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Assessment of heavy metal contamination in selected laboratories and classrooms in science village Nnamdi Azikiwe University Awka

[1]Obudulu C., Nwobodo, M. S., [1]Ikeh M. I., [1]Aghalu U. C., [1]Olisa C. S., [1]Chika, C. D.

[1] Department of Zoology, Nnamdi Azikiwe University, Awka

*Corresponding author Email: obuduluchibuzor@gmail.com

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ABSTRACT

Heavy metal contamination in educational environments, such as laboratories and classrooms, poses significant health risks to students and staff, yet comprehensive assessments of these settings remain scarce. This study aims to fill the research gap by systematically evaluating the levels of heavy metals in selected laboratories and classrooms, thereby providing critical insights for improving safety standards and promoting a healthier learning environment. This study investigates heavy metal contamination in laboratories and classrooms, focusing on the concentrations of Lead (Pb), Nickel (Ni), Cadmium (Cd), Mercury (Hg), Cobalt (Co), and Arsenic (As) using indoor dust analysis. The results reveal that Pb levels were higher in laboratories (0.1042±0.0272 mg/kg) compared to classrooms (0.0946±0.0362 mg/kg), although the difference was not statistically significant ($p>0.05$). Both environments exceeded the WHO/FAO acceptable limits for Pb. Similarly, Ni concentrations were greater in laboratories (0.1852±0.0464 mg/kg) than in classrooms (0.1215±0.0362 mg/kg), with no significant difference ($p>0.05$) and levels surpassing WHO/FAO standards. Cadmium levels were also higher in laboratories (0.0572±0.0419 mg/kg) compared to classrooms (0.0191±0.0137 mg/kg), again exceeding acceptable limits without significant differences ($p>0.05$). Mercury concentrations were higher in classrooms (0.0215±0.0048 mg/kg) than in laboratories (0.0127±0.0031 mg/kg), with significant difference ($p>0.05$), and both exceeding WHO/FAO limits. Cobalt levels were higher in classrooms (0.847±0.0750 mg/kg) than in laboratories (0.79±0.1669 mg/kg), and As concentrations were higher in laboratories (0.0663±0.0233 mg/kg) than in classrooms (0.0355±0.0152 mg/kg), with both showing no significant differences ($p>0.05$). Overall, this study highlights concerning levels of heavy metals in educational settings, necessitating further investigation and potential remediation efforts.

Keywords. Heavy metal, Laboratories, Classrooms, Contamination

1. Introduction

The presence of heavy metals in educational environments, particularly in laboratories and classrooms, has emerged as a significant public health concern. Heavy metals such as lead, cadmium, mercury, and arsenic are known for their toxic effects on human health, particularly in vulnerable populations such as children and adolescents (Guo *et al*., 2025). Recent studies have highlighted that exposure to these contaminants can lead to severe neurological, developmental, and cognitive impairments (da Silva, 2025). Despite the known risks, there remains a notable gap in the assessment of heavy metal contamination specifically within educational settings, particularly in laboratories where chemical experiments are conducted. While previous research has extensively documented heavy metal contamination in industrial and urban environments (Kabir *et al*., 2022; Skrbic *et al*., 2022), there is a paucity of studies focusing on the levels of these contaminants in school laboratories and classrooms. A recent systematic review by Heng *et al*. (2022) emphasized the need for targeted assessments in educational institutions, as these environments are often overlooked in environmental health studies. The review identified a critical gap in understanding the sources, levels, and potential health impacts of heavy metals in these settings, suggesting that educational institutions may inadvertently expose students and staff to hazardous materials. Furthermore, existing literature primarily addresses heavy metal contamination in terms of soil and water quality, with limited attention given to airborne

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contaminants and surface residues in classrooms and laboratories (Unsal *et al*., 2024). This oversight is particularly concerning given the increasing use of various chemicals in educational curricula and the potential for cross-contamination from laboratory activities. The need for comprehensive assessments of heavy metal contamination in educational environments is thus underscored by both the potential health implications and the current lack of empirical data. In light of these findings, this study aims to investigate the levels of heavy metal contamination in school laboratories and classrooms, identify potential sources of contamination, and evaluate the implications for student health and safety. By addressing this research gap, the study seeks to contribute to the growing body of literature on environmental health in educational settings and inform policy recommendations for safer learning environments.

