ORIGINAL RESEARCH ARTICLE

Physicochemical Analysis, Antibiogram and Molecular Characterization of associated Bacteria of Borehole Water in some Hostels of Rivers State University Main Campus, Port Harcourt, Nigeria

ABSTRACT

Several factors influence the quality of water for human consumption. Most of these factors are more of anthropogenic origin than nature and thus exercises an untold health effect on the end-users of such water body. Physicochemical analysis, antibiogram and molecular characterization of associated bacteria of borehole water in some hostels of Rivers State University Main Campus, Port Harcourt, Nigeria, was carried out. Water samples were collected from six (6) hostels for each study period, and subjected to standard laboratory procedures to analyse for parameters such as pH, nitrite, nitrate, dissolved oxygen (DO), electrical conductivity (EC), Phosphate, as well as standard procedures for antibiotics susceptibility and molecular characterization. Result of the physicochemical parameters showed that the parameters ranged from 5.26±3.53 mg/L to 7.61±0.01 mg/L for pH; 0.61±0.01 to 2.56±0.01 mg/L for Dissolved Oxygen (DO); 96±1.41 μS/cm to 503.5±0.71μS/cm for electrical conductivity; 4.56±0.03 mg/L to 20.3±0.01 mg/L for nitrate; 0.003±0mg/L to 0.03±0mg/L for nitrite; 0.12±0mg/L to 0.17±0mg/L for phosphate. Statistical evaluation showed there was a significant difference ($p < 0.05$) between the mean values of physicochemical parameters studied, except for pH that recorded no statistical difference ($p > 0.05$). From the study, 5.6% of *Staphylococcus* species were resistant to Pefloxacin and Rocephin, while 5.9% of *Bacillus* species were resistant to Ampiciox. Similarly, 3.33% of *Salmonella* species were resistant to Augumentin, while the rest of the gram negative isolates were either susceptible or within an intermediate range of susceptibility to the antibiotics tested. Molecular characterization of some bacterial species isolated had pairwise identity with *Klebsiella pneumonia* strain CP27 and *Escherichia coli* strain RIZHAO 498.1*, Staphylococcus haemolyticus* strain SH1. The study has shown that the physicochemical water quality variables were all within the WHO limits, with bacterial species having high percentage susceptibility to the antibiotics tested. Regular water quality monitoring is however recommended to ensure continuous access to water of good quality in hostels in the university community.

Keywords: Antibiogram, borehole water, physicochemical, molecular characterization, hostels, Rivers State University

1.0 Introduction

Water is one of the significant natural resources to man that contributes to the socio-economic and financial development of any given nation when adequately and effectively

utilized. Fundamentally, it is used for drinking, industrial purposes, recreational activities, fishing, irrigation, bathing, laundry, as well as aesthetics [1]. The physicochemical parameters of the water could be altered and provide a conducive zone for the proliferation of different microorganisms. Students consuming such contaminated water could accentuate their unhealthiness. However, it is against this background the need to carry out this research centers.

In Rivers State University, the main source of water for students' utilization is borehole water [2]. This water passes through several network of pipes to the various hostels. During this process, water can be interfered by contaminants or pollutants, and thus could affect the health status of the hostel dwellers who make use of this water day in day out. Leachates which may contain dissolved organic and inorganic elements and compounds such as Magnesium (Mg), Potassium (K), Sulphate (SO_4^{3-}), Ammonium (NH_4), Calcium (Ca), Sodium (Na), and heavy metals like Copper (Cu), Cadmium (Cd), Nickel (Ni), Chromium (Cr), Zinc (Zn), and lead (Pb) also contaminate the environment and therefore alter the physicochemical properties of the environment. More so, some of these substances like sulphate, nitrate and phosphate may serve as nutrients while some of the heavy metals like Cd, As, Pb, Cu, Cr among others when consumed at a rate higher than the maximum allowable limit could cause harm, carcinogenic and non-cancer health risk to the end-users [3,4].

