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Determination Of Heavy Metal Contents of Some Selected Borehole Water in Ubomu Community of Idah Local Government Area

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Abstract- This study was undertaken to assess/determine the concentration of some heavy metals of selected borehole water in Ubomu community in Idah LGA of Kogi State. Four water samples were collected from different points in the community. All the samples were analyzed for heavy metal concentration. The result obtained showed that some of the heavy metals determined were within the WHO/NSDWQ permissible limit for drinking water. The concentration of lead determined was 0.00mg/L indicating that the water was free of lead contamination. The concentration of zinc, copper and iron were within the WHO/NSDWQ permissible limit, whereas, the concentration of selenium, arsenic was above the WHO/NSDWQ permissible limits. Therefore, the water could be toxic for human consumption.

Keywords: Water, Heavy Metals, WHO, Concentration, Toxic

I. INTRODUCTION

Water is undeniably one of the most essential resources for sustaining life. lt plays a vital role in domestic use, agriculture, industry, and environmental balance. As the global population continues to grow, so does the demand for clean and safe water. However, access to potable water remains a significant challenge, particularly in developing countries where water infrastructure is either underdeveloped or poorly maintained (Olanrewaju & Eze, 2021). In many parts of sub-Saharan Afica, including Nigeria, millions of people still rely on untreated sources such as rivers, streams, wells, and boreholes for their daily needs (Animashaun *et al*., 2024).

Unfortunately, these water sources are increasingly exposed to contamination from both natural and anthropogenic activities. The rise in industrialization, poor waste disposal practices, agricultural runoff and open defecation have contributed significantly to the degradation of water quality (Akhtar *et al.,* 2021). When water becomes contaminated, it can serve as a medium for disease transmission or as a source of toxic substances, placing both human health and environmental stability at risk.

Groundwater, often accessed through boreholes, is generally considered safer than sůrface water due to natural filtration through geological layers. Nevertheless, this perception is not always accurate as groundwater can also be contaminated by pollutants from surface sources, 1eaking septic systems, or geological leaching of heavy metals (1brahim et al. 2024). Such contaminants are often colorless, tasteless, and odorless, making them difficult to detect without laboratory analysis. Long-term exposure to polluted water may result in serious health complications such as kidney damage, neurological disorders, productive problems, and cancer (Okoye *et al.,* 2023). Access to safe and clean water remains a persistent issue in many parts of Nigeria. In numerous rural and peri-urban areas, borehole water has become the most accessible source for drinking and domestic used. Unfortunately, due to inadequate environmental protection measures and a lack of regular water quality assessment, the safety of these water sources cannot be guaranteed (Sanimu & Hassan, 2020). Over time, groundwater sources can become compromised by agricultural residues, industrial effluents, and leachates from refuse dumps, which introduce harmful substances including heavy metals into the water system. These contaminants are not only hazardous but can accumulate in the body leading to chronic health effects (Agu & Nwachukwu, 2023). Despite these risks, there is limited published data on borehole water quality in many Nigerian communities. This gap in information makes it difficult to identify high-risk areas or implement timely interventions. There is therefore, the need to examine the physicochemical quality of borehole water and assess potential contamination from heavy metals. Without such studies. individuals may continue to consume water that silently undermines their health. The aim of this study is to determine the heavy metal content of some selected borehole water in Ubomu Community of Idah Local Government Area, Kogi State.

Heavy Metals

Heavy metals are metallic elements with high atomic weights and densities that are toxic or poisonous even at low concentrations. In borehole water, the presence of heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), arsenic (As), mercury (Hg), iron (Fe), and manganese (Mn) is a significant concern due to their potential adverse health and environmental impacts (Tchounwou et al., 2012; Oyem et al., 2015; Laoye et al., 2025) These metals may occur naturally through geochemical weathering of rocks and soil or be introduced anthropogenically through industrial discharge, agricultural runoff, mining activities, and leaching from waste disposal sites (Okoye & Akpan, 2022). According to the World Health Organization (WHO, 2017), heavy metals are among the most dangerous contaminants in drinking water due to their non- biodegradable nature and ability to accumulate in the food chain. Chronic exposure to these metals has been linked to a wide range of health issues including cancer, kidney failure, neurological disorders, liver damage, and reproductive problems. For instance, lead is a potent neurotoxin that affects brain development in children, while cadmium can cause kidney and bone damage (WHO, 2021).

