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Determination of Heavy Metals in Water Samples within the Southern Part of Kaduna State, Nigeria

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Abstract

This paper investigated the presence of heavy metals in water samples from three selected sites in the southern part of Kaduna State, Nigeria. Twelve (12) samples were analysed at the Federal Ministry of Agriculture and Rural Development, Kaduna using Atomic Absorption Spectrophotometer (AAS). Levels of some heavy metals, Zn, Cu, Mn, Fe, Ni, Cr, Cd, Pb, Ca, Mg, Na and K were determined in water samples collected from the research area. The results obtained show that, the recorded mean values of Zn, Cu, Mn, Cd and Mg were within the WHO/GDWQ guidelines; while Na and Ca recorded mean values below the World Health Organisation (WHO)/Guidelines for Drinking- Water Quality (GDWQ) minimum mean value, Ni, Fe, Cr and Pb were found to be considerably high in the water samples, which exceeded the WHO/GDWQ maximum mean value. Therefore, the result shows the presence of heavy elements in the sampled area. The low mean values of Ca and Na within the sampled area could lead to poor bone formation risk like rickets among the populace. While consumption of such vital elemental nutrients is recommended, it is however advised that the populace should avoid consumption of Ni, Fe, Cr and Pb in high content above the stipulated WHO/GDWQ guidelines.

Keywords: AAS; Contamination; Heavy metals; Water; Pollution.

I. Introduction

Water is considered essential for the sustenance of life. The importance of water cannot be overemphasised, everything we do requires water. All people irrespective of their development, economics and social condition are to have access to good quality drinking water. Approximately 50% of the Nigerian landmass is geologically underlain by crystalline basement rocks [1]. These crystalline rocks have proven to be a potential target for sustainable groundwater supply [1]. Although, there is a fast-growing concern throughout Nigeria about the contamination of groundwater as a result of human activities, especially in industrial and urban areas where the waste deposit is not properly treated. With this rapid growth in population, urbanization, industrialization and other developmental activities, groundwater resources have become vulnerable to depletion and quality degradation [2].

Heavy metals are elements with an atomic weight between 63.545 g and 200.5 g [3] and a specific gravity greater than four [4]. Exposure to these heavy metals has been linked with developmental retardation, various cancers, kidney damage and even death [5]. Thus, the need for industrial technology, biotechnology, legal measures and environmental awareness education to tackle the industrial and urban pollution across Nigeria. Therefore, it is quite imperative to conduct research with the view of exploring all possible sources of heavy metal pollution in the environment. It is expected that results

obtained could lead to the discovery of the presence of heavy metals and other contaminants, the levels at which they occur and their possible mode of control.

II. Materials and Methods

A. Sample Collection

Water samples were collected randomly in Kachia, Kajuru and Kujama Local Government Areas within Southern Kaduna State, Nigeria. The research area location is shown in Fig. 1. Samples of water were collected in a rubber container, labelled accordingly and stored in a refrigerator before analysis to inactivate bacteria and prevent any volume change that could occur due to evaporation.

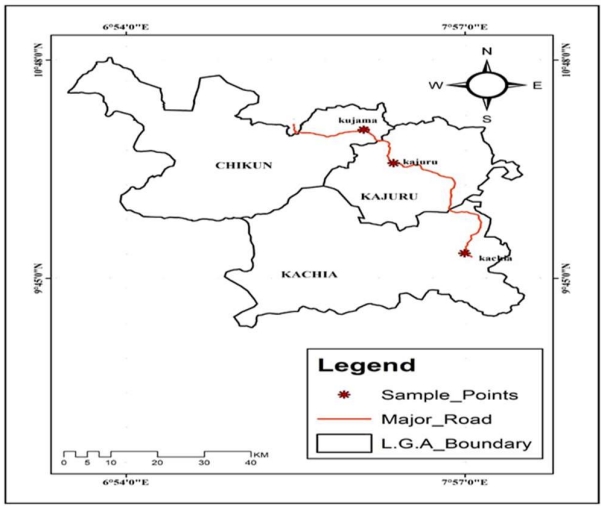

Fig. 1 Research Area

B. Digestion of Water Sample

The vigorous digestion method described by Gregg [6] was adopted. 100 ml of each of the representative water samples were transferred into Pyrex beakers containing 10 ml of concentrated HNO_3. The beaker and content were placed on a hot plate and digested till brown fumes of HNO_3 were emitted. Heating continued till when the content has reduced to 10 ml volume. The filtrates were transferred to 100 ml volumetric flasks and diluted to the mark with distilled water. These solutions were then used for the elemental analysis using the atomic Absorption Spectrophotometer (AAS).

