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Evaluation of the Heavy Metals Content and Health Risk to the Population from Consumption of Lettuce Cultivated in Katsina State, North West Nigeria

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This work contributes to the monitoring of heavy metals in agricultural produce in Katsina State, Northwest Nigeria, and the possible health risk to the consumer population. Samples of lettuce from the three senatorial zones that constitute to make up Katsina state in the North West of Nigeria were collected and the concentrations of seven heavy metals (Pb, Cd, Cr, Fe, Zn, Mn and Ni) in all the samples were evaluated by atomic absorption spectrometry. The health risk assessment methods developed by the United States Environmental Protection Agency (US EPA) were employed to explore the potential health hazards of heavy metals in the samples on the children and adult population. The highest mean concentration (mg/kg) was observed for Zn (range: 1.048-1.208), followed by Pb (range: 0.508-0.982), Fe (range: 0.684-0.978) and Cr (range: 0.135-0.261). While Cd has the lowest concentration (range: 0.042-0.051) with the heavy metals Mn and Ni being below detection level (BDL). The target hazard quotient (THQ) and the hazard index (Hi) for the heavy metals evaluated were within the safety limit. The overall cancer risk to the adults based on pseudo-total metal concentrations exceeded the target value, mainly contributed by the heavy metal Pb. Mn is the primary heavy metal posing non cancer risks while Pb caused the greatest cancer risk. It was concluded that consumption of the lettuce leaf samples from Katsina State may contribute to the population cancer burden.

Key words: Daily intake, Carcinogen, Environmental pollution, permissible limit

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INTRODUCTION

The distribution, sources and potential ecological and health risk of heavy metals in the soils, water bodies, sediment and various agricultural produce in areas of the world that have undergone rapid economic development have been widely researched by scholars (Mihaileanu *et al*., 2019; Hounkpe *et al*., 2017; Junianto *et al*., 2017; Mortuza and Al-Musnad, 2017; Mahfuza *et al*., 2017; Dibella *et al*., 2016). Environmental exposure to heavy metals is a well-known risk factor for cancers (Zhaoa *et al*., 2014), as chronic exposure to high levels of toxic metals have been associated with higher risk of cancers of the bladder, kidney, liver, pancreas, lung, and skin (IARC, 2012).

The paucity of information on the degree and severity of pollution by heavy metals and their import on human health in Katsina State necessitate this study. The results of the present study may likely have a key policy implication given that current global non communicable disease prevention strategies are focused primarily on tackling behavioural determinants (WHO, 2018). Recognizing environmental factors (such as toxic metals) as additional priorities, therefore, will help gain wider sociopolitical support for setting up appropriate legislation, preventive strategies and standards, and investment to tackle these major global determinants of cancer and non communicable diseases.

STUDY AREA

The study was carried out during 2016-2017 in Katsina State, Nigeria located between latitude $12^0 15'$N and longitude of $7^0 30'$E in the North West Zone of Nigeria, with an area of 24,192km^2 (9,341 sq meters) (Katsina state, 2016). The rainy season begins in April and ends in October, while the dry season starts in November and ends in March. The average annual rainfall, temperature, and relative humidity of Katsina State are 1,312 mm, 27.3ºC and 50.2%, respectively. Like most alluvial soils, the soil in Katsina state is the flood plain type and is characterized by considerable variations. The soil has two main types, which are soils with little hazards and soils with good water holding capacity (Katsina state, 2016). Katsina has been divided into three agro-ecological zones (Guinea Savannah; Sudan Savannah; Sub-Sahel Savannah), with farmers in the state engaged in the production of horticultural crops, such as Maize, Sorghum, Millet, Rice, Beans, Soybeans, Cotton, Cassava, Groundnut, Sweet Potatoes, vegetables and fodder crops (Katsina state, 2016).

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 4^0C until ready for use.

Vegetable samples were collected from each site of the sampling zones. The edible portion of the vegetable samples were properly separated and thoroughly washed under a running tap water to remove dust, dirt and possible parasite or their eggs. Then, 1% nitric acid solution was use to remove surface contaminants, and then rinsed with distilled water. Samples was chopped into small pieces using a clean stainless table knife and afterward dried to a constant mass in an oven at 80 ^{o}C for 48h. Replicate samples of each dried vegetable from the site were combined and pounded to fine powder using a porcelain mortar and pestle. Particle sizes of 0.05 to 0.2mm were obtained using laboratory sieves.

