International Research Journal of Public and Environmental Health Vol.3 (6),pp. 140-145, June 2016
Available online at http://www.journalissues.org/IRJPEH/
http://dx.doi.org/10.15739/irjpeh.16.018

ISSN 2360-8803

Original Research Article

Physicochemical and bacteriological assessment of some borehole waters in the Federal Capital Territory, Nigeria

Received 26 April, 2016 Revised 26 May, 2016 Accepted 2 June, 2016 Published 7 June, 2016

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A study on physicochemical and bacteriological assessment of borehole waters in the six Area Councils of Federal Capital Territory (FCT), Nigeria was carried out. The physicochemical results (pH, Conductivity, Calcium, Magnesium, lead, Cadmium, Zinc and Hardness) were carried out. These results were compared with the World Health Organization and National Agency for Food and Drug Administration and Control (NAFDAC). Borehole water sample from Bwari has the highest pH (7.5) while AMAC and Abaji have the lowest pH (6.9) value. The conductivity of the water samples ranged from 102.5 to 112.15 (µs/cm). The amount of calcium ranged from 4.25 to 4.95 (mg/l) while magnesium ranged from 1.0 to 2.7(mg/l). However, Zn^{2+}, Pb^{2+} and Cd^{2+} were not detected. The total aerobic count of the borehole waters analysed ranged from 2.45x105 to 3.45x106 of cfu/100ml, total coliform count ranged from 9 to 22.5 MPN/100 ml and a biological oxygen demand (BOD) range of 3.20-5.60mg/l. The bacteriological results of borehole water in the six Area Councils of FCT did not comply with the zero count per 100ml of WHO standard and this poses agreat health risk to consumers. Identifications of isolates were done and the presences of some bacteria were noted. Hence, there is need to enlighten the inhabitants on the treatment of borehole waters before consumption.

Key word: Physicochemical, bacteriological, water and borehole

INTRODUCTION

Water is an important constituent of all forms of life. It is essential for life as it is the medium in which all living processes occur. Water is a combination of hydrogen and oxygen atoms, with a chemical formula H_2O (Osei, 2005). Retra (2002) described water in its pure form as a substance that has a pH value of 7.0, freezing point of 0° C and the boiling point of 100° C at 760mmHg.Water is abundant in nature and is an important part of the earthly environment, covering about (75%) of the earth surface. It occurs as surface water in lakes, streams, rivers, ponds, shallow aquifers, oceans, seas, ice caps, glaciers, etc, and as ground water (when it accumulates in the ground) which is obtained as spring water, well water, and borehole water (Chandra et al., 2012).

The borehole is categorized as groundwater, because it is obtained from aquifers (underground layers of water-bearing rock) (Singleton, 1999). As the population grows worldwide, water demand also rises. The increasing demand for portable water supply for domestic and commercial needs have necessitated the inevitable use of groundwater (Sandhu et al., 1979). Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is potable and safe for drinking (Tebutt, 1983).

Potable water is defined as water that is free from disease producing-microorganisms and chemical substances deleterious to health (Ihekoronye and Ngoddy, 1985).

Serious ill health can be caused by water contaminated with faeces being passed or washed into river, stream, pool or being allowed to seep into well or borehole (Cheesbrough, 2006). There has been a report of borehole water contamination through much domestic waste water and livestock manure especially if there is a puncture in a layer of soil (Obi and Okacha, 2007). These waste and sewage, when deposited near the boreholes may travel with percolating rain water directly into the boreholes or may travel along the well-wall or surrounding material of the drill-holes (Obi and Okacha, 2007). The high prevalence of diarrhoea among children and infants is associated with the use of unsafe water and unhygienic practice (Oladipo et al., 2009; Tortora et al., 2002). Thus, many infectious diseases are transmitted by water through faecal oral contamination. Water may contain toxic inorganic chemicals which may cause either acute or chronic health effect (Tortora et al., 2002).

Since pipe borne water can be found only in the main towns of the federal capital territory (FCT); and with the tremendous influx of people into the F.C.T, people living in the satellite towns use boreholes as their main source of water. However, due to increase in population, public water supply from these boreholes is very unstable and unpredictable as supplies are often irregular. As a result, most of the people drilled their boreholes at a depth less than 30m which is often called wash boreholes. Considering the fact that industrial and human activities could affect borehole negatively, it has become an issue of necessity, to study the quality and safety of the boreholes water in the federal capital territory of Nigeria.

