg/kg).

## 2.5 HEAVY METAL HEALTH RISK ASSESSMENT

### 2.5.1 DAILY INTAKE OF METALS (DIM)

The daily intake of metals was calculated using the following equation:

$$\mathrm{DIM} = \frac{C_{\mathrm{metal}} * C_{\mathrm{factor}} * D_{\mathrm{intak}}}{B_{\mathrm{weight}}}$$

Where, $C_{metal}$, $C_{factor}$, $D_{intake}$ and $B_{weight}$ represent the heavy metal concentrations in the samples, the conversion factor, the daily intake of the food crops and the average body weight, respectively. The conversion factor (CF) of 0.085 (15) was used for the conversion of the samples to dry weights. The average daily intake of the maize was 0.527 kg person$^{-1}$ d$^{-1}$ (16) and the average body weight for the adult and children population was 60 kg (17) and 24 kg (18) respectively; these values were used for the calculation of HRI as well.

### 2.5.2 NON-CANCER RISKS

Non-carcinogenic risks for individual heavy metal for maize were evaluated by computing the target hazard quotient (THQ) using the following equation (19).

$THQ=CDI/R_fD$

CDI is the chronic daily heavy metal intake (mg/kg/day obtained from the previous section and $R_fD$ is the oral reference dose (mg/kg/day) which is an estimation of the maximum permissible risk on human population through daily exposure, taking into consideration a sensitive group during a lifetime (20). The following reference doses were used (Pb = 0.6, Cd = 0.5, Zn = 0.3, Fe = 0.7, Ni = 0.4, Mn = 0.014, Cr = 0.3) (21; 22).To evaluate the potential risk to human health through more than one heavy metal, chronic hazard index (HI) is obtained as the sum of all hazard quotients (THQ) calculated for individual heavy metals for a particular exposure pathway (23). It is calculated as follows:

$HI=THQ_1+THQ_2+\cdots+THQ_n$

Where, 1, 2 …, n are the individual heavy metals or vegetable and fruit species.

It is assumed that the magnitude of the effect is proportional to the sum of the multiple metal exposures and that similar working mechanism linearly affects the target organ (24). The calculated HI is compared to standard levels: the population is assumed to be safe when $HI < 1$ and in a level of concern when $1 < HI < 5$ (25).

## 2.6 CANCER RISKS

The possibility of cancer risks in the maize samples through the intake of carcinogenic heavy metals was estimated using the Incremental Lifetime Cancer Risk (ILCR) (26).

$ILCR=CDI \times CSF$

Where, CDI is chronic daily intake of chemical carcinogen, mg/kg BW/day which represents the lifetime average daily dose of exposure to the chemical carcinogen.

The US EPA ILCR is obtained using the cancer slope factor (CSF), which is the risk produced by a lifetime average dose of 1 mg/kg BW/day and is contaminant specific (19). ILCR value in food represents the probability of an individual's lifetime health risks from carcinogenic heavy metals' exposure (27). The level of acceptable cancer risk (ILCR) for regulatory purposes is considered within the range of $10^{-6}$ to $10^{-4}$ (20). The CDI value was calculated on the basis of the following equation and CSF values for carcinogenic heavy metals were used according to the literature (26).

$CDI= (EDI \times EFr \times ED_{tot})/AT$

UNDER PEER REVIEW

where EDI is the estimated daily intake of metal via consumption of maize; EFr is the exposure frequency (365 days/year); $ED_{tot}$ is the exposure duration of 60 years, average lifetime for Nigerian; AT is the period of exposure for non-carcinogenic effects (EFr × $ED_{tot}$), and 60 years life time for carcinogenic effect (19). The cumulative cancer risk as a result of exposure to multiple carcinogenic heavy metals due to consumption of a particular type of food was assumed to be the sum of the individual heavy metal increment risks and calculated by the following equation (26).

$$\sum ILCR_n = ILCR_1 + ILCR_2 + \cdots + ILCR_n$$

Where, n = 1, 2…, n is the individual carcinogenic heavy metal.

## 3. RESULTS AND DISCUSSION

The present study investigated the presence of heavy metals in maize which is a major component of the diet among the population in Katsina state, Nigeria. A total of 6 maize samples were analyzed for the presence of heavy metals in this study. As shown in Table 1, among the heavy metals evaluated, the highest concentration (mg/kg) was observed for Zn (range: 0.857-1.310), followed by Pb (range: 0.547-1.158), Fe (range: 0.087-0.668), Cr (range: 0.320-0.353) and Mn (range: 0.126-0.354). While Cd has the lowest concentration (range: 0.047-0.056). The results for the heavy metals analysed in the sampled seeds is similar to that reported for heavy metals in beans and some beans products from some selected markets in Katsina state, Nigeria (28).

