JOURNAL OF
ENVIRONMENTAL HYDROLOGY
Open Access Online Journal of the International Association for Environmental Hydrology

VOLUME 27 2019

ASSESSMENT OF WATER QUALITY OF KAJIM AND KAGORO SPRINGS IN KAURA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

Zugwai Bruno Bagu[1]
Aliyu Dadan Garba[1]
Taiye Adewuyi[1]
Tayo Taiwo[2]

[1]Department of Geography, Nigerian Defence Academy, Kaduna, Nigeria
[2]Exploits Consulting Limited, Abuja, Nigeria

This study assessed the quality of water from Kajim and Kagoro Springs as well as their importance in meeting the water needs of the people in the study area. Electrical conductivity, pH and temperature were measured in-situ, water sampling and laboratory analysis were carried out for 19 other parameters using Standard Methods for the Examination of Water and Waste Water established by the American Public Health Association (APHA). A questionnaire was administered to the people in the communities within the vicinity of the springs to assess the importance of the respective springs in meeting their water needs. The results of the study showed that the physico-chemical parameters investigated were within World Health Organization (WHO) guidelines and Nigerian Standard for Drinking Water Quality (NSDWQ) limits with the exception of lead which was detected (0.0214mg/l concentration) at Kagoro Spring, this was in excess of both WHO guideline and NSDWQ maximum permissible limit (0.0100mg/l). The examination of biological parameters showed that colonies of Escherichia coli and total coliform found in both Kajim and Kagoro Springs were too numerous to count (TNTC). The proportion of residents who opined that the springs were very important in directly meeting their water needs was 62% and 34% for Kajim and Kagoro respectively. The findings of this study imply that water from Kagoro spring harbours lead contamination and both springs contain Escherichia coli and total coliform colonies. Treatment for biological contaminants and lead contamination of Kagoro spring is strongly recommended before consumption by users.

INTRODUCTION

Water is the basic component of the fluids of living organisms (Stevenson, 2010) and is necessary for human survival (Feitelson, 2012). Water has a very wide range of uses to man, however, its countless applications are often constrained by availability and quality. Fresh water, unlike other important substances such as wheat, copper or oil, has no substitute for most of its uses to man (Postel, Daily and Ehrlich, 1996). A further limitation to the abundance of this resource as shown by both Postel *et al.* (1996) and Shiklomanov (1998) is the fact that the greater portion of it (two-thirds) is locked up in glaciers and permanent snow cover especially in Antarctica and Greenland, the Arctic and in mountainous regions of the earth. Only about 0.77% of earth's water is held in continental aquifers, lakes, rivers and swamps, soil pores, plant life and atmosphere (Postel *et al.*, 1996) where it is more easily accessible for human consumption.

Access to potable water is often limited in rural areas due to a range of factors including economic and infrastructural deficit, hence a dependence on whatever available source there is: In some rural settings such as Oke-Igbo in Ondo State, Nigeria, springs serve as the main source of water for domestic activities for communities (Awomeso, Gbadebo, Taiwo and Obayomi, 2010). The World Health Organization, WHO (2003a:3) emphasized that "the right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water, and it must be enjoyed without discrimination and equally by women and men." Access to safe water is an underlying determinant of human health, United Nations (2018) stipulated however, that over 40% of earth's global population is affected by water scarcity and particularly, women in sub-Saharan Africa cumulatively spend colossal amounts of time every year on collecting water, while about 1,000 children die on daily basis due to preventable water and sanitation-related diseases. Diseases associated with contaminated drinking-water constitute a major burden on human health (WHO, 2017). The combination of accelerated urbanization, fast population growth, climate change and low levels of water supply and sanitation coverage make Africa vulnerable to water-related disease WHO (2003b).

Groundwater is usually of higher quality because of its mode of occurrence, filtration through multiple layers of soils and rocks and relatively limited exposure to atmospheric and anthropogenic contaminants in comparison to surface water (Lajçi, Sadiku, Lajçi, Baruti and Nikshiq, 2017). Springs are sometimes perceived to be of exceptional quality according to Awomeso *et al.* (2010) and are assumed to be safe sources for most uses such as sanitation, domestic applications, cooking and drinking. This "safe status" accorded natural springs can be a problematic assumption because as USGS (2016) and Lajçi *et al.* (2017) emphasize, spring water has its own acceptability issues relating to concentration of naturally occurring major and trace elements often found in it and it can be susceptible to microbial contamination.

