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Health Risk Assessment of Lead, Cobalt and Nickel Intake Due to Consumption of Tomato (*Lycopersicon esculentum*) and Onion (*Allium cepa l.*) from the Bank of Komadugu River in Gashua, Yobe State, Nigeria

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Abstract: *Heavy metal contamination of edible parts of vegetables is presently a challenging environmental issue worldwide. The present study was designed to investigate the health risk assessment of lead, cobalt and nickel intake due to consumption of tomato (Lycopersicon esculentum) and onion (Allium cepa L.) from the bank of Komadugu River in Gashua, Yobe State, Nigeria. Concentrations of lead, cobalt and nickel were determined by flame atomic absorption spectrophotometry after digestion of the vegetable samples. Results obtained were compared with permissible limits from the World Health Organization (WHO), other regulatory bodies and previous works. Values of the pollution load indices (PLIs), estimated daily intake (EDI) and combined total hazard quotient (CTHQ) all revealed the absence of Pb, Co and Ni pollution in the tomato and onion samples.*

Keywords: *Contamination; Health Risk Assessment; Tomato; Onion; World Health Organization (WHO); Pollution Load Indices (PLIs); Estimated Daily Intake (EDI) ;Combined Total Hazard Quotient (CTHQ).*

1. Introduction

Vegetables are major part of human platter as they have high amounts of fibers, minerals, vitamins and antioxidants. Therefore, heavy metals contamination of vegetables cannot be ignored due to their significance in food quality assurance. Furthermore, the food chain pyramid is the track by which biologically toxic trace metals accumulated in humans and other animals can be determined (Gupta *et al.,* 2019; Prasad *et al.,* 2021). Nowadays, the increasing public awareness of health risk assessment associated with heavy metals contamination has become one of the hot topics worldwide. Prolonged consumption of high heavy metal levels through contaminated food may cause chronic heavy metals accumulation in humans' liver, kidney and bones resulting in kidney, cardiovascular, nervous and bone diseases (Anwar *et al.,* 2016). In addition, heavy metals may also create congenital disabilities which are responsible for low birth weight of born babies. Some heavy metals specifically Co (Simonsen *et al, 2011;* Wuana and Okieimen, 2011), Ni (Ihedioha *et al.,* 2014), and Zn (Mohammadi *et al.,* 2017) act as essential elements at certain concentrations in humans but they become noxious when exposed to higher doses. It was reported that Cd (Khan *et* *al.,* 2015), Pb (Jaishankar *et al.,* 2014), and hexavalent chromium [Cr (VI)] (Wang *et al.,* 2017) may cause carcinogenic effects even in trace quantities.

2. Materials and Methods

2.1 The Study Area

The Yobe River, also known as the Komadugu Yobe River is a river in West Africa that flows into Lake Chad through Nigeria and Niger. In Yobe State, it is located on longitud12º52´N and latitude 10º58´E in Gashua, Bade Local Government Area. Its tributaries include River Hadejia , River Jama'are , and the Komadugu Gana River. The river forms a small part of the international border between Niger and Nigeria with 150 km and flows a total of 320km (KYBP, 2006). There are concerns about changes in the river flow, economy and ecology due to upstream dams, the largest at present being the Tiga Dam in Kano State, with plans for the Kafin Zaki dam in Bauchi State (NPC, 2006). The River Yobe provides a means of subsistence for hundreds of thousands of people who work in a variety of commercial and agricultural endeavours along its almost 200 km length in the state's northern region, which spans seven local government areas (LGAs) from Nguru to Yunusari. Notable towns near the river include Gashua, Geidam and Damasak in Nigeria, and Diffa in Niger Republic (Wakawa *et al*, 2017).

