Physicochemical and Microbiological Assessment of Borehole Water Samples in Dutsin Ma, Dutsin Ma L.G.A., Katsina State, Nigeria

Okache, T. A., Adebayo, Q and Sani, M. M
Department of Food Science and Technology,
Federal University Dutsin Ma, Dutsin Ma,
Katsina State.
tokache@fudutsinma.edu.ng

Abstract
This research was carried out to determine the physicochemical and microbiological properties of borehole water in Dutsin Ma Local Government Area in Katsina State, Nigeria. Water samples were collected from boreholes in four zones which include; FUDMA, Yan Daka Palace, Wednesday market and Sokoto Rima all within the community. Some physicochemical and microbiological properties were assessed using standard analytical methods. The mean pH, Total Dissolved Solids and Turbidity for all the samples were within the range of 6.965 - 7.205, 44.0 - 65.5 mg/L and 1.370-3.655 NTU respectively. The mean total hardness, magnesium, calcium, chloride and salinity, for all samples were ranged between 17.955 - 31.750, 5.90 - 8.745, 9.765 - 23.005, 5.10 - 11.35 and 8.415 - 18.700 mg/L respectively. The mean chromium, lead, manganese and nickel in mg/L ranged from 0.0 - 0.005, 0.0 - 0.01, 0.0 - 0.01 and 0.0 - 0.01 respectively, however, arsenic and cadmium were not detected in all the water samples. Microbiological quality assessment showed that all the water samples had no feacal bacteria (0.0 cfu /mL) and their most probable number value was 2 MPN /100 mL. Therefore, the results for physical, chemical and microbiological analysis revealed that all the water samples examined were satisfactory as they were within the permissible WHO, SON, NAFDAC and NESREA standards for drinking water. However, there is need to examine the performance of these waters during storage to determine their shelf life.

Keywords: *Borehole; Dutsin Ma; Microbiological; Physicochemical; Water*

Introduction

Water indeed is an essential component of life (Osunkiyesi, 2012). The need for water in the day to day activities of man include for cooking, washing, drinking and for industrial activities (Akpoborie *et al.*, 2008). Water is available in large quantity as can be seen in oceans, sea, rivers, springs, lakes and ponds. Apart from air, water is the most important element to man. It is essential to humanity and the largest source of fresh water lies underground. It constitutes the largest part of most living matters. Water is an essential part of human nutrition, both directly as drinking water or indirectly as constituent of food. In addition to other applications in daily life, it also remains the most important medium of illness and infant mortality in many developing countries (Ford, 1999). It is also a key parameter influencing survival and growth of microorganisms in food and other microbial environments.

Drinking water has always been a major issue in many countries like Nigeria (Rajini *et al.*, 2010). To describe water as potable, it must satisfy specific criteria of the physical, chemical and microbiological standard. Majority of the rural populace in Nigeria do not have access to potable water (Shittu *et al.*, 2008). Surface water (rivers, stream, lake, dams), and ground

