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ASSESSMENT OF SOME HEAVY METALS IN SELECTED VEGETABLES GROWN IN TUDUN FULANI, UNGOGO, KANO - NIGERIA AND POTENTIAL RISK TO HUMAN HEALTH

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ABSTRACT

This research was aimed to assess the level of some heavy metals (Pb, Cd, Zn, Cu and Fe) in selected vegetables (spinach, cabbage, lettuce, onion, pepper, tomato and bitter leaf) grown in Tudun Fulani, Ungogo, Kano, Nigeria. Atomic absorption spectrophotometer was used to assess and evaluate the levels of these metals. The mean concentrations of the metals detected were in the range of 0.01 to 0.51; 0.07 to 0.2; 0.02 to 0.8; 0.04 to 1.8; and 0.25 to 2.11 mg/kg, for Pb, Cd, Zn, Cu and Fe respectively. Cd in pepper and Pb in bitter leaf were not detected as their concentrations were below detection limits of the machine. Cabbage had the highest mean concentration of lead (0.51 mg/kg), whereas lettuce has the least (0.01 mg/kg). In all the vegetables analyzed, with the exception of lettuce and bitter leaf, the concentrations of lead were greater than WHO/FAO recommended levels of lead in vegetables (0.03 mg/kg). The estimated daily intake of Cd, Zn, Cu and Fe through vegetables were below the maximum tolerable levels recommended by FAO/WHO and within the safety baseline levels for human consumption. The values obtained were comparable with those available in the literature.

Key words: Atomic Absorption Spectrophotometer, Heavy metals, Tudun Fulani and Vegetables.

INTRODUCTION

Vegetables are widely used as food or for cooking purpose and are very important in human diet because of presence of vitamins and minerals salts. They contain water, calcium, iron, sulphur and potash [1]. They also act as neutralizing agents for acidic substances forming during digestion [2]. Therefore, vegetables are very useful for the maintenance of health as a preventive treatment of various diseases [3].

The presence of heavy metals may have a negative influence on the quality of vegetables and human health. Vegetables are vital to the human diet, and in particular provide the well-known trace elements and heavy metals. Minor or trace elements are essential for good health if they come from an organic or plant source. In contrast, if they come from an inorganic or metallic source, they become toxic. The processes of plant growth depend on the cycle of nutrients including trace elements, from soil to plant [4]. Vegetables, especially leafy vegetables, accumulate higher amounts of heavy metals because they absorb these metals in their leaves.

The consumption of leafy vegetables in Kano is common. The people living in these areas consume substantial amount of leafy vegetables. Ungogo and Tudun Fulani in particular is an agricultural metropolitan area where vegetables are both cultivated and consumed.

The term "heavy metal" refers to any metallic element that has a relative density greater than 4 g/cm^3 [5]. Heavy metal pollution is one of the most serious environmental and human health risk problem associated with industrial progress. As a consequence of disastrous anthropogenic activities, the discharge of hazardous heavy metal poses devastating threat to environmental safety and subsequently leads to severe concerns on human health worldwide [6].

Heavy metals are among the major contaminants of food supply and may be considered the most important problem to our environment [7] that can reduce both the productivity of plants and endanger the safety of plant products as foods [8]. This problem is even getting more serious all over the world especially in developing countries. Heavy metals, in general, are not biodegradable, have long biological half-lives and have the potential for accumulation in the different body organs leading to undesirable side effects. Heavy metal contamination may occur due to factors including irrigation with contaminated water, the addition of fertilizers and metal-based pesticides, industrial emissions, transportation, harvesting process and storage [9].

Lead and cadmium are among the most abundant heavy metals and are particularly toxic. The excessive amount of these metals in food is associated with etiology of a number of diseases, especially with cardiovascular, kidney, nervous as well as bone diseases [10]. Lead is well known for its toxicity and adverse effects on human health. Absorption of ingested lead may constitute a serious risk to public health. Some chronic effects of lead poisoning are stomachache, heartburn, constipation and anemia [11].

Other metals such as copper and zinc are essential for important biochemical and physiological functions and necessary for maintaining good health throughout life [9].

Copper is necessary for body pigmentation in addition to iron, for the maintenance of a healthy central nervous system, for prevention of anemia, and is interrelated with the function of zinc and iron in the body [12]. Zinc is a component of a variety of enzymes, including the ribonucleic polymerases, alcohol dehydrogenase, carbonic anhydrase, and alkaline phosphatase in humans [13]. Deficiency of zinc can result from inadequate dietary intake, impaired absorption, excessive excretion or inherited defects in zinc metabolism [14] whereas copper deficiency is characterized by anemia, neutropenia and skeletal abnormalities [9].

