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Research Article

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Heavy metals and Microbiological evaluation of some public borehole water in Bida Metropolis

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Abstract

Many communities in Bida Niger State, Nigeria, are increasingly dependent on boreholes as source of water. The aim of this study is to examine the suitability of drinking water from 16 boreholes in Bida covering all the fourteen wards in Bida. Total coliforms was enumerated using the standard most probable number method and the heavy metals in the water samples were determined using the atomic absorption spectrometry method. Four probable bacterial organisms were isolated which include; *Escherichia coli, Klebsiella sp, Enterobacter sp* and *Salmonella sp*. *Escherichia coli* was isolated from six samples, *Klebsiella sp* was isolated from four samples and *Enterobacter sp* was also isolated from four samples while *Salmonella sp* was isolated from other four samples. Also the MPN Index Per mL ranged between 2.0 cfu/mL to 9.5 cfu/mL. Four heavy metals were tested for in the 16 samples which include Nickel (Ni), Manganese (Mn), Lead (Pb) and Chromium (Cr). One sample shows the presence Ni of though at low level (0.017 mg/L). Pb was determined in seven samples ranging f
rom 0.001mg/L to 0.042mg/L. The presence of Cr was observed in two samples with equal amount of 0.006mg/L. Manganese was below detection level all the samples. The result indicate that actions need to be taken on further treatment of the water before consumption even though all tested factors complied with recommended standards because prolonged consumption of such water could lead to unforeseen health hazards due to bioaccumulation.

Keywords: Heavy metals, Borehole water, Total coliforms, Bacteria

Introduction

Water is the most common compound on earth. Water is an essential resource for living systems, industrial processes, agricultural production and domestic use. Ninety seven percent of the world's water is found in oceans. Only 2.5% of the world's water is non-saline fresh water (Itodo and Itodo, 2010). However, 75% of all fresh water is bound up in glaciers and ice caps. Only 1% of fresh water is found in lakes, rivers, soils and 24% is present as ground water. The use of water increases with growing population, putting increasing strain on these water resources. An adequate supply of safe drinking water is one of the major prerequisites for a healthy life. The importance of clean water and the link between contaminated or putrid water and illness was recognized in the distant past, even though the actual cause of disease was not properly understood until the latter half of the 19th century (WHO, 1992).

In many developing countries, availability of water has become a critical and urgent problem and it is a matter of great concern to families and communities depending on non-public water supply system (Okonko *et al*., 2008). Increase in human population has exerted an enormous pressure on the provision of safe drinking water especially in developing countries (Umeh *et al.,* 2005). Unsafe water is a global public health threat, placing persons at risk of contacting diarrhoea and other diseases as well as chemical intoxication (Hughes and Koplan, 2005). Unsanitary water particularly has devastating effects on young children in the developing world. Each year, more than 2 million persons, mostly children less than 5 years of age, die of diarrhoea related disease (Kosek *et al.,* 2003; Parashar *et al.,* 2003). For children in this age group, diarrhoea related disease accounted for 17% of all death from 2000 to 2003 ranking third among causes of death, after neonatal causes and acute respiratory infections (WHO, 2005).

Materials and Methods

Water samples were collected from sixteen (16) boreholes within Bida metropolis. Some samples were from boreholes located near metal work sites while others were from boreholes located in normal residential areas in Bida, Niger State.

Presumptive Test, Isolation of Micro-Organisms, Tentative Grouping and Citrate Utilization Test were carried out using method described by Beishir, 1991.The method adopted by Claus, 1989 was used for Sugar Fermentation Test, Catalase Test, and Indole Test**.**

Heavy metals analysis was conducted using Atomic Absorption Spectrophotometer (AAS) model 210VGP after digestion of the samples as described by Udo and Ogunwale 1986.

Results

Table 1 below shows the result for the presumptive test for presence of coliform

Table 1: Presumptive Test for Presence of Coliform

Sample	Double strength 10ml of sample	Single strength 1ml of sample	Single strength 0.1ml of sample	Number of positive tubes 10:1:0.1	MPN	MPN Index Per mL or g
A	5	1	1	511	46	4.6
B	4	4	3	443	54	5.4
C	5	2	1	521	70	7.0
D	3	4	1	341	24	2.4
E	2	5	4	254	29	2.9
F	3	4	1	341	24	2.4
G	5	1	1	511	46	4.6
H	1	5	5	155	24	2.4
I	3	3	2	332	24	2.4
J	4	5	1	451	48	4.8
K	5	2	2	522	95	9.5
M	3	2	2	322	20	2.0
N	4	4	2	442	47	4.7
O	2	3	4	234	22	2.2
P	5	1	2	512	64	6.4

MPN = Most Probable Number of bacteria

Table 2 below shows the result for the confirmative test and gram staining.

