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Carcinogenic and non-carcinogenic human health risk assessment of some vegetables irrigated with wastewater in Jos, Plateau State, Nigeria

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Abstract

Aim: There is growing concern on the use of contaminated and untreated water from industrial discharge for irrigation during the dry season farming in many parts of northern Nigeria. Industries effluents are among the major sources of heavy metal pollution of water bodies and when used for irrigation could be a source of heavy metal bioaccumulation in crops. This study determined the potential non-carcinogenic and carcinogenic health risks in both children and adults through the consumption of some vegetables irrigated with polluted water in Bassa, Plateau, and Nigeria.

Methods: Four vegetable farms that exclusively use untreated industrial effluents were identified and eight commonly consumed vegetables were sampled for heavy metal analysis using atomic absorption spectrometry. The metals of interest were Cd, Pb, Cr, Cu, and Zn.

Results: Concentrations of Cd, Pb, and Cr in all the vegetables exceeded the WHO's permissible limits while Cu and Zn did not. Mean heavy metals in the vegetables ranged from 26.87–33.50 mg/kg (Cd), 4.17–10.90 mg/kg (Pb), 27.00–38.67 mg/kg (Cr), 10.60–24.38 mg/kg (Cu), and 1.77–3.42 mg/kg (Zn). Estimated daily intake (EDI) for Cd and Pb for both children and adults exceeded the oral risk-free dose (RFD) set by US-EPA. However, the EDI of Cu in children exceeds the RFD while the EDI of adults did not exceed RFD. Consumption of all the metal-contaminated vegetables posed a potential non cancer risk hazard index (HI ≥ 1) in both children and adults while the target cancer risks (TCR) were due to ingestion of Cd and Cr in the vegetables with TCR values above 1×10^{-4}.

Conclusions: This study found that adults and children population in this area are susceptible to non cancer and cancer health risks from the consumption of all the studied vegetables. Screening of industrial effluent should be prioritized and enforced to avoid crop heavy metal bioaccumulation.

Keywords

Heavy metals, wastewater, vegetables, health risk indices

Introduction

Heavy metal contamination of food crops from industrial untreated wastewater is a serious problem and a reason for concern in Nigeria [1]. In the global scene however, approximately 10% of the world's crops are cultivated through wastewater irrigation [2], and approximately 200 million hectares of farmlands are irrigated annually with any kind of water that is readily available or easily accessible irrespective of whether it is treated, not treated or hygienically safe. Thus, often times untreated and contaminated wastewater is used for irrigation, especially during the dry season [3]. Even though some industrial wastewater has nutrient constituents that could improve soil fertility and subsequently crop yield [4], the high metal contents and its associated toxicity and hazards to humans could be life-threatening. The long-term implication of prolonged and continuous use of wastewater for irrigation of crops and the build-up of metals in soil and subsequent transfer along the ecological food chain has caused severe consequences to human health [5].

Continuous health risk assessment is therefore required to guarantee safety and to assist in the management and evaluation of soil, crops, and resource quality generally [1]. For the dietary exposure of heavy metal contamination to humans, it is important to consider a thorough health risk assessment which typically involves four different steps: hazard identification, exposure assessment, dose-response assessment, and risk characterization [6]. Two main criteria viz, carcinogenic and non-carcinogenic are typically taken into account in health risk assessment [6]. The former refers to the likelihood that a person will be exposed to carcinogenic pollutants that could cause cancer, while the latter describes the possibility that a person will be exposed to non-carcinogenic pollutants that could cause chronic illnesses or injuries to tissues. Evaluation models and techniques created by the US-EPA and IRIS are utilized to determine the dangers to human health that are both carcinogenic and non-carcinogenic.

The consumption of contaminated food crops with heavy metals is the main pathway through which heavy metals enter human tissue [7]. Most of the food crops produced in this region of our study area are irrigated with wastewater which contains heavy metals and are transported and distributed to other parts of the country without any form of screening [8]. There are some studies that found high concentrations of heavy metals above the regulatory limits in some food crops irrigated with wastewater in northern Nigeria [9]. Excessive uptake of these toxic metals in the human system could lead to severe detrimental impacts and even death, especially to the vulnerable children and infants [4].