Lead was detected in all the samples, with 100% of samples seen to be higher than 0.01 mg/kg which is the maximum permissible limit set by WHO/FAO and also the maximum allowable concentration of 0.02 mg/kg by EU and 0.05 mg/kg limit set by USEPA (29). The high percentage of samples which were in violation of the maximum permissible limits of Pb set by WHO, EU and US EPA is a cause for public health concern considering the frequency of exposure. The Pb concentration range for the maize samples in this study is lower than that reported for leafy vegetables from Kaduna state Nigeria (30) and that reported for beans samples from Italy, Mexico, India, Japan, Ghana and Ivory Coast with a Pb concentration range of 4.084- 14.475ppm (31). But the results are higher than that reported for the concentration of Pb from Kano and Kaduna states, Nigeria (5; 33). The value was still higher than the range (0.116 to 0.390) reported by Ahmed and Mohammed in Egypt (0.116 to 0.390) in 2005, the range (0.007 to 0.032 mg/kg) reported by Okoye et al., (34) in a study conducted in South east of Nigeria in 2009 and the result reported for Pb in maize from Awka, Anambra state Nigeria (35). This difference has earlier been attributed to differences in anthropogenic activities that introduce metals into the soil in the areas where these Cereals were grown or even deposition of Pb on the surface of these grains during production, transport and Marketing or by emissions from Vehicles and industries (8).

The concentration of Cd (mg/kg) range from 0.047 to 0.056 in the Maize samples, these values are higher than the range (0.002 to 0.004 mg/kg) reported by Edem et al., (36) in Wheat flours in 2009 and the result of Cd in maize from Awka, Anambra state Nigeria (35).. The Cd concentration range for the maize samples in this study is lower than that reported for market sold legumes in eastern Nigeria, Europe, Asia and parts of West Africa (34; 31), that reported in a study for the Cadmium concentration range for both unprocessed and processed bean samples from Katsina state Nigeria (28), millet sample from Kano Nigeria and for locust beans from Odo-Ori market Iwo, Nigeria (32; 37). The values obtained by Ahmed and Mohammed (33) in Cereal products (0.091-0.143mg/kg) in 2005, Orisakwe et al., (38) in Owerri (0.00 to 0.24mg/kg) in 2012, and Dahiru et al., (32) in Kano (0.11 to 0.28mg/kg) in 2013 were however within the range of values obtained in this research work. These differences could be due to differences in the concentration of the metal in the soils where these Cereals were grown. These values are, however, below the WHO safe limit for Cd in Cereals as reported by Dahiru et al., (32) in 2013 and Orisakwe et al., (38) in 2012.

The Fe values for the present study are higher than the range reported by Edem et al., (36) in Calabar (0.002 to 0.004mg/kg) in 2009 but far below the joint FAO/WHO (39) permissible limit (40.7 mg/kg) for Fe in Cereals. These values are also too low to provide for the Recommended Daily allowance for Fe in both adult male (10mg/day) and female (15mg/day) from a nutritional point of view (5). In the present study, the mean Fe concentration in the maize samples is higher than that reported in a study that evaluates heavy metals in millet from Kaduna, Nigeria (5). The result is similar to that reported for market sold beans from Katsina, Nigeria (28) and the result of Fe in maize from Awka, Anambra state Nigeria (35), but is lower to that reported in a study in eastern Nigeria (34) and that recorded by Zahir et al., (40) in a study conducted in Pakistan and the results for the study conducted by Di Bella et al., (31) in various type of beans.

The heavy metal Zn values obtained in this study is similar to that reported in some studies (32; 41), but are higher than the range (0.04 to 0.19mg/kg) reported by Edem et al., (36) in 2009 but far below the range reported by Ahmed and Mohammed (33) in 2005 (4.893 to 15.450 mg/kg) and that reported in a study conducted by Sulyman et al., (42). These

UNDER PEER REVIEW

values also falls below the WHO permissible limit for Zn as reported by Umar et al., (43) and can also not provide for the required daily allowance for Zn which is 11mg/day for men and 8mg/day for women (5).

The result for the heavy metal Mn concentrations in the present study is lower than the results reported in some studies (31; 34), but is similar to that reported in the market sold beans from Katsina state (28).

