

Levels of Some Heavy Metals in Borehole Waters of Birnin Kebbi Metropolis, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author LS designed the study and wrote the first draft of the manuscript. Author JIB managed the statistical analysis of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The levels of Chromium (Cr), Lead (Pb), Copper (Cu), Zinc (Zn) and Iron (Fe) were determined in six different samples of Borehole waters obtained from six designated areas of Birnin Kebbi metropolis, Nigeria using atomic absorption spectrophotometer. The mean concentrations of the heavy metals ranged from 0.0005 mg/L Cr to 0.2108 mg/L Fe. The relative abundance of the metals in Borehole waters followed the sequence of Fe (0.1769 mg/L) > Cr (0.0342 mg/L) > Cu (0.0298 mg/L) > Zn (0.0052 mg/L). The levels of Cr and other metals were found below the SON/WHO recommended safe limits for metals in water. The low concentration of Cr and absence of Pb in all the samples examined are indications that these Borehole waters contribute fewer toxic effects of metals. The pH values of the water samples were far below the recommended values by the SON/WHO and these could be adjusted through pH correction.

Keywords: Heavy metals; borehole waters; Birnin Kebbi metropolis; spectrophotometry; contamination level.

1. INTRODUCTION

Water is one of the essentials that supports all forms of plant and animal life [1]. It is obtained from two principal natural sources; surface water such as fresh water from lakes, rivers, streams, etc. and ground water such as borehole water and well water [2,3]. Water has unique chemical properties due to its polarity and hydrogen bonds which means it can dissolve, absorb, adsorb or suspend many different compounds [4], thus, in nature, water is not pure as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities [3]. One of the most important environmental issues today is ground water contamination [5] being affected with the wide diversity of contaminants such as heavy metals, which receive particular attention considering their strong toxicity even at low concentrations [6]. The World Health Organization (WHO) and UNICEF reports for 2012 ranked Nigeria as the third country, after China and India, with the largest population without adequate water and sanitation conditions [7]. Generally, metals are transported as either dissolved species in water or as an integral part of suspended substances causing the most detrimental effects on aquatic life [8].

The sources of ground water contamination could be natural through ground water rock interaction or through anthropogenic source which involve human activities that can affect groundwater quality. Ground water pollution is man-made and regarded as the worse natural pollution that it eventually renders water unsuitable for use. It is also a frequent practice to apply agrochemicals or burn wastes on our farmlands to improve agricultural production. Thus, the application of agrochemicals or process of burning gets rid of organic matter to become ashes which are richer in metal contents. These ashes are either dissolved in rainwater and leached into the soil contaminating the underground waters, or washed away by runoff into streams and rivers, thereby contaminating the environment [9].

Heavy metal pollution is believed to cause diseases as a result of contamination of water with heavy metals due to anthropogenic activities [10]. Heavy metals found to contaminate water include arsenic, lead, chromium, cadmium,

copper, zinc and nickel [11]. Their long term exposure in water is attributed to cause Parkinson's disease (degenerative disease of the brain), Alzheimer's disease (brain disorder), muscular dystrophy (progressive skeletal muscle weakness), multiple sclerosis, etc. [12]. It is based on these facts that this study was carried out to determine the levels of chromium, lead, copper, zinc and iron in Borehole waters of Birnin Kebbi metropolis, Nigeria. Hence, the determination of such heavy metals in Borehole waters of Birnin Kebbi metropolis, Nigeria would assist in ascertaining the contamination level of these metals in the waters as well as their quality.

2. MATERIALS AND METHODS

2.1 Study Area

This study was aimed to cover the major areas (Badariya, Gwawangwaji, Kofa Sabuwa, Mobil Area, Gesse and Tudun Wada) of Birnin Kebbi metropolis. Birnin Kebbi is the capital of Kebbi state and headquarters of Birnin Kebbi Local Government Area. The metropolitan city lies between Latitudes 12^o15'00"N to 12^o35'00" N and Longitudes 4^o0'00"E to 4^o38'00"E [13] with a population figure of 268,620 as of 2006 (Fig. 1).

