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Assessing the Levels of Heavy Metal Contamination in Surface Water of Alau Dam in Maiduguri, Nigeria

[a]Mustapha Sanda, [b]Tijjani Inusa Atom, [c]Adamu Hussaini and [b]Aliyu Adamu

[a]Department of Physics, Borno State University, P. M. B. 1122, Maiduguri – Nigeria
[b]Department of Physics, Faculty of Science, University of Maiduguri, P. M. B. 1069, Maiduguri – Nigeria
[c]Nigerian Nuclear Regulatory Authority (NRA), Plot 564, Central Business District, Abuja – Nigeria

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Abstract

This study aimed to measure the levels of heavy metals in water samples from the Alau dam, an important source of water for the surrounding areas, using Atomic Absorption spectrometer methods. The metals analyzed were Cu, Zn, Mn, Fe, and Cr, which can have significant environmental and health impacts. The results showed that the mean concentrations of these metals in the middle of the dam were generally higher than those on the side of the dam, with Cu having the highest mean concentration at 0.067 mg/L. The results also showed a range of concentrations for each metal, with Fe having the widest range of 0.003-0.20 mg/L. These findings are important for understanding the potential exposure of individuals and the environment to heavy metals from the Alau dam. Exposure to high levels of heavy metals in water can cause various health problems such as kidney damage, nervous system damage, and cancer, and can also lead to bioaccumulation in the food chain, affecting entire ecosystems. The results of this study provide important information on the concentration of heavy metals in Alau dam and highlight the need for regular monitoring to ensure that the water is safe for human use and does not negatively impact the environment. This information can be used to inform policy decisions and environmental management strategies aimed at minimizing the risks associated with exposure to heavy metals.

1. Introduction

Water is a vital resource for human consumption and plays a significant role in the world economy [1-4]. However, about one-third of people globally lack access to safe drinking water, and contamination by heavy metals and other chemicals poses a potential threat to human health [5-9]. Heavy metals, such as cadmium, lead, mercury, and arsenic, are present in various consumer products, construction materials, and human activities, including mining, fossil fuel combustion, and waste disposal [10-21]. Exposure to these heavy metals can cause severe health effects, including reduced growth and development, liver cancer, and nervous system damage. Young individuals are more susceptible to heavy metal toxicity [22-25]. The bioaccumulation of lead in the human body interferes with proper mitochondrial functioning, while chronic exposure to cadmium can lead to lung cancer, prostatic proliferative lesions, bone fractures, and hypertension [26-31]. Contamination by heavy metals in drinking water has received significant attention due to its strong toxicity even at low concentrations. Heavy metal contamination can also have detrimental effects on the environment, wildlife, and human health, including soil contamination, water pollution, air pollution, and toxicity to both wildlife and humans [32-35].

Therefore, there is a need for continuous monitoring of water quality and joint efforts of governments, scientists, and communities to address this global challenge. Therefore, it is crucial to monitor and regulate the release of heavy metals into the environment and develop effective remediation strategies to address existing contamination. This includes implementing best practices in industry and agriculture to prevent heavy metal pollution and promoting the use of sustainable and environmentally friendly alternatives. Additionally, it is important to educate the public on the dangers of heavy metal exposure and ways to reduce their exposure to these harmful substances. By taking these steps, we can work towards a healthier and more sustainable future for both the environment and human health. The Alau Dam is situated at Latitude 11° 40' N and 12° 05' N and Longitude 130° 05' E and 130° 20' E, and is the largest dam in Borno State. The dam serves as a vital source of raw water for the town and nearby villages and provides water to a treatment plant for consumption by both humans and animals. However, the dam reservoir is composed of loam and clay soil, which may contain heavy metals such as *Cu, Zn, Mn, Fe*, and *Cr*, representing a potential exposure pathway for humans and the environment. In this study, Atomic Absorption Spectrophotometer methods (AAS) and photo-spectrometer were utilized to determine the levels of heavy metals (*Cu, Zn, Mn, Fe*, and *Cr*) present in the Alau Dam. The findings of this study will help raise awareness about the potential impacts of heavy metal pollutants in the surrounding mining area and the need for continued monitoring to ensure the safety of the water supply.