Iron is an essential element for humans. It is a constituent of hemoglobin, myoglobin and a number of enzymes, and as much as 30% of the body iron is found in storage forms such as ferritin and hemosiderin, in the spleen, liver, and bone marrow, and a small amount is associated with the blood transport protein transferin. Iron deficiency results in anemia [15].

The objectives of this research are; to determine the concentration of some heavy metals and their potential risk to human health in commonly consumed vegetables using Atomic Absorption Spectrophotometer as well as to evaluate and compare the results obtained with those of various researchers in the literatures

EXPERIMENTAL

Study Area

Tudun Fulani ward is located in western part of Ungogo Local Government Area of Kano State, Nigeria, along Longitude: 8.48°, Latitude: 12.04°and Altitude: 493m. It borders Bachirawa ward to the North, Rijiyar Zaki to the South, to the East and West it share border with Tudun Bojuwa and Yammata cikin gari wards respectively, in Dala Local Government. Small scale gardens are situated in this ward. Most of the farmers have less access to clean water, they used either well water or untreated waste water for watering the vegetables.

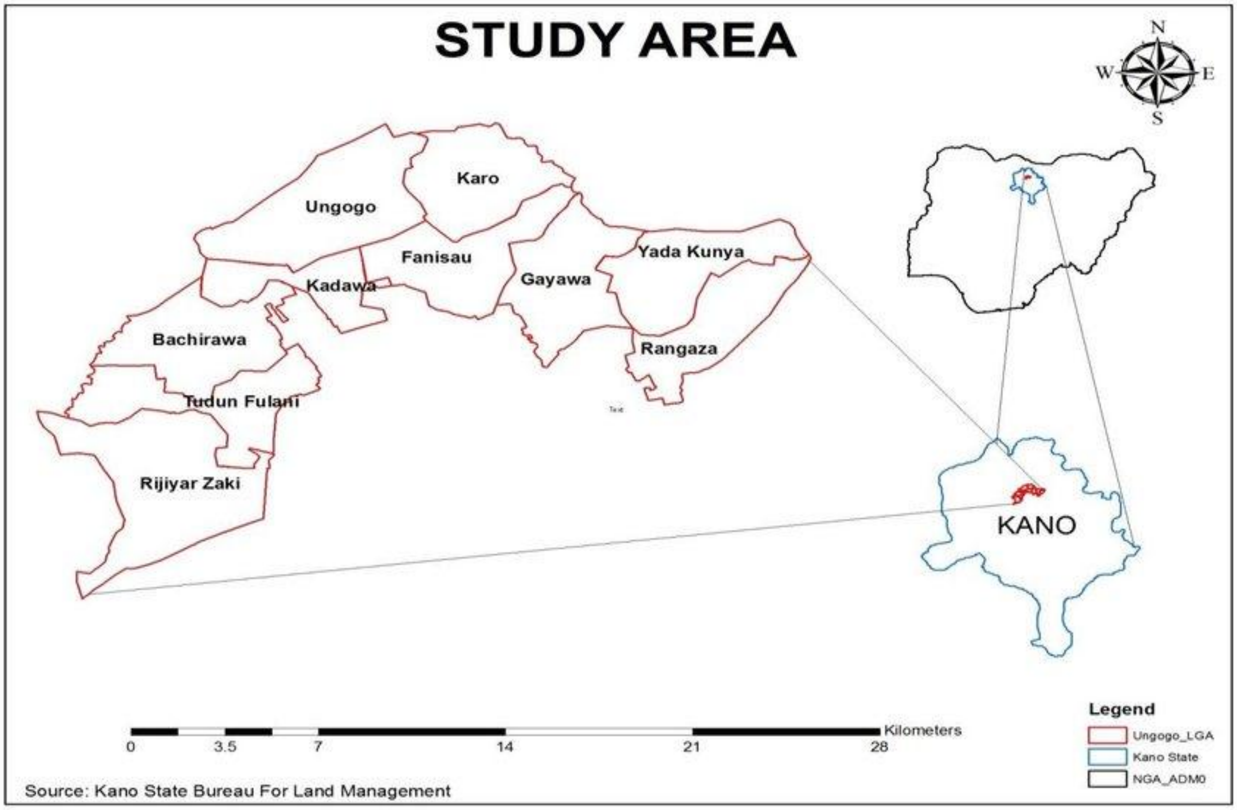

Figure 1: Map of Ungogo Local Government Area, Kano State [16]