It was reported by Umeh *et al.,* (2023)) that borehole water samples in the Niger Delta region of Nigeria showed elevated levels of lead and iron, often exceeding WHO and Nigerian Standards for Drinking Water Quality (NSDWQ) permissible limits. The sources of contamination were linked to oil exploration activities and improper waste management practices. Based on recent findings by Musa et al. (2023), heavy metals such as chromium and cadmium were detected in borehole water in the North-Central region of Nigeria at concentrations ranging from 0.002 mg/L to 0.015 mg/L for Cr and 0.001 mg/L to 0.009 mg/L for Cd. While some values were within permissible limits, the researchers warned of possible cumulative effects, especially in communities relying solely on borehole water for all domestic purposes. The NSDWQ (2015) and WHO (2021) have established guideline values for various heavy metals in drinking water to ensure public safety. For example, the maximum allowable concentrations for lead, cadmium, and chromium in drinking water are 0.01 mg/L, 0.003 mg/L, and 0.05 mg/L respectively (WHO, 2021). Exceeding these thresholds is considered unsafe and warrants immediate intervention. Furthermore, Olaniran and Ogunbode (2022) emphasized that heavy metal contamination in borehole water can also result from corrosion of metal pipes, especially in old or poorly maintained distribution systems. This adds to the risk in urban areas where water infrastructure is outdated or exposed to chemical leaching. Effective mitigation strategies include regular monitoring, public education. proper siting and construction of boreholes away from industrial and waste sites and the use of advanced treatment technologies such as reverse osmosis. activated carbon filtration, and chemical precipitation. In regions prone to heavy metal contamination, alternative water sources or treatment at the point of use may be necessary to safeguard public health.

Arsenic (As)

Arsenic is a naturally occurring toxic metalloid found in the Earth's crust and can enter groundwater systems through both geogenic and anthropogenic processes. According to the World Health Organization (WHO, 2017), arsenic contamination in groundwater is a nmajor concern globally, particularly in regions with high geological arsenic content. Arsenic exists mainly in two Oxidation states in water: arsenite (As*) and arsenate (Asst), with arsenite being more toxic. Based on findings by Hong et al., (2014); Rao et al., (2017), long-term consumption of arsenic- contaminated water has been associated with various health issues including skin lesions, cancer (particularly skin, lung, and bladder), cardiovascular diseases, and neurotoxicity. The WHO guideline limit for arsenic in drinking water is 0.01 mg/L. However, it was reported by Samaila, (2026) that borehole water in certain Nigerian communities had arsenic concentrations ranging between 0.015 and 0.065 mg/L, exceeding the permissible limit. According to Ibe and Al-Amshawee *et al*., (2020), arsenic contamination may result from pesticide use, industrial effluents, and natural leaching from arsenic-bearing minerals. Remediation methods include coagulation-flocculation, adsorption using activated alumina, and membrane filtration techniques.

Zinc (Zn)

Zinc is an essential trace element required for human metabolic functions. including enzyme activity and immune system regulation. It is naturally found in rocks and soil and can enter groundwater through the weathering of zinc- containing minerals or anthropogenic sources such as corrosion of galvanized pipes and industrial discharges (Ogunfowokan *et al.,* 2020). Although not highly toxie at low levels, excessive zinc concentrations in drinking water can cause health effects such as nausea, vomiting, and gastrointestinal irritation (WHO, 2017). The WHO and Nigerian Standard for Drinking Water Quality (NSDWO) set the permissible limit of zinc in potable water at 3.0 mg/L. A study by Agoro *et al*., (2020) on borehole water samples in southeastern Nigeria showed zinc levels ranging from 0.15 to 2.87 mg/L, which were within acceptable limits. However, elevated levels have occasionally been reported in areas near mining or industrial operations.

Iron (Fe)

Iron is one of the most abundant elements in the Earth's crust and is frequently detected in groundwater, including borehole water. It commonly enters aquifers through the dissolution of iron-bearing minerals, especially in reducing (low Oxygen) conditions (Olatunji et al., 2020). While iron is not classified as a primary contaminant, it can affect the aesthetic and operational quality of drinking water. Excess iron in water can cause metallic taste, staining of laundry and plumbing fixtures, and support the growth of iron bacteria, which produce slime and foul odors (WHO, 2017). The World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) recommend a maximum acceptable limit of 0.3 mg/L for iron in drinking water based on aesthetic Concerns. According to a study by Olajide et al. (2020), borehole water samples in parts of northern Nigeria showed iron concentrations ranging from 0.12 to 1.45 mg/L n 21 several cases, the values exceeded the WHO permissible limit, indicating possible geogenic contamination or corrosion of iron pipes. Although iron is an essential micronutrient, excessive intake over timne may contribute to health issues such as hemochromatosis in susceptible individuals (Umeh et al., 2023), Thus, regular monitoring of borehole water is important, particularly in iron-rich geological formations.