2.2 Sample Collection

Batch sampling was used to obtain representative samples in this research work. The water samples used for this study were collected from six different areas in Birnin Kebbi town: Badariya, Gwawangwaji, Kofa Sabuwa, Mobil Area, Gesse and Tudun Wada. The samples were collected in plastic gallons (2 litres capacity) which had been thoroughly washed, and filled with distilled water. The plastic gallons were emptied and rinsed several times with the water to be collected. Then, each gallon was partially filled with the collected water and vigorously shaken [14]. They were tightly covered immediately after collection and the temperature taken and then stored in a refrigerator at 4°C (Haier Thermocool) to slow down bacterial and chemical reaction rates [15]. All glass wares and plastic containers used were washed with detergent solution soaked overnight in 20% (v/v) nitric acid and then rinsed with tap water and finally with distilled water [16].

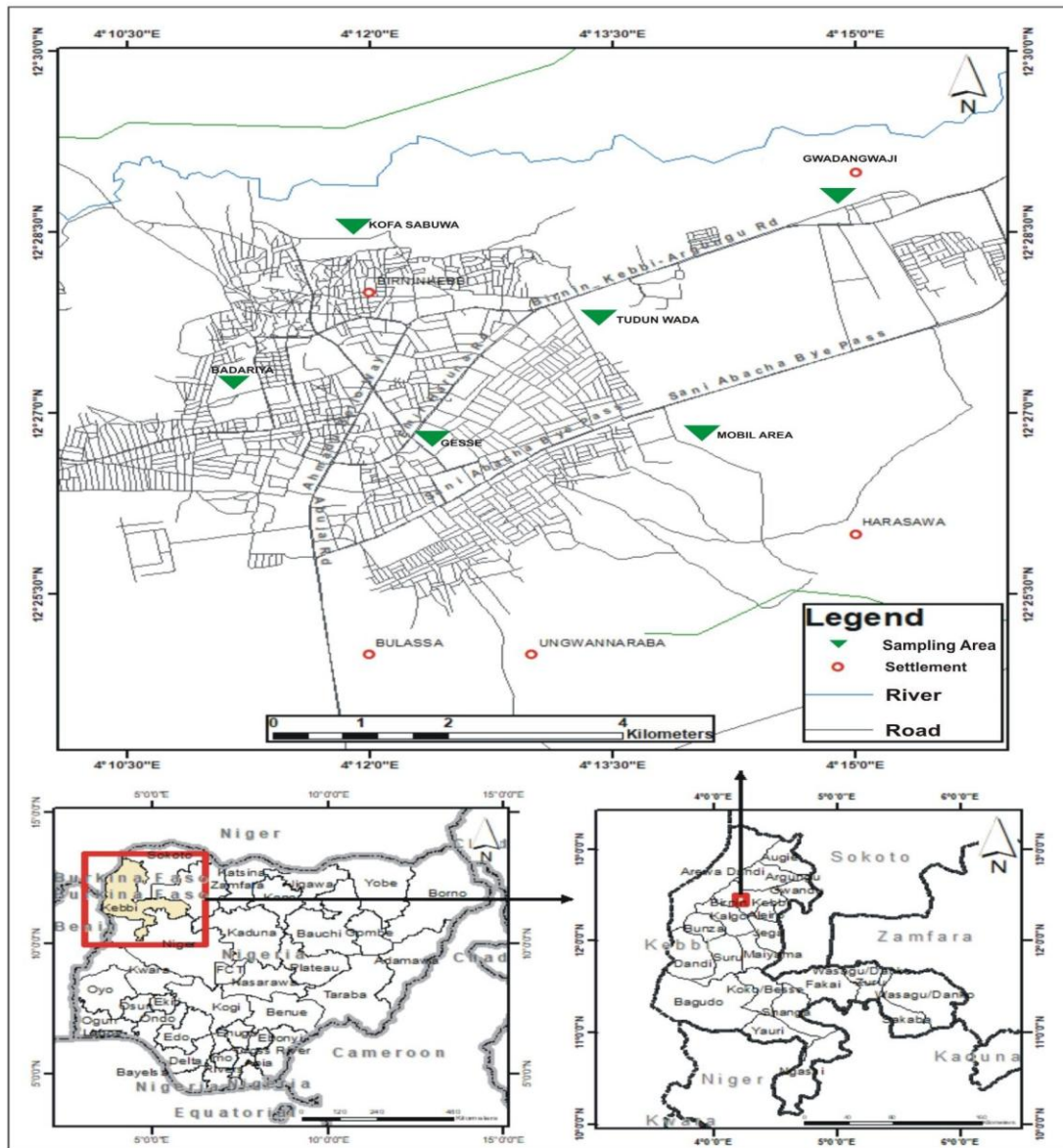


Fig. 1. Map of Birnin Kebbi metropolis showing sampling areas

2.3 Sample Treatment and Standard Preparation

Stock solutions of the metal salts and other reagents used were prepared as described by Shuaibu et al. [17]. The working standard solutions were prepared by serial dilution of various portions of the stock solutions to give aliquot solutions with concentration range of 0-13 mg/L.

2.4 Water pH Determination

The water pH was measured using a calibrated PHS-25 pH meter. The calibration of pH meter

was done using two buffer solutions of pH 6.86 and 7. About 40 cm³ of water sample was placed into a beaker. The electrode of the pH meter was inserted, and the pH reading was taken. The procedure was repeated for all the other samples. Three replicate determinations were carried out on each sample [17].

2.5 Sample Digestion

Digestion of the sample is one of the steps taken to preserve the samples from bacterial activities and to release metals into the analytical solution [18]. About 50 cm³ of the water sample was measured into a beaker and 5 cm³ of

