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Physicochemical Characteristics of Borehole Water Sources in a Tertiary Educational Institution in Katsina, Katsina State, Nigeria

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ABSTRACT: Physicochemical parameters are very crucial to get the exact idea about the quality of water in order to protect the natural ecosystem and also compare data obtained with standard values. This study focuses on determining the physicochemical properties of borehole water samples distributed within a tertiary educational institution in Katsina, Nigeria using standard methods. Data obtained reveals that, the pH of the water samples ranged from 6.75 – 7.78, Temperature 24.5 – 31.5ºC, Dissolved oxygen (DO) 3.79 – 4.98 mg/L, Biological oxygen demand (BOD) 0.25 – 1.32 mg/L, Turbidity 0.78 – 10.00 NTU, Electrical conductivity 56.85 – 220.00 µS/cm, Total dissolved solids 2.25 – 19.00 mg/L, Total hardness 3.32 – 7.24 mg/L. Chlorides and Sulphate levels ranged from 0.95 – 5.99 mg/L and 0.17 – 0.34 mg/L respectively. Analysis of Variance (ANOVA) revealed significant differences in most values obtained at different sites at $P \leq 0.05$. The water quality within the institution fell within the permissible standards of the WHO and therefore safe. However, the study recommends continuous surveillance of the water supplies at different seasonal intervals in order to determine any effect of seasonal variation on the quality of water and the commercialization of the water supplies into a table water factory in the nearest future.

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The utmost desire for water is that which is suitable for consumption with no health issue. Water is pertinent for the survival of all forms of life on earth. However the rapid increases in population, industrialization and urbanization all around the globe has resulted in a drastic increase in environmental pollution and the demand for safe and potable water (Li *et al.,* 2021). The potability of water is a function of anthropogenic activities and the quality of water is therefore considered as an essential factor to arbitrate environmental changes (Elumalai *et al.*, 2020). One of the targeted United Nation's Sustainable Development Goal (SDG) 6 is to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation. This will require tackling both the quantity and quality dimensions of drinking water as it has been the foundation for the prevention and control of water borne diseases (WHO, 2020). In Nigeria, water supplied to municipalities is majorly from two sources which are either surface or groundwater sources. Groundwater include sources emerging from deep beneath the earth's surface as a result of condensation overtime. Groundwater usually undergoes natural filtration through soil and rock layers and they emerge as springs or extracted as boreholes or wells. The presence of new toxic chemicals and their removals is a major concern to service providers, particularly in groundwater that has various anthropogenic activities within its surroundings. Most issues with groundwater sources includes; high lead, iron and manganese content and increased levels of both carbon dioxide and hydrogen sulphide. However, treatment of such water usually include flocculation, filtration and disinfections (Nikhat, 2017). Yusuf *et al.* (2015) reported that no single method of purification can completely eliminate 100% contaminants from drinking water, as this requires the collection of multiple methods. Physicochemical determinants that influence the quality of water includes; colour, odour, taste, turbidity, temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved organic carbon, total trihalomethanes, phenols, macro and micro nutrients. Turbidity alters the aesthetic value of

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water and shields pathogens from the treatment action of chemicals. At low pH water may taste sour and total heavy metals may rise while at high pH water becomes soapy or taste bitter. The pH of water is said to be neutral and may have health consequences if it becomes extremely high (Kolawole and Afolayan, 2017). EC is an indication of water salinity and mineral content and directly correlates with the TDS of water which is attributed to the release of deposits from pipes into water. High concentration of mineral ions makes water unfit and detrimental to human health and may results in corrosion of pipes (Saleh *et al.*, 2023). Therefore, water need to be made safe for consumption with acceptable limits as the primary aim of the Guidelines for drinking water quality is the protection of public health, which serves as a basis for the development of national standards which ensures the safety of drinking water supplies through the elimination or reduction of harmful constituents of water that are known to be hazardous to human health. With the increased concern in drinking water quality, the study aims at determining the physicochemical properties of borehole water samples distributed within a tertiary educational institution in Katsina, Nigeria.

