http://dx.doi.org/10.4314/bajopas.v9i2.26

Bayero Journal of Pure and Applied Sciences, 9(2): 141 - 144
Received: June, 2016
Accepted: November, 2016
ISSN 2006 – 6996

PHYSICOCHEMICAL QUALITY OF DRINKING WATER FROM VARIOUS WATER SOURCES OF KADUNA STATE, NIGERIA

Olukosi, O.M.[1]*, Ameh, J.B.[2], Abdullahi, I.O.[2], and Whong, C.M.Z.[2]
1- Department of Food science, Kano University of Science and Technology, Wudil, Nigeria
2- Department of Microbiology, Ahmadu Bello University, Zaria, Nigeria
*correspondence author: mofolu4real@yahoo.com

ABSTRACT
This study was undertaken in six Local government areas (LGA) of Kaduna from March 2014-February 2015, with the aim of determining some physicochemical parameters of water being used by residents in the study areas. The results were also compared with the World Health Organization (WHO), Nigerian Institute of Standards (NIS) permissible limits for all the parameters. A total of fifty samples from different water sources were analysed for the following parameters: Biological Oxygen Demand (BOD_5), Dissolved oxygen, Total Dissolved Solids (TDS), Nitrate, Electrical conductivity and pH using standard methods. The values for conductivity (441.57 ± 107.13µhos/cm) and TDS (220.78 ± 53.56mg/l) were significantly higher for the borehole water samples (P<0.05), while the pH (7.27 ± 0.11) and nitrate (15.38 ± 1.29mg/l) values were significantly higher during the rainy season (P<0.05). All the samples tested had their nitrate values less than the maximum level stipulated by both the NIS and WHO. Ninety-six percent of the samples had their pH and TDS within the recommended range (6.5-8.5 and 500mg/l respectively). For the conductivity, the WHO standard differs from the NIS standard, and 60% met the WHO standard while 96% met the NIS standard.
Key words: Potable water, Physicochemical parameters, season, WHO, NIS

INTRODUCTION

Water is an essential need for human existence, and its importance for individual health and the well-being of a nation cannot be underestimated. Notwithstanding, many people in developing countries do not have access to safe and clean drinking water, or to adequate amounts of water for basic hygiene (WHO and UNICEF, 2010). In many developing countries, there are lots of public health concerns related to the challenge of poor water quality and the risk of water-borne diseases (UNICEF/WHO, 2012). Most water sources in developing countries are polluted by both organic and chemical pollutants (Haylamicheal and Moges, 2012). Rapid urbanization, especially in developing countries like Nigeria, has affected the availability and quality of groundwater due to waste and effluent disposal practice, especially in urban areas (Makwe and Chup, 2013). Pollution is caused when a change in the physical, chemical or biological condition in the environment harmfully affects quality of human life, other animals and plants (Esemikose and Akoji, 2014). Agricultural practices, industrialization and discharge of sewage into water bodies are among the factors responsible for water pollution. Pollution easily arises when population growth outmatches availability of potable water due to inadequate urban planning processes (Oluyemi *et al.,* 2010).

To determine the quality of water, several parameters must be examined. Among the key parameters listed by World Health Organization (WHO) for the determination of water quality are conductivity, dissolved oxygen (DO), pH, color of water, taste and odour, turbidity, total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), micro-organisms such as faecal coliform bacteria (*Escherichia coli*), *Cryptosporidium* and *Giardia lamblia*; nutrients (fertilizers), dissolved metals and metalloids (lead, mercury, arsenic and so on) and dissolved organics (WHO, 2011).

The demand for drinking water in Kaduna state is supplied by ground water sources such as wells and boreholes, tap water in areas where it is available, packaged water and stream water in very rural areas where other safe sources of water are not available. The determination of water quality for human consumption is important for the well being of the ever increasing population. Therefore, monitoring the quality of water is one of the essential issues of drinking water management (Nirmala *et al.*, 2012). The objective of this study was to evaluate some physicochemical parameters in these potable water sources in the two different seasons (wet and dry seasons) and compare these values with the WHO and NIS guidelines for water that can be considered potable.

MATERIALS AND METHODS

Site description

The study area was Kaduna State which is in the centre of Northern Nigeria located on a latitude of 11° 12` N and a longitude of 07° 37`E with a population of 6,066,562 (National population commission, 2010). It is characterized by a tropical climate with two main seasons; a rainy season (May to October), with a mean annual rainfall of 1092.8mm, and the dry season which spans between November and April (Ukegbu, 2005).

Sample collection: Fifty samples comprising of ten each of borehole, stream, well, tap and sachet water were collected from six local government areas of the state. The samples were collected in clean 1litre containers and transported to the laboratory under cold storage for analysis within 24 hours.

