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Heavy Metals Assessment on Water Sampled from Selected Boreholes in Kaura Namoda Local Government Area, Zamfara State, Nigeria

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ABSTRACT

This research was carried out in response to the recent increase in the availability of underground water (borehole) as major sources of drinking water in kaura Namoda, Zamfara state, Nigeria. The aim of this research work was to assess the level of heavy metals pollution in the selected underground water. Twenty borehole water samples (BW1–BW20) were collected from selected area in kaura Namoda from month of March to April, 2022. Acid digestion and AAS were used for sample preparation and analysis respectively. the results obtained, shows that the average concentration value of Cd, Zn, Mn, Pb, and Fe are within the permissible limit of WHO and NSDW value except concentration of Pb 0.023±0.007, 0.021±0.008, 0.018±0.002, 0.020±0.006 and 0.016±0.001 mg/L in BW 3, 9, 11, 18 and 20 respectively which were above permissible limit for lead (0.01mg/L) and value obtained in BW 6, 8, 12, 16 and 17 for Fe are 0.821±0.004, 0.703 ± 0.431, 0.808± 0.006, 0.592± 0.103, 1.056±0.271 mg/L respectively. These values were above 0.4 mg/L permissible limit of Fe. Cu was not detected in all the water samples. In this case, possible adverse effects may result from ingestion of these heavy metals especially Pb from the affected boreholes. Therefore, there should be continues monitoring of borehole water in the study area.

INTRODUCTION

The quality of drinking water has now become a very important topic in all countries of the world, especially in developing countries like Nigeria. Though, water plays an important role that can never be overemphasized in human life, it is known to have great potentials for transmitting a variety of diseases and illness when it is contaminated or polluted (Aleksander, & Ciszewski, 2016). Water is said to be polluted when there is a natural or anthropogenic which induced change in the quality of water and renders it unsuitable or dangerous for its intended purpose (Daxer, 2010). The quality of water and its safety for human consumption especially when contaminated with heavy metal which are known to be toxic, has become considerable public and scientific concern in light of the evidence of their toxicity to human health and biological systems (Wojtkowska *et al.*, 2016). This is because heavy metals even at low concentrations receive particular concern considering their toxicity in human and biological system (WHO, 2008). Heavy metals are a collection of term that is used to describe metals and metalloids with specific gravity 5.0 or greater, especially those ones that are toxic to human health and biological systems (Leung & Jiao, 2006).

Heavy metals are known natural components of earth's crust and therefore, there is a range of normal background concentrations of these elements available in the soil, sediments, water and living organism (Marcovecchio *et al.*, 2007). Therefore, it is this concentration of the metals in comparison to the normal background concentration that forms the basis that determines whether or not a substance is polluted. The occurrence of heavy metals in water bodies can either be of natural origin or of anthropogenic activities (Niesiobedzka, 2016). Natural origins include eroded minerals within the water bodies, leaching of ore deposits and volcanism extruded products. Natural contaminants or pollution could also occur when water moving through rocks soil picks up elements capable of contaminating the water. Anthropogenic activities capable of impacting heavy metals on water bodies include several activities associated with fossil fuel and coal combustion, industrial processes, solid waste disposal, mining and metal processing, agricultural activities and among others (Ugonna,*et al.*,2020). Heavy metals can also enter water supply system through consumer waste as well as acid rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater (Alloy & Ryres, 2009).

Some heavy metals like manganese, copper, iron and zinc are known to be essential in maintaining human body metabolism due in a very small but critical concentration for healthy growth (Abraham, & Susan, 2017). Other heavy metals that include arsenic, mercury, cadmium and lead are not known to have any essential biochemical functions and are toxic at concentration above the tolerance of the human body and biological system. All heavy metals at excess concentration are dangerous biological system as they tend to bio-accumulate over time and has been associated with many health conditions (Sridher *et al.*, 2000).

