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Bacteriological and Physicochemical Qualities of Household Water Supply Sources from Two Towns in Ikorodu Suburb of Lagos State, Nigeria

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Abstract Groundwater has been identified as a major source of drinking water in Nigeria. However, increase in human activities is known to contaminate and deteriorate the quality of this source of water. This study evaluated the bacteriological and physicochemical qualities of household water supply sources from two towns in the Ikorodu suburb of Lagos State, Nigeria. A total of sixty (60) groundwater samples were collected from Imota and Isiwu communities. Total Heterotrophic Bacteria Count (THBC), Total Coliform Count (TCC), and faecal coliform detection in the water samples were carried out using standard microbiological methods. pH, conductivity, Total Dissolved Solid (TDS), and salinity of the water samples were determined using an Ionix PC 50 multi-meter. THBC of the samples from Imota town ranged from 0 - >300 cfu/mL, TCC ranged from 0 - >1100 MPN/100mL, and fecal coliforms were detected in 93.3% (28/30) of the samples, while THBC of samples from Isiwu town ranged from 5 - >300 cfu/mL, TCC ranged from 3 - >1100 MPN/100mL, and fecal coliforms were detected in 76.7% (24/30). The TCC showed that 96.7% (29/30) and 100% (30/30) of the water samples from Imota and Isiwu, respectively, contain coliforms, and the TCC of the water samples was far above the WHO standard for drinking water. The pH of the water samples was below the WHO standards of 6.5 - 8.5. This study showed the high contamination and poor bacteriological quality of the groundwater sources in the two communities. Therefore, there is a need for orientation and interventions in the community to safeguard public health.

Keywords Groundwater, Quality, Coliforms, Contamination

1. Introduction

Water is globally recognized as an essential resource and commodity for human survival and good health. Its access has been considered a universal human right and fundamental need, which is a critical component of the United Nations' Sustainable Development Goal (SDG). However, according to WHO [1], over 2 billion people globally live in water-stressed countries in 2021, and at least 1.7 billion use water sources contaminated with faeces. Also, one (1) in every three (3) people has been reported to lack access to safe drinking water. This problem is more pronounced in developing countries especially in rural areas where improved water sources are not available or limited. As a result, the majority depend on unprotected hand-dug wells, rivers, and rainwater for drinking, domestic use, recreation purposes and others [2,3]. According to Adamou et al. [4], groundwater sources in the form of wells and boreholes (sparsely distributed) are often the main source of drinking water in West African countries, including Nigeria. However, increase in anthropogenic activities such as urbanization, industrialization, agricultural practises including use of pesticides and fertilizers, mining activities, drainage of land surface, septic tanks, leaky sewage, and transportation, among others, has contributed greatly to contamination and deterioration of groundwater quantity and quality [5-7]. Not only that, natural processes such as climate, natural geological-hydrogeological conditions, water-rock interaction, slope, and drainage conditions also impact groundwater quality [7,8]. The threat to public health through groundwater contamination cannot be overemphasized. Enteric viruses and bacteria present microbiological threats to human health. Microbiologically contaminated water serves as a potential source of disease transmission such as diarrhoea, dysentery, salmonellosis, cholera, typhoid, shigellosis, polio, hepatitis, and so on [9-11]. Also, the presence of certain chemicals, such as heavy metals, chloride, nitrate, organic compounds, etc., has been reported to constitute significant hazards to human health [12]. Due to the negative consequences of the consumption of contaminated or polluted water, groundwater quality assessment has become important. Thus, the portability of groundwater cannot be deciphered solely by the general physical parameters such as colorless, odorless, and tasteless. Therefore, before water can be described as potable, it must comply with certain physical, chemical, and microbiological standards, which ensure that the water is palatable and safe for drinking. Studies on the assessment of physicochemical and microbiological qualities of groundwater samples have reported the poor sanitary conditions of groundwater samples from Makera, Kaduna South, Nigeria [13], Zaria, Nigeria [14], West Thrace, Turkey [15], Ouagadougou, Burkina Faso [7], and Triffa Plain, Morocco [16]. Therefore, this study aims at determining the bacteriological and physicochemical qualities of household groundwater sources from two towns (Imota and Isiwu) in the Ikorodu suburb of Lagos State, Nigeria.