Sample analysis

The Biological Oxygen Demand (BOD_5) and Dissolved Oxygen (DO) were determined using standard methods (APHA, 2005). The results were recorded in milligrams per litre (mg/l). Electrical Conductivity and Total Dissolved Solids were measured using the Hanna multi-parameter bench-top meter (Hanna, HI 98360) by following the manufacturer's instructions. Electrical conductivity was recorded in µmhos/cm while the Total dissolved solids was recorded in mg/l. Nitrate was determined using the Hanna nitrate bench-top meter (HI2216), following the manufacturer's instructions. The results were recorded in mg/l (APHA, 2005).

The mean of the values were taken and statistical analyses were performed using the software SPSS package for Windows version 21 (SPSS, Chicago, III., USA). One way ANOVA was used for the comparison of data among seasons and sample types. The mean and Standard Error (SE) were used for reporting and a P-value of <0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The mean values of the physicochemical parameters of samples from various water sources are presented in table 1. The mean values of conductivity and TDS for the borehole water were significantly higher than those for the other water sources. This could be attributed to the fact that boreholes are usually dug deep into the ground, thus, soluble minerals from the bedrock could be present. Table 2 shows the mean of all values obtained in the two different seasons. It was observed that the values obtained were generally higher during the wet season. Table 3 shows the comparison of the values obtained with the WHO and NIS standards for drinking water.

The higher nitrate content (15.38± 1.29mg/l) observed in the wet season can be attributed to the use of chemical fertilizers in urban farming which is done more in the wet season, also indiscriminate animal grazing, and improper disposal of animal and human wastes could be contributory factors. This agrees with a study by Ocheri *et al*., (2010) where it was observed that the nitrate content in hand-dug wells of Makurdi metropolis, Benue state were significantly higher during the wet season.

The water source with the highest nitrate content was stream water while the lowest was borehole. This conforms to findings in literature that nitrate concentrations in groundwater decrease with increasing depth (Akinwumi *et al.,* 2012).

Nitrate is the most highly oxidized form of nitrogen and the major sources of nitrates in drinking water are runoff from fertilizer use; leakage from septic tanks, sewage; and erosion of natural deposits (EPA, 2014). Drinking water that contains excess nitrates could pose a serious health hazard to the consumers, and is particularly a risk factor for developing many cancers (EPA, 2014; Njeze *et al.,* 2014).

All the 50 samples tested had their nitrate level within acceptable limits of NIS and WHO standards (50mg/l). However, the EPA(Environmental Protection Agency) of the United States of America set the maximum contaminant level(MCL) of nitrate in drinking water as 10mg/l. Going by this standard, 44(88%) of the samples exceeded the MCL for nitrate. In drinking water, a nitrate level of up to 3 mg/l is generally believed to be safe for drinking (Alhassan and Ujoh, 2012). Regulation of drinking water quality is so important that the United States Congress passed the safe drinking water act in 1974 (Njeze *et al*., 2014). As a result of that law, the regulation for nitrate became effective in 1992 and EPA set the maximum contaminant level (MCL) for nitrate as 10 mg/l. However, the current national standard for drinking water in Nigeria, allows a maximum contaminant level of 50 mg/L for nitrate (NSDWQ, 2007). Of particular worry is the level of nitrate in packaged water which is considered of better quality than other water sources.

A higher mean value of electrical conductivity was recorded for samples collected in the wet season (297.09 ± 65.82µmhos/cm) than those collected in the dry season (276.92 ± 36.91µmhos/cm). Thirty (60%) of the samples tested met the WHO standard, while 48(96%) met the NIS standard. The higher values in borehole samples are most likely due to the presence of soluble minerals from the bedrock of the soils (Oluyemi *et al.,* 2010). This indicates that the water should be treated before being consumed. The electrical conductivity of water is directly related to the concentration of dissolved solids in the water which influence the ability of that water to conduct an electrical current, (EPA, 2014). The electrical conductivity values gotten in this study agree with that of other researchers (Oluyemi *et al.,* 2010, Ibrahim and Ajibade, 2012; Abakpa *et* al., 2013; Oluyege *et al.,* 2014).

