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Physico-chemical characteristics of Borehole Water from Selected Wards in Bade Local Government Area, Yobe State, Nigeria

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ABSTRACT

This investigation was conducted with the aim of examining the physicochemical properties of borehole water in 10 areas within the Bade Local Government wards of Yobe State in Nigeria. The samples were collected using standard methods, and measurements of temperature and pH were taken at the point of collection. The analysis of heavy metals was carried out by means of Atomic Absorption Spectrophotometry (AAS). Determination of chloride, nitrite, phosphate, Total Dissolved Solids (TDS), turbidity, and conductivity were carried out using APHA standard methods. The results of the investigation showed that concentrations of Pb ranged from 0.078 mg/L to 0.127 mg/L. Sarkin Hausawa ward had the highest recorded Ni value (0.056 mg/L). The concentration of Cd (0.013 mg/L) is high at Gwiyo Kura compared to 0.005 and 0.004 mg/L from Sugum Tagali and Lawan Musa respectively. The levels of Pb, Ni and Cd exceeded the maximum threshold by WHO (2022) at most sampled wards. The pH, temperature, TDS, conductivity, chloride, nitrites, and phosphates in the studied samples were within the safety limits recommended by the WHO (2022), with the exception of high turbidity in samples taken from Gwiyo-Kura, Usir/Dawayo, and Katuzu wards which were between 6 - 9 NTU. The findings have demonstrated the necessity for monitoring of the physicochemical properties of borehole water in Bade LGA.

Keywords: Physicochemical, heavy metals, borehole water, concentrations, drinking water, Bade LGA

INTRODUCTION

Water is an essential compound for the sustenance of life in various ways and activities, including ecosystem services, nutrition supply, food security, industrial development, drinking, and health of all species, waste disposal, and human recreation [1, 2]. Water is crucial and indispensable for the existence and survival of all forms of life, sustainable development for food production and quality health [3, 4]. For instance, Saana *et al.* [5] and Shawai *et al.* [6] averred that approximately 70% of the human body is made up of water. Furthermore, it plays a fundamental role in creating and maintaining the delicate balance of ecosystems upon which all forms of life rely [7].

Water is utilized for human consumption and must therefore should be free from microbial, radiological, and heavy metal contamination [8]. The easily accessible freshwater resources, such as rivers, lakes, wetlands, and aquifers, constitute less than 1% of the global water supply and are currently facing a precarious situation [7]. Water, being a fundamental necessity for sustaining life, must be provided in an adequate, safe, and accessible manner to everyone. Enhancing accessibility to safe drinking water can result in significant health benefits [9].

In spite of being conventionally regarded as a safe source of good quality water worldwide, groundwater has recently been found to be contaminated with heavy metals beyond natural background levels due to the burgeoning urbanization and industrialization [10]. Groundwater stands as the largest reservoir of potable water, due to its natural filtration process through rock and soil, which makes it less vulnerable to contamination from surface water sources, thereby rendering it a reliable and good-quality drinking water source for human use and consumption [11]. The quality of these water bodies varies considerably based on their location and other environmental factors. Water serves a myriad of purposes across a variety of communities, including agriculture, power generation, and domestic applications [8, 12, 13]. Hence, ensuring the provision of high-quality drinking water is of utmost importance in enhancing the quality of human life and preventing potential water-borne diseases [3, 14]. Potable and high-quality water is not only essential for health but is also a fundamental human need that requires proper management, treatment techniques, and monitoring/control overtime [15].

Groundwater primarily originates from precipitation or snowmelt, which infiltrates through soil and pore spaces of rocks. Other potential sources include water infiltrating lakes and streams, recharged ponds and wastewater treatment systems [16]. Drinking water standards, as indicated by Aturamu [17], rely on two primary criteria: the absence of unpleasant taste, odour, and colour, and of substances with adverse physiological effects. Nonetheless, human activities, especially the production and disposal of industrial waste and sewage systems, pose potential sources of groundwater contaminants.

If contaminated water is supplied to a community, the inhabitants of such a community may be infected by water-borne and other related diseases due to chemicals [17].

