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Research Article

Evaluation of Perceived Impact of Canal Water on Groundwater Quality and the Residents in Orile-Agege, Lagos State, Nigeria

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Abstract— A significant portion of the global population relies on groundwater for drinking and domestic use, particularly in Nigeria, where urban and rural communities depend on it due to limited surface water access. This study assessed the perceived impact of canal water on the groundwater quality and residents in the Orile-Agege area of Lagos State, Nigeria. Physicochemical and microbiological properties were evaluated to determine suitability for domestic use using a mixed-methods approach. Sixteen samples from boreholes, wells, and canal water were analyzed, and 250 household respondents along the canal were surveyed. Data were summarized using descriptive statistics and compared against the World Health Organization (WHO) and National Standard for Drinking Water Quality (NSDWQ) guidelines. Correlation analysis explored relationships between groundwater quality parameters and canal water. Results showed the groundwater was acidic, hard, and contaminated with high nitrate levels, total coliforms, and E. coli, largely due to indiscriminate waste disposal, abattoir runoff, solid waste dumps, and agricultural activities near the canal. The study concluded that groundwater in the area is unsuitable for drinking or domestic use without treatment, emphasizing the need for public education and remediation efforts.

Keywords—Drinking water, groundwater quality, WHO, canal water, NSDWQ, Lagos State

1. Introduction

Groundwater is an essential source of freshwater worldwide, supplying a substantial portion of the global population with water to drink. Both urban and rural communities in Nigeria rely heavily on groundwater to meet their water needs, especially in places with inconsistent or limited access to surface water. Groundwater is a major source of water supply for residential, agricultural, and industrial uses in the Orile-Agege region of Lagos State [1]. The reliance on groundwater in the area has increased due to population growth and urbanization, putting pressure on the available water resources. Efforts are being made to ensure sustainable management of groundwater in the area through monitoring and regulation of contamination.

Orile-Agege is a densely populated urban area situated between Old Abeokuta Road and the Lagos-Abeokuta Expressway. The local government area has experienced rapid urbanization, with an increasing population and expanding industrial and commercial activities. As a result, there is a growing demand for groundwater resources to meet the water needs of residents and various economic sectors.
However, the quality of groundwater in urban areas is often compromised due to human activities, improper waste disposal, industrial effluents, and agricultural practices [2]. These activities can introduce contaminants into the groundwater, posing potential risks to public health and the environment, especially the runoff of the abattoir waste into the canal, which increases the level of contaminants in the environment.

Knowing the importance of groundwater as a source of drinking water, it is essential to assess its quality in the study area. By evaluating the groundwater quality, potential contamination sources can be identified and appropriate measures can be implemented to safeguard public health and ensure the sustainability of water resources [3].

Moreover, conducting a study along the canal between Old Abeokuta Road and the Lagos Abeokuta Expressway allows for a focused examination of a specific area that may be subject to unique challenges and pollution sources. Understanding the groundwater quality in this specific zone will provide valuable insights for local authorities, policymakers, and residents to make informed decisions regarding water resource management, water treatment, and pollution control [4].

The findings of this study will contribute to a better understanding of the current state of groundwater quality, identify potential risks, and provide a basis for developing strategies to protect and manage groundwater resources effectively [5]. The rest of the paper is organized as follows: Section 1 contains the introduction to the study, Section 2 contains the related work of the study, Section 3 contains the materials and methods, Section 4 contains the results, Section 5 contains the discussion of the findings, and Section 6 contains the conclusion and recommendation of the study.

2. Related Work

Groundwater is a vital resource for drinking, cooking, and domestic use in many communities. In Orile-Agege, Nigeria, pollution from a canal poses a significant threat, with contamination arising from industrial activities, poor waste management, agricultural runoff, and inadequate sanitation systems. Untreated pollution can spread, causing long-term environmental harm and public health risks. Identifying pollution sources and assessing groundwater quality are crucial for developing mitigation strategies and safeguarding community health [5],[6].

A comprehensive review of groundwater quality studies is necessary to understand contamination sources and areas of concern. Such an approach aids in the development of effective mitigation strategies, emphasizing the importance of regulations and monitoring systems to prevent further pollution. Ensuring groundwater protection is vital for maintaining public health and environmental sustainability.

2.1 Groundwater

Groundwater is the water stored beneath the Earth's surface in saturated zones called aquifers. It is a critical resource supporting ecosystems and providing drinking water. Groundwater contamination is a widespread issue adversely affecting ecological and human health. Sources of contamination include industrial waste, agricultural runoff, and improper household waste disposal. Effective monitoring and mitigation are essential to ensure groundwater protection for residents and environmental sustainability [9].

2.2 Groundwater Quality

Groundwater quality encompasses chemical, physical, and biological parameters, such as pH, dissolved oxygen, heavy metals, and microbial indicators. Regular assessments help determine its suitability for drinking, irrigation, and other uses. Monitoring also identifies contamination sources and supports remediation efforts, addressing long-term trends and sustainability challenges. Anthropogenic activities and natural processes have increased groundwater contamination, but remediation techniques, such as bioremediation and chemical treatments, are being developed to address these issues [9],[10].

2.3 Hydrogeology

Hydrogeology examines groundwater movement and aquifer properties, including permeability, porosity, and recharge mechanisms. This knowledge is crucial for interpreting quality data, identifying contamination sources, and managing alternative water resources. Understanding hydrogeological processes also supports the design of remediation strategies and predicts human impacts on aquifer systems. Such insights are fundamental for sustainable groundwater management and protection [11],[12].

2.4 Groundwater Pollution

Groundwater pollution results from harmful substances entering aquifers, often through industrial activities, agricultural practices, urban runoff, and improper waste disposal. This poses significant risks, particularly in low-income areas where access to clean water is limited. Diseases like cholera and dysentery are common consequences of contaminated groundwater. Effective pollution control measures and sustainable water management practices are essential for ensuring safe drinking water and protecting vulnerable communities [13],[14].

2.5 Water Sampling and Analysis

Water sampling involves collecting representative samples from wells or boreholes for laboratory analysis, employing methods like grab sampling and purging to ensure accuracy. Laboratory tests evaluate physical, chemical, and microbiological parameters to assess water quality [15]. These results determine water suitability for drinking and identify contaminants. This information is vital for implementing appropriate treatment methods, ensuring safe drinking water for vulnerable populations, and addressing contamination risks [16].

2.6 Water Quality Indices (WQI)

Water quality indices (WQI) simplify groundwater quality assessment by combining multiple parameters into a single numerical value. This approach facilitates the comparison and classification of water quality while identifying potential risks to human health and ecosystems [17]. WQI analysis of parameters like pH, dissolved oxygen, and contaminants provides valuable insights, guiding policymakers and stakeholders in prioritizing interventions and ensuring access to safe drinking water [18].