concentrated HNO₃ was added. The sample was digested using hot plate in a fume cupboard until the solution reduces to 5-6 cm³ with a characteristic colour, indicating complete digestion. Each digest was then allowed to cool and transferred to a 50 cm³ acid washed volumetric flask and the volume brought to the 50 cm³ mark with deionized water. Diluted digest was then filter and kept in sample bottles ready for analysis [19]. The level of each metal in the three samples were determined using AA-6300 model AAS machine while result was presented as mean value of triplicate analysis [15].

2.6 Atomic Absorption Spectrophotometric Analysis

Heavy metals concentration in the samples were assessed using Atomic AAS photometer (AA-6300 Model) equipped with a digital read-out system. Working standards were prepared through serial dilution of 1000 ppm metal stock solution in each case to lower concentration. Calibration curves were constructed by plotting absorbance values versus concentrations. The metal concentrations in the sample digest were determined as described in [16].

2.7 Statistical Analysis of Data

Data obtained were analyzed using Microsoft Excel and results were expressed as mean ± standard deviation.

3. RESULTS AND DISCUSSION

3.1 Borehole Waters pH

Water pH of the samples ranged from 3.83 to 4.66 indicating acidic. The results have shown that the water samples contain both dissolved organic and inorganic acidic compounds lowering the pH values far below the minimum standard values by SON/WHO (Table 1). This could be adjusted through pH correction through water treatment procedure.

The results did not indicate any metal dominating in all Borehole water samples examined. MOB water sample recorded highest levels of Cr and Cu which are 0.195 and 0.066 mg/L respectively while BDR water sample recorded highest level of Zn which is 0.011 mg/L. Similarly, highest level of Fe was recorded by KSW water sample which is 0.211 mg/L (Table 2).