2. Materials and Methods

2.1 Study Area

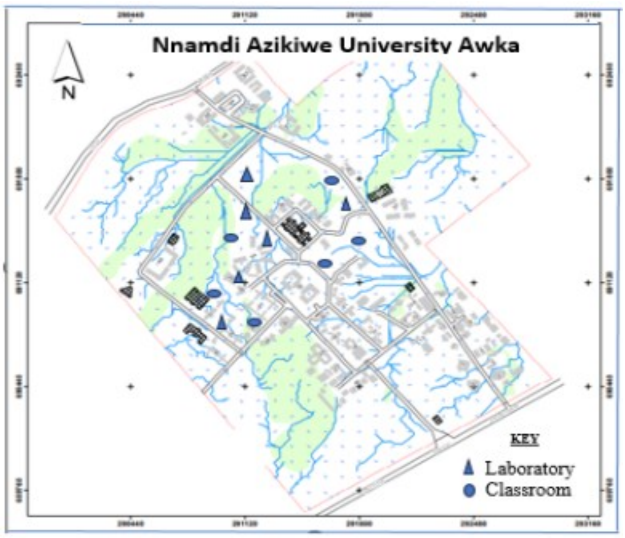

Fig 1. Map of the study area (Nnamdi Azikiwe University)

The research was conducted at Nnamdi Azikiwe University in Awka, Anambra State, Nigeria, located at geographical coordinates 6° 16' 0" North and 7° 3' 0" East. The university spans over 100 acres, featuring a rich variety of flora and fauna (Ogbodo et al., 2025). The area includes several streams, agricultural lands, numerous buildings, and forested regions. Awka is situated within Nigeria's tropical rainforest zone, experiencing two distinct seasons: the wet season from April to October and the dry season from November to March. The average temperature ranges from 28.5º C between June and December to 33º C from January to April (Okeke et al., 2021).

2.2 Material collection and preparation

In this study, a total of twelve sites were selected, consisting of six laboratory halls and six classrooms. The chosen laboratories included those for Biology, Physics, Chemistry, Biochemistry, Microbiology, and Parasitology, while the classrooms covered biology, physics, chemistry, microbiology, parasitology, and biochemistry. Indoor settled dust was used as the medium for assessing heavy metal contamination. Dust samples were collected from the window sills of both laboratories and classrooms using plastic brushes, which were then transferred into dust pans. Eight window sill per site was used. Each sill measures 100cm by 5cm. Samples from each site, weighing approximately 2g, were placed in clean, labeled polyethylene bags. The samples were then taken to the laboratory for heavy metal analysis, which involved homogenization, drying, digestion, and extraction. The analysis was performed using the Agilent FS240AA Atomic Absorption Spectrophotometer, following the methodology set forth by the American Public Health Association (APHA) in 1995 (Singhal and Singh, 2024). The study aimed to detect six heavy metals: lead (Pb), nickel (Ni), mercury (Hg), cobalt (Co), arsenic (As), and copper (Cu).

2.3 Statistical Analysis

Statistical analysis to compare the variance in heavy metal concentration in collected samples was conducted using SPSS 2020.

3. Results

The findings of the study comparing heavy

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3.1 Lead

The findings indicate that the concentration of lead (Pb) was higher in Laboratories (0.1042±0.0272 mg/kg) than in Classrooms (0.0946±0.0362 mg/kg). There was no significant difference in the mean Pb concentration among the two sample types ($p>0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Pb levels in both Classrooms and Laboratories exceeded the acceptable limit established by WHO/FAO (Figure 2).