Table 2: Confirmative Test and Gram Staining

Sample	Gram Staining	Colony Appearance	Microscopy
A	-	Dark blue-colonies with metallic green sheen	Rod-shaped bacilli
B	-	Dark blue-colonies with metallic green sheen	Rod-shaped bacilli
C	-	Dark blue-colonies with metallic green sheen	Rod-shaped bacilli
D	-	Smaller brown, dark-coloured mucoid colonies	Rod-shaped bacilli
E	-	Brown, dark centred, mucoid colonies	Rod-shaped bacilli
F	-	Brown, dark centred, mucoid colonies	Rod-shaped bacilli
G	-	Smaller brown, dark-coloured mucoid colonies	Rod-shaped bacilli
H	-	Smaller brown, dark-coloured mucoid colonies	Rod-shaped bacilli
I	-	Dark blue-colonies with metallic green sheen	Rod-shaped bacilli
J	-	Pinkish colonies with dark center	Rod-shaped bacilli
K	-	Dark blue-colonies with metallic green sheen	Rod-shaped bacilli
L	-	Brown, dark centred, mucoid colonies	Rod-shaped bacilli
M	-	Smaller brown, dark-coloured mucoid colonies	Rod-shaped bacilli
N	-	Pinkish colonies with dark center	Rod-shaped bacilli
O	-	Brown, dark centred, mucoid colonies	Rod-shaped bacilli
P	-	Dark blue-colonies with metallic green sheen	Rod-shaped bacilli

+ = Positive, - = Negative

Table 3 below shows the result for the biochemical test.

Table 3: Biochemical tests

Sample	Sugar Fermentation Test							Probable Identification
	Glucose	Lactose	Sucrose	Galactose	Catalase	Citrate	Indole	
A	+	+	-	+	+	-	+	*Escherichia coli*
B	+	+	-	+	+	-	+	*Escherichia coli*
C	+	+	-	+	+	-	+	*Escherichia coli*
D	+	+	+	+	+	+	-	*Klebsiella species*
E	+	+	+	+	+	+	-	*Enterobacter species*
F	+	+	+	+	+	+	-	*Enterobacter species*
G	+	+	+	+	+	+	-	*Klebsiella species*
H	+	+	+	+	+	+	-	*Klebsiella species*
I	+	+	-	+	+	-	+	*Escherichia coli*
J	+	+	+	+	+	+	-	*Salmonella species*
K	+	+	-	+	+	-	+	*Escherichia coli*
L	+	+	+	+	+	+	-	*Enterobacter species*
M	+	+	+	+	+	+	-	*Klebsiella species*
N	+	+	+	+	+	+	-	*Salmonella species*
O	+	+	+	+	+	+	-	*Enterobacter species*
P	+	+	+	+	+	-	+	*Escherichia coli*

+ = Positive, - = Negative

Table 4 below shows the result for the concentration of heavy metals in samples.

Table 4: Concentration of Heavy metals in Samples

Sample	Ni (ppm)	Mn(ppm)	Pb (ppm)	Cr (ppm)
A	0.000	0.000	0.000	0.000
B	0.000	0.000	0.017	0.000
C	0.000	0.000	0.042	0.006
D	0.017	0.000	0.000	0.006
E	0.000	0.000	0.033	0.000
F	0.000	0.000	0.025	0.000
G	0.000	0.000	0.025	0.000
H	0.000	0.000	0.000	0.000
I	0.000	0.000	0.000	0.000
J	0.000	0.000	0.000	0.000
K	0.000	0.000	0.008	0.000
L	0.000	0.000	0.000	0.000
M	0.000	0.000	0.000	0.000
N	0.000	0.000	0.001	0.000
O	0.000	0.000	0.000	0.000
P	0.000	0.000	0.000	0.000

ppm = mg/L, Ni = Nickel, Mn = Manganese, Pb = Lead, Cr = Chromium

Discussion

Water fit for drinking from any source should be free from bacterial presence and those with bacterial constituent should be treated before consumption. All the borehole water samples were devoid of faecal coliform, they were however not free of total coliforms which are probably from the environmental sources and are nonfaecal in origin. The MPN (cfu/100mL) in the study ranged from 2.0 to 9.5 MPN (cfu/100mL) (Table 1). The study revealed low bacterial activities in all the samples except sample K (Federal Low cost I) which showed a high bacterial activity of 9.5 MPN (cfu/100mL) though it was below the set standard of 10 MPN (cfu/100mL) as stipulated by the Standard Organization of Nigeria (SON, 2006). Samples D, E, F, H, I, L, M and O. all had extremely low bacterial load of 2.4, 2.9, 2.4, 2.4, 2.4, 2.6, 2.0 and 2.2 MPN (cfu/100mL) respectively (Table 1). The other samples of A, B, C, G, J, N and P showed mild bacterial load with 4.6, 5.4, 7.0, 4.6, 4.8, 4.7 and 6.0 MPN (cfu/100mL) respectively (Table 1). All samples fell within the standard set by various health governing bodies such as SON and WHO which is 10 MPN (cfu/100mL). Hence it can be said that the boreholes are fit for consumption except for sample K which may need to be treated before consumption.

