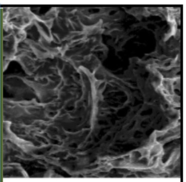
JEBAT, 2022, Vol 5, No 2, 46-52
https://doi.org/10.54987/jebat.v5i2.766

HIBISCUS PUBLISHER

JOURNAL OF ENVIRONMENTAL BIOREMEDIATION AND TOXICOLOGY

Website: http://journal.hibiscuspublisher.com/index.php/JEBAT/index



JEBAT VOL 5 NO 2 2022
SEM of *Musa × paradisiaca*

Assessment of Physico-Chemical Properties and Enumeration of Coliform in Domestic Water Sources in Pindiga

Terhide Samuel Tyohemba[1]*, Yunana Felicia[1], Suwaiba Muhammad Ladan[2], Nelson Ndukwe Nwachukwu[1], Catherine Ojebbah Attah[3], Ahmadu Jummai[4] and Memi Gabriel Galadima[1]

[1]Department of Biological Sciences, Federal University, Kashere, V2G3+R8V, 771103, Barri, Gombe State, Nigeria.
[2]Department of Chemical Sciences, Federal University, Kashere, V2G3+R8V, 771103, Barri, Gombe State, Nigeria.
[3]Chemistry Department, Federal College of Education, B.U.K Road, Kano, Nigeria.
[4]Medical Biotechnology Department, National Biotechnology Development Agency, X9PH+9PV, Umaru Musa Ya'adua Way, Airport Rd, Lugbe, Abuja, Nigeria.

*Corresponding author:
Terhide Samuel Tyohemba
Department of Biological Sciences,
Federal University, Kashere,
V2G3+R8V, 771103, Barri,
Gombe State,
Nigeria.
Email: terhide27@gmail.com

HISTORY

Received: 15th Oct 2022
Received in revised form: 24th Nov 2022
Accepted: 15th Dec 2022

KEYWORDS

Coliform
Domestic Water
Borehole
Hand dug well
Pindiga

ABSTRACT

This study was conducted to determine the level of contamination of domestic water sources in Pindiga, Akko Local Government, Gombe State, to observe the trend of quality change of these water sources, if any. Water samples were collected and analyzed for the presence of coliforms and physicochemical quality using standard methods. The results show that the mean value recorded for the physicochemical parameters and the total coliform count among the domestic water sources were within stipulated limits of WHO and NSDWQ except for the chloride mean value of 444.9±437.3 mg/L recorded in borehole water, Biochemical Oxygen Demand means value of 154±8.58 mg/L (hand dug well) and 166.83±32.67 mg/L (borehole) and total hardness mean value of 626.5±510.26 mg/L recorded in hand dug well. Although most of the Physicochemical parameters and the total number of coliforms in domestic water sources were within acceptable limits, continuous monitoring and quality assessment of these domestic water sources in relation to their purification process is needed to maximize safety and healthy life for everyone.

INTRODUCTION

Water is life, and Only 2.4% of the world's total water is spread on land, and only a small percentage of it can be used as fresh water. Fewer than 0.3 to 0.5% of the water that is available to humans is fresh water [1]. Water is now a rare and limited resource. This is a result of both overexploitation and the expanding population [2,3]. Approximately 1 billion people in poor nations do not have access to clean drinking water today [1]. The necessity to use sources of water other than conventionally treated waters at maximum risk of microbiological and chemical pollution has been prompted by the growing shortage of excellent quality water in developing countries. As a result, water-related illnesses like diarrhoea, which make up 10% of the disease burden in underdeveloped nations, are particularly prevalent there [4]. Surface water, boreholes, and hand-dug wells are the main sources of water supply for most places. Human activity has contaminated these water sources, particularly the hand-dug wells and surface water. Most residents use pit latrines, and indiscriminate household waste disposal contributes to the contamination of water sources by these activities, which also include the use of pit latrines by most residents [5]. The majority of hand-dug wells are shallow and frequently left uncovered, making them vulnerable to contamination from surface water during intense precipitation as well as human activity [5].

Additionally, contaminants in drinking water that are concentrated above their allowable levels cause health issues like fluorosis, typhoid, jaundice, cholera, preterm babies, and other issues, particularly in newborns [6]. Around 70% of Ghana's population relies largely on groundwater for drinking [7]. Any fresh water that is found in soil pores and rock formation fissures below the surface of the earth is known as groundwater. Because it seems pure and clean, groundwater is typically regarded as one of the best sources of water. This is due to the several layers of rocks and sediments it passes through, which act as a kind of natural filtration mechanism. However, insufficient source protection and poor resource management can lead to groundwater contamination and a decline in groundwater quality. Human activity is almost invariably the cause of groundwater contamination. Groundwater is prone to intentional or unintentional pollution in regions with high population density and intense human activity. Chemicals, microbes, fertilizers, fuel minerals, and metals, among others, can contaminate groundwater [6].

