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HEALTH RISK ASSESSMENT OF HEAVY METAL LEVELS IN VEGETABLES GROWN AROUND WATER BODIES IN CHIKUN LGA, KADUNA STATE, NIGERIA

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ABSTRACT

Levels of some heavy metals (Ni, Fe, Cu, Pb and Zn) were determined in vegetables (tomato, moringa and spinach) grown near water bodies in Chikun LGA, Kaduna State, Nigeria. The vegetable samples were collected from three different locations: Karatudu, Ungwan Markus and Ungwan Zarmai. Heavy metals analysis was carried out using Atomic Absorption Spectrometry (AAS) and Human health risk factors were determined for the vegetable samples. The range of levels of heavy metals for tomato were observed to be BDL – 67.05 mg/kg for Fe; 18.05 – 22.85 mg/kg for Cu; and 10.23 – 26.02 mg/kg for Zn. Moringa was observed to be 43.05 – 258.15 mg/kg for Fe; 21.00 – 21.25 mg/kg for Cu; and 17.95 – 28.34 mg/kg for Zn. Spinach was found to be 596.45 – 1248.75 mg/kg for Fe; 19.70 – 24.40 mg/kg for Cu; and 25.04 – 147.51 mg/kg for Zn. Ni and Pb were below detection limit (BDL) for the vegetables except for spinach, having a Ni concentration of 1.95 mg/kg which was below WHO standard (2016). The target hazard quotient (THQ) for the vegetable samples were less than one, which implied non- carcinogenic risk except Karatudu spinach (KTS) which had a value of 1.66, implying possibility of adverse health effect. The hazard index (HI) for the samples were less than one, implying that consumers are not likely to face health risk with exception of Karatudu spinach (KTS) and Ungwan Markus spinach (UMS) which had values of 2.25 and 1.15 respectively.

Keywords: Health risk, Heavy metals, Water bodies, Concentration, Vegetables

INTRODUCTION

Nigeria is faced with the problem of inefficient management of man-made wastes, especially wastes generated by industries, deposited in the surrounding environment. Pollution is caused when a change in the physical, chemical or biological condition in the environment harmfully affect the quality of human life including other animals and plants [1].

Natural water bodies and hand-dug wells serve as the only sources of water to some communities in Chikun Local Government Area (LGA), in Kaduna State, Nigeria. Apart from improving water supply to the populace, the water bodies are used for domestic purposes, fishing and irrigation farming for the production of vegetables, rice and sugar cane. Water bodies of Karatudu, Ungwan Markus and Ungwan Zarmai, in this study receive large quantities of effluents from Kaduna Refining and Petrochemical Company (KRPC) which are released directly or indirectly into them [2].

To mitigate the problem of water shortage during the dry season, supplementary irrigation is provided by pumping water from nearby water bodies. Although, irrigation is useful for sustaining agricultural production in any locality, it is imperative that only good quality water is used because contaminated water affects both soil and crop qualities adversely. Irrigation water, irrespective of its source, contains some dissolved salts. It is the concentration and proportion of dissolved elements that determine the suitability of water for irrigation [3].

Heavy metals are commonly found naturally in foodstuffs, fruits and vegetables, and in commercially available multivitamin products. Heavy metals are non-biodegradable and persistent environmental contaminants which may be deposited on the surfaces and then adsorbed into the tissues of the vegetables. Plants take up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environment as well as from waste water irrigation and contaminated soils [4].

Tomato (*Solanum lycopersicum*), Moringa (*Moringa oleifera)* and Spinach (*Spinacia oleracea*) were assessed in this study since they were mostly grown and consumed by people living within Karatudu, Ungwan Markus and Ungwan Zarmai communities.