The quality of water depends on several factors, and not solely a function of its appearance, taste as well as odor. According to Kirkwood (1998), water must be safe for human consumption and as such must be free from pathogenic microorganisms and must meet the standard guideline of the physio-chemical properties of water and must be available in adequate quantity for human use. Thus, dormitory or hostel dwellers should have all the simple necessities for them to stay healthy and develop naturally while they remain on school premises. Physicochemical properties broadly can be physical properties, solvation properties related to interactions with different media, and properties or molecular attributes that define intrinsic chemical reactivity. It includes such parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), alkalinity, and the levels of fluoride, arsenic, lead, and nitrate is generally considered to set guidelines and

categorize the physicochemical water quality [5,3]. More so, physicochemical properties in water are important components in terms of nutrient to human. Albeit, not all the physicochemical element or substances that are essential to human body and by extension public health. Appropriate and adequate quantity of minerals are needed for human consumption but when taken in very low or very high quantity imposes life threatening or risk to human health [6]. Nitrate, sulphate and phosphate ions are nutrients that are good for plants health [3]. Preferably, to ascertain water quality and purity, all standard procedure for testing water quality (i.e., parameters such as temperature, color, odour, pH, turbidity, BOD, COD, dissolved oxygen, alkalinity, hardness, temperature, pH, Electrical conductivity, Dissolved oxygen, Alkalinity, turbidity etc.,) should be performed or determined [7,8,9]

Modern researchers have used molecular approaches to demonstrate that the population of culturable microbial group in an environment is only representative of a minute proportion of the microbial community which differs both in structures and function [10]. Researchers have utilized different molecular methods to analyze microbial populations in various water bodies. These studies showed the versatility of the microbial groups in water. Gene sequencing is a more objective method for identifying bacteria, as it does not require optimal growth or even a viable microorganism. Additionally, it can define taxonomical relationships among bacteria. Molecular techniques have also been used for the characterization and detection of antibiotic resistance genes in *Pseudomonas species* isolated from *Tympanotonus fuscatus* [11], and other aquatic biota.

Therefore, the isolation, identification of different bacteria in water resources used for drinking and other domestic activities including information on the presence of multidrug resistance microorganisms in such water resources, identification of the physicochemical water quality parameters will help to determine the purity and quality of such water source. This is because water serve as a vehicle for the transmission of various diseases to man and animals. More so, bacteria exercising multidrug resistance makes treatment that arises from these infections very difficult in most cases. Hence, taking a study on bacteriological and physicochemical water quality parameters in the Hostels of Rivers

State University to ascertain its suitability for drinking and domestic utilization is highly justifiable.

2.0 Materials and Methods

2.1Study Area

The study area, Rivers State University (RSU) formally called the Rivers State University of Science and Technology (RSUST) Port Harcourt, Nigeria was established in October, 1980 from the Rivers State College of Science and Technology which was itself established in 1972. It is located at Nkpolu-Oroworukwo in Port Harcourt, the capital of Rivers State, Nigeria. It is the first Technological University in Nigeria and the first state owned State University in the Niger Delta region of Nigeria. The motto of the University is “Excellence and Creativity”. The University runs 37 programmes at the undergraduate level and 86 at the postgraduate level. Today, the University has several outside campuses such as Emohua, Ahoada, Etche, and Sapinwa. The university lies between Latitude *4.824167,* and longitude *7.033611* [2].

2.2 Collection of Water Samples

Borehole water samples were collected from six hostels (hostel B, C, D, H, FCMB and PG hostel) as indicated in Table 1. A total of 12 samples were used for the analysis. For a period of two months, using sterile bottles of 1.5 liters. The water samples were placed in an ice-packed cooler and transported to the laboratory for further analysis.

Table 1 GPS Coordinate of Sampling Sites for Hostels

S/N	Sample location	Borehole	Latitude	Longitude
1	FCMB Hostel	Tap water	4.78874	6.98384
2	Hostel C	Tap water	4.79173	6.98234
3	Hostel D	Tap water	4.79153	6.98224
4	Hostel H	Tap water	4.79599	6.98260

5	PG Hostel	Tap water	4.79588	6.98251
6	Hostel B	Tap water	4.79258	6.98332

Source: Author's Field Survey, 2024.

2.3. Determination of the physicochemical Properties of the Water Samples

Parameters such as temperature, pH, nitrate nitrogen, phosphate, conductivity, dissolved oxygen, and total dissolved solid were determined using the methods from [12].

