

Full Length Research Paper

Physicochemical and bacteriological analyses of drinking water from wash boreholes in Maiduguri Metropolis, Borno State, Nigeria

Mustafa Alhaji Isa*, Ibrahim Alkali Allamin, Haruna Yahaya Ismail and Abubakar Shettima

Department of Microbiology, University of Maiduguri, P. O. Box 1069, Maiduguri, Borno State, Nigeria.

Accepted July 27, 2012

Physicochemical and bacteriological analyses of water samples were carried out from five wash borehole used for drinking purpose in Maiduguri Metropolis, Nigeria. The bacteriological analysis was carried out using multiple tube (most probable number) technique for enumeration of both total coliform count and differential *Escherichia coli* count. The results obtained were compared with World Health Organization (WHO), National Agency for Food and Drug Administration and Control (NAFDAC) and Nigeria Standard of Drinking Water Quality (NSDWQ) standard for drinking water. None of the samples complied with the bacteriological standard as the total coliform count ranges between 6×10^3 and 145×10^3 MPN/ml. Also, with the exception of samples from Hausari and Bulabulin-ngarannam, the other samples did not comply with the pH standard recommended by WHO, NAFDAC and NSDWQ. Total dissolved solid of the water samples from Hausari also exceeded the standard requirements. Although no *E. coli* was detected in the entire samples, there is need to create awareness about the present situation of the wash boreholes and the necessity for further treatment by consumers, before it can be used for both drinking and domestic purposes.

Key word: World Health Organization (WHO), National Agency for Food and Drug Administration and Control (NAFDAC), Nigeria Standard of Drinking Water Quality (NSDWQ), water, wash boreholes.

INTRODUCTION

The quality of drinking water is a powerful environmental determinant of health (WHO, 2010). Water plays an indispensable role in sustenance of life and it is a key pillar of health determinant, since 80% of diseases in developing countries are due to lack of good quality water (Cheesbrough, 2006). Drinking water quality management has been a key pillar of primary prevention for over one and half centuries and it continues to be the foundation for the prevention and control of water borne diseases (WHO, 2010). Contaminated water is a global public health threat placing people at risk of a host of diarrhoeal and other illness as well as chemical intoxication (Okonko et al., 2009). The major risk to human health is faecal contamination of water supplies.

Serious ill health can be caused by water contaminated from 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 many 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). There are several variants of the faecal-oral pathway of water borne disease transmission. These include contamination of drinking water catchments (example, human or animal faeces), water within the distribution system (such as leaky pipe or obsolete infrastructure) or of stored household water as a result of unhygienic handling (WHO, 2010). Increase in human

*Corresponding author. E-mail: mustafaalhajiisa@gmail.com.

population pose a great pressure on provision of safe drinking water especially in developing countries (Okonko et al., 2009). Consequently, water borne diseases such as cholera and typhoid often have their outbreak especially during dry season (Banu and Menakuru, 2010; Adenkunle et al., 2004). High prevalence of diarrhoea among children and infants can be due to 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. Diseases due to drinking of contaminated water leads to the death of five million children annually and make 1/6 of the world population sick (Shittu et al., 2008). Also, water may contain toxic inorganic chemicals which may cause either acute or chronic health effect. Acute effects include nausea, lung irritation, skin rash, vomiting and dizziness, sometime death usually occurred. Chronic effect, like cancer, birth defects, organs damage, disorder of the nervous system and damage to the immune system are usually more common (Erah et al., 2002). Inorganic chemicals like lead may produce adverse health effect which include interference with red blood cell chemistry, delay in normal physical and mental development in babies and young children, slit deficit in attention span, hearing and learning abilities of children and slight increase in blood pressure in some adults. Also, presence of chromium in drinking water had been shown to result in chronic toxic effect (including liver and kidney damage, internal haemorrhage and respiratory disorders) in animal and human by ingestion. Although, the sources of metal contaminants of the underground water are uncertain, it may likely be due to natural process and anthropogenic activities (Erah et al., 2002). In addition, rural water also have excessive amount of nitrite from microbial action on agricultural fertilizer, when ingested nitrite compete for oxygen in the blood (Oladipo et al., 2009).

