



Heavy Metal and Microbial Contents of Borehole Water in Birnin Kebbi and Kalgo Metropolis, Kebbi State, Nigeria

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ABSTRACT

This study was aimed at determining the heavy metal content and microbial loads of pipe borne water in Birnin Kebbi and Kalgo metropolis. Water was collected in sterilized sample bottles from public and private boreholes from different locations in Birnin Kebbi and Kalgo metropolis. The water samples were analyzed for the presence of selected heavy metals via Atomic Absorption Spectroscopy while standard procedures were used for the bacterial, coliform and yeast count. The results show that concentration of Lead was found to be above WHO limit ($Pb \leq 0.01$ ppm), higher than the WHO limit for Iron ($Fe \leq 0.03$ ppm) in all but those from Gwadangwaji and Tudun Wada areas of Birnin Kebbi and Illela yari area of Kalgo. Cadmium, which was only detected in samples from Illela yari and Ungwar jeji area of Kalgo metropolis higher than the WHO limits ($Cd \leq 0.003$). Nickel was also detected in high concentration in some of the water samples while Copper and Chromium were within the WHO limit ($Cu \leq 1.0$, $Cr \leq 0.003$) in all the water samples. In the coliform detection test, all the samples revealed normal levels of coliform. Yeast was recorded above the normal range only in Haliru Abdu area of Birnin Kebbi whereas other samples were within the WHO limits. From the results of this study, it is concluded that the pipe-borne water supply from the majority of the sampled areas were contaminated with some heavy metals and Bacteria. It is therefore advised that, water from borehole need to be treated further before consumption in order to get rid of contaminants. Neglecting this might pose a significant public health risk.

Keywords: Heavy metals, Bacterial count, Pipe borne water, Coliform, Yeast

INTRODUCTION

Water is one of the most essential compounds to life on Earth. It forms about 50 to 60% of body weight and plays a substantial role in all the vital processes of our body (Kawther and Alwakeel, 2007). Hygienic water is essential for social development, justice and welfare; so essential that it has been as the earth's milk (Sharad and Vijay, 2010; Yahaya *et al.*, 2019). Accessibility of clean potable water does not only play a crucial role in economic development and social welfare, but it is an essential element in health, food production and poverty reduction (Ashbolt *et al.*, 2001). Despite its importance, water is the most poorly managed resource in the world (Chutter, 1998). The public health significance of water cannot be over emphasized. Many infectious diseases are transmitted by water through the fecal oral route. Diseases contacted through drinking water kills about five million people annually (WHO, 2004).

According to the world health organization, about 80% of all illness in developing countries is related to water and sanitation and 15% of all child mortality below the age of five years in developing countries is attributed to diarrheal diseases (Thompson and Khan, 2003; WHO, 2004).

Heavy metal pollution of water is increasingly being blamed as the cause of diseases associated with water contamination worldwide (Yahaya *et al.*, 2019). Common among the heavy metals detected in water include arsenic, cadmium, chromium, copper, lead, nickel, and zinc (Lambert *et al.*, 2000). The long term exposure to these metals result in physical, muscular, neurological degenerative processes that cause Alzheimer's disease (brain disorder), Parkinson's

disease (degenerative disease of the brain), muscular dystrophy (progressive skeletal muscle weakness), multiple sclerosis (Yahaya and Okpuzor, 2011).

Lead is one of the most common heavy metal in drinking water, if occurred more than its permissible limit confers deleterious effect to biological systems (Ashbolt *et al.*, 2001). Heavy metals like copper are the essential trace elements but show toxicity in excess. The major sources of heavy metal pollution in urban areas of Africa are anthropogenic activities, while contamination from natural sources predominates in the rural areas. Anthropogenic sources of pollution include those associated with fossil fuel and coal combustion, industrial effluents, solid waste disposal, mining and metal processing. In higher animals, these heavy metals bio-accumulates via feeds, green fodder, drinking water and pharmaceuticals, consumption of mineral supplements with high content of trace metal and licking of painted surfaced containing metallic pigments (Raikwar *et al.*, 2008). However, among these pathways, the atmosphere tends to be of greatest to human health, as a result of the quantities of contaminants involved and the widespread dispersion and exposure (Raikwar *et al.*, 2008).