water (borehole and well) can serve as sources for drinking water but with the increasing contamination of surface water there is an increasing resilience on groundwater for drinking and domestic purposes, since it is believed to be pure through natural purification processes (Shyamala *et al.*, 2008). However, failing home septic can allow coliforms in the effluent to flow into the table, aquifers, drainage ditches and nearby surface waters. To limit the effects of these sources of pollution to boreholes water, boreholes is preferably located at least 30 meters away from latrines and about 17 m from septic tanks (WHO, 2006; NESREA, 2007).
Generally, groundwater quality varies from place to place, sometimes depending on seasonal changes (Vaishali and Punita, 2013). During passage through the ground, water dissolves minerals in rocks, collect suspended particulate matter, particularly those from organic sources as well as pathogenic microorganisms from faecal matters (Onuh and Isaac, 2009). Major ions in drinking water are correlated with palatable mineralization that affects the quality of drinking water (Delphia *et al.*, 2009). Certain mineral are also toxic such as the heavy metals. Although, some of the heavy metals such as zinc, manganese, nickel and copper act as micro-nutrients at low concentration. Some of the metals such as calcium, magnesium, potassium and sodium are essential to sustain life and must be present for normal body functions. Also, cobalt, copper, iron, manganese, molybdenum and zinc are needed at low levels as catalyst for enzyme activities. However, excess exposure to heavy metals can result in toxicity (Momodu *et al.*, 2010).
Also coliform bacteria are a group of intestinal bacteria used as indicators to determine if treated water is acceptable for human consumption. Coliforms will not likely cause illnesses, however, their presence in drinking water indicates the presence of disease-causing organisms (Nwachukwu and Otokunefor, 2006). Increase in human population has exerted an enormous pressure in human provision of safe drinking water in developing countries (Umeh *et al.*, 2005). Water borne diseases are caused by pathogenic microorganisms which are directly transmitted when contaminated water is consumed (Abudullahi *et al.*, 2013). Clean groundwater is a vital resource, fundamental to our everyday activities, health and economic wellbeing and ultimately our survival. Contamination of groundwater can directly limit any of its uses (Ehionola *et al.*, 2009).
Access to good water has been a challenge to humans due to pollution of the limited fresh water resources around. Dutsin Ma community, the study area, houses a lot of people ranging from University staff and students, Government College, businessmen and has a lot of boreholes. Within these communities are various improperly managed sanitation systems which can predispose the water system to infection by bacteria and other microorganisms. It is therefore imperative due to a direct impact on the health of individuals to analyze the physicochemical and microbiological properties of these waters to investigate the possibilities of pollution in water from these boreholes.

Materials and Methods

Sample collection

The borehole water samples was aseptically collected from four boreholes within Dutsin Ma metropolis, in a clean 2.0 Litre sample bottle and labeled as follows; A, B, C and D representing FUDMA, Yan Daka Palace, Wednesday market and Sokoto Rima borehole waters respectively. The nozzles of the borehole were swabbed with cotton wool soaked in 70% ethanol and then exposed to flame for 10 seconds to ensure sterility. The water samples collected were kept between the temperature of 4-10^{o}C and transported to the laboratory less than two hours of collection and analyzed within 24 hours. The apparatus used in this study and the specifications were of analytical standard.

Physicochemical Properties of Borehole waters in Dutsin Ma.

Determination of pH was as described by Geotechnical Engineering Bureau. (2007), turbidity was as described by NITTRC. (2009), total dissolved solids (TDS) as described by Shams. (2012), alkalinity, total hardness, calcium hardness, magnesium hardness and chloride were as described by Barbara. (2002),

Determination of Heavy Metals

Method as described by Momodu *et al. (*2010) was used to determine heavy metals in the water samples. The digested water samples were analysed for the presences of lead (Pb), cadmium (Cd), Zinc (Zn), Iron (Fe), and Copper (Cu).

Microbiological Analysis

The standard plate method as described by Cheesbrough, 2000 was used.

Statistical Analysis

The analysis of variance (ANOVA) was used to analyze all data using the statistical package for social sciences (SPSS) version 21 for windows. Mean separation was performed by the LSD test ($p \leq 0.05$).

Results

Physical analysis of borehole water samples in DutsinMa

The results for physical analysis of borehole water samples A, B, C and D from Dutsin-Ma Local Government Area were as presented in Table 1. The pH ranged from 6.965 to 7.205 with sample C having the least value while sample B had the highest value. There was however, significant difference ($p<0.05$) between sample B and all the other samples. Total dissolved solids (TDS) were 44.0, 51.5, 65.5 and 48.0 mg/L respectively, with sample C having the highest value and it was significantly different ($p<0.05$) from all the other samples. In terms of turbidity, Sample D had the highest value of 3.655 NTU while sample B had the least value of 1.370 NTU. Sample D is however, significantly different ($p<0.05$) from all the other samples. Colour was uniformly 5 HAZEN and was within the permissible not more than 15 HAZEN recommended by (WHO, 2011).