Table 1. Table showing the mean values of pH and temperature of the Borehole waters

Sample ID	pH	Temperature (°C)
BDR	3.96 ± 0.060	31.70 ± 0.528
GWG	4.84 ± 0.035	30.09 ± 0.888
KSW	3.83 ± 0.069	31.00 ± 0.840
MOB	4.65 ± 0.670	30.03 ± 0.028
GES	4.66 ± 0.036	29.80 ± 0.200
TDW	4.50 ± 0.396	31.80 ± 0.262
Range	3.83 - 4.660	30.03 - 31.80
SON/WHO safe limit (2008)	6.50 - 8.50 ^a	30 ^a

BDR= Badariya area; GWG=Gwadangwaji area; KSW=Kofa Sabuwa area; MOB= Mobil area; GES= Gesse area; TDW=Tudun Wada area; °C=Degree Celsius; ID=Identity; Source a = [20]

Table 2. Table showing the metal levels (mg/L) of the Borehole waters

Sample ID	Cr	Pb	Cu	Zn	Fe
BDR	0.003±0.000	ND	0.023±0.017	0.011±0.039	0.161±0.029
GWG	0.001±0.000	ND	0.007±0.000	0.004±0.012	0.153±0.017
KSW	0.002±0.000	ND	0.023±0.008	0.003±0.000	0.211±0.063
MOB	0.195±0.025	ND	0.066±0.062	0.006±0.000	0.167±0.100
GES	0.003±0.000	ND	0.013±0.003	0.003±0.000	0.183±0.010
TDW	0.002±0.000	ND	0.047±0.000	0.004±0.000	0.186±0.051
Mean±SD	0.034±0.004s		0.030±0.015	0.005±0.009	0.177±0.045
Range	0.001-0.195		0.007-0.066	0.003-0.011	0.153-0.211
SON/WHO Safe limit (2008)	0.05 ^a	0.01 ^a	2 ^a	3 ^a	0.3 ^b

BDR = Badariya area; GWG =Gwadangwaji area; KSW = Kofa Sabuwa area; MOB = Mobil area; GES = Gesse area;

TDW = Tudun Wada area; ID=Identity; ND = Not detected; SD = Standard deviation; Source: a= [18]; b = [20]

Fig. 2 shows the natural distribution of the metals examined in water samples; with Fe and Cr depicting the highest concentration while Zn shows the least concentration among the metals examined.

The sequence of metal concentrations examined in the water samples was Fe > Cr > Cu > Zn presented in Fig. 3.

The contamination status of the heavy metals in water is normally ascertain via comparison of the experimental values with standard reference values from literature. Fortunately, specifications of heavy metals in water are available or rather feasible. Hence, in this study, water metal contents were compared with SON/WHO standard reference values. Thus, the extent of contamination was determined through comparison with safe limit values (Table 2).

3.2 Heavy Metals

3.2.1 Chromium

Hexavalent chromium is toxic and mutagenic. Even though, trivalent chromium is an essential trace element and is required for the proper metabolism of sugar in human [21]. The mean chromium level in the water samples was 0.034 mg/L and had range of 0.001 to 0.195 mg/L (Table 2). The level was below the natural concentration limit of 0.05 mg/L in water [22]. This finding is similar to the studies reported by Ekere et al. [23] as the reported value for Cr was 0.01 mg/L. Also, the levels of Cr found in this study were similar to results reported in the same areas where Cr ranged from 0.0177 to 0.0333 mg/L [12]. The level of chromium could be attributed to the lower concentrations of chromium compounds in the soil of the studied areas.

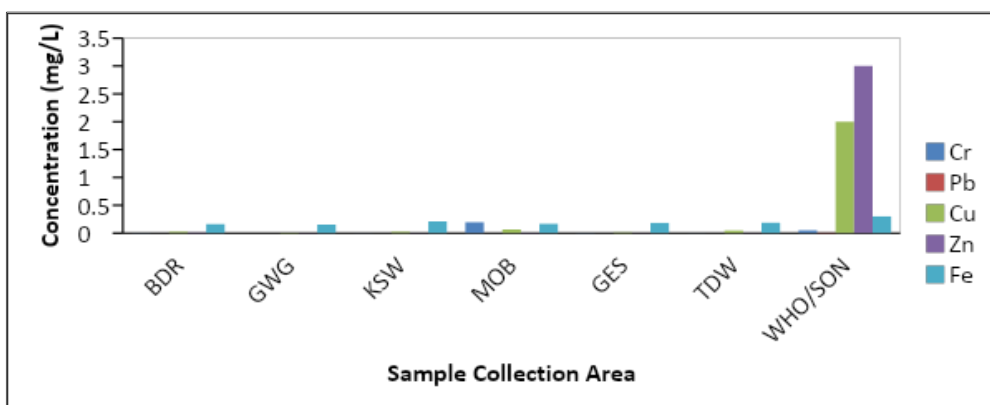


Fig. 2. Figure showing the mean distribution of the metals in the Borehole waters