Despite the alarming levels of toxic metals detected in some vegetables irrigated with wastewater and pesticides, there is paucity of information on the health risk to humans in both adults and children. Information from this study will be a remarkable contribution to heavy metal toxicity of crops and could provide baseline data on the carcinogenic and non-carcinogenic health risk associated with heavy metal levels in vegetables that are consumed daily. Most studies in this region focused on the assessment of concentrations of heavy metals in food crops, while the human health risks are usually not considered. This study will, therefore, aim at determining the potential human risk of developing cancer and non-carcinogenic risk from the consumption of some common vegetables irrigated with wastewater.

Materials and methods

Study area

The study area is Bassa, a region in Plateau State located at 10°04'55" N, 8°47'05" E (Figure 1). It is an area that has been known for mining activities for decades. The wastewater, therefore, is constantly discharged to water bodies from tin and coal industries in this region. This water is used by farmers for irrigation of crops during the dry season.

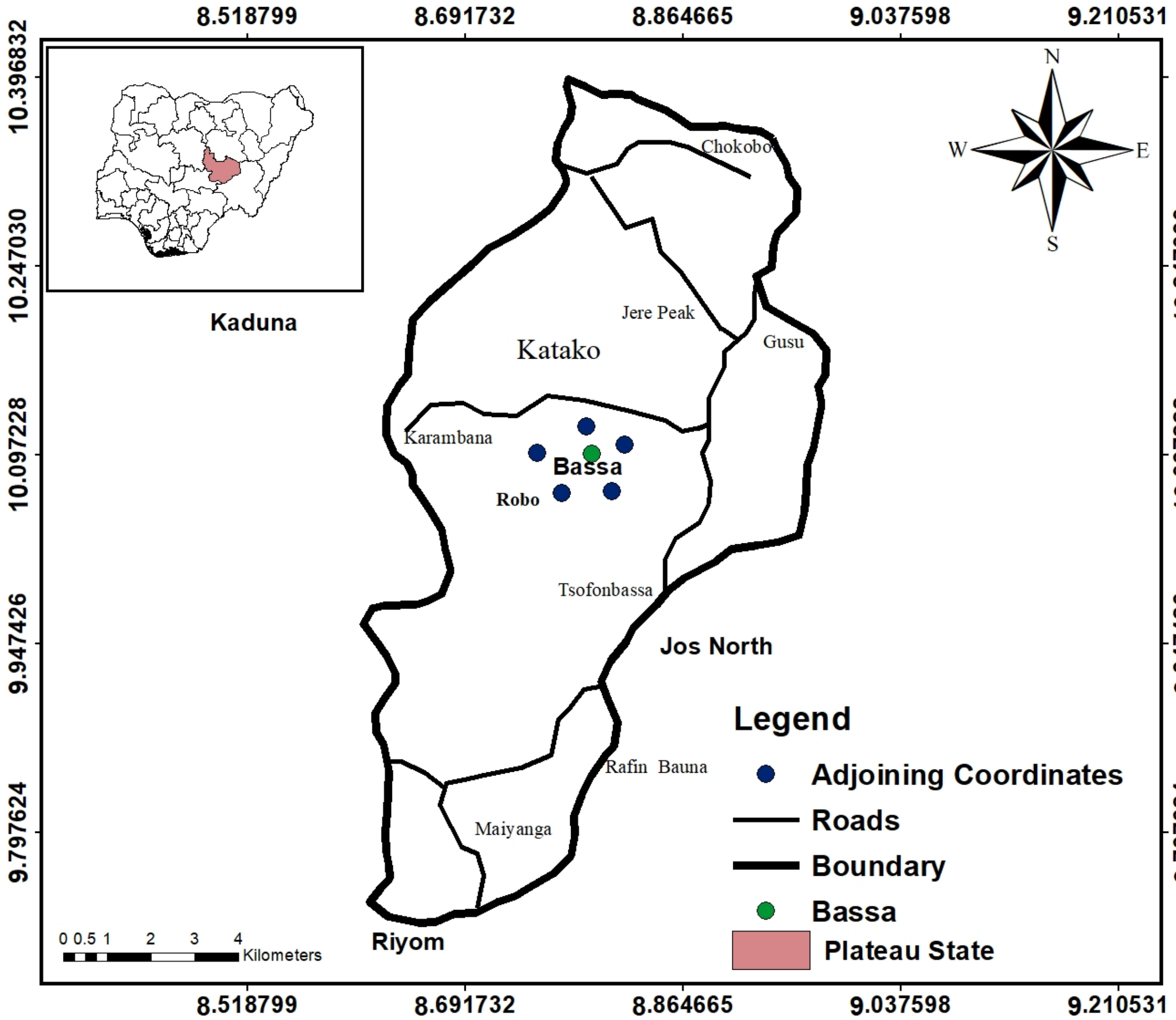

Figure 1. Map showing the sampling points in the study area

Sample collection

Random sampling technique was employed in the collection of eight vegetables namely; tomato, pepper, onion, carrot, spinach, lettuce, bell pepper, and cucumber. Samples of their edible parts were harvested from the farmlands in five replicates. Edible portion of each vegetable 20 g was taken and transferred into a clean brown paper envelope and transported to the Department of Ecology laboratory at Abubakar Tafawa Balewa University (ATBU) Bauchi, Nigeria.

Preparation of samples

The samples from each plant were sliced into tiny pieces and oven-dried at 80°C, and were mashed with a stainless steel blender and run through a 2 mm sieve. The resultant fine dry powder was stored at room temperature prior to analysis.

Heavy metal analysis

One gram of each plant sample was digested with a 15 mL combination of three acids [70% high purity Sigma-Aldrich (nitric acid) HNO_3, 65% (perchloric acid) $HClO_4$, and 70% (sulfuric acid) H_2SO_4 in a 5:1:1 ratio] in 50 mL conical flasks. The samples were heated at 80°C until they became clear. The resulting solution was filtered using Whatman filter paper No.40 and diluted to 50 mL with deionized water. The digested samples were analysed for Cr, Cu, Cd, Zn, and Pb using the atomic absorption spectrophotometer (AAS) Buck Scientific 210 GP as described by Zhong et al. [10]. The atomic absorption spectrometry instrumentation and condition of operation are shown in Table 1.