Table 1: Physical analysis of borehole water samples in Dutsin Ma

Samples	pH	Total Dissolved Solids (mg/L)	Turbidity (NTU)
A	7.005 ± 0.007^a	44.000 ± 1.414^a	2.060 ± 0.071^a
B	7.205 ± 0.007^b	51.500 ± 2.121^a	1.370 ± 0.028^a
C	6.965 ± 0.064^a	65.500 ± 4.949^b	1.930 ± 0.042^a
D	7.000 ± 0.014^a	48.000 ± 1.414^a	3.655 ± 0.983^b
WHO, SON	6.9-8.2	< 500mg/L	5 NTU

Values are means of duplicate determinations. Mean values along the same column with different superscript are significantly different ($p<0.05$)

A= FUDMA borehole water; B= Yan Daka Palace borehole water; C= Wednesday market borehole; D= Sokoto Rima borehole water

Chemical analysis of borehole water samples in Dutsin Ma

The results for chemical analysis of water samples in Dutsin Ma are as presented in Table 2. Total hardness reveals that for samples A, B, C and D, the values were 23.300, 17.955, 24.950 and 51.750 mg/L respectively. There was significant difference ($p<0.05$) among all the samples. Values for magnesium were 5.900, 8.190, 7.750 and 8.745 mg/L for samples A, B, C and D respectively. There was however, no significant difference ($p<0.05$) among samples. Calcium content ranged from 9.765 mg/L in B to 23.005 mg/L in D. All the samples were significantly different ($p<0.05$) from each other. Values for chloride content reveals that sample B had the least score of 5.1 mg/L while sample D had the highest score of 11.35 mg/L. However, sample C was not significantly different ($p<0.05$) from sample D. Results for salinity showed that sample D had the highest value of 18.7 mg/L while sample A had the least value of 13.7 mg/L. Sample C was however, not significantly different ($p<0.05$) from sample D.

Table 2: Chemical Analysis of borehole water in samples in Dutsin Ma

Sample	Total hardness	Magnesium	Calcium Mg/L	Chlorides	Salinity
A	23.300 ± 0.424^{b}	5.900 ± 1.697^{a}	17.400 ± 1.273^{b}	8.300 ± 0.424^{b}	13.700 ± 0.707^{b}
B	17.955 ± 0.078^{a}	8.190 ± 0.297^{a}	9.765 ± 0.375^{a}	5.100 ± 0.141^{a}	8.415 ± 0.233^{a}
C	24.950 ± 0.071^{c}	7.750 ± 1.061^{a}	17.200 ± 1.131^{b}	11.050 ± 0.212^{c}	18.200 ± 0.424^{c}
D	31.750 ± 1.061^{d}	8.745 ± 2.397^{a}	23.005 ± 1.336^{c}	11.350 ± 1.061^{c}	18.700 ± 1.697^{c}
WHO, SON, NESREA	≤ 150	< 60	< 60	≤ 250	≤ 250

Values are means of duplicate determinations. Mean values along the same column with different superscript are significantly different ($p<0.05$)

A= FUDMA borehole water; B= Yan Daka Palace borehole water; C= Wednesday market borehole; D= Sokoto Rima borehole water

Heavy metals composition of borehole water in Dutsin Ma

Table 3 shows the results of chromium, lead, manganese and nickel for samples A, B, C and D as they ranged from 0.0 - 0.005, 0.0 - 0.01, 0.0 - 0.01 and 0.0 - 0.01 mg/L respectively. There was however no significant difference ($p<0.05$) among all samples for all the parameters under this study. Arsenic and Cadmium were also determine but not detectable in all the water samples.

Table 3: Heavy Metals analysis of borehole water samples in Dutsin Ma (mg/L)

Samples	CHROMIUM	LEAD mg/L	MANGANESE	NICKEL
A	0.000 ± 0.000^{a}	0.000 ± 0.000^{a}	0.000 ± 0.000	0.005 ± 0.007^{a}
B	0.005 ± 0.007^{a}	0.000 ± 0.000^{a}	0.010 ± 0.000	0.000 ± 0.000^{a}
C	0.005 ± 0.007^{a}	0.010 ± 0.000^{b}	0.000 ± 0.000	0.010 ± 0.000^{a}
D	0.000 ± 0.000^{a}	0.006 ± 0.006^{ab}	0.000 ± 0.000	0.006 ± 0.006^{a}
WHO, SON	0.05	0.01	0.02	0.2

Values are means of duplicate determinations. Mean values along the same column with different superscript are significantly different ($p<0.05$)

A= FUDMA borehole water; B= Yan Daka Palace borehole water; C= Wednesday market borehole; D= Sokoto Rima borehole water

Microbiological quality of borehole water samples in Dutsin Ma.

Results of microbiological quality of borehole water samples in Dutsin Ma are as presented in Table 4.