2.4 Antimicrobial Susceptibility Test

This test was done to measure the ability of the antibiotic to inhibit bacterial growth *in vitro* by disc diffusion. Sub – cultured isolates of 24 hours were aseptically streaked on to nutrient agar plates. Using sterile forceps, standard antibiotics disc was placed on the surface of the inoculated plates, incubated at 37°C for 24 hours. After 24hrs, the plates were intercepted according to the clinical laboratory standard institute guidelines [13].

A sterile swab stick was dipped into the tube containing the bacterial suspension and its turbidity is equivalent to 0.5m McFarland Turbidity Standard. The swab was used to swab the surface of the petri dish evenly which contain already prepared Muller Hinton Agar in three dimensions and rotating the plates to about 60°C to ensure even distribution of the organisms. The agar was allowed to dry for about 3-5 minutes. Using sterile forceps, antimicrobial disc was placed evenly on the surface of the inoculated plate and the disc was placed 15mm away from the edge of the plate. After applying the discs, the plates were incubated in an inverted position aerobically at 35°C FOR 16-8 hours. The diameter of each zone of inhibition was measured in mm using a ruler on the underside of the plate and recorded for reference purpose [14].

2.5 Molecular Identification

2.5.1 Extraction of DNA

DNA extraction is a phenomenon by which DNA is separated from proteins, membranes and other cellular materials contained in the cell [15]. This was done using ZR

Fungal/Bacterial DNA Miniprep. About 2mls of bacterial broth was added to a ZR Bashing TM Lysis Tube. About 750ul Lysis solution was also added to the tube. To secure in a bead fitted with 2 ml tube holder assembly and process at maximum speed for less than 5 minutes. ZR Bashing TM Lysis Tube was centrifuged in a micro centrifuge at > 10,000xg for 1 minute. Then 400µl supernatant was transferred to a Zymo-spin TM IV Spin Filter (orange top) in a collection Tube and centrifuge at 7,000 x g for 1 minute. 1,200µl Fungal/Bacterial DNA Binding Buffer was added to the filtrate in the collection Tube and 800µl of the mixture was added to Zymo-Spin TM IIC Column in the Collection Tube and centrifuge at 10,000 x g for 1 minute.

About 200ul DNA Pre –Wash Buffer was added to the Zymo-Spin TM IIC Column in a new Collection Tube and centrifuge at 10,000 x g for 1 minute and 500ul Fungal /Bacterial DNA Wash Buffer was added to the Zymo-Spin TM IIC Column and centrifuged at 10,000 x g for 1 minute. The Zymo-Spin TM IIC Column was transferred to a clean 1.5 ml micro centrifuge tube and 100µl (35µl minimum) DNA Elution Buffer was added directly to the column matrix. The column was centrifuged at 10,000x g for 30 seconds to elute the DNA.

2.5.2 Electrophoresis of DNA and PCR

One gram of agarose (for DNA) and 2g of agarose for PCR were measured and mixed with 100ml 1× TAE in a microwavable flask. The solution was microwaved for 1-3 min until it completely dissolved (but not over boiled to prevent some of the buffer from evaporating and thus alter the final percentage of agarose in the gel.

The agarose solution was allowed to cool down at about 50°C for 5 minutes and 10µL EZ vision DNA stain was added. EZ vision binds to the DNA and allows visualizing the DNA under ultraviolet (UV) light. Agarose was poured into a gel tray with well comb in place and a newly poured gel at 4°C was placed for 10-15 minutes until it completely solidified.

2.5.3 Loading Samples and Running an Agarose Gel

Loading buffer were added to each DNA samples. Once solidified, the agarose gel was placed into a gel box (electrophoresis unit). The gel box was filled with 1×TAE until the gel is covered. A molecular weight ladder was carefully loaded into the first lane of the gel and the samples were also carefully loaded into the additional wells of the gel. The gel at

80-150 V was allowed to run for about 1-1.5 hours. After which, the power was turned off, electrodes were disconnected from the power source, and then the gel was carefully removed from the gel box. DNA fragments were visualized under UV trans illuminator.