2. Materials and Methods

2.1. Study Area

This study was carried out in Imota and Isiwu towns. Imota and Isiwu are two sizeable towns in the Ikorodu suburb of Lagos State, Nigeria. Imota is located on coordinates 6.66362°N, 3.66945°E, and Isiwu is located on coordinates 6.65961°N, 3.61872°E. The local population is quite multicultural and originates from various native tribes, among other origins.

2.2. Sample Collection

A total of sixty (60) groundwater samples, comprising 30 each from Imota and Isiwu towns, were collected from different household water supply sources, both wells and boreholes. The water samples were collected into sterile sample collection bottles and transported in icepacks to the Microbiology Laboratory, Caleb University, Imota, Lagos, for analysis.

2.3. Bacteriological Analysis

2.3.1. Total Heterotrophic Bacteria Count (THBC)

The Total Heterotrophic Bacteria Count (THBC) of each of the water samples was carried out using the standard pour plate technique [17]. One milliliter of each of the water samples was aseptically plated out on Nutrient Agar, and the plates were incubated for 24 hours at 37°C. The number of emerging colonies was counted, and the colony-forming unit per mL was computed for the water samples.

2.3.2. Total Coliform Count (TCC)

This was carried out using the Most Probable Number (MPN) technique [17]. Nine-tube method was used, and each of the tubes contained MacConkey broth with Durham tube inverted inside. The first set of three tubes contained 10 mL each of double-strength broth, while the second and the third sets contained 10 mL each of single-strength broth. The three sets of tubes were inoculated with 10 mL, 1 mL, and 0.1 mL each of the water samples. The test tubes were then incubated at 37°C for 48 hours. The tubes were checked, and tubes showing gas formation were considered presumptive coliform positive. The exact MPN values were then determined using the MPN index table.

2.3.3. Detection of Thermotolerant Fecal Coliforms/*E. coli*

Detection of fecal coliforms was done using the streaking technique by inoculating a loopful of culture broth from positive Most Probable Number (MPN) test tubes into petri dishes containing Eosin Methylene Blue (EMB) agar under aseptic conditions and incubated at 44°C for 24 hours [17]. Growth of colonies characteristics of *E. coli* indicated the presence of fecal coliforms and was recorded as positive.

2.4. Isolation and Identification of Bacteria

Selected bacterial colonies from the Nutrient agar plates were subcultured until pure isolates were obtained. All the isolates were subjected to identification using the classical morphological and biochemical characterization. Colonial morphology, Gram's staining, catalase, indole production, citrate utilization, urease production, sugar fermentation (lactose, mannitol, sucrose, glucose), and hydrogen sulphide production tests were carried out as described by Cheesbrough [18]. The isolates identity was determined using the Advanced Bacterial Identification Software (ABIS) profile online [19].

2.5. Physicochemical Analysis

The pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), and salinity of the water samples were determined using the Ionix PC 50 multimeter. The equipment was standardized with buffers 4, 7 and 10 before use, and the readings were compared with the drinking water standards established by the World Health Organization [20].

2.6. Statistical Analysis

Data generated were analyzed using Statistical Package for Social Sciences (SPSS version 29.0.2.0) (IBM, Inc., Chicago). Means and some other descriptive statistics were determined. Independent samples T-test and correlation analysis were carried out to compare the results from the two towns and determine the relationship between the water quality parameters. Statistical significance was determined at $p < 0.01$ and $p < 0.05$.