Water quality refers to a measure of the condition of water relative to the requirements of a particular purpose, designated use or need, taking into cognisance its physical, chemical, biological and radiological characteristics (Johnson, Ambrose, Basset, Bowen, Crummey, Isaacson, Johnson, Lamb, Saul and Winter-Nelson, 1997; Diersing and Nancy, 2009). This implies that contrary to the intuitive perception that the status accorded any particular water body is absolute, the various explanations offered in Johnson *et al.* (1997), Diersing and Nancy (2009) and WHO (2017) show that water quality status is only relative to a specified usage, purpose or designation. Water quality guidelines and regulations are built around water quality characteristics which serve as indicators of water quality.

Inadequacy of the water quality parameters and data provided in previous water quality studies such as Obada and Oladejo (2013) and Abdulkadir, Maikaje and Umar (2013) hindered such studies from depicting the water quality status of Kajim and Kagoro natural springs at the time of these studies. During a reconnaissance survey, it was also observed that some members of the communities around Kajim and Kagoro springs consume the spring water based on a common belief that the spring water is fit for direct human consumption however, the pertinent questions in this setting include: is the water from Kajim spring and Kagoro spring fit for drinking and domestic use? How important are these springs in meeting the water needs of the people in the communities around them? This study employed scientific methods to ascertain the quality status of the water from these two natural sources in the area.

AIM AND OBJECTIVES

The aim of this study is to assess the quality of water from Kajim and Kagoro Springs and their importance to the residents of the surrounding communities in Kajim and Kagoro. The aim was to be achieved through the following objectives:

- To examine water quality parameters of the springs for domestic use with reference to WHO Guidelines for drinking-water and NSDWQ.
- To assess the contribution of the springs in meeting the water needs of the people in the communities around.

STUDY AREA

This study was carried out in Kajim, Kpak-Kagoro and Fada Kagoro communities in Kaura Local Government Area of Kaduna State, Nigeria. Kajim Spring is located at Latitude 9° 40′ 51.3″ North and Longitude 8° 30′ 49.2″ East, while Kagoro Spring is located at Latitude 9° 36′ 17.8″ North and Longitude 8° 24′ 35.8″ East. The spring locations are shown in Figure 1.

METHODOLOGY

This study involved field measurements, water sampling and laboratory analysis for the investigation of water quality parameters, these were carried out using American Public Health Association's (APHA) Standard Methods for the Examination of Water and Waste Water (APHA, 2005) in June 2018. Temperature, pH and electrical conductivity (EC) were measured *in-situ,* six water samples were collected, three samples from Kajim spring and three from Kagoro spring. The samples were kept in a cool box below 10° C while in transit and taken to the laboratory for chemical and biological analysis.

Laboratory analysis commenced within 24 hours of sample collection at National Geosciences Research Laboratory and National Water Resources Institute in Kaduna Metropolis. The parameters investigated, instruments and methods used during this study are presented in Table 1.

The mean of numerical values obtained from the analysis of physical, chemical and biological parameters were computed and compared with WHO guidelines for drinking-water and Nigerian Standards for Drinking Water Quality.

A questionnaire was administered using random sampling technique to residents of the communities in the vicinity of Kajim spring and Kagoro spring, respondents were asked to choose one option in response to the following question: "how important is the spring water in meeting your water needs?"

and the options given were: very important, sometimes important, just an alternative or not important. The responses for each spring location were compiled in a spreadsheet for analysis.