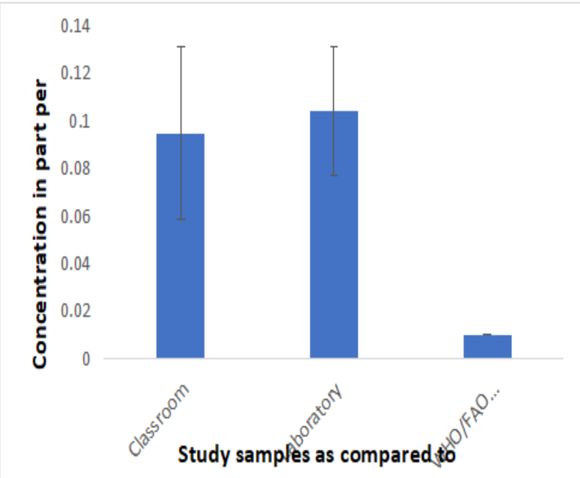

Fig 2. Concentration of Lead (ppm) in study samples as compared to WHO/FAO limit

3.2 Nickel

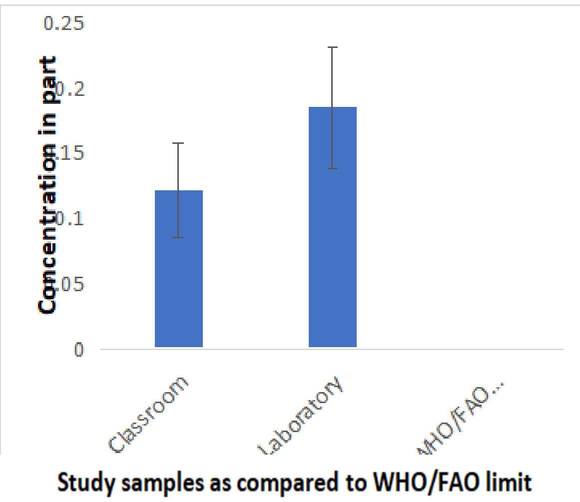

Fig 3. Concentration of Nickel (ppm) in study samples as compared to WHO/FAO limit

The findings indicate that the concentration of Nickel (Ni) was higher in Laboratories (0.1852±0.0464 mg/kg) than in Classrooms (0.1215±0.0362 mg/kg). There was no significant difference in the mean Ni concentrations among the two sample types ($p>0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Ni levels in both Classrooms and laboratories exceeded the acceptable limit established by WHO/FAO (Figure 3).

3.3. Cadmium

The findings indicate that the concentration of Cadmium (Cd) was higher in Laboratories (0.0572±0.0419 mg/kg) than in Classrooms (0.0191±0.0137 mg/kg). There was no significant difference in the mean Cd concentrations among the two sample types ($p>0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Cd levels in both the Classrooms and Laboratories exceeded the acceptable limit established by WHO/FAO (Figure 4).

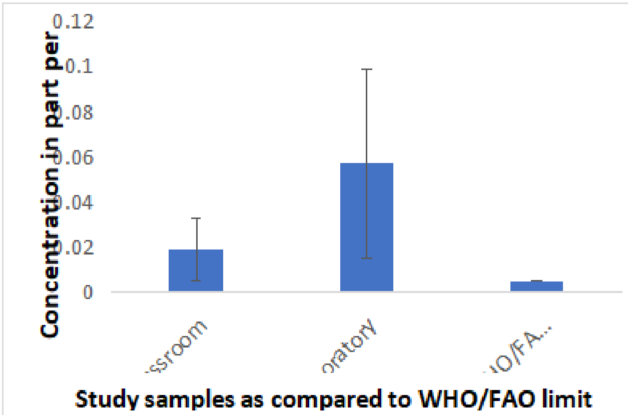

Fig 4. Concentration of Cadmium (ppm) in study samples as compared to WHO/FAO limit

3.4 Mercury

The findings indicate that the concentration of Mercury (Hg) was higher in Classroom (0.0215±0.0048 mg/kg) than in the Laboratories (0.0127±0.0031 mg/kg). No significant difference was observed in the mean Hg concentrations across the two sample types ($p>0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Hg levels in both the Classrooms and

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Laboratories exceeded the acceptable limit established by WHO/FAO (Figure 5).