Table 1. Wavelength, detection limit, and limit of quantification

Heavy metal	Detection limit (LOD)	Limit of quantification (LQD)	Wavelength	Flame type
Cd	5.0 ppb	16.5 ppb	228.9 nm	Air/Ace thane
Pb	0.8 ppm	2.64 ppm	283.2 nm	Air/Ace thane
Cr	0.02 ppm	0.066 ppm	357.9 nm	Air/Ace thane
Cu	0.005 ppm	0.0165 ppm	324.7 nm	Air/Ace thane
Zn	0.05 ppm	0.165 ppm	213.9 nm	Air/Ace thane

Adapted from [8].

Quality control

All of the chemicals and reagents utilized were of analytical grade using a calibration curve created from a stock solution (1,000 ppm). The concentration of each metal was determined and a standard working solution of 100 ppm was then created using the serial dilution formula ($C_1V_1 = C_2V_2$). Each working standard received 1 milliliter of HNO_3, which was then diluted with deionized water to the appropriate volume. The absorbencies of the working standard solutions of each metal, which were made from standard solutions of the corresponding metals were determined.

The absorbance as a function of metal ion standard concentration was plotted to create a calibration curve for each metal ion concentration to be examined. By utilizing AAS (BUCK scientific model 210 GP) to read the absorbance and compare it to the corresponding standard calibration curve, the presence of metal ions in the sample was identified. Each sample had three replicates and blanks were run periodically to guarantee the analysis's quality. For Cu, Cr, Pb, Cd, and Zn, the corresponding detection limit (LOD) and limit of quantification (LQD) were presented in (Table 1). The estimated percentage of recovery falls between 75 and 120 percent were determined. To guarantee the quality of the analysis, duplicate determinations were performed on every sample and blanks.

Health risk assessment

Estimated daily intake of metal

The estimated daily intake (EDI) (mg/kg/day) of metals was computed using the formula below, which is outlined by Kumar et al. [11].

$$EDI = \frac{M \times K \times I}{W}$$

Where: W = average body weight; I = daily vegetable consumption; K = conversion factor; M = level of metals content in food crops (mg/kg) (US-EPA, 2024) [12]. Since the fresh weight of food crops was converted to dry weight, a conversion factor is thus used as 0.085 g [13].