In a study in Orissa, India, WQI was used to assess spatial and temporal changes in groundwater quality across 24 samples collected during summer and post-monsoon seasons. The post-monsoon higher dissolved solid concentrations, which indicated poorer water quality due to increased seepage and groundwater movement, demonstrated WQI's capacity to track seasonal variations [19].

2.7 Health Effects of Contaminated Groundwater

Contaminated groundwater poses significant health risks, exposing communities to heavy metals, pesticides, and microbial pathogens. These contaminants can cause gastrointestinal disorders, organ damage, and increased cancer risk. Regular monitoring and testing of groundwater, coupled with appropriate water treatment methods, are crucial to ensuring public health and safe drinking water availability [20],[21].

Chemical analysis identifies specific contaminants like heavy metals and pesticides, while physical parameters such as pH, temperature, and turbidity provide a comprehensive understanding of groundwater quality. Such analyses reveal contamination sources, which may be both geogenic and anthropogenic, and highlight correlations between chemical variables and spatial variations in water quality [22].

2.9 Statistical and Modeling Approaches

Mathematical models and statistical analyses, such as regression, time series, and geostatistics, enhance groundwater quality evaluation. These methods identify trends, spatial patterns, and seasonal variations in data, offering predictive insights into future contamination risks. Hydrological modelling simulates contaminant movement and dispersion, aiding in effective remediation planning [23], [24].

3. Experimental Method

3.1 Description of Study Area

Orile-Agege, Lagos, Nigeria, known for its diverse population, is a study area with urban, suburban, residential, commercial, and industrial zones. The canal between Old Abeokuta Road and Lagos-Abeokuta Expressway significantly impacts groundwater quality due to potential runoff, seepage, and contamination. Socio-economic factors, population density, income levels, and sanitation access also affect groundwater quality and health outcomes. The global positioning system (GPS) coordinates of the samples location are as shown in table 1.

Table 1: Global Positioning System

	LOCATION 1		LOCATION 2	
POSITION	**Longitude**	**Latitude**	**Longitude**	**Latitude**
CWS	6°38'39"N	3°18'43"E	6°38'21"N	31°83'0"E
GWS1	6°38'38"N	3°18'44"E	63°82'1"N	3°183'2"E
GWS2	6°38'37"N	3°18'45"E	63°82'0"N	3°183'5"E
GWS3	6°38'36"N	3°18'46"E	63°82'0"N	3°183'8"E
	LOCATION 3		**LOCATION 4**	
POSITION	**Longitude**	**Latitude**	**Longitude**	**Latitude**
CWS	6°38'2"N	3°18'23"E	6°37'44"N	3°18'13"E
GWS1	6°38'2"N	3°18'26"E	6°37'46"N	3°18'12"E
GWS2	6°38'4"N	3°18'30"E	6°37'47"N	3°18'10"E
GWS3	6°38'3"N	3°18'34"E	6°37'49"N	3°18'9"E

(CWS: Canal Water Sample; GWS: Canal Water Sample)

3.2 Procedure for Data Collection

Specific locations along the canal where residents use groundwater sources (wells or boreholes) were identified and recorded using a Global Positioning System (GPS) device.

Fig. 1: Geographical Map of the Sampling Area

Water samples were collected from four specific locations along the canal (CWS) and from an equidistance groundwater location (GWS) along the canal following proper procedures to prevent contamination. One canal water sample (CWS) was collected, as well as three groundwater samples (GWS) at each of the locations. Each sample container with location information was labelled and recorded. All collected samples were preserved in a cooler with an ice pack from the field and stored in the refrigerator till the next day, then packed in the cooler before being transported to the laboratory for analysis. This prevents changes in water chemistry during transit.

A structured questionnaire was administered to 250 residents to assess perceptions, water usage patterns, and health concerns about groundwater quality. Informed consent was obtained, and the study area was observed for potential contamination sources or human activities.

4 Procedure for Laboratory Analysis

4.1 Physical Variables

Water turbidity was measured using the Nephelometric method with optical nephelometers and a turbidity meter, calibrated on a multipoint scale (0, 2, 100, and 400 NTU) and recorded in NTU. Using the potentiometric method and a multi-parameter meter (IONIX PC-50) in TDS mode, total dissolved solids (TDS) were measured and verified against certified conductivity standards.

4.2 Chemical Variables

The study measured pH, electrical conductivity, salinity, and total hardness of unfiltered water samples using standardized methods. pH was determined with a multimeter in pH mode and validated with traceable buffer solutions. Electrical conductivity and salinity were measured using the potentiometric method, with results validated against certified standards. Total hardness was assessed via burette titration, where samples were treated with pH 10 buffer and titrated with 0.08 M EDTA. Hardness was calculated using the provided equation.

$$\textbf{Total Hardness (TH)} \left(\frac{mg}{L} \textbf{ as } CaCO3\right) = \frac{(A\,(ml) x\ B\ x\ 10000)}{Sample\ volume\ (ml)} \quad ...1$$

Where:
A = Titre (ml)
B = Molarity of EDTA

Chloride was determined in unfiltered water samples by burette titration method. An aliquot (10 – 20 ml) of the test sample was titrated with standard 0.014 M silver nitrate titrant, with potassium chromate as end-point indicator. The chloride concentration was calculated as follows:

$$\textbf{Chloride } (mg/L) = \frac{(Titre\ (ml) x\ 35450\ x\ molarity\ of\ titrant)}{Sample\ volume\ (ml)} \quad 2$$

The study assessed dissolved oxygen (DO) and biochemical oxygen demand (BOD) in water samples. DO was measured using the membrane electrode method with a probe directly immersed in the solution. For BOD, samples were aerated, and initial DO levels were recorded. After a 5-day incubation, final DO levels were measured, and the 5-day BOD was calculated from the difference.

$$BOD_5\ (mg/L) = (DO\ initial - DO\ final) \times (dF) \qquad ...3$$

DOinitial = Dissolved oxygen at day zero
DOfinal = Dissolved oxygen after 5 days of incubation
dF = Dilution factor = 1 (when no dilutions are made)

The COD was determined by using the closed reflux colorimetric method (Hach method 8000, SM 5220 C, 5220 D), in which a 2 ml aliquot (or a dilution) of a homogenous mix of the sample was digested with dichromate/sulfuric acid COD reagent in a reactor (Grant QBD 2) at 150 °C for 2 h. The mixture was then cooled to room temperature, and the COD of the test solution was determined at 420 nm using a spectrophotometer (HACH DR 3900).