Water-borne illnesses like gastroenteritis, cholera, typhoid, giardiasis, stomach aches and pains, vomiting, respiratory infections, liver damage, and even cancer (due to DNA damage) have all been linked to the use of contaminated groundwater. These illnesses are brought on by a variety of chemicals, including CFCs, MTBE, and others [8]. Inputs from the atmosphere, soil and water-rock interactions, as well as pollution sources like mining, clearing land for agriculture, acid rain, and domestic and industrial wastes, all have an impact on groundwater quality [9, 10]. However, due to contamination from sources such as septic tanks [11], landfill leachates, home sewage [8], agricultural runoff/agricultural fields [12], and industrial wastes, the quality of groundwater is declining more quickly [9]. It is also crucial to remember that one of the most crucial factors in studies of water resources is groundwater quality [13]. It is mostly governed by the host's and associated rocks' discharge-recharge patterns, as well as polluted activities [14].

Water's suitability for different purposes depends on the type and concentration of dissolved minerals, and groundwater has a higher mineral content than surface water [15]. In reaction to daily, seasonal, and climatic variables, groundwater quality is continually changing. It is vitally important to continuously evaluate water quality measures since shifts in water quality have far-reaching repercussions on people and other living things. Groundwater contamination also depends on the local geology, and it happens quickly in limestone regions and hard rock places where there are large cavern systems below the water table [16]. In Nigeria, the majority of the rural population lacks access to clean water, therefore they rely on well, stream, and river water for domestic use.

Groundwater, pipe-borne water, and other natural water supplies in Nigeria have been reported to have poor microbiological and physicochemical quality, with coliform counts far higher than the W.H.O.'s recommended standard [1,17]. It is possible to link the need for elaborating on significant criteria in water quality evaluation to the idea that these factors shouldn't be overlooked when assessing the overall potability of water. The variations in physical, chemical, and biological conditions that it encounters cause changes in the quality of groundwater [16]. In developing countries where the availability of potable water is a major concern, poor drinking water quality has been linked to several human ailments including cholera and diarrhoea. Therefore, the purpose of this study is to evaluate the physical and chemical characteristics and count the coliforms present in groundwater in Pindiga, Akko L.G.A., and Gombe state to aid policymakers in creating criteria to prevent groundwater contamination.

MATERIAL AND METHODS

Sample Site and Study Area

The location of this study was Pindiga, Gombe State, Nigeria. The town of Pindiga is located between latitudes 04°15' and 5N and 8°25'E. Pindiga Town, which is in the Gombe state's Akko Local Government Area and is bordered to the north by Tumu Village and the south by Kashere, is situated. It covers 331.551 square kilometres of land. Pindiga Town is a coastal community located in a tropical area.

Sample Collection

Boreholes and hand-dug wells in Pindiga town and its surrounding villages, specifically Gujubawo (A1), Garin alkali (B1), Ubandoma street (C1), and Madagaska street (D1)., were the sources of water samples for physicochemical analysis and total coliform count. Twelve (12) samples each from boreholes and hand-dug wells were used to produce the 24 samples, which were then conveniently analyzed for the parameters listed below: temperature, conductivity, turbidity, iron, dissolved oxygen, total hardness, sulphate, chloride, phosphate, sodium, iron, biochemical oxygen demand, magnesium, and total coliform count. Within two hours of collection, the water samples were analyzed in the lab in triplicate

Physico-chemical Analysis

Total dissolved solids, appearance, hardness, conductivity, pH, colour, odour, and other conventional parameters are used to evaluate the quality and portability of water for drinking.

Temperature

A thermometer was used to measure the temperatures of the samples. The thermometer bulb was inserted into the water sample in the beaker and left there for a few minutes before the reading was obtained [19].

Conductivity

The Hanna Instrument H18733 conductivity meter was utilized. A conductivity reading was displayed after the conductivity meter probe had been cleaned with distilled water and put into the sample in a beaker [19].

pH

Utilizing a pH meter, the pH was determined (Model: Mettler Toledo Mp 220). After inserting the pH meter probe into the beaker-containing water sample, the READ key was depressed to obtain the pH reading [19].

Turbidity

After adding the sample to the turbidimeter bottle, it was cleaned with a cloth to remove any possible fingerprints that might have influenced the reading. The turbidity reading was then shown once the bottle was put on the turbidimeter and the READ key was pressed [19].

Iron

A test tube containing 5 mL of water sample and 0.3 mL of iron reagent (Fe) was filled, agitated, and left to stand for three minutes. The iron concentration was then measured using a spectrophotometer at a wavelength of 420 nm [19].

Dissolved Oxygen

Using the APHA [19] method, the dissolved oxygen was calculated. One glass bead was put into a reaction cell that was overflowing with other materials. It added oxygen reagent 02 - 1k (5 drops). After mixing for 10 seconds, 5 more drops of the oxygen reagent 02 - 2k were added. Finally, 10 drops of the oxygen reagent 02-3k were added, and mixed, and the dissolved oxygen value was read out at a wavelength of 498 nm in the spectrophotometer.

Total Hardness

Using a pipette, 1 mL of the sample and 1 mL of the total hardness reagent H-1k were introduced to a reaction cell. Total hardness in a spectrophotometer at a wavelength of 450 nm was obtained after a three-minute reaction period [19].

Sulphate

2.5 mL of the water sample and 0.2 mL of the sulphate reagent SO4-1A were put into a test tube and stirred. The sulphate reagent SO4-2A powder was added and stirred with 1 level spoonful. The solution was then tempered for five minutes in a water bath at 40°C. The solution was filtered through Whatman No. 1 filter paper after 2.5 mL of the sulphate reagent SO4-3A was added, mixed, and removed. Following that, the filtrate was combined with 0.4 mL of the sulphate reagent SO4-4A. Once more, the solution was tempered for 7 minutes at 40°C in a water bath. This was put into a circular cell and put in a spectrophotometer to determine the amount of sulfate in the water sample. The wavelength chosen was 520 nm [19].