C. Metal Analysis

A total of twelve (12) metallic elements were determined in the pre-treated samples of water using an Atomic Absorption Spectrophotometer (AAS) as described by Gregg [6]. These include Zn, Cu, Mn, Fe, Ni, Cr, Cd, Pb, Ca, Mg, Na and K.

III. Results and Discussion

The recorded values of heavy metals analysed in the water samples from the three sampling sites within the southern part of Kaduna State Nigeria are presented in Table I.

Table I. Recorded values of Heavy Metals Analysed.

S/No	Sample ID	Zn (mg/l)	Cu (mg/l)	Mn (mg/l)	Fe (mg/l)	Ni (mg/l)	Cr (mg/l)	Cd (mg/l)	Pb (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)
1	Kachia	0.21	0.14	0.21	0.57	0.31	0.15	0.08	0.06	1.85	1.71	6.26	2.67
2	Kajuru	0.19	0.18	0.28	0.89	0.09	0.94	0.06	0.48	1.18	0.99	4.40	2.69
3	Kujama	0.17	0.19	0.36	2.15	0.12	0.35	0.09	0.89	1.18	0.87	6.67	3.71

From the above-obtained results, it is clear that the water contains a certain amount of heavy metals capable of polluting the environment and indirectly affecting living organisms within that area. The mean value of Zn within the study area is between 0.21 mg/l - 0.19 mg/l, which is below the WHO/GDWQ with a minimum mean value of 1 mg/l. The cu mean value is between 0.14 mg/l - 0.19 mg/l, which is within the WHO/GDWQ guideline with a minimum mean value of 0.001 mg/l.

Mn was recorded within the research area with the highest value at Kujama (0.36 mg/l), below the WHO/GDWQ maximum mean value of 5.0 mg/l, while relatively lower at Kajuru (0.28 mg/l) and Kachia (0.21 mg/l). Fe was recorded at Kujama with the highest mean value of 2.15 mg/l above the WHO/GDWQ maximum mean value of 2 mg/l, while those of Kachia (0.57 mg/l) and Kajuru 0.89 mg/l) were within the WHO/GDWQ guidelines. Kajuru and Kujama have Ni mean values of 0.09 mg/l and 0.12 mg/l respectively, which is within the WHO/GDWQ minimum mean value of 0.01 mg/l, while Kachia has a Ni mean value of 0.31 mg/l which is above WHO/GDWQ maximum mean value of 0.25 mg/l. The Cr mean values of Kachia (0.15 mg/l) and Kujama (0.35 mg/l) were within the WHO/GDWQ minimum mean value guidelines. The Cd mean values of Kachia (0.08 mg/l), Kajuru (0.06 mg/l) and Kujama (0.09 mg/l) were all less than the WHO/GDWQ maximum mean value of 0.15 mg/l. Pb was recorded with the highest mean value of 0.89 mg/l and 0.48 mg/l at Kujama and Kajuru respectively, which are all above the WHO/GDWQ maximum mean value of 0.1 mg/l, while the lowest mean value was recorded at Kachia (0.06 mg/l) and is within the WHO/GDWQ minimum mean value of 0.005 mg/l. Ca was recorded with mean values of 1.85 mg/l, 1.18 mg/l and 1.18 mg/l at Kachia, Kajuru and Kujama respectively, which were all below the WHO/GDWQ minimum mean value of 30 mg/l. The Mg recorded was found to be within the WHO/GDWQ minimum mean value of 0.1 mg/l, with Kachia (1.71 mg/l), Kajuru (0.99 mg/l) and Kujama (0.87 mg/l). Na recorded mean values of 6.26 mg/l, 4.40 mg/l and 6.67 mg/l at Kachia, Kajuru and Kujama respectively, which were all below the WHO/GDWQ minimum mean value of 100 mg/l. Lastly, K was recorded with 2.67 mg/l, 2.69 mg/l and 3.71 mg/l at Kachia, Kajuru and Kujama respectively, which are all within the WHO/GDWQ minimum mean value of 0.2 mg/l. The following bar chart diagrams (Fig. 2, 3 and 4) depicts the various quantities of the heavy metals recorded in the research areas (Kachia, Kajuru and Kujama) as shown in Table I.