**Table 1 Heavy Metal Concentration (mg/kg) In Maize Cultivated in the Three Senatorial Zones of Katsina State**

| Location | Heavy metal | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mn | Zn | Pb | Cd | Ni | Fe | Cr |
| Birchi | BDL | 1.176±0.0003 | 0.770±0.0001 | 0.047±0.0001 | BDL | 0.568±0.0007 | BDL |
| Dabai | 0.316±0.0016 | 0.857±0.0005 | 1.100±0.0002 | 0.056±0.0002 | BDL | 0.603±0.0012 | BDL |
| Funtua | BDL | 1.310±0.0019 | 1.009±0.0002 | 0.049±0.0002 | BDL | 0.668±0.0004 | 0.353±0.0009 |
| Kafur | 0.354±0.0005 | 1.054±0.0007 | 1.158±0.0004 | 0.053±0.0003 | BDL | 0.394±0.0018 | BDL |
| Katsina | 0.126±0.0003 | 1.149±0.0002 | 0.547±0.0003 | 0.048±0.0002 | BDL | 0.528±0.0003 | BDL |
| Malunfashi | BDL | 1.126±0.0006 | 0.739±0.0003 | 0.052±0.0001 | BDL | 0.087±0.0013 | 0.320±0.0011 |

The degree for heavy metal toxicity to humans depends on daily consumption rate (44). The results for the estimated daily intake (EDI) of the heavy metals in adults and children on consumption of the cultivated maize were given in Tables 2 and 3. From the tables, the estimated daily intake of the heavy metals (Pb, Zn, Cd, Cr, Fe and Mn) in both adults and children were lower than the tolerable daily intake limit set by the USEPA (45) in both samples.

**Table 2 Daily intake of Heavy Metal in Adults from Consuming Cultivated Maize from Katsina State**

| Location | | | | Heavy Metal | | |
|---|---|---|---|---|---|---|
| | Mn | Zn | Pb | Cd | Fe | Cr |
| Birchi | BDL | 0.000878 | 0.000575 | 0.000035 | 0.000424 | BDL |
| Dabai | 0.000236 | 0.000640 | 0.000821 | 0.000042 | 0.000450 | BDL |
| Funtua | BDL | 0.000978 | 0.000753 | 0.000037 | 0.000499 | 0.000264 |
| Kafur | 0.000264 | 0.000787 | 0.001180 | 0.000040 | 0.000294 | BDL |
| Katsina | 0.000094 | 0.000858 | 0.000259 | 0.000036 | 0.000563 | BDL |
| Malunfashi | BDL | 0.000841 | 0.000552 | 0.000039 | 0.000065 | 0.000796 |

**Table 3 Daily intake of Heavy Metal in Children from Consuming Cultivated Maize from Katsina State**

| Location | | | | Heavy Metal | | |
|---|---|---|---|---|---|---|
| | Mn | Zn | Pb | Cd | Fe | Cr |
| Birchi | BDL | 0.002195 | 0.001437 | 0.000088 | 0.001060 | BDL |
| Dabai | 0.000590 | 0.001600 | 0.002053 | 0.000105 | 0.001126 | BDL |
| Funtua | BDL | 0.002445 | 0.001883 | 0.000092 | 0.001247 | 0.000659 |
| Kafur | 0.000661 | 0.001967 | 0.002161 | 0.000099 | 0.000735 | BDL |
| Katsina | 0.000235 | 0.002145 | 0.001021 | 0.000090 | 0.000986 | BDL |
| Malunfashi | BDL | 0.002102 | 0.001379 | 0.000097 | 0.000162 | 0.000597 |

The non-cancer risks (THQ) of the investigated heavy metals through the consumption of the maize sample for both adults and children inhabitants of the study area were determined and presented in Tables 4 and 5. The THQ has been recognized as a useful parameter for evaluating the risk associated with the consumption of metal-contaminated foods (46). THQ is interpreted as either greater than 1 (>1) or less than 1 (<1), where THQ >1 shows human health risk concern (47). Bhalkhair and Ashraf (16) in their study have put forward the suggestion that the ingested dose of heavy metals is not equal to the absorbed pollutant dose in reality because a fraction of the ingested heavy metals may be excreted, with the remainder being accumulated in body tissues where they can affect human health. Risk level of Target Hazard Quotient (THQ < 1) was observed for all the evaluated heavy metals for both adults and children. It indicates that intake of these heavy metals through consumption of the maze does not poses a considerable non-cancer risk. The THQ for the samples was in the decreasing order Zn>Pb>Fe>Cr>Cd, for all the samples respectively. The sequence of risk was the same for both adults and children although the children had higher THQ values in all cases. Similar observations have been reported previously by Mahfuza et al., (48), Micheal et al. (19) and Liu et al. (26). Further, the non-cancer risks for each sample were expressed as the cumulative HI, which is the sum of individual metal THQ. All the studied samples showed the risk level (HI < 1) with the highest in the sample from Kafur and lowest in the sample from Birchi.