MATERIALS AND METHODS

Study Area

The federal Capital Territory is located in the geographical centre of Nigeria for easy accessibility to all parts of the country. It lies between the latitude of 8°30` N and 9° 15` W and longitude 6° 47` S and 7° 20` E. It is bounded to the North by Kaduna and Niger States, to the South by Kogi State, to the East by Nasarawa State and to the West by Niger State. In the present study, six Area councils including, Abuja Municipal Area Council (AMAC), Abaji, Bwari, Gwagwalada, Kuje and Kwali, were used for the analysis.

Materials

The materials used include Thermometer, pH meter (AGS-75), conductivity meter (LF90), sterilized petri dishes, hand lens, absorbent pads, water samples, membrane filtration apparatus, marker, Bunsen flame, hot plate, forcep, distilled water, incubator, autoclave, filter paper (0.45µm), wire loop, membrane lauryl sulpahte broth, eosin methylene blue, nutrient agar, microscope, clean grease free glass slides spatula, weighing balance, bijoux bottles, incubator, autoclave, porcelain evaporating dish 100cm capacity, desiccators, drying over for operation at 103 °C to 105 °C, Analytical balance, durham tubes.

Collection of samples

This study was carried out between the months of February and May. Two borehole water samples were randomly collected from six different boreholes in the Area councils and used for both physicochemical and bacteriological analyses.

Procedure for physicochemical analysis

The physicochemical determined are pH, conductivity, temperature, calcium, Magnesium, Cadmium, Lead, Zinc and total hardness, using the methods of FAO (1997).

pH Value

The pH were determined using the pH meter (AGS-75). The pH meter was standardized with buffer solutions of different pH values before being used (Ademoroti, 1996).

Electrical Conductivity

Electrical conductivity was estimated with conductivity meter (LF90 model). The conductivity meter was first standardized with buffer solution and temperature of different water samples before the steady readings were noted (Ademoroti, 1996).

Temperature

The temperature of each sample was determined with mercury-bulb thermometer by immersing the bulb vertically into the water samples and allowed to stand till the temperature reading was steady according to (Ademoroti, 1996).

Preparation for Cations Standards

Calcium (Ca)

A 1000 ppm of calcium was prepared by dissolving 0.92g of calcium chloride ($CaCl_2$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Magnesium (Mg)

A 1000 ppm of magnesium was prepared by dissolving 2.59g of magnesium sulphate ($MgSO_4$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Cadmium (Cd)

A 1000 ppm of cadmium was prepared by dissolving 0.79g of cadmium sulphate ($CdSO_4.8H_2O$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Lead (Pb)

A 1000 ppm of lead was prepared by dissolving 0.4g of lead nitrate (Pb $(NO_3)_2$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

Zinc (Zn)

A 1000 ppm of zinc was prepared by dissolving 1.02g of zinc pentahydrate ($ZnSO_4 . 7H_2O$) in about 15ml of distilled deionized water and then later made it up to 250ml. (Ademoroti, 1996).

All the cations as mentioned above were determined by the concentration of the element in the unknown sample and calculated by reading the sample concentration from the calibration curve and multiplying it by the dilution factor (Adams, 1995).

Determination of Total Hardness

Total Hardness was determined using EDTA Trimetric method (Apha, 1995).

Procedure for Bacteriological Analysis

Total Aerobic Count; using the Spread Plate Technique

This was done by preparing tenfold serial dilution of the samples and later, 0.05ml from chosen dilutions (10^3 and 10^4) were dispensed onto dry, sterile surfaces of nutrient agar plates, and spread out using a sterile hockey-stick shaped glass rod. They were allowed undisturbed for 30 minutes on the bench and later incubated upside down (to avoid possible contamination from the water vapours) at 37°C for 24 hours till consistent colony forming units (CFU) were obtained. The CFU were counted and recorded for each sample (Agbu et al., 1988).

Most Probable Numbers (MPN) technique

The technique was carried out in three stages of Presumption, Confirmatory and Completed Tests as adopted by Isu and Onyeagba (1998).

Biological Oxygen Demand (BOD):

This was done by using Winkler's method, as reported by Ademoroti (1996). The BOD is a test to measure the amount of biodegradable organic materials present in a sample of water.

The results are expressed in terms of mg/l of dissolved oxygen (D.O), which microorganisms, principal bacteria will consume while degrading these materials (Ademoroti, 1996).