The use of groundwater is of great importance to Maiduguri inhabitants, as superficial water sources are lacking in the vicinity. Although, Lake Alau has been dammed up for that reason and serve as a reservoir for drinking water since the late 1980s (Rudiger, 2002). Many boreholes have been drilled with a depth of more than 600 m all over Maiduguri metropolis (Rudiger, 2002). Although, 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 30.48 m which are often called wash boreholes. These boreholes are widely recognized within the vicinity and it becomes an important source of drinking water in the area. The population congestion and consequent indiscriminate dumping of polluted water may enhance the infiltration of harmful compound into the ground water. Thus, the possibility of these contaminations may justify the purpose of this research. The objective of the present study was to analyze and determine the overall

physical, chemical and bacteriological quality of drinking water from wash boreholes in Maiduguri Metropolis and the results was compared with the standard guidelines set by WHO, NAFDAC and NSDWQ. It should be noted, however, that there are no available literatures or researches that have been conducted on wash boreholes in the identified area upon which the authors can lay their hands. This research would also provide an insight into the water quality of the boreholes in Maiduguri, Nigeria.

MATERIALS AND METHODS

Sample site

Maiduguri Metropolitan area is the capital of Borno state, located in North eastern Nigeria. It covers more than 3000 km² of different land units. Maiduguri and its immediate environs is known for its dryness, with semi-arid climate, savannah or tropical grasslands vegetation, light annual rainfall of about 300 to 500 mm and the average daily temperature ranging from 22 to 35°C, with mean of the daily maximum temperature exceeding 40°C between March and June before the onset of the rains in July to September. It has mainly sandy loam soils (Arku et al., 2011). It is divided into twenty-one different geographical zones (Rudiger, 2002). In this study, five geographical zones were randomly selected; these include Bulabulin-ngarannam, Hausari, Moduganari, Gwange and Mashamari. Sampling sites were selected based on their closeness to refuse and waste disposal site. Water samples were collected from five different wash boreholes in the month of February and used for both physicochemical and bacteriological analyses.

Collection of water samples

Water samples were collected from five wash boreholes located at different geographical zones within Maiduguri Metropolis using two sterile 250 ml plastic bottles for each sample. To ensure the sterility of the samples, the borehole taps were sterilized by means of cigarette lighters, after which the taps were opened to flow for 1 to 2 min. Then, the plastic bottles were filled with water up to 200 ml leaving some space to allow shaking before analysis. The collected samples were delivered to the laboratory within 30 min of collection.

Physicochemical analysis

The water from samples were analysed for temperature, colour, turbidity, pH, total dissolve solid, conductivity, total alkalinity, manganese, iron, chromium, nitrite, copper and fluoride as describe by FAO (1997a).

Bacteriological analysis

Bacteriological characteristics of the water samples were determined using multiple tube fermentation method (most probable number) for enumeration of both total coliform count and differential *Escherichia coli* count. Lauryl Tryptose Broth (LTB) along with fermentation tubes (Durham tubes) was used. A serial dilution of the water sample to be tested was made and inoculated into LTB growth media. Samples were then incubated at 35°C for 48 h for the presumptive test for total coliform count. After the positive tubes were transferred to Brilliant green lactose bile broth (confirmation test) and incubated for 48 h at 35°C, the growth or gas production confirmed the presences of coliform (Nollet Leo, 2007).

Table 1. Physicochemical analyses of water samples from wash boreholes.

S/N	Parameter	Gwange	Mashamari	Hausari	Moduganari	Bulabullin Ngarannam	WHO		NAFDAC	NSDWQ
							Highest desirable level	Maximum permissible level		
1	Temperature at the time of analysis (°C)	26.6	27.5	29.2	28.3	30.0	-	40	-	Ambient
2	Colour (TCU)	Not determined	6		15	15				
3	Turbidity (NTU)	0.77	0.85	0.78	0.85	0.98	5	25	-	5
4	Ph	6.04	6.50	5.72	6.28	6.60	7.0-8.5	6.5-9.2	6.5-8.5	6.5-8.5
5	Total dissolve solid (mg/L) (TDS)	374	332	547	94	247	500	1500	500	500
6	Conductivity (µs/cm)	747	664	1092	189	496	NS		NS	1000
7	Total Alkalinity (mg/L)	60	100	60	60	100	80	120	100	-
8	Iron (mg/L)	0	0	0	0	0	-	-	-	0.3
9	Chromium (mg/L)	0	0	0	0	0	-	-	-	0.05
10	Nitrite (mg/L)	0	0	0	0	0	-	-	-	0.2
11	Copper (mg/L)	0.11	0.32	0.47	0.05	0.09	-	-	-	1
12	Fluoride (mg/L)	0.33	0.15	0.63	0.92	0.13	-	-	-	1.5