The average adult body weight in Nigeria is estimated to be 60 kg by Hart et al. [6], while the average weight of children in Nigeria (6–12 years old) is estimated as 29.37 kg by Eze et al. [14]. The daily rate of food crop intake for adults and children in Nigeria is 0.086 kg/day [6].

Hazard quotient

The Hazard quotient (HQ) was determined using (US-EPA, 2024) [15].

Given as:

$$HQ = \frac{DIM}{RFD}$$

Where: DIM = daily minimum intake; RFD = risk-free dose.

The daily rate of human exposure that is not expected to have a substantial negative impact on health for a lifetime is calculated as the RFD. The values recorded for the heavy metals were: Cr = 1.5 mg/kg/bw/day, Cd = 0.001 mg/kg/bw/day, Pb = 0.004 mg/kg/bw/day, Cu = 0.04 mg/kg/bw/day, and Zn = 0.3 mg/kg/bw/day [12].

Hazard index

The hazard index (HI), which represents the potential harm to human health from intake of several heavy metals in the vegetables, was computed in accordance with US-EPA [12]. It is the total of all the HQs, as indicated by the equation below:

$$HI = \sum HQ = HQ_{Cd} + HQ_{Pb} + HQ_{Cr} + HQ_{Cu} + HQ_{Zn}$$

Target cancer risk

Target cancer risk (TCR) is the likelihood that an adult or child will get cancer at some point in their lifetime as a result of prolonged exposure to carcinogenic metals. TCR was calculated using the cancer potency slope factor (CPSF) equation [15, 16].

$$TCR = EDI \times CPSF$$

CPSF values were taken as Cr = 0.5 mg/kg/day and Pb = 0.0085 mg/kg/day as described by WHO [17].

Statistical analysis

Analysis of variance (ANOVA) was used to analyze the mean differences between the heavy metals in each plant using statistical software "R" 2014 version as described by Dytham [18] and Ayejoto and Egbueri [19].

Results

The concentrations of the metals in the vegetables are presented in Table 2. The concentration of Cd differed significantly at $p < 0.05$ in all the vegetables. The Cd concentrations ranged between 26.87 mg/kg (spinach) and 33.50 mg/kg (pepper) and exceeded WHO permissible limit in all the vegetables.

Table 2. Heavy metal concentrations in the edible parts of vegetables (mg/kg)

Name of sample	Botanical name	Hausa name	Heavy metals				
			Cd	Pb	Cr	Cu	Zn
Tomato	*Solanum lycopersicum*	Tumatur	$32.45 \pm 0.34^{de*}$	$10.90 \pm 1.49^{b*}$	$31.00 \pm 0.29^{c*}$	16.98 ± 0.45^{d}	2.22 ± 0.32^{ab}
Pepper	*Capsicum annuum*	Attarugu	$33.50 \pm 0.05^{f*}$	$10.40 \pm 0.83^{b*}$	$30.33 \pm 0.17^{bc*}$	12.38 ± 0.18^{b}	1.77 ± 0.25^{a}
Onion	*Allium cepa*	Albasa	$31.93 \pm 0.22^{d*}$	$10.70 \pm 0.97^{b*}$	$29.67 \pm 0.17^{bc*}$	10.60 ± 0.35^{a}	2.28 ± 0.54^{ab}
Carrot	*Daucus carota*	Karas	$28.62 \pm 0.44^{bc*}$	$6.02 \pm 0.80^{a*}$	$29.17 \pm 1.09^{b*}$	21.22 ± 0.42^{e}	2.22 ± 0.38^{ab}
Spinach	*Spinacia oleracea*	Alayyaho	$26.87 \pm 0.09^{a*}$	$4.17 \pm 1.14^{a*}$	$32.67 \pm 0.44^{d*}$	15.18 ± 0.10^{c}	3.42 ± 0.73^{b}
Lettuce	*Lactuca sativa*	Salad	$32.98 \pm 0.31^{ef*}$	$10.78 \pm 1.02^{b*}$	$38.67 \pm 0.44^{e*}$	24.38 ± 0.71^{f}	2.22 ± 0.07^{ab}
Bell pepper	*Capsicium cerasiforme*	Tattase	$28.92 \pm 0.34^{c*}$	$5.93 \pm 0.54^{a*}$	$27.00 \pm 0.29^{a*}$	17.48 ± 0.80^{d}	2.40 ± 0.48^{ab}
Cucumber	*Cucumis sativus*	Kokwanba	$27.98 \pm 0.32^{b*}$	$5.27 \pm 0.70^{a*}$	$27.17 \pm 0.44^{a*}$	17.78 ± 0.25^{d}	2.67 ± 0.48^{ab}
Safe limits[#]			0.20	0.30	2.30	40.00	60.00