Research work was carried out by Mohammed and Folorunsho [5] on Heavy metals concentration in soil and *Amaranthus retroflexus* grown on irrigated farmlands in the Makera Area, Kaduna, Nigeria and the results obtained ranged from 0.001 to 0.002 mg/kg for Pb, 14.19 to 69.07 mg/kg for Zn, 3.04 to 8.65 mg/kg for Cu and 331.60 to 1839.00 mg/kg for Fe. Similarly, Lere *et al.* [6] carried out studies on Health risk assessment of heavy metals in irrigated fruits and vegetables cultivated in selected farms around Kaduna metropolis, Nigeria and obtained results ranging from 0.26 to 1.72 mg/kg for Pb, 2.75 to 7.91 mg/kg for Fe, 0.26 to 0.56 mg/kg for Cu and 0.10 to 1.29 mg/kg for Zn. Also, Adedokun *et al.* [7] in similar study on Potential human health risk assessment of heavy metals intake via consumption of some leafy vegetables obtained from four markets in Lagos metropolis, Nigeria, obtained results ranging from 4.21 to 20.80 mg/kg for Zn, 0.13 to 2.91 mg/kg for Ni and 2.34 to 14.08 mg/kg for Cu.

Research works have been carried out in communities like Rido, Juji, NNPC and Romi on the assessment of heavy metals while some communities have not been assessed. Due to this, carrying out analysis on vegetables grown around water bodies of Karatudu, Ungwan Markus and Ungwan Zarmai is important to know the level of contamination of the vegetables cultivated around these areas in order to provide information to relevant monitoring authorities so as to carry out control measures.

This research is aimed at assessing the health risk of heavy metals in vegetables grown around selected water bodies in Chikun LGA. The objectives are for the determination of heavy metals (Ni, Cu, Fe, Pb and Zn) and determination of human health risk factors through the assessment of target hazard quotients and hazard indices of the vegetable samples.

MATERIALS and METHODS

Study Area

Chikun LGA is located in the southern part of Kaduna State (Figure 1). Romi river, which lies within Longitude 10°25'35.3 N and Latitude: 7°20' 25.06E, is a major river in Chikun LGA. Romi River is a tributary of Kaduna River which is the largest water body flowing through Chikun and traverses Romi village and its environs (Rido, Juji, Karatudu, Goningora) crossing the Abuja road and eventually discharging into Kaduna River at Garko [8].