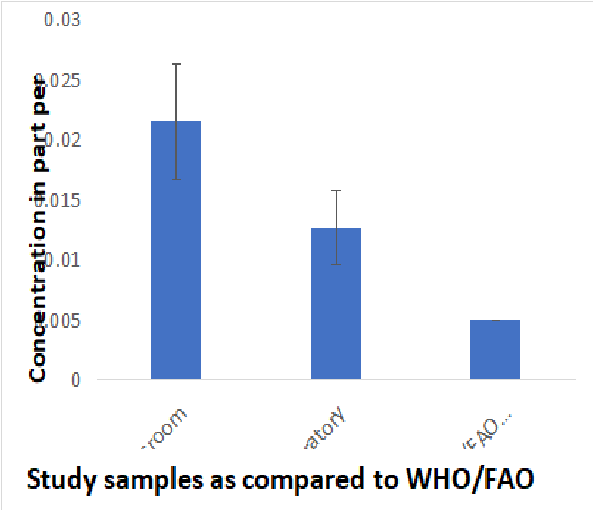

Fig 5. Concentration of Mercury (ppm) in study samples as compared to WHO/FAO limit

3.5. Cobalt

The findings indicate that the concentration of Cobalt (Co) was higher in Classrooms (0.847±0.0750 mg/kg) than in the Laboratories (0.79±0.1669 mg/kg). No significant difference was observed in the mean Co concentrations across the two sample types ($p>0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Co level in both the Classrooms and Laboratories exceeded the acceptable limit established by WHO/FAO (Figure 6).

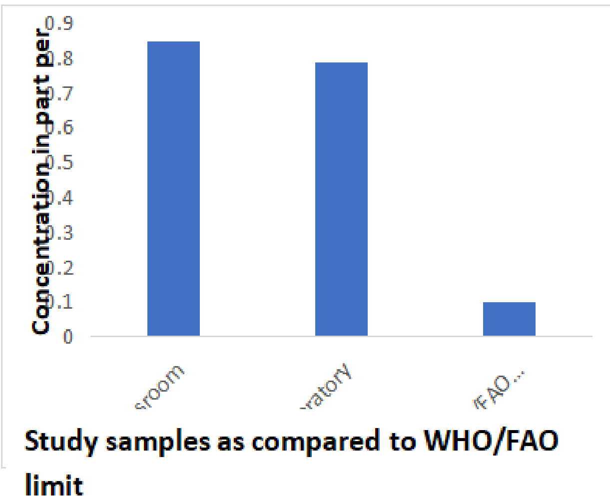

Fig 6. Concentration of Cobalt (ppm) in study samples as compared to WHO/FAO limit

3.6 Arsenic

The findings indicate that the concentration of Arsenic (As) was higher in Laboratories (0.0663±0.0233 mg/kg) than in Classrooms (0.0355±0.0152 mg/kg). There was no significant difference in the mean As concentrations among the two sample types ($p>0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average As levels in both the Classrooms and Laboratories exceeded the acceptable limit established by WHO/FAO (Figure 7).

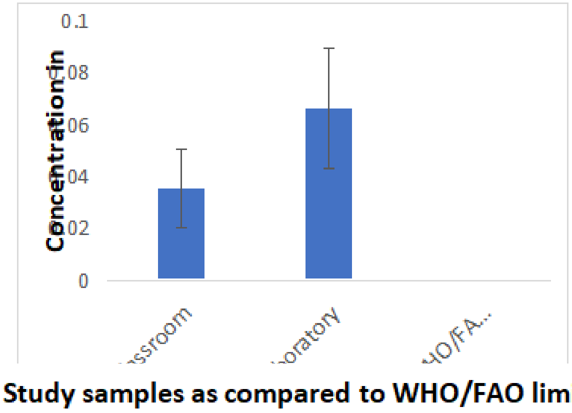

Fig 7. Concentration of Arsenic (ppm) in study samples as compared to WHO/ FAO limit

4. Discussion

The assessment of heavy metal contamination in educational environments, particularly in laboratories and classrooms, is critical for understanding potential health risks to students and staff. The findings of our study reveal concerning levels of heavy metals, including Lead (Pb), Nickel (Ni), Cadmium (Cd), Mercury (Hg), Cobalt (Co), and Arsenic (As), in both laboratories and classrooms, with concentrations exceeding the acceptable limits set by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO).

