Geochemical Investigation of the Concentration of Some Metals in Well Water, Malete, Kwara State

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DOI : https://doi.org/10.51583/IJLTEMAS.2024.131233

Received: 31 December 2024; Accepted: 08 January 2025; Published: 23 January 2025

Abstract: Access to safe and clean drinking water is essential but underground water contamination by some (heavy) metals poses a serious threat to water quality in many areas. This research focus was to analyze the concentration of various metals in underground water samples obtained from different locations in Malete, Kwara State, Nigeria. The metals of interest include lead (Pb), chromium (Cr), manganese (Mn), uranium (U), and cobalt (Co), which are associated with adverse health and environmental effects, such as cancer and other forms of diseases. Through atomic absorption spectrophotometry (AAS), the samples collected from Westend 1, Westend 2, Yidi road, New Yidi road, and School Road were analyzed to assess the concentration of some metals that can pose health risks. The results showed that the average lead (Pb) concentration across samples was 0.07 mg/L, chromium (Cr) was 0.02 mg/L, the average manganese (Mn) concentration was 0.16 mg/L, Uranium (U) averaged at 0.02 mg/L and Cobalt (Co) was found at an average concentration of 0.03 mg/L. The results were compared with the World Health Organization (WHO) drinking water quality standards. Chromium (Cr) concentration was below the WHO standard of 0.05 mg/L suggesting a low risk of chromium toxicity. while other metals were above the standard. Hence ,the results identified potential sources of metal contamination and represents a significant step toward addressing the environmental and health challenges posed by some metals contamination in Malete.

I. Introduction

Groundwater, often referred to as the hidden treasure beneath the Earth's surface, is a vital resource for drinking, irrigation, and industrial activities. Groundwater serves as one of the most essential resources, especially in areas where surface water resources are limited. In many rural and semi-urban regions, well water is the primary source of potable water. However, groundwater resources are increasingly threatened by contamination from both natural and anthropogenic sources. Heavy metals and radioactive element such as Uranium contamination of groundwater is a significant concern due to the potential adverse effects on human health and the environment. Metals such as lead (Pb), chromium (Cr), manganese (Mn), cobalt (Co), and uranium (U) are toxic even at low concentrations, posing a range of health risks, including neurological disorders, kidney damage, and cancers (Renner, 2010; Rasaee *et al*., 2007; Tchounwou *et a*l., 2012).

In Nigeria, groundwater contamination is exacerbated by industrial activities, agricultural practices, and improper waste disposal. The reliance on untreated water sources, such as wells, exposes communities to elevated levels of toxic metals, often surpassing the permissible limits established by the World Health Organization (WHO) and national standards (Edema *et al*., 2001). In the Malete area of Moro Local Government, Kwara State, many residents depend on well water for drinking and domestic purposes, making it essential to assess the safety and quality of this vital resource.

Heavy metals, although naturally occurring, can enter the groundwater system through various pathways. Geochemical processes such as the weathering of mineral-rich rocks can contribute to the natural presence of metals in water. However, human activities, such as industrial discharges, mining, and the use of chemical fertilizers in agriculture, are significant contributors to metal contamination (Guevara-Riba *et al*., 2004). In Malete, as in many rural communities, the absence of effective wastewater treatment systems and proper waste management practices exacerbates the problem of metal pollution in groundwater. In addition to human health risks, metal contamination can have detrimental effects on the environment. Metals such as lead and mercury can accumulate in the food chain, affecting soil quality, aquatic ecosystems, and biodiversity (Arpong et al., 2009; Arporg et al., 2009). The persistence of metals in the environment, due to their resistance to biodegradation, leads to long-term ecological damage.(Oyebanji et al., 2019). Therefore, understanding the sources and pathways of heavy metal contamination is crucial for protecting both human health and the environment (Mohan and Pihman, 2013).

In literature, geophysical and geochemical methods provide valuable tools for investigating groundwater contamination such as Electrical Resistivity Tomography (ERT). By integrating geochemical techniques with geophysical data, researchers have gained a comprehensive understanding of the factors influencing metal concentration in groundwater. These methods help identify contamination sources, delineate contamination pathways, and assess the impact of geological formations on the distribution of metals in groundwater (Umeoguaju *et al*., 2021).