Table 1: Physicohemcial parameters of water samples from various sources

Parameter	Borehole	Packaged	**Sample type** Stream	Tap	Well	P-value
Nitrate(mg/l)	11.28±0.89[a]	13.39±1.47[a]	16.16±2.39[a]	11.48±2.02[a]	14.382±1.09[a]	0.913
pH	6.91±0.08[a]	7.35±0.18[a]	7.23±0.18[a]	7.14±0.16[a]	7.09±0.16[a]	0.329
DO(mg/l)	1.46±0.18[a]	1.46±0.17[a]	1.32±0.22[a]	1.68±0.35[a]	1.47±0.24[a]	0.905
BOD(mg/l)	0.65±0.17[a]	0.56±0.08[a]	0.51±0.08[a]	0.72±0.13[a]	0.51±0.09[a]	0.734
CONDUCT.(µmhos/cm)	441.57±107.13[b]	109.7±9.11[a]	256.69±40.9[ab]	105.68±16.47[a]	437.07±88.5[b]	0.002*
TDS(mg/l)	220.78±53.56[b]	54.89±4.56[a]	128.34±20.50[ab]	52.84±8.37[a]	143.6±18.89[b]	0.02*

ANOVA, Tukey HSD test, P≤ 0.05; all values are mean ± Standard Error of means

In each category, values with different superscript are significantly different

KEY

Conduct.- conductivity

TDS- Total dissolved solids

±- plus or minus

*Significant at P ≤ 0.05

The DO of the samples collected in the dry season was higher than those of the wet season. This may be because DO varies with water temperature and altitude. Cold water holds more oxygen than warm water (EPA, 2014) and the temperature of water would naturally be cooler in the dry season than in the wet season. Tap water had the highest mean DO content (1.68 mg/l) while the stream water had the lowest mean value (1.32mg/l). This agreed with the study carried out by Oluyemi *et al.* (2010) where tap water sampled had a higher DO content as compared to the other water sources sampled. This may be due to aeration process during water treatment (Nirmala *et al*., 2012).

There was no significant difference between the mean values of samples from all sources. The pH values were significantly higher during the rainy season (P< 0.05). This agrees with some results of the study carried out by Makwe and Chup (2013). Furthermore, all the samples had their pH within the acceptable range specified by the WHO and NIS (6.5 - 8.5). The pH values, which quantify acidity and alkalinity of water showed that the water samples are safe for agricultural, recreational and domestic uses. This result agrees with other studies done in other parts of Nigeria (Oluyemi *et al*., 2010; Esemikose and Akoji, 2014; Oluyege *et al*., 2014)

The mean value of BOD of samples collected in the dry season was higher than those collected in the rainy season, though the difference was not statistically significant. All the samples had their BOD within the specified limit set by the WHO (6mg/l). This agrees with the findings of Oluyemi *et al.* (2010) and suggests that the water from the whole area is less polluted by organic matter.

Table 2: Physicohemcial parameters of water samples by season

Parameter	**Season** Dry	Wet	P-value
Nitrate(mg/l)	11.49±0.34	15.38±1.29	0.0035*
pH	7.00±0.08	7.27±0.11	0.029*
DO(mg/l)	1.52±0.11	1.40±0.16	0.269
BOD(mg/l)	0.63±0.08	0.53±0.06	0.163
Conductivity(µmhos/cm)	276.92±36.91	297.09±65.82	0.396
TDS(ppm)	138.46±18.45	148.54±32.91	0.396

T-test, P≤ 0.05; all values are mean ± Standard Error of means
In each category, values with different superscript are significantly different
KEY
Conduct.- conductivity
TDS- Total dissolved solids
±- plus or minus
*Significant at P ≤ 0.05

Table 3: Compatibility of samples to available standards for various physicochemical parameters

PARAMETER	**WHO STANDARD**	**NIS STANDARD**	**n(%)**
NITRATE(mg/l)	50	50	50(100)
PH	NG	6.5 – 8.5	48(96)
DO(mg/l)	NG	NG	-
BOD(mg/l)	6	NG	50(100)
CONDUCT.(µs/cm)	250	1000	30(60)(WHO), 48(96)(NIS)
TDS(mg/l)	500	500	48(96)

KEY: Conduct..-Conductivity;TDS- Total dissolved solids; NG- Guideline not specified; WHO-World Health Organization;NIS-Nigerian Industrial Standard; n-number of samples that met the standard;%-percentage=no of samples that met standard/total number of samples tested(50) x 100

Ninety-six percent of the samples had their TDS values within the NIS and WHO acceptable limit. This result is in agreement with that of Oluyemi *et al*. (2010) and Ibrahim and Ajibade (2012). For the samples whose values exceeded the maximum limit, some treatments such as addition of coagulants may be required to make these waters suitable for domestic purposes (Nirmala *et al*., 2012).

CONCLUSION

In conclusion, water used for drinking in parts of Kaduna state studied were generally of good physicochemical quality. Although, the values for nitrate, pH, BOD and TDS were within acceptable limits, conductivity and TDS values of the borehole water samples were significantly higher than the other sample types, while the nitrate and pH values were significantly higher during the rainy season.