[#] Source: WHO (2019) [17]. Mean values with * are above WHO limits; mean followed with different letters across the column are significant at $p < 0.05$

Pb concentrations in the vegetables ranged between 4.17 mg/kg (spinach) and 10.90 mg/kg (tomato) and all the samples exceeded WHO permissible limits.

The concentrations of Cr ranged between 27.00 mg/kg (bell pepper) and 38.67 mg/kg (lettuce) and exceeded WHO permissible limit in all the vegetables.

Cu concentrations ranged between 10.60 mg/kg (onion) and 24.38 mg/kg (lettuce) and were below WHO permissible limit in all the vegetables.

Zn concentrations ranged between 1.77 mg/kg (pepper) and 3.42 mg/kg (spinach) and were below WHO permissible limit.

EDI of metal and RFD

Table 3 shows the EDI of metals through the consumption of the vegetables under this study. The daily intake for adults (mg/kg/bw/day) varied from 0.039–0.048, 0.006–0.016, 0.039–0.055, 0.015–0.035, and 0.003–0.005 for Cd, Pb, Cr, Cu, and Zn respectively, while that of the children (mg/kg/bw/day) varied from 0.079–0.098, 0.012–0.032, 0.079–0.113, 0.031–0.071, and 0.005–0.010 for Cd, Pb, Cr, Cu, and Zn respectively. The study found that EDI of Cd and Pb in children and adults exceeds the RFD set by the US-EPA, while Cr and Zn do not exceed it. In addition, the EDI of children's Cu exceeded RFD, while the EDI of adults did not exceed.

Table 3. Estimated daily intake (EDI) of heavy metals through consumption of vegetables (mg/kg/bw/day)

Name of sample	Categories	Estimated daily intake				
		Cd	Pb	Cr	Cu	Zn
Spinach	Adults	0.039	0.006	0.047	0.022	0.005
	Children	0.079	0.012	0.096	0.044	0.010
Cucumber	Adults	0.040	0.008	0.039	0.025	0.004
	Children	0.082	0.015	0.080	0.052	0.006
Carrot	Adults	0.041	0.009	0.042	0.030	0.003
	Children	0.084	0.018	0.085	0.062	0.006
Bell pepper	Adults	0.041	0.009	0.039	0.025	0.003
	Children	0.085	0.017	0.079	0.051	0.007
Onion	Adults	0.046	0.015	0.043	0.015	0.003
	Children	0.094	0.031	0.087	0.031	0.007
Tomato	Adults	0.047	0.016	0.044	0.024	0.003
	Children	0.095	0.032	0.091	0.050	0.006
Lettuce	Adults	0.047	0.015	0.055	0.035	0.003
	Children	0.097	0.032	0.113	0.071	0.006
Pepper	Adults	0.048	0.015	0.043	0.018	0.003
	Children	0.098	0.030	0.089	0.036	0.005
RFD[#]		0.001	0.004	1.500	0.040	0.300

[#] Source: US-EPA, (2019) [12]. RFD: risk-free dose

HQ

The HQ and HI are presented in Table 4. The HQ for each of the metals in the vegetables was below the WHO tolerable limit of 1. The only exception was HQ for Cd which was above 1 in all the vegetables for both adults and children. The HQ for adults ranged between 3.273 and 4.081 (Cd), 0.126–0.332 (Pb), 0.002–0.003 (Cr), 0.032–0.074 (Cu), and 0.001–0.001 (Zn) while HQ values for children ranged from 6.686–8.337 (Cd), 0.259–0.678 (Pb), 0.004–0.006 (Cr), 0.066–0.152 (Cu), and 0.001–0.003 (Zn).

HI

The HI values recorded the lowest value in spinach and the highest value in pepper. HI ranged from 3.448 to 4.439 for adults and 7.048 to 9.068 for children in spinach and pepper respectively. The HI in all vegetables was above the WHO tolerable limit of 1.