Chloride

2.5 mL of the chloride reagent Cl-1 was mixed with 5 mL of the water sample in a test tube. Additionally, the chloride reagent Cl-2 was added, agitated, and allowed to stand for 1 minute before the spectrophotometer detected the chloride concentration at a wavelength of 460 nm [19].

Phosphate

A test tube containing 5 mL of the water sample had 0.5 mL of the phosphate reagent PO4-1A added to it and stirred. One level spoonful of the phosphate reagent PO4-2A was then added. Before reading out the phosphate content at a wavelength of 420 nm, 5 minutes of reaction time was allowed [19].

Sodium

A reaction cell contained 0.5 mL of the sodium reagent Na-1k, along with 0.5 mL of the water sample, which was then mixed. Before reading the sodium concentration from the spectrophotometer, one minute of reaction time was allowed [19].

Biological Oxygen Demand (BOD)

Water samples were kept at room temperature (25^0C) in a dark closet for more than five days before the Winklers method, as described by APHA, was used to determine their oxygen content [20].

Total Coliform Count

Using the membrane filtering method, the Total Coliform Count (TCC) was carried out. Each water sample was filtered through 50 mL of 0.45-m filter paper before being placed on nutrient, mFC, and mENDO agar plates and cultured for 24 to 48 hours at 37 °C. The colonies from nutrient agar plates were also purified and sub cultured on MacConkey agar, blood agar, mannitol salt agar, cetrimide agar, and bile esculin agar plates. The blue and metallic sheen colonies from mFC and mENDO plates were purified and identified. Gram staining and morphological/biochemical techniques were used to isolate and screen pure colonies [19,21].

Statistical Analysis

The contamination of water samples was described using the mean, range, and standard deviation. The data obtained were compared to the Nigeria Standard of Drinking Water Quality (NSDWQ) and WHO (World Health Organization) drinking water standards. SSPS version 22 was used to do the statistical analysis.

RESULTS

Physicochemical properties and total coliform count of domestic water sources (hand-dug well and borehole) in Pindiga

Temperature, pH, electrical conductivity, and turbidity were the physical parameters that were analyzed. Results of temperature for hand dug well (**Table 1**) show that the sampled water ranged between 27.8 to 29.7^0C with a mean value of 28.5^0C, the least value was recorded in Garin Alkali (B_1) and the highest value was recorded in Ubandoma (C_1), pH ranged between 6.5 and 7.6, with the mean value of 7.07, the least value was recorded in Ubandoma(C_1) and the highest value in Madagaska (D_1), Turbidity ranged between 1.36 to 3.28 NTU, with a mean value of 2.42 NTU, the least value was recorded in Ubandoma (C_1) and the highest value in Madagaska (D_1), Conductivity ranged between 5.42 and 16.58 us/cm, where the least and highest value were found in Gujubawo (A_1) and Garin Alkali (B_1) respectively. The major cations and anions were the chemical parameters that were analyzed.

The major cations include Mg^{2+}, Fe^{2+} and Na^+. The major anions include Cl^-, SO_4^{2-}, PO_4^{2-}, CO_3^{2-} as well as Dissolved Oxygen, Biological Oxygen Demand and Total hardness. The results of these chemical parameters show that the Mg^{2+} ranged between 2.32 and 12.61 mg/L with the mean value of 8.12 mg/L, the least value was recorded in Garin Alkali (B_1) and the highest value in Ubandoma (C_1), Fe^{2+} ranged between 0.000 to 0.0616 mg/L with the mean value of 0.0616 mg/L, where the lowest value was found in Gujubawo (A_1), Garin Alkali (B_1) and Ubandoma (C_1) respectively and the highest value in Madagaska (D_1), Na^+, ranged between 6.75 and 9.21 mg/L with the mean value of 7.93 mg/L, the lowest value was found in Garin Alkali (B_1), and the highest value in Ubandoma (C_1), Cl^-, ranged between 47.9 to 259.9 mg/L with the mean value of 114.95 mg/L, the lowest value was recorded in Ubandoma (C_1) and the highest one in Garin Alkali (B_1), SO_4^{2-} ranged between 2.40 to 5.6 mg/L with the mean value of 3.94 mg/L, the lowest value was found in Garin Alkali and the highest one in Ubandoma (C_1), PO_4^-, ranged between 0.64 to 13.25 mg/L the lowest value was found in Garin Alkali (B_1) and the highest value in Gujubawo (A_1), total hardness ($CaCO_3$) ranged between 120 to 1070 mg/L, the lowest value was found in Gujuwabo (A_1) and the highest value in Madagaska (D_1).