The awareness of the concentration levels of some heavy metals in the water sampled from the selected boreholes in comparison with the World Health Organization and Nigeria Standards for Drinking Water, will help in prevention of the health effects associated with high concentration of heavy metals such cancer, gene

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mutation and immune destruction, especially when it higher than permissible limit (WHO, 2008), (Aleksander, & Ciszewski, 2016).

This research is in response to the recent increase in the availability of boreholes as a major source of water supply in the study area and the need to ascertain the status of these selected heavy metals of interest in the water sourced from the boreholes.

RESEARCH METHODOLOGY

Description of the Study Area and Sampling Site

Kaura - Namoda local Government Area in Zamfara State of Nigeria is located between latitude 12^0 16'43.56" to 12^0 41´4.48N and longitude 6^0 25' 34.87" to 6^0 51'53.92E. The inhabitants of the area are predominantly farmers that engage in commercial crops and animal production. The major source of their water in recent time is the groundwater in the form of boreholes which are drilled across the entire study area mostly as government projects and in some cases by individuals. Figure 1 shows the map of the sampling sites.

Research Materials and Tools

The chemicals and reagents used in the research are of analytical grade and used as purchased.

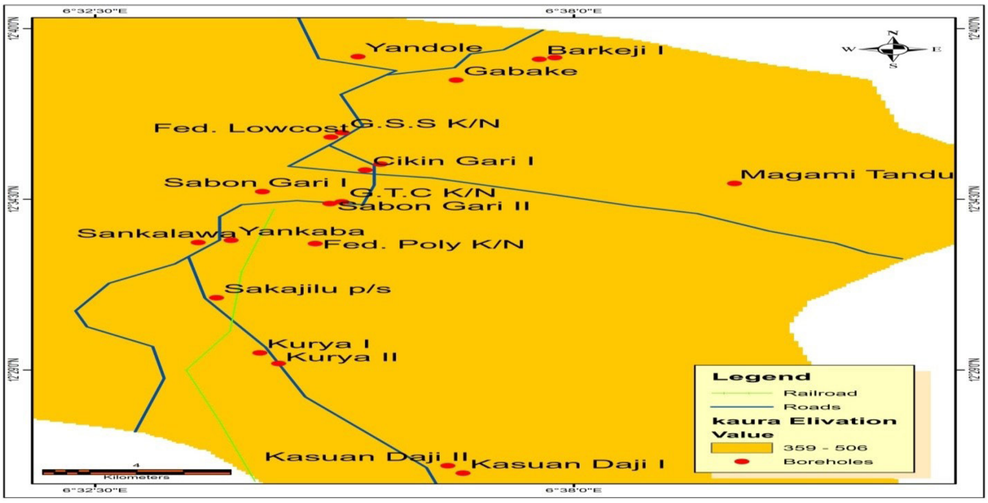

Figure 1: Map of Kaura Namoda Local Government Area of Zamfara State Showing the Various Sampling Locations
Source: Adopted and modified from administrative map of Zamfara State

pH meter (EIL 7045/46 Kent, England), Atomic Absorption Spectrophotometer(AAS HP-MY14470001, Perkin Elmer, UK) and chemical weighing balance B300, Ohausa, USA

Sample Collection

The co-ordinates points of all the boreholes sampled were taken using a global positioning system (GPS) model N20230 (Etrex Garmin) in Table1. Twenty sampling points (Boreholes) were selected and each sampled three