Heavy metals are among the water contaminants. The leaching process typically introduces the heavy metals into groundwater. As these elements have been identified to be potentially toxic within specific limiting values, there exist considerable potential health hazards for human nutrition. Severe exposure to Cd may result in pulmonary effects such as bronchiolitis, emphysema, alveolitis, and renal infection [18]. When Cd concentrates particularly in the kidney, the liver, the blood-forming organs, and the lungs, most frequently, it results in kidney damage and metabolic anomalies, causing reduced haemoglobin synthesis and disturbance in kidney functioning, joints, reproductive, cardiovascular, and nervous system [19]. While Pb can affect every organ and system in the body, it can also damage the brain and kidney and even cause miscarriage in women [20], and can also damage the organ responsible for sperm production [20].

Nitrogen in the form of nitrate is a naturally occurring element found in the soil. Nitrates are commonly sourced from fertilizers, annual feedlots, municipal wastewater, and nitrogen fixation by legumes, bacteria, and lightning. Although a large amount of nitrate is necessary for high crop yields, excessive levels of nitrate in drinking water may cause methemoglobinemia [21]. Sulphates enter underground water through discharge from textile mills, tanneries, mines, smelters, fertilizers, and pulp and paper mills. They are also naturally occurring as sulphate minerals such as gypsum or sulphate as pyrite or sedimentary rocks [22]. Drinking water containing sulphate concentrations above the WHO permissible limit may cause stomach acidity [23]. Phosphates are known to encourage the growth of plankton and aquatic plants, but only become toxic at high levels [24] and were also attributed to elevated toxic metals exposure as revealed by Moody *et al.* [25] and Scharer *et al.* [26].

Based on assertions, a significant proportion of renal complications among patients receiving treatment at the University of Maiduguri Teaching Hospital in Nigeria emanate from the Bade Local Government Area. Given this circumstance, the investigators were prompted to conduct a study to assess the levels of heavy metals, pH, conductivity, temperature, total dissolved solid, salinity, turbidity, chloride, nitrite and phosphate in the borehole water supply of the Ten (10) wards located within the Bade Local Government Area, with the aim of comparing the values with the WHO recommended limits for drinking water.

MATERIALS AND METHODS

Sample Collection

Water samples were collected from boreholes in 10 Wards of Bade Local Government Area (Katuzu, Sabon-Gari, Gwiy-Kura, User/Dawayo, Dagon, Subgum/Tagalog, Takari, Lawan Fanami, Lawan Musa, Sarkin Hausawa). The temperature and pH of each sample were taken at the point of collection with a thermometer and pH meter (Jenway 3505 model), respectively. The samples were collected in sterilized bottles and taken to the laboratory for physicochemical analysis.

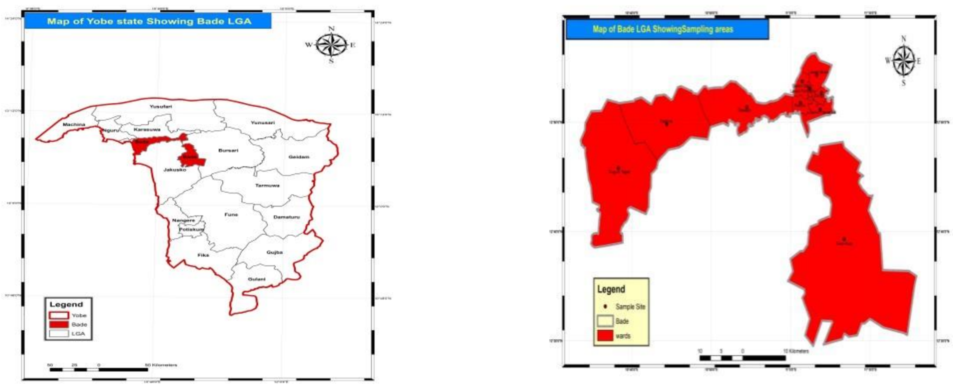

Figure 1. Map of Yobe State and Bade Local Government indicating the sampling sites

Sample Analysis

The samples' physicochemical analysis was carried out following standardized APHA methods as described by Chikumbusko *et al* [27].

Electrical conductivity, Total dissolved solids and salinity were determined by conductivity meter (HACH Sensiond model). Temperature and pH were determined with a thermometer and a pH meter (Jenway 3505 model) respectively. Chloride was determined by APHA titrimetry. Nitrite, and Phosphorus-Phosphate were determined by APHA colorimeter (HACH DR/890 model); while turbidity was done, using a turbidimeter.