Dissolved oxygen ranged between 0.72 to 3.66 mg/L, the lowest value was found in Ubandoma (C_1) and the highest one in Garin Alkali (B_1), biological oxygen demand ranged between 185 to 212.3 mg/L, the lowest value was found in Gujubawo (A_1) and the highest value in Madagaska street (D_1). Total coliform count (TCC) ranged between 1-9 to 7.5-9 cfu/100 mL, the lowest value was found in Madagaska street (D_1) and Garin Alali (B_1) and the highest one in Gujubawo (A_1) and Ubandoma street (C_1). Results for borehole (**Table 2**) of temperature show that the sampled water ranged between 28.7 to 31.2 °C with a mean value of 29.93 °C. The least value was recorded in Garin Alkali (B_1) and the highest value was recorded in Madagaska street (D_1), pH ranged between 6.5 and 7.1, with a mean value of 7.13, the least value was recorded in Ubandoma (C_1) and the highest value in Garin Alkali (B_1), Turbidity ranged between 1.64 to 5.97 NTU, with a mean value of 3.69NTU, the least value was recorded in Garin Alkali (B_1) and the highest value in Ubandoma street (C_1).

Table 1. Physicochemical properties and total coliform count of some hand-dug wells in Pindiga.

Parameter/Unit	Location				Range	Mean ±S.D	WHO (2008)		NSDWQ (2007)
	A$_1$	B$_1$	C$_1$	D$_1$			HDL	MPL	
Temperature (^{0}C)	28.3	27.8	29.7	28.3	27.8 – 29.7	28.5 ± 0.82	20 – 30	40	Ambient
pH	7.0	7.2	6.5	7.6	6.5 – 7.6	7.08 ± 0.46	7.0–8.5	6.5 – 9.2	6.5 – 8.5
Turbidity (NTU)	3.23	1.36	1.81	3.28	1.36 – 3.28	2.42 ± 0.98	5	25	5
Conductivity (us/cm)	5.42	16.58	54.9	5.43	5.42 – 16.58	20.58 ± 23.48	500	1400	
Total Hardness (mg/L)	120	254.4	1060.8	1070.9	120 – 1070	626.5 ± 510.26	500		150
D O (mg/L)	1.81	3.66	0.72	2.49	0.72 – 3.66	2.17 ± 1.23	14		
SO_4^{2-} (mg/L)	2.87	2.40	5.6	4.9	2.40 – 5.6	3.94 ± 1.55	200	400	100
PO_4^- (mg/L)	13.25	0.64	N.D	10	0.64 – 13.25	17.22 ± 12.74	200		
B O D (mg/L)	185.3	194.7	203.7	212.3	185.3-212.3	154 ± 8.58			≤ 5
Fe^{2+} (mg/L)	0.000	0.000	0.000	0.0616	0.000 – 0.0616	0.0154 ± 0.031	0.1		0.3
Mg^{2+} (mg/L)	10.70	2.32	12.61	6.87	2.32 – 12.61	8.13 ± 4.55	20	30	0.2
Cl^- (mg/L)	103.9	259.9	47.9	48.1	47.9 – 259.9	114.95 ± 100.16	250		250
Na^+ (mg/L)	7.74	6.75	9.21	8.05	6.75 – 9.21	7.94 ± 1.01	200		200
TCC (cfu/100ml)	9	1	9	1	1 – 9	5 ±4.62			10

KEY: A$_1$ = Gujubawo, B$_1$ = Garin Alkali, C$_1$ = Ubandoma street, D$_1$ = Madagaska street
HDL = Highest Desirable Level MPL = Maximum Permissible Level

Table 2. Physicochemical properties and total coliform count of some boreholes in Pindiga.

Parameters/Units	Location				Range	Mean±SD	WHO (2008)		NSDWQ (2007)
	A$_1$	B$_1$	C$_1$	D$_1$			HDL	MPL	
Temperature (^{0}C)	29.6	28.7	30.2	31.2	28.7 – 31.2	29.93±1.05	20-30	40	Ambient
pH	6.6	8.3	6.5	7.1	6.5 – 7.1	7.13± 0.83	7.0-8.5	6.5-9.2	6.5-8.5
Turbidity (NTU)	3.57	1.64	5.97	3.58	1.64 – 5.97	3.69 ± 1.77	5	25	5
Conductivity (us/cm)	6.22	22.0	1800	6.20	6.20 – 1800	458.6 ± 894.3	500	1400	
Total Hardness (mg/L)	91.2	33.6	52.8	50.6	33.6 – 91.2	57.05 ± 24.33	500		150
D O (mg/L)	2.41	2.34	3.39	3.36	2.41 – 3.39	2.88 ± 0.58	14		
SO_4^{2-} (mg/L)	3.32	6.80	4.0	6.10	3.32 – 6.8	5.06 ± 1.66	200	400	100
PO_4^- (mg/L)	3.89	4.54	1.5	8.57	1.5 – 8.57	4.63 ± 2.94	200		
B O D (mg/L)	187.3	185.0	1`76.7	118.3	118.3-187.3	166.83 ± 32.67		1000	≤ 5
Fe^{2+} (mg/L)	0.0096	0.000	0.0013	0.1150	0 – 0.0096	0.032 ± 0.056	0.1		0.3
Mg^{2+} (mg/L)	10.29	11.63	8.54	2.04	2.04 – 11.63	8.13 ± 4.25	20	30	0.2
Cl^- (mg/L)	1079	159.9	391.8	148.8	148.8 – 1079	444.9 ± 437.3	250		250
Na^+ (mg/L)	8.59	8.90	6.06	7.04	6.06 – 8.9	7.65 ± 1.34	200		200
TCC (mg/L)	9	6	9	6	6 – 9	7.5 ±1.73			10

KEY: A$_1$= Gujubawo, B$_1$ = Garin Alkali, C$_1$ = Ubandoma street, D$_1$ = Madagaska street
HDL = Highest Desirable Level MPL = Maximum Permissible Level

Conductivity ranged between 6.20 and 1800us/cm, where the least and highest value were found in Madagaska street (D$_1$) and Ubandoma street (C$_1$) respectively. The major cations and anions were the chemical parameters that were analyzed. The major cations include Mg^{2+}, Fe^{2+} and Na^+. The major anions include Cl, SO_4^{2-}, PO_4^-, CO_3^{2-} as well as Dissolved Oxygen, Biological oxygen demand and Total hardness.