UNDER PEER REVIEW

**Table 4 Heavy Metal Target Hazard Quotient and Health Risk Index in Children from Consuming Cultivated Maize from Katsina State**

| | | | | Target Hazard Quotient | | | Health Risk Index (HRIs) |
|---|---|---|---|---|---|---|---|
| **Location** | | | | **Heavy Metal** | | | |
| | **Mn** | **Zn** | **Pb** | **Cd** | **Fe** | **Cr** | |
| Birchi | BDL | 0.007317 | 0.002395 | 0.000176 | 0.001515 | BDL | 0.011402 |
| Dabai | 0.042129 | 0.005332 | 0.003423 | 0.000209 | 0.001608 | BDL | 0.052699 |
| Funtua | BDL | 0.008150 | 0.003139 | 0.000183 | 0.001781 | 0.002169 | 0.015449 |
| Kafur | 0.047193 | 0.006558 | 0.003602 | 0.000198 | 0.001051 | BDL | 0.058601 |
| Katsina | 0.016786 | 0.007149 | 0.001702 | 0.000179 | 0.001408 | BDL | 0.027224 |
| Malunfashi | BDL | 0.007005 | 0.002299 | 0.000194 | 0.000232 | 0.001991 | 0.011721 |

**Table 5 Heavy Metal Target Hazard Quotient and Health Risk Index in Adults from Consuming Cultivated Maize from Katsina State**

| | | | | Target Hazard Quotient | | | Health Risk Index (HRIs) |
|---|---|---|---|---|---|---|---|
| **Location** | | | | **Heavy Metal** | | | |
| | **Mn** | **Zn** | **Pb** | **Cd** | **Fe** | **Cr** | |
| Birchi | BDL | 0.002927 | 0.000958 | 0.000070 | 0.000606 | BDL | 0.004561 |
| Dabai | 0.016850 | 0.002133 | 0.001369 | 0.000083 | 0.000643 | BDL | 0.021078 |
| Funtua | BDL | 0.003260 | 0.001256 | 0.000073 | 0.000712 | 0.000088 | 0.005389 |
| Kafur | 0.018877 | 0.002623 | 0.001966 | 0.000079 | 0.000420 | BDL | 0.023974 |
| Katsina | 0.006721 | 0.002859 | 0.000432 | 0.000072 | 0.000563 | BDL | 0.010647 |
| Malunfashi | BDL | 0.002802 | 0.000920 | 0.000078 | 0.000093 | 0.000796 | 0.004688 |

Cd and Pb are classified by the IARC as being carcinogenic agents (49). Chronic exposure to low doses of Cd, and Pb could, therefore, result in many types of cancers (50). The computed ILCR and cumulative incremental lifetime cancer risk (∑ILCR) for Cd, and Pb through the cultivated Maize samples are presented in Tables 6 and 7. US-EPA recommended the safe limit for cancer risk is below about 1 chance in 1,000,000 lifetime exposure (ILCR $< 10^{-6}$) and threshold risk limit (ILCR $> 10^{-4}$) for chance of cancer is above 1 in 10,000 exposure where remedial measures are considerable and moderate risk level (ILCR $> 10^{-3}$) is above 1 in 1,000 where public health safety consideration is more important (27; 51). In adults the ILCR for Cd violated the threshold risk limit ($>10^{-4}$) in all the studied samples, while the ILCR for Pb reached the moderate risk limit (>10−3) except for the sample from Kafur which is above the limit ($>10^{-2}$). In children ILCR for Cd in all samples and Pb for samples from Birchi, Katsina and Malunfashi have reached the moderate risk limit ($>10^{-3}$) while the ILCR for Pb in samples from Dubai, Funtua and Kafur is above the limit ($>10^{-2}$). The trend of risk for developing cancer as a result of consuming the studied maize samples showed: Kafur> Dabai > Funtua> Malunfashi > Katsina (Tables 6 and 7).