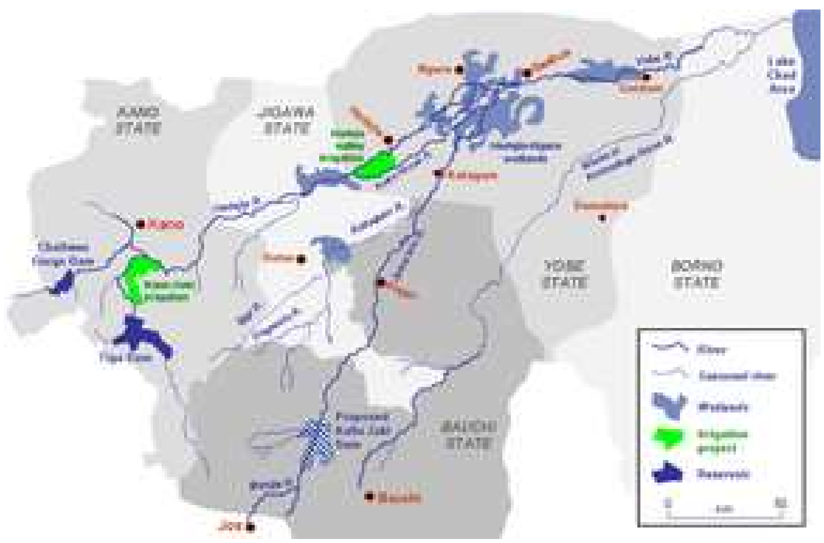


Figure 1: Catchment Area of the Komadugu River

2.2 Instruments, Apparatus and Reagents

All equipment and instruments used in this research were calibrated before conducting the experiments. All glassware used were thoroughly washed with detergents and tap water and then rinsed with deionized water. Suspected contaminants were cleaned with 10% concentrated nitric acid (HNO_3) and metal surfaces rinsed with deionized water. The digestion tubes were soaked with 1% (w/v) potassium dichromate in 98% (v/v) H_2SO_4.

In preparation of reagents, chemicals of analytical grade purity and distilled water were used. All glassware and plastic containers were washed with detergents.

2.3 Digestion of Tomato and Onion Samples

The tomato and onion samples were first air dried and then dried at 100°C in an oven (Model 30GC) for 2 hours. The samples were cooled and ground to fine powder. A microwave digester (Master 40 serial No: 40G106M) was used in digesting the tomato and onion samples in a digestion tube to which 0.1g of sample was added at a time, followed by 6mL of 65% HNO_3 and 2mL of 30% H_2O_2 and then allowed to stand for a while. The digestion was carried out at 180°C and 1800W in a time of 30 minutes. The digestion was followed by cooling at room temperature in the microwave and the sample was diluted with de-ionized water. Potential presence of selected heavy metals in chemicals used in digestion was determined. Blanks were used simultaneously in each batch of the analysis to authenticate the analytical quality (SINEO, 2013).

2.4 Atomic Absorption Spectrometric Analysis

The tomato and onion extracts were analyzed for lead (283.5nm), cobalt (240.7nm) and nickel (232.0nm) using flame atomic absorption spectrophotometry. Blank determinations were made prior to sample analysis. Heavy metal concentrations in tomato and onion extracts were obtained in triplicates from calibration curves and expressed as mg/kg. Metals in chemicals used in digestion were determined. Blanks were used simultaneously in each batch of the analysis to authenticate the analytical quality (SINEO, 2013).

2.5 Statistical Analysis

The data were analyzed in triplets and expressed as mean and standard deviation. The mean of all treatments was subjected to a One-way analysis of variance (ANOVA) using IBM SPSS Statistics 23 software and mean differences were performed using the Tukey test. All graphs were plotted using Microsoft Excel 2013.

3. Results and Discussion

3.1 Heavy Metals in Plants

Many plants contain both essential and toxic metals over a wide range of concentrations. It is well known that plant takes up metals by absorbing them from contaminated soil as well from deposits on part of the plant exposed to the air from polluted environment. Heavy metal contamination may occur due to irrigation with contaminated water, addition of fertilizer, pesticides and industrial emission. Transportation, harvesting process, storage and sale of vegetables and fruits contaminated with heavy metals is associated with etiology of a number of diseases especially in cardiovascular kidney, nervous system and bones (Hamurcu *et al.,* 2010; Ismail *et al.,* 2011). It is therefore very essential to sensitize the general public on the effects of heavy metals in onions, tomatoes and other vegetables grown in Gashua and other towns along the bank of Komadugu River.