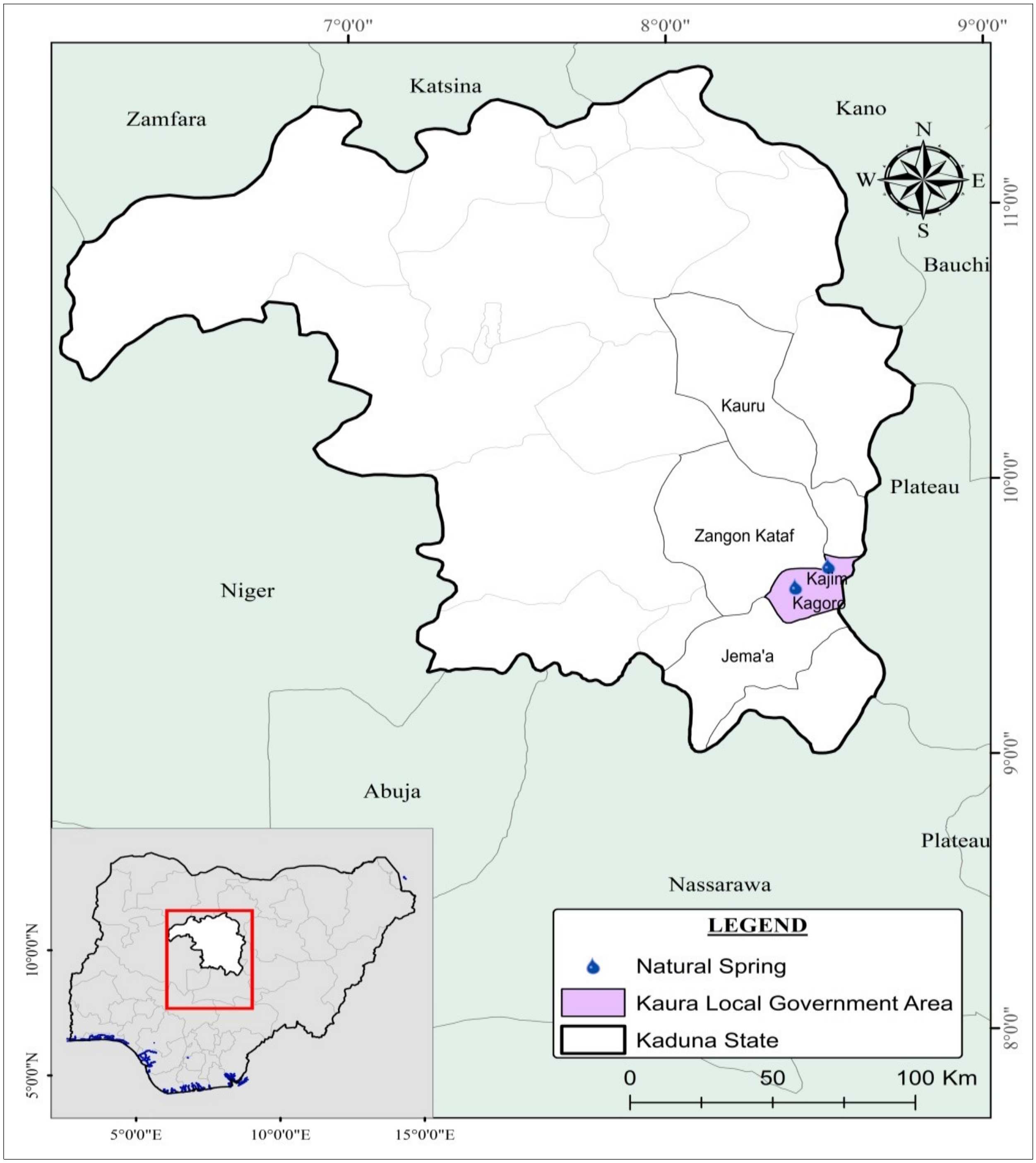

Figure 1. Kajim and Kagoro Springs in Kaura Local Government Area, Kaduna State. Source: OpenStreetMap Foundation (2011), Field Work (2018).

Table 1. Water Quality Parameters Investigated, Instruments and Methods used.

Parameter	Instrument	Method
pH	Hach sensION^{TM+} MM150	APHA4500-H^+
Temperature	Hach sensION^{TM+} MM150	APHA 2550B
EC	Hach sensION^{TM+} MM150	APHA2510B
TDS	WagtechWE30120 Conductivity/TDS meter	APHA 2510B
Hardness	Titration Apparatus	APHA 2340C
Alkalinity	Titration Apparatus	APHA 2320B
Chloride	Titration Apparatus	APHA 4500-Cl^- B
Nitrate	Wagtech Potalab 7100 Photometer	APHA 4500-NO^{3-} E
Sulphate	Hach DR/2010 Spectrophotometer	APHA 4500-$SO4^{2-}$ E
Sodium, Magnesium, Iron, Nickel, Copper, Zinc, Cadmium, Lead.	Thermo Scientific iCE3000	APHA 3111 B
E. coli	Membrane Filtration Apparatus	APHA 9222
Total Coliform	Membrane Filtration Apparatus	APHA 9222

Source: Adapted from APHA (2005), Laboratory Work (2018).

RESULTS AND DISCUSSION

The results of the examination of physico-chemical parameters of water quality of Kajim and Kagoro springs, along with WHO guidelines and NSDWQ maximum permissible limits for drinking-water are presented in Table 2.