2.5.4 16S rRNA Amplification

The 16S rRNA Amplification was carried out using an ABI 9700 Applied Biosystems Thermal Cycler and method described by [16]. The 16S rRNA region of the rRNA gene of the bacterial isolates were amplified using the forward primer 27F: 5'-A GAGTTTGATCMTGGCTCAG-3'and Reverse primer 1525R: 5'-AAGGAGGTGWTCCARCCGCA-3'. The PCR mix include: 12.5µl of Taq 2X Master Mix from New England Biolabs (M0270); 1µl each of 10µM. The PCR conditions were isolated as follows: Initial denaturation at 94°C for 5mins, followed by 36 cycles of denaturation at 94°C for 30secs, annealing at 56°C for 30secs and elongation at 72°C for 45sec. Followed by a final elongation step at 72°C for 7 minutes and temperature held at 10°C.

2.5.5 DNA Sequencing

Sequencing of the amplified product was carried out using the Genetic Analyzer 3500xl sequencer from Applied Biosystems using manufacturers' manual while the sequencing kit used was BigDye terminator v3.1 cycle sequencing kit. Bio-Edit software and MEGA X were used for all genetic analysis.

3.0 RESULTS

3.1 Physicochemical quality of the water samples from the various hostels studied

The analyzed physicochemical result presented in Table 2 showed that the pH varied between 5.26±3.53 mg/L and 7.61±0.01 mg/L with the highest at the Hostel C sample, and the least pH obtained from Hostel H. However, the mean showed Hostel H and Hostel B were within the acidic range of 5.26 and 6.28 and Hostel C, D, P.G and FCMB were less acidic.

The dissolved oxygen was found to be within the range 1.11±0.01 and 2.56±0.01 mg/L with PG Hostel having the least value, while Hostel D had the highest value.

The electrical conductivity of the water samples ranged between 96±1.41 μS/cm and 419.5±0.71μS/cm. Hostel H had the least value of 96±1.41 μS/cm and FCMB Hostel had the highest electrical conductivity of 419.5±0.71 μS/cm.

Results of the analysis for nitrate – nitrogen had the least value of 4.56±0.03 mg/L obtained from Hostel H, while Hostel B had the highest value of 20.3±0.01 mg/L.

The least nitrite – nitrogen of 0.003±0 mg/L was obtained at Hostel D with Hostel B and FCMB Hostel having the highest nitrite – nitrogen of 0.03±0 mg/L.

The amount of phosphate varied between 0.12±0 mg/L and 0.17±0 mg/L with the least obtained from Hostel B and Hostel C, while the highest was obtained from PG hostel and Hostel D.

However, statistical analysis using one - way analysis of variance showed that there was a significant difference ($p < 0.05$) in the values of physicochemical quality studied, except for pH that showed no significant difference ($p > 0.05$).

In comparison with World Health Organization regulatory standards (WHO) the study showed that all parameters evaluated were within the limits required (Table 2).

Table 2: Physicochemical Quality of the Underground water source studied

Parameters	Period	HOSTEL B	HOSTEL C	HOSTEL D	HOSTEL H	PG HOSTEL	FCMB HOSTEL	p-value	WHO Limits (2004)
pH	Month 1	6.28	7.60	7.42	7.75	7.34	7.26	0.5858	6.5 – 8.5
	Month 2	6.27	7.62	7.40	2.76	7.32	7.27		
	Mean ±std	6.28±0.01	7.61±0.01	7.41±0.01	5.26±3.53	7.33±0.01	7.27±0.01		
Electrical Conductivity (μS/cm)	Month 1	503	199	230	95	108	419	<0.0001*	1000 μS/cm
	Month 2	504	201	232	97	110	420		
	Mean ±std	503.5±0.71^{a}	200±1.41^{d}	231±1.41^{c}	96±1.41^{f}	109±1.41^{e}	419.5±0.71^{b}		
Dissolved Oxygen (mg/L)	Month 1	0.60	1.80	2.55	1.30	1.10	1.2	<0.0001*	65 – 8 mg/L
	Month 2	0.62	1.82	2.57	1.32	1.12	1.4		
	Mean ±std	0.61±0.01^{d}	1.81±0.01^{b}	2.56±0.01^{a}	1.31±0.01^{c}	1.11±0.01^{c}	1.3±0.14^{c}		
Nitrate (mg/L)	Month 1	20.32	15.62	19.58	4.54	13.45	19.25	<0.0001*	50 mg/L
	Month 2	20.34	15.60	19.59	4.58	13.48	19.28		
	Mean ±std	20.3±0.01^{a}	15.6±0.01^{d}	19.6±0.01^{b}	4.56±0.03^{f}	13.5±0.02^{e}	19.27±0.02^{c}		
Nitrite (mg /L)	Month 1	0.024	0.013	0.002	0.011	0.008	0.031	<0.0001*	0.2mg/L
	Month 2	0.026	0.016	0.003	0.012	0.009	0.032		
	Mean ±std	0.03±0^{b}	0.01±0^{c}	0.003±0^{d}	0.01±0^{cd}	0.01±0^{d}	0.03±0^{a}		
Phosphate (mg/L)	Month 1	0.118	0.124	0.173	0.146	0.1674	0.162	<0.0001*	5.0mg/L
	Month 2	0.119	0.125	0.174	0.147	0.1675	0.163		
	Mean ±std	0.12±0^{b}	0.12±0^{e}	0.17±0^{a}	0.15±0^{d}	0.17±0^{f}	0.16±0^{c}		