Biochemical test

The biochemical test such as catalase, gelatin hydrolysis, oxidase, imvic, indole, methyl red, voges-proskauer, simmon citrate and gram staining were carried out and each plate was confirmed and given a positive or negative scores. However, isolates were confirmed by biochemical test according to (Isu and Onyeagba, 1998).

RESULTS

The results obtained from the physicochemical, bacteriological and biochemical analysis of borehole water in FCT, Nigeria are shown in Tables 1, 2 and 3 respectively. These results were compared with that of the World Health Organization (WHO) and National Agency for Food and Drug Administration and Control (NAFDAC). From the physicochemical parameters (pH, Conductivity, Calcium, Magnesium, lead, Cadmium, Zinc and Hardness) as presented in Table 1, showed bore-hole water sample from Bwari have the highest pH (7.5) while AMAC and Abaji has the lowest pH (6.9). All the borehole water samples pH values are within the range of WHO and NAFDAC standards.

The conductivity of the water samples ranged from 102.5 to 112.15 (µs/cm) and the highest was recorded in Gwagwalada (112.15µs/cm), while the quantity of Calcium found in the borehole water samples ranged from 4.25 to 4.95 (mg/l) and the highest was in Gwagwalada (4.25mg/l) as well. The Magnesium measured at (mg/l) also ranged from 1.0 to 2.7(mg/l) while there was no trace of lead, Cadmium and Zinc were found. The Highest value for hardness (5.5mg/l) was observed in Gwagwalada water sample while borehole water sample from Bwari had the least hardness of (4.55mg/l).

The result of the bacteriological analysis of the borehole water in the FCT area council exceeded the WHO set standard (Table 2). The total aerobic count in Kwali ($3.45x10^6$cfu/100ml) was the highest value recorded, while Gwagwalada ($2.45x10^5$cfu/100ml) was the lowest. The total coliform count and BOD were recorded highest in Kwali as well, at (22.50 MPN per 100ml) and (5.60mg/l) respectively.

The results of biochemical analysis of borehole waters of the FCT area councils show that some microorganisms are observed, presented Table 3. The occurrence of these microorganisms may be as a result of the nature of the soil, or process of handling during drilling.

DISCUSSION

The results of physicochemical parameters of borehole water obtained in this study show, that the pH values of the water samples fell within the range of 7.50 to 6.90 which do comply with standard requirements by WHO, (1984). The pH results obtained in this study suggest that isolates identified may tend to thrive in slightly acidic environments

Table 1. Physicochemical Parameters of Different Borehole Water Samples in FCT

S/N	PARAMETERS	GWAGWALADA	AMAC	ABAJI	BWARI	KUJE	KWALI	WHO	NAFDAC
1	pH	7.10	6.95	6.90	7.50	7.0	7.15	7.0-8.5	6.5-8.5
2	Conductivity(µs/cm)	112.15	104.85	103.00	103.05	102.5	102.8	-	-
3	Calcium(mg/l)	4.95	4.5	4.35	4.45	4.35	4.25	-	-
4	Magnesium(mg/l)	1.30	1.20	1.75	1.00	1.00	2.7	-	-
5	Lead(mg/l)	NT	NT	NT	NT	NT	NT	-	-
6	Cadmium(mg/l)	NT	NT	NT	NT	NT	NT	-	-
7	Zinc(mg/l)	NT	NT	NT	NT	NT	NT	-	-
8	Hardness(mg/l)	5.50	5.00	4.70	4.55	4.95	4.75	-	-

Table 2. Bacteriological analysis of different borehole water samples in FCT

S/N	SAMPLE LOCATION	TOTAL AEROBIC COUNT (cfu/100ml)	TOTAL COLIFORM COUNT (MPN per 100ml)	BOD (mg/l)
1	GWAGWALADA	2.45×10^5	9.00	3.20
2	AMAC	3.30×10^6	16.00	4.45
3	ABAJI	2.55×10^6	9.00	4.15
4	BWARI	2.93×10^6	11.50	4.45
5	KUJE	3.30×10^6	11.50	3.70
6	KWALI	3.45×10^6	22.50	5.60
7	WHO	Zero per 100ml	Zero per 100ml	

Table 3. Biochemical characterization of bacteria isolated from borehole water in FCT

