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Heavy Metal Levels in Tomatoes from Fadama Area Near BUA Cement PLC Sokoto, Northwest, Nigeria

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ABSTRACT

Background and Objective: Elevated levels of heavy metals pose a significant health risk to consumers. This study aimed to assess the accumulation of heavy metals in tomato fruits grown around the Fadama area of BUA Cement PLC in Wamakko Local Government, Sokoto State. **Materials and Methods:** Fresh raw tomato fruits were collected from four different locations near BUA Cement. These tomato fruits were then analyzed using an Atomic Absorption Spectrophotometer (AAS) to determine the concentrations of heavy metals present. The least significant difference test was used to compare treatment means at p = 0.05. **Results:** These findings highlight the presence of heavy metals in tomato fruits grown in the study area. The elevated levels of copper, nickel, cadmium, chromium, zinc and lead suggest a potential risk to human health through the consumption of these contaminated tomatoes. Therefore, it is crucial to implement effective control and preventive measures to reduce the harmful effects of heavy metals on vegetables grown in the study area. The implementation of strategies such as soil remediation, proper waste management practices and regular monitoring of heavy metal levels can help mitigate the risks associated with heavy metal accumulation in agricultural produce. **Conclusion:** Furthermore, raising awareness among farmers and consumers about the potential health risks and promoting safe agricultural practices are essential steps toward ensuring food safety and protecting public health in the study area.

KEYWORDS

Heavy metal level, tomatoes, BUA Cement, PLC Cement, Fadama area, Sokoto, Northwest, Nigeria

INTRODUCTION

Various industries are located throughout the world to generate things for domestic and commercial use. The majority of these companies produce waste effluents that are released into the environment with no pre-treatment and high levels of harmful inorganic and organic contaminants[1]. The contaminated effluents from these enterprises are dispersed through drains or by surface flow, which has an impact on the vegetation and nearby water bodies[1]. Additionally, wastes produced by human activity in the home and workplace can be properly managed[2,3]. Poor management of these wastes or residues may have negative effects on human health[1].

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Heavy metal contamination of food products is one of the most important aspects of food quality assurance[4-6]. Heavy metal concentrations are higher in urban environments in developing countries like Nigeria because of unchecked, fast industrial and urban growth[1].

Vegetable surfaces may become contaminated with heavy metal emissions from factories and cars during the growing, transporting and selling phases. According to Al-Jassir *et al.*[7], atmospheric deposition has led to increased levels of heavy metals in vegetables sold in markets in Riyadh City, Saudi Arabia. According to Sharma *et al.*[8] atmospheric deposition can dramatically increase the levels of heavy metal contamination in vegetables that are frequently sold in Varanasi, India, markets.

Chronic buildup of heavy metals in the human kidney and liver due to extended exposure to hazardous levels of heavy metals through meals may cause disruption of several biochemical processes and disorders of the heart, neurological system, kidneys and bones[9,10]. While some heavy metals, such as cadmium (Cd), arsenic (As) and chromium (Cr), operate as carcinogens, others, such as copper (Cu), zinc (Zn), manganese (Mn), cobalt (Co) and molybdenum (Mo), act as micronutrients for the growth of animals and humans when present in trace quantities[11]. Vegetables' quality and safety are at risk from heavy metal contamination brought on by soil and air contamination. The health of both humans and animals is in danger when heavy metals are consumed through food. Heavy metals with known cancer-causing properties include cadmium (Cd) and palladium (Pb)[11]. High levels of the heavy metals Cu, Cd and Pb were linked to a high incidence of upper gastrointestinal cancer in fruits and vegetables[12].

As a result, environmental issues and associated health risks to the populace are more severe in developing nations like Nigeria where environmental safety rules are not actually in place. Therefore, the purpose of this investigation was to assess the accumulation of heavy metal in tomato fruits grown around the Fadama area of BUA Cement PLC, Sokoto State.

MATERIALS AND METHODS

Heavy metal levels in tomatoes from Fadama area near BUA Cement PLC, Sokoto, Northwest, Nigeria were carried out between July, 2022 to September, 2022.

