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Full Length Research Article

ASSESSMENT OF HEAVY METAL CONTAMINATION IN SELECTED EXOTIC VEGETABLE SAMPLES FROM EKE-AWKA MARKET, AWKA, ANAMBRA STATE

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ABSTRACT
This study assessed the levels of heavy metals Lead (Pb), Nickel (Ni), Mercury (Hg), Cobalt (Co) and Arsenic (As) in selected exotic vegetables, including spring onion, cabbage, green pea and carrot, using the Atomic Absorption Spectrophotometer method. Pb concentration was highest in spring onions (0.03175±0.02 mg/kg) and lowest in green peas (0.0205±0.01 mg/kg), with no significant differences observed among samples ($p > 0.05$). All Pb levels fell within the acceptable limits set by the WHO/FAO. Nickel concentrations were highest in green peas (0.0695±0.01 mg/kg) and lowest in cabbage (0.04625±0.01 mg/kg), also below the safety thresholds. For Hg, the highest concentration was found in carrots (0.05875±0.02 mg/kg) and the lowest in spring onions (0.0175±0.01 mg/kg), with mean concentrations not significantly different ($p > 0.05$). Cobalt peaked in spring onions (0.0745±0.02 mg/kg) and was lowest in cabbage (0.03875±0.01 mg/kg), all compliant with WHO/FAO standards. Arsenic levels were highest in green peas (0.033±0.00 mg/kg) and lowest in spring onions (0.01175±0.00 mg/kg), with no significant variations ($p > 0.05$). While heavy metal concentrations in these vegetables were within safe limits, ongoing monitoring is essential to protect public health and ensure food safety.

Keywords: Heavy metal, Contamination, Spring onion, Cabbage, Green pea, Carrot.

INTRODUCTION

The increasing consumption of exotic vegetables in urban areas has raised concerns about food safety, particularly regarding heavy metal contamination. Heavy metals such as lead, cadmium, arsenic, and mercury can accumulate in plant tissues and pose serious health risks to consumers, including neurotoxicity and carcinogenic effects (Zhang *et al*., 2020; Rani *et al*., 2021). Despite the growing market for these vegetables, there is a conspicuous lack of comprehensive studies on their heavy metal levels, especially in rapidly urbanizing regions with high pollution (Khan *et al*., 2022).

Recent studies have highlighted the importance of monitoring heavy metal contents in agricultural products, indicating that even minor contamination can have significant public health implications (Munir *et al*., 2021; Mititelu *et al*., 2025). However, much of the existing literature focuses on staple crops, leaving a significant research gap regarding exotic vegetables that are increasingly incorporated into diets for their nutritional benefits and culinary appeal (Mphande, 2025).

This study aims to fill this gap by assessing the extent of heavy metal contamination in selected exotic vegetables available in the market. By analyzing these vegetables, we aim to provide up-to-date data and insights to inform food safety regulations and raise public awareness of the potential risks of consuming contaminated produce.

MATERIALS AND METHODS

Study Area

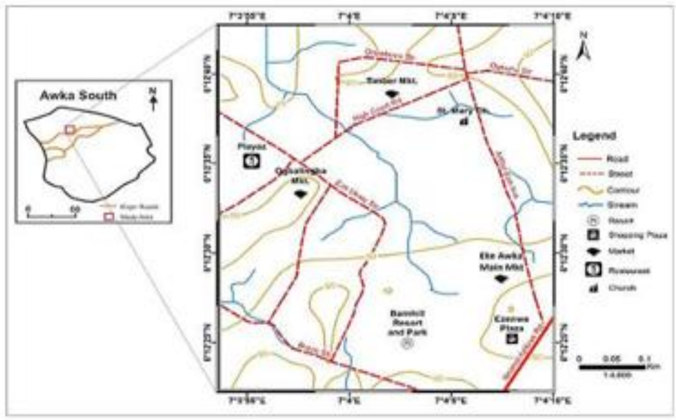

Figure 1: Map of the study area (Eke-Awka)
(Source: Ezeonyejiaku *et al*., 2023**)**

The research was conducted at Eke-Awka Market, a significant commercial hub in Awka, the capital city of Anambra State, Nigeria, located at 6.2100° N latitude and 7.0833° E longitude (Nwafor *et al*., 2024). This market serves as a vital center for trade and commerce, providing a wide range of goods and services to the local population and surrounding communities (Johnson *et al*., 2022). Awka is located in the southeastern region of Nigeria, approximately 30 kilometers from the commercial city of Onitsha and about 60 kilometers from Enugu, the capital of Enugu State.