The results show that all physico-chemical parameters investigated were within WHO and NSDWQ acceptable limits, this concurs with the outcome of a study by Obada and Oladejo (2013) in the same area.

Iron, nickel, copper and cadmium were not detected in all the samples, lead was not detected in Kajim. The results also indicate that the concentration of lead in Kagoro Spring exceeds both the WHO and NSDWQ limits. Lead is associated with cancer, interference with vitamin D metabolism, adverse affects on mental development in infants, toxicity to the central and peripheral nervous systems (Standards Organisation of Nigeria, 2015). The WHO limit of 0.01mg/L was set as a provisional guideline level based on treatment and analytical achievability and hence, is not a health-based guideline level (WHO, 2017) therefore, its concentration in drinking-water must be as low as practicable. The lead contamination may have originated from underlying geology or from human activities involving the use of synthetic chemicals.

The results obtained provide a comparative perspective to concentrations of the major chemical elements and physical parameters between Kajim spring water and Kagoro spring water, a graphic representation of the major chemical elements composition and other water quality parameters of both springs is presented in Figure 2.

Table 2. Results of Physico-chemical Examination of Kajim and Kagoro Spring Water.

		Standards		Kajim Spring	Kagoro Spring
Parameter	Unit	WHO	NSDWQ	Mean	Mean
pH	none	6.5-8.5	6.5-8.5	7.0	6.6
Temperature	°C	Cool*	ambient	24.9	23.0
EC	µS/cm	1000	1000	168.1	15.1
TDS	mg/L	500	500	84.5	9.5
Hardness	mg/L	500	150	84.5	6.0
Alkalinity	mg/L	500	none	99.5	19.0
Chloride	mg/L	250	250	32.2	6.7
Nitrate	mg/L	50	50	2.5	0.7
Sulphate	mg/L	250	100	3.5	3.0
Sodium	mg/L	200	200	6.5643	3.4988
Magnesium	mg/L	none	20	6.5453	0.0575
Iron	mg/L	2	0.3	ND	ND
Nickel	mg/L	0.07	0.02	ND	ND
Copper	mg/L	2	1	ND	ND
Zinc	mg/L	3	3	0.1295	0.0960
Cadmium	mg/L	0.003	0.003	ND	ND
Lead	mg/L	0.01	0.01	ND	0.0214

ND = Not Detected, TNTC = Too Numerous To Count, *Non health based value
none = No unit/chemical or health based guideline value/max. permissible limit
WHO = World Health Organization (2017) Guidelines for Drinking-water Quality
NSDWQ = Nigerian Standard for Drinking Water Quality (NIS554:2015)
Source: Field Work (2018), WHO (2017), Standards Organisation of Nigeria (2015).