HEAVY METALS DETERMINATION

5 g of each Sample was dried at 80^0C 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 550^0C 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 ($HN0_3$) 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 (AOAC, 1995) and the results were given in mg/kg.

DAILY INTAKE OF METALS (DIM) IN SAMPLES

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 sample and the average body weight, respectively. The conversion factor (CF) of 0.085 was used for the conversion of the samples to dry weights. . The average daily intake of the samples were taken as 0.527 kg person^{-1} d^{-1}(Bhalkhair and Ashraf, 2015), and the average body weight for the adult and children population was taken from literature to be 60 kg **(**Orisakwe *et al*., 2015**)** and 24 kg (Ekhator *et al*., 2017) respectively; these values were used for the calculation of health risk index (HRI) as well.

NON-CANCER RISKS

Non-carcinogenic risks for individual heavy metal of the samples were evaluated by computing the target hazard quotient (THQ) using the following equation (Micheal *et al*.,2015).

THQ=CDI/RfD

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 (Li and Zhang, 2010). 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) (Li *et al.*,2013; US-EPA, 2002).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 (NFPCSP Nutrition Fact Sheet, 2011). It is calculated as follows:

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

Where 1, 2 …. *n* are the individual heavy metals in samples.

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 (RAIS, 2007). The population is assumed to be safe when HI < 1 and in a level of concern when 1 < HI < 5 (Guerra *et al.*, 2012).

CANCER RISKS

The possibility of cancer risks in the studied samples through intake of carcinogenic heavy metals was estimated using the Incremental Lifetime Cancer Risk (ILCR) (Liu *et al.*, 2013).

$$ILCR= CDI\times CSF$$

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 (Micheal *et al.*, 2015). The following cancer slope factor for specific heavy metals were used; Pb = 0.0085 mg/kg/day (Kamunda et al., 2016), Cd = 0.38 mg/kg/day (Yang et al., 2018). ILCR value in sample represents the probability of an individual's lifetime health risks from carcinogenic heavy metals' exposure (Pepper *et al.*, 2012). The level of acceptable cancer risk (ILCR) for regulatory purposes is considered within the range of 10^{-6} to 10^{-4} (Li and Zhang, 2010). 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 (Liu *et al.*, 2013).

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

where EDI is the estimated daily intake of metal via consumption of the samples; EFr is the exposure frequency (365 days/year); ED_{tot} is the exposure duration of 60 years, average lifetime for Nigerians; AT is the period of exposure for non-carcinogenic effects (EFr × ED_{tot}), and 60 years life time for carcinogenic effect (Micheal *et al.*, 2015). 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 (Liu *et al.*, 2013).

$$\sum 1_n=ILCR_1+ILCR_2+\cdots+ILCR_n$$

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

RESULTS AND DISCUSSION

The present study investigated the presence of heavy metals in Lettuce which is a component of the diet among the population in Katsina state, Nigeria. A total of 3 composite Lettuce 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: 1.048-1.208), followed by Pb (range: 0.508-0.982), Fe (range: 0.684-0.978) and Cr (range: 0.135-0.261). While Cd has the lowest concentration (range: 0.042-0.051) with the heavy metals Mn and Ni being below detection level (BDL). Heavy metal by heavy metal analysis has revealed that the sample from Ingawa has the lowest Mn concentration, while the sample from Funtua has the highest. For the heavy metal Zn, the sample from Zango has the lowest concentration, while the sample from Dabai has the highest Zn concentration. The concentration of the heavy metal Pb is lowest in the sample from Katsina, and highest in the sample from Ingawa. In the same vein the lowest concentration of the heavy metal Cd is in the sample from Matazu and highest in the sample from Daura. The sample from Ingawa has the lowest Fe concentration, while the sample from Katsina has the highest. Cr concentration is lowest in the sample from Dabai and highest in the sample from Birchi.

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

Zone	Pb	Cr	Zn	Ni	Fe	Mn	Cd
Katsina	1.9360 ±0.0002	BDL	1.0820±0.0004	BDL	1.4510 ±0.0003	0.4510 ±0.0002	0.0580 ±0.0002
Funtua	1.8250 ±0.003	BDL	0.9280 ±0.0002	BDL	1.3150 ±0.0002	0.3860 ±0.0004	0.0520 ±0.0002
Daura	1.7330±0.0004	BDL	0.8910 ±0.0002	BDL	1.4210±0.0003	0.6210±0.0012	0.0560±0.0006

Values are expressed as Mean ± SD

The degree for heavy metal toxicity to humans depends on daily consumption rate (Singh *et al.,* 2010). The results for the estimated daily intake (EDI) of the heavy metals on consumption of the cultivated Lettuce were given in Tables 2 and 3. From the tables the estimated daily intake of the heavy metals (Pb, Zn, Ni, Cd, Cr, Fe and Mn) in both adult and children were lower than the tolerable daily intake limit in all the samples. The order of sequence of daily metal intake in both adult and children from consumption of the Lettuce leaf samples in the various sampling sites is as follows: Katsina (Pb>Fe>Zn>Mn>Cd); Funtua (Pb>Fe>Zn>Mn>Cd); Daura (Pb>Fe>Zn>Mn>Cd).

