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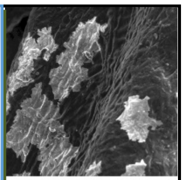

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Assessment of Borehole Water Quality in Usmanu Danfodiyo University Sokoto (Permanent Site), Nigeria

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ABSTRACT

It is acknowledged that access to high-quality water is crucial for any significant human development. Ten boreholes were used in obtaining the water sample. The samples were analyzed using the American Public Health Association (APHA) suggested procedures. The test parameters were compared to the chemical drinking water quality guideline established by the World Health Organisation. In a situation where the value is not provided, we relied on other pieces of literature. The research shows that the alkalinity, iron (Fe^{+}), calcium (Ca^{2+}), magnesium (Mg^{+}), nitrate (NO^{3-}), pH, conductivity, phosphate (PO_4^{3-}), and total hardness ($CaCO_3$) are all in line with the guidelines permissible limit which means are within the no-problem zone limits for health. While copper (Cu^{2+}) was found to be within the permissible limit 2 mg/L in all the samples but BH_1 (Junior Staff Quarters) 3mg/L which has health problems such as digestive disturbances, problems with the central nervous system, mucosal irritability, Wilson's illnesses, and liver and kidney damage.

INTRODUCTION

Water is indispensable to life [1]. Since life began in water and is sustained by water, the human body contains around 60% water [2]. Water is responsible for many physiological processes in the human body. Thus all aspects of cell structure and functions are adaptable to the physical and chemical properties of water [3]. It is realized that access to high-quality water is crucial for any significant human development [4]. Water pollution poses an intimidating problem to global water resources which are already scarce [1]. In most nations, it was unavoidable to rely on surface and subsurface water sources for drinking water. Both artificial and natural causes have an impact on the quality of this water. The quality of the water can be impacted by natural disasters, agricultural runoff, industrial and domestic discharges, rising population and economic expansion, and other factors. [4]. Sewage and cultivation activities result in high levels of toxic elements in urban groundwater. The concentration of organic, inorganic, heavy metals, and toxic chemicals is high in various parts of the world continuously [5].

According to UNICEF/WHO, 2012 Nigeria is dealing with many waterborne-related problems, and it is troubling that the majority of the population lacks access to clean drinking water and must rely on using contaminated sources to meet a necessity [6]. Similarly, the World Health Organisation, 2004 stated that out of an estimated 1.8 million deaths in Africa, 88% are attributed to water-related diseases. These calls for the quality assessment of the various sources of water as contamination remains a dominant problem [7].

This work aimed to analyse the chemical contamination indicators of the major source of water (boreholes) located at the permanent site of Usmanu Danfodiyo University Sokoto to ascertain the safety of this water by comparing it to drinking water standard guidelines by the World Health Organisation and other reliable literature.

MATERIALS AND METHODS

Chemicals and Reagent

Analytical-grade supplies were used for every chemical and reagent obtained from the biochemistry department of Usmanu Danfodiyo University Sokoto, Nigeria.

Water sampling

Ten sampling boreholes designated as BH_1, BH_2, BH_3, BH_4, BH_5, BH_6, BH_7, BH_8, BH_9, and BH_{10} were selected within the University Permanent Site (**Table 1**). As part of our quality control procedures, water samples were individually collected in sterile one-liter plastic containers. Before collection, non-ionic detergent was used to wash all the bottles, and they were then washed with deionized water before use [8]. Before performing the final water sampling, the bottles were three times washed with distilled water at the place of collection. Prior to being transported to the lab, all samples were stored at 4^{o}C and each bottle was tagged with the sampling location.

Table 1: Location of sampled boreholes and acronym assigned to each.

Location of borehole	Acronym
Junior staff quarters	BH_1
Model primary school	BH_2
PTF (stadium)	BH_3
PTF (energy research center)	BH_4
Hostel (I block)	BH_5
Clinic	BH_6
Library	BH_7
Faculty of Management Science	BH_8
Faculty of Law	BH_9
UDUS sachet water Company	BH_{10}

Note: BH= Borehole

Methodology

The color, taste, and smell observation using sense organs was determined by the method described by Ademoroti, 1996 [9]. Chemical analysis was conducted using standard laboratory methods suggested by APHA (American Public Health Association, 1995) [10]. Using indicators of chemical contamination, such as alkalinity and iron (Fe^+), copper (Cu^{2+}), calcium (Ca^{2+}), magnesium (Mg^+), nitrate (NO^{3-}), pH, conductivity, phosphate (PO_4^{3-}) and total hardness ($CaCO_3$) samples were analysed to identify their quantities. The results were compared to the chemical drinking water quality guideline values issued by the World Health Organization in 2011 [11]. In cases where the World Health Organization's 2011 guidelines don't include a guideline value, we have relied on values from previous World Health Organization publications and other works of literature. These indicators' chemical concentrations from boreholes that are higher than the recommended values are considered polluted.