Selenium (Se)

Selenium is a naturally occurring netalloid found in sedimentary rocks and soils. In trace amounts, it is essential for human health, playing a role in antioxidant defense systems and thyroid hormone metabolism. However, at elevated concentrations, selenium becomes toxic and may lead to adverse health effects such as hair and nail britleness, gastrointestinal disturbances, and neurological abnormalities (WHO, 2017). Selenium can enter borehole water through natural leaching from selenium-rich rocks, industrial waste discharge, and agricultural runoff, especially from areas where selenium-containing fertilizers or pesticides are used (Rosen et al., 2023). Its presence in groundwater is often influenced by geochemical conditions such as pH and redox potential. The WHO guideline value for selenium in drinking water is 0.04 mg/L, and the same value is adopted by the Nigerian Standard for Drinking Water Quality (NSDWO). Most borehole water studies in Nigeria report selenium concentrations below this limit. For example, Plant *et al*., (2014) found selenium levels in boreholes in Ondo State ranging from 0.005 to 0.025 mg/L, indicating minimal health risk in that region.

Despite its low detection freguency, the potential for selenium toxicity at higher concentrations underscores the need for regular water quality assesSments, especially in areas with known selenium-rich geology or industrial influence.

Cadmium (Cd)

Cadmium is a highly toxic heavy metal that poses significant risks to human health even at very low concentrations, It is not essential for any known biological function and is primarily' introduced into groundwater through anthropogenic sources such as mining activities, industrial waste disposal, corrosion of galvanized pipes, and phosphate fertilizers (Ogundele *et al.,* 2021). Natural weathering of cadmium-bearing rocks may also contribute to its presence in borehole water. Cadmium exposure through drinking water has been linked to serious health conditions including kidney dysfunction, skeletal damage (Itai-Itai disease), and various forms of cancer (WHO, 2017). Due to its toxicity, the World Health Organization (WHO) and the Nigerian Standard for 5Drinking Water Quality (NSDWQ) set the maximum permissible concentration of cadmium in potable water at 0.003 mg/L. In sevetal parts of Nigeria, cadmium contamination in borehole water has been a concern. For instance, Ezeh et al. (2022) observed cadmium concentrations above the recommended limits in boreholes near industrial zones in Rivers State. This highlights the importance of monitoring and controlling cadmium sources, particularly in urban and agriculturally intensive areas.

Copper (Cu)

Copper is a naturally occurring metal that is essential in small amounts for human health, playing a role in enzymatic reactions, iron metabolism, and connective tissue development. However, when present in excess, it can lead to adverse health effects such as gastrointestinal irritation, liver and kidney damage, and in extreme cases, Wilson's disease, a genetic disorder causing copper accumulation in tissues (WHO, 2017). Copper typically enters borehole water through the corrosion of copper plumbing, mining activities, and industrial discharge. It may also result from leaching of copper-bearing minerals in the subsurface (Afolabi & Akinlolu, 2021). In groundwater systems, copper is mnore likely to be found in acidic conditions or in the presence of oxidizing agents. The World Health Organization (WH0) and the Nigerian Standard for Drinking Water Quality (NSDWQ) recommend a maximum allowable concentration of 2.0 mg/L of copper in drinking water. Concentrations beyond this level can affect taste, color, and safety of the water. Studies from urban boreholes in Lagos and Delta States have reported varying copper levels, with most remaining below permissible limits. However, cases of elevated copper levels have been associated with aging plumbing systems and nearby industrial waste disposal (Chukwu *et al.,* 2020). Copper levels in borehole water, while often overlooked, are critical in determining the safety and palatability of drinking water supplies.

Materials and Methods

Materials and Apparatus

Some of the materials employed in the course of this research include: Atomic Absorption Spectrophotometer (AAS) , Conical flasks, burettes, pipettes, beakers, Hot plate, filter paper, and Whatman No. 42 Glass desiccator, Sample containers, Distilled water, Concentrated nitric acid (HNO_3), Eriochrome Black T, Ethylenediaminetetraacetic acid (EDTA), Standard metal solutions. All laboratory analyses were conducted using standard procedures recommended by the American Public Health Association (APHA, 2017)