Table 4: Microbiological quality of borehole water samples in Dutsin Ma

Samples	MPNV (MVP/100ml)	Feacal coliform cfu/100ml
A	2.000±0.000	0
B	2.000±0.000	0
C	2.000±0.000	0
D	2.000±0.000	0
WHO	7.0 MPN/100ml	0.0 cfu/100ml

A= FUDMA borehole water; B= Yan Daka Palace borehole water; C= Wednesday market borehole; D= Sokoto Rima borehole water

Discussion

The pH expresses the extent of acidity or alkalinity of a sample. Chinendu *et al*. (2011) reported that portable water that is acidic can have adverse effects on the digestive and lymphatic systems in humans. However, results from this research falls within the acceptable range of 6.9 - 8.2 recommended by WHO, (2011) and SON, (2007) as it ranged from 6.95 to 7.205. The differences in acidity among samples could be as a result of the soil type which may leach some materials into the water aquifer. These results were similar to the 6.91 reported by Ibrahim and Nuraddeen (2014) for borehole water in Dutsin Ma.

The Total Dissolved Solids (TDS) values ranged from 44.0 to 65.5 mg/L. Low TDS water consumption in humans could lead to some health challenges such as goiter, hypertension, heart diseases, especially in the presence of poor dietary habits (Akpoborie, 2008). The results were lower than the (17-198 mg/L) reported by Anake *et al*. (2013) for different water sources in Ogun and lower than the average TDS of 237 mg/L reported by Iliyasu (2009) for ground water in Kabo area in kano state. The low TDS suggest that these boreholes are properly sited, that is, far from possible causes of dissolved matters such as latrines and septic tanks, urban run-off and industrial waste water. However, the results from this study were within the (SON, 2007; WHO, 2011) standard of less than 500 mg/L for drinking water.

Turbidity affects clarity of water and presents an unpleasant looks of water. The mean turbidity of all the boreholes water samples were below the NESREA, (2007) and WHO, (2011) standard of not more than 5.0 NTU set for drinking water. The results from this study were lower than the 5.0 NTU reported by Ibrahim and Nuraddeen (2014) for borehole water in Dutsin Ma, and the difference could be attributed to seasonal variations. The low values of turbidity were as expected as the water samples were clear and colourless from physical observation. The level of turbidity may not shield pathogens from disinfectant as suggested by Barbara (2002) for water with high turbidity. Therefore, further purification of these water samples is possible.

Hardness in water is caused by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations. The results of total hardness, obtained from this research indicates that all the water samples in Dutsin Ma boreholes were soft and suitable for drinking as they were found to be far below the not more than 150 mg/L recommended by (WHO, 2011; NESREA, 2007). The magnesium content of the borehole water were in the range of 5.9 - 8.745 mg/L, which is below the 60 mg/L recommended maximum for drinking water (WHO, 2011; SON, 2007; NESREA, 2007). The calcium content of borehole water in Dutsin Ma was in the range of 9.765 - 23.005 mg/L, this was within the permissible level of below 60 mg/L recommended by WHO (2011). The presence of calcium in the water sample is an indication that there could be deposit of limestone, gypsum, e.tc. However, the quantity of calcium implies that the most economic softening process would be required.

A high concentration of chloride of above 250 mg/L sometimes gives a salty taste in drinking waters and might harm metallic pipes (Sebiawu *et al*., 2014). This can also lead to increased concentrations of metals in the supply (WHO, 2006). However, the chloride concentrations