Results for borehole (**Table 2**) of temperature show that the sampled water ranged between 28.7 to 31.2 °C with a mean value of 29.93 °C, the least value was recorded in Garin Alkali (B$_1$) and the highest value was recorded in Madagaska street (D$_1$), pH ranged between 6.5 and 7.1, with a mean value of 7.13, the least value was recorded in Ubandoma (C$_1$) and the highest value in Garin Alkali (B$_1$), Turbidity ranged between 1.64 to 5.97 NTU, with a mean value of 3.69NTU, the least value was recorded in Garin Alkali (B$_1$) and the highest value in Ubandoma street (C$_1$), Conductivity ranged between 6.20 and 1800us/cm, where the least and highest value were found in Madagaska street (D$_1$) and Ubandoma street (C$_1$) respectively. The major cations and anions were the chemical parameters that were analyzed. The major cations include Mg^{2+}, Fe^{2+} and Na^+. The major anions include Cl^-, SO_4^{2-}, PO_4^-, CO_3^{2-} as well as Dissolved Oxygen, Biological oxygen demand and Total hardness.

The results of these chemical parameters show that the Mg^{2+} ranged between 2.04 and 11.63 mg/L with the mean value of 8.13 mg/L, the least value was recorded in Madagaska street (D$_1$) and the highest value in Garin Alkali (B$_1$), Fe^{2+} ranged between 0.000 to 0.1150 mg/L with the mean value of 0.032 mg/L, where the lowest value was found in Garin Alkali (B$_1$), and the highest value in Madagaska (D$_1$), Na^+, ranged between 6.06 and 8.9 mg/L with the mean value of 7.65 mg/L, the lowest value was found in Garin Alkali (B$_1$), and the highest value in Ubandoma (C$_1$), Cl^-, ranged between 47.9 to 259.9 mg/L with the mean value of 114.95 mg/L, the lowest value was recorded in Ubandoma street (C$_1$) and the highest one in Garin Alkali (B$_1$), SO_4^{2-} ranged between 3.32 to 6.80 mg/L with the mean value of 3.32 mg/L, the lowest value was found in Gujubawo (A$_1$) and the highest one in Garin Alkali (B$_1$), PO_4^{2-}, ranged between 1.5 to 8.57, with a mean of 4.63 mg/L the lowest value was found in Ubandoma street (C$_1$) and the highest value in Madagaska (D$_1$), total hardness ($CaCO_3$) ranged between 33.6 to 91.2 mg/L, the lowest value was found in Garin Alkali (B$_1$) and the highest value in Garin Alkali (B$_1$), Dissolved oxygen ranged between 2.41 to 3.39 mg/L, the lowest value was found in Gujubawo (A$_1$) and the highest one in Ubandoma street (C$_1$), biological oxygen demand ranged between 118.3 to 187.3 mg/L, with a mean value of 166.83 the lowest value was found in Madagaska street (D$_1$) and the highest value in Gujubawo (A$_1$). TCC ranged between 6 to 9 cfu/100 mL, the lowest value was found in Garin alkali (B$_1$) and Madagaska (D$_1$) and the highest value in Gujubawo (A$_1$) and Ubandoma (C$_1$).

DISCUSSION

Regarding the WHO and NSDWQ recommendations for drinking water quality, the physicochemical parameters for the various home water sources are discussed. Given that just a small spectrum of chemical reactions and biological activities are affected by hydrogen ion concentration (pH), its significance is clear [24]. The mean pH concentration trend found in this study's hand-dug wells and boreholes is neutral to slightly alkaline, and the pH range fell within the permitted range for drinking water, which is 6.5 to 9.2 [22]. This result is in line with that of Shittu *et al.* [25], who noted a comparable pH range for water used for swimming and drinking in Abeokuta, Nigeria. The pH value measured for borehole water is comparable to findings from Ogbonna *et al*. [26] for various groundwater samples, who found that the type of soil and free carbon(iv)oxide level in the water bodies [27] might determine the pH of groundwater. The bacterial numbers may be impacted as a result of changes in the Carbon oxide/Bicarbonate/Carbonate balance.

Temperature is a key physicochemical factor in determining the suitability of water for human consumption as it affects a variety of processes in water bodies, including the speed of chemical reactions, the solubility of gases, and the amplification of tastes and colours of water [25]. The main water temperature within the study area for the borehole and hand-dug well was 29.93± 1.05°C C and 28.5±0.82°C respectively. Due to factors including climatic conditions, geographical soil type and depth, and groundwater, which may affect the biochemical and physiological activities of organisms found in the water sources, both sources of water have high temperatures that may be explained by these factors [28]. The observed results were within the WHO's recommended permissible limit [22] and the NSDWQ [23]. This outcome is comparable to that of Mezgebe *et al.* [29] who reported the highest water temperature of 28°C from varied drinking water temperatures not exceeding 15°C because the coolness of the water improves its palatability [22].