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue XII, December 2024

The quality of groundwater is of significant concern globally, particularly in areas where well water serves as the primary source for domestic, agricultural, and industrial purposes. Geophysical and geochemical techniques, primarily used for subsurface exploration, have proven instrumental in investigating groundwater contamination, its sources, and distribution (Edema *et al*., 2005;.Allan, 2005; Paul, 2005). These methods provide valuable insights into the movement, distribution, and concentration of contaminants, such as heavy metals, that pose significant risks to human health and the environment (Hopanhayn 2006; Jackson *et al*., 2010; Reimer *et al*., 2012)..

In this research, some metals, including lead (Pb), chromium (Cr), manganese (Mn), Uranium (U), and cobalt (Co), are of particular concern due to their toxic nature, even in trace concentrations (Hussey *et al*., 2005; Chang *et al*., 2010; Johnson *et a*l., 2013) . These elements can originate from natural processes, such as the weathering of mineral-rich rocks, or anthropogenic activities, including industrial discharges, agricultural runoffs, and improper waste disposal. Once introduced into groundwater systems, heavy metals can persist for extended periods, accumulating in living organisms and causing long-term health and ecological impacts (Andrianisa *et al*., 2008; .Benard, 2008;

By contributing to the understanding of metal contamination in Malete, this study underscores the importance of regular monitoring and proactive measures to mitigate the risks posed by toxic metals in drinking water. It also aligns with broader efforts to ensure sustainable water management in rural and semi-urban communities in Nigeria.

In this study, we apply a geochemical perspective to investigate the concentration of some metals in well water within Malete, Moro Local Government Area, Kwara State, Nigeria. This region relies heavily on groundwater due to the limited availability of surface water, making it crucial to assess the water's safety for consumption and use.

II. Materials and methods

Sample collection and treatment

The well water sample was collected from 5 wells within different zones in Malete, Moro local government, Kwara state, Nigeria with 1 litre which was sterilized with HCl before collection to rid the container of any contaminants. A drop of HCl was added to the well water sample for prevention against microbial invasion and to retain the nutrient in the sample. The sample was transported to the laboratory in a cooler lined with ice block so as to help maintain the well water normal temperature which is 28^{o}C. All the glass wares used for this analysis were washed and cleaned to remove any trace of impurities in them. After washing, the glass wares were kept in oven to 110 ^{o}C until they were needed for the analysis.

Determination of the Concentration of Lead

10 ml of the water sample was measured into a 100 ml conical flask and 6 drops of 10% potassium cyanide was added to it, followed by 25 ml of ammonium sulphate and 0.5 ml of 10% $NaS0_4$ (Sodium sulphate), The solution was made up to 50 ml mark with distilled water and its absorbance was measured at a wavelength of 430 nm using Ultraviolet-visible spectrophotometer

Calculation

$$\frac{Concentration X\ dilution\ \ factor\ X\ 1000}{1000\ X\ volume\ of\ H_{20}} \quad (mg/L).$$

Determination of the Concentration of Chromium

10 ml of water sample was measured into a 100 ml volumetric flask and 10 ml of 0.01 M NH_4 OH was added to flask containing the water, 5 ml of 0.01 M EDTA was also added and the solution was made up to 50ml with distilled water. The absorbance was measured at a wavelength of 307.6 nm.

Determination of the Concentration of Manganese

10 ml of water sample was weighted into a 100 ml volumetric flask and 10 ml 10% potassium cyanide was added, the solution was made up to 50 ml with distilled water and its absorbance was measure at a wavelength of 346.2 nm using an Ultraviolet – visible spectrophotometer.

Determination of the Concentration of Cobalt

10 ml of the water sample was weighed into 50 ml volumetric flask and 0.01 M NH_4 OH was added to it and the solution was made up to 50 ml mark with distilled water and its absorbance was measured at the wavelength 620 nm using Ultraviolet-visible spectrophotometer.