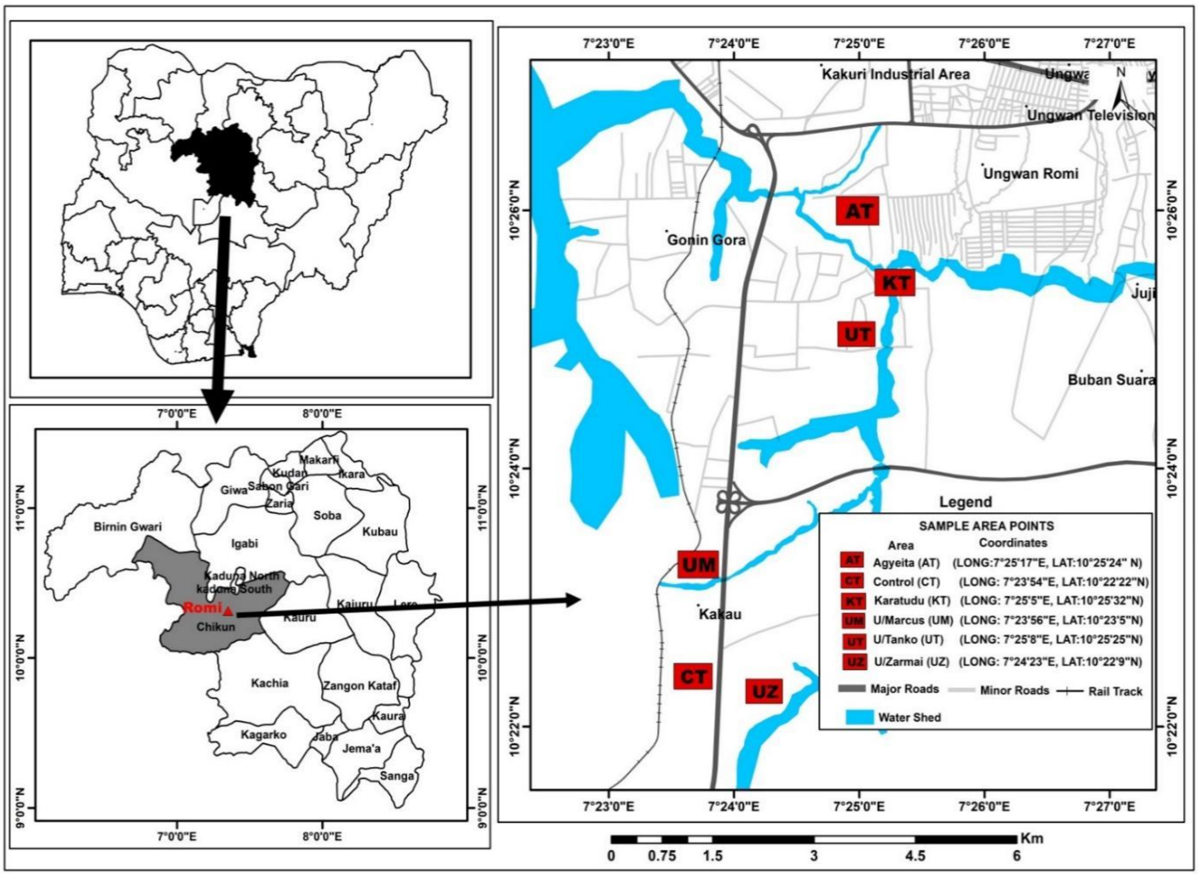

Figure 1: Map Showing Study Area and Sampling Points

Samples Collection

About 30 tomato fruits and 50 g each of leafy vegetables (whole plant of spinach and young moringa plants) were collected randomly from surrounding farms at three different locations: Karatudu, Ungwan Markus and Ungwan Zarmai, and sealed in clean polyethylene bags, labeled and transported to the laboratory for analysis [9]. Controls for each of the vegetables (tomatoes, moringa and spinach) were collected at 2 km away from the sampling points.

Samples Preparation

The tomatoes were rinsed thoroughly, sliced into small pieces and oven-dried at 105 ^{o}C for 48 hours. The dried samples were crushed into powder using a clean mortar and pestle and sieved through 2 mm mesh sieve. The sieved samples were then placed in a clean polythene bag before digestion [10]. The spinach and moringa were properly rinsed with tap water and then with distilled water to remove any attached soil particles. They were then cut into smaller pieces and placed in a large clean crucible and oven- dried at 100 ^{o}C for 48 hours. The dried samples were ground into fine particles using a clean mortar and pestle and sieved using 2 mm mesh size and then placed in a polythene bag prior to analysis [11].

Samples Digestion and Analysis

Exactly 0.5 g each of sieved vegetable samples was weighed into 100 cm^3 beaker, 5 cm^3 concentrated HNO_3 acid followed by 2 cm^3 $HClO_4$ acid were added and digested at low heat using hot plate set at 70 ^{o}C until the content was about 2 cm^3. The digested samples were allowed to cool and then filtered into a 50 cm^3 standard volumetric flask using Whatman no. 42 filter paper. The beaker was rinsed with small portions of distilled water and filtered into the flask and made up to the mark with distilled water [11]. The digested samples were taken to Ahmadu Bello University, Zaria, Multi- user laboratory for AAS analysis (Model AA FS 280). The analysis was carried out in triplicate for five metals; Ni, Fe, Cu, Pb and Zn.

Human Health Risk Assessment

The non-carcinogenic risk of heavy metals to humans was determined by assessing the estimated daily intake of metals (EDI) and target hazard quotient (THQ). The cumulative non-carcinogenic health hazard posed on exposure to a combination of all investigated heavy metals was assessed by determining hazard index (HI). As provided by Sharma *et al*. [12], EDI was evaluated using the following expression:

$$\mathrm{EDI} = \frac{C_{veg} \times \mathrm{IR}}{\mathrm{BW}} \quad (1)$$

$$\mathrm{THQ} = \frac{\mathrm{EDI} \times \mathrm{EF} \times \mathrm{ED}}{\mathrm{AT} \times \mathrm{RfD}} \times 10^{-3} \tag{2}$$