Atomic Absorption Spectrophotometer (A.A.S.) model ABZ-4F8B2314D4 was used for the heavy metal analysis. Each water sample was digested with *aqua regia*. The working standard for each metal was prepared from their salts by dissolving an appropriate amount of metal salts in deionized water to 1000 ppm. Further dilutions of 1000 ppm stock solutions were made for the development of calibration curves, as described by Samali *et al*. [24].

Statistical Analysis

Data collected were subjected to analysis of variance. F-test was used to test for significant differences among treatment means [28]. Treatment means were compared using Duncan's Multiple Range Test [29]. The data were analyzed using the general linear model procedure of statistical analysis using system software version 9.0 [30].

RESULTS AND DISCUSSIONS

Table 1 displays the heavy metal concentrations in borehole water from 10 wards in Bade LGA. The findings indicated that the Sarkin Hausawa ward had the highest recorded Ni value (0.056 mg/L), Katuzu, 0.048 mg/L and Sugum Tagali, 0.039 mg/L, while Lawan Fanani, 0.023 mg/L and Lawan Musa, 0.021 mg/L were slightly above the WHO permissible limit of Ni 0.02 mg/L [23]. This suggests that the location of the water points along the river Yobe bank, where refuse is disposed may influence the values, resulting in a statistically significant difference at the 1% probability level among the locations regarding Ni content. It is essential to note that Ni is a potential carcinogen.

For Co, the analytical method used did not detect any values in the samples investigated from all the sampled wards. Similarly, Cd concentrations from Sabon Gari, Usir/Dawayo, and Lawan Fanami wards did not show any values for Cd. However, there was no significant difference observed at 5% probability level among Takari and Katuzu wards regarding Cd content. Cd concentration levels were within the WHO limits (0.003 mg/L), except for samples from Gwiyo Kura that was highest (0.013 mg/L) and above WHO permissible limit [23], and Sugum/Tagali (0.005 mg/L) and Lawan Musa (0.004 mg/L) wards, where agricultural activities may have caused the high Cd values observed.

This study recorded high levels of Pb concentrations ranging from 0.078 mg/L to 0.127 mg/L in the analyzed samples from all studied locations. This concentration exceeded Pb permissible limit in water. The analyzed Pb samples from Sarkin Hausawa ward had a substantial amount of Pb, recording the highest amount (0.127 mg/L). Therefore, there is a statistically significant difference at the 1% level among the locations regarding Pb composition.

The high Pb concentrations in these areas may result from agricultural activities due to fertilizer applications and sewage disposal.

Table 1: Heavy metals in the water samples (mg/L)

Location	Ni	Co	Cd	Pb
Gwiyo Kura	0.009h	ND	0.013a	0.092g
Sabon Gari	0.008i	ND	ND	0.078j
Dagona	0.000j	N.D.	0.003d	0.107d
Usir/Dawayo	0.017f	ND	ND	0.095f
Sugum/Tagali	0.039c	ND	0.005b	0.083i
Takari	0.010g	ND	0.002e	0.087h
Katuzu	0.048b	ND	0.002e	0.120b
Lawan Fanami	0.023d	ND	ND	0.120b
Lawan Musa	0.021e	N.D.	0.004c	0.118c
Sarkin Hausawa	0.056a	N.D.	0.001f	0.127a
S.E. ±	0.0011	-	0.0008	0.0035
Significant	**	-	**	**

Means followed by the same letter within a column of a treatment group are not significantly different statistically at 5% levels of probability using DMRT. **, - and ND significant at 1 %, not available and not detected respectively.

Table 2 presents the physicochemical parameters of the analyzed water, including pH values that ranged from 7.66 to 9.22. This indicates that the water in the study areas is alkaline and potable, according to WHO guidelines. The highest temperature recorded was 25.80 °C, well below the WHO's maximum limit of 28 °C for drinking water. Furthermore, a significant difference was observed in the 1% probability of water temperature in the sampled locations. TDS in the studied water ranged from 41.8 mg/L to 156 mg/L, with the lowest and highest values observed in the Takari and Sarkin areas, respectively. TDS is a highly significant parameter in water quality analysis as it directly affects and correlates with important water properties such as turbidity, conductivity, alkalinity, and hardness. The analyzed water samples were within the desirable limit of 500 mg/L but not more than 300 mg/l, which is unsuitable for drinking purposes.