III. Results and discussion

The concentrations of metals in well water samples from five locations in Malete, Moro, were determined using Atomic Absorption Spectrophotometry (AAS). The data highlights variations in the levels of Lead (Pb), Chromium (Cr), Manganese (Mn), Uranium (U), and Cobalt (Co) across the sampled sites. These results were compared with the WHO standards for drinking water quality (Table 1), Edition, F. (2011).

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue XII, December 2024

Table 1: Concentration of some heavy metals and radioactive element in well water samples from Malete, Moro local government..

Location	**Pb (mg/L)**	**Cr (mg/L)**	**Mn (mg/L)**	**U (mg/L)**	**Co (mg/L)**
Westend 1	0.05	0.02	0.15	0.01	0.03
Westend 2	0.08	0.03	0.18	0.02	0.04
Yidi road	0.06	0.01	0.12	0.01	0.02
New Yidi Road	0.07	0.02	0.14	0.02	0.03
School Road	0.09	0.04	0.20	0.03	0.05
WHO standard (mg/L)	0.01	0.05	0.40	0.03	0.07

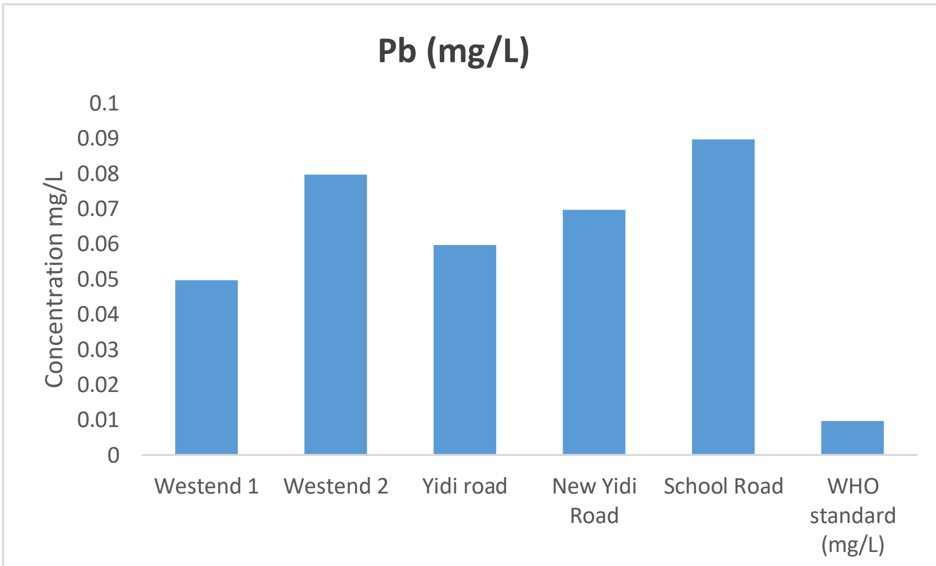

Figure 1: Chart showing the concentration of Pb in all selected locations

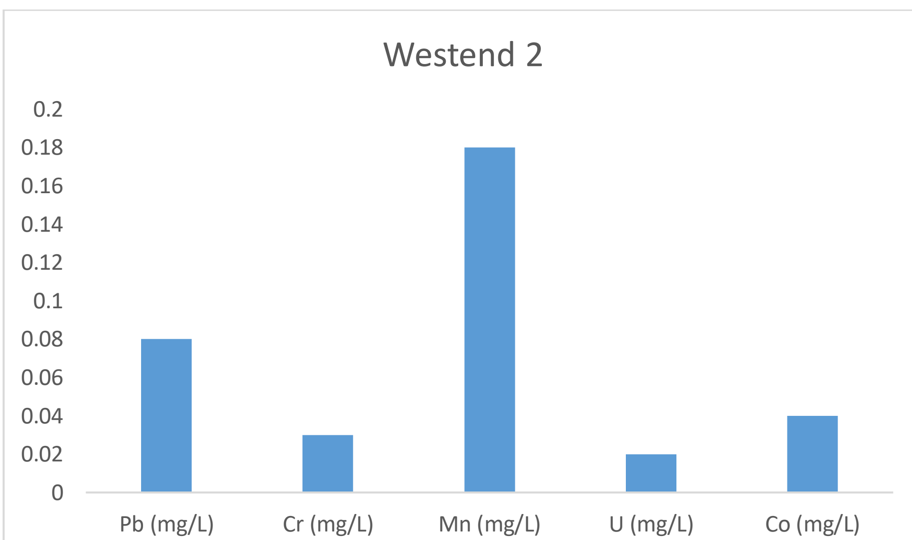

Figure 2: Chart of concentration of some metals in well water samples at Westend-2