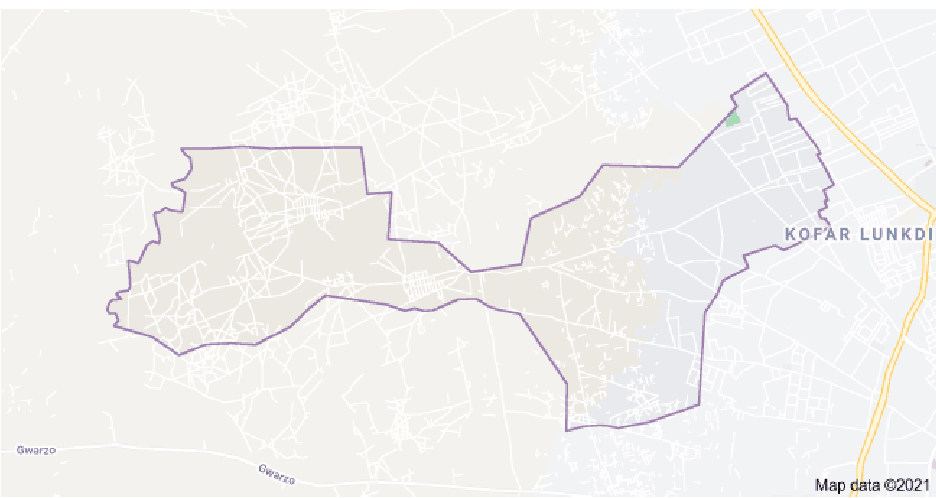

Figure 2: Map of Tudun Fulani, Ungogo Local Government Area [16]

Chemicals and Reagents

All the chemicals and reagents were of analytical grade and were purchased from Sigma Aldrich or Merck (Germany)

Materials

Perkin-Elmer Pinacle 900 H Atomic Absorption Spectrophotometer (AAS) was used for this analysis. Certified Atomic Absorption Spectroscopic standard stock solutions (1000 mg/L) of Pb, Cd, Zn, Cu and Fe were prepared using Lead (II) chloride ($PbCl_2$), Cadmium (II) chloride ($CdCl_2$), Zinc (II) chloride ($ZnCl_2$), Copper (II) chloride dihydrate ($CuCl_2.2H_2O$) and Iron (II) chloride hexahydrate ($FeCl_2.6H_2O$). Working standard solutions of 2, 4, 6, 8 and 10 mg/L were prepared by appropriate dilutions of the stock solution. Deionized water was used in the preparation of all the solutions.

Sampling

Samples of fresh vegetables were collected at different locations from production grounds of Tudun Fulani, near solid waste disposal sites of the area. Samples were collected randomly (Three samples for each vegetable) in order to estimate the total heavy metal content (Pb, Cd, Zn, Cu and Fe) in the samples.

Sample Preparation and Treatment

About 200 g each of five edible portions of vegetable samples were used for analysis while damaged or rotten samples were removed. The samples were stored in polythene bags until analysis under refrigerated condition (<10°C). The samples were thoroughly washed and then dried using oven dry method at 105 °C for 48 h to determine the moisture content [17]. Dried samples were powdered in a manual grinder and were used for heavy metal analysis. Powdered samples (3 g each) with three replicates for each vegetable were accurately weighed and placed in a porcelain crucible and two drops of concentrated nitric acid were added to the solid as an ashing aid. Dry ashing process was carried out in a muffle furnace by stepwise increase of temperature up to 550°C and then left to ash at this temperature for 6 h [18]. The ash was dissolved in 20 mL of 0.5 molar nitric acid and stirred very well. The ash suspension was filtered in a 100 mL plastic bottle with Whatman No 1 filter paper and the volume was made up to the mark with more deionized water.

Statistical Analysis

In the analysis of the data, IBM SPSS Statistics Software Version 23 was used and the results were expressed as Mean ± Standard deviation (SD). Parametric tests of one-way analysis of variance

(ANOVA), confidence level of 95% and significance level of 0.01 were considered in comparing the average concentration of the metals in the vegetable samples.

RESULTS AND DISCUSSION

All the results provided here are means of three replicates. The values of concentration (mg/kg) were given as mean ± SD.

Table 1: Percentage of moisture in the vegetable samples

Samples	Weight of Fresh Sample (g)	Weight of Dried Sample (g)	Weight of Water (g)	Percentage of Moisture
Spinach	200	56	144	72
Cabbage	200	42	158	79
Lettuce	200	46	154	77
Onion	200	40	160	80
Pepper	200	62	138	69
Tomato	200	28	172	86
Bitter leaf	200	54	146	73

Table 1 shows the percentage of moisture in different sample of vegetables in the range of 69 to 86 %. Tomato sample has the highest amount of water while pepper has the least as shown above.