High TDS values may also influence other qualities of water, such as taste, hardness, corrosion properties, and osmoregulation of freshwater organisms [28].

The measurement of electrical conductivity pertains to the capacity of an aqueous solution to conduct an electric current. A high value of conductivity indicates a higher concentration of dissolved ions. The range of the water samples' conductivity was 88 µS cm^{-1} to 329 µS cm^{-1}. In certain samples, the electrical conductivity surpassed the permissible limit set by WHO (250 µS cm^{-1}). The high level of conductivity can be attributed to the existence of dissolved ions. A significant difference was observed among the locations in terms of conductivity, with a probability of 1%.

The chloride content of the water samples ranged from 0.01 mg/L to 0.07 mg/L. Chloride generally do not pose a threat to human health. However, the sodium component of table salt is associated with heart and kidney diseases. The amount of chloride in the samples were below the WHO [23] recommended limit of 250 mg/L. High chloride levels can affect the taste of water, especially when sodium is the predominant cation. In addition, excessive chloride can corrode metals and affect the taste of food products.

The value of nitrite was in the range of 0.005 mg/L to 1.23 mg/L. It was below the detectable limit of the instrument used in the Gwiyo Kura and Katuzu wards. There was a significant difference among the locations at a 1% probability level. Nitrite can directly react with haemoglobin in human blood to produce methemoglobin, which destroys the red blood cell's ability to transport oxygen. This condition is particularly serious in babies under three months. The levels of nitrite obtained in the samples were within the permissible limit (50 mg/L) set by WHO [23].

The turbidity values of the samples varied from 3.0 NTU to 19.0 NTU. Turbidity is caused by suspended particles or colloidal matter obstructing light transmission through the water. Although there are no health-based guidelines for turbidity, it is recommended that it does not exceed 5 NTU according to WHO [23]. Based on the results, the samples from Dagona, Takari and Lawan Musa wards recorded permissible limit at 5 NTU respectively; however, studied samples from Gwiyo Kura, Usir/Dawayo, and Katuzu wards exceeded the recommended threshold at 6 NTU, 19 NTU and 6 NTU respectively.

The phosphate values for the samples ranged from 0.07 mg/L to 2.75 mg/L. There is a significant difference among the locations concerning phosphate contents, with a probability of

1%. Phosphates are not toxic to people or animals except when present at very high levels. An extremely high level of phosphate may cause digestive problems.

Table 2: Physicochemical parameters of the water samples

Ward Locations	pH	Tempt. (ºC)	TDS (mg/L)	Salinity (%)	Conductivity (µS/cm)	Chloride (mg/L)	Nitrite (mg/L)	Phosphate (mg/L)	Turbidity (NTU)
Gwiyo Kura	8.82c	25.8a	100.1d	0.1c	213.0d	0.01e	ND	2.75a	6.0b
Sabon Gari	9.02b	25.7b	75.7g	0.1c	160.7g	0.03c	0.005g	2.50b	3.0e
Dagona	8.64d	25.7b	100.1d	0.1c	212.0e	0.04b	0.328b	0.12g	5.0c
UsIr/Dawayo	9.22a	25.8a	72.7h	0.1c	154.8h	0.07a	0.024d	0.61e	19.0a
Sugum/Tagali	8.06g	25.8a	88.8e	0.1c	188.7f	ND	ND	0.07h	3.0e
Takari	8.33e	25.3d	41.8i	0.0d	88.3i	0.03c	0.021e	2.75a	5.0c
Katuzu Lawan	7.66i	25.6c	75.8f	0.1c	160.9g	0.02d	ND	0.28f	6.0b
Fanami	7.89h	25.6c	144.5b	0.1c	304.0b	0.03c	0.076c	2.40c	4.0d
Lawan Musa	8.07g	25.7b	124.4c	0.1c	263.0c	0.04b	1.232a	1.56d	5.0c
Sarkin Hausawa	8.10f	25.7b	156.2a	0.2a	329.0a	ND	0.013f	0.11g	3.0e
S.E. ±	0.006	0.029	0.024	0.011	0.158	0.002	0.0002	0.005	0.152
Significant	**	**	**	**	**	**	**	**	**

Means followed by the same letter within a column of a treatment group are not significantly different statistically at 5% levels of probability using DMRT. **, ND significant at 1% and not detected respectively.