Likewise in this study, four organisms were isolated from the water samples whose probable identification includes; *Escherichia coli, Klebsiella sp, Enterobacter sp* and *Salmonella sp. Escherichia coli* was isolated from six of the samples (Sample A, B, C, I, K and P), *Klebsiella sp* was isolated from four of the samples (D, G, H and M), *Enterobacter sp* was isolated from four of the samples (E,F, L and O) while *Salmonella sp* was isolated from two of the samples (J and N) (Table 2 and 3). The presence of *Klebsiella sp*., *Salmonella sp*., *Escherichia coli* and *Enterobacter sp* in borehole water samples are however unacceptable from the public health point of view (Agbabiaka and Sule, 2010). These organisms could be pathogenic. Therefore, there is need for caution when using these contaminated borehole water sources for any purposes. Agbabiaka and Sule, (2010) and Uzoigwe and Agwa (2012) also suggested the same thing when they conducted a similar research on selected borehole in Ilorin Kwara State metropolis and Port Harcourt Rivers State respectively.

Borehole which serves as the major source of drinking water for the people in most sub-Saharan Africa could be infected by toxic metals by natural or anthropogenic sources. Exhaust from vehicles, use of fertilizers, refuse dumps, use of non-biodegradable materials could be the possible sources of the toxic metals. The ingestion of these metals could be detrimental to human health especially when they are consumed over a long period of time even in very low concentrations as observed in this study.

Four heavy metals were tested for in this study which include; Nickel (Ni), Manganese (Mn), Lead (Pb) and Chromium (Cr). These metals were selected because they pose very high danger to human health when in poisonous quantity. The presence of Pb was observed in sample B (0.017mg/L), sample C (0.042mg/mL), sample E (0.033mg/L), sample F (0.025mg/L), sample G (0.025mg/L) and sample N (0.001mg/L) (Table 4). Ni was only observed in sample C and Cr was observed in sample C (0.006 mg/L) and sample D (0.006mg/L) while Mn was absent in all the samples (Table 4). It can be observed that the Sample C contained two metals (Ni and Cr). This could be as a result of the blacksmith activities occurring in the area. Though the concentration of these determined metals was within recommended standard, its relevance in the water samples cannot be overemphasized. Even at a very low level, the presence of these metals in drinking water can pose danger as a result of bioaccumulation due to continues consumption thus, water meant for consumption must be free from chemical and heavy metals for it to be safe for drinking. This is supported by similar work conducted by other researchers (Dada, 2009 and Ashbolt *et al.,* 1993

Conclusion

The investigations carried out in this study revealed that the bore hole water are fit for consumption though drastic steps need to be taken to curtail incidence of bioaccumulation of heavy metals in the body which if not tackled will eventually lead to carcinogenic health hazards. The presence of bacteria in the water should also not be overlooked since they can be pathogenic when consumed in large quantity over a period of time.

Considering the level of coliform colonies observed, it is imperative to advise that care should be taken in consumption of the water and if possible, disinfection should be done before consumption. As human population is on the increase and technology continually being exploit, it is anticipated that pollution of water will rise. Hence, adequate protection of water pollution should be enforced. The sites of boreholes are very important as clean and hygienic environment promote safety of water.

The absolutely low levels of heavy metal contents across the sampled boreholes show they are not polluted and as such suitable for human consumption. However, their presence are not negligible as they can also cause harm over prolong period of consumption. The presence of these heavy metals in the water sample can be attributed to activities of the area

especially sample C where the borehole is located in front of a local (blacksmith) metal smelting site. Due to this fact, the geologist drilling boreholes have to be educated on the importance of ensuring that such sites are not used for drilling of boreholes since they can pose a danger to human health.

Recommendations

In order to maintain and improve on the present quality status of boreholes in Bida Metropolis, routine monitoring and assessment of boreholes mostly the indiscriminate sinking of boreholes to meet the ever increasing demands of people in the area by sanitary inspection officers is suggested. Also the following recommendations are also postulated:

- Further researches should be conducted to further investigate the presence of the heavy metals in some of the boreholes especially the sample C borehole which is located close to a blacksmith workshop.
- The populace should be educated on the importance of maintaining clean and hygienic environment around the borehole to ensure the safety of water from such boreholes.
- The government both at the Federal and State level should consider it a matter of urgency to ensure that environmental protection agencies enforce the law on environment.
- Pit latrines, Toilet Suck-away and dump sites should not be located near boreholes.
- Animal breeding and cultivation should be done away from boreholes since these are one of the major sources of pathogenic micro organisms in water.

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