3.2 Abundance of Heavy Metals in Tomato and Onion

The average concentrations of lead, cobalt and nickel in tomato and onion are shown in the tables below

Table 1: Mean Concentrations of Lead, Cobalt and Nickel in Tomato

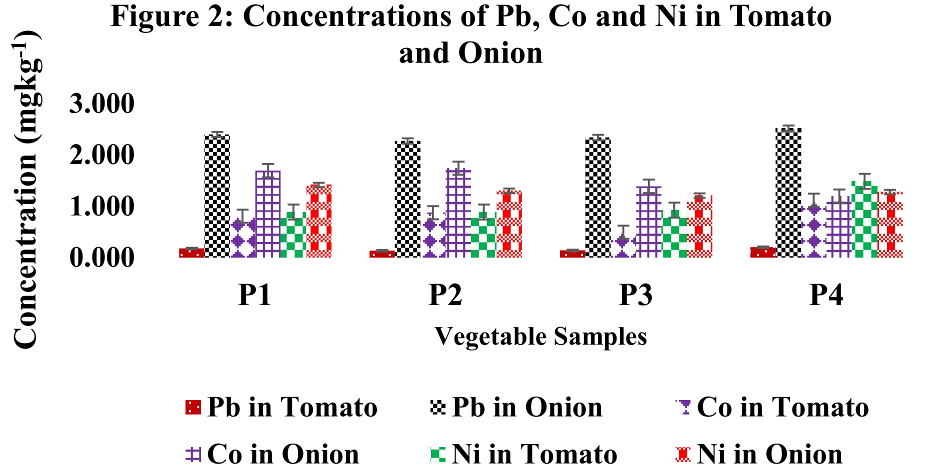
	Pb (mg/kg)		Co (mg/kg)		Ni (mg/kg)	
Sample Point	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
P1	0.170	0.190	0.733	0.873	0.790	0.960
P2	0.120	0.140	0.741	0.965	0.810	0.960
P3	0.120	0.160	0.380	0.682	0.780	1.210
P4	0.200	0.210	0.853	1.358	1.300	1.610

Table 2: Mean Concentrations of Lead, Cobalt and Nickel in Onion

	Pb (mg/kg)		Co (mg/kg)		Ni (mg/kg)	
Sample Point	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
P1	2.32	2.51	1.483	1.872	1.27	1.56
P2	2.18	2.38	1.566	1.886	1.08	1.48
P3	2.25	2.48	1.218	1.524	1.00	1.31
P4	2.32	2.71	1.087	1.284	1.15	1.42

Figure 2 shows the concentrations of Pb, Co and Ni in tomato and onion.

Figure 2: Concentrations of Pb, Co and Ni in Tomato and Onion



3.2.1. Lead

The mean concentrations of lead in tomato and onion samples obtained in this study were in the range 0.133 ± 0.010 to 0.200 ± 0.008 and 2.270±0.083 to 2.518±0.175mgkg^{-1} respectively. In both vegetables, the mean concentrations followed the order P4 > P1 > P3 > P2. Whereas Pb levels in tomato were in consonance with 0.3 and 0.2mg/kg set by the World Health Organization (WHO) and United States Environmental Protection Agency (USEPA) respectively, the corresponding values in onion were tenfold these permissible limits. These results were much higher than values reported by Negi *et al.,* (2012): 0.040±0.002mgkg^{-1} in onion and garlic wastes, Bystrická *et al.,* (2015): 0.05±0.02mgkg^{-1} for selected varieties of onion (*Allium cepa L.*) grown in the different locations and Harmanescu *et al.* (2011): 0.13±0.05mgkg^{-1} for vegetables grown in old mining area. The following workers reported slightly higher values of Pb than the value reported for tomato in this study; Gupta *et al.,* (2022): 0.66±0.60mgkg^{-1} accumulated in vegetables, Leblebici (2020): 0.67±0.16mgkg^{-1} for green vegetables grown in Nevşehir, Yaradua *et al.* (2020):1.31±0.0001mgkg^{-1} in onion bulbs cultivated in Katsina State. On the other hand, the following values were higher than the values reported for both tomato and onion in this study; Gebrekidan *et al.* (2013): 4.90-70.79 mgkg^{-1} accumulated in vegetables and fruits grown in Ginfel river near Sheba Tannery, Tigray, Northern Ethiopia, Abdullahi *et al.* (2007): 13.199±3.99 mgkg^{-1} for tomatoes and onions from irrigated farmlands on the Bank of River Challawa, Kano, Jung (2008): 14.143 + 0.051mgkg^{-1} uptake by plants in the vicinity of a Korean Cu-W Mine.