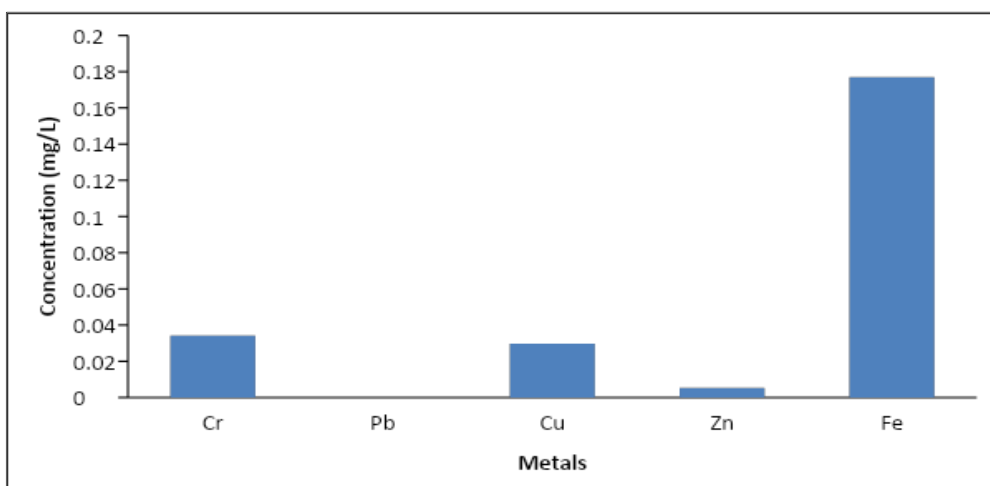


Fig. 3. Figure showing the general trend for the mean levels of the metals in the Borehole waters

3.2.2 Copper

Copper is an essential nutrient which support plants and animals' growth. At high doses, it causes stomach and intestinal distress, liver and kidney damage, as well as anaemia [24]. The mean copper level in the water samples was 0.030 mg/L and had a range of 0.007 to 0.066 mg/L (Table 2). The mean copper level was below the natural concentration limit of 2.0 mg/L in water [22]. Shemishere et al. [12] reported similar results of Cu, which ranged from 0.207 to 0.428 mg/L from the same areas. The low level of copper may be due to geological factors of the studied area.

3.2.3 Zinc

Zinc is essential for the normal growth and reproduction for higher plants, animals, and humans. Hence it is called a micronutrient [25]. The mean zinc level in the water samples was 0.0052 mg/L and a had range of 0.003 to 0.011 mg/L (Table 2). The mean zinc level was below the natural concentration limit of 3.0 mg/L in water [22]. Okparaocha and coworkers [20] reported similar finding in the Zn level ranged from 0.020 to 0.090 mg/L.

3.2.4 Iron

Iron is a biologically essential component of every living organism. It is toxic at very high concentration [26]. The mean iron level in the water samples was 0.177 mg/L and had a range of 0.153 to 0.211 mg/L (Table 2). The mean iron level was below the natural concentration limit of 0.3 mg/L in water [22]. This work agrees with the reported value of Fe (0.270 mg/L) by Okparaocha et al. [20].

4. CONCLUSION

The pH of the Borehole water samples contained both dissolved organic and inorganic acidic compounds as indicated by the their pHs. The pH could be corrected. However, all the levels of heavy metals examined are below the recommended safe limits prescribed by SON/WHO. It has also been observed that the general trend for the mean levels of metals examined in the Borehole waters showed that: Fe > Cr > Cu > Zn.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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