TCR

The TCR is presented in Table 5. The values of Cr and Cd exceeded the maximum threshold level of 1×10^{-4} for both children and adults while TCR for Pb was below 1×10^{-4}.

Table 4. Values of hazard quotient (HQ) and hazard index (HI)

Name of sample	Categories	HQ					HI
		Cd	Pb	Cr	Cu	Zn	Cumulative
Spinach	Adults	3.273	0.126	0.002	0.046	0.001	3.448
	Children	6.686	0.259	0.005	0.094	0.003	7.048
Cucumber	Adults	3.409	0.160	0.002	0.054	0.001	3.627
	Children	6.964	0.327	0.005	0.111	0.002	7.409
Carrot	Adults	3.486	0.183	0.002	0.065	0.001	3.738
	Children	7.122	0.374	0.005	0.132	0.002	7.635
Bell pepper	Adults	3.523	0.181	0.002	0.053	0.001	3.760
	Children	7.194	0.369	0.004	0.109	0.002	7.678
Onion	Adults	3.891	0.326	0.002	0.032	0.001	4.252
	Children	7.947	0.665	0.005	0.066	0.002	8.686
Tomato	Adults	3.953	0.332	0.003	0.052	0.001	4.341
	Children	8.076	0.678	0.005	0.106	0.002	8.867
Lettuce	Adults	4.018	0.328	0.003	0.074	0.001	4.425
	Children	8.209	0.670	0.006	0.152	0.002	9.040
Pepper	Adults	4.081	0.317	0.002	0.038	0.001	4.439
	Children	8.337	0.647	0.005	0.077	0.001	9.068

HQ and HI ≥ 1: potential health risk

Table 5. Values of target cancer risk

Name of sample	Categories	Metals		
		Cr	Pb	Cd
Spinach	Adults	0.023411	5.08E–05	0.577633
	Children	0.047827	0.000104	1.180048
Cucumber	Adults	0.019469	6.42E–05	0.601642
	Children	0.039774	0.000131	1.229094
Carrot	Adults	0.020903	7.33E–05	0.615258
	Children	0.042702	0.000150	1.256912
Bell pepper	Adults	0.019350	7.23E–05	0.621708
	Children	0.039530	0.000148	1.270089
Onion	Adults	0.021261	0.000130	0.686567
	Children	0.043434	0.000266	1.402588
Tomato	Adults	0.022217	0.000133	0.697675
	Children	0.045386	0.000271	1.425281
Lettuce	Adults	0.027711	0.000131	0.709142
	Children	0.056611	0.000268	1.448706
Pepper	Adults	0.021739	0.000127	0.720250
	Children	0.044410	0.000259	1.471399

Discussion

This study shows a high accumulation of heavy metals in the edible parts of the vegetables which was linked to the industrial wastewater used for irrigation of crops. The mean concentrations of Cd, Pb, and Cr in the vegetables exceeded the permissible limits set by WHO [17]. This could be attributed to the use of industrial wastewater that is contaminated with heavy metals in Bassa province. The wastewater from the coal and tin mining industries is usually discharged to streams and locals use it for irrigation of crops. The bioaccumulation of these metals by the vegetables could pose potential human health risks. Carcinogenic metals such as Cd, Pb, and Cr recorded at high levels in the vegetables are a source of concern. These metals even at low levels have adverse effects on humans [20]. The threats to health risks could even go beyond

Bassa province since vegetables from this region are transported and sold in other regions of Nigeria. The consumption of metal-contaminated food crops is the main pathway into the human system and has been shown to cause several human health illnesses such as kidney and liver damage, blood pressure, and cardiovascular disease among others [21].