Table 2: Mean Concentrations of the Heavy Metal ions in the Samples

Vegetables	Scientific Name	Mean Conc. (mg/kg) ± SD				
		Pb	Cd	Zn	Cu	Fe
Spinach	*Spinacia oleracea*	0.02 ±0.00	0.10 ±0.00	0.05 ±0.10	1.80 ±0.04	1.20 ±0.10
Cabbage	*Brassica oleracea*	0.51±0.10	0.17 ±0.20	0.09 ±0.02	1.20 ±0.01	2.11 ±0.02
Lettuce	*Lactuca sativa*	0.01 ±0.01	0.08 ± 0.1	0.02±0.00	0.55±0.11	0.71±0.10
Onion	*Allium cepa*	0.05 ±0.00	0.20 ±0.10	0.12 ±0.01	0.05±0.10	0.25±0.03
Pepper	*Capsicum sp*	0.09 ±0.00	ND ±0.00	0.07 ±0.11	0.30±0.12	0.90±0.01
Tomato	*Lycopersicum esculentum*	0.06 ±0.11	0.10 ±0.01	0.03±0.00	0.21±0.01	0.39±0.00
Bitter leaf	*Vernonia amygdalina*	ND±0.00	0.07 ±0.00	0.80±0.03	0.04±0.01	0.45±0.12
*FAO/WHO		0.03	0.30	6.0	4.0	42.5

Key: ND = Not Detected; *FAO/WHO Maximum permissible limits of the elements in vegetables (mg/kg) dry weight [19].

Table 2 shows the mean concentrations of the metals that were in the range of 0.01 to 0.51, 0.07 to 0.2, 0.02 to 0.8, 0.04 to 1.8 and 0.25 to 2.11 mg/kg for Pb, Cd, Zn, Cu and Fe respectively. The highest mean concentrations of Pb, Cd, Zn and Cu were detected in cabbage, onion, bitter leaf and spinach respectively, while the lowest mean concentrations of Cd and Cu were detected in bitter leaf, whereas the least concentration of Pb and Zn were detected in lettuce. In addition, cabbage was also found to have the highest mean concentration of Fe (2.11 mg/kg) and onions have the lowest (0.25 mg/kg). Cd in pepper and Pb in bitter leaf were not detected or their concentrations were below detection limits of the machine.

The levels of Pb were in the range of 0.01 to 0.51mg/kg in spinach, cabbage, onion, pepper and tomatoes. Cabbage has the highest concentration of lead (0.51 mg/kg), whereas lettuce has the least (0.01 mg/kg). In all the vegetables analyzed, with the exception of lettuce and bitter leaf, the concentrations of lead were greater than WHO/FAO recommended levels of contaminants in vegetables (0.03mg/kg). The results obtained here were in agreement with the results reported by David and Minati [20].

Heavy metals like Cd, Fe, Cu and Zn in the garden could be ascribed to agricultural materials that were added to the soil. The estimated daily intakes of Cd, Zn, Cu and Fe through vegetables were found to be below the maximum tolerable levels recommended by FAO/WHO and are within the safety baseline levels/tolerable limits for human consumption and the values obtained are comparable with those available in the literature. Pb is a contaminant that is known to emanate from traffic activities, such as fuel combustion, lubricating oil, tyre and brake wear, road abrasion, and road runoff, which in one way or the other can have negative effect on roadside grown vegetables. The higher levels of lead in the vegetables could also be attributed to the location of the garden, which is situated close to the hectic road traffic, Ungogo metal pots molding industry and refuse dump sites.

RECOMMENDATIONS AND CONCLUSIONS

The results revealed that the mean concentrations of Pb in the vegetables were higher than the set standards and all other heavy metals were within the safety baseline levels/tolerable limits for human consumption. No matter how low levels of heavy metals are present in vegetables, their presence is not desirable. Therefore, this study suggests the regular scrutiny and monitoring of the heavy metals present in vegetables, irrigating water and foodstuff to avoid extreme accumulation in the food chain and hence get away human health risks. Consequently, this study encourages environmentalists, administrators and public health workers to create public awareness to avoid the consumption of vegetables grown in contaminated areas, hence reducing potential health risks.

Conflicts of Interest

All the authors declared that, they have no conflicts of interest regarding the publication of this article.

