DETERMINATION OF HEAVY METALS CONCENTRATION IN SOME SELECTED VEGETABLES FROM MAMUDO, POTISKUM LOCAL GOVERNMENT AREA, YOBE STATE

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ABSTRACT

Soil is a vital environmental, ecological and agricultural resource that has to be protected from further degradation as an adequate supply of healthy food is needed for the world's increasing population. Heavy metals' accumulation in the soil is of great concern in agricultural production due to the adverse effects on food quality, crop growth and environmental health. The concentration of heavy metals [Zinc (Zn), Iron (Fe), Lead (Pb), Copper (Cu), Cadmium (Cd) and Chromium (Cr)] in vegetables (Tomato fruit and Spinach leaves) and soils (Tomato and Spinach soils) were collected from different farmlands in Mamudo, Potiskum L.G.A of Yobe State and analyzed using Atomic Absorption Spectrometer (AAS). The results revealed all the heavy metals were detected in all the samples with Zn (7.2), Fe (7.5), Pb (4.0), Cu (113.9), Cd (29.1), Cr (4.7) mg/kg respectively for the tomatoes samples and Zn (7.1), Fe (18.3), Pb (21.8), Cu (95.7), Cd (50.8), and Cr (2.7) mg/kg respectively for the spinach. The concentration of the heavy metals were within the normal range World Health Organization (WHO) and Food and Agricultural Organization (FAO) safe limits of 20 – 100, 400 – 500 and 0.5 – 30 for Zn, Fe and Pb respectively in plants samples. But the concentration of the heavy metals were above the normal range WHO/FAO safe limits of $2.5 < 2.4$ and $< 0.1 – 1$ for Cu, Cd, and Cr respectively in plants samples. The high concentration level of Cu, Cd and Cr could be attributed to the high level of metal work, vehicular emissions, addition of fertilizers, pesticides, herbicides and other chemicals to the soil to enhance the agricultural crops. Therefore, the vegetables samples are not safe for consumption with regards to Cu, Cd and Cr.

Key words: Heavy metals, Soil, Vegetables, Yobe State, Absorption.

INTRODUCTION

Toxicity in the environment has been on the increase due to heavy metals accumulation from human and anthropogenic factors. Naturally, heavy metals are released from soil debris blown by wind, forest fires, volcanic eruptions, biogenic processes, and marine salt [1]. Soil is a vital environmental, ecological and agricultural resource that has to be protected from further degradation as an adequate supply of healthy food is needed for the world's increasing population [2]. Heavy metals' accumulation in the soil is of great

ISSN 0795 - 22066

concern in agricultural production due to the adverse effects on food quality, crop growth and environmental health [3, 4]. Contamination of soils by heavy metals causes serious environmental problem, particularly in agricultural production system with significant implications on human health [5, 6]. These heavy metals are not biodegradable, with long biological half-lives, toxic in nature and the accumulation of these heavy metals with time produces reactive oxygen species that can cause oxidative stress, leading to the production of various diseases [7] such as cardiovascular, renal, neurological, bone diseases, brain damage, mental retardation, cerebral palsy, lung cancer, gastrointestinal abnormalities, darmatitis and even death of unborn fetus [8, 9]. Metals usually found as contaminants in vegetables include: Arsenic (As), Cadmium (Cd) and Lead (Pb), they metals pose as significant health risk to humans, particularly in elevated concentrations above the very low body requirements [10, 1].

Vegetables are essential for human nutrition, particularly as sources of vitamin C, folic acid, minerals, niacin, thiamine, pyridoxine and dietary fiber, their biochemical role and their anti-oxidative effects [11]. Vegetables absorb metals from contaminated soils, besides deposits on the parts of the vegetables exposed to polluted air [12], and since vegetables are at the bottom of the food chain subsequently transferred along the food chain via consumption [13, 14]. Therefore, monitoring the concentration of heavy metals becomes important in order to be aware of the level of their toxicity and avoid unnecessary exposure. Hence, the need to assess the levels of heavy metals in frequently consumed vegetables, (tomato fruits and spinach leaves) and their supporting soils grown in Mamudo, Potiskum Local Government area of Yobe for safety assessment of the environment and human health.