CONCLUSION

Clean and safe water is a fundamental necessity in every community, as it is deemed as the essence of life. Its significance lies in its pivotal role in sustainable development for food production and good health. The findings obtained from this study revealed that most of the areas investigated had high levels of heavy metals. This occurrence of high levels of heavy metals in water poses a potential risk to the health of humans and animals in such areas. The contamination of groundwater in these communities may stem from various human activities such as the disposal of wastes, poor and excessive agricultural chemical practices. The factors contributing to groundwater contamination can be mitigated by providing good sanitation facilities by the government and drilling boreholes to potable water levels while also ensuring that Government agencies engage in continuous monitoring activities.

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REFERENCES

1. Dankawu, U.M., Adamu, G.D., Mahraz, M.N., Benedict, J.N., Yakubu, A. & Uzair, M. (2021). Determination of Radon Concentration and The Annual Effective Dose Due Inhalation for Some Borehole and Well Water Supply in Dutse, Jigawa State Nigeria. *Journal of Science, Technology, Mathematics and Education* (JOSTMED), 16, 22-24.
2. United Nation Environmental Programme (UNEP) (2023). Why does water matter? Freshwater Strategic Priorities 2022-2025, 1-24.
3. Ackah, M., Anim, A.K., Gyamfi, E.T., Acqah, E.S., Nyarko, L., Kpattah, S., Brown, E., Hanson, J.E.K., Fianko, J.R. & Zakaria, N. (2012). Assessment of the Quality of Sachet water consumed in urban Township of Ghana using physic-chemical indicators: A preliminary study. *Advances in Applied Science Research*, 3(4), 2120-2127.
4. Saana, S.B.B.M., Fosu, S.A., Sebiawu, G.E., Jackson, N. & Karikari, T. (2016). Assessment of the Quality of Groundwater for Drinking Purposes in the Upper West and Northern Regions of Ghana. *Springerplus*, 5, 2001,
5. Shawai S.A.A., Nahannu, M. SAbdulkadir, S. & Minjibir, S.A (2018). Evaluation of Physicochemical Parameters and Some Heavy Metals in Water Samples Used for Irrigation Purpose along River Tatsawarki in Tarauni L.G.A, Kano. *International Journal of Scientific Research in Chemical Sciences* 5(6), 1-4
6. Young, S. L., Frongillo, E. A., Jamaluddine, Z., Melgar-Quiñonez, H., Pérez-Escamilla, R., Ringler, C. & Rosinger, A. Y. (2021). Perspective: The Importance of Water Security for

Ensuring Food Security, Good Nutrition, and Well-being, *Advances in Nutrition*, 12 (4), 1058–1073.