Study area: One of the 23 Local Government Areas (LGAs) of Sokoto State created in 1989 is Wamakko. Its main office is in the Wamakko Town (study area). The LGA is situated in Sokoto's Western Region. Bound in the north by the Kware Local Government, the Bodinga Local Government, the Sokoto North Local Government in the East and the West by the Binji Local Government. The 697 km^2 is covered by the Wamakko local government. According to the Sokoto State Business Directory[13], Wamakko has an area of 697 km^2 and a population of 209,204 and attracts rural-urban migrants. The Sokoto State serves as a referral centre for more than 10 million people of the Nigerian States of Sokoto, Zamfara and Kebbi and neighboring Niger and Benin Republic in the West African sub-region. The study site, the town of Wamakko, is segmented into wards. Arkilla, Bado/Kasarawa, Gumbi, Kalambainal/Girabshi, Gidan Bub Gidan Yaro, Gidan Hamidu/Gidan Kaya, Wamakko, Dundaye/Gunburawa and Gwamatse are some of these wards. The majority of people are Hausa/Fulani and their main lines of work include farming and raising animals[14].

The maximum daily temperatures of Sokoto, one of Nigeria's hottest cities, are typically below 40°C (104.0°F) for most of the year and the city is dry, which helps to keep the heat bearable[15]. The brief rains are a far cry from the frequent torrential downpours experienced in many tropical areas. The harmattan wind, which spreads Sahara dust across the landscape, controls the climate from late October to February, known as the "cold season". As a result of the dust, temperatures are greatly reduced[14].

This study was carried out at the Fadama areas near the cement factory in the Kalambaina area of Wamakko Local Government Area of Sokoto State, Nigeria. At 13°3'23"N Latitude and Longitude: 5°12'5"E.

The primary activities of BUA Cement PLC are the extraction, processing and trading of limestone as well as the production and distribution of cement. The largest private employer of labourers in North-West Nigeria is the cement mill, which is situated in the Wamakko Local Government Area of the Kalambaina region of Sokoto State[16].

Sample collection: The sample collection period was from February to April, 2022. The samples were collected from four Fadama fields near the cement factory in four areas namely Girafshi, Gantsare, Tanidawa and Danbari. A total of eight fresh tomato fruits the family name: (Solanaceae) well botanical name: (S*olanum lycopersicum*) and the local name: Dan Eka, were collected from four different Fadama and two tomato samples per plot were taken representing each farmland. The sample was given a voucher number (UDUS/ANS/0528) at the herbarium of the Department of Biological Sciences, Usman Danfodiyo University Sokoto for identification, identified by Abdulaziz Salihu (herbarium officer). The samples were packed in a clean polythene bag, labelled and transported to the Department of Soil Science, Faculty of Agriculture for digestion and transferred to the Central Laboratory of Usmanu Danfodiyo University Sokoto for atomic spectrometry for analysis of heavy metals (Cd, Cr, Pb, Ni, Cu and Zn) content[17].

Sample preparation: The tomato fruit samples were washed thoroughly with distilled water to remove the dust particles and other pollutants from the outer surface. Then, they were sliced down into small pieces (0.5 cm)[18].

Digestion of metals: For digestion, 2 g of the sample was taken into a beaker, 2 mL of nitrate acid and 4 mL perchloric acid and heated to digest on a hot plate under a fume cupboard for about 10-15 min, then it was allowed to cool and dilute with distilled water to make it 50 mL/volume and flited with filter paper, the sample was ready for heavy metal analysis[18].

Determination of heavy metals: Determination of heavy metals was done with an atomic spectrometry machine (Shimadzu AAS6300) to determine the concentration of cadmium, chromium, lead, nickel, copper and zinc at the Central Laboratory Unit of Usmanu Danfodiyo University Sokoto.

Statistical analysis: The data was analyzed using sample descriptive statistical analysis using SPSS version 20. One-way Analysis of Variance (ANOVA) was used to determine significant differences between the mean concentrations of the heavy metals. The least significant difference test was used to compare treatment means at $p = 0.05$.

RESULTS AND DISCUSSION

The results from this study showed the presence of six heavy metals in four samples of (A, B, C and D) in tomato fruits grown around the Fadama area of BUA Cement PLC. The heavy metals detected are zinc (Zn), copper (Cu), nickel (Ni), chromium (Cr), cadmium (Cd) and lead (Ld) as shown in Table 1. It can be seen from Table 1 that copper (Cu) and nickel (Ni) recorded the highest mean concentration of (5.09 mg/L each), were in the four (4) samples examined the following by cadmium (5.04 mg/L), chromium (5.03 mg/L) while lead (5.01 mg/L) mean average of the concentration.