The graph shows the Pb level in well water from five locations in Malete, Nigeria. School Road has the highest Pb level at 0.09 mg/L, Westend 1 has the lowest Pb level at 0.05 mg/L. The other locations have similar Pb levels at around 0.08 mg/L. The average value Pb level in all the water samples is 0.07 mg/L.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue XII, December 2024

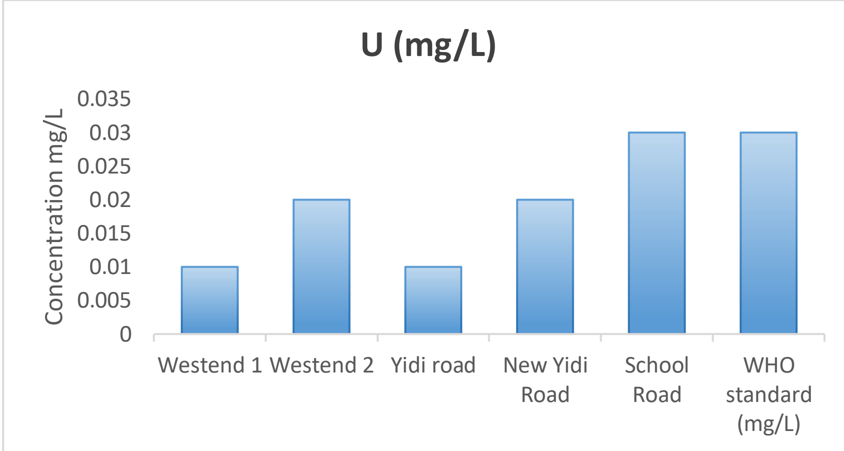

Figure 3: Chart showing the concentration of Uranium (U) in all 5 locations compared with WHO standards

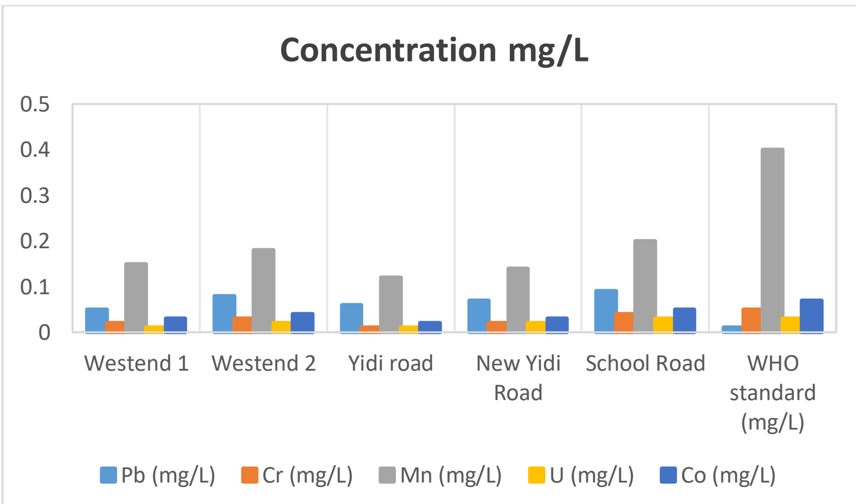

Figure 4: Chart showing the concentration of Pb, Cr, Mn, Uranium (U) and Co in all locations compared with WHO standards