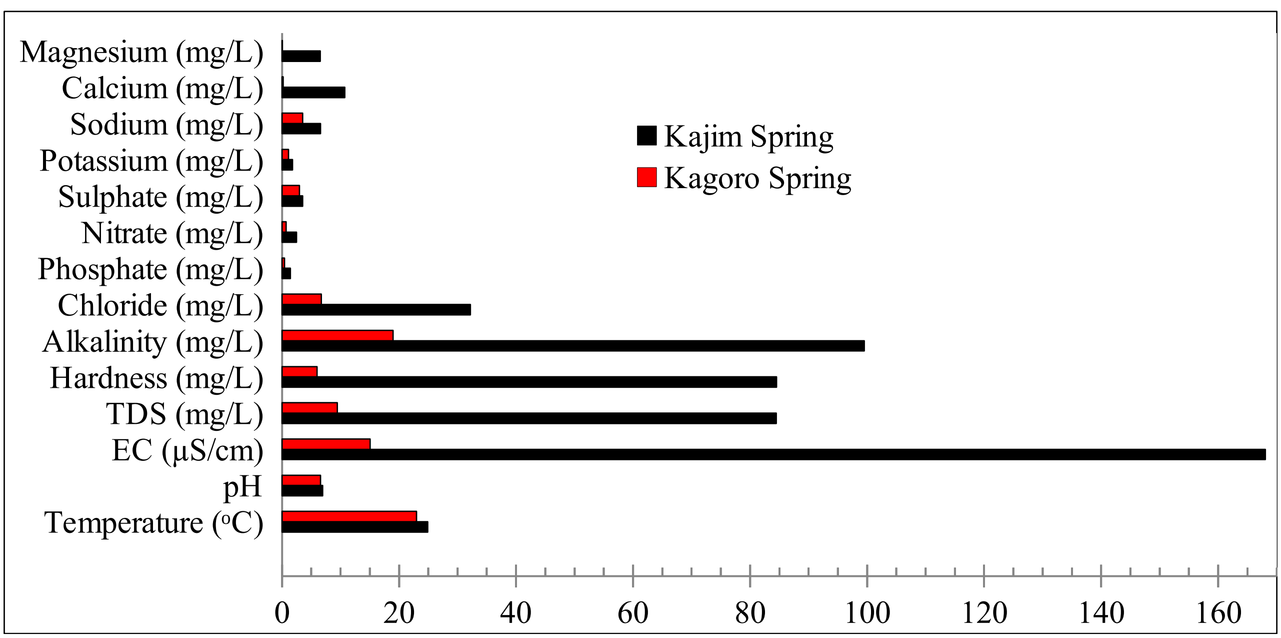

Figure 2: Major Elements and Water Quality Parameters of Kajim and Kagoro Springs. Source: Field Work (2018).

Figure 2 shows that there is greater concentration of naturally occurring elements in Kajim spring water than in Kagoro spring water. The higher degree of mineralization of Kajim spring water may be due to interaction with its basaltic source rock "The Newer Basalts", described by Obaje (2009) as rich in ferromagnesian minerals with high concentrations of elements such as magnesium and calcium.

The results of the examination of biological parameters of water quality of Kajim and Kagoro springs, along with WHO guidelines and NSDWQ maximum permissible limits for drinking-water are presented in Table 3.

Table 3. Results of Biological Examination of Kajim and Kagoro Spring Water.

		Standards		Kajim Spring	Kagoro Spring
Parameter	Unit	WHO	NSDWQ	Mean	Mean
Total Coliform	cfu/100mL	0	10	TNTC	TNTC
E. coli	cfu/100mL	0	0	TNTC	TNTC

TNTC = Too Numerous To Count
WHO = World Health Organization (2017) Guidelines for Drinking-water Quality
NSDWQ = Nigerian Standard for Drinking Water Quality (NIS554:2015)
Source: Field Work (2018), WHO (2017), Standards Organisation of Nigeria (2015).

The concentration of *E. coli* and total coliform bacteria in Kajim and Kagoro springs exceed both WHO and NSDWQ limits, the colonies were too numerous to count, this implies significant microbial contamination which may have been from human, wild life or livestock sources such as cattle faeces which were observed in the vicinity of the spring. Previous studies carried out in the vicinity of Kajim and Kagoro springs by Abdulkadir, Maikaje and Umar (2013) and Obada and Oladejo (2013) did not investigate for biological contamination however, the results obtained in other locations by Awomeso *et al.* (2010) and Ali, Rubina and Hussain (2018) clearly suggest that microbial contamination of natural springs is not a very rare phenomenon. The microbial contamination detected in both Kajim and Kagoro springs imply that water from the two sources would require some treatment such as boiling, chlorination or exposure to ultraviolet rays to eliminate the microbes in order to make it safer for drinking. The use of special carbon filters, reverse osmosis or distillation could be employed to remove lead from Kagoro spring water before consumption.

Results obtained from the survey showed that 62% of the people around Kajim spring and 34% of the people around Kagoro spring consider the corresponding springs to be very important in meeting their daily water needs. The disparity in the contribution of the springs to the people of Kajim and Kagoro may be due to reliable access to pipe-borne water within Fada Kagoro and the limited access to pipe-borne water within Kajim Community.

RECOMMENDATIONS

The people should be sensitized on the need to treat the water by boiling or sterilization and carbon filtration or use of reverse osmosis before consumption.

The concentration of lead (0.0214mg/L) in Kagoro spring should be investigated to determine the source, in order to proffer and adopt long term mitigation measures considering its toxic nature.

The spring emergence points should be protected from surface run-off, livestock and unauthorized activities which result in contamination.

Further studies on the hydrogeology of the areas contiguous with Kagoro and Kajim should be undertaken to determine the distribution and potential of the groundwater resource of the area for optimum exploitation.

CONCLUSION

The examination of water quality parameters of Kajim and Kagoro springs for domestic use with reference to WHO Guidelines for drinking-water and NSDWQ was achieved, based on the examination carried out, it can be concluded that water from both Kajim and Kagoro springs contain biological contaminants such as *E. coli.*

The assessment of the contribution of the springs in meeting the water needs of the people in the communities around was also achieved, the outcome showed the extent of importance of the springs to people in the corresponding communities around them.