MATERIAL COLLECTION AND PREPARATION

For this study, a total of 16 vegetable samples were collected, consisting of 4 spring onions, 4 cabbages, 4 green beans and 4 carrots. The sample size was determined using a stratified approach to ensure representation across the various vegetable types being studied, balancing the need for comparative analysis with a manageable overall sample size. These samples were randomly sourced from various vendors in the market. They were then stored at low temperatures and transported to the laboratory for heavy metal analysis. Sample preparation for heavy metal analysis involved homogenization, drying, digestion, and extraction processes. The analysis was performed using the Agilent FS240AA Atomic Absorption Spectrophotometer, following the

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methodology outlined by the American Public Health Association (APHA) in 1995 (Singhal & Singh, 2024). Each vegetable sample, weighing 2.0 grams, was first washed, dried, and digested with concentrated nitric acid to dissolve the metals. The resulting digest was then filtered and diluted to a suitable volume before being introduced into the atomic absorption spectrophotometer (AAS). The AAS measures absorbance at specific wavelengths corresponding to the heavy metal of interest, enabling quantification using a calibration curve. Finally, the concentration of the heavy metal in the vegetable sample was calculated and expressed in ppm (parts per million) or mg/kg. The study focused on detecting five heavy metals: cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), and mercury (Hg).

RESULTS

The findings of the study comparing heavy metal contamination in selected exotic vegetables are presented below.
Heavy metal concentration in the selected samples

Lead

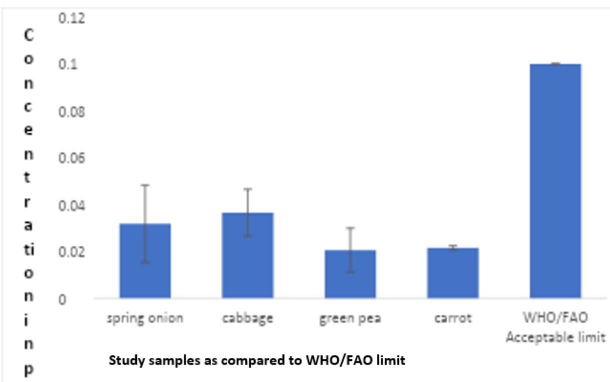

Figure 2: Concentration of Lead (ppm) in study samples

The findings indicate that the concentration of Lead (Pb) was highest in spring onions (0.03175±0.02) and lowest in green peas (0.0205±0.01) (Figure 2). There was no significant difference in the mean Pb concentrations among the four sample types ($p > 0.05$). Furthermore, compared with WHO/FAO standards, the average Pb levels across all four sample types were below the acceptable limit set by WHO/FAO.

Nickel

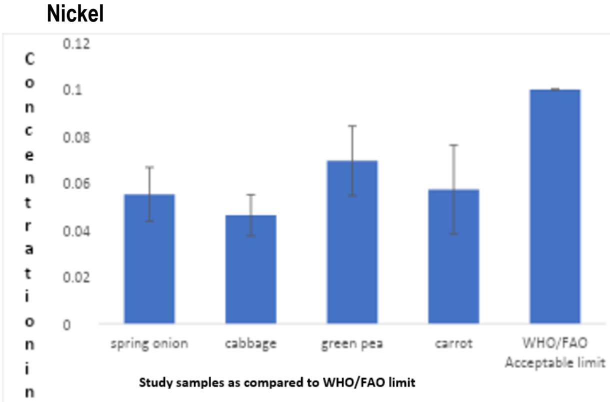

Figure 3: Nickel concentration (ppm) in study samples.

The findings indicate that the concentration of Nickel (Ni) was highest in green peas (0.0695±0.01) and lowest in cabbage (0.04625±0.01) (Figure 3). There was no significant difference in the mean Ni concentrations among the four sample types ($p > 0.05$). Furthermore, compared with WHO/FAO standards, the average Ni levels across all four sample types collected were below the acceptable limit established by WHO/FAO.