2. Methodology

To ensure the true contents of the dam, the samples were collected at the middle of the dam and in the morning before the fishing activities on the dam. Upstream samples were also collected for the purpose of comparism. Samples collected at these points are based on the velocity, gradient and turbidity of the dams. Collected samples are taken in a 2-litre plastic container and further kept for 48 *hours* at room temperature for normal condition to avoid multiplication of external factors for equilibrium to be reacted prior to the time of atomic absorption spectrometry. The sampling was limited to the periods of two months which considered enough to obtain necessary and vital information for the purposes of the study. The samples were taken from the collection spots to the laboratory at water treatment plant and Geology department, University of Maiduguri for analysis.

The Basic instrument and materials in Atomic Absorption Spectrometer (AAS) are: line source emitting the spectrum of the desired analytic element (Table 1), aqueous sample atomizer, monochrometer to isolate the desired exciting spectral line, photo detector, read-out system, sample cell bottle and ample container.

Table 1: The distribution element between states in Atomic Absorption Spectrometer

Radionuclide	**Resource line (*nm*)**	**DE (*eV*)**	**Nil. No. *g/l* (Temperature 2000 °C – 3000 °C)**
Cu	422.7	2.931×10^{-9}	5.00×10^{-1}
Zn	589.0	2.109×10^{-6}	5.68×10^{-4}
Fe	852.1	1.454×10^{-4}	7.24×10^{-3}
Cr	213.9	5.507×10^{-15}	5.50×10^{-10}
Mn	285.2	4.353×10^{-4}	1.50×10^{-2}

In the laboratory each samples was standardized using distilled water by rinsing the sample cell with the distilled water and the calibration of the measuring equipment was carried out using a certified standard calibration of the heavy metals solutions provided by the water treatment, the number is then adjusted to the desired number it displays the actual calibration value for the solution. In order to obtain a correct measurement, the method of calibration described by the water analyst was employed. The calibration was of two methods. The first was the calibration of the solution to standard and the second was for the samples both were done for efficiency in measuring the concentration of the heavy metals identify in Alau dam.

In order to realize the aim and objective of the project, by Using Atomic Absorption spectrometer, it was possible to measure, identify and determine the concentration of *Cu*, *Zn*, *Fe*, *Mn* and *Cr*. It is also possible to show the mean heavy metals concentration in the Alau dam at various locations for atomic absorption spectrometer. The measurement of the heavy metals was done at the water analysis laboratory of the water treatment plant, Maiduguri and Geochemistry laboratory, Geology department, University of Maiduguri. In both case the result of a heavy metals is only partially known. Using the Atomic absorption spectrometer, which were connected to the power source, the counting or measurement errors for the determination of the concentration values of heavy metals varied between 60% and 80%. The mean concentration values for the heavy metals in this study are lower when compared to chemical composition of the elements. However, the concentration value is just about 2% of the recommended values.

3. Results and Discussion

The project aimed to measure the concentration of heavy metals in water samples collected from Alau dam using Atomic Absorption Spectroscopy techniques. The analysis identified *Cu*, *Zn*, *Fe*, *Mn*, and *Cr* in the water samples, with their concentrations ranging from 0.067-0.25 *mg/l* for Cu, 0.003-0.20 *mg/l* for Fe, 0.014-0.004 *mg/l* for Cr, 0.257 *mg/l* for Mn, and 0.04 mg/l for Zn. The results showed that the contribution to radiation dose and hazards is minimal and insignificant to pose any health hazards to the inhabitants living in the area.