The degree of ions in water is measured by electrical conductivity, which significantly affects the taste and, in turn, the user's acceptance of the water. Both for the hand-dug well and the borehole, the mean values recorded are all within acceptable limits. The electrical conductivity of samples of borehole water from Ubandoma street varied significantly (C1). The WHO permitted limits (1400 s/cm) were exceeded (1800 s/cm). This is a sign of the millions of tons of salt that are present in the salt range, as well as differences in the mineral and chemical qualities of the water body that cause bad taste and a high percentage of total dissolved solids. The results of this study corroborated Adetunde and Glover's report [30]. This region's groundwater is good for home use, irrigation, and other uses. Low conductivity means that the water's surface catchments only provide a little amount of dissolved organic compounds in the ionized form [31]. The diluting impact of the increased water volume within water bodies during the rainy season may be responsible for the decrease in conductivity seen in the study area.

One of the most important indicators of water quality, dissolved oxygen provides both direct and indirect data on the availability of nutrients, the degree of pollution, the metabolic activities of microbes, stratification, and photosynthesis in the water body [32]. When compared to WHO limits for drinking water, the mean DO values for both the borehole (2.88 ± 0.58 mg/L) and the hand-dug well (2.17 ± 1.23 mg/L) were within acceptable ranges. Only a little amount of dissolved oxygen is affected by water temperature, with warm water dissolving less oxygen than cold water [33]. Therefore, one of the reasons for the low DO values seen in the current study could be due to the high temperature of the water sources. All living organisms place a significant value on dissolved oxygen. Water bodies may contain it due to direct air diffusion or autotrophic production during photosynthesis. Reduced dissolved oxygen levels in rivers may be a sign that there are too many bacteria there, which may have depleted the dissolved oxygen. Although dissolved oxygen may not directly endanger human health, other compounds in the water may be affected [34].

The mean BOD concentrations found in the study area's boreholes and hand-dug wells were 166.83 ± 32.67 mg/L and 1.54 ± 8.74 mg/L, respectively. The high range of BOD obtained from both water sources indicates that drinking sources were highly polluted by organic matters such as faecal matter and improper disposal of household waste material that found their way into water bodies through runoffs. However, these values were above the WHO and NSDWQ guidelines set for the maximum tolerable limit of BOD in drinking water. Similarly to this, additional research revealed that a high BOD level contributes to a drop in the value of dissolved oxygen [22]. BOD estimates the quantity of oxygen used by bacteria and other microorganisms that oxidize organic materials present in water [34].

Phosphate was found in both hand-dug wells and boreholes within the research area, with mean values of 4.63 ± 2.94 mg/L and 17.22 ± 12.74 mg/L, respectively. This could be due to the terrain or geology of the sampling location, which affects the amount of phosphate in the groundwater. Since phosphate is a key component of fertilizer and detergents, the range of phosphate in this study is low since there is no seepage from runoffs or sewage discharges. The mean values of phosphates obtained in this study are within the permitted limit of WHO. This finding suggests that water from these sources cannot be kept for an extended period in an open container because phosphate increases the growth of algae, which can lead to eutrophication, a condition more common in lakes and occasionally rivers [35].

Hardness is a crucial factor in reducing the harmful effects of hazardous elements. The buildup of calcium and magnesium salts in water makes the water harder and more polluted [36]. The mean total hardness measured in borehole water samples (57.05 ± 24.33 mg/L) is less than the level deemed safe for consumption by the WHO and NSDWQ. As a result, the water won't precipitate soap, deposit scale, and the amount of crust that accumulates in containers will be greatly reduced. Ubandoma and Madgaska had the highest values, however, the mean total hardness measured in the hand-dug well water sample (626.5 ± 510.26 mg/L) exceeded the maximum permissible limit set by WHO and NSDWQ. The high total hardness found in the water sample from the hand-dug well may have been caused by the soil composition of the sampling sites and the absence of casting on the good wall. This outcome is consistent with that which Ezeribe *et al.* [37] and Bello *et al.* [38] both reported. Although hard water does not provide a health risk, it is an inconvenience when used for home chores like washing and cleaning.

In comparison to the WHO and NSDWQ permissible limits for drinking water, which are 400 and 100 mg/L, respectively, the mean sulphate concentration recorded from both borehole (5.06 ± 1.766 mg/L) and hand-dug well (3.94 ± 1.55 mg/L) water samples was low. The geological profile of the soil and the mineral makeup of the source of the water sample can be implicated in the low level of sulphate. Sulphate ions naturally occur in groundwater as a result of the dissolving of sulphides such pyrites from the inert stratified minerals by percolating water [38].

The mean concentration of chlorides in the borehole water samples (444.9 ± 437.3 mg/L) exceeded the WHO and NSDWQ standard limit for drinking water, with Gujubawo (A1) having the highest level. Chlorine used as a disinfectant in water purification for human consumption may be the cause of the high concentration. Because chlorides naturally occur in the geological strata of boreholes and are a widely dispersed element in all types of rocks in one way or another, the amount of chloride is a result of this [38]. The mean concentration of chloride in the hand-dug well water samples, however, was within the permissible WHO and NSDWQ standard for portable water

(114.95 ± 100.16 mg/L). Both the hand-dug well (2.42 ± 0.98 NTU) and the borehole (3.69 ± 1.77 NTU) had mean turbidity levels that were within the NSDWQ's and WHO's a permissible limit of 5 NTU. High levels of suspended and colloidal particles in water typically give it an unattractive appearance.