Lead (Pb) contamination of the environment is an important human health problem. Children are vulnerable to Pb toxicity. It causes damage to the central nervous system and, in some extreme cases, can cause death. Lead is widespread, especially in the urban environment, and is present in the atmosphere, soil, water and food. Pb tends to accumulate in surface soil because of its low solubility, mobility and relative freedom from microbial degradation of in the soil. Lead is present in soil as a result to weathering and other pedogenic processes acting on the soil parent material or from pollution arising caused by the anthropogenic activities such as mining, smelting and waste disposal or through the adoption of unsafe and unethical agricultural practices such as using of sewage sludge, and waste water in production of vegetable crops or cultivation of vegetables near highways and industry regions. Lead concentrations are generally higher in the leafy vegetables than other vegetables. Factors affecting lead uptake include its concentration in the soil, soil pH, soil type, organic matter content, plant species and unsafe agricultural practices. Generally, as Pb concentration increase, dry matter yields of roots, stems and leaves as well as total yield decrease (Feleafel *et al.,* 2013).

3.2.2 Cobalt

The mean concentrations of cobalt in tomato and onion samples obtained in this study were in the range 0.491±0.133–1.114±0.236mgkg^{-1}and 1.197±0.093–1.740±0.144mgkg^{-1} respectively. The mean concentrations of Co followed the order P4 > P2 > P1 > P3 in tomato and P2 > P1 > P3 > P4 in onion. Though, there is no specific limit for Co in vegetables set by United States Environmental Protection Agency (USEPA) and World Health Organization WHO, when compared with previous research findings, the Co values obtained in this study were less than the values reported by various researchers; Gebrekidan *et al.* (2013) reported 0.107±0.01 mgkg^{-1} in vegetables and fruits grown in Ginfel river near Sheba Tannery, Gupta *et al* (2022) reported 0.32±0.30mgkg^{-1} in vegetables, Negi *et al.* (2012) reported 0.21±0.001mgkg^{-1} in onion and garlic wastes, Ikechukwu *et al.* (2019) reported 0.072±0.001mgkg^{-1} in selected fruits in Umuahia market, Nigeria.

Cobalt is an essential nutrient for prokaryotes, human beings and other mammals but has not been considered an essential micronutrient for plants. Instead, this element, along with other elements, such as aluminum (Al), selenium (Se), silicon (Si), sodium (Na) and titanium (Ti), has been considered as a beneficial element for plant growth (Pilon-Smits *et al.,* 2009). According to Pais (1992), an element that can improve plant health status at low concentrations but has toxic effects at high concentrations is known as a beneficial element. For an element to be considered essential, it must be required by plants to complete its life cycle. It must not be replaceable by other elements and must directly participate in plant metabolism (Arnon and Stout, 1939). Of the 92 naturally occurring elements on earth, 82 have been found in plants (Reimann *et al.,* 2001).