Sample Collection

The study was conducted in Ubomu community, situated within Idah Local Government Area of Kogi State, Nigeria. The community is a semi-rural area characterized by dispersed settlements, small-scale farming, and growing residential expansion. Due to the absence of reliable pipe-borne water supply, most inhabitants rely on borehole water for drinking, cooking, and general domestic use. This heavy reliance necessitates the evaluation of the water quality in terms of its physicochemical properties and possible contamination by heavy metals. Water samples were collected in clean sterilized 1 litre plastic bottles. Prior to collection, the bottles were rinsed thoroughly with the borehole water from the respective sampling points. The boreholes were allowed to pump for 10 minutes before collection to obtain a representative sample. The bottles were tightly capped, labelled as samples A, B, C, and D. Immediately after collection, the samples were preserved by acidifying them with a few drops of concentrated nitric acid to reduce the pH to below 2. This step helped to prevent microbial growth, precipitation, and adsorption of metals onto the container walls. All samples were stored in an ice-cooled container at approximately 4°C. They were then transported to the chemistry laboratory in the department of Science Laboratory technology, Federal Polytechnic, Idah, Kogi State for analysis within 24 hours to maintain sample integrity.

Heavy Metal Analysis Using Atomic Absorption Spectrophotometer (AAS)

To determine the concentration of heavy metals (Selenium, Cobalt, Arsenic, Copper, Cadmium, Zinc, and Iron), each water sample was first subjected to wet acid digestion. Precisely 100 mL of the water sample was poured into a digestion flask, and 5 mL of concentrated nitric acid (HNO;) was added. The mixture was heated gently on a hot plate in a fume cupboard until a clear solution was obtained, indicating complete digestion. The digest was then cooled, filtered using Whatman No. 42 filter paper, and the volume made up to 100 mL with deionized water. Each digested sample was then introduced into the Atomic Absorption Spectrophotometer (AAS), which had been pre-calibrated using standard metal solutions. The respective metal concentrations were measured at their characteristic wavelengths: Selenium (Se) at 196.0 nm, Arsenic (As) at 193.7 nm, Cadmium (Cd) at 228.8 nm, Cobalt (Co) at 240.7 nm, Copper (Cu) at 324.8 nm. Zinc (Zn) at 213.9 nm, and Iron (Fe) at 248.3 nm. The results were recorded in mg/L.

Quality Control and Quality Assurance

All equipment used in the analysis was calibrated daily before use. Blank samples and standard reference materials were analyzed alongside real samples. Triplicate analyses were conducted to minimize random errors. All reagents used were of analytical grade, and glassware was washed thoroughly, soaked in nitric acid overnight, and rinsed with deionized water before use.

Data Analysis

The data obtained from the laboratory analysis were compiled and analysed using Microsoft Excel 2019. The mean and standard deviation for each parameter were calculated, and the results were compared with the World Health Organization (WHO, 2017) and Nigerian Standard for Drinking Water Quality (NSDWO, 2015) guidelines. Tables were used where necessary to show comparative variations across the sample points.

Table 1: Heavy Metal Concentrations in Borehole Water Samples Compared with WHO and NSDWO Standards

Heavy Metal	Sample A (mg/L)	Sample B (mg/L)	Sample C (mg/L)	Sample D (mg/ L)	WHO Limit (mg/L)	NSDWQ Limit (mg/L)
Selenium	0.020	0.036	0.0738	0.480	0.010	0.010
Zinc	0.020	0.080	0.110	0.150	3.000	3.00p
Cadmium	0.0001	0.0008	0.0012	0.0015	0.003	0.003
Cobalt	-0.005	-0.008	-0.006	-0.004	0.070	ND
Arsenic	0.2412	0.2725	0.2468	0.3349	0.100	0.100
Iron	0.2283	0.7276	0.5716	0.2984	0.300	0.300
Copper	0.0023	0.0034	0.0036	0.007	2.000	1.000

Conclusion

This study was conducted to determine heavy metal concentration of borehole water in Ubomu Community of Idah Local Government Area, Kogi State. The results obtained revealed that some of the heavy metals analysed were within the WHO/NSDWQ permissible limit for drinking water while some were above the limit. The level of lead determined were 0.00mg/L indicating that the water samples were free of lead contamination. Cobalt concentration in the water samples was below detectable value. This is an importance result as human health is directly affected by what it consumes and longtime exposure of these heavy metals may result to some health threats. So monitoring heavy metals in water is essential in order to prevent excessive buildup of these metals in human system.

Recommendations

Based on the findings of this study, it is recommended that efforts be made to regularly monitor the water quality and also to increase public awareness on proper water handling and storage practices at the household level to minimize the risk of secondary contamination. The community should be sensitized on the importance of treating water before use. Local authorities and public health officials are encouraged to strengthen protection measures around water sources to prevent contamination from human and environmental activities. Furthermore, relevant government agencies and non-governmental organizations should support the community with resources for routine water analysis and small-scale water treatment facilities. Ensuring the sustainability of safe drinking water in Ubomu Community requires a collaborative effort involving the community members, public health experts, environmental officers, and policy-makers.

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