RECOMMENDATIONS

The contamination of drinking water by organic and inorganic substances needs to be checked and corrective measures should be put in place to avoid the short and long-term effects of pollution, especially during the rainy season. The government should provide clean and potable water for the consumption of the residents.

The guidelines for maximum contaminant limit set by the local bodies need to be reviewed so that they harmonise with that set by international bodies. There is need for continuous monitoring of packaged water by the NAFDAC so as to ensure quality.

ACKNOWLEDGEMENT

We acknowledge the technical support of Mr Paul Alika and Mal. Yahaya of the Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria in the analyses of the samples.

REFERENCES

Abakpa, G.O., Umoh, V.J., Ameh, J.B. and Yakubu, S.E. (2013). Microbial quality of irrigation water and irrigated vegetables in Kano State, Nigeria. *International Food Research Journal* 20(5): 2933-2938

Akinwumi, O.O., Eletta, O.A. and Odebunmi, O. (2012). Analysis of nitrates and nitrites in groundwater of Ilorin environs. *Journal of Environmental Science and Engineering,* 1: 656-662.

Alhassan, M.A. and Ujoh, F. (2012). Assessment of the Chemical Quality of Potable Water Sources in Abuja, Nigeria. *British Journal of Applied Science & Technology*, 2(2): 146-172.

APHA (American Public Health Association) (2005). Standards for the Examination of Water and Wastewater 21st Edn. APHA: Washington DC, USA.

Esemikose, E. E. and Akoji I. G. (2014). Microbiological and Physicochemical Studies on Water Pollution of Ogane-Aji Rive *Journal of Science & Multidisciplinary Research* (2):41-46.

EPA (Environmental Protection Agency) (2014). National Secondary Drinking Water Standards by Brian Oram, Water Research Center.http://www.waterresearch.net/index. php/standards/secondary-standards

Haylamicheal, I.D. and Moges, A. (2012). Assessing Water Quality of Rural water Supply Schemes as a measure of Service delivery sustainability: A Case Study of Wondo Genet District, Southern Ethiopia, *African Journal of Environmental Science and Technology,* 6(5):229 –236.

Ibrahim, S. I. and Ajibade, L.T. (2012). Assessment of water quality and domestic uses in medium-sized towns of Niger state, Nigeria. *Transnational Journal Of Science And Technology ,* Vol. 2(5): 63-75.

Makwe, E. and Chup, C.D. (2013). Seasonal variation in physico-chemical properties of groundwater around Karu abattoir. *Ethiopian journal of environmental studies and management ,* vol. 6 (5):489-497.

Njeze, G. E., Dilibe, U. and Ilo, C. (2014). Nitrate and drinking water from private wells: Will there be an epidemic of cancers of the digestive tract, urinary bladder and thyroid? *Nigerian Journal of Clinical Pract* ,17:178-82.

Nigerian Standard for Drinking Water Quality (NSDWQ) (2007), Nigeria, Ministry of Water Resources, Nigeria, pp. 1-2.

Nirmala B., Suresh Kumar B.V., Suchetan P.A. and Shet Prakash M. (2012). Seasonal Variations of Physico Chemical Characteristics of Ground Water Samples of Mysore City, Karanataka, India. *International Research Journal of Environment Sciences*,1(4):43-49.

Ocheri, M., Iyange, M. and Obeta, M.C. (2010). Seasonal variation in nitrate levels in hand dug wells in Makurdi metropolis*. Pakistan Journal of Nutrition* 9 (6): 539-542.

Oluyege, J. O., Olowomofe, T.O and Abiodun, O.R. (2014).Microbial contamination of packaged drinking water in Ado-ekiti metropolis, south western Nigeria. *American Journal of Research Communication,* 2(10):231-246.

Oluyemi, E. A., Adekunle, A. S., Adenuga, A. A. and Makinde, W. O. (2010) Physico chemical properties and heavy metal content of water sources in Ife North Local Government Area of Osun State, Nigeria *African Journal of Environmental Science and Technology*, 4(10):691-697.

Ukegbu, K. A. (2005). The National Year Book of Nigeria (3rd Edition). Gold Star Publications. PP 255-256.

WHO and UNICEF (2010). Rapid assessment of drinking-water quality in the Federal Republic of Nigeria: country report of the pilot project implementation in 2004-2005 / WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland. Page viii

WHO (2011). Nitrate and nitrite in drinking-water Background document for development of WHO Guidelines for Drinking-water Quality. Pp 10-16.

UNICEF/WHO (2012), "Progress on drinking water and sanitation: 2012 update. WHO/UNICEF Joint Monitoring Programme for water supply and sanitation". UNICEF, New York. http://www.wssinfo.org/fileadmin/user-upload/resources/jmpreport 2012.