4.3 Microbiological Variables
Water samples were homogenized, transferred to a sterile membrane filter, and placed on a Petri dish containing culture media. The dishes were incubated at 35°C for 22-24 hours for total coliform and 44.5°C for E. coli. After incubation, colonies with characteristic appearances were counted for each type of bacteria. The concentration of bacteria in each sample was determined by dividing the number of colonies by the volume of the sample filtered and multiplying by 100.

4.4 Heavy Metals Variables
Heavy metals in the sample digestate filtrate were analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES), with results validated against calibration curves from certified metal standards. Sample pretreatment involved digesting 100 mL of water with 5 mL HNO_3 on a hot plate at 100°C for 30 minutes, followed by dilution with deionized water and filtration through Whatman #1 filter paper. Metal concentrations were determined using Agilent Expert II software: cadmium at 226.502 nm, total chromium at 226.502 nm, arsenic at 188.979 nm, and lead at 220.353 nm.

4.5 Questionnaire Administration
A survey was conducted to assess residents' usage, perception, health, and environmental awareness of groundwater quality. The survey involved 250 respondents from different households in the area.

4.5 Procedure for Data Analysis
The study used descriptive and inferential statistics to summarize groundwater quality parameters and residents' responses from questionnaires. Physical, chemical, and microbiological parameters were analyzed, and comparisons were made with water quality standards and regulations for drinking water and other purposes. A correlation analysis was conducted to explore potential relationships between groundwater quality parameters and canal water. The results were interpreted based on research objectives and existing literature, discussing implications, potential contamination sources, and the impact on residents and the environment. The study aimed to assess groundwater suitability for various purposes.

5. Results and Discussion

5.1 Results of Laboratory Analysis of the Water Samples
The minimum, maximum, mean and standard deviation of the physical, chemical, microbiological, and heavy metal properties of the canal and groundwater are presented in table 2.

The water quality analysis revealed that canal water samples (CWS) are generally more polluted than groundwater samples (GWS) due to various sources of contamination, such as domestic wastewater channels, industrial and agricultural runoff, and indiscriminate solid waste disposal. The pH values of CWS range from 6.9 to 7.5, while GWS has pH values from 4.5 to 6.7. The acidity of the groundwater could be due to other sources of pollution but not the canal, as the canal water falls within the accepted range. According to [25], in his study, other sources of pH variation in groundwater could include natural geological processes, such as the presence of acidic minerals or the leaching of chemicals from surrounding rocks. Additionally, human activities like mining or the use of fertilizers and pesticides can also contribute to changes in pH levels in groundwater, as agreed by [28], which states, “Human factors indeed are major factorial determinants of the contamination source." The acidifications in groundwater occur during natural processes like precipitation, photosynthesis, and decomposition [26]. The total dissolved solids (TDS) and electrical conductivity (EC) values of CWS and GWS exceed WHO standards for drinking water. The temperature values of both CWS and GWS are similar, with turbidity values ranging from 23 to 26.1 NTU. The dissolved oxygen (DO) values of CWS and GWS are lower, indicating less oxygen available for aquatic life and oxidation processes. The chemical oxygen demand (COD) and biological oxygen demand (BOD) values of CWS and GWS are much higher, indicating more organic matter and biodegradable substances than groundwater. The total hardness values of both CWS and GWS are similar, but the total coliform and E. coli values are higher, signifying more fecal contamination resulting from sewage or animal waste in the canal water.

This indicated that the canal water sources may be more susceptible to contamination and may require additional treatment processes to ensure safe drinking water. The lead and arsenic values of both CWS and GWS are below the detection limit, indicating that they do not have significant levels of toxic metals.

The study compares groundwater samples with World Health Organization (WHO) and the National Standard for Drinking Water Quality (NSDWQ) standards for various parameters. The results revealed that the groundwater samples are acidic, with pH below 6.5-8.5, and total dissolved solids and electrical conductivity within permissible limits. The temperature is close to 25°C, and the turbidity is below 5.0 NTU. The dissolved oxygen is above the required value, and the chemical oxygen demand and biological oxygen demand are below recommended values. The total hardness is below 100 mg/l, and the nitrate, nitrite, ammonia, chloride, sulphate, lead, cadmium, and total chromium levels are below permissible values. The total phosphorus is not stated in the standards, but it can cause eutrophication in surface water bodies. The total coliform and E. coli levels are above acceptable values, and arsenic and total chromium levels are not stated in the standards. In a study by [27], he states that the contamination observed by higher levels of E. coli and total coliform can lead to ill health like gastrointestinal illnesses and waterborne diseases.

Table 2: Descriptive statistics of the groundwater samples in the four locations

S/N	PARAMETERS	LOCATION 1				LOCATION 2				LOCATION 3				LOCATION 4			
		MEAN	MIN	MAX	STDEV	MEAN	MIN	MAX	STDEV	MEAN	MIN	MAX	STDEV	MEAN	MIN	MAX	STDEV
1	pH	5.53	4.5	6.7	1.11	5.27	5	5.7	0.38	5.53	4.9	6.1	0.60	5.30	4.7	5.9	0.60
2	Total dissolved solids (TDS) mg/l	166.00	89	304	119.78	87.33	70	120	28.31	135.67	85	229	80.93	197.67	94	371	151.07
3	Electrical conductivity *u*S/cm	520.00	107	813	367.98	147.00	140	157	8.89	268.33	152	462	168.85	345.67	179	620	239.40
4	Temperature ^oC	24.77	24.2	25.1	0.49	24.87	24.7	25.1	0.21	24.03	23	24.8	0.93	24.53	24.2	25	0.42
5	Turbidity	1.61	1.22	1.9	0.35	1.24	1.11	1.4	0.15	1.36	1.21	1.61	0.22	1.66	1.35	1.9	0.28
6	Dissolved oxygen (DO) mg/l	5.53	4.9	6	0.57	5.10	4.6	5.8	0.62	5.13	4.1	6.2	1.05	5.37	5.2	5.5	0.15
7	Chemical Oxygen Demand (COD) mg/l	1.67	0	3.8	1.94	2.33	0	6.4	3.54	1.14	0	3.2	1.79	8.10	0	17.9	9.07
8	Biology Oxygen Demand (BOD) mg/l	2.20	1.01	3.5	1.25	1.90	1.4	2.5	0.56	2.62	1.15	3.7	1.32	22.17	1.2	39.7	19.48
9	Total Hardness	27.77	17.3	41	12.09	17.00	15	18	1.73	23.67	15	31	8.08	19.97	15	24.9	4.95
10	Nitrate (NO_3^-) mg/l	1.62	0.6	3.5	1.63	1.33	0.73	2.05	0.67	1.79	0.84	2.7	0.93	3.21	0.88	7.3	3.55
11	Nitrite (NO_2^-) mg/l	0.68	0.31	0.98	0.34	0.59	0.21	1.05	0.43	0.96	0.37	1.7	0.68	0.99	0.35	1.79	0.73
12	Ammonia (NH_3) mg/l	0.02	0	0.04	0.02	0.04	0	0.1	0.06	0.04	0	0.08	0.04	0.17	0.02	0.43	0.22
13	Total Phosphorus mg/l	0.24	0.24	0.24	-	0.12	0.12	0.12	-	0.01	0.01	0.01	-	0.13	0.11	0.15	0.03
14	Chloride (Cl) mg/l	16.12	5	33.37	15.14	13.99	13.99	14	0.01	36.10	21	60	20.94	10.31	5.31	14.29	4.58
15	Sulphate (SO_4) mg/l	3.06	1.78	4.24	1.23	2.92	1.35	5	1.88	2.74	1.89	3.99	1.10	3.22	2.25	5	1.54
16	Total Coliform (MPN/100ml)	626.67	107	900	450.25	319.00	9	801	423.09	112.43	10.3	213	101.36	209.33	7	475	240.34
17	E. Coli (cfu|ml)	1.67	0	4	2.08	2.00	0	5	2.65	2.33	0	7	4.04	0.33	0	1	0.58
18	Lead (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
19	Arsenal (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
20	Cadmium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
21	Total Chromium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Source: Field Survey (2023)