MATERIALS AND METHODS

Study area: Federal college of Education, (F.C.E) Katsina is situated in Batagarawa local government area of Katsina state, Nigeria. Its geographical coordinates are between Latitude 12°55'50.4" North and Longitude 7°36'08.7" East as shown in Figure 1. The area is dominated by the Hausa tribe and the average annual temperature is 35ºC, wind speed is estimated at 5km/h and humidity level is 11%. Batagarawa was established in 1991 and has an area of 433km^2 and a population of 184,575 at the 2006 census (NPC, 2006).

Sample collection: Water samples were obtained from 10 (ten) selected borehole water sources within Federal college of Education, Katsina, Katsina state, Nigeria. The sampling points include; A (College administrative block), B (School of languages), C (School of Education), D (School of vocation and technology), E (School of sciences), F (Microteaching laboratory), G (School of Arts and social sciences), H (Student hostel), I (Staff quarters) and J (Gymnasium) as shown in figure 2. The sampled points were chosen based on the accessibility and regular usage of the water. A total of 20 water samples were collected from distribution taps in the early morning hours when activities is less and evening hours when usage is at peak, these was done using standard methods as described by Ogah and Ukaegbu (2019). Certain parameters such as pH, Electrical Conductivity and Temperature of the samples were determined at the point of sampling and all samples collected were properly sealed and transferred to the laboratory in coolers with ice block for proper analysis.

Fig 1: Map of Katsina state indicating Batagarawa local government area

Fig 2: Geographical map of the sampling points.

Physicochemical analysis of water samples: The pH of water samples was determined using a calibrated pH meter, the temperature using mercury-bulb thermometer, turbidity using a HACH 2100N Turbidimeter and electrical conductivity (EC) was measured using the EC digital meter. Dissolved oxygen (DO) and the biological oxygen demand (BOD_5) after five (5) days of incubation was detected using the digital DO meter HI 9143 Microprocessor and deduced using the methods described by Agbabiaka and Olofintoye (2019). Total dissolved solids (TDS), Total hardness, and the detection of chlorides and sulphates in the water samples were determined using standard methods described by APHA (2005) and Ogah and Ukaegbu (2019). All analysis was done in triplicates on each water sample collected.

Statistical analysis: All the data generated in this study were analyzed descriptively by analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS version 23.0).

RESULTS AND DISCUSSION

The mean pH values of the water samples obtained from all points ranged from 6.75 - 7.78 which fell within permissible limit of 6.5 – 8.5 recommended by the National standard for drinking water quality (NSDWQ, 2007) and that of WHO (2011) guidelines for drinking water quality. pH in water is a reflector of the nature of chemical reactions and biological systems in water. The temperature of the water samples ranged from 24.5 °C to 32.5 °C. The highest mean value was obtained in sample I while sample H had the lowest mean value which corresponds with the values obtained by Agbabiaka *et al.* (2021). Temperature is said to be an essential determinant of the survival of most microorganisms as their cellular metabolic activities depends upon it. The turbidity of the water samples measured ranged from 0.78 NTU – 10.00 NTU with the highest turbidity value recorded in sample B while the lowest value was reported in samples from point A. All sampled points conformed with the recommended limits of 5 NTU by the WHO (2020) except for sampled point B which recorded turbidity value of 10.00 NTU, this could be as a result of sediments accumulated along the point of water distribution resulting from aging water infrastructure and the nature in which water is been channeled to such point. Kolawole and Afolayan (2017) also reported high turbidity levels above the permissible limits. Turbidity is therefore a measure of suspended particles and corresponds directly with the electrical conductivity values obtained during the study. Total dissolved solids (TDS) in water samples were very low, ranging from 2.25 mg/L to 19.00 mg/L and also fall within the WHO (2020) recommended permissible limits of 500 mg/L. TDS in water reflects the presence of organic and inorganic materials dissolved in water and at higher levels gives water an obnoxious odour and a loathsome taste (Adegboyega *et al.,* 2015).