3. Results

The bacteriological quality parameters of the water samples from the two towns are shown in Table 1 and Table 2. The THBC of the samples from Imota town ranged from 0 - >300 cfu/mL, Total Coliforms Count (TCC) ranged from 0 - >1100 MPN/100mL, and fecal coliforms were detected in 93.3% (28/30) of the samples (Table 1). THBC of the samples from Isiwu town ranged from 5 - >300 cfu/mL, TCC ranged from 3 - >1100 MPN/100mL, and fecal coliforms were detected in 76.7% of the samples (Table 2). Figure 1 showed a Nutrient agar plate with THBC >300 cfu/mL. Most Probable Number (MPN) tubes indicating presence of coliforms due to colour change and gas production trapped in inverted Durham's tubes are shown in Figure 2. Fecal coliforms growth on Eosin Methylene Blue agar plate after 24 hours incubation at 44^{o}C is shown in Figure 3.

Table 3 showed the biochemical characteristics of selected bacterial isolates from the groundwater samples and their probable identities. Figure 4 showed *Escherichia coli* culture growing on Eosin Methylene Blue agar plate. The frequency of occurrence of the bacterial isolates from the groundwater samples in this study is shown in Figure 5. The highest occurrence was recorded with *E. coli* (23%), followed by *Klebsiella pneumoniae* (18%), *Proteus mirabilis* (17%), *Salmonella* species (12%), *Pseudomonas aeruginosa* (12%), *S. aureus* (12%), and *Enterobacter aerogenes* (6%).

The physicochemical quality parameters of the water samples from Imota town show the pH, TDS, conductivity, and salinity of the samples ranging from 3.43 - 5.97, 28 - 391 µs/cm, 20 - 277 mg/L and 0.01 - 0.19 mg/L, respectively (Table 4). Table 5 also showed the physicochemical parameters of the groundwater samples from Isiwu ranging from 4.17 - 5.61, 45.7 - 278 µs/cm, 23.5 - 287 mg/L, and 0.02 - 0.17 mg/L for pH, TDS, conductivity, and salinity, respectively.

Correlation analysis of the water quality parameter tested in groundwater samples from Imota (Table 6) shows that there is a significant negative correlation between pH and the other three physicochemical parameters (conductivity ($r= -0.673$, $p < 0.01$), TDS ($r= -0.674$, $p < 0.01$), and salinity ($r= -0.679$, $p < 0.01$)). Also, there is a significant positive correlation between TDS and conductivity ($r=1.000$, $p < 0.01$), salinity and conductivity ($r=0.986$, < 0.01), and TDS and salinity ($r=0.986$, $p < 0.01$), while there was no correlation between any of the bacteriological quality parameters. Similarly, the correlation analyses of the water quality parameter tested in the groundwater samples from Isiwu (Table 7) show that there is a significant positive correlation between TCC and detection of faecal coliforms/*E. coli* ($r=0.401$, $p < 0.05$), TCC and salinity ($r=0.674$, $p < 0.01$), TCC and conductivity ($r=0.380$, $p < 0.05$), and Conductivity and salinity ($r=0.614$, $p < 0.01$).

Table 1. Bacteriological quality parameters of the water samples from Imota town

Sample Code	THBC CFU/ml	Double strength	Single strength	Single strength	MPN Index per 100ml	Fecal Coliforms
		10ml	1ml	0.1ml		
B1	0	0	0	0	0	-
B2	80	3	2	1	150	-
B3	>300	3	0	0	23	+
B4	>300	3	0	0	23	+
B5	>300	3	3	2	1100	+
B6	72	3	3	1	460	+
B7	>300	3	3	3	>1100	+
B8	>300	3	3	3	>1100	+
B9	3	3	2	3	290	+
B10	56	3	1	1	75	+
B11	149	3	3	3	>1100	+
B12	>300	3	3	3	>1100	+
B13	152	3	3	3	>1100	+
B14	2	3	3	3	>1100	+
B15	221	3	2	1	150	+
B16	14	3	2	0	93	+
B17	>300	3	3	2	1100	+
B18	218	3	1	0	43	+
B19	175	2	3	1	36	+
B20	84	3	3	3	>1100	+
B21	>300	3	3	1	460	+
B22	58	3	3	3	>1100	+
B23	53	3	3	3	>1100	+
B24	49	3	2	3	290	+
B25	182	1	2	1	15	+
B26	>300	3	3	3	>1100	+
B27	101	3	2	1	150	+
B28	>300	2	3	1	36	+
B29	32	3	3	3	>1100	+
B30	>300	3	2	0	93	+
WHO Standard	**100**				**0**	**0**
Satisfactory	**13 (43.3%)**				**1 (3.3%)**	**2 (6.7%)**
Unsatisfactory	**17 (56.7%)**				**29 (96.7%)**	**28 (93.3%)**