3.2. Antibiotics Susceptibility profile of the bacterial species isolated

The results as shown in Table 3 and 4 showed the susceptibility pattern to conventional antibiotics. The information showed that most of the isolates were sensitive to the antibiotics tested. However, 5.6% of *Staphylococcus* species were resistant to Pefloxacin and Rocephin, while 5.9% of *Bacillus* species were resistant to Ampiciox. The rest of the isolates were sensitive to the various antibiotics tested at varying number of isolates. Similarly, 3.33% of *Salmonella* species were resistant to Augumentin based on standards [13]. The rest of the gram negative isolates were either susceptible or within an intermediate range of susceptibility to the antibiotics tested.

Table 3. Antimicrobial Susceptibility pattern of the Gram positive isolates

Probable Isolate	*Bacillus* spp. (n = 17)			*Staphylococcus* spp. (n = 18)		
	R	**I**	**S**	**R**	**I**	**S**
Antibiotics						
CPX	0	2 (11.7)	15 (88.2)	0	0	18 (100)
AZ	0	1 (5.9)	16 (94.1)	0	1 (5.6)	17 (94.4)
LEV	0	0	17 (100)	0	1 (5.6)	17 (94.4)
E	0	0	17 (100)	0	0	(100)
PEF	0	0	17 (100)	1 (5.6)	0	17 (94.4)
CN	0	1 (5.9)	16 (94.1)	0	0	(100)
APX	1(5.9)	3 (17.7)	13 (76.4)	0	5 (27.8)	13 (72.2)
Z	0	3 (17.6)	14 (82.4)	0	3 (16.7)	15 (83.3)
AM	0	2 (11.8)	15 (88.2)	0	5 (27.8)	13 (72.2)
R	0	0	17 (100)	1 (5.6)	17 (94.4)	1 (5.6)

CPX – Ciprofloxacin, AZ – Azithromycin, LEV – Levofloxacin, E – Erythromycin, PEF – Pefloxacin, CN – Gentamycin, APX – Ampiciox, Z –Zinnacef, AM –Amoxicillin,R – Rocephin

Table 4. Antimicrobial Susceptibility pattern of the Gram Negative isolates

Probable Isolate	***Shigella* spp. n = 2**			***Pseudomonas* spp. n= 10**			***Salmonella* spp. n=3**			***Klebsiella* spp. n= 10**		
Antibiotics	**R** No. (%)	**I** No. (%)	**S** No. (%)	**R** No. (%)	**I** No. (%)	**S** No. (%)	**R** No. (%)	**I** No. (%)	**S** No. (%)	**R** No. (%)	**I** No. (%)	**S** No. (%)
CN	0	0	2 (100)	0	0	10 (100)	0	0	3 (100)	0	0	10 (100)
PEF	0	0	2 (100)	0	0	10 (100)	0	0	3 (100)	0	0	10 (100)
OFX	0	0	2 (100)	0	0	10 (100)	0	1 (33.3)	2 (66.6)	0	1 (10)	9 (90)
S	0	0	2 (100)	0	0	10 (100)	0	1 (3.33)	2 (66.6)	0	0	10 (100)
SXT	0	0	2 (100)	0	1 (10)	9 (90)	0	0	3 (100)	0	0	10 (100)
CH	0	0	2 (100)	0	0	10 (100)	0	1 (3.33)	2 (66.6)	0	1 (10)	9 (90)
SP	0	0	2 (100)	0	0	10 (100)	0	0	3 (100)	0	0	10 (100)
CPX	0	0	2 (100)	0	0	10 (100)	0	0	3 (100)	0	1 (10)	9 (90)
AM	0	1(50)	1 (50)	0	0	10 (100)	0	0	3 (100)	0	2 (20)	8 (80)
AU	0	0	2 (100)	0	2 (20)	8 (80)	1 (3.33)	1 (3.33)	1 (3.33)	0	4 (40)	6 (60)