3.2.3 Nickel

The mean concentrations of Ni in tomato and onion samples obtained in this study were in the range 0.885±0.068–1.485±0.142mgkg^{-1}and 1.208±0.141–1.415±0.122mgkg^{-1} respectively. The mean concentrations of Ni in tomato followed the order, P4 > P3 > P1 > P2 and in onion, P1 > P2 > P4 > P3. Though, there is no specific limit for Ni in vegetables set by United States Environmental Protection Agency (USEPA) and World Health Organization (WHO), when compared with previous research findings, Ni concentrations in this study were higher than reported values by various researchers; Murtic *et al* (2018) reported a value of 2.16±0.11mgkg^{-1} in tomato (Lycopersicum esculentum Mill), Bystrická *et al.* (2015) reported 0.05±0.02 mg/kg in selected varieties of onion (*Allium cepal*), Harmanescu. *et al.* (2011) reported a value of 0.03±0.01mgkg^{-1} in vegetables grown in old mining area, Gebrekidan *et al.* (2013) reported 0.03±0.01mgkg^{-1} in vegetables and fruits. Contamination of agricultural products with heavy metals including Ni has become an important concern throughout the world due to potential adverse effects on human health. The industrial use of nickel has led to environmental pollution by metal and its byproducts during production, recycling and disposal. Eggplant (*Solanum melongena L.*) is a vegetable crop consumed by many ethnic groups and grown in many parts of the world. A study was conducted to investigate effects of Ni concentration on metabolic activities affecting developmental responses in eggplant. Seeds of eggplant, cv. Hybrid P.K.123, were sown in refined sand at levels from 0.1 to 400 µM. Exposure of plants to Ni > 50 µM decreased biomass, concentration of photosynthetic pigments in leaves, concentration of Fe in leaves and stem, and activities of catalase and peroxidase. Decreased concentration of chlorophyll and activities of heme enzymes, catalase and peroxidase with increased Ni may indicate interference by Ni in iron metabolism of plants. Concentration of Ni in plants and proline and activities of superoxide dismutase and ribonuclease increased with increasing levels of nickel. Oxidative damage measured as level of lipid peroxidation was observed in leaves of plants. At 400 µM Ni, visible symptoms of Ni toxicity, chlorosis and necrosis were observed on young leaves along veins and margins at 10 days after treatment. Appearance of metal-specific toxicity effects is likely the result of membrane damage as a consequence of production of reactive oxygen species (ROS) especially at higher (300–400 µM) levels of Ni (Pandey *et al.,* 2010).

3.3 Pollution Index Parameters

- ➢ The most common pollution index parameters include pollution load index (PLI), estimated daily intake (EDI) and target hazard quotient (THQ).
- ➢ LPI is a preliminary parameter, which gives only the sign of pollution by a metal in a sample.
- A PLI > 1 indicates that heavy metal pollution may exist subject to the values of EDI and THQ.
- ➢ A PLI < 1 shows outrightly that no pollution exists in a sample (Tomlinson *et al.,* 1980).
- ➢ EDI and THQ are confirmatory parameters.
  - If EDI > RfD (the oral reference dose of a metal) and HTQ > 1, pollution by a metal exists in a sample.
  - If HTQ < 1, no pollution by a metal exists in a sample.

- The three parameters are calculated from the following equations;
  - $LPI = \left(CF_1 \times CF_2 \times CF_3 \times CF_4 \times \ldots\ldots\ldots\ldots \times CF_n\right)^{\frac{1}{n}}$, where CF_n is the concentration of the nth element under investigation.
  - $EDI = \frac{D_{intake} \times C_F \times C_m}{B_{weight}}$, where

- D_{intake} is the average daily intake of food= 0.585kg of vegetable/person/day
- C_F is the conversion factor =0.08045
- Cm is the metal concentration in the vegetable (mg/kg dry weight basis)
- B_{weight} is the average body weight for adults (70 kg) (Yaqub *etal*., 2021)

- $THQ = \frac{EDI}{RfD}$, where, EDI= Estimated Daily Intake, RfD = Oral Reference Dose.

3.4 Human Health Risk Assessment Due to Tomato and Onion Intake

The PLI of Pb, Co and Ni in tomato (*Lycopersicon esculentum*) in this study is 0.426, suggesting no pollution of tomato by these metals.

The PLI of Pb, Co and Ni in onion (*Allium cepa L.*) in this study is 1.670, suggesting pollution of onion to a certain degree by these heavy metals may exist subject to the values of EDI and HTQ.

The EDI, THQ and RfD of Pb, Co and Ni in tomato and onion are shown in **figure 3.**

Figure 3: Estimated Daily Intake, Target Hazard Quotient and Oral Reference Dose for Pb, Co and Ni in Tomato and Onion