Table 2. Daily Metal intake, Target Hazard Quotient and Health Risk Index in Adults from Consumption of Lettuce Cultivated in the Three Senatorial Zones of Katsina State

Heavy metal	Daily intake of metal			Target Hazard Quotient		
	Katsina	Funtua	Daura	Katsina	Funtua	Daura
Mn	0.000381	0.000288	0.000464	0.022720	0.020584	0.033116
Zn	0.000808	0.000693	0.000665	0.002693	0.002309	0.002217
Pb	0.001445	0.001363	0.001294	0.002409	0.002271	0.002156
Cd	0.000043	0.000039	0.000042	0.000866	0.000078	0.000084
Ni	BDL	BDL	BDL	BDL	BDL	BDL
Fe	0.001083	0.000982	0.001061	0.002693	0.002309	0.001516
Cr	BDL	BDL	BDL	BDL	BDL	BDL
Health Risk Index				0.033933	0.026675	0.039089

The non-cancer risks (THQ and HRI) of the investigated heavy metals through the consumption of the lettuce leaf samples for both adults and children inhabitants of the study area were determined and presented in Tables 2 and 3, the results have revealed that the THQ value is less than 1 with the highest being that for the heavy metal Mn of the sample from Daura (0.0331 in adult; 0.1136 in children) and the heavy metal Cd in the sample from Funtua (0.00007 in adult; 0.00018 in children) having the lowest THQ value. Likewise the HRIs is less than 1 in both the children and adult population, with the sample from Kafur (0.0230 in adult; 0.0586 in children) having the highest HRI and the sample from Birchi (0.0046 in adult; 0.0114 in children) having the lowest HRI.

Table 3. Daily Metal intake, Target Hazard Quotient and Health Risk Index in Children from Consumption of Lettuce Cultivated in the Three Senatorial Zones of Katsina State

Heavy metal	Daily intake of metal			Target Hazard Quotient		
	Katsina	Funtua	Daura	Katsina	Funtua	Daura
Mn	0.000842	0.000721	0.001159	0.060127	0.051461	0.113624
Zn	0.002020	0.001732	0.001663	0.006732	0.005774	0.005543
Pb	0.036131	0.003406	0.003235	0.006022	0.005671	0.005391
Cd	0.000108	0.000971	0.000105	0.000217	0.000194	0.000209
Ni	BDL	BDL	BDL	BDL	BDL	BDL
Fe	0.002708	0.002454	0.002652	0.003869	0.003506	0.003789
Cr	BDL	BDL	BDL	BDL	BDL	BDL
Health Risk Index				0.076966	0.066612	0.128554

The results for the ILCR and ∑ILCR from consumption of the lettuce leaf samples are presented on tables 4 and 5. From the results, the lettuce samples ILCR for Cd violated the threshold risk limit (>10^{-4}) while the ILCR for Pb has reached the moderate risk limit (>10^{-3}) in all the studied Lettuce leaf samples in adults. In children the ILCR for Cd has reached the moderate risk level (>10^{-3}) while the ILCR for Pb is above the moderate risk level (>10^{-2}). The sampling area trend of risk for developing cancer as a result of consuming the studied samples showed: Katsina senatorial zone > Funtua senatorial zone> Daura senatorial zone for both adult and children.

The calculated cumulative cancer risk (∑ILCR) of all the studied Lettuce is within the moderate risk limit (>10^{-3}) in adults, while in children it has reached the moderate risk limit (>10^{-3}) in the samples from Daura and Funtua senatorial zone and is beyond the moderate risk limit (>10^{-2}) for the sample from Katsina senatorial zone. Also, the sample from Katsina senatorial zone has the highest chances of cancer risks (ILCR 9.755425×10^{-3} in adults; ILCR 2.276482×10^{-2} in children) and the sample from Daura senatorial zone has the lowest chances of cancer risk (ILCR 8.778236×10^{-3}adults; ILCR 2.259252×10^{-3}in children). This indicate that consumption of the Lettuce sample from Katsina senatorial would result in an excess of 98 cancer cases per 10,000 people exposure in adults and 23 cancer cases per 1,000 people exposure in children, while consumption of the Lettuce sample from Daura senatorial zone would result in an excess of 88 cancer cases per 10,000 people exposure in adults and 23 cancer cases in children per 10,000 people exposure.