REFERENCES

[1] Sobukola, O.P., Adeniran, O.M., Odedairo, A.A. & Kajihausa, O.E. (2010). Heavy metal level of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. *Afr.J. Food Sci*., 4(2), 389-393.

[2] Thompson, H.C. & Kelly, W.C. (1990). Vegetable Crops. 5th Edn., McGraw Hill Publishing Company Ltd., New Delhi.

[3] D' Mello, J.P.G. (2003). Food Safety: Contaminants and toxins. *CABI Publishing*, Wallinford, Oxon, UK, 480

[4] Mohamed, A.E., Rashed, M.N. & Mofty, A. (2003). Assessment of essential and toxic elements in some kinds of vegetables. *Ecotoxicol Environ* Saf 5 (2), 251–260

[5] Salhotra, P. & Rashmi, V. (2017). Determination of Heavy Metals Contamination in Some and Fruits Samples from the Market of Jagdalpur, Chhattisgarh State. *IOSR Journal of Applied Chemistry (IOSR-JAC)* Volume 10, Issue 5 (2), 110-113.DOI: 10.9790/5736-100502110113

[6] Fatma, A. A., Amira, M. H. & Moustafa, Y. E. (2020). Assessment of the heavy metal bioremediation efficiency of the novel marine lactic acid bacterium, *Lactobacillus plantarum Scientific Reports*10:314. DOI.org/10.1038/s41598-019-57210-3 11

[7] Zaidi, M.I., Asrar, A., Mansoor, A. & Farooqui, M.A. (2005). The heavy metal concentrations along roadside trees of Quetta and its effects on public health. *J Appl Sci* 5, 708–711. DOI: 10.3923/jas.2005.708.711.

[8] Zheljazkov, V.D., Craker, L.E. & Xing, B. (2006). Effects of Cd, Pb, and Cu on growth and essential oil contents in dill, peppermint and basil. *Environ Exp Bot* 58, 416-428. DOI:10.1016/j.envexpbot.2005.06.008

[9] Radwan, M.A. & Salama, A.K. (2006). Market basket survey for some heavy metals in Egyptian fruits and vegetables. *Food Chem Toxicol* 44: 1273–1278.DOI: 10.1016/j.fct.2006.02.004

[10] Steenland, K. & Boffetta, P. (2000). Lead and cancer in humans: where are we now? *Am J Ind Med* 38, 295 – 299

[11] Bolger, M., Carrington, C., Larsen, J.C. & Petersen, B. (2000). Safety evaluation of certain food additives and contaminants. Lead. WHO Food *Addit Ser* 44, 212–273

[12] Duran, A., Tuzen, M., & Soylak, M. (2007). Trace element levels in some dried fruit samples from Turkey. *Int J Food Sci Nutr.*, 59, 581 - 589. doi.org/10.1080/13561820701507910

[13] Goldhaber, S.B (2003). Trace element risk assessment: essentiality vs toxicity. *Regul Toxicol Pharmacol* 38, 232 - 242. doi: 10.1016/s0273-2300(02)00020-x.

[14] Colak, H., Soylak, M. & Turkoglu, O. (2005). Determination of trace metal content of various herbal and fruit teas produced and marketed in Turkey. *J Trace Elem Electrolytes Health Dis* 22, 192 - 195.DOI:10.5414/TEP22192

[15] Neriman, B., Cevdet, N. & Pelin, G. E. (2010). Heavy metal levels in leafy vegetables and some selected fruits. *J. Verbr. Lebensm* 5, 421 - 428. DOI 10.1007/s00003-010-0594-y

[16] Kano State Bureau for Land Management, 2021.

[17] AOAC (1990). Official Method of Analysis. Association of Official Analytical Chemists, Arlington, USA.

[18] Ray, L., Debopam, B., Himadri, B., Sibabrata, M. Anju, Pal & Debabrata, B. (2010). Heavy metal contamination in fruits and vegetables in two districts of West Bengal, India. *EJEAFChe,* 9 (9), 1423-1432.

[19] WHO (2013). Tech. Rep., “Guidelines for the safe use of waste water and food stuff”. Report of the joint WHO/FAO Volume 2 No. 1, World Health Organization (WHO) and Food and Agriculture Organization (FAO), Geneva, Switzerland, 2013.

[20] David, S. & Minati S. K. (2018). Levels and Health Risk Assessment of Heavy Metals in Soil, Water, and Vegetables of Dar-es Salaam, Tanzania, *Hindawi Journal of Chemistry* doi.org/10.1155/2018 /1402674.