MATERIALS AND METHODS

Collection of plant sample

Samples collected were tomato fruits, spinach leaves and their supporting soils obtained from Mamudo and transferred down to the laboratory. The samples were collected randomly from different angles in two farmlands; samples from each farmland were mixed to form a composite sample, the soil samples were sampled at 15 cm depth rooting zone. Potiskum is a Local Government area in Yobe State, Nigeria, on the A3 highway at 11°43′ N 11°04′ E. It had an area of 559 square kilometers (216 sq mi) with a population of 205,876 at the 2006 census and the postal code of the area is 631. Mamudo is

ISSN 0795 - 22066

a town in Potiskum local government area of Yobe state and the town is 5 km from the headquarter Potiskum and 100 km from the state capital Damaturu.

Preparation of Samples

The tomato and spinach samples were washed thoroughly with distilled water to remove soil particles and dust. The samples were cut into small pieces, air dried, grounded into fine powder with a mortar and pestle and finally sieved. While the soil samples were air dried crushed with a mortar and pestle, and sieved. These samples were then stored in plastic bags and labeled as: Tomato fruit (TF); Spinach leaves (SL); Tomato Soil (TS); and Spinach Soil (SS) for further use.

Digestion of Soil Samples

The digestion of soil samples were carried out as reported by [15]. One gram (1 g) each of the soil samples were digested with nitric acid, hydrogen chloride and perchloric acid in the ratio of 1:3:1 at 90 °C, while plant samples were digested with nitric acid and hydrochloric acid in the ratio of 1:3 at 90°C, until white fumes were observed and the volume reduced to almost $^{1}/_{3}$ of the initial volume during which a clear solution was observed. The digests were filtered through filter paper (Whattman No. 1) and diluted with distilled water to 100 cm^3 in volumetric flasks. The resulting solutions were transferred into clean sterile containers for analysis of heavy metals using Winckm AA320N Atomic Absorption Spectrophotometer.

RESULT AND DISCUSSION

Samples of vegetables (Tomato fruit and Spinach leaves) and soils (Tomato and Spinach soils) were collected from different farmlands and analyzed for heavy metals (zinc, iron, lead, cadmium, copper and chromium) using Atomic Absorption Spectrometer and the results as shown in Tables 1. It was observed that the order of concentration found in all the samples is Cu > Cd > Pb > Fe > Zn > Cr as shown on Fig 1.

ISSN 0795 - 22066

Table 1: Mean Concentrations (mg/kg) of Heavy Metals in the Samples

Samples	Metals (mg/kg)					
	Pb	Zn	Cd	Cr	Cu	Fe
Tomato fruits	4.00	7.20	29.10	4.70	113.90	7.50
Spinach leaves	21.80	7.10	50.80	2.70	95.70	18.30
Tomato Soil	6.90	2.50	28.00	4.30	36.80	17.20
Spinach Soil	20.40	8.60	56.20	3.50	90.90	11.20