Table 4. Incremental Life Time Cancer Risk in Adults from Consumption of Lettuce Cultivated in the Three Senatorial Zones of Katsina State

Zone	ILCR		∑ILCR
	Pb	Cd	
Katsina	9.1059E-03	6.4950E-04	9.7554E-03
Funtua	8.5838E-03	5.8233E-04	9.1662E-03
Daura	8.1511E-03	6.2712E-04	8.7782E-03

Table 5. Incremental Life Time Cancer Risk in Children from Consumption of Lettuce Cultivated in the Three Senatorial Zones of Katsina State

Zone	ILCR		∑ILCR
	Pb	Cd	
Katsina	2.2765E-02	1.624E-03	2.2765E-02
Funtua	2.1460E-03	1.4558E-03	2.2915E-03
Daura	2.1025E-03	1.5678E-03	2.2593E-03

DISCUSSION

The heavy metal Pb was above 0.01 mg/kg in all the samples, which is the maximum permissible limit set by WHO/FAO and also above the maximum allowable concentration of 0.02 mg/kg by EU and 0.05 mg/kg limit set by USEPA. The high percentage of food samples which were in violation of the maximum permissible limits of Pb set by the WHO, EU, and US EPA is a cause for public health concern. The Pb concentration range for the leaf samples in this study is lower than that reported for leafy vegetables from Kaduna state Nigeria (Mohammed and Folorunsho, 2015) 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 (Di Bella *et al.,* 2016).

The Pb values are also higher than that reported for the concentration of Pb in cereals from Kano and Kaduna states, Nigeria (Dahiru *et al.,* 2013; Babatunde and Uche, 2015). This difference has earlier been attributed to differences in anthropogenic activities that introduce metals into the soil in the areas where these vegetables were grown or even deposition of Pb on the surface of these leafy vegetables during production, transport and Marketing or by emissions from Vehicles and industries (Gottipolu *et al.,* 2012). But the values are similar to concentrations of Pb reported for leafy vegetables and onion bulb samples from Katsina state, Nigeria (Yaradua *et al*., 2019a, b; Yaradua *et al.,* 2020)

The Cd concentration range for the samples in this study is similar to that reported in a study for the Cadmium concentration range for both unprocessed and processed bean samples from Katsina state Nigeria (Yaradua *et al*., 2017) and for locust beans from Odo-Ori market Iwo, Nigeria (Olusakin *et al*., 2016). The values are also lower than those obtained by Orisakwe *et al.* in

Owerri (0.00 to 0.24mg/kg) in 2012 and Dahiru *et al.,* in Kano (0.11 to 0.28mg/kg) in 2013 and that reported for various beans samples from Europe, Asia and parts of West Africa (Di Bella *et al.,* 2016), These differences could be due to differences in the concentration of the metal in the soils where these vegetables were grown.

The Fe values for the present study are higher than that reported in a study that evaluate heavy metals in millet from Kaduna, Nigeria (Babatunde and Uche, 2015), but 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 (Babatunde and Uche, 2015). In the present study, the mean Fe concentration in the leaf samples is similar to that reported for market sold beans and Hibiscus leaves from Katsina, Nigeria (Yaradua *et al*., 2017; Yaradua *et al.,* 2019a), but is lower to that reported in a study in eastern Nigeria (Okoye *et al*., 2009) and that recorded by Zahir et al., (2009) in a study conducted in Pakistan and the results for the study conducted by Di Bella *et al*., (2016).

The heavy metal Zn values obtain in this study is similar to that reported in some studies (Dahiru *et al*., 2013; Yahaya *et al*., 2015), but are higher than that reported in a study conducted bySulyman*et al*., (2015).These values also falls below the WHO permissible limit for Zn(Umar *et al*., 2012) and can also not provide for the required daily allowance for Zn (Babatunde and Uche, 2015).

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 Lettuce does not pose a considerable non-cancer risk. The THQ for the samples was in the decreasing order Mn>Zn>Pb>Fe>Cd, for all the Lettuce samples respectively. With the risk sequence being the same for both adults and children although the children had higher THQ values in all cases. Similar observations have been reported previously by Yaradua *et al*. (2019a), Mahfuza *et al*. (2017), Micheal *et al*. (2015) and *Liu et al*. (2013).

