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Full Length Research Article

ASSESSMENT OF HEAVY METAL CONTAMINATION IN SELECTED WELLS AND BOREHOLES IN AMANSEA, AWKA NORTH, ANAMBRA STATE, NIGERIA

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ABSTRACT

This study assessed heavy metal contamination in selected wells and borehole water in Amansea, Awka North, Anambra State, focusing on the concentrations of Lead (Pb), Nickel (Ni), Cadmium (Cd), Mercury (Hg), Cobalt (Co), and Arsenic (As). The Agilent FS240AA Atomic Absorption Spectrophotometer method was used. Our findings reveal that well water contains higher concentrations of Pb (0.0467±0.0233) and Ni (6.143±1.0655) compared to borehole water (Pb: 0.0095±0.0062; Ni: 4.40316±1.1099), although no significant differences were observed ($p > 0.05$). Both water sources exceeded WHO/FAO acceptable limits for Pb (0.01) and Ni (0.02). Cadmium levels were also higher in well water (0.0267±0.0091) than in borehole water (0.0157±0.0072), with both exceeding safety standards (0.003). Mercury concentrations were slightly higher in borehole water (0.1198±0.0379) than in well water (0.1175±0.0561), but again, no significant difference was noted ($p > 0.05$), with both sources surpassing acceptable limits. Cobalt levels were higher in borehole water (0.1543±0.1492) compared to well water (0.0133±0.0079), exceeding WHO/FAO limits only in borehole water. Lastly, Arsenic levels were higher in borehole water (0.0175±0.0054) than in well water (0.0155±0.0028), with both exceeding safety thresholds. These results underscore the urgent need for monitoring and remediation strategies to address heavy metal contamination in water sources, safeguarding public health in Amansea.

Keywords: Heavy metal, Water contamination, borehole, well

INTRODUCTION

Access to clean and safe drinking water is a critical component of public health. However, in many developing countries, including Nigeria, the quality of water sources remains a significant concern due to various forms of contamination. Amongst these, heavy metal contamination poses a severe risk to both human health and the environment. Heavy metals such as lead, cadmium, arsenic, and mercury can enter water sources through industrial discharges, agricultural runoff, and improper waste disposal, leading to serious health implications for communities reliant on these water sources (Sambo *et al*., 2024). Despite the growing body of literature addressing water quality in Nigeria, there remains a notable gap in comprehensive studies specifically assessing heavy metal contamination in wells and boreholes, particularly in rural and semi-urban communities. Previous research has predominantly focused on surface water quality or urban areas, leaving a significant portion of the population unexamined. For instance, studies by Ibe *et al.* (2025) and Oyebode *et al.* (2025) have highlighted the presence of heavy metals in various water bodies; however, they do not provide an in-depth analysis of groundwater sources, such as wells and boreholes, which are crucial for many households in Nigeria. The need for targeted research in this area is urgent, as communities relying on these water sources may be unknowingly exposing themselves to harmful levels of heavy metals. Recent studies have indicated alarming trends in heavy metal concentrations in groundwater across various regions in Nigeria, with implications for public health and safety (Egbueri *et al*., 2025). Amansea is experiencing rapid urban expansion that has led to significant change in land use, affecting both agricultural productivity and the natural environment. This underscores the need for effective strategies to mitigate the adverse effects of urbanization. Therefore, this study aims to assess heavy metal contamination in selected wells and boreholes in Amansea, filling the existing research gap and providing valuable insights that can inform public health policies and water management strategies.

MATERIALS AND METHODS

Study Area

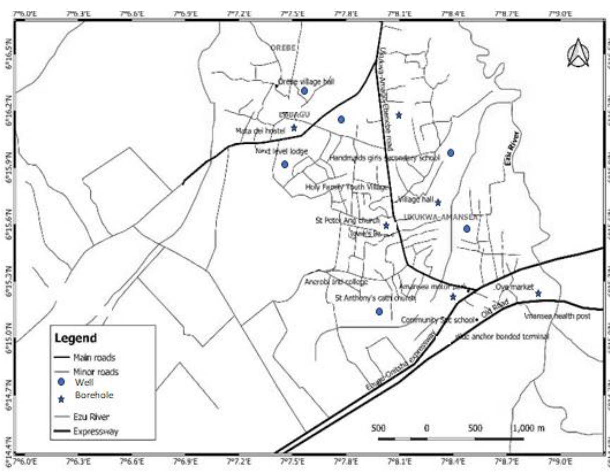

Figure 1. Map of the study area (Amansea) (Source: NAU, 2023)