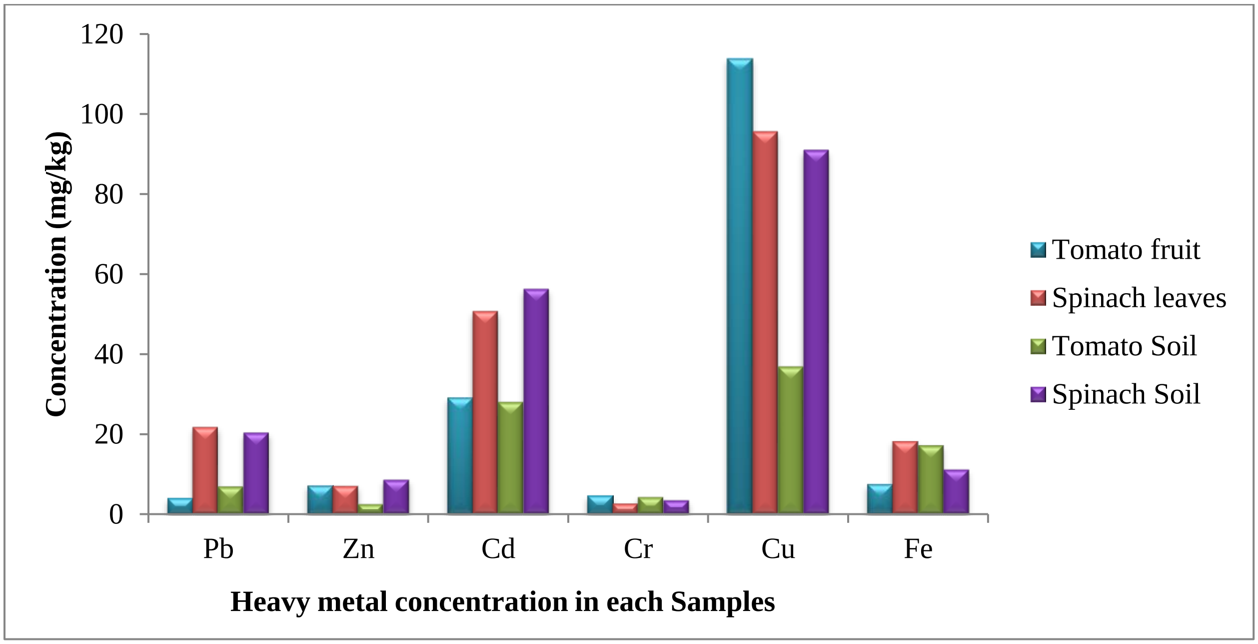

Fig 1: Chart representing Concentrations of Metal in the Samples

Comparing the various concentrations of the heavy metals within each sample with that of the permissible range given by [16, 17] (Table 2) it was observed that zinc, iron and lead were found to be within the permissible normal concentration range set by [16, 17]. While copper, cadmium and chromium were found to be present in higher concentration range, above the permissible normal concentration range, this is with possible risk of overexposure.

Zinc is an essential nutrient in human and animals having physiological functions involved in numerous enzymatic reactions

ISSN 0795 - 22066

[18], its deficiency has been suggested to result in humoral and cell-mediated immunity, dermatitis, anorexia, retardation in growth, poor wound healing, hypogonadism with impaired reproductive capacity, impaired immune function and depressed mental function, hence increasing the susceptibility to infection [19, 20]. Iron is an important micronutrient that is responsible for many major biological functions such as transporting oxygen within the iron-containing hemoglobin complex, cellular proliferation etc [21], its deficiency causes symptoms such as anemia, reduced resistance to infection, reduced work productivity, weakness, fatigue, inability to regulate body temperature and eating pica [22]. Lead is considered highly hazardous for plants, animals, microorganisms and its main sources contamination are mines, fuel combustion and sewage sludge [23]. Exposure to lead causes acute toxicity even at trace levels and can adversely affect the central and peripheral nervous system [24]. Since the amount of zinc, iron and lead found in the samples fall below the national and international guidelines for metals in food and vegetables, it therefore, implies that the vegetables samples are suitable for consumption.

Copper concentration levels in the plant samples exceeded the normal and toxic concentration level for copper given by national and international guidelines for metals in food and vegetables (Table 2). Copper is an essential metal for human, animals and plants, but it is required in trace amount due to its toxicity, especially towards neurodegenerative disease [25, 18]. Although copper homeostasis plays an important role in the prevention of copper toxicity, excessive exposure can result in adverse health effects including liver and kidney damage, anaemia and immunotoxicity [26, 27]. All the samples exhibited a very high concentration of cadmium compared to its < 2.4 mg/kg and chromium < 0.1 - 1 mg/kg given by the national and international guidelines for metals in food and vegetables permissible limit recommend by [16, 17] (Table 2). The high concentration of cadmium in the samples may be as a result of the use of pesticides and herbicides in agriculture [28]. Cadmium is known to be an established carcinogen [18], extremely toxic to human, in particular adversely affecting kidneys and bones [29, 9]. Since the amount of copper, cadmium and chromium found in all the samples exceeds the national and international guidelines for metals in food and vegetables, the vegetable samples are

ISSN 0795 - 22066

therefore not suitable for human and animal consumption.