Table 2: The concentration of the heavy metals in the middle and by the side of Alau dam

Sample locations	**Average Concentration (*mg/l*)**				
Middle of the dam	*Cu*	*Fe*	*Cr*	*Mn*	*Zn*
X_1	0.067	0.005	0.014	0.257	0.040
X_2	0.250	0.200	0.004	0.257	0.040
By the side of the dam					
Y_1	0.066	0.020	0.013	0.001	0.001
Y_2	0.240	0.210	0.003	0.003	0.000

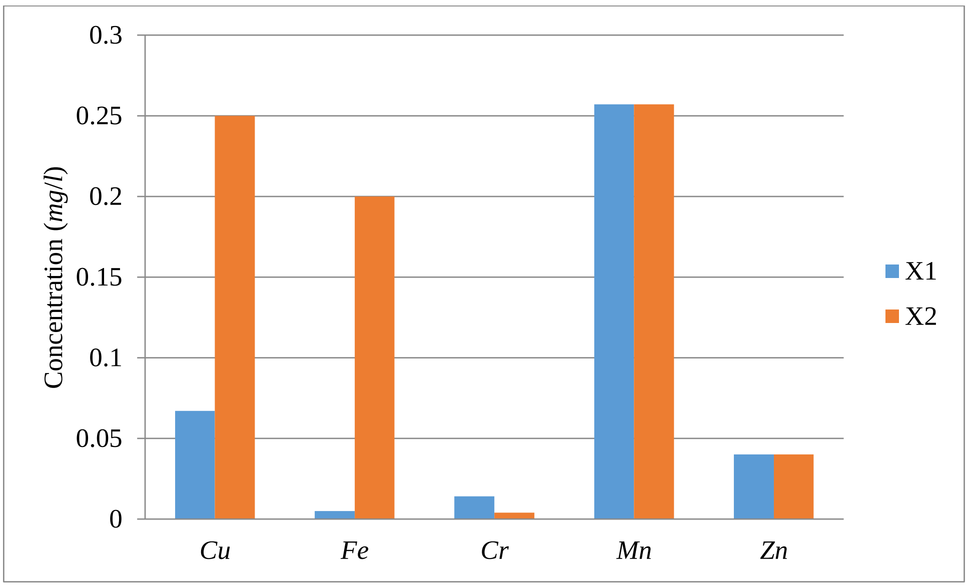

Figure 1: The concentration of some heavy metals present in water samples from four middle locations of the Dam

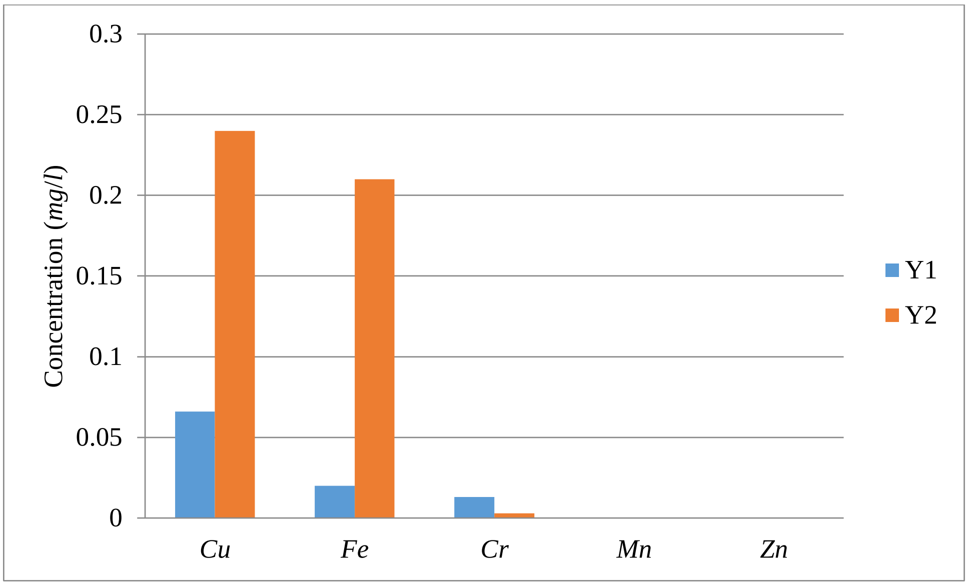

Figure 2: The concentration of some heavy metals present in water samples from four side locations of the Dam

These results are important because the presence of heavy metals in water sources can have potential health risks for individuals who consume the water. Exposure to high levels of heavy metals can lead to increased risk of cancer and other health problems. However, the results of this study suggest that the concentration of heavy metals in Alau dam is within safe limits and does not pose a threat to the health of the surrounding population. The measurement of heavy metals in water samples is an important aspect of environmental monitoring, and the results of this project provide valuable information on the concentration of these elements in Alau dam. The results suggest that the water is safe for human consumption, and further monitoring should be conducted to ensure that the concentration of heavy metals remains within safe limits.