According to Olade (1987), the impact of these contaminants is confined mostly to the urban centers with large populations, high traffic density and consumer-oriented industries. Natural sources of pollution include weathering of mineral deposits, bush burning and wind blowing dusts. Among the heavy metals, the most serious effect of pollution is presently connected with lead (Pb) emission (Olade, 1987).

In Africa and other developing countries, water-borne diseases infect millions (Fenwick 2006). These diseases are usually as a result of contamination with microbes such as bacteria and fungi (Pandey *et al.*, 2014). According to World Health Organization (WHO), 3.4 million people, mostly children, die from water-related diseases annually (WHO 2014). According to United Nations Children's Fund (UNICEF) assessment, 4000 children die daily as a result of contaminated water (UNICEF 2014). WHO (2010) reports that over 2.6 billion people lack access to clean water, which is responsible for about 2.2 million deaths each year, of which 1.4 million are in children. Improving water quality can reduce the global disease burden by approximately 4% (WHO 2010).

However, groundwater resources are under a serious threat due to high interest in mechanized agricultural practices and rapid urbanization, as well as, domestic and industrial usage. There has been an increase in indiscriminate drilling of boreholes by individuals without proper regulations. Some boreholes are sited near septic tanks. Septic systems that are improperly sited, designed, constructed, or maintained can contaminate groundwater with bacteria, viruses, nitrates, detergents, oils, and other chemical substances. To this end,

this study assessed the heavy metal levels and microbial loads in public and private pipe borne water consumed in selected areas in Kalgo and Birnin Kebbi metropolis.

MATERIALS AND METHODS

Source of Materials

Private and public pipe borne water supplied from ten (10) locations in Birnin Kebbi and three (3) locations in Kalgo were selected for this study. Two water samples (private and public) each from ten different areas in Birnin Kebbi metropolis and two samples (private and public) from three areas in Kalgo were collected in plastic containers which have been sterilized with 10% methanol solution making a total of 26 samples in all. The samples were assigned codes; A1 to A10 (public) and B1 to B10 (private) for Birnin Kebbi, then C1 to C3 (public) and D1 to D3 (private) for Kalgo. The samples were carried into the laboratory and stored in a refrigerator at 4°C prior to analysis. The samples were later screened for lead (Pb), copper (Cu), cadmium (Cd), chromium (Cr), Nickel (Ni), and iron (Fe) using Atomic Absorption Spectroscopy as well as for bacterial, coliform and yeast counts. All the reagents used for the analyses, including aqua-regia solution (3:1 mixture of concentrated HNO₃ and HCl) were of analytical reagent grade.

Table 1: Selected locations in Birnin Kebbi

Locations	Area code (public)	Area code (Private)
Rafinatiku	A1	B1
Gesse	A2	B2
Badariya	A3	B3
Haliru Audu	A4	B4
Nasarawa	A5	B5
Rafin bara'u	A6	B6
Bayan kara	A7	B7
G.R.A	A8	B8
Gwandangwaji	A9	B9
Tudunwada	A10	B10

Table 2: Selected locations in Kalgo

Locations	Area code (public)	Area code (private)
Unguwar jeji	C1	D1
Illela yari	C2	D2
Kalgo Market area	C3	D3

Table 3: Levels of Heavy Metals Detected in the Public Pipe Borne Water Samples from Birnin Kebbi and Kalgo Metropolis