All the studied samples showed the risk level (HI < 1) which suggests that the inhabitants of Katsina state might not be exposed to non-carcinogenic health risk through the intake of heavy metals.

The THQ of below 1 reported for all the samples analysed is lower than the results of THQ for cabbage and tomato in a study carried out by Gebeyehu and Bayissa (2020) in Mojo, Ethiopia that calculated a THQ of above 1and that of a study conducted by Yi *et al*. (2017) that reported a THQ of above 1 in fish samples from upper Yangtze river, China, and in a study carried out in Enyigba, south eastern Nigeria for Pb in lemon grass and Mn in leafy vegetables (Obiora *et al*., 2016), the value is also lower than the THQ values above 1 reported in a study conducted in the western region of Saudi Arabia on Okra vegetable (Bhalkhair and Ashraf, 2016), they are also lower than the THQ values for cereals, green leafy vegetables, roots and tubers from Vadodara (Chandorkar and Deota, 2013) and the values reported by Mahfuza *et al*. (2017) for vegetables and fruits from Bangladesh. But the results are similar to the THQ of below 1 in tea leaves from Puan County, Guizhou province China (Zhang *et al*., 2018).

All the studied samples showed the risk level (HI < 1) with highest in Lettuce sample from Daura senatorial zone and lowest in the Lettuce sample from Katsina senatorial zone. It suggests that the inhabitants of Katsina state might not be exposed to non-carcinogenic health risk through the intake of heavy metals. The HI in the samples differ from the HI values reported for vegetables from Tamale metropolis, Ghana that showed that the calculated hazard index (HI) for both adult and children from consumption of their evaluated sample was above 1 (Ametepey *et al.,* 2018), the value is also lower when compared to the HI values of more than 1 reported for cabbage and tomato from Mojo, Ethiopia (Gebeyehu and Bayissa, 2020), the results of Obiora *et al*. (2016) in a study conducted in Enyigba, south eastern Nigeria for Pb in lemon grass and Mn in leafy vegetables, the results of HI reported for Okra vegetable from Saudi Arabia(Bhalkhair and Ashraf, 2016), the HI values reported for cereals, green leafy vegetables, roots and tubers from Vadodara (Chandorkar and Deota, 2013) and the values reported by Mahfuza *et al*. (2017) for vegetables and fruits from Bangladesh. But the HRI values are similar to what was reported for *Clarias gariepinus* samples from Imo River, Nigeria (0risakwe *et al*., 2014) and the reported HI values for leafy and fruit Vegetables, and cereals from Katsina state, Nigeria (Yaradua *et al*., 2019a, b, c, d;).

The computed values for ILCR and ∑ILCR from consumption of the lettuce samples that raises the level of health concern for the consumer population as they may contribute to the population cancer burden is in agreement to what was reported by Gebeyehu and Bayissa (2020), in vegetables from Mojo Ethiopia, the values are also similar toILCR and ∑ILCR values reported from consumption ofmeat and sea food samples from Xiamen, China (Chen *et al.,* 2011), the ILCR and ∑ILCR in Vegetables from Pearl River Delta South China (Chang *et al.,* 2014), in fruits and vegetables from Jamaica (Antoine *et al*,. 2017), in vegetables from a Pb/Zn smelter in Central China (Li *et al.,* 2018) in vegetables grown in Patuakhali province Bangladesh (Islam *et al.,* 2018) and in fruit, root and leafy vegetables, and fruits as reported in a study conducted inBangladesh (Mahfuza *et al.,* 2017). However the results differ from the results for vegetables from some selected communities from Rivers State, Nigeria that reported non carcinogenic cancer risks from the vegetable samples in the study (Ogbo and Kingsley, 2019).

CONCLUSSION

This work contributes to the monitoring of heavy metal exposure in various food items cultivated in Katsina and possible carcinogenic and non carcinogenic risk to the population. The target hazard quotient (THQ) and the hazard index (Hi) for the heavy metals evaluated were within the safety limit. The overall cancer risk to the adults based on pseudo-total metal concentrations exceeded the target value, mainly contributed by the heavy metal Pb. Mn is the primary heavy metal posing non cancer risks while Pb caused the greatest cancer risk. It was concluded that consumption of the lettuce leaf samples from Katsina State may contribute to the population cancer burden.

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