In a study conducted by [37] it was found that the mean values for Iron (Fe) in Alau reservoir ranged between 0.07 + 0.001 mg/l and 0.12 + 0.001 mg/l. The majority of stations in the reservoir exhibited low to moderate metal concentrations, indicating a relatively low level of pollution. The study also compared the heavy metal concentrations in Alau reservoir with other West African sahel reservoirs [36] and found them to be similar. The contamination observed in various stations could be attributed to activities such as domestic washing with soap, the use of fertilizers, herbicides, and pesticides in irrigated farm lands. The minor fluctuations in heavy metal concentrations within the reservoir were mainly linked to agricultural activities, as well as the deposition of dry and wet particles by harmattan winds and floods [37]. According to [38] risk assessment plays a crucial role in ensuring water quality. It acts as a supportive tool by identifying hazardous events and evaluating the effectiveness of control measures. The participation and commitment of all stakeholders, including water service providers, health organizations, agriculture agencies, water resources and environmental entities, consumers, administrators, and the catchment community, are considered fundamental strategies for avoiding or reducing health risks. These strategies involve defining appropriate mitigation plans, implementing corrective actions, developing infrastructure, designing supporting programs, and fostering collaboration among the stakeholders. Another study by

[39]focused on the sediment of Alau dam. The concentrations of Iron (Fe), Manganese (Mn), and Zinc (Zn) in the sediment were found to exceed the guideline limits set by the USEPA and WHO. This is concerning as the sediments are utilized by aquatic animals. The authors recommended conducting periodic investigations to monitor the concentrations of these elements and to identify and mitigate the sources of pollution. This proactive approach is essential to ensure that the food web in the study area is not at risk of heavy metal contamination. Overall, the study concluded that there is no significant heavy metal contamination in Alau reservoir. Therefore, based on the current findings, immediate environmental concerns regarding the reservoir are not warranted. The analysis conducted in the study emphasized the importance of improving existing measures and implementing new ones to reduce risks as part of the Water Safety Plan's objectives [36-39].

4. Conclusion

The measurement of heavy metal concentrations in water samples is crucial for environmental monitoring, especially in bodies of water that serve as sources of drinking water, or for agricultural and industrial purposes. The Alau dam is an important water source for the surrounding areas, and a study was conducted to measure the levels of heavy metals in the water using Atomic Absorption spectrometer. The study focused on five metals: Cu, Zn, Mn, Fe, and Cr, all of which can have significant environmental and health impacts. The results of the study indicated that the mean concentrations of these metals in the middle of the dam were generally higher than those on the side of the dam, with copper showing the highest mean concentration at 0.067 mg/L. The concentrations for each metal varied within a range, with iron having the widest range of 0.003-0.20 mg/L. These findings provide important information regarding potential exposure to heavy metals from Alau dam, both for individuals and the environment. The presence of heavy metals in water can have detrimental effects on human health and the environment. High levels of exposure to these metals can lead to kidney damage, nervous system disorders, and even cancer. Additionally, heavy metals can accumulate in aquatic organisms, causing bioaccumulation in the food chain and impacting entire ecosystems. Consequently, regular monitoring of heavy metal levels in bodies of water is crucial to mitigate the risks associated with exposure. The study conducted on Alau dam contributes vital information on the concentration of heavy metals present and underscores the significance of regular monitoring to ensure the safety of water for human use while safeguarding the environment. The results can inform policy decisions and environmental management strategies aimed at minimizing the risks associated with heavy metal exposure. Therefore, the measurement of heavy metal concentrations in water samples is essential for environmental monitoring and safeguarding public health. The studies conducted on Alau dam highlight the levels of heavy metal contamination and emphasize the importance of ongoing monitoring to ensure water safety and environmental protection. The results provide valuable insights for stakeholders and can guide the implementation of mitigation measures to minimize heavy metal pollution.

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