Water Samples	Mean concentration of heavy metals (ppm)					
	Lead (Pb)	Copper (Cu)	Cadmium (Cd)	Chromium (Cr)	Nickel (Ni)	Iron (Fe)
A1	0.0123±0.00033	0.233±0.00033	ND	0.0203±0.00033	0.0073±0.00033	0.431±0.00033
A2	0.0147±0.00033	0.234±0.00033	ND	0.0213±0.00033	0.0053±0.00033	0.442±0.00067
A3	0.0133±0.00067	0.315±0.00033	ND	0.0233±0.00067	0.0093±0.00033	0.332±0.00058
A4	0.0127±0.00033	0.323±0.00033	ND	0.0243±0.00067	0.01±0.0004	0.343±0.00033
A5	0.0113±0.00033	0.229±0	ND	0.0217±0.00033	ND	0.422±0.00033
A6	0.0117±0.00067	0.231±0.00033	ND	0.0217±0.00067	ND	0.523±0.00033
A7	0.0213±0.00067	0.234±0.00033	ND	0.0263±0.00067	ND	0.551±0.00033
A8	0.02±0.0001	0.224±0.00033	ND	0.0263±0.00067	ND	0.520±0.00033
A9	0.0317±0.00033	0.431±0.00033	ND	0.0203±0.00067	ND	0.225±0.00067
A10	0.0313±0.00033	0.428±0.00033	ND	0.0207±0.00067	ND	0.256±0.00033
C1	0.0223±0.00033	0.238±0.00067	0.006±0.00003	0.0217±0.00067	ND	0.521±0.00067
C2	0.0243±0.00033	0.341±0.00033	0.006±0.00002	0.027±0	0.0047±0.00067	0.256±0.00033
C3	0.0263±0.00033	0.304±0.00033	ND	0.0203±0.00033	0.0273±0.00033	0.486±0.00067
WHO Limit, 2003	≤ 0.01	≤ 1.0	≤ 0.003	≤ 0.05	≤ 0.02	≤ 0.3

Values were expressed as Mean ± SD; ND = Not detected; WHO = World Health Organization

Heavy Metal Analysis

About 0.5 mL of each water sample were digested at 120°C for 3 hours after mixture with 25 mL of aqua-regia solution. The digested material was filtered into 100 ml beaker, and the solution was analyzed for the selected heavy metals using Atomic Absorption Spectrometer (UNICAM model 969) (Adelaja *et al.*, 2012).

Bacteria Count Detection Test

Nutrient agar medium containing, casein hydrolysate 4.0 gL⁻¹, yeast extract 3.0 gL⁻¹, glucose 2.0 gL⁻¹, beef extract 1.5 gL⁻¹, peptone 6.0 gL⁻¹ and agar 20.0 gL⁻¹ (pH 7.0) were prepared in Petri plates. About 0.5 mL of each water sample was transferred into a plate and then incubated at 37°C for 24-48 hours. Each sample was run in triplicates (Feng *et al.*, 2002). Thereafter, the total number of colonies in each plate was counted with the aid of a colony counter. The Colony Forming Unit (CFU) was estimated using the formula: CFU = Number of Colonies x Dilution Factor/Sample Volume (mL).

Coliform Detection Test

The coliform detection was carried out by standard multiple tube fermentation technique consisting a series of preliminary and confirmatory tests. Presumptive test was carried out using lactose broth medium containing malt extract (3.0 g/L), peptone (10 g/L), lactose (5.0 g/L) and Bromothymol blue indicator (1.0 g/L). Ten (10) mL of the medium was transferred into test tubes after which inverted Durhams tubes and 5 ml of water sample were added to it. After 24 hour incubation at 37°C, the test tubes were examined for the presence of acid and gas. Acid production was indicated by a change in colour, while gas production was indicated by the accumulation of gas bubbles in the inverted Durham tubes. A confirmatory test was conducted using Eosine Methylene Blue (EMB) agar medium containing peptone (10 g/L), potassium phosphate (2.0 g/L), lactose (1.0 g/L), eosin Y (2.0 g/L), methylene blue (1.3 g/L) and agar (20 g/L). A loop full of culture from each positive fermentation tube was streaked over the sterile agar EMB plates. The plates were

incubated at 37°C for 24 hours. A final check of colonies that appeared after the confirmatory test was performed by growing the colonies on the nutrient agar slant and in Durham tubes containing lactose broth. After incubation for 24 hours at 35°C, the lactose broth was examined for the production of gas. Bacteria cultures from nutrient agar slants were used to prepare a slide and, after Gram staining, it was examined under the microscope. The presence of gram negative, non-spore forming rod that ferment lactose, confirmed the presence of coliforms in the water samples (Feng *et al.*, 2002).