Table 1: Physicochemical analysis of water samples at different sites

Sampled points	pH	Temp. (°C)	Turbidity (NTU)	Electrical conductivity (µS/cm)	Dissolved oxygen (mg/L)	BOD_5 (mg/L)	Total dissolved solids (mg/L)	Total hardness (mg/L)	Chlorides (mg/L)	Sulphates (mg/L)
A	7.05 ± 0.35^{c}	28.50 ± 2.50^{bc}	0.78 ± 0.03^{f}	56.85 ± 0.35^{e}	4.76 ± 0.01^{ab}	0.25 ± 0.55^{f}	3.10 ± 1.90^{e}	6.88 ± 0.00^{b}	2.03 ± 0.25^{c}	0.18 ± 0.08^{cd}
B	7.78 ± 0.25^{a}	31.00 ± 1.00^{ab}	10.00 ± 0.0^{a}	220.00 ± 59.0^{a}	4.03 ± 0.02^{c}	1.32 ± 0.11^{a}	19.00 ± 0.0^{a}	7.24 ± 0.00^{a}	3.95 ± 0.05^{b}	0.31 ± 0.02^{b}
C	7.30 ± 0.10^{b}	31.00 ± 2.00^{ab}	1.99 ± 1.01^{bc}	74.00 ± 1.70^{c}	4.95 ± 0.00^{a}	1.00 ± 0.15^{b}	4.92 ± 0.08^{d}	4.20 ± 0.00^{ed}	0.90 ± 0.09^{ef}	0.23 ± 0.01^{c}
D	6.92 ± 0.68^{cd}	28.50 ± 0.50^{bc}	2.55 ± 0.45^{ab}	102.90 ± 44.5^{bc}	3.79 ± 0.11^{d}	0.55 ± 0.02^{e}	6.60 ± 0.10^{c}	4.84 ± 0.01^{d}	1.00 ± 0.00^{d}	0.33 ± 0.08^{ab}
E	7.31 ± 0.49^{b}	31.50 ± 1.50^{a}	0.85 ± 0.04^{d}	167.25 ± 3.05^{ab}	4.06 ± 0.20^{bc}	0.58 ± 0.05^{d}	12.50 ± 0.0^{b}	4.60 ± 0.02^{d}	0.98 ± 0.00^{e}	0.21 ± 0.03^{c}
F	6.75 ± 0.25^{d}	28.50 ± 1.50^{bc}	0.82 ± 0.03^{ed}	66.65 ± 1.75^{cd}	3.87 ± 0.13^{d}	0.74 ± 0.12^{bcd}	2.25 ± 0.25^{f}	4.04 ± 0.00^{e}	1.00 ± 0.00^{d}	0.20 ± 0.01^{c}
G	7.51 ± 0.29^{ab}	26.50 ± 0.50^{c}	1.07 ± 0.07^{c}	161.10 ± 18.3^{abc}	4.67 ± 0.01^{b}	0.68 ± 0.34^{cd}	2.75 ± 0.25^{ef}	6.26 ± 0.14^{bc}	3.90 ± 0.00^{bc}	0.34 ± 0.02^{a}
H	7.61 ± 0.19^{ab}	24.50 ± 0.50^{cd}	1.00 ± 0.0^{cd}	168.40 ± 0.80^{ab}	4.98 ± 0.43^{a}	1.29 ± 0.08^{ab}	2.50 ± 2.50^{f}	5.96 ± 0.00^{cd}	5.99 ± 0.05^{a}	0.33 ± 0.03^{ab}
I	7.06 ± 0.34^{c}	32.50 ± 2.50^{a}	2.00 ± 0.0^{bc}	132.75 ± 42.8^{b}	3.98 ± 0.02^{cd}	0.82 ± 0.11^{c}	6.50 ± 0.00^{c}	6.04 ± 0.00^{c}	3.98 ± 0.01^{b}	0.24 ± 0.05^{c}
J	7.10 ± 0.40^{bc}	29.00 ± 1.00^{b}	0.85 ± 0.25^{d}	59.75 ± 2.25^{d}	4.65 ± 0.00^{b}	0.58 ± 0.38^{d}	7.00 ± 0.00^{c}	3.32 ± 0.40^{f}	0.95 ± 0.05^{e}	0.17 ± 0.08^{d}