7. Kılıç, Z. (2020). The importance of water and conscious use of water. *International Journal of Hydrogen Energy, 4(5), 239–241.*
8. Garba, N. N., Rabi'u, N., Dewu, B.B.M.,Sadiq, U. & Yamusa, Y.A. (2013). Radon assessment in ground water sources from Zaria and environs, Nigeria. *International Journal of Physical Sciences* 8(42), 1983-1987
9. Monaj, K. & Avinash, P. (2012). A review of permissible limits of drinking water. *Indian J. CCUP. Environ. Med.* 16(1), 40-44.
10. Bhutiani, R., Kulkarni, Dipali Bhaskar., Khanna, D. R., & Gautam, A. (2017). Geochemical distribution and environmental risk assessment of heavy metals in groundwater of an industrial area and its surroundings, Haridwar, *India. Energy, Ecology and Environment*, 2(2), 155–167.
11. Lawal. A.O., Ali, Z.N. & Myina, O.M. (2013). Cadmium, Chromium, Lead and Zinc in Groundwater supply from Residential area in the vicinity of industrial layout in Kakuri, Kaduna state. Chemical Society of Nigeria, 36th Annual International Conference, Workshop and Exhibition, *Book of Proceedings*, 1(1) 156-161.
12. Ndikilar, C.E., Abdullahi, S. & Ayuba, D.K. (2016). Determination of Radioactivity Concentration and Estimation of Annual Effective Dose for All Age Categories of Drinking Water Collected from Dutse Town, Nigeria. Environmental Science, Corpus ID: 20761242
13. Shittu A., Chifu E N., Suleiman, A. B., & Hafeez Y. H (2016). Assessment of Heavy Metals and Radioactivity Concentration in Drinking Water Collected from Local Wells and Boreholes of Dutse Town, North West, Nigeria. *Journal of Environment Pollution and Human Health*, 1, 1-8.
14. Yahaya, T. O., Salisu, T. F., AbdulRa'uf, M. S., Mairiga, J. P. & Sani, G. S. (2021). Physicochemical, Heavy Metal, And Microbial Characteristics of Water Samples Collected from River Argungu In Kebbi State, Nigeria. *Journal of Innovative Research in Life Sciences.* 3(2),32-39
15. Abdulraheem, F.S., Al-Khafaji, Z.S., Hashim, K.S., Muradov, M., Kot, P. & Shubbar, A.A. (2020). Natural filtration unit for removal of heavy metals from water IOP Conf. Series: *Materials Science and Engineering* 888 012034

16. Adetunde, L.A., Glover, R.L.K. & Oguntola, G.O. (2011). Assessment of the groundwater Quality in Ogbomso Township of Oyo State of Nigeria. *IJRRAS* 8(1), 115-122.
17. Atarmu. A.O. (2012). Physical, Chemical and Bacterial Analyses of Groundwater in Ikere Township, Southwestern Nigeria. *International Journal of Science and Technology*, 2(5), 301-308.
18. Young, R.A. (2005). Toxicity profiles: Toxicity summary for cadmium. Risk assessment information system at the University of Tennessee. *(rais.ornl.gov/tox/profiles/cadmium.shtml)*
19. Ogwuegbu, M.O.C. & Muhanga, W. (2005). Investigation of lead concentration in people's blood in the copper belt province of Zambia. *Journal of Environment* 1,66 – 75.
20. Martin, S.P.G.B., & Griswold, W. (2009). Briefs for Citizens Human Health Effects of Heavy Metals. Environmental Science, Corpus ID: 39070726.
21. Suleiman, F.B. & Abdul, A.A. (2013). Analysis of Nitrates, sulphates and Nitrites in water from Dams in Katsina state. Chemical Society of Nigeria, 36th Annual International Conference, *Workshop and Exhibition Book of Proceedings*, 156-161.
22. Fawell, J.K. & Mascarenhas, R. (2004). Sulphate in drinking water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/03.04/114.
23. WHO (2022). Guidelines for drinking-water quality Fourth edition incorporating the first and second addenda.
24. Samali, A., Kirim, R.A & Mustapha, K.B. (2012). Qualitative and quantitative evaluation of some herbal teas commonly consumed in Nigeria. *African J. Pharmacology*, 6(6): 384-388.
25. Scharer, K., Veits, G, Brockhaus, A & Ewers U. (1991). High lead content of deciduous teeth in chronic renal failure. *Pediatr Nephrol*, 5(6),704–7.
26. Zheng, L.Y., Umans, J.G., Yeh, F., Francesconi, K.A., Goessler, W., Silbergeld, E.K., Roche, K.B., Guallar, E., Howard, B.V., Weaver, V.M. & Navas-Acien, A. (2015). The association of urine arsenic with prevalent and incident chronic kidney disease: evidence from the Strong Heart Study. *Epidemiology*, 26(4), 601–12
27. Chikumbusko, C.K., Christabel, K., Chikondi, M., & Theresa, M. (2013). Water quality assessment in Bangwe Township, Blantyre City, Malawi. *African journal of Environmental Science and Technology*; 7(5), 259-266.
28. Snedecor, G.W. & Cochran, W.G. (1967) Statistical methods. 6th Edition, The Iowa State University Press, Ames.
29. Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*. 11 (1), 1–42.
30. SAS Institute Inc. (2004). Online documentation for SAS, version 8.