Table 2: Mean Concentrations (mg/kg) and Standards for Normal and Toxic Concentrations Required for Heavy Metals in the Samples

Samples				Metals	Normal	Toxic	FAO/WHO
TF	**SL**	**TS**	**SS**	**(mg/kg)**	**conc.**	**conc.**	**STD Range**
4.00	21.80	6.90	20.40	Pb	1 - 5	20	0.50 – 30
7.20	7.10	2.50	8.60	Zn	15 - 15	200	20 – 100
29.10	50.80	28.00	56.20	Cd	-	-	< 2.4
4.70	2.70	4.30	3.50	Cr	< 0.1 - 1	2	< 0.1 – 1
113.90	95.70	36.80	90.90	Cu	3 - 15	20	2.5
7.50	18.30	17.20	11.20	Fe	50 - 25	>500	400 – 500

Key: TF = Tomato fruit; **SL** = Spinach leaves; **TS** = Tomato Soil; **SS** = Spinach Soil; **Conc.** = Concentration; STD = Standard; **WHO** = World Health Organization and **FAO** = Food and Agricultural Organization

CONCLUSION

The results obtained showed that all the selected heavy metals analyzed were detected in all the samples. Zinc, iron and lead were found to be within normal concentration range set by WHO and therefore the vegetables samples are safe for consumption; while copper, cadmium and chromium were found to be present in a higher concentration, above the normal concentration range which could be due illegal dumping of refuse, agrochemicals and other substances into the environment or improper use of fertilizers, pesticides and animal waste since there was no industry near the farmlands. Therefore, the vegetables samples are not safe for consumption with regard to copper, cadmium and chromium.

REFERENCES

[1] Madiha, Z., Rashid, A., Ayesha, A., Yasir, S., Liaqat, A., Mahpara, F., Khalid, A. K., and Shuangfei, L. (2022). Health and environmental effects of heavy metals. *Journal of King Saud University-Science*, *34*(1), 1-8.

[2] Bassey, F. I., Iwegbue, C. M. A., Obi-Iyeke, G. E., Tesi G. O., Rotu, A. R., Gobe, O. A., and Tsafe, A. I. (2014).

ISSN 0795 - 22066

Heavy Metals in Soils and Tomatoes Grown in Urban Fringe Environment in Asaba, Delta State, Nigeria. *Nigerian Journal of Basic and Applied Science* 22(1&2): 27-31.

[3] Islam, E., Yang, X., He, Z. and Mahmood, Q. (2007). Assessing potential dietary toxicity of heavy metals in selected vegetables and food crops. *Journal of Zhejiang University Science B*, 8(1): 1-13.

[4] Zwolak, A., Sarzyńska, M., Szpyrka, E., and Stawarczyk, K. (2019). Sources of soil pollution by heavy metals and their accumulation in vegetables: A review. *Water, air, & soil pollution*, *230*(7), 1-9.

[5] Kachenko, A. G. and Singh, B. (2006). Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. *Water Air Soil Pollution* 169:101-123.

[6] Moore, F., Shakeri A., and Modabberi, S. (2009). Heavy metal contamination and distribution in the Shiraz industrial complex zone soil, South Shiraz, Iran. *World Applied Science Journal*, 6: 413-425.

[7] Fu, Z., and Xi, S. (2020). The effects of heavy metals on human metabolism. *Toxicology mechanisms and methods*, *30*(3), 167-176.

[8] Dungchai, W., Siangproh, W., Lin, J. M., Chailapakul, O., Lin, S., & Ying, X. (2007). Development of a Sensitive Micro-magnetic Chemiluminescence Enzyme immunoassay for the Determination of Carcinoembryonic Antigen. *Analytical and Bioanalytical Chemistry*, *387*(6), 1965-1971.

[9] Engwa, G. A., Ferdinand, P. U., Nwalo, F. N., and Unachukwu, M. N. (2019). Mechanism and health effects of heavy metal toxicity in humans. *Poisoning in the modern world-new tricks for an old dog*, *10*, 70-90.

[10] Dolma, T., and Cupta, A. J. (2008). Character Association and Path Coefficient Analysis in Lettuce (*Lactuca sativa L.*) Genotypes under Kashmir Conditions. *Vegetable Science*, *35*, 185-189.

[11] Ülger, T. G., Songur, A. N., Çırak, O., and Çakıroğlu, F. P. (2018). Role of vegetables in human nutrition and disease prevention. *Veg. Importance Qual. Veg. Hum. Health*, 7-32.