The finding from the study in Table 2 revealed that the copper and nickel concentrations observed in the present study are beyond the permissible limits[19]. Zinc, chromium, cadmium and lead concentration are above the limit amended by WHO permissible limit, respectively.

Table 1: Heavy metals concentrations in tomato fruit grown in the study area

	Tomato samples (mg/L)				
Heavy metals	A	B	C	D	Mean (average)
Zn	2.09	3.90	6.04	8.06	5.02
Cu	2.08	3.94	6.16	8.18	5.09
Ni	2.02	3.98	6.29	8.09	5.09
Cr	2.03	3.90	6.09	8.11	5.03
Cd	2.00	3.86	6.09	8.06	5.04
Pb	2.01	3.87	6.11	8.19	5.01

Zn: Zinc, Cu: Copper, Ni: Nickel, Cr: Chromium, Cd: Cadmium and Pb: Lead

Table 2: Heavy metals concentrations in tomato fruit grown in the study area compared to permissible limits

	Samples number				
Heavy mental	A	B	C	D	Permissible value of plant (mg/kg)
Zn	2.09	3.90	6.04	8.06	0.60
Cu	2.08	3.94	6.16	8.18	10.00
Ni	2.02	3.98	6.29	8.09	10.00
Cr	2.03	3.90	6.09	8.11	1.30
Cd	2.00	3.86	6.09	8.19	0.02
Pd	2.01	3.87	6.11	8.06	2.00

Zn: Zinc, Cu: Copper, Ni: Nickel, Cr: Chromium, Cd: Cadmium and Pb: Lead

The results of this study showed the presence of heavy metal concentrations in tomato fruits grown in the Fadama Area of BUA Cement Factory in Sokoto. The zinc (Zn) values for the collected samples (A, B, C and D) were found to be 2.09, 3.90, 6.04 and 8.06 mg/L, respectively. Sample D exhibited the highest zinc concentration, while sample A had the lowest. The average zinc concentration recorded was 5.02 mg/L. All the zinc values exceeded the acceptable limit of 0.60 mg/L, contrasted with the findings of a previous study by Warrah *et al.*[18] in the same area, which reported a recovery of 0.83 mg/L. Additionally, Onwuka *et al.*[19] reported a recovery of 0.07 mg/L in Umuahia Metropolis, Abia. The variation in heavy metal concentrations among the samples could be attributed to factors such as season, atmospheric conditions or other environmental factors. Zinc is relatively immobile in soil; however, food crops often accumulate high levels of zinc. Bermudez *et al.*[20] have reported elevated concentrations of zinc in vegetables and fruits grown near cement industries. The presence of zinc in soil can disrupt the decomposition of organic matter by microbes, leading to excessive accumulation of zinc in plants beyond their tolerance levels. As the production of zinc continues to increase, it poses a potential threat to ecosystems and the food chain[21].

Regarding copper (Cu), the values for samples A, B, C and D were 2.08, 3.94, 6.16 and 8.18 mg/L, respectively. Sample D exhibited the highest copper concentration, while sample A had the lowest. The average copper concentration recorded was 5.09 mg/L. All the copper values remained below the acceptable limit of 10 mg/L. This finding contradicted the recovery of 1.65 mg/L reported by Warrah *et al.*[18] in the same area. In the Umuahia Metropolis, Abia, Onwuka *et al.*[19] reported a recovery of 0.02 mg/L. Copper can enter surface and groundwater sources through contaminated soil and polluted urban dust. Groundwater samples often exhibit critical levels of copper, which can contaminate drinking water and lead to health issues such as renal failure, liver damage, anemia and gastrointestinal problems. Common sources of copper in drinking water include copper pipes and additives used to control algal growth[21].