Table 2. Bacteriological quality parameters of the water samples from Isiwu town

Sample Code	THBC CFU/ml	Double strength	Single strength	Single strength	MPN Index per 100ml	Fecal Coliforms
		10ml	1ml	0.1ml		
W1	>300	3	3	3	>1100	+
W2	147	3	2	0	93	+
W3	>300	3	0	2	93	+
W4	28	2	3	1	120	+
W5	43	2	2	0	21	+
W6	8	1	2	0	11	-
W7	97	2	3	0	93	+
W8	53	3	3	3	>1100	+
W9	42	3	3	3	>1100	+
W10	12	3	3	3	>1100	+
W11	>300	2	3	3	1100	+
W12	6	2	3	3	1100	+
W13	8	2	2	2	35	+
W14	96	3	3	3	>1100	+
W15	56	3	3	3	>1100	+
W16	66	2	1	0	15	-
W17	24	1	1	0	7	-
W18	19	1	0	0	4	-
W19	26	1	0	1	7	+
W20	56	1	0	1	7	+
W21	44	0	1	0	3	+
W22	32	1	0	1	7	+
W23	17	1	0	0	4	-
W24	41	1	1	0	7	+
W25	32	1	1	0	7	+
W26	43	2	2	0	21	-
W27	88	0	0	1	3	-
W28	5	0	0	1	3	+
W29	33	0	1	1	7	+
W30	88	1	1	1	11	+
WHO Standard	**100**				**0**	**0**
Satisfactory	**4 (13.3%)**				**0 (0%)**	**7 (23.3%)**
Unsatisfactory	**26 (86.7%)**				**30 (100%)**	**23 (76.3%)**

Figure 1. Nutrient Agar plates with total heterotrophic bacteria count (THBC)

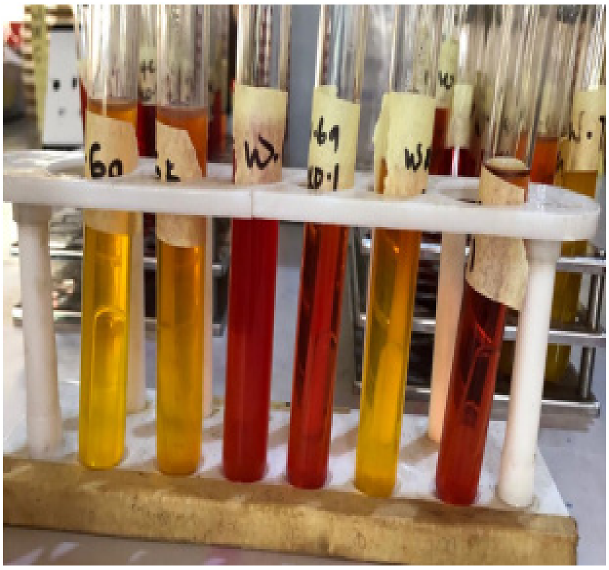

Figure 2. Most Probable Number (MPN) tubes indicating presence of coliforms due to colour change and gas production