Table 3: Descriptive statistics of the canal water samples across the four locations

S/N	Parameters	Mean	Minimum	Maximum	Standard deviation
1	pH	7.18	6.90	7.50	0.25
2	Total dissolved solids (TDS) mg/l	478.25	463.00	487.00	10.87
3	Electrical conductivity *u*S/cm	918.00	846.00	970.00	60.49
4	Temperature ^oC	25.08	24.30	26.10	0.75
5	Turbidity	5.03	4.80	5.30	0.22
6	Dissolved oxygen (DO) mg/l	4.30	3.90	4.70	0.41
7	Chemical Oxygen Demand (COD) mg/l	326.15	172.00	390.40	103.80
8	Biology Oxygen Demand (BOD) mg/l	144.03	127.30	150.00	11.15
9	Total Hardness	26.00	20.00	37.00	7.62
10	Nitrate (NO_3^-) mg/l	28.85	19.70	49.70	14.00
11	Nitrite (NO_2^-) mg/l	9.35	7.15	11.70	1.99
12	Ammonia (NH_3) mg/l	0.44	0.17	0.60	0.19
13	Total Phosphorus mg/l	0.81	0.71	0.86	0.07
14	Chloride (Cl) mg/l	111.00	105.72	115.11	4.44
15	Sulphate (SO_4) mg/l	16.56	13.76	18.64	2.16
16	Total Coliform (MPN/100ml)	557.00	224.00	1359.00	538.80
17	E. Coli (cfu|ml)	10.75	6.00	16.00	4.27
18	Lead (mg/l)	<0.01	<0.01	<0.01	<0.01
19	Arsenal (mg/l)	<0.01	<0.01	<0.01	<0.01
20	Cadmium (mg/l)	<0.01	<0.01	<0.01	<0.01
21	Total Chromium (mg/l)	<0.01	<0.01	<0.01	<0.01

Source: Field Survey (2023)

5.2 Respondents Responses through Structured Questionnaire

Understanding the opinions, preferences, and experiences of individuals is fundamental in this research work. The data obtained through structured questionnaires administered, expressing the views, thoughts, and experiences of respondents on specific subjects are presented below:

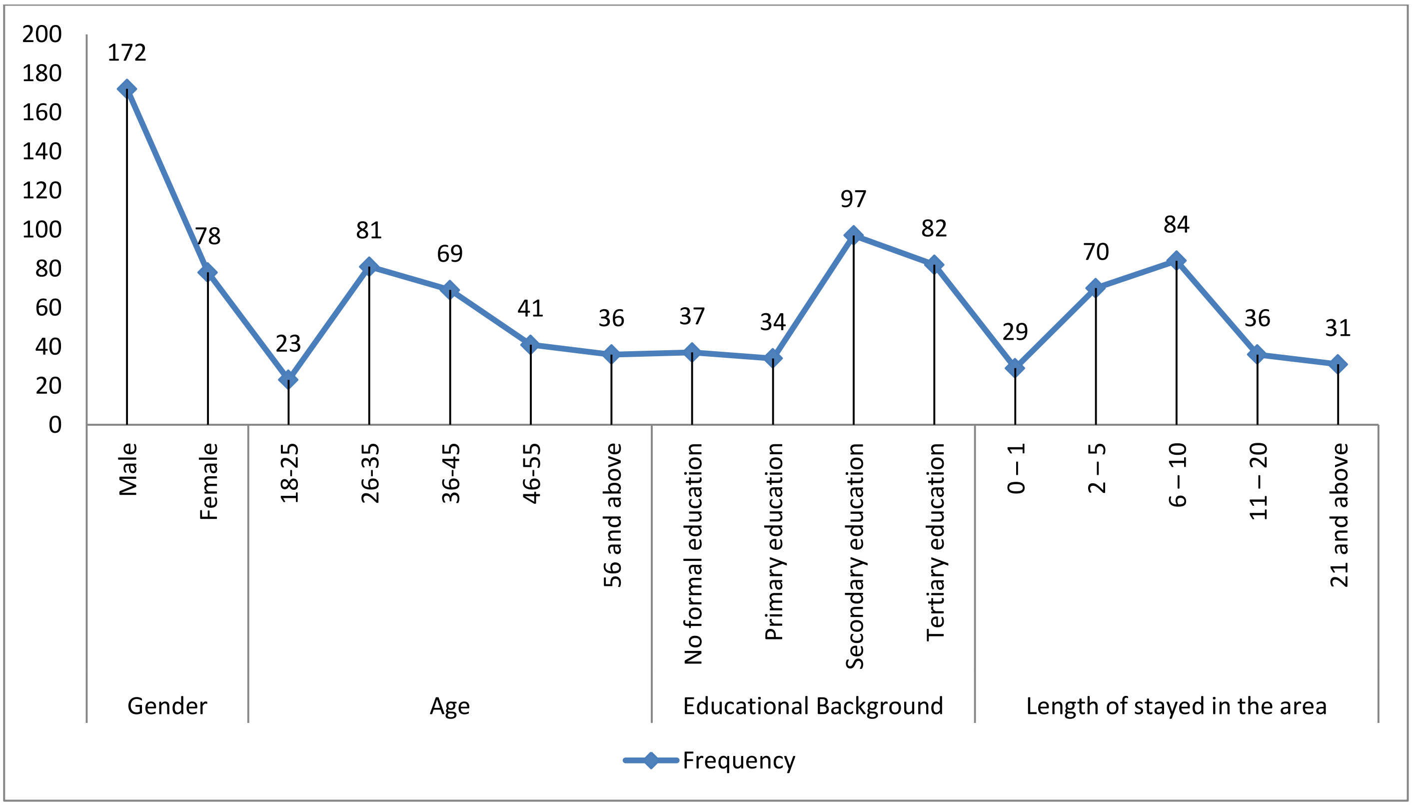

Fig. 2 Demographic Information of Respondents

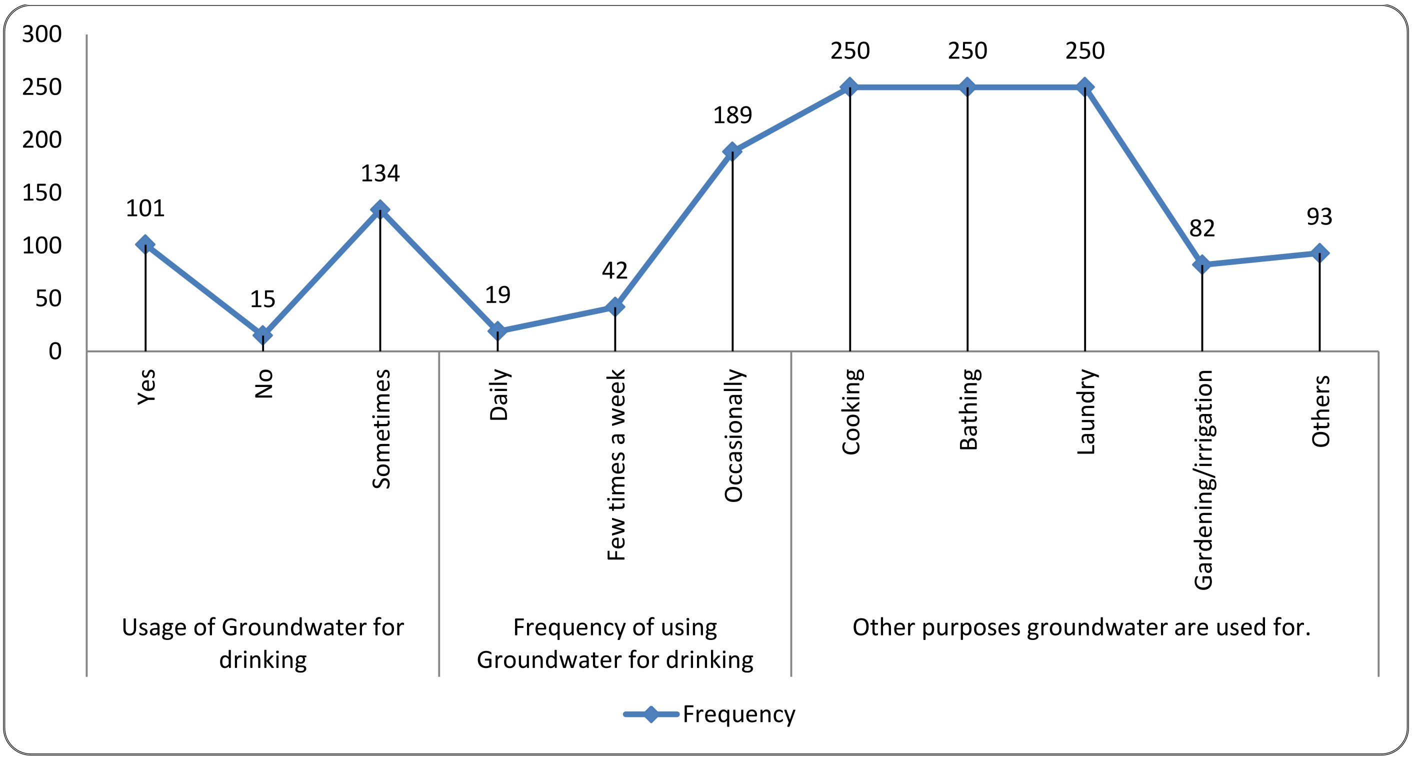

Fig. 3 Groundwater Usage by Respondents

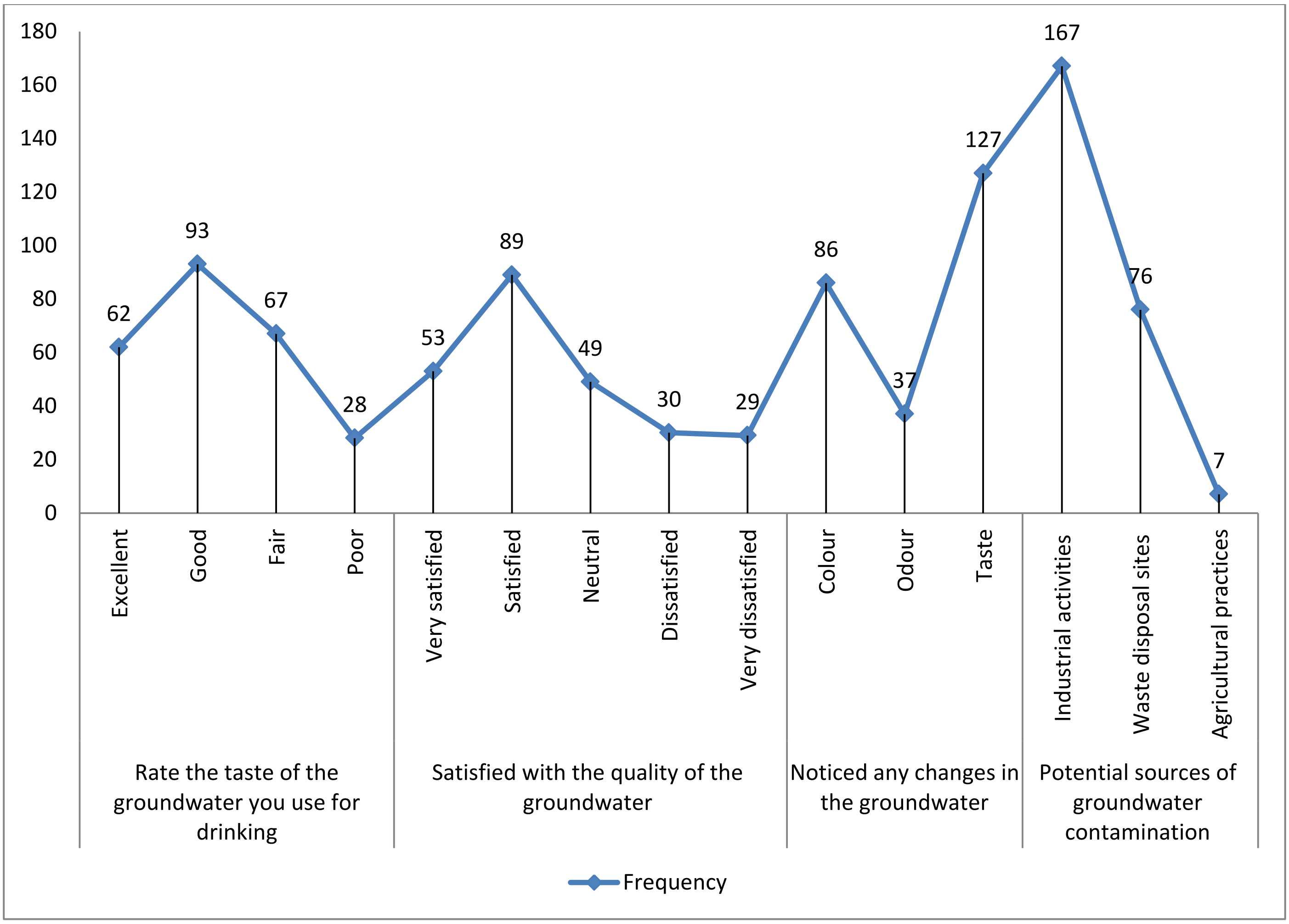

Fig. 4 Respondents Perceptions of Groundwater Quality

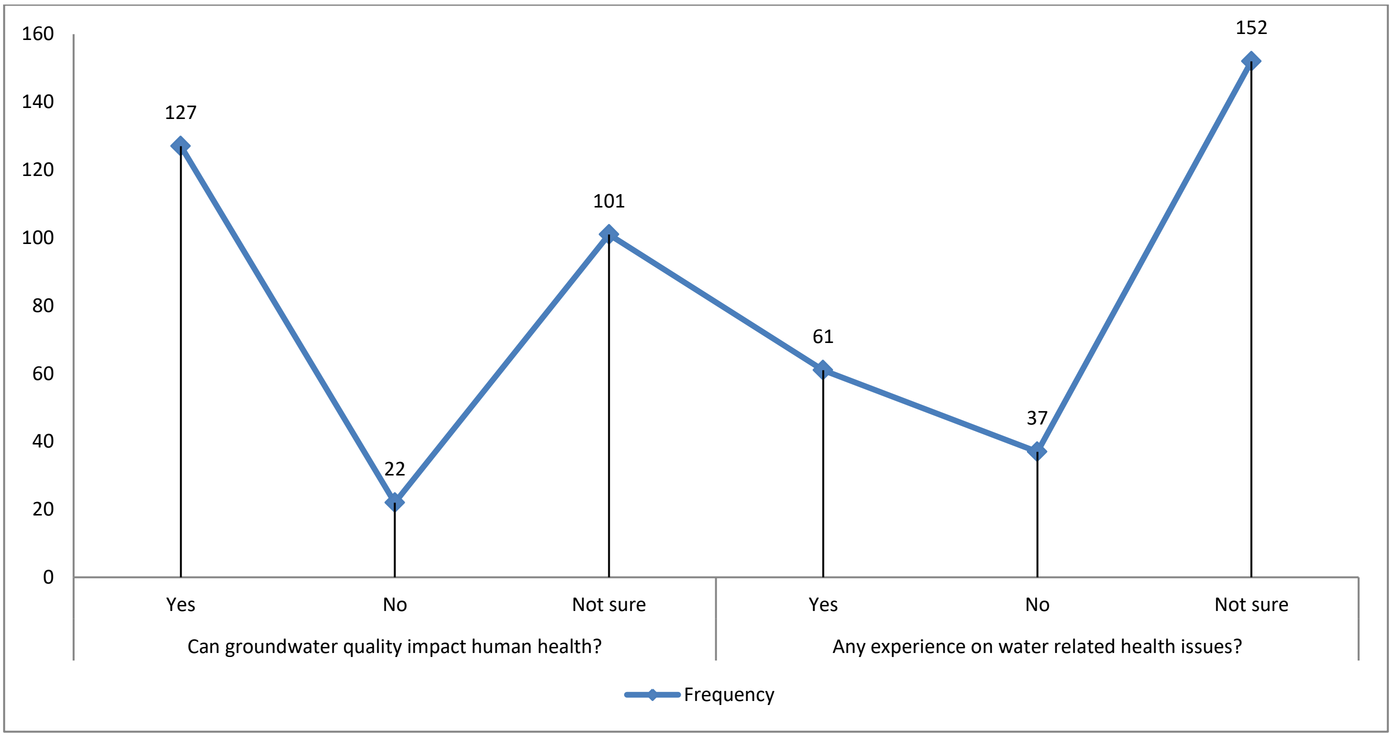

Fig. 5 Respondents view relating the Groundwater Quality and Health Implication

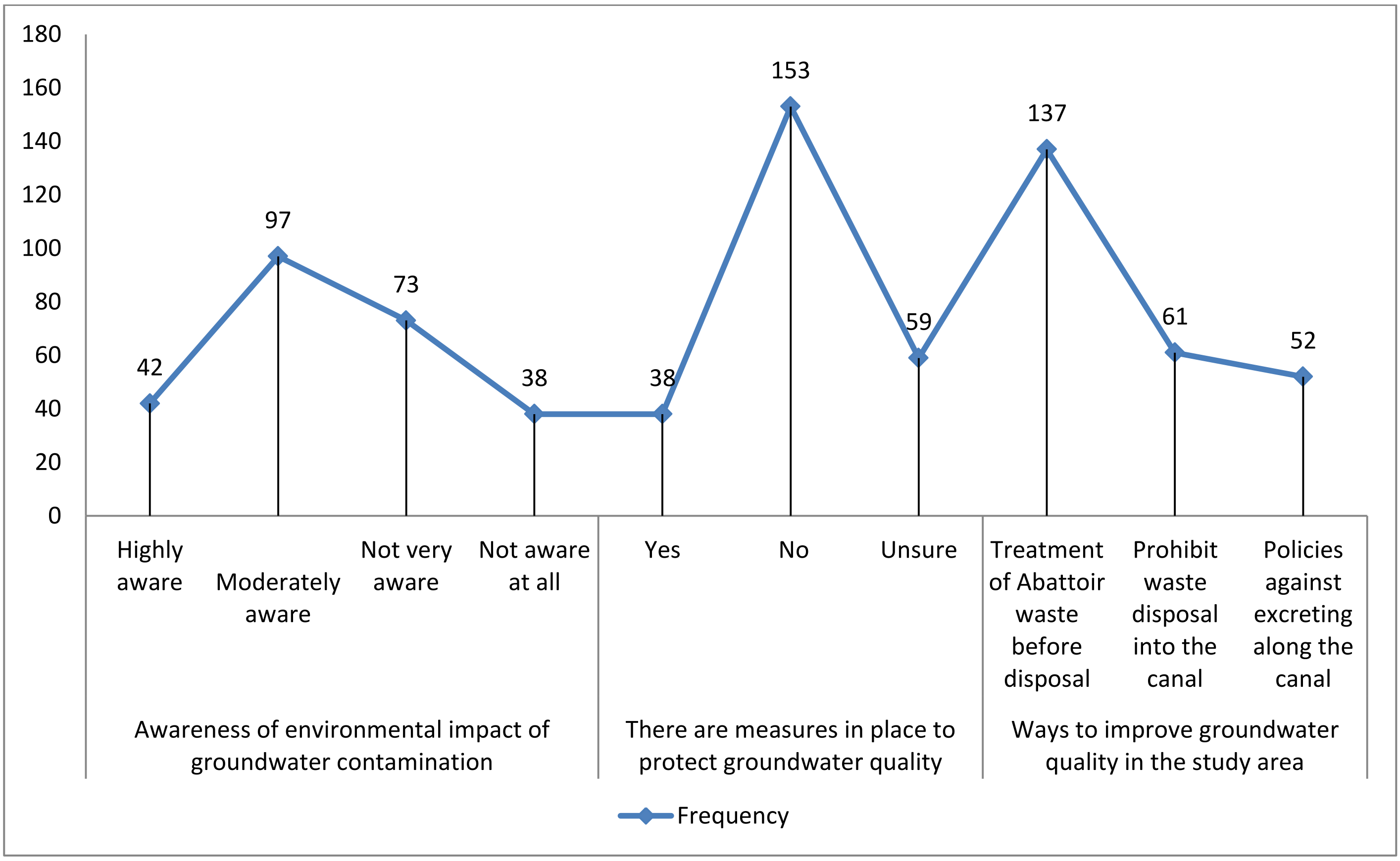

Fig. 6 Respondents Environmental Awareness on Groundwater

5.3 Comparisons of the Analyzed Groundwater Parameters with Relevant Water Quality Standards

To identify the suitability of the groundwater in the study area for various uses, including drinking, it is essential to compare the result of the groundwater parameters analyzed in the laboratory with relevant water quality standards. Below is a table presenting the comparison of the mean groundwater value at each of the locations with the World Health Organization (WHO) and the Nigeria Standard for Drinking Water Quality (NSDWQ).