Moreover, cumulative cancer risk (∑ILCR) in adults of all the studied maize samples reached the moderate risk limit ($>10^{-3}$) except for the sample from Kafur which is above the moderate risk limit ($>10^{-2}$) (Table 6). While the cumulative cancer risk (∑ILCR) in children of all the studied maize samples was above the moderate risk limit ($>10^{-2}$) except for the sample from Katsina which is within the moderate risk limit ($>10^{-3}$) (Table 7). Furthermore, among all the studied samples maize sample from Kafur has the highest chances of cancer risks (ILCR $1.297980 \times 10^{-2}$ in adults, $1.510018 \times 10^{-2}$ in children) and sample from Katsina has the lowest chances of cancer risk (ILCR $1.68603093 \times 10^{-3}$ in adults, $7.775840 \times 10^{-3}$ in children). These risk values indicate that the consumption of the sample from Kafur will result in an excess of 13 cancer cases in adults and 15 cancer cases in children per 1000 people exposure. While consumption of the sample from Katsina would result in an excess of 17 cancer case in adults and 78 cancer case in children per 10,000 people exposure (US-EPA, 2001). Prompt action should be needed to control the excessive use of heavy metal-based fertilizer and

UNDER PEER REVIEW

pesticides and also emission of heavy metal exhaust from automobiles should be checked to save the population from cancer risk.

Table 6 **Incremental Life Time Cancer Risk from Consuming Cultivated Maize from Katsina State**

| Location | ILCR | | ∑ILCR |
|---|---|---|---|
| | Pb | Cd | |
| Birchi | 6.036660E-03 | 5.265000E-04 | 6.563000E-03 |
| Dabai | 8.622810E-03 | 6.062410E-04 | 9.229059E-03 |
| Funtua | 7.909650E-03 | 5.490000E-04 | 8.458650E-03 |
| Kafur | 1.238580E-02 | 5.940000E-04 | 1.297980E-02 |
| Katsina | 1.632330E-03 | 5.370000E-04 | 1.686030E-03 |
| Malunfashi | 5.705710E-03 | 5.820000E-04 | 6.287710E-03 |

Table 7 **Incremental Life Time Cancer Risk** in Children **from Consuming Cultivated Maize from Katsina State**

| Location | ILCR | | ∑ILCR |
|---|---|---|---|
| | Pb | Cd | |
| Birchi | 9.045183E-03 | 1.315845E-03 | 1.037003E-02 |
| Dabai | 1.293456E-02 | 1.567815E-03 | 1.450237E-02 |
| Funtua | 1.254884E-02 | 1.371840E-03 | 1.392068E-02 |
| Kafur | 1.361635E-02 | 1.483830E-03 | 1.510018E-02 |
| Katsina | 6.431997E-03 | 1.343850E-03 | 7.775847E-03 |
| Malunfashi | 8.689665E-03 | 1.455825E-03 | 1.014549E-02 |

## 4. CONCLUSION

This study determines the heavy metals concentration in cultivated maize samples from Katsina state Nigeria. Results from this study have shown that with the exception of the heavy metal Pb the concentration values of Cr, Zn, Cd and Fe in the samples were generally lower than the USEPA, WHO/FAO maximum permissive limits. The results have indicated that the estimated daily intake of the heavy metals was lower than the tolerable daily intake limit set by the USEPA in both samples. The risk level of Target Hazard Quotient (THQ < 1) was observed for all the evaluated heavy metals for both adults and children. It indicates that the intake of these heavy metals through consumption of the soya beans does not pose a considerable non-cancer risk. Therefore the intake of individual heavy metals through consumption of the samples in this area is safe for the inhabitants. The THQ for the samples was in the decreasing order Zn>Pb>Fe>Cr>Cd, for all the samples respectively. All the studied samples showed the risk level (HI < 1) with the highest in the sample from Dubai and the lowest in the sample from Funtua. In adults, the ILCR for Cd violated the threshold risk limit (>$10^{-4}$) in all the studied samples, while the ILCR for Pb reached the moderate risk limit (>$10^{-3}$) except for the sample from Kafur which is above the limit (>$10^{-2}$). In children ILCR for Cd in all samples and Pb for samples from Birchi, Katsina and Malunfashi have reached the moderate risk limit (>$10^{-3}$) while the ILCR for Pb in samples from Dabai, Funtua and Kafur is above the limit (>$10^{-2}$). The trend of risk for developing cancer as a result of consuming the studied maize samples showed: Kafur> Dabai > Funtua> Malunfashi > Katsina. The cumulative cancer risk (∑ILCR) in adults of all the studied maize samples reached the moderate risk limit (>$10^{-3}$) except for sample from Kafur which is above the moderate risk limit (>$10^{-2}$). While the cumulative cancer risk (∑ILCR) in children of all the studied maize samples above the moderate risk limit (>$10^{-2}$) except for sample from Katsina which is within the moderate risk limit (>$10^{-3}$). Among all the studied samples maize sample from Kafur has the highest chances of cancer risks (ILCR $1.297980 \times 10^{-2}$ in adults, $1.510018 \times 10^{-2}$ in children) and sample from Katsina has the lowest chances of cancer risk (ILCR $1.68603093 \times 10^{-3}$ in adults, $7.775840 \times 10^{-3}$ in children). The study suggests that consumption of the studied maize samples in Katsina state is of public health concern as they may contribute to the population cancer burden.