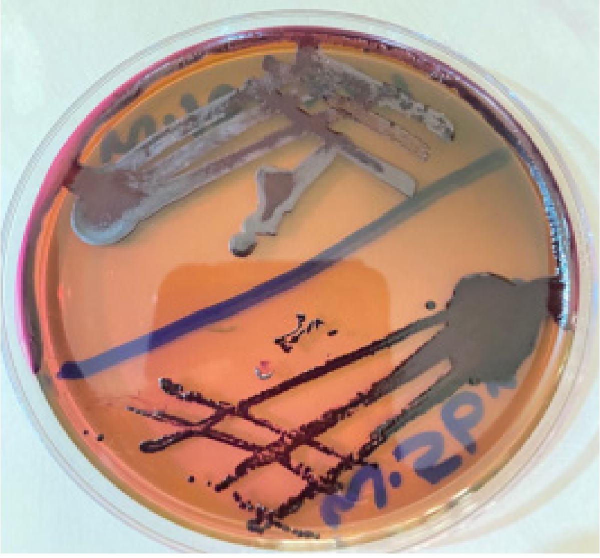

Figure 3. Fecal coliforms growth on Eosin Methylene Blue agar plate after 24 hours incubation at 44°C

Table 3. Biochemical characteristics of selected bacteria isolates from the groundwater samples and their probable identities

Isolate code	Source	Gram Reaction	Cell Morphology	(KOH Test)	Catalase Test	Indole Test	Urease Activity	Citrate Test	H_2S production	Mannitol	Sucrose	Glucose	Probable Identity
W1	Well	+	Cocci	-	+	-	+	+	+	+	+	A	*S. aureus*
W2	Well	-	Rod	+	+	+	-	-	+	+	+	A/G	*E. coli*
W4	Well	-	Rod	+	+	+	-	-	+	+	+	A/G	*E. coli*
W5	Well	-	Rod	+	_	-	-	-	-	-	-	A/G	*P. mirabilis*
W5b	Well	-	Rod	+	+	-	+	+	+	+	+	A/G	*K. pneumoniae.*
W7	Well	-	Rod	+	+	+	-	-	+	+	+	A/G	*E. coli*
W7b	Well	-	Rod	+	+	+	-	+	-	+	-	A/G	*Salmonella sp.*
W8	Well	+	Cocci	-	+	-	+	+	+	+	+	A	*S. aureus*
W8b	Well	-	Rod	+	-	-	-	-	-	-	-	A/G	*P. mirabilis*
B1	Borehole	-	Rod	+	-	-	-	+	+	+	+	A/G	*E. aerogenes.*
B2	Borehole	-	Rod	+	+	-	-	+	-	-	-	NIL	*P. aeruginosa*
B4	Borehole	-	Rod	+_	+	-	+	+	+	+	+	A/G	*K. pneumoniae*
B8b	Borehole	-	Rod	+	-	-	-	-	-	-	-	A/G	*P. mirabilis*
B13b	Borehole	-	Rod	+	+	+	-	+	-	+	-	A/G	*Salmonella sp.*
W6	Well	-	Rod	+	+	+	-	-	+	+	+	A/G	*E. coli*
W9	Well	-	Rod	+	+	-	+	+	+	+	+	A/G	*K. pneumoniae.*
W5C	Well	-	Rod	+	+	-	-	+	-	-	-	-	*P. aeruginosa*

Keys: + (positive), -(negative), A(acid production), G(gas production), A/G(acid and gas production)