NS: No standard; NAFDAC (2001), WHO (2001), NSDWQ (2007).

RESULTS

Physicochemical parameters of water samples from five wash boreholes within the Maiduguri Metropolis were analysed. The result is presented in Table 1 and indicated that the temperature of the water samples at the time of the analysis ranged from 26.6 to 30°C, with water samples from Bulabulin-ngarannam having the highest temperature of 30°C, while Gwange had the lowest temperature of 26.6°C (Table 1).

Water sample from Bulabulin-ngarannam had the highest turbidity of 0.98 NTU, while Gwange had 0.77 NTU, none of the samples had objectionable colour. The pH of the water samples ranged from 6.0 to 6.6, while the total dissolve

solid ranged from 94 to 574 mg/L and conductivity measured at µs/cm also ranged from 189 to 1098. Total alkalinity ranged from 60 to 100, while the copper content ranged from 0.05 to 0.47 mg/L, with the water sample from Hausari having the highest copper content of 0.47 mg/L and that of Moduganari having the lowest copper content of 0.05 mg/L. Fluoride also ranged from 0.13 to 0.92 mg/L, but nitrite, chromium and iron were not detected in each of the samples (Table 1).

The most probable number for presumptive total coliform count of the water samples ranged from 6000 to 145,000 MPN per 100 ml. Water sample from Gwange had the highest coliform count of 145,000 MPN per 100 ml, followed by that of Bulumkutu, Bulabulin-ngarannam and Hausari

with 65,000, 36,000 and 35,000 MPN per 100 ml, respectively. However, lowest coliform count of 6000 MPN per 100 ml was recorded in water sample from Mashamari (Table 2).

DISCUSSION

The result of physicochemical analysis of water shows that the pH of the water samples from Gwange, Hausari and Moduganari do not comply with standard requirements. Their values are less than the lower limits of the pH (6.5) recommended by WHO, NAFDAC and NSDWQ, except for those from Mashamari and Bulabulin-ngarannam. Even though pH has no direct effect on human health,

Table 2. Bacteriological analysis of water.

Site	Total coliform count	Differential <i>Escherichia coli</i> count (cfu)
Mashamari	6.00 x 10 ³	Not detected
Gwange	145.00 x 10 ³	Not detected
Hausari	35.00 x 10 ³	Not detected
Bulabulin ngarannam	36.00 x 10 ³	Not detected
Bulumkutu	65.00 x 10 ³	Not detected
WHO standard	0 per 100 ml	0 per 100 ml
NSDWQ standard	10 per 100 ml	0

its indirect action on physiological process cannot be over emphasized (Adenkunle et al., 2004; NSDWQ, 2007). Also total dissolve solid (TSD) of the water sample from Hausari exceeded the standard recommended by WHO, NAFDAC and NSDWQ (500 mg/l). The TDS is the term used to describe the inorganic salt and small amount of organic matter present in solution or water. The principal constituents are usually calcium, magnesium, sodium and potassium cation, carbonate, hydrogen carbonate, chloride, sulphate and nitrate anion (WHO, 1996). The presence of TDS in water may affect its taste (WHO, 1996). It has been reported that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste (WHO, 1996; Bruvold and Ongerth, 1969). The turbidity of all water samples used in this study is in agreement with both WHO and NSDWQ standard. Water turbidity is very important because high turbidity is often associated with higher level of disease causing microorganism, such as bacteria and other parasites (Shittu et al., 2008). The total alkalinity of all water samples are in agreement with both WHO (80 to 120 mg/l) and NAFDAC (100 mg/l) standard. Also, fluoride content of all water samples fell within the standard limit of NSDWQ (1.5 mg/l), likewise the copper content of all the water samples used in this study which is in agreement with NSDWQ standard of 1 mg/l. Although, presence of copper above the standard set by NSDWQ may cause gastrointestinal distress with a shorter term exposure, while a long term exposure may experience liver or kidney damage (EPA, 2012).