ISOLATE NO.	GRAM REACTION	IND	MR	VP	S.C	GH	OX	CAT	PROBABLE ORGANISM
A(1-5)	GR	+	+	_	_	_	_	_	*Escherratia spp., Shigella spp., Morganella spp., Acinobacter spp., Aeromonas spp.*
B(1-4)	GR	_	+	_	+	_	_	_	*Salmonella spp., Citrobacter spp., Paracolobactrum spp., Edwardsiella spp.*
C(1-2)	GR	_	_	_	+	_	_	_	*Aerobacterspp and Capnocytophage spp.*
D(1-3)	GR	+	+	_	+	_	_	_	*Serratia spp., Kelebiesella spp., providencia spp.*
E(1)	GR	_	_	_	_	+	+	_	*Pseudomonas spp.*
F(1)	GR	+	+	+	+	_	_	_	*Enterobacter spp.*
G(1)	GR	+	+	+	+	+	_	_	*Proteus spp.*

GR-Gram Reaction, IND-Indole, MR-Methyl Red, VP-Voges-Proskauer, S.C-Simmon Citrate, GH-Gelatin Hydrolysis, OX-Oxidase, CAT- Catalase

which are consistent with the report of Jideani (2003). The pH range in this study is close to neutrality and would allow the growth of most bacterial species. Eniola et al., *(*2007) obtained similar pH ranges of 6.54 – 7.80 and 6.54 to 7.90 for borehole water. The lower conductivity ranges from102.5 to 112.5 µs/cm was observed in the water samples collected from all the areas councils, and this is in agreement with Nigeria Standard of Drinking Water Quality (NSDWQ, 2007). These results correspond to the similar study in Gwagwalada area Council by Etu-Effeotor (1998). The cations determined in this study were Ca^{2+} and Mg^{2+}, while Cd^{2+}, Zn^{2+} and pb^{2+} were not detected in the samples and this may not necessarily mean that there was an absolute absence of these cations in water samples but that they could be occurring in minute quantities that may not have been detected by the AAS SP9 model. The values of borehole water noted Ca^{2+} (4.25-4.95mg/l) and Mg^{2+} (1.0-2.7mg/l) were within the standard of (WHO 1984), tolerable values of 500mg/l and 150mg/l for Calcium and Magnesium respectively and also agree with the results of Etu-Effeotor, (1998). The total hardness for borehole water in FCT is 23.95mg/l which falls within the WHO (1984) set standard of ≤ 500mg/l and the result agrees with the range of 61-120mg/l according to (Udom et al., 2002),

The result of the bacteriological study shows the total aerobic bacteria and total coliform counts in the borehole water to be highest in Kwali (3.45x10^{6}cfu/100ml and 22.5MPN per 100ml).The total aerobic bacteria and total coliform counts of all the water samples were generally high. They exceeded the standard requirement of zero total aerobic bacteria and total coliform counts per 100 ml for WHO (WHO, 2001). High total coliform counts showed that the water from the wash boreholes may have been contaminated.

It could be suggested that the long-term usage of boreholes may lead to deterioration of the water quality; because the pipeline may become corroded with random cracks and in most cases clogged with sediments (Onemano and Otun, 2003). The BOD the showed highest value of (5.6mg/l) in Kwali and the lowest value in Gwagwalada (3.20mg/l), and these values show that the borehole oxygen demand is in agreement with the WHO (1984) standard of 6mg/l as well as that of Etu-Effeotor (1998), recorded range of 1.9-4.21mg/l in Gwagwalada Area Council too.

Finally, the samples from the borehole waters in FCT were positive for some isolates as shown in Table 3 above. About Seventeen genera of bacteria which include *Escherichia spp, Shigella spp, Morganella spp, Acinobacter spp, Aeromonas spp, Salmonella spp, Citrobacter spp*, Paracolobactrum *spp*, Edwardsiella *spp*, Aerobacterspp, Capnocytophage *spp*, Serratia *spp*, *Klebsiella spp, Providencia spp, Pseudomonas spp, Enterobacter spp* and *Proteus spp*, were isolated from the borehole water and these organisms could be pathogenic.

Conclusion

Based on the results from the physicochemical analyses, the FCT borehole waters are safe for consumption as it complied with the WHO (1984) standard. However, the bacteriological and biochemical results showed poor quality for drinking and other domestic uses, and these a poses health risk for the inhabitants. From the present observations and experiments, it is recommended that obtained from this research, there is need of continuous water quality monitoring and steady sanitation around the boreholes cites.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of the paper.

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