The research was conducted in Amansea, a vibrant community located in Awka North Local Government Area of Anambra State, Nigeria. It is bounded in the south by Awka town, in the north by the Manu River in Ebenebe town, in the west by Mgbakwu and to the east by Ezinato/Ubibia stream. Amansea lies within 6.21° to 6.27° North latitude and 7.07° to 7.14° East longitude. The town has a relative humidity of 79.4% with an annual rainfall of 2000-3000mm (Ikeh *et al*., 2024). The area is characterized by its lush vegetation, rolling hills, and a mix of rural and semi-urban landscapes. It is within the rainforest area of Nigeria and

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experiences an annual rainfall of 1000 – 1500 mm. The area has two distinct seasons: a wet season from April to October and a dry season from November to March (Offorbuike *et al*., 2024). Amansea has experienced urbanisation, which has led to a population increase. The increase in population is due to the influx of people to Awka capital territory after the creation of Anambra State in 1991 and the proximity of the town to Awka, the seat of the government, the location of Nnamdi Azikiwe University, and the town also contributes to the increase in its population.

Sampling Protocol

For this study, a total of three wells and three boreholes were identified for assessment of heavy metal contamination. The selection criteria included proximity to potential contamination sources, such as nearness to areas of industrial activities, agricultural runoff, and urban development. Water samples were collected in the dry season to minimize variability due to seasonal changes in water quality. Sampling was conducted in the early morning hours from 7 am to 8 am to reduce the influence of diurnal variations in water quality. All sampling equipment, including 1-litre capacity glass sampling bottles, was pre-cleaned with hydrochloric acid (HCL) and rinsed with deionized water to prevent cross-contamination. Gloves were worn during the entire sampling process to avoid contamination from skin oil.

Sampling procedure

For each well, water samples were collected directly using a clean, sterilized glass sampling bottle. The bottles were submerged to a depth of approximately 1 meter below the water surface to ensure representative sampling. Each well was purged of at least three well volumes before sample collection to remove stagnant water. The bottle was sealed immediately after filling to minimize exposure to air. Each water sample was immediately stored following collection under cool conditions until analysis within 24 hours.

Prior to sampling, each borehole was purged by allowing water to flow for approximately 5 minutes before sample collection to ensure that stagnant water was flushed out. This is done to ensure that the samples reflect the current groundwater quality. Using pre-cleaned, glass sampling bottles, 1-liter samples were collected directly from the borehole outlet. Care was taken to avoid contamination by not touching the bottle openings and using gloves throughout the process. The bottle was sealed immediately after filling to minimize exposure to air. Collected samples were then stored under cool conditions until analysis within 24 hours. The methodology used followed the standard procedures outlined by APHA 2017; US EPA, 2017 to ensure accurate and reproducible results.

Sample preparation for heavy metal analysis involved filtration, dilution, acid digestion, calibration, and atomization processes. The analysis was performed using the Agilent FS240AA Atomic Absorption Spectrophotometer, following the methodology outlined by the American Public Health Association (APHA) in 1995 (Singhal and Singh, 2024). Each sample weighed 2.0 grams. The study focused on the detection of six heavy metals: lead (Pb), nickel (Ni), mercury (Hg), cobalt (Co), arsenic (As), and copper (Cu).

Statistical Analysis

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

RESULTS

The findings of the study assessing heavy metal concentration in wells and boreholes is presented below.

Lead

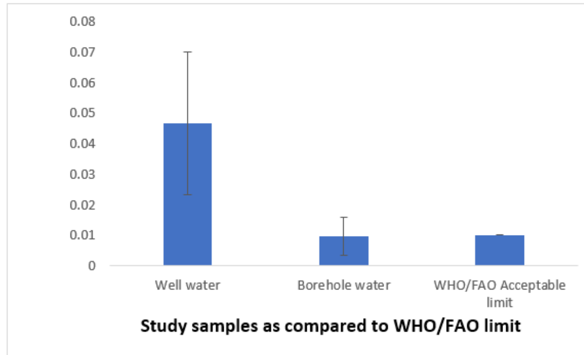

Figure 2. Concentration of Lead (ppm) in study samples as compared to the WHO/FAO limit

The findings indicate that the concentration of Lead (Pb) was higher in Well water (0.0467±0.0233) than in Borehole water (0.0095±0.0062). There was no significant difference in the mean Pb concentrations among the two sample types ($p > 0.05$). Furthermore, when compared to the standards set by WHO/FAO, the average Pb level in Well water was above the acceptable limit established by WHO/FAO (0.01), while the Borehole water was not.