ACKNOWLEDGEMENTS

This paper was reviewed by Associate Professor Taiye Adewuyi and Dr. Aliyu Dadan Garba of the Department of Geography, Nigerian Defence Academy, Kaduna, Nigeria.

REFERENCES

Abdulkadir, F.M., D.B. Maikaje, and Y.A. Umar. 2013. The Influence of Physico-Chemical and Ecological Factors on the Distribution of Freshwater Snails in Manchok Water Intake in Kaduna State, Nigeria. Nigerian Journal of Chemical Research, Vol. 18(1), pp. 58-66.

Ali, S., R. Rubina, and S. Hussain. 2018. Assessment of Freshwater Springs,Associated Diseases and Indigenous Perception in Ghizer, Gilgit-Baltistan, Pakistan. Pak J Med Sci. Vol. 34(1).

Awomeso, J.A., A.M. Gbadebo, A.M. Taiwo, and O. Obayomi. 2010. Hydrochemical Characteristics of Springs in Oke–Igbo, Ondo State, Nigeria. Journal of Applied Sciences and Environmental Management, Vol. 14(3).

Dadah, A.J., E.I. Ikeh, G. Ayanbimpe, S.O. Omotainse, P.M. Dede, and A.C. Igweh. 2017. Animal Trypanosomosis in Kaura Local Government Area, Kaduna State, Nigeria. Microbiology Research Journal International, Vol. 21(6), pp. 1-6.

Diersing, N. and F. Nancy. 2009. Water Quality: Frequently Asked Questions. Florida Brooks National Marine Sanctuary, Key West, FL. FL, Vol. 2.

Feitelson, E. 2012. What is Water? A Normative Perspective. Water Policy, Vol. 14(S1), pp. 52-64.

Johnson, D.L., S.H. Ambrose, T.J. Bassett, M.L. Bowen, D.E. Crummey, J.S. Isaacson, D.N. Johnson, P. Lamb, M. Saul, and A.E. Winter-Nelson. 1997. "Meanings of Environmental Terms". Journal of Environmental Quality, Vol. 26, pp. 581–589.

Lajçi, N., M. Sadiku, X. Lajçi, B. Baruti, and S. Nikshiq. 2017. Assessment of Major and Trace Elements of Fresh Water Springs in Village Pepaj, Rugova Region, Kosova. J. Int. Environmental Application & Science, Vol. 12(2), pp. 112-120.

Obada, E.M. and O.I. Oladejo. 2013. Groundwater Quality Appraisal in SouthernParts of Kaduna State, Nigeria. American Journal of Environmental Engineering, Vol. 3(1), pp. 77-83.

Obaje, N.G. 2009. Geology and Mineral Resources of Nigeria. Springer: (Lecture Notes in Earth Sciences), Vol. 120, Pp. 221.

OpenStreetMap Foundation. 2011. Nigeria-Shapefiles: Administrative. URL: https://bit.ly/2Hzboyl

Postel, S., G. Daily, and P. Ehrlich. 1996. Human Appropriation of Renewable Fresh Water. Science, Vol. 271(5250), pp. 785-788.

Shiklomanov, I. A. 1998. World Water Resources: a New Appraisal and Assessment for the 21st Century, a Summary of the Monograph World Water Resources. Paris: UNESCO, Pp. 1-37.

Standards Organization of Nigeria. 2015. Nigerian Standard for Drinking Water Quality. NIS554:2015, Lagos: SON.

Stevenson, A. (Ed.) 2010. Definition of Water in English. Oxford Dictionary of English, Oxford University Press, URL: https://bit.ly/2GXw3Ps

United Nations. 2018. UNDP Sustainable Development Goals, Goal 6 Clean Waterand Sanitation. URL: https://bit.ly/2i9QSd6

USGS 2016. Study and Interpretation of the Chemical Characteristics of NaturalWater. URL: https://bit.ly/2n2tFuR

WHO 2003a. The Right to Water. Health and Human Rights Publication Series, Vol. 3, pp.1-43.

WHO 2003b. Global Water Supply and Sanitation Assessment 2000 Report. Geneva:World Health Organization.

WHO 2017. Guidelines for Drinking-water Quality: Fourth Edition IncorporatingFirst Addendum. 4th Ed. Geneva: World Health Organization.

ADDRESS FOR CORRESPONDENCE
Zugwai Bruno Bagu
Department of Geography,
Nigerian Defence Academy,
Kaduna, Nigeria (+2348033486572)
Email: crucisbruno@gmail.com