Table 4: Comparison of the mean groundwater value at each of the location with WHO and NSDWQ

S/N	PARAMETERS	MGW1	MGW2	MGW3	MGW4	WHO	NSDWQ
1	pH	5.53	5.27	5.53	5.30	6.5- 8.5	6.5- 8.5
2	Total dissolved solids (TDS) mg/l	166.00	87.33	135.67	197.67	500	500
3	Electrical conductivity *u*S/cm	520.00	147.00	268.33	345.67	1000	1000
4	Temperature ^oC	24.77	24.87	24.03	24.53	25	NS
5	Turbidity	1.61	1.24	1.36	1.66	5.0	5.0
6	Dissolved oxygen (DO) mg/l	5.53	5.10	5.13	5.37	5. 0	5.0
7	Chemical Oxygen Demand (COD) mg/l	1.67	2.33	1.14	8.10	10-20	-
8	Biology Oxygen Demand (BOD) mg/l	2.20	1.90	2.62	22.17	10	-
9	Total Hardness	27.77	17.00	23.67	19.97	100	150
10	Nitrate (NO_3^-) mg/l	1.62	1.33	1.79	3.21	10	10
11	Nitrite (NO_2^-) mg/l	0.68	0.59	0.96	0.99	0.001	0.001
12	Ammonia (NH_3) mg/l	0.02	0.04	0.04	0.17	<1.5	1.0
13	Total Phosphorus mg/l	0.24	0.12	0.01	0.13	NS	NS
14	Chloride (Cl) mg/l	16.12	13.99	36.10	10.31	250	100
15	Sulphate (SO_4) mg/l	3.06	2.92	2.74	3.22	200	100
16	Total Coliform (MPN/100ml)	626.67	319.00	112.43	209.33	10	10
17	E. Coli (cfu|ml)	1.67	2.00	2.33	0.33	0	0
18	Lead (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01	0.01
19	Arsenal (mg/l)	<0.01	<0.01	<0.01	<0.01	-	-
20	Cadmium (mg/l)	<0.01	<0.01	<0.01	<0.01	0.003	0.003
21	Total Chromium (mg/l)	<0.01	<0.01	<0.01	<0.01	-	-

(MGW: Mean of the groundwater sample, WHO World Health Organization, NSDWQ: Nigeria Standard for Drinking Water Quality, <: less than, NS: not stated)

5.4 Correlation Analysis

This analysis was conducted to establish the potential relationship between the groundwater quality parameters and the canal water at the various locations in the study area. Table 5 presented the comparison between the canal water samples collected at various locations with the mean of the groundwater samples collected in the respective locations. The correlation analysis between the groundwater samples and the canal water samples is shown in Table 6.

Table 5: Comparison of the mean groundwater at the various locations with the respective canal water samples