RESULTS AND DISCUSSION

pH

The pH scale ranges from 1 to 14, with 7 being a neutral solution; anything below this range is acidic, and anything above this range is basic. The pH of the most basic solution is 14, whereas the pH of the most acidic solution is 1. Generally, there is no health risk associated with the pH of drinking water because most borehole water ranges from 6.54 to 7.13 with an average of 6.84 (**Table 2**) which is within the World Health Organisation's permissible limit. However, very low pH levels may result in a number of health problems, including irritation of the mucous membranes, eyes, and skin. So also, extremely high pH levels (10–12.5) can irritate the stomach and induce hair fiber swelling [14].

Conductivity

Ion concentration in water is indirectly measured by conductivity. Since it is frequently used as a substitute for total dissolved solids (a conductivity of 1400 S/cm is equal to 1000 g/L of dissolved solids), it serves as an indicator of the water's taste and salinity [15]. For the borehole water, the samples' electrical conductivity ranged from 139.3 to 167 s/cm (**Table 2**). All the conductivity values were below the World Health Organisation's permissible limits for unpolluted water of 1500 µs/cm.

Table 2. Values of the physical parameters of the water studied.

Sample	pH	Conductivity (µs/cm)
BH_1	7.13±0.03	144.3±0.33
BH_2	6.54±0.01	165.3±1.21
BH_3	6.77±0.02	159.7±0.81
BH_4	6.73±0.01	142.7±0.81
BH_5	6.91±0.01	164.3±0.33
BH_6	6.79±0.01	146.0±0.56
BH_7	6.78±0.01	167.0±0.33
BH_8	6.91±0.01	139.3±0.81
BH_9	6.60±0.01	140.3±0.81
BH_{10}	7.10±0.07	141.3±1.76
WHO	6.5 – 8.5	1500µs/cm

Note: All results are mean ± SD for 3 determinations, World Health Organisation (WHO, 2011) standard and Borehole (BH).

Table 3. Values of the chemical parameters of the water studied.

sample	TH ($CaCO_3$) mg/L	Alkalinity (mg/L)	Nitrate NO_3^- mg/L	Phosphate PO_4^{3-} mg/L	Calcium Ca^{2+} mg/L	Magnesium Mg^{2+} mg/L	Copper Cu^{2+} mg/L	Iron Fe^{2+} mg/L
BH_1	3.2±0.10	290±12.14	1.2±0.12	0.06±0.05	2.4±0.029	4.5±0.35	3.5±0.17	0.1±0.30
BH_2	3.7±0.08	270±11.54	1.1±0.01	0.11±0.08	2.8±0.04	5.2±0.16	1.2±0.10	0.08±0.02
BH_3	4.1±0.03	220±16.06	2.5±0.13	0.07±0.06	2.1±0.02	3.8±0.10	0.9±0.10	0.2±0.60
BH_4	2.9±0.10	270±5.71	1.0±0.12	0.06±0.03	2.9±0.37	6.5±0.20	1.7±0.26	0.03±0.02
BH_5	3.5±0.20	210±17.32	1.6±0.12	0.06±0.07	1.8±0.01	5.8±0.40	1.8±0.10	0.07±0.01
BH_6	1.3±0.08	270±5.77	1.1±0.13	0.06±0.02	1.5±0.04	3.1±0.10	0.1±0.03	0.01±0.05
BH_7	3.4±0.20	160±15.28	1.9±0.17	0.06±0.03	1.2±0.32	3.9±0.24	2.2±0.17	0.05±0.08
BH_8	4.3±0.08	240±15.28	2.3±0.18	0.09±0.07	1.4±0.35	7.3±0.42	0.8±0.23	0.2±0.10
BH_9	1.1±0.10	210±5.77	2.7±0.18	0.09±0.04	1.3±0.03	4.3±0.80	0.7±0.12	0.06±0.05
BH_{10}	1.7±0.17	190±11.54	0.8±0.01	0.06±0.04	1.5±0.02	2.7±0.32	0.6±2.54	0.1±0.50
WHO	500	300^a	50	1^b	150	50^C	2	0.3

a: The World Health Organization (2011) did not recommend alkalinity health-based guideline value; instead, Akhtar et al. [5].
b: The World Health Organization (2011) did not recommend a phosphate health-based guideline value; instead, Fadiran et al.[12] was used.
C: The World Health Organization (2011) did not recommend a magnesium health-based guideline value; instead, Health Canada [13] was used
All results are mean ± SD for 3 determinations, Total hardness (TH), Nitrate (NO_3^-), Phosphate (PO_4^{3-}), Calcium (Ca^{2+})), magnesium (mg^{2+}), Iron (Fe^{2+}), copper (Cu^{2+}), World Health Organisation (WHO, 2011) standard and Borehole (BH).