recorded in this study were lower than the WHO (2011) standard therefore it is regarded satisfactory for utilization. Salinity in this study were within the range of 8.45 - 18.700 mg/L, and were similar to the results of the work of Anake *et al*. (2013) who reported 10 – 80 mg/L for different water sources in Ota, Ogun State. However, the salinity in this research was below the not more than 250 mg/L recommended by WHO (2011) and hence it could be regarded as safe for drinking.
Heavy metals are elements having atomic weights of between 63.546 to 200.590 and a specific gravity greater than 4.0 that is, at least five (5) times that of water. Excess exposure to heavy metals can result in toxicity (Momodu *et al*., 2010). excess lead may cause central and peripheral nervous system damage, kidney damage, hearing impairment, anemia, premature birth, excess mecury may cause inflammation of mouth and gums, swelling of salivary glands, tooth loss, high concentration of mecury and lead may cause irreversible brain damage, excess nickel may cause heart and liver damage, excess cobalt may cause heart problem and thyroid damage, excess cromium may cause liver damage, kidney damage and skin disorder (Telang *et al.*, 2014). However, results of heavy metals from this research for chromium, lead, manganese and nickel were highest at 0.005, 0.01, 0.01 and 0.01mg/L respectively and was lower than the 0.0033, 0.07, 0.026 and 0.03 mg/L reported by Wanboje and Ekundayo (2013) for assessment of heavy metals in surface water of the Ikpoba reservoir Benin City. The results from this research were within the (WHO, 2011; SON, 2007; NESREA, 2007) recommended standard of 0.05, 0.01, 0.02 and 0.2 mg/L for chromium, lead, manganese and nickel respectively, suggesting that these boreholes were properly sited.
The bacteriological analysis showed that enteric pathogens like Salmonella species, Staphylococcus species, Shigella species and Escherichia coli were absent from the analyzed water that is 0.0 cfu/100ml and it was in line with the guidelines of WHO (2011) and SON (2007) which stipulates that drinking water should be of zero feacal coliform count per 100 ml. This result is an indication that the boreholes are well sited and are far from facilities such as soak aways. The most probable number value showed that all the samples had 2 MVN/100 ml. This could be so because of the surrounding where these boreholes are located because these bacteria were non-feacal. However, values were below the 7 MPN/ 100 ml recommended by WHO, 2011.

Conclusion

The study was conducted to assess the quality of borehole water in Dutsin Ma Local Government Area, on the bases of physicochemical and microbiological characteristics, and the results showed that the waters were satisfactory as they all met the WHO, SON and NESREA recommended standard for drinking water in terms of pH, turbidity, total dissolved solids, colour, hardness, chloride, salinity, heavy metal content and microbial load. The study further revealed that the waters were soft, hence does not need any economic method of softening procedure or any robust purification strategies to ensure potability. However, the presence of these levels of calcium and magnesium observed in the water samples is an indication that there could be minerals such as limestone, gypsum, dolomite among others in the soil of Dutsin Ma.

Recommendation

There is need to investigate the shelf life of these water samples (for one to three weeks) to ascertain whether it is potable with time, as most waters are not used immediately after fetching but kept for later usage.

References

Abudullahi, B. T., Ahmed, S. B. & Mohammed, S. A. (2013). Bacteriological and physicochemical properties of borehole water in Niger-state polytechnic, Zungeru campus. Indian J. Sci. Res. 4(1): 1-6.

Akpoborie, T., Egbo, S. H. O., Ebenuwa, C. C & Emeshili, E. M. (2008) Comparative study of the satchet water in Asaba Metropolis, South-South, Nigeria. Book of proceeding of international conference of the chemical Society of Nigeria held in Effurun, Delta State.

Anake, W. U., Ehi-Eromosele, C. O., Siyanbola, T. O., Edobor, O. A., Adeniyi, I. O. & Taiwo, O. S. (2013). Physico-Chemical and Microbial Assessment of Different Water Sources in Ota, Ogun State. *International Journal of Current Research*. 5(7), 1797-1801.

Barbara, A. H. (2002): *Drinking Water Chemistry (A Laboratory Manual).*Boca Raton London: Lewis Publishers U.K.

Cheesbrough, M. (2000). District laboratory practice in tropical countries. Cambridge University press, Cambridge, UK. Pp. 143 -180.

Chinedu, S. N., Nwinyi, O. C., Oluwadamisi, A. Y. & Eze, V. N. (2011). Assessment of water quality in Canaanland, Ota, Southwest Nigeria. Agriculture and Biology Journal of North America, 3(4). 579-583.

Delphia, I., Jung, A. V. & Baures, E. (2009). Impact of climate on surface water quality in relation to drinking water production. Environmental International. 35: 225-1233

Ehinola, O. A., Oladunjoye, M. A, Adabannija, M. A. & Coker, T. J. (2009): Quality of Underground Water and the Health Hazard Implication in Agbowo Area of Ibadan. *Science Focus*. 14(2). 223-230.