Yeast Detection Test

About 0.5 mL of each water sample was transferred into a Petri plate containing malt agar medium and yeast extract peptone dextrose (YPD) medium and incubated at 25-30°C. The malt agar was composed of malt extract 3%, mycological peptone 0.5% and agar 1.5%, pH 5.5, while the YPD agar medium was prepared from yeast extract 1%, peptone 2%, dextrose 2%, agar 1.5% and ampicillin 100 µg/µL (pH 6.5). After 24 to 72 hours of incubation, the number of yeast colonies was counted using colony counter (Feng *et al.*, 2002).

Table 4: Heavy Metals Detected in the Private Pipe Borne Water Samples from Birnin Kebbi and Kalgo Metropolis

Water samples	Mean concentration of heavy metals (ppm)					
	Lead (Pb)	Copper (Cu)	Cadmium (Cd)	Chromium (Cr)	Nickel (Ni)	Iron (Fe)
B1	0.0277±0.00067	0.313±0.00033	ND	0.0313±0.00067	0.0047±0.00067	0.487±0.00033
B2	0.0283±0.00067	0.273±0.00033	0.011±0	0.0307±0.00033	0.0287±0.00033	0.344±0.00033
B3	0.0273±0.00067	0.207±0.00033	ND	0.0287±0.00033	0.0283±0.00033	0.362±0.00033
B4	0.0243±0.00033	0.223±0.00033	ND	0.0277±0.00033	0.005±0	0.364±0.00067
B5	0.0243±0.00067	0.240±0.00033	0.009±0	0.0277±0.00033	0.005±0	0.364±0.00067
B6	0.0257±0.00067	0.242±0.00033	ND	0.0177±0.00088	0.019±0	0.332±0.00033
B7	0.0237±0.00067	0.244±0.00033	ND	0.0207±0.00067	0.019±0	0.433±0.00033
B8	0.0293±0.00033	0.261±0.00067	ND	0.018±0.001	0.015±0	0.474±0.00033
B9	0.0303±0.00033	0.261±0.001	0.001±0	0.021±0.001	0.017±0	0.574±0.00033
B10	0.0303±0.00033	0.428±0.00058	ND	0.0223±0.00088	ND	0.254±0.00058
D1	0.0243±0.00033	0.304±0.00033	ND	0.0333±0.00067	0.015±0	0.344±0.00033
D2	0.0237±0.00067	0.334±0.00033	ND	0.0323±0.00033	0.015±0	0.362±0.00033
D3	0.0247±0.00067	0.346±0.00033	ND	0.0313±0.00033	0.013±0	0.339±0.00033
WHO Limit, 2008	≤ 0.01	≤ 1.0	≤ 0.003	≤ 0.05	≤ 0.02	≤ 0.3

Values were expressed as Mean ± SD; ND = Not detected; WHO = World Health Organization

Microorganisms count from public pipe-borne water samples collected from Kalgo and Birnin Kebbi.

As shown in Table 5, the bacterial count in all the samples exceeded the WHO limits. Coliform was not recorded in all the samples and yeast was counted in only A1 and A3 samples above the WHO limits.

Statistical Analysis of Results

Data were expressed as Mean ± Standard Deviation using Microsoft Office Excel.

RESULTS

Level of Heavy metals in Public Pipe-borne Water Samples from Birnin Kebbi and Kalgo metropolis.

As indicated in Table 3. Iron was observed to be above the WHO limits in all the samples from different location in Kalgo and Birnin Kebbi. Copper and Chromium were below the WHO limits while Cadmium was not detected in all but C1 and C2.

Level of Heavy metals in Private Pipe-borne Water Samples from Birnin Kebbi and Kalgo metropolis.

Lead was observed to be above the WHO limits in all the samples analyzed. Iron content was recorded to be above the WHO limits in all but B10. Cadmium was detected in B2, B5 and B10 alone was this values were below the WHO limits. Chromium detected varying concentration in all the samples were below the recommended WHO limits.