Lead (Pb) was found to be present at higher concentrations in laboratories (0.1042±0.0272 mg/kg) compared to classrooms (0.0946±0.0362 mg/kg). Although the difference was not statistically significant

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(p>0.05), both environments exhibited Pb levels above WHO/FAO standards. This finding aligns with recent literature that highlights the prevalence of Pb contamination in educational settings, often attributed to the use of lead-containing materials and inadequate ventilation systems (Dobrescu *et al*., 2022; Parra *et al*., 2024). The chronic exposure to Pb is known to have detrimental effects on cognitive development and overall health, particularly in children (WHO, 2021). This includes increased risk of learning disabilities, autism spectrum disorder (ASD), and attention deficit hyperactivity disorder (ADHD) (Desye *et al*., 2023).

Similarly, Nickel (Ni) concentrations were higher in laboratories (0.1852±0.0464 mg/kg) than in classrooms (0.1215±0.0362 mg/kg), again with no significant difference (p>0.05). The elevated levels of Ni in laboratory settings may be linked to the use of nickel-based compounds in various experiments and materials, which has been documented in recent studies (Levicka & Orlikova, 2024). The health implications of Ni exposure include respiratory issues and skin allergies, underscoring the need for monitoring and management strategies in these environments (Genchi *et al*., 2020).

The study also revealed that Cadmium (Cd) concentrations were higher in laboratories (0.0572±0.0419 mg/kg) compared to classrooms (0.0191±0.0137 mg/kg), with no significant statistical difference (p>0.05). The presence of Cd, often associated with batteries and industrial processes, raises concerns given its toxicological profile, which includes potential kidney damage and bone fragility (Hung *et al*., 2025). Both environments exceeded the WHO/FAO limits for Cd, necessitating immediate attention to reduce exposure risks.

In terms of Mercury (Hg), the concentration was higher in classrooms (0.0215±0.0048) than in laboratories (0.0127±0.0031 mg/kg), but again no significant difference was found (p>0.05). The presence of Hg, particularly in educational settings, may stem from the use of mercury-containing instruments and the improper disposal of hazardous materials (Palathoti *et al*., 2022). The neurotoxic effects of Hg, particularly in developing children, warrant stringent regulatory measures and educational interventions. Health implications include immune system alteration leading to autoimmune diseases and increased vulnerability to infection. It also includes neurocognitive deficits and neuromotor disabilities (Madera, 2023).

Cobalt (Co) levels were higher in classrooms (0.847±0.0750 mg/kg) than in laboratories (0.79±0.1669 mg/kg), yet no significant difference was observed (p>0.05). The elevated Co levels in classrooms could be linked to the use of cobalt-based pigments in art supplies and other materials commonly found in educational settings (Zamek *et al*., 2021). While Co is essential in trace amounts, excessive exposure can lead to respiratory and cardiovascular issues, highlighting the importance of monitoring (Zhu *et al*., 2021).

Finally, Arsenic (As) concentrations were higher in laboratories (0.0663±0.0233 mg/kg) than in classrooms (0.0355±0.0152 mg/kg), with no significant difference (p>0.05). The presence of As, often associated with contaminated water sources and industrial activities, poses serious health risks, including carcinogenic effects (Shokoohi *et al*., 2024). The exceedance of WHO/FAO limits in both environments calls for urgent remediation efforts. The trend of the analysis of heavy metal contamination in laboratories and classrooms indicates significant exceedances in mean values compared to WHO/FAO benchmarks. Lead (Pb), Nickel (Ni), Cadmium (Cd), Mercury (Hg), Cobalt (Co), and Arsenic (As) concentrations in both settings are markedly higher than the established safety limits. Laboratories show the highest levels, particularly for Lead (0.1042 mg/L) and Cobalt (0.79 mg/L), while classrooms also reflect concerning levels, particularly for Cobalt (0.847 mg/L). This trend underscores a pressing issue of heavy metal contamination in educational environment, necessitating immediate attention and intervention.

Conclusion

The findings of this study underscore a critical public health concern regarding heavy metal contamination in educational settings. The consistent exceed of WHO/FAO standards for multiple heavy metals in both laboratories and classrooms highlights the need for comprehensive monitoring, risk assessment, and the implementation of effective mitigation strategies. Future research should focus on identifying specific sources of contamination and developing interventions to minimize exposure, thereby safeguarding the health of students and educators alike.

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