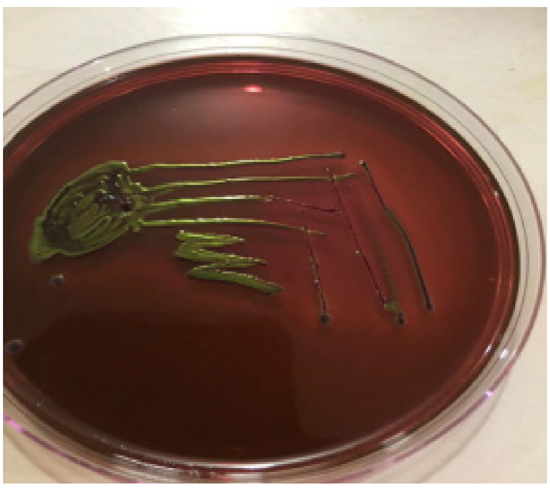

Figure 4. *Escherichia coli* culture growing on Eosin Methylene Blue agar plate

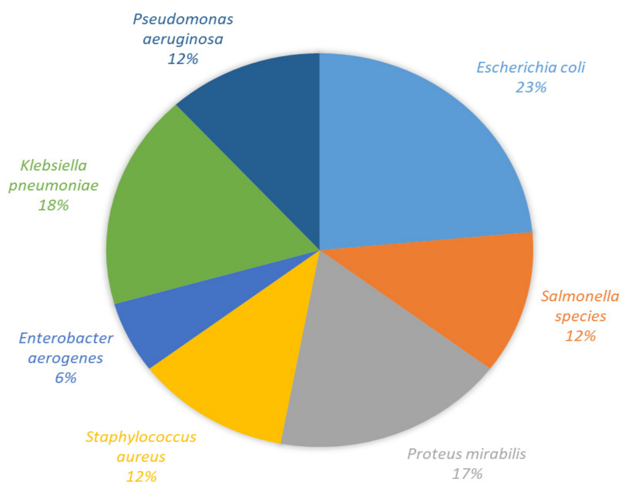

Figure 5. Frequency of occurrence of the bacterial isolates from the groundwater samples

Table 4. Physicochemical quality parameters of the water samples from Imota town

Sample code	pH	Conductivity (μs/cm)	TDS (mg/L)	Salinity (mg/L)
B1	4.96	87.6	61.5	0.04
B2	4.66	86.4	61.2	0.04
B3	4.58	60.6	43.0	0.03
B4	5.44	92.3	65.3	0.04
B5	4.81	152.3	108.0	0.07
B6	4.16	174.7	124.0	0.08
B7	3.43	270.0	191.0	0.13
B8	3.79	287.0	204.0	0.14
B9	4.04	248.0	176.0	0.12
B10	4.04	247.0	175.0	0.12
B11	4.68	46.0	32.8	0.02
B12	5.07	35.0	24.8	0.01
B13	4.28	250.0	177.0	0.12
B14	5.73	77.4	54.9	0.04
B15	4.8	126.4	86.4	0.06
B16	5.56	61.0	43.4	0.03
B17	4.66	121.2	86.1	0.06
B18	4.38	83.8	59.7	0.04
B19	4.45	83.9	59.4	0.04
B20	5.63	79.7	56.4	0.04
B21	3.99	391.0	277.0	0.19
B22	5.66	78.4	55.8	0.04
B23	5.5	73.7	52.2	0.03
B24	4.46	65.8	46.8	0.03
B25	4.67	66.1	46.9	0.03
B26	4.44	334.0	236.0	0.16
B27	4.27	332.0	235.0	0.16
B28	4.97	28.0	20.0	0.01
B29	5.97	75.4	53.6	0.03
B30	5.32	37.3	26.6	0.02
Mean	**4.75**	**138.40**	**97.99**	**0.07**
Min	**3.43**	**28.0**	**20.0**	**0.01**
Max	**5.97**	**391**	**277**	**0.19**
WHO Standard	**6.5 - 8.5**	**400**	**1000**	**-**