Table 1: Sampling locations and their respective point co-ordinates

S/no	Point Coordinates	Sample locations	Designation
1	12°38'20.5" N 6°36'38.8"E	Gabake Mesa	BW1
2	12°35'007". N 6°39'50.7" E	Magami Tandu	BW2
3	12°39'00.6" N 6°37'36.11" E	Barkeji I	BW3
4	12°39'03.9" N 6°37'46.9"E	Barkeji II	BW4
5	12°39'05.7"N 6°35'31.3"E	Yandole	BW5
6	12°33'04.2" N 6°35'01.6"E	Fed. Poly. Kaura	BW6
7	12°33'10.7" N 6°34'03.7"E	Yankaba	BW7
8	12°35'26.6" N 6°34'03.7"E	Kurya II	BW8
9	12°29'33.1"N 6°34'23.5"E	Kurya 1	BW9
10	12°25'40.4"N 6°36'43.5"E	Kasuwan-Daji I	BW10
11	12°25'54.7" N 6°36'33.1"E	Kasuwan Daji II	BW11
12	12°29'12.4"N 6°36'48"E	Cikin Gari I	BW12
13	12°31'19.7"N 6°33'53.6"E	Sakajiki primary Sch.	BW13
14	12°34'21.7"N 6°35'11.6"E	Sabon-gari I	BW14
15	12°38'44.9"N 6°34'25.4"E	Sabon-gari II	BW15
16	12°36'38.7"N 6°35'20.4"E	GSS K/Namoda	BW16
17	12°36'30.2" N 6°35'12.6"E	Federal low-cost Kaura	BW17
18	12°35'38.5"N 6°36'46.8"E	Cikin- gari II	BW18
19	12°35'26.7"N 6°35'20.4"E	GTC K/Namoda	BW19
20	12°38'20.5"N 6°36138.8 "E	Sankalawa	BW20

times weekly between the month of March and April, 2022 according to standard procedures (AOAC, 2005). All the samples were collected in pre-cleaned one litre polythene plastic bottle, preserved in a 0.1M HNO3 solution, labeled according to the sampling points and taken to the laboratory for analysis. The sampling locations and designations are presented in Table 1.

Samples Analysis

Water samples were digested using acid digestion method as the standard method described by (AOAC, 2005). 100cm3 of each water sample was measured into 250 cm3 beaker and 10cm3 of conc. HNO3. The mixture was heated on a hot plate until the solution boils and the color of the solution becomes colorless and clear. It is then evaporated to about 30cm3 by volume and the mixture filtered and transferred into 100 cm3 standard flask and make up to mark with distilled water. These digested solutions of all the water samples were used for triplicate determinations of each metal using atomic absorption spectrometer (AAS) (Adepoju *et al*.,2009)

RESULTS AND DISCUSSION

Metal levels were determined in each of the sampled water and the mean and the standard deviation values were evaluated over three sampling times as given in table 2. The minimum and the maximum values of the zinc ranged from 0.037 ± 0.016 to 0.800±0.014 mg/l (Table 2). All the borehole water analyzed had values below the permissible limit of 3.0 mg /L as provided by WHO AND NSDW. The detectable level of zinc in all the samples analyzed could mean that the source of contamination is common and is probably the dissolution of minerals of zinc compound in the underground water. The minimum and the maximum values of the manganese ranged from 0.026 ± 0.001 to 0.182 ± 0.054 mg/L (Table 2). All the values obtained were below the 0.4 mg/L (WHO) and 0.2 mg/L (NSDW) for manganese. The detectable presence of manganese in all the samples analyzed could mean that the source contamination is common to all the boreholes and is probably the dissolution of minerals of manganese compound in the underground water. The iron contents of the sampled water ranged from 0.088 ± 0.015 to 1.056 ± 0.271 mg/l (Table 2). All the borehole water analyzed had iron content below the WHO and NSDW maximum permissible limit of 0.3 mg/l except for water form boreholes designated as BW6, BW8, BW12, BW16 and BW17.which are above the permissible limit. The detectable level of iron in all the samples could mean common source which is probably from the iron bearing minerals in the rocks as they interacts with the underground water. The minimum and maximum values of lead obtained ranged from 0.006 ± 0.002 mg/L to 0.023±0.007 mg/L (Table 2). Lead above the WHO and NSDW maximum permissible limits of 0.01mg/l was detected in BW3, BW9, BW11, BW17, BW18 and BW 20 boreholes and therefore do pose adverse health risk to the consumers especially when accumulated over a long period of time (Obaje,*et al*.,2020). The underlying rocks may contain minerals of lead composition capable of impacting lead on the groundwater. The minimum and the maximum value of cadmium obtained ranged from 0.0020 ± 0.0010 mg/L to 0.0070 ± 0.0030mg/L (Table 2). The detectable level of cadmium in all the samples analyzed could mean that the source of contamination is common to all sample locations though at different