UNDER PEER REVIEW

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Ihekoronye AF, Ngoddy, O. Integrated Food Science and Technology for the Tropics. London, Macmillan Publishers Ltd, 1985; 237-351

2. Doe ED, Awua AK, Gyamfi OK, Bentil NO. Levels of selected heavy metals in wheat flour on the Ghanaian market, a determination by atomic absorption spectrophotometer, Am. J. Appl. Chem. 2013; 1(2) 17-21

3. Okaka, JC. Handling, storage and processing of plant foods. Academic publisher, Nigeria, 2005 pp. 250270

4. Abdulrazak S, Otie D, Oniwapele YA. Proximate analysis and anti-nutritional factors of groundnut and melon husk. Online J. Anim. Feed Res., 2014 4(2): 25-28

5. Babatunde OA, Uche E, A comparative evaluation of the heavy metals content of some cereals sold in Kaduna, North west Nigeria. International Journal of Scientific & Engineering Research, 2015; Volume 6, Issue 10, 485ISSN 2229-5518

6. Haware DJ, Pramod HP, Determination of specific heavy metals in fruit juices using Atomic Absorption Spectrophotometer (AAS), Int. J. Res. Chem. Environ., 2011; 4(3)163-168

7. Bempah CK, Kwofie AB, Tutu AO, Danutsui D, Bentil N. Assessing the potential dietary intake of heavy metals in some selected fruits and vegetables from Ghanaian markets, Elixir Pollut. 2011; 39: 4921-4926

8. Gottipolu RR, Flora SJ, Riyaz B. Environmental Pollution-Ecology and human health: P. Narosa publishing house, 2012; New Delhi India.110 002, 166-223

9. Obi IU, Maize: Agronomy, Diseases, Pests and Food values. 1st Edn., Optimal Computer Solutions Ltd., Enugu, Nigeria, 1991; pp: 34-51

10. FAO World agriculture: Towards 2015/2030.Summary Report, Food and Agricultural Organization (FAO) Rome, Italy, 2002.

11. Gbogidi OM, Eruotor PG, Akparobi SO, Nnaji GU Evaluation of crude oil contaminated soil on the mineral nutrient elements of maize (Zea mays L.). J. Agron., 2007; 6: 188-193.

12. Dowswell CR, Paliwal RL, Cantrell RP. Maize in the Third World, West View Press1996, Boulder, Colorado

13. Katsina State investor's handbook, Yaliam Press Ltd 2016: 12-15

14. A.O.A.C Official Methods of Analysis 18th Edition, Association of Official Analytical Chemists, 1995 U.S.A

15. Jan FA, Ishaq M, Khan S, Ihsanullah I, Ahmad I, Shakirullah M, A comparative study of human health risks via consumption of food crops grown on wastewater irrigated soil (Peshawar) and relatively clean water irrigated soil (lower Dir). J. Hazard. Mater, 2010; 179: 612–6219. Balkhaira KS, Ashraf MA, Field accumulation risks of heavy metals in soil and vegetable crop irrigated with sewage water in western region of Saudi Arabia. Saudi Journal of Biological Sciences 2015; 23 (1): S32-S44

16. Balkhaira KS, Ashraf MA, Field accumulation risks of heavy metals in soil and vegetable crop irrigated with sewage water in western region of Saudi Arabia. Saudi Journal of Biological Sciences 2015; 23 (1): S32-S44

17. Orisakwe OE, Mbagwu HOC, Ajaezi GC, Edet UW, Patrick U, Uwana PU. Heavy metals in sea food and farm produce from Uyo, Nigeria Levels and health implications. Sultan Qaboos Univ Med J. 2015; 15(2): e275–e282.