Table 5. Physicochemical quality parameters of the water samples from Isiwu town

Sample code	pH	Conductivity (µs/cm)	TDS (mg/L)	Salinity (mg/l)
W1	4.61	86.8	76.0	0.07
W2	4.55	152.7	79.3	0.16
W3	4.86	141.2	34.6	0.14
W4	4.88	67.8	78.0	0.13
W5	4.78	78.9	96.0	0.09
W6	4.63	267.0	105.2	0.08
W7	4.82	212.0	129.8	0.14
W8	4.17	98.6	165.0	0.17
W9	4.57	104.7	167.8	0.13
W10	4.40	189.4	89.0	0.11
W11	4.38	230.0	54.0	0.08
W12	4.35	123.8	43.0	0.05
W13	5.33	278.0	47.5	0.09
W14	5.61	198.7	67.8	0.17
W15	5.60	167.8	39.5	0.07
W16	5.00	54.6	23.5	0.02
W17	4.99	89.0	78.6	0.05
W18	4.77	67.5	76.7	0.04
W19	4.65	45.8	87.3	0.05
W20	4.74	69.0	89.9	0.05
W21	4.84	127.8	34.7	0.06
W22	4.72	45.7	87.7	0.04
W23	4.95	234.0	56.7	0.06
W24	4.85	89.8	87.9	0.04
W25	5.04	78.7	67.6	0.03
W26	5.25	56.0	287.0	0.04
W27	5.14	67.4	178.4	0.05
W28	4.90	76.2	56.7	0.04
W29	4.93	67.8	178.5	0.03
W30	5.26	267.0	267.0	0.06
Mean	**4.85**	**127.79**	**97.69**	**0.08**
Min	**4.17**	**45.7**	**23.5**	**0.02**
Max	**5.61**	**278**	**287**	**0.17**
WHO Standard	**6.5 - 8.5**	**400**	**1000**	**-**

Table 6. Correlation analyses of the water quality parameter tested in groundwater samples from Imota

Water Quality Parameter	THBC	TCC	pH	Conductivity	TDS	Salinity	Faecal Coliforms
THBC	1.000	-0.027	-0.260	0.116	0.117	0.107	0.301
TCC		1.000	0.078	0.172	0.173	0.196	0.285
pH			1.000	-0.673**	-0.674**	-0.679**	-0.054
Conductivity				1.000	1.000**	0.986**	-0.031
TDS					1.000	0.986**	-0.031
Salinity						1.000	0.031
Faecal Coliforms							1.000

**Correlation is significant at the 0.01 level (2-tailed)

Table 7. Correlation analyses of the water quality parameter tested in groundwater samples from Isiwu

Water Quality Parameter	THBC	TCC	pH	Conductivity	TDS	Salinity	Faecal Coliforms
THBC	1.000	0.331	0.038	0.087	0.039	0.336	0.201
TCC		1.000	-0.278	0.380*	-0.033	0.674**	0.401*
pH			1.000	-0.004	-0.109	-0.264	-0.260
Conductivity				1.000	-0.158	0.614**	0.191
TDS					1.000	0.030	-0.082
Salinity						1.000	0.357
Faecal Coliforms							1.000

* Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

4. Discussion

The bacteriological quality analysis study of the household groundwater supply sources in the two towns indicated the poor sanitary conditions of groundwater. This study revealed high contamination and poor bacteriological quality of the groundwater sources from Imota and Isiwu communities, due to the fact that 96.7% (29/30) and 100% (30/30) of the groundwater samples, respectively, contain coliforms. The TCC of the majority of the water samples in this study was far above the WHO standard for drinking water (0 MPN/100mL). This is similar to the findings of Sanusi et al. [13], Mbahi et al. [21], and Sule et al. [14], who reported the presence of total coliforms in all borehole and well water samples from Makera, Kaduna State (4 - 17 MPN/100mL), Sabon Gari, Adamawa State (350 - >1800 MPN/100mL), and Zaria, Kaduna State (34 - 2400 MPN/100mL), respectively. Similarly, a high number of the water samples in this study (Table 1 and Table 2) (98.3% from Imota and 76.3% from Isiwu) contain fecal coliforms/*E. coli* compared to 29%, 34%, and 55% reported by Gebrewahd et al. [10], Traore et al. [7], and Keesar et al. [22] in studies conducted in Ethiopia, Burkina Faso, and India, respectively. Total coliforms are a group of bacteria whose presence in water samples serves as an indicator of water pollution, while the presence of faecal coliforms including *E. coli,* indicates recent contamination with faeces of humans and cold-blooded animals. Thus, the groundwater samples from the two towns in this study are unfit for human consumption due to the presence of faecal coliforms as against WHO standards. According to Seivaboh et al. [23], groundwater contamination as observed in this study may be due to the entry of microorganisms into the groundwater through leakage from run-offs, septic tanks, and soak-away pits. This predisposes the population to waterborne diseases due to enteric pathogens.