All the water samples analysed in this study have unobjectionable colour which is in agreement with the standard colour of 6 TCU by WHO and 5 TCU by both NAFDAC and NSDWQ (NAFDAC, 2001; WHO, 2001; NSDWQ, 2007). Higher conductivity of 1092 μ s/cm was observed in the water sample collected from Hausari, although there is no disease or disorder associated with conductivity of drinking water (NSDWQ, 2007). Iron, chromium and nitrite were not detected in each of the samples.

The total coliform counts of all the water samples were generally high. They exceeded the standard requirement of 10 total coliform count per 100 ml for NSDWQ and zero total coliform count per 100 ml for WHO (NSDWQ,

2007; WHO, 2002). High total coliform counts vividly indicate that the water from the wash boreholes is faecally contaminated. The water sample from Gwange had the highest total coliform count (145,000 MPN per 100 ml). This finding is not surprising considering the high population and close proximity of the wash borehole to pit latrines. The sewage could seep slowly into underground water, thereby polluting it. Also, 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 sediment (Onemano and Otun, 2008). This will allow the passage of inorganic metals and bacteria. The implication of this finding is the possibility of the presence of pathogens that may cause acute intestinal illness, which are generally considered discomfort to health and could become fatal for some susceptible groups (such as infants, elderly and those who are sick) (Addo et al., 2009; Olowe et al., 2005; NSDWQ, 2007). In addition to human and animal waste contamination, parasitic organism such as *Giardia* and *Cryptosporidium* may be present (EPA, 2003; Shittu et al., 2008). Generally, underground water is often considered as the purest form of water (Shittu et al., 2008), although it's vulnerability to contamination could be due to improper construction, animal waste, proximity to toilet facilities, sewage, refuse dump site and various human activities surrounding it (Bilton, 1994; Shittu et al., 2008). However, no *E. coli* were detected in all the water samples, which indicate that all the water samples are free from recent faecal contamination. The ability to detect faecal contamination in drinking water is necessary, as pathogenic microorganisms from human and animal faeces in drinking water pose the greatest danger to public health.

Conclusion

The principal aims of monitoring drinking water are to prevent the spread of water borne diseases and to protect the health of the community. The importance of access to good quality water cannot be overemphasized. Increase in population in Maiduguri Metropolis coupled with the rise in human activity pose a great pressure on

provision of safe drinking water. This necessitates large number of people to consume water from wash boreholes which constitute a major health problem due to close proximity of wash boreholes to pit latrines. This study recorded high number of coliform counts in water samples analyzed, thus making it unsafe for drinking and require further treatment. Therefore, there is an urgent need for awareness to be created about the present situation of these wash boreholes, to enlighten the people on the necessity for further treatment of this water before they can be used for drinking and domestic purposes.