Key = Mean ± Standard error, ANOVA, DMRT (Duncan multiple range test) (n = 10). A, B, C. D, E, F, G, H, I, J = College administrative block, School of languages, School of Education, School of vocation and technology, School of sciences, Microteaching laboratory, School of Arts and social sciences, Student hostel, Staff quarters and Gymnasium respectively. Values with different superscripts within same column are significantly different and those with the same superscripts have no significant difference at $p \leq 0.05$.

Electrical conductivity is a measure of the total ionic content in water, a reflector of how well water can conduct electricity and maybe an indicator of the level dissolved salts in water. The electrical conductivity values ranged from 56.85 µS/cm to 220.00 µS/cm as observed in samples A and B, respectively. This is in line with the acceptable limits of 0 - 1000 µS/cm recommended by the National standard for drinking water quality (NSDWQ, 2007) and that of WHO (2011) guidelines for drinking water quality. Total hardness in water occurs due to the amount of calcium, magnesium and carbonates in the water sample. The hardness value of the water samples in F.C.E Katsina can be classified as soft based on the classification of Subramanian (2010) as values ranged from 3.32 mg/L to 7.24 mg/L and conformed to the WHO (2011) maximum limits of 200mg/L. Dissolved oxygen (DO) ranged from 3.79 – 4.98 mg/L which is similar with the findings of Ladokun and Oni (2015) and were within acceptable limits of 5mg/L recommended by WHO (2020). Sufficient amount of dissolved oxygen indicates good water quality, good aeration and less pollution in water. Aeration enhances neutral taste and prevent odour in water. Biological oxygen demand (BOD_5) of the water samples ranged from 0.25 mg/L to 1.32 mg/L as obtained in sample A and B respectively and were within acceptable limits of 3mg/L recommended by WHO (2020). The values also corresponds with the findings of Batagarawa and Idris (2017) in a similar study. A high BOD value depicts a heavily polluted water and a measure of degradable organic matter present in water as microorganisms use the atmospheric oxygen dissolved in the water for the oxidation of organic matter. This amount of dissolved oxygen used up by microorganisms while oxidizing organic materials is regarded as the biological oxygen demand (BOD_5) after five (5) days of incubation in the absence of light. The chlorides content of the water samples ranged from 0.90 mg/L – 5.96 mg/L which corresponds with the findings of Sule *et al.* (2017) and lower than that observed by Abubakar and Said (2022). The values however fell within the maximum permissible limits of 250 mg/L stated by WHO (2020). However, the low chloride contents may have contributed to the low electrical conductivity of the water samples. The mean concentration of sulphates for the samples analyzed ranged from 0.17 mg/L – 0.34 mg/L as observed in samples J and G respectively which fell within the maximum permissible limits of 250 mg/L stated by WHO (2020). High level of sulphates in water reflects contamination of industrial wastes and domestic sewages in the water (Ebri *et al.,* 2016). Analysis of variance (ANOVA) revealed that there are significant differences in the values obtained from different sites, this therefore indicates that they quality of water from each sampled point differ greatly from each other except for others which were closely related (Table 1).

Conclusion: Findings from this study indicates that the water quality is satisfactory and falls within the acceptable standards for drinking water quality recommended by world health organization (WHO) and Nigerian standard for drinking water quality (NSDWQ). However, proper maintenance of the water infrastructure such as regular washing and replacement of worn-out pipes and taps is required in order to keep up the standards of the water quality and more importantly, the commercialization of the water supplies into a table water factory in the nearest future.

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