Similar studies have reported the isolation of the same species of bacteria from groundwater samples [24-27], as observed in this study. The predominant bacterial isolates in this study are members of the *Enterobacteriaceae* family, especially the coliform group. They are found in human intestinal tracts and are parts of the normal flora. Some of them have been implicated in cases of urinary tract infections and waterborne diseases, including diarrhoea. The presence of these organisms in groundwater is an indication of faecal contamination.

Of the four physicochemical parameters, three (pH, conductivity, and TDS) are of significance in water quality testing. pH is a measure of the acidity and alkalinity of a solution, and it influences the solubility of metals and certain minerals. All the groundwater samples (100%) in this study have acidic pH, below WHO standards of 6.5 - 8.5 and thus are unsuitable for consumption. This is similar to the study carried out by Akpataku et al. [8], where 81.3% of groundwater samples in Lome, Togo had acidic pH.

Acidity of groundwater samples results from interplay between cofactors, organic matter loads, a low proportion of carbonates or other acid-consuming minerals in the aquifer matrix, solid waste incineration, atmospheric acid deposition and emission of acid rain gas, and deforestation due to urbanization [8]. Acidic groundwater has been reported to increase the mobility and concentration of poisonous heavy metals in the aquifer and consumption of such may affect human health [28]. The conductivity and TDS of the groundwater samples in this study are less than the WHO standards of 400 µs/cm for conductivity and 1000 mg/L for TDS. Therefore, in terms of these two parameters, the groundwater samples are of good quality. Lower conductivity and TDS have been reported from studies on groundwater quality conducted in Ogbomoso [24] and Kaduna [13], Nigeria. TDS is a measure of the dissolved inorganic and organic matters. Higher TDS concentrations in water can impart its flavour, cause nausea, lung irritation, vomiting, and may lead to chronic diseases such as liver and kidney diseases. On the other hand, electrical conductivity is a measure of free ions concentration in water. Water in its pure form is a good insulator and not a good conductor of electricity. Landfill/septic leachate, agricultural run-off, impermeable surface run-off, geological characteristics of the environment, and evaporation contribute to electrical conductivity in water. It is calculated using salinity and TDS, and it decreases with increasing water purity.

The significant correlation between conductivity, TDS, and salinity is in order, because electrical conductivity is related to the ionic content of water, which is a function of dissolved ionizable solids [29]. Comparison of the results from the two towns using the T-test revealed that there is no significant difference between the physicochemical parameters (pH, conductivity, TDS, and salinity) of the groundwater samples from the two towns. This may be due to the likelihood that the two towns are under the same geological conditions. However, there is a significant difference ($p < 0.05$) between the THBC, TCC, and occurrence of faecal coliforms/*E. coli* in the groundwater samples from the two locations, as the THBC, TCC, and percentage of faecal coliforms presence are higher in groundwater samples from Imota compared to that of Isiwu town. This may insinuate that conditions responsible for microbiological contamination of groundwater are more prevalent in Imota town.

5. Conclusions

This study revealed that the groundwater sources in Imota and Isiwu are unsuitable for household use due to contamination with coliforms and thermotolerant faecal coliforms including *E. coli*. These potential bacterial pathogens can cause episodes of water-borne diseases outbreak such as cholera, dysentery, typhoid fever, e.t.c. Therefore, there is a need for continuous monitoring and quality assessment, orientation and interventions in the community to safeguard public health. Residents using the groundwater as their source of water should be educated on the possible risks associated with consumption of contaminated water and the possible means of water treatment such as boiling and use of chlorine tablets to prevent possible adverse health effects. As the locations of groundwater sources are crucial because a sanitary environment promotes the safety of the groundwater, there is need to avoid siting wells or boreholes close to waste disposal sites, septic tanks or pit latrines. Additionally, the public needs to be informed about the need of ensuring clean and hygienic environment around the borehole and well water sources to ensure the safety of the water from such sources. Therefore, it is suggested that further studies across different seasons with a larger sample size and the possible health risks and outcomes on the population should be carried out.

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