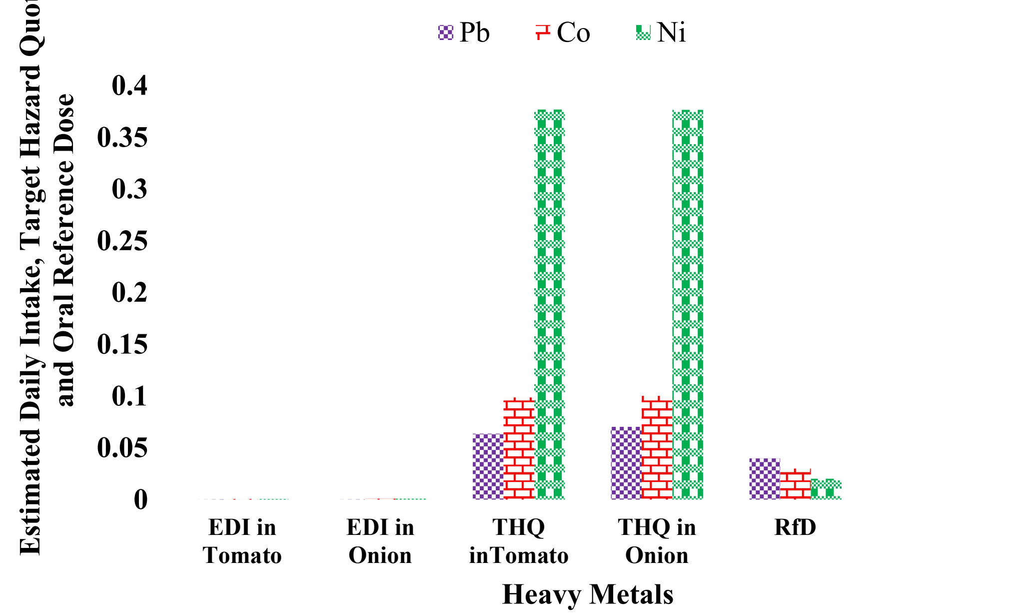


Table 3: EDI, THQ and RfD of Pb, Co and Ni in Tomato and Onion

Pollution Index	Pb	Co	Ni
EDI in Tomato (mg/kg bw/day)	0.00011	0.00055	0.00070
EDI in Onion (mg/kg bw/day)	0.00160	0.00101	0.00088
THQ in Tomato	0.06366	0.09856	0.37701
THQ in Onion	0.07003	0.10015	0.37661
Oral Reference Dose (RfD)	0.04	0.03	0.02

The EDI values of Pb, Co and Ni in tomato were 0.000011, 0.00055 and 0.00070. These are less than the oral reference doses of Pb (0.04), Co (0.03) and Ni (0.02). So, there is no pollution of tomato by these metals. This is further confirmed by the THQ values of the metals; Pb (0.06366), Co (0.09856) and Ni (0.37701). Similarly, there is no pollution of onion by the metals.

4. Conclusion

Concentrations of lead, cobalt and nickel in tomato (*Lycopersicon esculentum*) and onion (*Allium cepa L.*) samples were determined by Atomic Absorption Spectrophotometry after microwave digestion of samples of the vegetables. The values obtained were compared with permissible limits set by the World Health Organization (WHO), United States Environmental Protection Agency (USEPA) and results reported by previous workers. The pollution load index (PLI), estimated daily index (EDI) and target hazard quotient (THQ) were used to assess pollution potentials of Pb, Co and Ni to tomato (*Lycopersicon esculentum*) and onion (*Allium cepa L.*) samples. There parameters indicated that, there was no Pb, Co and Ni pollution in tomato and onion.

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Authors' Contributions
Dagari M.S.: Conceptualization, design and supervision of the research work; Editing of the write-up
Saleh A. W.: Undertaking the research work, write-up and data analysis.

References

Abdullahi, M. S., Uzairu, A., Harrison, G. F. S. and Balarabe, M. L. (2007). Trace Metals Screening of Tomatoes and Onions from Irrigated Farmlands on the Bank of River Challawa, Kano, *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 6(3):1869-1878.

Anwar, S., Nawaz, M. F., Gul, S., Rizwan, M., Ali, S. and Kareem, A. (2016). Uptake and Distribution of Minerals and Heavy Metals in Commonly Grown Leafy Vegetable Species Irrigated with Sewage Water. *Environ. Monit. Assess.,* 188(9):541

Arnon, D. I. and Stout, P. R. (1939). The essentiality of certain elements in minute quantity for plants with special reference to copper. *Plant Physiol.,* 14:371-375.