Table 2: Mean and Standard Deviation of Values of Heavy Metals over three Sampling Periods in all the Sampled Boreholes

Sample	Zn (mg/l)	Pb (mg/l)	Mn (mg/l)	Fe (mg/l)	Cd (mg/l)	Cu (mg/l)
BW1	0.037±0.016	0.007±0.002	0.061±0.001	0.149±0.007	0.0025±0.0007	ND
BW2	0.263±0.018	0.008±0.001	0.018±0.002	0.228±0.001	0.0025±0.0002	ND
BW3	0.300±0.070	0.023±0.007	0.182±0.054	0.141±0.001	0.0023±0.0008	ND
BW4	0.080±0.028	0.008±0.001	0.081±0.027	0.312±0.027	0.0025±0.0003	ND
BW5	0.040±0.014	0.008±0.001	0.026±0.001	0.088±0.015	0.0020±0.0010	ND
BW6	0.800±0.014	0.007±0.002	0.150±0.063	0.8214±0.004	0.0030±0.0010	ND
BW7	0.095±0.017	0.009±0.004	0.062±0.001	0.095±0.009	0.0025±0.0009	ND
BW8	0.130±0.019	0.007±0.003	0.061±0.001	0.703±0.431	0.0040±0.0010	ND
BW9	0.057±0.014	0.021±0.008	0.062±0.001	0.320±0.047	0.0030±0.0002	ND
BW10	0.306±0.158	0.006±0.002	0.030±0.018	0.095±0.060	0.0025±0.0001	ND
BW11	0.680±0.339	0.018±0.002	0.034±0.018	0.163±0.032	0.0025±0.0001	ND
BW12	0.282±0.088	0.009±0.006	0.042±0.013	0.808±0.013	0.0030±0.0010	ND
BW13	0.320±0.029	0.010±0.003	0.041±0.022	0.265±0.026	0.0030±0.0010	ND
BW14	0.246±0.019	0.008±0.003	0.049±0.016	0.257±0.035	0.0030±0.0010	ND
BW15	0.150±0.040	0.010±0.006	0.044±0.017	0.123±0.029	0.0040±0.0010	ND
BW16	0.234±0.020	0.009±0.007	0.053±0.013	0.592±0.103	0.0030±0.0010	ND
BW17	0.465±0.181	0.015±0.004	0.081±0.001	1.056±0.271	0.0040±0.0001	ND
BW18	0.304±0.202	0.020±0.006	0.121±0.009	0.237±0.028	0.0070±0.0030	ND
BW19	0.494±0.274	0.010±0.002	0.062±0.011	0.057±0.014	0.0040±0.0001	ND
BW20	0.279±0.016	0.016±0.001	0.061±0.012	0.170±0.092	0.0040±0.0010	ND
WHO limit	3.0	0.01	0.4	0.4	0.03	2.0
NSDW limit	3.0	0.01	0.2	0.4	0.03	1.0

ND (Not Detected)

degrees. The source of contamination could originate from application of fertilizer which is common in the study area (Asoker *et al*., 2002). Copper was below detectable limit in all the boreholes. Nevertheless, this study is only applicable to the individual boreholes tested because there could be possible variations in the other area, especially in locations or areas where rocks of different composition and solubility are existing (Nash, &Mc Call 1994).

CONCLUSION AND RECOMMENDATION

Concentration of Pb, Zn, Mn, Cu, Cd and Fe in water sampled from selected boreholes in Kaura Namoda has been determined using atomic absorption method (AAS). The findings revealed that some of the boreholes investigated had iron, lead and cadmium values that were not in conformity with the WHO and NSDW recommended permissible limit for drinking water. Therefore, possible adverse effect due to consumption of the water containing high level of these parameters may occur among the inhabitants of this study area especially in the cases of lead and cadmium if they bio-accumulates beyond the tolerable concentrations in the body. The researchers recommend regular water quality assessment to the state water board so as to remedy or closing down any borehole that the water is not in conformity with the acceptable standards for drinking water.

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