Nickel

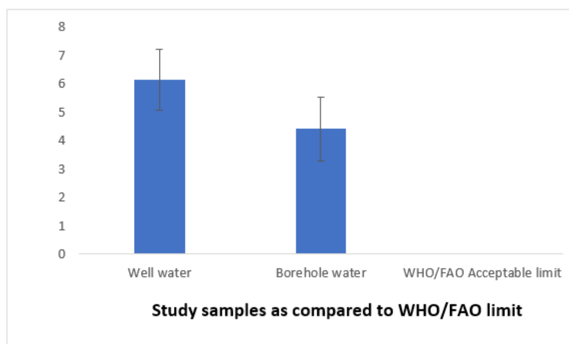

Figure 3. Concentration of Nickel (ppm) in study samples as compared to the WHO/FAO limit

The findings indicate that the concentration of Nickel (Ni) was higher in Well water (6.143±1.0655) than in Borehole water (4.40316±1.1099). 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 Well water and Borehole water exceeded the acceptable limit established by WHO/FAO.

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Cadmium

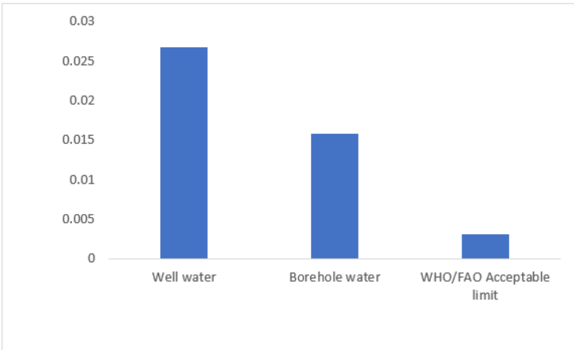

Figure 4. Concentration of Cadmium (ppm) in study samples as compared to the WHO/FAO limit

The findings indicate that the concentration of Cadmium (Cd) was higher in Well water (0.0267±0.0091) than in Borehole water (0.0157±0.0072). 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 (0.003 ppm), the average Cd levels of both Well and Bore-hole water exceeded the acceptable limit established by WHO/FAO

Mercury

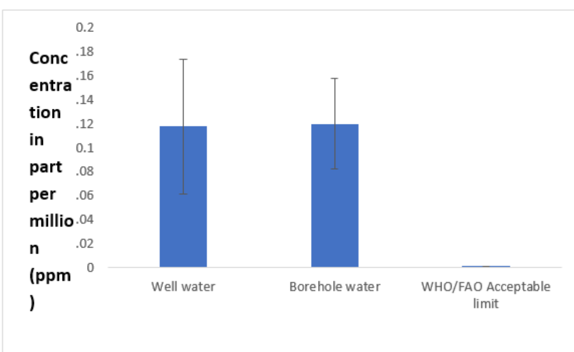

Figure 5. Concentration of Mercury (ppm) in study samples as compared to the WHO/FAO limit

The findings indicate that the concentration of Mercury (Hg) was slightly higher in Borehole water (0.1198±0.0379) than in Well water (0.1175±0.0561). 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 well water and Borehole water exceeded the acceptable limit established by WHO/FAO

Cobalt

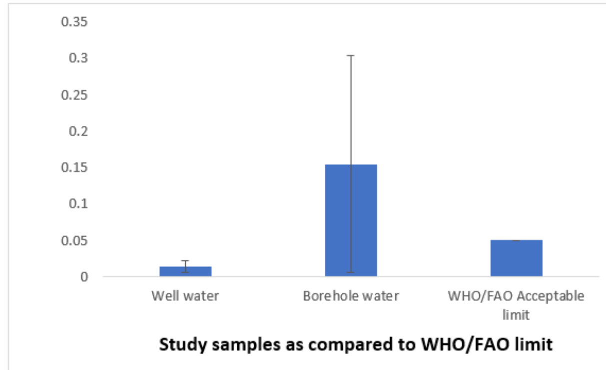

Figure 6. Concentration of Cobalt (ppm) in study samples as compared to the WHO/FAO limit

The findings indicate that the concentration of Cobalt (Co) was higher in Borehole water (0.1543±0.1492) than in Well water (0.0133±0.0079). 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 levels in Borehole water exceeded the acceptable limit established by WHO/FAO, while those of well water did not.