Where EDI = estimated daily intake of metals (mg/person/day)

C_{veg} = heavy metal concentration in vegetable leaves in mg/kg

IR = ingestion rate of vegetables (65 g/person/day)

BW = average body weight (70 kg)

EF = exposure frequency (365 days/year)

ED = exposure duration (70 years)

AT = average time of exposure (ED × 365 days)

RfD = oral reference dose (Pb = 0.0035, Cu = 0.40, Fe = 0.7, Ni = 0.02 & Zn = 0.3) according to USEPA [13].

THQ < 1 implies non-carcinogenic risk while THQ > 1 implies no carcinogenic risk.

The hazard index was estimated using the following:

$$\mathrm{HI} = \sum \mathrm{THQ} \tag{3}$$

HI < 1 implies that exposed population is safe while HI > 1 means they are not safe.

RESULTS AND DISCUSSION

From Table 1, the concentrations for Ni and Pb in tomatoes were all below detection limit. Concentrations of Fe were below detection limit for all sampling points except KTT which had a value of 67.05 mg/kg and was above the WHO [14] permissible limit of 48 mg/kg. The concentrations of Cu ranged from 18.05 mg/kg (CTT) to 22.85 mg/kg (UMT), which were below the permissible limit of 30 mg/kg. The concentrations of Zn ranged from 10.23 mg/kg (CTT) to 26.02 mg/kg (KTT) and were below the permissible limit of 60 mg/kg. The concentrations of Ni and Pb in moringa were all below detection limit. The concentrations of Fe ranged from 43.05 mg/kg to 275.40 mg/kg and were above the permissible limit of 48 mg/kg [14] across all the sampling points except CTM. Concentrations of Cu ranged from 16.40 mg/kg (CTM) to 21.25 mg/kg (UMM), which were below the permissible limit of 30 mg/kg. The concentrations of Zn ranged from 10.76 mg/kg (CTM) to 28.34 mg/kg (KTM) and were below the permissible limit of 60 mg/kg. The concentrations of Ni in spinach were below detection limit for all the sampling points except KTS which had a value of 1.95 mg/kg and was below the permissible limit of 10 mg/kg [14]. Concentrations of Fe ranged from 47.35 mg/kg (CTS) to 1248.75 mg/kg (KTS) and were above the permissible limit of 48 mg/kg for all sampling points except CTS. High levels of Fe in vegetables result in nutrients deficiency, leaves discoloration and stunted growth [15]. Concentrations of Cu ranged from 16.10 mg/kg to 24.40 mg/kg and were below the permissible limit of 30 mg/kg. The concentrations of Zn ranged from 10.58 mg/kg (CTS) to 147.51 mg/kg (KTS). These values were above the permissible limit of 60 mg/kg except CTS and UZS. High levels of Zn in plants may lead to alteration in structure of the chloroplast and reduce efficiency of photosynthetic energy conversion [15].

Table 1: Heavy Metal Concentration (mg/kg) for Vegetable Samples

Samples	Ni	Fe	Cu	Pb	Zn
KTT	BDL	67.05±1.91	21.15±0.35	BDL	26.02±5.88
UZT	BDL	BDL	20.90±0.85	BDL	11.40±0.05
UMT	BDL	BDL	22.85±0.35	BDL	21.71±0.13
CTT	BDL	BDL	18.05±0.78	BDL	10.23±0.07
KTM	BDL	258.15±91.15	19.65±0.64	BDL	28.34±0.03
UZM	BDL	250.25±5.45	21.00±1.70	BDL	17.95±1.48
UMM	BDL	275.40±142.13	21.25±0.50	BDL	20.47±2.10
CTM	BDL	43.05±15.91	16.40±1.00	BDL	10.76±0.13
KTS	1.95±0.07	1248.75±202.59	19.70±1.41	BDL	147.51±3.00
UZS	BDL	596.45±128.20	21.25±0.64	BDL	25.04±3.58
UMS	BDL	670.45±162.28	24.40±1.84	BDL	66.62±0.73
CTS	BDL	47.35±1.49	16.10±0.85	BDL	10.58±0.04
WHO [14]	10	48	30	2	60