Mercury

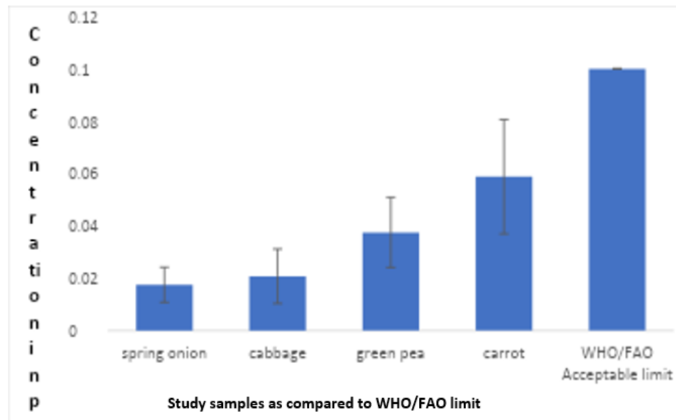

Figure 4: Mercury concentration (ppm) in study samples.

The findings indicate that the concentration of Mercury (Hg) was highest in carrots (0.05875±0.02) and lowest in spring onions (0.0175±0.01) (Figure 4). No significant difference was observed in the mean Hg concentrations across the four sample types ($p > 0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Hg levels in all four sample types collected were below the acceptable limit established by WHO/FAO

Cobalt

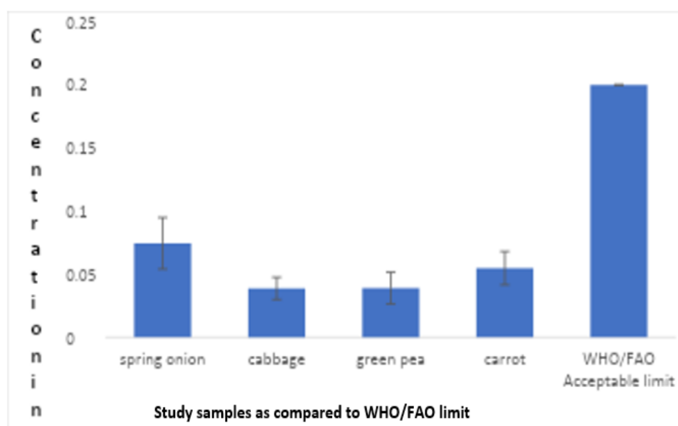

Figure 5: Concentration of Cobalt (ppm) in study samples.

The findings indicate that the concentration of Cobalt (Co) was highest in spring onion (0.0745±0.02) and lowest in cabbage (0.03875±0.00) (Figure 5). No significant difference was observed in the mean Co concentrations across the four sample types ($p > 0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Co levels in all four sample types were below the acceptable limit established by WHO/FAO

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Arsenic

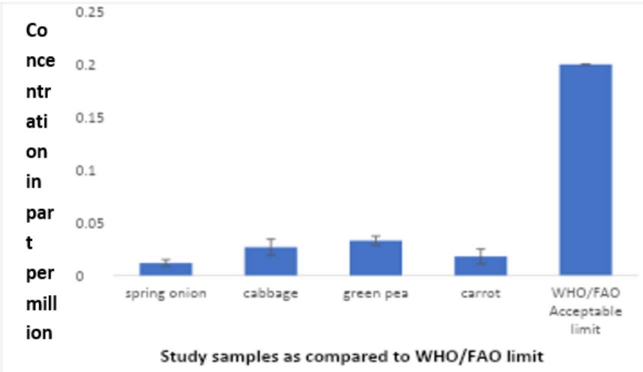

Figure 6: Arsenic concentration (ppm) in study samples.

The findings indicate that the concentration of Arsenic (As) was highest in green peas (0.033±0.00) and lowest in spring onions (0.01175±0.00) (Figure 6). There was no significant difference in the mean As concentrations among the four sample types ($p > 0.05$). Furthermore, compared with WHO/FAO standards, the average As levels across all four sample types collected were below the acceptable limit established by WHO/FAO.

DISCUSSION

The assessment of heavy metal contamination in selected exotic vegetables, specifically spring onion, cabbage, green beans, and carrot, is critical due to the potential health risks associated with their consumption and provides vital insights into food safety and public health, particularly in urban market systems where produce is common. This study focused on the concentrations of five key heavy metals: Lead (Pb), Nickel (Ni), Mercury (Hg), Cobalt (Co), and Arsenic (As) in various vegetables obtained from local markets. The results indicate that all measured heavy metal levels were below the standards set by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), suggesting a relatively safe consumption of these vegetables under current agricultural practices.