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Total hardness

Generally, Calcium and magnesium are indicators of hardness in water. The combination of temporary carbonate compounds and permanent bi-carbonate compounds constitutes total hardness. Calcium and magnesium alter the chemical makeup of water, rendering soap insoluble. Hard water can result in the formation of scum and curd while boiling, hardening of boiled vegetables, fabric discolouration, and health issues such as diarrhoea, excessive gas, kidney stones, and cardiovascular problems [5, 16]. According to the international WHO standard (WHO, 2011), the maximum allowable limit of total hardness (TH) for drinking purposes is 500 mg/L. The borehole water's total hardness, which ranged from 1.1 to 4.3 mg/L (**Table 3**), is regarded as being quite soft and suitable for home use.

Alkalinity

Alkalinity gauges a body of water's capacity to balance acids and bases and keep a constant pH level. Without the presence of a buffer, any acid added to a body of water would cause its pH to alter instantaneously [17]. Low alkalinity water typically has a high pH and is acidic. One negative side effect of low alkalinity is eye discomfort. Scaling on pipes and plumbing fittings as well as dry skin can result from very alkaline water [18]. Numerous other health issues, including the development of kidney stones, the generation of excessive gas, and acute irritation of the eyes, skin, and mucous membranes [19], can also be brought on by high alkalinity levels. The borehole water's total alkalinity varied from 160 to 290 mg/L (**Table 3**). Since WHO did not suggest a legal limit for alkalinity in 2011, all water samples were found to be below the 300 mg/L allowable limits indicated by Akhtar et al. [5].

Nitrate

The nitrate (NO_3) concentration of water samples ranged from 0.8 to 2.7mg/L. Nitrate levels in drinking water shouldn't be higher than 50mg/L by WHO, 2011. All samples recorded lower nitrate values far below WHO permissible limits (**Table 3**). It is crucial to note that the low levels of nitrate found in this study may be due to less anthropogenic contamination that has been present in the studied area over time.

Calcium

The carbonate form of calcium contributes to the hardness of water, it is a vital mineral in water because it aids in the development of strong bones and teeth. [1]. The concentration of calcium in the samples ranged from 1.2 to 2.9 mg/L (**Table 3**). All the samples were below the WHO, 2011 limit 150mg/L. This indicates that all the samples are within the permissible limit.

Copper

The concentration of copper in the samples ranges from 0.1 to 3.5 mg/L (**Table 3**). ALL the samples measured are within the acceptability limit 2 mg/L WHO, 2011 except sample BH_1 (Junior Staff Quarters) which has a value 3.5 mg/L which deviate from the WHO, 2011 guideline that make it unfit for domestic purpose. Consuming too much copper can result in a number of serious health issues, including mucosal irritation, Wilson's illnesses, liver and kidney damage, widespread capillary damage, hepatic and renal damage, and gastrointestinal disturbances [20-22]. Industrialization, the treatment of electronic waste, the treatment of municipal waste, natural metal erosive processes, metal dissolution, and groundwater table leaching are some of the sources of copper that contaminate water.

Iron

When compared to hemosiderotic damage to other organs, such as the liver and kidney, which can be fatal, the effect of iron overload on some organs, such as the skin, is negligible [23]. The concentration of iron in the samples ranged from 0.01 to 0.2 mg/L (**Table 3**) which is within the WHO, 2011 permissible limit.

Magnesium

Magnesium is a necessary component of the human body and is important for metabolic activities, blood coagulation, muscle contraction, and blood pH regulation. The carbonates of magnesium also cause water hardness [1]. The concentration of magnesium in the samples ranged from 2.7 to 7.3 mg/L (**Table 3**) which is within the Health Canada, 1978 [13] permissible limit 50 mg/L, as no guideline for magnesium was proposed by WHO, 2011.

Phosphate

All of the water samples had phosphate values between 0.06-0.11 mg/L (**Table 3**). The WHO did not provide any health-based guidelines for phosphate in 2011, and the figure of 1 mg/L is based on work by Fadiran et al. [12]. As a result, the samples' phosphate concentration is within the allowable range. The low amount of phosphate may be caused by a lack of phosphate-containing rock systems or low levels of these systems in the area where boreholes are located. It may also be caused by the sparing use of fertilizers that include phosphate in this area. [24].

CONCLUSION

All the parameters studied indicated that the waters were within the no-problem zone i.e. within the permissible limits for health and aesthetic considerations. But copper was found to exceed the permissible limit in sample BH_1 (Junior Staff Quarters) making it unfit for drinking. Acute health issues caused by copper include liver and kidney damage, mucosal irritation, Wilson's illnesses, gastrointestinal disturbances, and central nervous system issues. Therefore, a precautionary measure needs to be employed to protect the health of the people, technique for copper removal, water treatment, purification, and disinfection need to be used, also routine analyses of this type should also be embarked upon on a regular basis to maintain their suitability for consumption and also monitoring anthropogenic activities within the area is necessary.

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