CPX – Ciprofloxacin, OFX – Tarivid , S – Streptomycin, SXT – Septrin , PEF – Pefloxacin, CN – Gentamycin, CH– Chroramphenicol, SP –Sparfloxacin, AM –Amoxicillin, AU – Augumentin,

3.3 Molecular Identification of Bacteria Isolated from the Water Sources

Results of the 1% agarose gel electrophoresis for the visualization of the 16s rRNA region of the rRNA gene of the isolates showed that the PCR products were amplified to possess a molecular weight that each corresponds to 1500 base pairs. The purified lanes labelled D1, PG2 and PGB shown in Plate 1 represented the 16s rRNA gene bands (1500bp), while lane M represents the 1000 base pair (bp) molecular ladder.

The obtained 16s rRNA sequence from the isolate produced an exact match during the megablast search for highly similar sequences from the NCBI non-redundant (nr/nt) database. The evolutionary distances computed using the Jukes-Cantor method were in agreement with the phylogenetic placement of the 16s rRNA of the isolates, D1, PG2 and PGB within the *Klebsiella pneumonia, Escherichia coli, Staphylococcus haemolyticus,* respectively (Figure 1).

Basic Local Alignment Search Tool (BLAST) report revealed the genomic identities of the isolates as isolate D1, PG2 and PGB had 84.71%, 78.10% and 75.15% pairwise identity with *Staphylococcus haemolyticu*s strain SH1 (with accession number, MK886483.1), *Escherichia coli strain* Rizhao 4981(with accession number, MN314234.1) and *Klebsiella pneumoniae* strain CP27 (with accession number, PP346491.1).