Lead (Pb) Concentration. The highest concentration of Pb was detected in spring onion (0.03175 ± 0.02) and the lowest in green pea (0.0205 ± 0.01), with no significant differences among the samples. These findings are consistent with previous studies, such as those by Osae *et al.* (2023), in which Pb levels in vegetables from urban markets also remained within safe limits. However, chronic exposure to Pb, even at low concentrations, poses significant health risks, particularly for vulnerable populations like children, where neurotoxic effects can manifest (Schneider *et al.*, 2023). In contrast, some studies reported higher Pb levels, particularly in leafy green vegetables from urban gardens in polluted areas, indicating that localized factors may influence metal uptake (Augustsson *et al.*, 2023). For example, studies by Badamasi *et al.* (2023) in Nigeria indicate higher Pb levels in leafy vegetables collected from heavily industrialized regions, underscoring the influence of localized environmental factors on metal accumulation. Continuous monitoring in urban agricultural settings is therefore imperative to mitigate these risks.

Nickel (Ni) Concentration. The findings revealed that Ni concentrations were highest in green peas (0.0695 ± 0.01) and lowest in cabbage (0.04625 ± 0.01). These values align with research conducted by Yu *et al.* (2025), which found comparable Ni levels in various vegetable crops across urban areas. Research conducted in other Nigerian cities also aligns with these results; for instance, Afolabi *et al.* (2026) noted similar low Ni accumulations in urban agricultural produce. Despite compliance with WHO/FAO limits, it is important to note that Ni exposure has been linked to respiratory issues and skin allergies, and that there is ongoing research on its carcinogenic potential (Rafati et al., 2025). The consistent Ni concentrations across different vegetable types suggest that agricultural practices and regional soil chemistry may play a crucial role in influencing heavy metal uptake. As urbanization continues to expand, proactive measures should ensure safe levels of Ni in horticultural products.

Mercury (Hg) Concentration. Hg levels were highest in carrots (0.05875 ± 0.02) and lowest in spring onions (0.0175 ± 0.01). These findings are consistent with those reported by Lazovic et al. (2023), which indicate low Hg levels in vegetables well below WHO guidelines. However, Hg is a potent neurotoxin even at trace levels, and concerns regarding bioaccumulation and environmental contamination from industrial sources remain prominent (Wu *et al.*, 2024). Some studies have suggested that Hg levels can vary significantly among vegetable types, largely influenced by the growing environment and the use of contaminated irrigation water (Kaur *et al.*, 2025). In Nigeria, Oloruntoba *et al.* (2024) highlighted specific urban areas where Hg levels exceeded permissible limits. Therefore, robust monitoring programs that target mercury levels in agricultural practices near industrial zones are essential to address potential health risks.

Cobalt (Co) Concentration. The highest Co concentration was found in spring onion (0.0745 ± 0.02), while cabbage exhibited the lowest level (0.03875 ± 0.01). These levels are comparable to those reported by Khan *et al.* (2024), highlighting a general trend of low Co accumulation in vegetables. Research in other locations, such as Minna, Nigeria, has demonstrated similarly low Co levels (Muhammad, 2025). Although Co is an essential trace element, chronic exposure can lead to harmful health effects, including respiratory distress (Tang *et al.*, 2024). Our study's findings indicate that levels across different samples remain stable and below safety limits, likely due to current agricultural practices that mitigate excessive metal accumulation. Nonetheless, research should continue to monitor the long-term implications of Co in the diet, particularly where dietary sources of cobalt may overlap or contribute to elevated levels.

Arsenic (As) Concentration. As concentrations were highest in green peas (0.033 ± 0.00) and lowest in spring onions (0.01175 ± 0.00). These concentrations are consistent with findings from Patel *et al.* (2023), who highlighted the pervasive issue of arsenic contamination in vegetables, particularly in areas where irrigation water is contaminated. Long-term exposure to low levels of As poses serious health risks, including cancer and skin lesions (Budi *et al.*, 2024). Comparatively, a study by Musa *et al.* (2025) in Nigeria reported significantly higher As levels in root vegetables, emphasizing the impact of specific local agricultural practices on metal accumulation. While our results indicate compliance with WHO/FAO limits, the continuing challenges associated with arsenic exposure necessitate an integrated approach to water management and agricultural practice reform to safeguard public health.

Conclusion
In conclusion, the results of this study indicate that while heavy metal levels in the selected exotic vegetables are currently below the WHO/FAO safety limits, it is imperative to maintain vigilant monitoring and implement effective agricultural guidelines. The potential health risks associated with chronic exposure highlight the need for ongoing research, particularly in urban farming contexts. Addressing heavy metal contamination requires a multi-faceted approach that includes improved agricultural practices, enhanced consumer education, and stronger regulatory frameworks to ensure food safety.

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