[12] Haiyan, W., and Stuanes, A. O. (2003). Heavy metal pollution in air-water-soil-plant. Water Air Soil Pollut.; 147:79–107.

[13] Intawongse, M., and Dean, J. R. (2006). Uptake of heavy metals by vegetable plants grown on contaminated soil and their bioavailability in the human gastrointestinal tract. *Food additives and contaminants*, *23*(1), 36-48.

[14] Singh, J., and Kalamdhad, A. S. (2011). Effects of heavy metals on soil, plants, human health and aquatic life. *Int J Res Chem Environ*, *1*(2), 15-21.

[15] APHA. American public health Association (2005). Standard method for the examination of water and wastewater 16th Ed. Pp75-86.

[16] WHO/FAO, (2007). Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 13th Session. Report of the Thirty Eight Session of the Codex Committee on

ISSN 0795 - 22066

Food Hygiene. Houston, United States of America, ALINORM.

[17] WHO/FAO, Codex Alimentarius Commission (2001). Food Additives and Contaminants. Joint FAO/WHO Food Standards programme, ALINORM 01/12A:1-289.

[18] Filippini, T., Cilloni, S., Malavolti, M., Violi, F., Malagoli, C., Tesauro, M., Bottecchi, I., Ferrari, A., Vescovi, L., and Vinceti, M. (2018). *Dietary intake of cadmium, chromium, copper, manganese, selenium and zinc in a Northern Italy community. Journal of Trace Elements in Medicine and Biology: Organ of the Society for Minerals and Trace Elements (GMS)*, *50*, 508-517.

[19] Prasad, A. S., and Bao, B. (2019). Molecular mechanisms of zinc as a pro-antioxidant mediator: clinical therapeutic implications. *Antioxidants*, *8*(6), 164.

[20] Chasapis, C. T., Ntoupa, P. S. A., Spiliopoulou, C. A., and Stefanidou, M. E. (2020). Recent aspects of the effects of zinc on human health. *Archives of toxicology*, *94*(5), 1443-1460.

[21] Phipps, O., Brookes, M. J., and Al-Hassi, H. O. (2021). Iron deficiency, immunology, and colorectal cancer. *Nutrition Reviews*, *79*(1), 88-97.

[22] Neidlein, S., Wirth, R., and Pourhassan, M. (2021). Iron deficiency, fatigue and muscle strength and function in older hospitalized patients. *European Journal of Clinical Nutrition*, *75*(3), 456-463.

[23] Ahmed, R., Yamin, T., Ansari, M. S., and Hasany, S. M. (2006). Sorption behaviour of lead (II) ions from aqueous solution onto Haro river sand. *Adsorption Science & Technology*, *24*(6), 475-486.

[24] Bellinger, D. C., Stiles, K. M., and Needleman, H. L. (1992). Low-level lead exposure, intelligence and academic achievement: a long-term follow-up study. *Pediatrics*, *90*(6), 855-861.

[25] Shao, W. Z., Ivanov, V. V., Zhen, L., Cui, Y. S., and Wang, Y. (2004). A study on graphitization of diamond in copper–diamond composite materials. *Materials letters*, *58*(1-2), 146-149.

[26] ATSDR (2007). Toxicology profile for Lead. Atlanta, Georgia, United States. US Department of Health and Human Services. *Agency for Toxic Substances and Disease Registry*. 1-582.

[27] Shabbir, Z., Sardar, A., Shabbir, A., Abbas, G., Shamshad, S., Khalid, S., Murtaza, G. M., Dumat, C., and Shahid, M. (2020). Copper uptake, essentiality, toxicity, detoxification and risk assessment in soil-plant environment. *Chemosphere*, *259*, 127436.

[28] Jones, L. H. P. and Jarvis, S. C. (1981). The fate of heavy metals, in The Chemistry of Soil Processes, D. J. Green and M. H. B. Hayes, Eds., John Wiley and Sons, New York, p. 593.

[29] Alloway, B. J. (1995). Heavy Metals in Soils, (2nd Ed). Blackie Academic and Professional, London, UK. 102:216-218.

ISSN 0795 - 22066