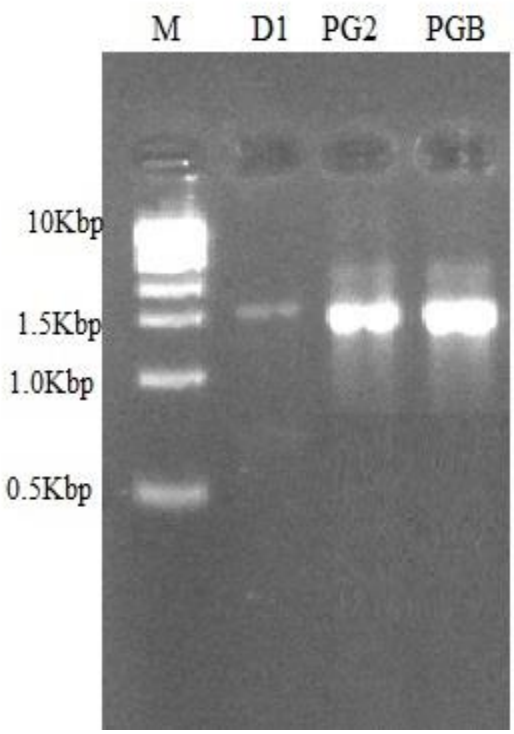

Plate 1: 16 SrRNA Gene bands at 1500 base pairs of the isolates

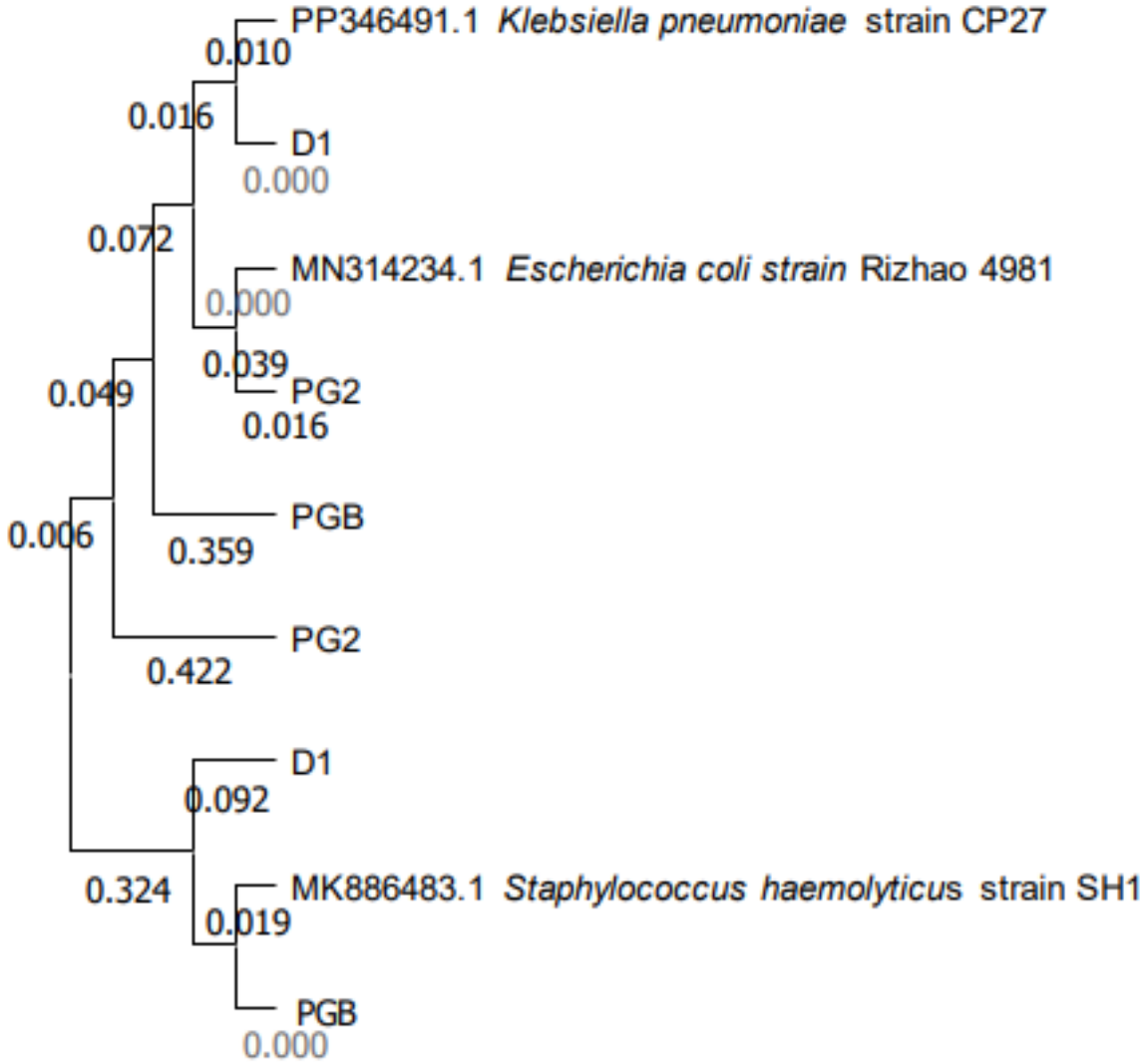
PP346491.1 Klebsiella pneumoniae strain CP27
0.010
0.016
D1
0.000
0.072
MN314234.1 Escherichia coli strain Rizhao 4981
0.000
0.039
0.049
PG2
0.016
PGB
0.006
0.359
PG2
0.422
D1
0.092
0.324
MK886483.1 Staphylococcus haemolyticus strain SH1
0.019
PGB
0.000

Figure 1: Phylogenetic Profiling of the Bacterial Isolates.

4.0 DISCUSSION

Water quality is influenced by various factors, most especially anthropogenic factors relating to solid waste disposal around residential areas, including students' hostels [17] which via leaching introduces both chemical and biological contaminants into ground water formations. The quality of water is therefore, determined by its biological, physical and chemical attributes. Analysis of the physical and chemical variability of water quality provides information necessary for the classification of water and thus determines the usefulness of water source. This study evaluated some physicochemical parameters in the borehole water used in hostels within Rivers State University, and reported a significant statistical difference in the mean physicochemical parameters across the samples, except for pH that showed no significant difference ($p > 0.05$).