Bystrická, J., Musilová, J., Tomáš J., Tóth, T., Kavalcová, P., Šiatkovský, O. (2015). Intake of Heavy Metals In Selected Varieties of Onion (Allium Cepa L), Grown in the Different Locations. *Environmental Protection and Natural Resources,* 26(3):17-21.

Feleafel, M. N. and Mirdad, Z. M. (2013). Hazard and Effects of Pollution by Lead on Vegetable Crops. *J Agric Environ Ethics*, 26:547–567.

Gebrekidan, A., Gebresellasie, G. and Mulugeta, A. (2013) Toxicological Assessment of Heavy Metals Accumulated in Vegetables and Fruits Grown in Ginfel river near Sheba Tannery, Tigray, Northern Ethiopia. *Ecotoxicology and Environmental Safety,* 95:171–178.

Gupta, N., Yadav, K. K., Kumar, V., Kumar, S., Chadd, R. P. and Kumar, A. (2019). Trace Elements in Soil-Vegetables Interface: Translocation, Bioaccumulation, Toxicity and Amelioration – A Review. *Sci. Total Environ*. 651:2927–2942.

Gupta, N., Yadav, K. K., Kumar, V., Prasad, S., Cabral-Pinto, M. M. S., Jeon B-H., Kumar, S., Abdellattif, M. H. and Alsukaibia, A. K. D (2022). Investigation of Heavy Metal Accumulation in Vegetables and Health Risk to Humans from Their Consumption. Front. *Environ. Sci*. 10:791052. doi: 10.3389/fenvs.2022.791052.

Hamurcu, M., Ozcan, M. M., Dursun, N. and Gezgin, S. (2010). Mineral and Heavy Metal Levels of Some Fruits Grown at the Roadsides, *Food and Chemical Toxicology,* 48:1767–1770.

Harmanescu, M., Alda, L. M., Bordean, D. M., Gogoasa, L. and Gergen, L. (2011). Heavy Metals Health Risk Assessment for Population Via Consumption of Vegetables Grown n Old Mining Area; A Case Study: Banat, Romania. *Chemistry Central Journal*, 5:Pp64,

Ihedioha, J. N., Okoye, C. O. B., and Onyechi, U. A. (2014). Health Risk Assessment of Zinc, Chromium, and Nickel from Cow Meat Consumption in an Urban Nigerian Population. *Int. J. Occup. Environ. Health,* 20:281–288.

Ikechukwu, U.R., Victor, E. O., Uchenma, N. O., Nwuke, C. P., Nduka, F. O. and Ogbonmaya, P. (2019). Evaluation of Heavy Metals in Selected Fruits in Umuahia Market, Nigeria: Associating Toxicity to Effect for Improved Metal Risk Assessment. *Journal of Applied Biology & Biotechnology,* 7(04):39-45.

Ismail, F., Anjum, M. R., Mamon, A. N. and Kazi, T. G. (2011). Trace metal Contents of Vegetables and Fruits of Hyderabad Retail Market, *Pakistan Journal of Nutrition,* 10(4):365-372.

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B. and Beeregowda, K. N.(2014). Toxicity, Mechanism and Health Effects of Some Heavy Metals. *Interdiscip. Toxicol.,* 7:60–72.

Jung, M. C. (2008). Heavy Metal Concentrations in Soils and Factors Affecting Metal Uptake by Plants in the Vicinity of a Korean Cu-W Mine. Department of Earth and Environmental Sciences, College of Natural Sciences Sejong University, Seoul, 143-747.

Khan, A., Khan, S., Khan, M. A., Qamar, Z. and Waqas, M. (2015). The Uptake and Bioaccumulation of Heavy Metals by Food Plants, Their Effects on Plants Nutrients, and Associated Health Risk: a Review. *Environ. Sci. Pollut. Res.,* 22(18):13772–13799.

KYBP (2006).*Komadugu Yobe Basin Water Audit Report* by Afremedev Consultancy Services Limited for FMWR IUCN-NCF Komadugu Yobe Basin Project, Kano, Nigeria

Leblebici, Z., Kar, M. and Başaran, L. (2020). Assessment of the Heavy Metal Accumulation of Various Green Vegetables Grown in Nevşehir and Their Risks Human Health. *Environ Monit Assess.,* 192:483.