Table 5: Microorganisms Isolated From public pipe-borne water Samples Collected from Kalgo and Birnin Kebbi metropolis

Water samples	Bacterial Count (cfu mL ⁻¹)	Coliform Count (cfu mL ⁻¹)	Yeast Count (cfu mL ⁻¹)
1	130 X 10 ²	0.00	0.00
A2	1.40 X 10 ¹	0.00	0.00
A3	1.10 X 10 ³	0.00	1.10 X 10 ¹
A4	1.20 X 10 ³	0.00	0.00
A5	1.10 X 10 ⁴	0.00	0.00
A6	1.30 X 10 ⁵	0.00	0.00
A7	1.10 X 10 ¹	0.00	0.00
A8	1.50 X 10 ¹	0.00	0.00
A9	1.50 X 10 ¹	0.00	0.00
A10	1.10 X 10 ²	0.00	0.00
C1	1.30 X 10 ²	0.00	0.00
C2	1.40 X 10 ¹	0.00	0.00
C3	1.30 X 10 ³	0.00	1.10 X 10 ¹
WHO Limits, 2008	≤ 100 cfu mL ⁻¹	0 cfu100 mL ⁻¹	≤ 50cfumL ⁻¹

Table 6: Microorganisms enumerated from private pipe-borne water samples collected from Kalgo and Birnin Kebbi metropolis.

Water samples	Bacterial Count (cfu mL ⁻¹)	Coliform Count (cfu mL ⁻¹)	Yeast Count (cfu mL ⁻¹)
B1	1.20 x 10 ⁴	0.00	0.00
B2	1.20 x 10 ³	0.00	0.00
B3	1.30 x 10 ²	0.00	0.00
B4	1.30 x 10 ²	0.00	1.10 x 10 ⁴
B5	1.20 x 10 ²	0.00	0.00
B6	1.20 x 10 ³	0.00	0.00
B7	1.20 x 10 ¹	0.00	0.00
B8	1.10 x 10 ⁵	0.00	0.00
B9	1.30 x 10 ⁵	0.00	0.00
B10	1.10 X 10 ³	0.00	0.00
D1	1.20 X 10 ³	0.00	0.00
D2	1.10 X 10 ³	0.00	0.00
D3	1.10 X 10 ³	0.00	0.00
WHO Limits, 2008	≤ 100 cfu mL ⁻¹	0 cfu100 mL ⁻¹	≤ 50cfumL ⁻¹

Microorganisms count from private pipe-borne water samples collected from Kalgo and Birnin Kebbi.

The bacterial count in all the samples exceeded the WHO limits. Yeast was recorded in only B4 while coliform was not detected in all the samples

DISCUSSION

This study determined the safety status of selected pipe borne water consumed and sold in Birnin Kebbi and Kalgo metropolis, Kebbi State, Nigeria with regard to some heavy metals and microbial loads. Table 3 shows the mean concentration of heavy metals in the public pipe borne water samples collected from Birnin Kebbi and Kalgo. Iron was detected at abnormal levels in majority of the water samples with A6, A7, A8, and C1 having the highest concentration (≥ 0.5 ppm), followed by A1, A2, A5, and C3 in which the concentration was (≥ 0.4 ppm). Only four samples A9, A10, and C2 has iron level within the WHO specified limits. Nickel concentrations were detected at normal levels in the samples, A1, A2, A3, A4, and C3 as each had limited concentration of Ni below the WHO limit, while A5, A6, A7, A8, A9, A10, C1 and C2 were free of the nickel tested. Lead was found in high concentration above WHO range in the samples, A7, A8, A9, A10, C1, C2, C3 while the other sample were within the limit. Only C1 and C2 had cadmium above the WHO limit while Chromium and Copper were not detected in all of the public samples.

Table 4 shows the mean concentration of heavy metals in private pipe borne water samples collected from Birnin Kebbi and Kalgo. B9 had the highest concentration (> 0.5 ppm), followed by B1, B7, B8 in which the concentration was (> 0.4 ppm). Only sample B10 has iron level within the WHO specified limits. B2, B3 were the most contaminated with nickel as each contained nickel at concentrations above the WHO limits, followed by B1, B4, B5, B6, B7, B8, B9, D1, D2 and D3 which were not polluted with Nickel as each had limited concentration of Ni below the WHO limit, while A5, A6, A7, A8, A9, A10, C1 and C2 were free of the nickel tested. All the private samples had Lead concentration above the WHO limit. Cadmium was only detected in B2, B5 and B9 within the WHO limit while other samples were free. Chromium and Copper were detected in all the samples below the WHO limit.