Arsenic

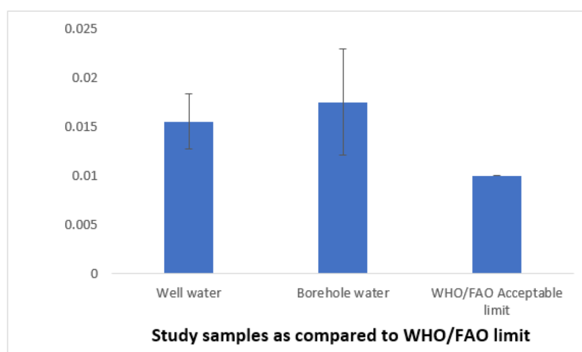

Figure 7. Concentration of Arsenic (ppm) in study samples as compared to the WHO/FAO limit

The findings indicate that the concentration of Arsenic (As) was higher in Borehole water (0.0175±0.0054) than in Well water (0.0155±0.0028). 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 Well and Borehole water were above the acceptable limit established by WHO/FAO.

DISCUSSION

The assessment of heavy metal contamination in selected wells and boreholes reveals critical insights into water quality and potential health risks for communities relying on these water sources. The findings indicate varying concentrations of heavy metals, including Lead (Pb), Nickel (Ni), Cadmium (Cd), Mercury (Hg), Cobalt (Co), and Arsenic (As), with implications for public health, environmental safety, and future research directions.

Lead (Pb) Concentration: The study found that the concentration of Lead was significantly higher in well water (0.0467±0.0233) compared to borehole water (0.0095±0.0062), although the difference was not statistically significant ($p > 0.05$). Importantly, the average Pb levels in well water exceeded the acceptable limit set by WHO/FAO, while borehole water did not. The elevated levels of Lead in well water pose a serious health risk, particularly for vulnerable populations such as children and pregnant women, as lead exposure can lead to developmental issues and neurological damage (Ajibola *et al*., 2024; Bjørklund et al., 2024). The implication of these findings suggests an urgent need for remediation strategies and public health interventions to minimize exposure to lead in drinking water sources.

Nickel (Ni) Concentration: Nickel concentrations were also higher in well water (6.143±1.0655) compared to borehole water (4.40316±1.1099), with no significant difference ($p > 0.05$). Both sources exceeded WHO/FAO acceptable limits. Nickel exposure can lead to respiratory issues and skin allergies, and chronic exposure may result in more severe health effects (Khan *et al*., 2022). The findings suggest a pressing need for water quality assessments and public health interventions to mitigate nickel exposure from drinking water.

Cadmium (Cd) Concentration: The concentration of Cadmium was higher in well water (0.0267±0.0091) than in borehole water (0.0157±0.0072), with no significant difference ($p > 0.05$). Both sources exceeded acceptable limits. Cadmium is known for its toxic effects on kidneys and bones, and its presence in drinking water is a significant public health concern (Charkiewicz *et al*., 2023). The results highlight the necessity for community education on the risks of cadmium exposure and the implementation of filtration systems to reduce cadmium levels in drinking water.

Mercury (Hg) Concentration: Mercury concentrations were slightly higher in borehole water (0.1198±0.0379) compared to well water (0.1175±0.0561), with no significant difference ($p > 0.05$). Both sources exceeded WHO/FAO limits. Mercury is highly toxic and can cause neurological and developmental damage (Wu *et al*. 2024). The findings necessitate urgent action to monitor and mitigate mercury contamination, particularly in areas where industrial activities may contribute to water pollution.

Cobalt (Co) Concentration: Cobalt concentration was higher in borehole water (0.1543±0.1492) than in well water (0.0133±0.0079), with no significant difference ($p > 0.05$). The average cobalt levels in borehole water exceeded acceptable limits. While cobalt is an essential trace element, excessive exposure can lead to adverse health effects, including respiratory and cardiovascular issues (Lundin *et al*., 2023). The results indicate a need for further investigation into the sources of cobalt contamination and potential health risks associated with long-term exposure.

Arsenic (As) Concentration: Arsenic levels were higher in borehole water (0.0175±0.0054) than in well water (0.0155±0.0028), with no significant difference ($p > 0.05$). Both sources exceeded acceptable limits. Arsenic is a known carcinogen and can cause various health problems, including skin lesions and developmental effects (Ozturk *et al*., 2022; Ganie *et al*., 2024). The findings emphasize the importance of regular arsenic testing in drinking water supplies and the need for community awareness programs about the dangers of arsenic exposure.

The findings of this study highlight the urgent need for ongoing monitoring of heavy metal concentrations in both well and borehole water sources in Amansea. Future research should focus on identifying the sources of contamination, assessing the long-term health impacts of exposure, and developing effective remediation strategies. Additionally, public health initiatives aimed at educating communities about the risks associated with heavy metal exposure and promoting safe water practices are essential.

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