Lyu, S., Wei, X., Chen, J., Wang, C., Wang, X. and Pan, D. (2017). Titanium as a beneficial element for crop production. *Front. Plant. Sci.* 8:Pp597.

Mohammadi, M. J., Yari, A. R., Saghazadeh, M., Sobhanardakani, S., Geravandi, S. and Afkar, A. (2017). A Health Risk Assessment of Heavy Metals in People Consuming Sohan in Qom, Iran. *Toxin Rev.,* 37 (4):278–286.

Murtic, S., Zahirovic, C., Civic, H., Karic, L. and Jurkovic, J. (2018). Uptake of Heavy Metals by Tomato Plants (Lycopersicum esculentum Mill). And their distribution inside the plant. *Agriculture and Forestry,* 64(4):251-261.

Negi, R., Satpathy, G., Tyagi, Y. K. and Gupta, R. K (2012). Biosorption of Heavy Metals by Utilising Onion and Garlic Wastes *Int. J. Environment and Pollution*, 49(3-4):179-196.

NPC (2006).National Population Commission, http://www.population.gov.ng

Pais, I. (1992). Criteria of essentiality, beneficiality and toxicity of chemical elements. *Acta Aliment*. 21:145–152.

Pandey, V. K. and Gopal, R. (2010). Nickel Toxicity Effects on Growth and Metabolism of Eggplant, *International Journal of Vegetable Science*, 16(4):351-360.

Pilon-Smits, E. A., Quinn, C. F., Tapken, W., Malagoli, M. and Schiavon, M. (2009). Physiological functions of beneficial elements. *Curr. Opin. Plant. Biol.* 12:267–274.

Prasad, S., Yadav, K. K., Kumar, S., Gupta, N., Cabral-Pinto, M. M. S. and Rezania S. (2021). Chromium Contamination and Effect on Environmental Health and its Remediation: A Sustainable Approaches *J. Environ. Manage*. 285: 112174.

Reimann, C., Koller, F., Frengstad, B., Kashulina, G., Niskavaara, H. and Englmaier, P. (2001). Comparison of the element compositin in several plant species and their substrate from a 1555000 km2 area in northern Europe. *Sci. Total. Environ.,* 278:87-112.

Simonsen, L. O., Brown, A. M., Harbak, H., Kristensen, B. I., and Bennekou, P. (2011). Cobalt Uptake and Binding in Human Red Blood Cells. *Blood Cell Mol. Dis.,* 46, 266–276.

SINEO (2013). Operating Manual of Master 40 Microwave Digester

Tomlinson, D. L., Wilson J. G., Harris C. R. and Jeffrey D. W. (1980). Problems in the Assessment of Heavy Metal Levels in Estuaries and the Formation of a Pollution Index, *Heglonder Meeresunter,* 33:566 - 575

Wakawa LD, Suleiman AA, Ibrahim Y, Adam LI (2017). Tree Species Biodiversity of a Sahelien Ecosystem in North-East Nigeria. Bartın Orman Fakültesi Dergisi,; 19(2): 166-173.

Wang, Y., Su, H., Gu, Y., Song, X., and Zhao, J. (2017). Carcinogenicity of Chromium and Chemoprevention: *A Brief Update. Ott.,* 10:4065–4079.

.Wuana, R. A., and Okieimen, F. E. (2011). Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. *ISRN Ecol.,* 12, 402647.

Yaqub, G., Khan, A., Ahmad, M. Z. and Irshad, U. (2021). Determination of Concentration of Heavy Metals in Fruits, Vegetables, Groundwater, and Soil Samples of the Cement Industry and Nearby Communities and Assessment of Associated Health Risks, *Hindawi Journal of Food Quality,* Pp 9.

Yaradua, A. I., Alhassan, A. J., Nasir, A., Matazu, S. S. Usman, A. Idi, A. Muhammad, I. U. Yaro, A. S and Nasir, R (2020). Human Health Risk Assessment of Heavy Metals in Onion Bulbs Cultivated in Katsina State, North West Nigeria. *Archives of Current Research International,* 20(2):30-39.