UNDER PEER REVIEW

18. Ekhator OC, Udowelle NA, Igbiri S, Asomugha RN, Igweze ZN, Orisakwe OE. Safety Evaluation of Potential Toxic Metals Exposure from Street Foods Consumed in Mid-West Nigeria. Journal of Environmental and Public Health Volume 2017, Article ID 8458057

19. Micheal B, Patrick O, Vivian T. Cancer and non-cancer risks associated with heavy metal exposures from street foods: Evaluation of roasted meats in an urban setting. Journal of Environment Pollution and Human Health, 2015; 3, 24–30

20. Li S, Zhang Q. Risk assessment and seasonal variations of dissolved trace elements and heavy metals in the Upper Han River, China. Journal of Hazardous Materials, 2010; 181, 1051–1058

21. Li PH, Kong S, Geng CM, Han B, Sun RF, Zhao RJ, Bai ZP, Assessing the hazardous risks of vehicle inspection workers' exposure to particulate heavy metals in their work places. Aerosol and Air Quality Research, 2013; 13, 255–265

22. United States Environmental Protection Agency. EPA Human Health Related Guidance, OSWER, 2002; 9355 (pp. 4–24). Washington, DC: United States Environmental Protection Agency

23. NFPCSP Nutrition Fact Sheet; Joint report of Food Planning and Nutrition Unit (FMPU) of the ministry of Food of Government of Bangladesh and Food and Agricultural Organization of the United Nation (FAO) September 14, 2011; 1–2, National Food Policy Plan of Action and Country Investment Plan, Government of the People's Republic of Bangladesh

24. The Risk Information System, 2007; Retrieved from http://rais.oml.govt/tox/rap_toxp.shtml

25. Guerra F, Trevizam AR, Muraoka T, Marcante NC, Canniatti-Brazaca SG, Heavy metals in vegetables and potential risk for human health. Scientia Agricola, 2012; 69, 54–60.10.1590/S0103-90162012000100008

26. Liu X, Song Q, Tang Y, Li, W, Xu J, Wu J, Wang F, Brookes, PC. Human health risk assessment of heavy metals in soil–vegetable system: A multi-medium analysis. Science of the Total Environment, 2013; 463–464, 530–540

27. Pepper IL, Gerba CP, Brusseau ML. Environmental and pollution Science: Pollution Science Series, 2012; pp. 212–232. Academic Press

28. Yaradua AI, Alhassan AJ, Shagumba AA, Nasir A, Idi A, Muhammad IU, Kanadi AM. Evaluation of heavy metals in beans and some beans product from some selected markets in Katsina state Nigeria. Bayero Journal of Pure and Applied sciences.2017http://dx.doi.org/10.4314/bajopas.v10i1.1S

29. Landrigan PJ, Fuller R, Acosta NJR, Adeyi O, Arnold R, Basu N, Zhong M, The Lancet Commission on pollution and health. The Lancet, 2017; https://doi.org/10.1016/S0140-6736 (17)32345-0

30. Mohammed SA, Folorunsho JO, Heavy metals concentration in soil and Amaranthus retroflexus grown on irrigated farmlands in Makera Area, Kaduna, Nigeria. Journal of Geography and Regional Planning, 2015; Vol. 8(8), pp. 210 - 217

31. Di Bella G, Clara N, Giuseppe D B, Luca R, Vincenzo L T, Angela G P, Giacomo D, Mineral composition of some varieties of beans from Mediterranean and Tropical areas. International Journal of Food Sciences and Nutrition 2016; vol. 67, no. 3, 239–248

32. Dahiru MF, Umar AB, Sani MD. Cadmium, Copper, Lead and Zinc Levels In Sorghum And Millet Grown In The City Of Kano And Its Environs. Global Advanced Research Journal of Environmental Science and Toxicology (ISSN: 2315-5140). 2013; Vol 2(3), 082-085

33. Ahmed KS, and Mohammed AR. Heavy Metals (Cd, Pb) and Trace Elements (Cu, Zn) Contents Of Some Food Stuffs from Egyptian Markets. Emir J. Agric.sci, 2005; 17(1):34-42.