Ford, T. E. (1999). Microbiological Safety of Drinking Water, United State and Global Perspective Environmental Health perspective (suppl.1), pp 191-206

Geotechnical Engineering Bureau (2007): *Test Method for Determination of pH Value of Water or Soil by pH Meter*. New York.

Ibrahim, Y. E. & Nuraddeen, A. M. (2014): An Assessment of Some Water Quality Properties of Groundwater in Dutsin-Ma Metropolis. *International Journal of Current Microbiology and Applied Sciences*. 3(5). 644-649.

Iliyasu, G. (2009): Suitability of Groundwater for Various Uses in Kabo Area Kano State. *Techno Science Africana Journal*. 4(10). 84-90.

Momodu, M. A. & Anyakora, C. A. (2010): Heavy Metal Contamination of Ground Water: The Surulere Case Study. *Research Journal Environmental and Earth Sciences.* 2(1). 39-43.

National Environmental Standards of Regulations Enforcement Agency (Establisment) Act 2007.

National Institute of Technical Teachers Training and Research Chennai NITTRC (2009): [Online]. [Retrieved 2014 Nov. 10, 6:23pm]. Available From: http://www.nitttrc.ac.in/

Nwachukwu C. I. & Otokunefor, T. V. (2006). Bacteriolgical quality of drinking water supplies in the University of Port Harcourt, Nigeria. Nig. J. Microbiol. 20: 1383-1388.

Onuh, J.O & Isaac, V. U. (2009). Physicochemical and microbiological quality of water sources from some major towns in Igala Land. Nigeria food journal. 27(22): 66.

Osunkiyesi, A. A. (2012) Physicochemical analysis of Ogun River(water samples) within two locations (AkinOlugbade and Lafenwa) in Aboekuta, Ogun State. IOSR Journal of Applied Chemistry.1(4):24-27.

Rajini, K., Roland, P., John, C. & Vincent, R. (2010). Microbiological and physicochemical analysis of drinking water in George. Nature and science. 8(8): 261 -265.

Sebiawu, E. G,, Fosu, S. A. & Saana, S. B. B. M. (2014) A physicochemical and bacteriological analysis of borehole water samples from the water municipality of the upper West Region, Ghana. Applied Water Science. 12(2):548-552.

Shams, A. (2012): *Eco Study* [Online]. [Retrieved 2014 Nov. 13, 4:07pm]. Available from: http://shamsalamin.wordpress.com/teaching/

Shittu, O. B., Olaitan, J. O. & Amusa, T. S. (2008). Physicochemical and bacteriological analysis of water used for drinking and swimming purposes in Abeokuta, Nigeria. African Journal of Biomedical Research. 2: 238 – 290.

Shymala, R., Shanthi, M & Lalitha, P. (2008) Physico-chemical analysis of Borewell water samples of Telungupalayam Area in Coimbatore district,Tamilnadu, India.E-journal of Chemistry.5(4):924-929.

Standard Organisation of Nigeria SON (2007): Nigerian Standard for Drinking Water Quality. (SON) Act Cap – 412 (2007)

Taleng, T., Saxena, M.K., & Sharma, D. (2014): *Chemistry and Environmental Engineering.* New Delhi, ISBN 978-224-3562-7.

Umeh, C. N., Okorie, O. I & Emesiani, G. A. (2005). Towards the provision of safe drinking water: the bacteriological quality and safety of sachet water in Akwa, Anambra state. In the book of abstract of the 29th annual conference and general meeting on microbes as agents of sustainable development, organized by Nigeria society for microbiology (NSM) University of Agriculture, Abeokuta. pp. 22.

Vaishali, P. & Punita, P. (2013) Assessment of seasonal variations in water quality of River Mini, at Sindhrot, Vadodara. Int. J. Environ. Sci. 3, 1424–1436.

Wangboje O. M. & Ekundayo, O.T. (2013): Assessment of Heavy Metals in Surface Water of the Ikpoba Reservoir, Benin City. *Nigerian Journal of Technology (NIJOTECH)* 32 (1) : 61-66

World Health Organization WHO (2006): *Guideline for Drinking Water Quality* – 3rd Edition. WHO Press, Geneva, Switzerland.

World Health Organization WHO (2011): *Guideline for Drinking Water Quality* – 4th Edition.