The WHO and NSDWQ permissible limit of 200 mg/L was not exceeded by the mean sodium concentrations in the study area's hand-dug well (7.94 ± 1.01 mg/L) or borehole (7.65 ± 1.34 mg/L) water samples. Higher availability of sodium ions in the bloodstream as a result of excessive sodium intake from drinking water increases heart size, blood pressure, and the risk of stroke and hypertension [34]. Within the study area, the mean concentrations of iron for water samples taken from hand-dug wells (0.0154 ± 0.031 mg/L) and boreholes (0.032 ± 0.056 mg/L) were both within the permissible limits set by the WHO (0.1 mg/L) and NSDWQ (0.3 mg/L), respectively. Many of the rocks and soils that make up the crust of the earth include the very common metal iron. In rare instances, iron is discovered in groundwater that is discharging into a lake through springs and contains ferrous iron [22,23].

One of the most prevalent elements in the crust of the earth is magnesium. It is a vital component of water hardness and is found in all naturally occurring waters. Dolomites and mafic minerals (amphibole) in rocks are the sources of magnesium in natural water. The average magnesium concentration in the study area's borehole (8.13 ± 4.25 mg/L) and hand-dug well (8.12 ± 4.55 mg/L) water samples was within the WHO-permissible limit [22]. The average total coliform counts found in water samples taken from both hand-dug wells and boreholes were below the NSDWQ level established for drinking water.

CONCLUSION

The results of this study demonstrated that domestic water sources (borehole and hand-dug well) in the study area had physicochemical characteristics and a total coliform count that was within safe limits, except the mean total hardness level (hand-dug well), and more specifically, the total hardness concentration (hand-dug well) in Ubandoma (C1) and Madagaska (D1) water samples, which exceeded the WHO permissible limit for drinking water. To prevent septic tanks and pit latrines from contaminating groundwater, the government should enforce good house planning. Health authorities should support proper public awareness efforts about in-house raw water treatment to raise the standard of drinking water. Furthermore, it is important to promote a more thorough assessment of residential water quality. To make regular assessments of the key water quality indicators, a water quality laboratory should be created at the local government area's headquarters. Having a resource inventory of data on water quality will be made easier due to this monitoring.