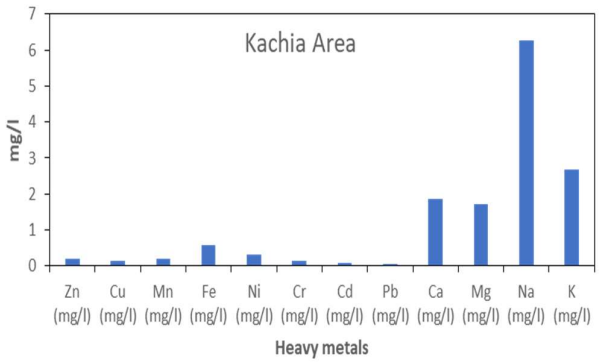

Fig. 2 Recorded Heavy Metals from Kachia Local Government Area.

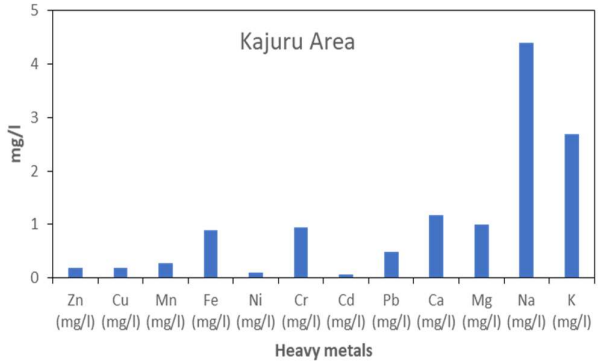

Fig. 3 Recorded Heavy Metals from Kajuru Local Government Area.

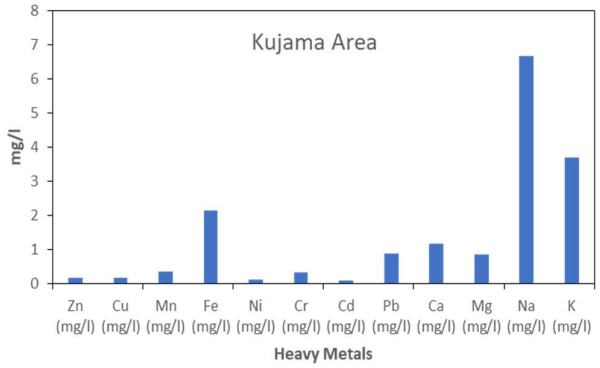

Fig. 4 Recorded Heavy Metals from Kujama Local Government Area.

The mean values of Ni from Kachia, Fe and Cr from Kajuru were found to be above the maximum allowed concentration (Table II). Similarly, the mean value of Pb from the polluted areas (Kajuru and Kujama) was above the maximum mean value, while Ca and Na were found to be less than the minimum mean values. The results for the other remaining heavy metals (Zn, Cu, Mn, Cd, Mg and K) analysed indicated that they are below the maximum mean values and less than the minimum mean value. Since water contaminated by these heavy metals can be absorbed into the food chain and consumed by human beings, these findings imply that the consumption of polluted water by human beings within these study areas could be hazardous to their health. Also, the mean values of Pb from the polluted areas which were found to be above the maximum mean value could have some toxic effects on human beings if consumed from the water or irrigated agricultural products from the study area, since Pb can easily displace Ca in the bone to form softer denser spots [7].

Table II WHO/GDWQ Guidelines [8].

Metal	WHO/GDWQ Guidelines		
	Mean Value (mg/l)	Maximum Value (mg/l)	Minimum Value (mg/l)
Zn (mg/l)	5.000	15.000	1.000
Cu (mg/l)	2.000	3.000	0.001
Mn (mg/l)	0.100	0.500	0.001
Fe (mg/l)	0.300	2.000	0.100
Ni (mg/l)	0.020	0.250	0.010
Cr (mg/l)	0.050	0.500	0.001
Cd (mg/l)	0.005	0.150	-
Pb (mg/l)	0.010	0.100	0.005
Ca (mg/l)	150.000	500.000	30.000
Mg (mg/l)	70.000	1000.000	0.100
Na (mg/l)	200.000	400.000	100.000
K (mg/l)	12.000	50.000	0.200
		- 0.0000005	

IV. Conclusion

This study has shown that the contamination of water by heavy metals is an issue of environmental concern. The results from this research have revealed the presence of significant concentrations of Ni, Fe, Cr and Pb in waters in the Kajuru and Kujama Local Government Areas of Kaduna State, Nigeria, while concentrations of Ca and Na were seen to fall below the WHO/GDWQ guidelines in waters in Kachia, Kajuru and Kujama Local Government Areas. Thus, with the health issues such as cancer, kidney problems and retarded growth related to the intake of these heavy metals, it is recommended that education and legislation on the management of pollution in villages within the study area should be intensified to forestall the effects of wastewater-related problems.

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