These findings show drinking water in Birnin Kebbi and Kalgo may be grossly contaminated with heavy metals and pose a significant health threat to the consumers. The reason for the variations in the values obtained may be attributed to the lack of good hygienic state of the septic tanks used in storing the water. High levels of iron will impart a bitter taste to water making it have that metallic taste like that of blood, a brownish color to laundered clothing and plumbing fixtures, emergence of iron bacteria and discoloured beverages, and may also result in haemochromatosis, a condition in which normal regulatory mechanism do not operate effectively, leading to tissue damage as a result of the accumulation of iron (Arko *et al.*, 2019). Low-level exposure to chromium can irritate the skin and cause ulceration. Long-term exposure can cause kidney, liver damage, and damage too circulatory and nerve tissue.

Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium (Lenntech, 2011). Lead is the most toxic of the heavy metals. In humans, exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system (Duruibe *et al.*, 2007; Lenntech, 2011). Natural processes and anthropogenic activities has been shown to contaminate groundwater (Egwari and Aboaba, 2002). Such activities could be domestic, agricultural or industrial in nature. So contamination of surface and ground water could be blamed for the high levels of heavy metals detected.

Table 5 and 6 shows the counts of the microorganisms enumerated from the water samples from Birnin Kebbi and Kalgo. Bacterial colonies were detected above the WHO limits in all the samples from Birnin Kebbi except in A2, A7, A8, A9 and B7 where they were detected within the limit specified by WHO. In samples collected from Kalgo bacterial colonies were detected above the WHO limits C1, C3, D1, D2, and D3, whereas only C2 was within the normal range. Bacterial colonies were detected above WHO limits in majority of the samples indicating that water supply in those areas are not suitable for consumption. Jega *et al* (2017) also detected *Salmonella typhi*, *Escherichia coli*, *Citrobacter species*, *Enterobacter species* and *Serratia marcescens* in a public water supply in Birnin Kebbi. Similar results were reported by Gulumbe *et al* (2016) who isolated several bacterial colonies from a dam in Aliero. Some bacteria species can cause cholera, diarrhea, dysentery, respiratory diseases, gastrointestinal diseases, etc. (Igarashi *et al.*, 2017). Similar results have also been reported by Yayaha *et al* (2019) who assessed the heavy metals content and microbial loads of sachet water in Birnin Kebbi metropolis.

Coliforms were not detected in all of the samples, even though most coliforms do not cause diseases, some uncommon strains of *E. coli*, mostly the 0157:H7 can cause severe illnesses (NYSDH, 2017; Yahaya *et al.*, 2019). Yeast was found in A3 and C3 at level within the WHO limit while in B4 it was found to be abnormally high, proving that the water in that area is unsafe for consumption. Certain yeast has been shown to can cause allergic reactions, produce mycotoxins and be pathogenic to humans (Patterson and Lima, 2005).

CONCLUSION

From the results of this study, it can be concluded that the piped borne water supply from the majority of the sampled areas were contaminated with heavy metals. It is also clear from the study that the water samples were not free from bacteria and yeast contamination. Therefore, awareness on the possible risks associated with consuming pipe-borne water contaminated with heavy metals and microbes should be given to rural communities where such is the source of water. The Municipal Assembly (Town Council) should

demand that water quality tests are conducted on all pipe-borne water occasionally. They should also be educated on possible means of treating of water such as boiling, use of chlorination tablets and use of water filters so as to prevent possible adverse health effects.

Conflict of Interest: The authors declare no conflict of interest.

Authors Contribution: Yahaya T. O designed the experiment, Nana A. A., Anyebe A.A. and Bello A. collected the samples and well as carried out the experiments while Shemishere U.B. wrote the manuscript and supervised the successful completion of the work.

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