Table 2: Target Hazard Quotient and Health Risk Index for Vegetables

Samples	THQ (Ni)	THQ (Fe)	THQ (Cu)	THQ (Pb)	THQ (Zn)	HRI
KTT	0.00	0.09	0.05	0.00	0.08	0.22
UZT	0.00	0.00	0.05	0.00	0.04	0.08
UMT	0.00	0.00	0.05	0.00	0.07	0.12
CTT	0.00	0.00	0.04	0.00	0.03	0.07
KTM	0.00	0.34	0.05	0.00	0.09	0.48
UZM	0.00	0.33	0.05	0.00	0.06	0.44
UMM	0.00	0.37	0.05	0.00	0.06	0.48

CTM	0.00	0.06	0.04	0.00	0.03	0.13
KTS	0.09	1.66	0.05	0.00	0.46	2.25
UZS	0.00	0.79	0.05	0.00	0.08	0.91
UMS	0.00	0.89	0.05	0.00	0.21	1.15
CTS	0.00	0.06	0.04	0.00	0.03	0.13

Table 2 reveals that the Target Hazard Quotient (THQ) was less than one for all vegetables except KTS which had a value of 1.66. This implies non- carcinogenic risk except sample KTS (for Fe) which was greater than one implying that there is a possibility of adverse health effect. The hazard risk indices (HRI) for tomatoes, moringa and spinach in this study were all less than one except for KTS and UMS having values of 2.25 and 1.15 respectively. This implies that consumers are likely to face health risk from consumption of spinach from Karatudu (KT) and Ungwan Markus (UM).

Table 3: ANOVA for Metal Concentration of Vegetables Samples

ANOVA						
		Sum of Squares	Df	Mean Square	F	Sig.
Nickel	Between Groups	215.793	11	19.618	2.687	0.052
	Within Groups	87.620	12	7.302		
	Total	303.413	23			
Copper	Between Groups	130.635	11	11.876	11.319	0.000
	Within Groups	12.590	12	1.049		
	Total	143.225	23			
Iron	Between Groups	3247341.543	11	295212.868	31.230	0.000
	Within Groups	113435.470	12	9452.956		
	Total	3360777.013	23			
Lead	Between Groups	3200.333	11	290.939	1.294	0.332
	Within Groups	2699.000	12	224.917		
	Total	5899.333	23			
Zinc	Between Groups	33740.223	11	3067.293	579.773	0.000
	Within Groups	63.486	12	5.291		
	Total	33803.709	23			

Table 3 shows that there is significant difference ($p < 0.05$) at 95 % confidence limit between the sampling points for all the metals of the analyzed vegetable samples except for Pb which had no significant difference across the sampling points. This implies that the samples have no common source(s) of pollution.

CONCLUSION

In this study, the objectives were achieved and the results revealed that vegetables obtained from Karatudu (KT), Ungwan Markus (UM) and Ungwan Zarmai (UZ) were contaminated with Fe and Zn across the sampling points. This might be as a result of excessive application of agrochemicals, impurities in fertilizers and effluents discharged from industries. The THQ values were less than one for all the vegetables, which implies that there is non-carcinogenic risk. The HRI values were all less than one, implying that consumers are not exposed to health risk. It was observed that spinach had higher concentrations than moringa and then tomatoes which agrees with the fact that leafy vegetables accumulate much higher content of heavy metals as compared to other vegetables. Therefore, regular assessment of heavy metals in soils, water and foodstuffs is essential to avoid extreme accumulation in the food chain. Monitoring authorities should also carry out control measures to prevent further pollution of these water bodies used for irrigation farming.

REFERENCES

[1] Ahalya, N., Ramachandra, T. V. & Kanamadi, R. D. (2003). Biosorption of Heavy Metals. *Research Journal of Chemistry and Environment*, 7(4), 71- 79.