REFERENCES

- Adenkunle LV, Sridhar MKC, Ajayi AA, Oluwade PA, Olawuyi JF (2004) Assessment of the health and socio-economic implication of sachet water in Ibadan, Nigeria. *Afri. J. Biomed. Res.* 7(1):5-8.
- Arku AY, Musa SM, Mofoke ALE, Dibal JM (2011). Re-examining raw effluents from Nigerian Bottling Company Maiduguri for crop irrigation. *J. Appl. Phytotechnol. Environ. Sanit.* 1 (1):43-49.
- Addo KK, Mensah GI, Bekoe M, Bonsu C, Akyen ML (2009) Bacteriological quality of sachet water produced and sold in Teshie-Nungua, Surburbs of Accra, Ghana. *Afr. J. Food Agric. Nutr. Dev.* 9(4):1019-1030.
- Banu N, Menakuru H (2010) Enumeration of Microbial Contamination in School Water. A Public Health Challenge. *Health* 2(6): 582-588. doi: 10.4236/health.2010.26086.
- Bilton G (1994). *Waste Water Microbiology*. Gainesville, New-York. Wiley IBS. pp. 118.
- Bruvold WH, Ongerth HJ (1969). Taste quality of mineralized water. *J. Am. Water Works Assoc.* pp. 61-170.
- Cheesbrough M (2006). *District laboratory Practice in Tropical Countries*. Part 2. Cambridge University Press. pp. 143-157.
- EPA (2003). Environmental Protection Agency, Safe Drinking Water Act. EPA 816-F-03 016.
- EPA (2012). Environmental Protection Agency Basic information about copper in drinking water. Available on <http://water.epa.gov/drinking/contaminants/basicinformation/copper.cfm>. Last update on 6 march 2012.
- Erah PO, Akujieze CN, Oteze GE (2002). A quality of ground water in Benin City: A baseline study on inorganic chemicals and microbial contaminants of health importance in boreholes and open wells. *Trop. J. Pharm. Res.* 1(2): 75-82.
- FAO (1997a). *Chemical Analysis Manual for Food and Water*, 5th ed. FAO Rome I. P:20-26.
- NAFDAC (2001). National Agency for Food and Drug Administration and Control, Ministry Safety bulletin, Volume 1. Recommendation, National agency for food, Drug, Administration and control. Lagos, Nigeria.
- NSDWQ (2007). Nigeria Standard for Drinking Water Quality, Nigeria Industrial Standard, Approve by Standard Organization of Nigeria Governing Council. ICS 13. 060. 20: 15-19.
- Nollet Leo ML (2007) *Hand Book of Water Analysis*. CRC Press Taylor and Francis Group.
- Obi CN, Okocha CO (2007) Microbiological and Physico-Chemical of Selected Bore-hole Waters in World bank Housing Estate, Umuahia, Abia State, Nigeria. *J. Eng. Applied Sci.* 2(5):920-929.
- Okonko IO, Ogunjobi AA, Kolawale OO, Babatunde S, Oluwole I, Ogunnusi TA, Adejoyi OD, Fajobi EA (2009). Comparative Studies and Microbial Risk Assessment of a Water Samples Used for Processing Frozen Sea foods in Ijora- Olopa, Lagos State, Nigeria. *EJEAFChe.* 8(6): 408-415.
- Oladipo C, Onyenike IC, Adebisi AO (2009) Microbiological analysis of some vended Sachet water in Ogbomoso, Nigeria. *Afr. J. Food Sci.* 3(12):406-412.
- Olowe OA, Ojurongbe O, Opaleye OO, Adedosu OT, Oluwe RA, Eniola KIT (2005) Bacteriological Quality of Water Samples in Osogbo Metropolis. *Afr. J. Clin. Exper. Microbiol.* 6(3): 219-222.
- Onemano JI, Otun JA (2003). Problems of Water quality standard and monitoring in Nigeria. Paper presented at the 29th WEDC International Conference at Abuja Sheraton Hotel and Tower, Nigeria on 22-26 September 2003.
- Rudiger KV (2002). To the memory of Dr. Ursula (Uschi) Greinert-Byer. Published Drukerei Franz Hansen, Bergisan Gladbach. 70-90.
- Shittu OB, Olaitan JO, Amusa TS (2008) Physico-Chemical and Bacteriological Analysis of Water Used for Drinking and Swimming Purpose. *Afr. J. Biochem. Res.* 11:285-290.
- Tortora, JG, Funke RB Case LC (2002) *Microbiology an introduction*. Media update of seven edition. Including Bibliography and index Publisher. Daryl fox. pp. 258-260.
- World Health Organization (WHO) (1996). Total dissolve solid in drinking water. Guideline for drinking water quality. 2:0-1.
- World Health Organization (WHO) (2001). *Guidelines for Drinking Water Quality, Recommendation*, Geneva. p. 130.
- World Health Organization (WHO) (2010). *Guidelines for Drinking-water Quality. Recommendation*, Geneva, p: 1-6. Retrieve from http://www.who.int/water_sanitation_health/WHS_WWD2010_guidelines_2010_6_en.