For cadmium (Cd), the values for samples A, B, C and D were 2.00, 3.86, 6.09 and 8.06 mg/L, respectively. The average cadmium concentration recorded was 5.04 mg/L. All the cadmium values exceeded the acceptable limit of 0.02 mg/kg. This finding contradicted the recovery of 8.1 mg/L reported by Warrah *et al.*[18] in the same area, while in the Umuahia Metropolis, Abia, Onwuka *et al.*[19] reported a recovery of 0.48 mg/L. Variations in heavy metal concentrations among the samples could be attributed to seasonal variations, atmospheric conditions or other environmental factors. High concentrations of cadmium can negatively impact various organs such as the liver, placenta, kidneys, lungs, brain and bones. Experimental data have indicated that cadmium may also have carcinogenic effects in humans[10].

The nickel (Ni) values for samples A, B, C and D were 2.02, 3.98, 6.29 and 8.09 mg/L, respectively. Sample D exhibited the highest nickel concentration, while sample A had the lowest. The average nickel concentration recorded was 5.09 mg/L. All the nickel values remained below the acceptable limit of 10 mg/L. In contrast, Warrah *et al.*[18] reported a recovery of 5.5 mg/L in the same area and Onwuka *et al.*[19] recorded 0.08 mg/L in the Umuahia Metropolis, Abia. Nickel can enter surface and groundwater sources through contaminated soil and polluted urban dust. Critical levels of nickel have been reported in groundwater samples.

Regarding chromium (Cr), the values for samples A, B, C and D were 2.03, 3.90, 6.09 and 8.11 mg/L, respectively. Sample D exhibited the highest chromium concentration, while sample A had the lowest. The average chromium concentration recorded was 5.03 mg/L. All the chromium values exceeded the acceptable limit of 1.30 mg/L. This finding contradicted the recovery of 4.23 mg/L reported by Warrah *et al.*[18] in the same area. In the Umuahia Metropolis, Abia, Onwuka *et al.*[19] reported a recovery of 0.04 mg/L. The variation in heavy metal concentrations among the samples could be attributed to seasonal variations, atmospheric conditions or other environmental factors.

Lastly, for lead (Pb), the values for samples A, B, C and D were 2.01, 3.87, 6.11 and 8.06 mg/L, respectively. Sample D exhibited the highest lead concentration, while sample A had the lowest. The average lead concentration recorded was 5.01 mg/L. All the lead values exceeded the acceptable limit of 2 mg/L. The elevated lead levels could be attributed to the presence of clay deposits in the area. This finding contradicted the recovery of 2.68 mg/L reported by Warrah *et al.*[18] in the same area, while Bermudez *et al.*[20] recorded 1.57 mg/L in the Umuahia Metropolis.

Based on the findings of this study the following recommendations were made:

- Farmers should be enlightened on the effect of heavy metals contamination on vegetables
- The BUA Cement PLC should employ technological innovations that will reduce the emission of heavy metals from its machinery
- Farmers working on farms near the BUA Cement PLC should wear a protective covering to reduce the effects of heavy metals on their health
- There is a need for a collaborative effort between governments at all levels, the BUA Cement and other stakeholders to address the effect of heavy metals on human health, the environment and agricultural practices in the study area

The study was limited to heavy metal contamination on tomato being the major vegetable grown in the area.

CONCLUSION

The analysis of heavy metal concentrations in tomatoes grown around the Fadama area of BUA Cement factory in Sokoto State revealed significant contamination levels, exceeding permissible limits set by regulatory bodies. The elevated levels of zinc, copper, cadmium, nickel, chromium and lead emphasize the need for effective control measures and preventive strategies to mitigate risks to human health and the environment. The study highlights the dynamic nature of heavy metal concentration and emphasizes the urgency of comprehensive measures, including better waste management, sustainable agricultural practices and stricter regulations. Promoting awareness among farmers and consumers is crucial and collaborative efforts are needed to address this issue, ensuring the safety and quality of agricultural produce.

SIGNIFICANCE STATEMENT

In this sense, the lack of practical environmental safety regulations makes environmental problems and possible health dangers to the public more prominent in developing countries like Nigeria. Thus, is study was aimed to assess heavy metals in tomatoes from Fadama area near BUA Cement PLC Sokoto, Northwest, Nigeria. By educating farmers about the negative effects of heavy metals on plants, including increased pH levels and decreased nutritional value of soil, society will gain a better understanding of the causes and consequences of heavy metal pollution for human health and the environment. Along with offering advice on how to control the accumulation of heavy metals in the environment for the government, farmers and the general people.

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