[2] Zaky, S. K., Abubakar U. S., Ezra A. G., Abdulhameed, A. & Nayaya, A. J. (2019). Impacts on Urban Tropical River: Heavy Metal Pollution Perspective. *FUW Trends in Science & Technology Journal*, 4 (3), 744- 749.

[3] Yakubu, S., Adeniyi, S. A. & Folorunsho, J. O. (2017). Assessment of irrigation water quality sourced from River Galma in Zaria, Nigeria. *KIU Journal of Social Sciences*, 3 (2): 193- 199.

[4] Akan, J., Kolo, B., Yikala, B. & Ogugbuaja, V., (2013). Determination of some heavy metals in vegetable samples from Biu local government area, Borno State, North Eastern Nigeria. *Int. J. Environ. Monit. Anal*. 1, 40- 46.

[5] Mohammed, S. A. and Folorunsho, J. O., (2015). Heavy metals concentration in soil and *Amaranthus retroflexus* grown on irrigated farmlands in the Makera Area, Kaduna, Nigeria. *Journal of Geography and Regional Planning*, 8(8), 210- 217.

[6] Lere, B. K., Basira, I., Abdulkadir, S., Tahir, S. M., Ari H. A. & Ugya A. Y. (2021) Health risk assessment of heavy metals in irrigated fruits and vegetables cultivated in selected farms around Kaduna metropolis, Nigeria, *Egyptian Journal of Basic and Applied Sciences*, 8 (1), 317- 329.

[7] Adedokun, A. H., Njoku, K. L., Akinola, M. O., Adesuyi, A. A. and Jolaoso, A. O. (2016). Potential human health risk assessment of heavy metals intake via consumption of some leafy vegetables obtained from four markets in Lagos metropolis, Nigeria. J*ournal of Applied Sciences and Environmental Management*, 20 (3), 530– 539.

[8] Yunana M. A., Siaka S. & Simon, S. (2012). Effects of Refinery and Petrochemical Effluents on the Vegetation of Romi River Area of Kaduna State. *World Journal of Applied Science and Technology,* 4 (2) 179- 188.

[9] Okibe, F. G., Ekwumemgbo, P. A., Sallau M. S. & Abanka, O. C. (2010). Fluoride content of soil and vegetables from irrigation farms on the bank of river, Galma, Zaria, Nigeria. *Austr. Journal of Basic Applied Sci*ence, 4 (5), 779-784.

[10] Edogbo, B., Okolocha, E.,Maikai, B., Aluwong T. & Uchendu, C. (2020). Risk Analysis of Heavy Metal Contamination in Soil, Vegetables and Fish Around Challawa Area in Kano State, Nigeria. *Scientific African*, 7 (2020) e00281.

[11] Okpanachi, C.B., Agbaji, E. B. & Omenesa, H. Z. (2016). Assessment of selected heavy metal level in soil and maize (*Zea mays*) plant within the vicinity of auto mechanic workshops in Gwagwalada, Abuja, Nigeria. *International Journal of Plant & Soil Science*, 12 (2), 1-11.

[12] Sharma, S., Nagpal, A. K. & Kaur, I. (2018). Heavy Metal Contamination in Soil, Food Crops and Associated Health Risks for Residents of Ropar Wetland, Punjab, India and its Environs. *Food Chem*. 255, 15- 22. dio:10.1016/foodchem.2018.02.037.

[13] USEPA (2021). Regional Screening Levels (RSLs) - Generic Tables. Washington, DC, USA: United States Environmental Protection Agency.

[14] World Health Organization (2016). Guidelines for drinking water quality, 3rd Ed. World Health Organization, Geneva, Switzerland. pp. 688.

[15] Bonnet, M., Camares, O. & Veisseire, P. (2000). Effects of zinc and influence of *Acremonium lolii* on growth parameters, chlorophyll a fluorescence and antioxidant enzyme activities of ryegrass (*Loliumperenne* L. cvApollo). *Journal of Experimental Botany*, 51 (346), 945- 953.