REFERENCES

1. World Health Organization Guidelines for drinking-water quality: second addendum. Recommendations World Health Organization 2008;1.
2. Bouwer H. Integrated water management: emerging issues and challenges. Agri Wat Manage 2000;45(3):217-228.
3. Balogun DO, Okewu AA, Maikano AA, Ibrahim A, Sule NI, Abdullahi MM. Groundwater Quality Assessment of Kano Metropolis using Water Quality Index and Geospatial Techniques. Int J Eng Res Tech (IJERT). 2021;10(7):2278-0181.
4. Ogunware AE, Adedigba PA, Oyende YE, Adekoya AA, Daramola AR. Physicochemical, bacteriological and biochemical assessment of water samples from unprotected wells in Lagos state metropolis. Asian J Biochem Genet Mol Biol. 2020:24-36
5. Ali ZN, Imam MM, Abdulkadir FM. Physicochemical and bacteriological analysis of well water in Zango–Abattoir Kaduna–Nigeria. Niger J Chem Res 2012;17:16-22.
6. Spalding RF, Exner ME. Occurrence of nitrate in groundwater—a review. J Environ Qual. 1993;22(3):392-402.
7. Kortatsi BK, Tay CK, Anornu G, Hayford E, Dartey GA. Hydrogeochemical evaluation of groundwater in the lower Offin basin, Ghana. Environ Geol. 2008 Feb;53(8):1651-1662
8. Eisen C, Anderson MP. The effects of urbanization on ground water quality Milwauke, Wisconsin, USA. Jackson (ed). Aquifer Contamination and Protection SRH 1980(30):378-390.
9. Zhang W, Jiang F, Ou J. Global pesticide consumption and pollution: with China as a focus. Proc Int acad Ecol Env Sci2011 Aug 1;1(2):125.
10. Postma D, Appelo CA. Reduction of Mn-oxides by ferrous iron in a flow system: Column experiment and reactive transport modeling. Geochim Cosmochim Acta. 2000;64(7):1237-1247.
11. Prakash KL, Somashekar RK. Groundwater quality- Assessment on Anekal Taluk, Bangalore Urban district, India. J Environ Biol. 2006;27(4):633-637.
12. Mustafa AI, Ibrahim AA, Haruna YI, Abubakar S. Physicochemical and bacteriological analyses of drinking water from wash boreholes in Maiduguri Metropolis, Borno State, Nigeria. Afr J Food Sci. 2013;7(1):9-13.
13. Ackah M, Agyemang O, Anim AK, Osei J, Bentil NO, Kpattah L, Gyamfi ET, Hanson JE. Assessment of groundwater quality for drinking and irrigation: the case study of Teiman-Oyarifa Community, Ga East Municipality, Ghana. Proceed Int Acad Ecol Environ Sci. 2011 Dec 1;1(3-4):186.
14. Sayyed MR, Wagh GS. An assessment of groundwater quality for agricultural use: a case study from solid waste disposal site SE of Pune India Proc Int Acad Ecol. Environ Sci. 2011 Dec 1;1(3-4):195-201.
15. Odonkor ST, Addo KK. Bacteriological profile and physico-chemical quality of ground water: a case study of bore hole water sources in a rural Ghanaian community. Int J Curr Microbiol Appl Sci. 2013;2(8):21-40.
16. Singh O, Kasana A, Singh KP, Sarangi A. Analysis of drivers of trends in groundwater levels under rice–wheat ecosystem in Haryana, India Nat Resour Res. 2020;29(2):1101-1126.
17. Dada AC. Sachet water phenomenon in Nigeria: Assessment of the potential health impacts. Afr J Microbiol Res. 2009;3(1):15-21
18. Amadi AN, Ameh IM, Ezeagu GG, Angwa EM, Omanayin YA. Bacteriological and physico-chemical analysis of well Water from villages in Edati, Niger State, North-central Nigeria. Int J Eng Res. 2014;10(3):10–6
19. Baird RB, Eaton AD, Clesceri LS. Standard methods for the examination of water and wastewater. Rice EW, editor Washington, DC: American public health association; 2012
20. Federation WE, APH Association Standard methods for the examination of water and wastewater. American Public Health Association (APHA): Washington, DC, USA 2005;21.
21. Prescott LM, Harley JP Harley Prescott. Laboratory Exercises in Microbiology, Fifth Edition.
22. World Health Organization. Guidelines for drinking-water quality: second addendum Recommendations. World Health Organization 2008;2.
23. Nigerian standard for drinking water quality Nigerian Industrial Standard, NIS 2007;554:13–14.
24. Kolawole OM, Alamu FB, Olayemi AB, Adetitun DO. Bacteriological analysis and effects of water consumption on the hematological parameters in rats. Int J Plant Anim Environ Sci. 2013;3(2):125-131.
25. Shittu OB, Olaitan JO, Amusa TS. Physico-chemical and bacteriological analyses of water used for drinking and swimming purposes in Abeokuta, Nigeria. Afr J Biomed Res 2008;11(3)
26. Ogbonna DN. Seasonal dynamics of microbial population and physicochemical characteristics of a water body receiving industrial pollutants in Port Harcourt, Nigeria. Agric Biol J. North Am. 2010;1:1333-1339.
27. Okonko IO, Ogunjobi AA, Adejoye OD, Ogunnusi TA, Olasogba MC. Comparative studies and microbial risk assessment of different water samples used for processing frozen sea-foods in Ijora-olopa, Lagos State, Nigeria. Afr J Biotech. 2008;7(16):2902-2907.

28. Ekhaise FO, Anyasi CC. Influence of breweries effluent discharge on the microbiological and physicochemical quality of Ikpoba River, Nigeria. Afr J Biotech. 2005;4(10).
29. Mezgebe K, Gebrekidan A, Hadera A, Weldegebriel Y Assessment of physico-chemical parameters of tsaeda agam river in mekelle city, tigray, Ethiopia. Bull Chem Soc Ethiopia. 2015;29(3):377-385.
30. Adetunde LA, Glover RL, Oguntola GO. Assessment of the ground water quality in Ogbomoso township of Oyo State of Nigeria. Int J Res Rev Appl Sci. 2011;8(1):115-122.
31. Gidey KM, Zeleke E Households willingness to pay for improved water services in urban areas: A case study from Nebelet town, Ethiopia. J Dev Agric Econ. 2015 Jan 2;7(1):12-19.
32. Premlata V. Multivariant analysis of drinking water quality parameters of lake Pichhola in Udaipur, India. Biol Satya Prakashan 2009;1:86–91.
33. Tenagne AW. The impact of urban storm water runoff and domestic waste effluent on water quality of Lake Tana and local groundwater near the city of Bahir Dar, Ethiopia. Cornell University 2009.
34. Adesakin TA, Oyewale AT, Bayero U, Mohammed AN, Aduwo IA, Ahmed PZ, Abubakar ND, Barje IB. Assessment of bacteriological quality and physico-chemical parameters of domestic water sources in Samaru community, Zaria, Northwest Nigeria. Heliyon. 2020;6(8):e04773.
35. Abolude DS, Edia-Asuke UA, Aruta M, Ella EE. Physicochemical and bacteriological quality of selected well water within Ahmadu Bello university community, Samaru, Zaria, Nigeria. Afr J Nat Sci(AJNS). 2019;19:1119-1104.
36. Bhatt JP, Manish K, Pandit MK. Elevational gradients in fish diversity in the Himalaya: water discharge is the key driver of distribution patterns. PLoS One. 2012;7(9):e46237.
37. Ezeribe AI, Oshieke KC, Jauro A. Physico-chemical properties of well water samples from some villages in Nigeria with cases of stained and mottle teeth. Sci World J. 2012 Oct 15;7(1):1-3.
38. Bello OO, Osho A, Bankole SA, Bello T. Bacteriological and physicochemical analyses of borehole and well water sources in Ijebu-ode, southwestern Nigeria. IOSR J Pharm Biol Sci. 2013;8(2):18–25.