S/N	**PARAMETERS**	**CWS1**	**MGW1**	**CWS2**	**MGW2**	**CWS3**	**MGW3**	**CWS4**	**MGW4**
1	pH	7.5	5.53	7.2	5.27	7.1	5.53	6.9	5.3
2	Total dissolved solids (TDS) mg/l	478	166	463	87.33	487	135.7	485	197.7
3	Electrical conductivity *u*S/cm	966	520	970	147	846	268.3	890	345.7
4	Temperature ^oC	24.9	24.77	25	24.87	24.3	24.03	26.1	24.53
5	Turbidity	4.8	1.61	5.1	1.24	4.9	1.36	5.3	1.66
6	Dissolved oxygen (DO) mg/l	3.9	5.53	4.7	5.1	4	5.13	4.6	5.37
7	Chemical Oxygen Demand (COD) mg/l	390.4	1.67	357.1	2.33	172	1.14	385.1	8.1
8	Biology Oxygen Demand (BOD) mg/l	149.4	2.2	149.4	1.9	150	2.62	127.3	22.17
9	Total Hardness	20	27.77	22	17	25	23.67	37	19.97
10	Nitrate (NO_3^-) mg/l	22.4	1.62	23.6	1.33	19.7	1.79	49.7	3.21
11	Nitrite (NO_2^-) mg/l	10.15	0.68	11.7	0.59	7.15	0.96	8.4	0.99
12	Ammonia (NH_3) mg/l	0.5	0.02	0.6	0.04	0.5	0.04	0.17	0.17
13	Total Phosphorus mg/l	0.86	0.24	0.71	0.12	0.86	0.01	0.79	0.13
14	Chloride (Cl) mg/l	109	16.12	105.7	13.99	114.2	36.1	115.1	10.31
15	Sulphate (SO_4) mg/l	18.64	3.06	17.79	2.92	16.04	2.74	13.76	3.22
16	Total Coliform (MPN/100ml)	1359	626.7	381	319	224	112.4	264	209.3
17	E. Coli (cfu|ml)	12	1.67	9	2	16	2.33	6	0.33
18	Lead (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
19	Arsenal (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
20	Cadmium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
21	Total Chromium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

(CWS: Canal Water Sample, MGW: Mean of the groundwater sample)

Table 6: Correlation Analysis

	Column 1	*Column 2*	*Column 3*	*Column 4*	*Column 5*	*Column 6*	*Column 7*	*Column 8*
Column 1	1							
Column 2	**0.961952**	1						
Column 3	0.808784	0.776971	1					
Column 4	0.947009	0.959013	**0.622809**	1				
Column 5	0.721355	0.718734	0.976461	0.550816	1			
Column 6	0.782098	0.83776	0.930759	0.691499	**0.954999**	1		
Column 7	0.744585	0.699301	0.991747	0.538223	0.976702	0.906777	1	
Column 8	0.863069	0.901017	0.926741	0.788015	0.932591	0.981669	**0.954999**	1

Summary

Locations	**Correlation**	**Value**
Location 1	Canal Water Sample and Mean Groundwater Sample	0.961952
Location 2	Canal Water Sample and Mean Groundwater Sample	0.622809
Location 3	Canal Water Sample and Mean Groundwater Sample	0.954999
Location 4	Canal Water Sample and Mean Groundwater Sample	0.954999

5.5 Demographic Result of the Survey

The majority were male, aged between 26 and 45, with secondary or tertiary education. Groundwater usage varied from daily (8%) to occasionally (76%). Most respondents used groundwater for drinking, cooking, bathing, laundry, gardening, irrigation, and other purposes. Perceptions of groundwater quality varied, with most rating it as good or fair (27%). Most respondents were satisfied with the quality, with changes in color, odor, and taste reported. Potential sources of contamination were industrial activities, runoff of abattoir waste, waste disposal sites, and agricultural practices. Over half of respondents believed groundwater quality could impact human health, with diarrhea, skin infections, typhoid fever, and stomach aches being the most common related illnesses. Environmental awareness indicated moderate or slight awareness of groundwater contamination, with 38% taking actions to protect groundwater quality. Common actions taken to forestall the infections included boiling water before drinking, using water filters or purifiers, disposing of waste properly, and avoiding dumping chemicals or waste into wells or boreholes. The survey results also revealed that Orile-Agege Local Government Area residents frequently use groundwater for drinking and cooking, but many perceive its quality as low, as observed in changes in color, odor, and taste. Some experience health issues due to contaminated water. The findings indicated the need for improving groundwater quality management and raising public awareness.

In the correlation analysis between canal water and groundwater samples at the four locations, the results showed a high positive correlation between canal water and groundwater, indicating that canal water quality influences groundwater quality. However, a moderate positive correlation was observed between canal water and groundwater samples at location 2, indicating that other factors also affect groundwater quality [29].

6. Conclusion and Future Scope

The findings of this study reveal that the groundwater in the study area is generally acidic, hard, and contaminated with high levels of nitrate, total coliforms, and E. coli when compared to national and international standards for drinking water quality, such as the National Standard for Drinking Water Quality (NSDWQ) and World Health Organization (WHO) guidelines. The primary sources of this contamination include indiscriminate waste disposal, runoff from abattoirs, solid waste dumps, and agricultural activities occurring along the canal. As a result, the groundwater in the area is deemed unsuitable for drinking and domestic use without proper treatment. This underscores the urgent need for targeted interventions to manage and restore water quality in the region, coupled with efforts to raise public awareness about the risks associated with contaminated groundwater.

The study highlights the necessity of a comprehensive hydrogeological survey to pinpoint the sources, pathways, and receptors of contamination. Periodic monitoring of water samples across different depths, locations, and seasons is essential to accurately assess physicochemical and microbiological parameters and track temporal changes. Comparing these findings with established national and international water quality standards is critical to identifying health risks posed to the local population. Implementing suitable remediation measures, such as installing boreholes, water filters, and treatment facilities, is imperative to mitigate contamination. Furthermore, educating residents about proper waste disposal, sanitation, and hygiene practices is vital in preventing further groundwater pollution. Continuous monitoring and evaluation of remediation efforts are essential to ensure long-term improvement in water quality and to safeguard public health.

Future work could explore advanced and cost-effective treatment technologies suitable for the region. Additionally, the establishment of a robust water quality monitoring framework and policies that integrate local communities into water management efforts could significantly enhance the sustainability of remediation measures. Further studies should also investigate the socio-economic factors affecting groundwater use and quality to develop more inclusive and effective solutions.

Data Availability Statement

The datasets generated and analyzed during the research titled *"Evaluation of the Perceived Impact of Canal Water on Groundwater Quality and the Residents in Orile-Agege, Lagos State, Nigeria"* are available from the corresponding author upon reasonable request. The data supporting the findings of this study are securely stored and can be provided in an accessible format for verification and further research. Requests for the data should be directed to *Raimot Titilade Akanmu* (raimot.akanmu@lasu.edu.ng) or *Emmanuel Ameh Elijah* (elijah.emmanuel@envillepoly.edu.ng).

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this research article titled *"Evaluation of the Perceived Impact of Canal Water on Groundwater Quality and the Residents in Orile-Agege, Lagos State, Nigeria."* The research was conducted with full transparency and academic integrity, and no financial, personal, or professional relationships have influenced the results or interpretation of the data presented in this study.

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Author Contributions

Raimot Titilade Akanmu contributed to the conceptualization of the study, data analysis, and manuscript writing. She also supervised the overall research process and provided critical revisions to the manuscript. Emmanuel Ameh Elijah contributed to the methodology design, data collection, and interpretation of results. He also played a key role in drafting and reviewing the manuscript. Both authors read and approved the final manuscript

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