The highest concentration of Cd content was recorded in pepper. Pepper is one of the major spices that is used daily in all parts of Nigeria and the high Cd recorded should be a serious concern. There were, however, other studies that reported Cd levels in vegetables with varying concentrations. For example, in Zaria, Nigeria, Tanimu et al. [21] found 72 mg/kg in cabbage leaves irrigated with wastewater. This value was much higher than what was obtained in this study. In contrast, lower values of 1.76 mg/kg were reported in Pakistan [22]. In Bangladesh however, a much lower Cd (0.041 mg/kg) in some vegetables was reported [23]. Lower values of Cd in vegetables could be attributed to either the source of the water for irrigation which might have very low Cd concentration or perhaps a strict regulation and control of toxic metals by the government agency which might include treatment of any metal-contaminated water before discharge. Cr and Pb are among the carcinogenic metals, and long-term exposure could lead to the development of intestinal and nervous system cancers [1]. This study recorded high Cr and Pb levels in the vegetables which exceeded the WHO permissible limits [17]. There were other studies though that recorded lower values of Cr, Pb, and other metals in Nigeria [20, 21]. These lower values of metals in the vegetables were linked with lower metal contamination from the source of the water used for irrigation of crops. However, there were similar records of higher values of metal-contaminated vegetables in other parts of the developing countries. For example, 15.99 mg/kg concentrations of Cr were observed in spinach irrigated with wastewater in Pakistan [24]. The concentration of Zn in all the studied vegetables was generally very low with no health risk due to its values below the tolerable limit [16]. Heavy metal uptake in vegetables also depends on vegetable physiology, metal concentration in the soil, soil attributes and chemistry, and plant uptake mechanism [25]. There were reports of much higher Zn in other varieties of vegetables in Zaria [22, 23]. Cu concentrations in the vegetables do not pose any cancer risk due to their relatively lower values, unlike a previous study that reported higher values with potentially carcinogenic risk in Nigeria [21].

The EDI values of Cd, and Pb, for both the children and adult population had exceeded the oral RFD (the daily exposure of an individual to toxins or pollutants that can pose no appreciable hazard over a lifetime) and are likely to cause human health risks. The EDI for Cu exceeded the reference value in spinach, cucumber, carrot, tomato, lettuce, and bell pepper and thus put children at high hazard risk. There were other studies though that reported lower EDI values from the consumption of vegetables irrigated with industrial wastewater [23]. These lower values could be due to government's policy of regulation and treatment of effluents before discharge.

The HQ of Cd for both children and adults was found to be greater than the threshold value of 1. This is an indication of likelihood of potential human health risks. However, HQ values of Cd in children were several-fold higher compared to HQ values obtained through adult consumption. Thus, children will experience a greater risk of Cd contamination than adults. Similar studies reported HQ > 1 for Cd, Pb, Cr, and Cu in vegetables irrigated with wastewater [22, 24]. In Bangladesh, for example, HQ values greater than 1 were reported for children viz 2.720, 2.629, and 0.269 for Pb, Cd, and Cr, and 1.807, 1.203, and 1.746 for adults respectively [23].

The HI values for both adults and children populations were all > 1 and thus revealed severe cumulative health risks of Cd, Pb, Cr, Cu, and Zn. A greater than 1 HQ value of vegetables irrigated with wastewater in Pakistan was reported [22] and in Bangladesh for Pb and Cr [23].

This study revealed higher values of HI in children compared to that of adults. Thus, the children population in this region is most susceptible to the cumulative effect of heavy metals through the uptake of the studied vegetables. This risk could extend beyond this region since vegetables are transported from the local markets to other parts of Nigeria.

Based on the TCR values of this study, adults and children are susceptible to carcinogenic risks posed by Cd and Cr exposure from consumption of the vegetables. Similar TCR values of 9.3E–05 and 6.1E–05 for Cd and Pb were reported by [24, 25]. The TCR values for lead could be regarded as within the safe limits.

In conclusion, this study has found that both adults and children could be exposed to non cancer and cancer risks from the consumption of the studied vegetables that were irrigated with contaminated industrial wastewater in the Bassa region of Plateau State located in northern Nigeria. Regulation should be put in place to enforce compliance of treating industrial wastewater before discharge. This would drastically control and reduce metal contamination of water bodies in channels and streams and the eventual transfer of metals to food chain through irrigation. The need for effective and sustainable monitoring cannot be over emphasized.

Abbreviations

AAS: atomic absorption spectrophotometer

CPSF: cancer potency slope factor

EDI: estimated daily intake

HI: hazard index

HQ: hazard quotient

RFD: risk-free dose

TCR: target cancer risk

Declarations

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Author contributions

UB: Conceptualization, Project administration, Data curation, Formal analysis, Writing—original draft. AA: Conceptualization, Supervision, Writing—review & editing, Investigation. Both authors read and approved the manuscript.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publication

Not applicable.

Availability of data and materials

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