34. Okoye COB, Odo IS, Odika IM. Heavy metals content of grains commonly sold in markets in south-east Nigeria. Plant Products Research Journal, 2009; vol. 13, SSN 1119-2283

35. Sab-Udeh SS, Okerulu IO, Determination of Heavy Metal Levels of some Cereals and Vegetables sold in Eke-Awka Market Awka, Anambra State, Nigeria. Journal of Natural Sciences and Research, 2017; Vol 7, No 4

UNDER PEER REVIEW

36. Edem CA, Grace I, Vincent O, Rebecca E, Matilda O. A Comparative Evaluation Of Heavy Metals In Commercial Wheat Flours Sold In Calabar –Nigeria. Pakistan Journal of Nutrition, 2009; 8, 585-587

37. Olusakin PO, Olaoluwa DJ, Evaluation of Effects of Heavy Metal Contents of Some Common Spices Available in Odo-Ori Market, Iwo, Nigeria. J Environ Anal Chem., 2016; 3:174. doi:10.41722380-2391.1000174

38. Orisakwe EO, John KN, Cecilia NA, Daniel OD, Onyinyechi B. Heavy Metals Health Risk assessment for Population Consumption of Food Crops and Fruits in Owerre-Southern Nigeria. Chem. Cent., 2012; 6, 77

39. FAO/WHO Codex Alimentarius Commission Food additives and contaminants: Joint FAO/WHO Food Standards Program; ALINORM, 2011; 01/12A:1-289

40. Zahir E, Naqvi II, Mohi Uddin SH. Market basket survey of selected metals in fruits from Karachi city (Pakistan), Journal of Basic and Applied Sciences 2009; 5(2):47-52

41. Yahaya MY, Umar RA, Wasagu RSU, Gwandu HA, Evaluation of some heavy metals in food crops of Lead polluted sites of Zamfara State Nigeria, International Journal of Food Nutrition and Safety, 2015; 6(2): 67-73

42. Sulyman YI, Abdulrazak S, Oniwapele, YA, Ahmad A, (2015) Concentration of heavy metals in some selected cereals sourced within Kaduna state, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), e-ISSN: 2319-2402,p- ISSN: 2319-2399. 2015; Volume 9, Issue 10 Ver. II (Oct. 2015), PP 17-19

43. Umar M, Stephen SH, Abdullahi M. Levels of Fe and Zn in stable cereals: malnutrition implications in Rural North-east Nigeria. Food and public Health Journal, 2012; 2(2), 28-33

44. Singh A, Sharma RK, Agrawal M, Marshall FM. Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropical area of India, Food Chem. Toxicol., 2010; 48, 611–619, doi:10.1016/j.fct.2009.11.041

45. SEPA limits of pollutants in food. State environmental protection administration, 2005; China GB2762

46. Agbenin JO, Danko M, Welp G. Soil and vegetable compositional relationships of eight potentially toxic metals in urban garden fields from northern Nigeria J. Sci. Food Agric., 2009; 89 (1), pp. 49–54

47. Bassey SC, Ofem OE, Essien NM, Eteng MU. Comparative Microbial Evaluation of Two Edible Seafood P. palludosa (Apple Snail) and E. radiata (Clam) to Ascertain their Consumption Safety. J Nutr Food Sci 2014; 4: 328. doi: 10.4172/2155-9600.1000328

48. Mahfuza SS, Rana S, Yamazaki S, Aono T, Yoshida S. Health risk assessment for carcinogenic and noncarcinogenic heavy metal exposures from vegetables and fruits of Bangladesh. Cogent Environmental Science, 2017; 3: 1291107 http://dx.doi.org/10.1080/23311843.2017.1291107

49. Tani FH, Barrington S. Zinc and copper uptake by plants under two transpiration rates. Part I Wheat (Triticum aestivum L.) Environmental Pollution, 2005; 138, 538–547.10.1016/j.envpol.2004.06.005

50. Jarup L, Hazards of heavy metal contamination British Medical Bulletin, 2003; 68, 167–182

51. Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ, Heavy metal toxicity and the environment. Molecular Clinical and Environmental Toxicology, 2014; 101, 133–164

52. Adewole MB, Uchegbu LU (2010) Properties of soils and plants uptake within the vicinity of selected automobile workshops in Ile-Ife Southwestern Nigeria. Ethiopian Journal of Environmental Studies and Management 3(3): 31- 35.

53. Rabe JM, et al. Assessment of Contaminated Soil with Some Heavy Metals in Selected Auto Repair Shops in Katsina North Western, Nigeria. J Waste Manage Xenobio 2018, 1(2): 000113

UNDER PEER REVIEW