Discussion

The concentration of Pb across all locations ranged from 0.05 mg/L to 0.09 mg/L, exceeding both WHO standards of 0.01 mg/L. The highest Pb level was recorded at School Road (0.09 mg/L), posing significant health risks such as cancer.. This contamination likely stems from anthropogenic sources such as lead-based paints, plumbing systems, construction of roads and industrial effluents. Chromium (Cr) concentrations ranged between 0.01 mg/L and 0.04 mg/L, below the permissible limit of 0.05 mg/L set by WHO and Nigerian standards. The relatively low levels suggest minimal immediate health risk from chromium toxicity, but vigilance is necessary, especially concerning the more toxic hexavalent chromium (Cr-VI). Possible sources include industrial activities like leather tanning and electroplating. Manganese (Mn) levels ranged from 0.12 mg/L to 0.20 mg/L, all within safe limits as there are no explicit WHO or Nigerian standards for Mn in drinking water. Mn, though essential in trace amounts, can lead to neurological disorders in excessive concentrations. The highest Mn concentration was at School Road (0.20 mg/L). Likely sources include the natural weathering of rocks and soils. Uranium (U) concentrations varied between 0.01 mg/L and 0.03 mg/L, all below the WHO provisional guideline of 0.03 mg/L. Uranium contamination, even at low levels, is of concern due to its radiotoxicity and nephrotoxic effects. The elevated levels at School Road (0.03 mg/L) may stem from natural geogenic processes. Cobalt (Co) concentrations ranged from 0.02 mg/L to 0.05 mg/L, well below the WHO standard of 0.07 mg/L. Cobalt is a trace element essential for human health, but excessive intake can lead to adverse effects, including gastrointestinal distress and cardiovascular complications.

Spatial Distribution of Metal Contamination

The concentrations of metals at Westend 1 and Westend 2 were relatively uniform, indicating consistent contamination sources, likely anthropogenic in origin. In contrast, variations in chromium (Cr) and manganese (Mn) levels along Yidi Road and New Yidi Road suggest localized contamination, potentially linked to waste disposal or agricultural runoff. Notably, School Road exhibited consistently higher concentrations of lead (Pb), Manganese (Mn), and Uranium (U), which could be attributed to either localized pollution or natural enrichment, warranting further investigation.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue XII, December 2024

Graphical representations, including bar graphs and charts (Figures 1–4), effectively highlight spatial trends in metal concentrations. School Road stands out as a hotspot for contamination, with significantly higher proportions of Pb, Mn, U, and cobalt (Co). The variability observed across other locations points to a mixture of geogenic and anthropogenic contributions to metal contamination.

IV. Conclusion

A comprehensive analysis of well water samples from Malete, Nigeria, was conducted and has provided valuable insights into the composition of various metals component in the area. Notably, the concentration of lead (Pb) in the well water was measured at 0.09 mg/L, reflecting potential variations from standard benchmarks established by the Standard Organization of Nigeria (SON), Atiku et al, (2018). The elevated lead content could potentially be attributed to multiple factors, including the introduction of lead-containing waste from nearby human activities and vehicular emissions.

Furthermore, the study identified a cobalt concentration of 0.05 mg/L in Malete's well water, indicating a degree of discrepancy with local standards. Manganese and chromium levels, quantified at 0.20 mg/L and 0.04 mg/L respectively, also demonstrated some variations from established local benchmarks. These findings underscore the need for continued monitoring of metal concentrations in well water within the Malete community. The study findings regarding uranium indicated a concentration level in the well water samples that closely approximates the provisional guideline value of 0.03 mg/L set by the World Health Organization (WHO) for drinking water quality. This observation highlights the importance of sustained vigilance and measures to ensure uranium concentrations remain within acceptable limits for community consumption. Collectively, these outcomes emphasize the complex interplay of metals in Malete's well water and the necessity of implementing effective strategies for maintaining water quality. While certain metal concentrations may raise questions, the study serves as a valuable foundation for informed decision-making and the development of appropriate measures to ensure the safety of the local water supply. It is therefore, recommended that indiscriminate discharge of solid waste around the well water in Malete should be also watched so as to reduce the risk of metal contamination of the well water.

Acknowledgement

Our appreciations go to Mr Okubo for his effort in the analysis of the selected metals for this research..

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