The result of physicochemical factors affecting water quality showed that all the variables were within the WHO recommended limits except for pH that had limits below recommended value from one of the samples. This indicates that the water sources are safe for use. pH is a measure of acidic or alkaline nature of a solution [18]. The mean pH values of the water sample ranged from 5.26 – 7.41 indicating that the water samples were slightly acidic to alkaline. This result is in consonance with the study carried out by [19], in which pH ranged from 4.15 – 7.24.

Electrical conductivity quantifies the concentration of ions in water, which influences taste and thus has a significant impact on the user's acceptance of the water. High electrical conductivity in water can occur when water contains heavy metals and metal ions solution [20]. The mean conductivity values recorded ranged between 96±1.4 μS/cm to 503±0.71 μS/cm, which is within WHO permissible limit. Low level of electrical conductivity suggests high purity but it can also mean a deficiency in essential electrolytes like calcium and magnesium, which is vital for human health. Consumption of water with very low mineral content can lead to electrolyte imbalance. Findings were lesser than the values obtained by a previous author [21] which was 303 μS/cm -8972 μS/cm.

The dissolved oxygen (DO) content of the water samples examined was highest in Hostel D sample (2.56±0.01mg/L) and lowest in PG Hostel (1.11±0.01mg/L) which is within the World Health Organization's permissible limit of 6.5-8 mg/L. However, high dissolve oxygen (DO) level can speed up corrosion in water supply pipes while low level reported in this study can result in poor taste and odor in drinking water. The result obtained in this findings was not in consonance with other researchers [19, 22] who reported values that ranged from 3.04±0.20mg/L to 7.36±0.01mg/L. This difference is attributable geochemical variation between the study locations.

Nitrite concentration recorded from the water samples ranged from 0.01±0mg/L to 0.03±0 mg/L and nitrate of the water samples ranged from 4.56±0.03mg/L to 20.3±0.01 mg/L which was within WHO standard limit of drinking water. Low level of nitrate observed in this study shows the water is safe but also indicates overly treated water, where beneficial nutrients are also removed. Nitrite is more toxic than nitrate, low level obtained in this study is safe and indicates effective water treatment. Thus, high nitrite concentration can induce cyanosis in newborns under 3 months.

Phosphate of the water samples ranged from 0.12±0 mg/L to 0.17±0 mg/L. However, too much phosphate in water can cause eutrophication. The phosphate level in this study fell below the WHO standard limit of drinking water. As a result, they are suitable for household use. The findings of this report were lower than the values obtained by [23] which was 0.25±0 mg/L- 1.08±0 mg/L, and this difference is attributable to lithological and anthropogenic factors.

Molecular studies were also carried out to further characterise the bacterial species present in the water samples. The 16S rRNA region of the bacterial DNA from the samples used was seen aligning themselves at 1500 base pairs (1500bp) which proved the presence of bacterial species in the water samples corresponding with the previous research that bacteria are about 1500 base pair long. While cultural characterization is important for several reasons, molecular characterization helps to identify microorganisms up to their strains and provides their accession numbers [10]. In this study, *Staphylococcus haemolyticu*s strain SH1 (with accession number, MK886483.1), *Escherichia coli strain* Rizhao 4981(with accession number, MN314234.1) and *Klebsiella*

pneumoniae strain CP27 (with accession number, PP346491.1) were observed using a PCR-dependent molecular technique.

Staphylococcus haemolyticus is a Gram- positive bacterium and a member of coagulase – negative (CoN) staphylococci. It is part of the skin flora of humans, and its largest populations are usually found at the axillae, perineum, and inguinal areas [24]. It can be an opportunistic pathogen in humans, affecting people with compromised immune system, and is an important hospital- derived (nosocomial) infection. They are highly antibiotic – resistant phenotype and have the ability to form biofilms which makes *Staphylococcus haemolyticus* a difficult pathogen to treat [25].

Escherichia coli is a member of the bacterial family of enterobacteriaceae, is the most prevalent commensal inhabitant of the gastrointestinal tracts of humans and warm-blooded animals, as well as an important pathogen [26]. *Klebsiella* spp that cause pneumonia disease is *Klebsiella pneumonia* followed but to lesser degree by *Klebsiella oxytoca. Klebsiella pneumonia* is a facultative, anaerobic, non-motile, lactose – fermenting, and Gram-negative rods [27]. It exists as normal flora in the gastrointestinal tract of animals and humans and also normally inhabitants of soil, water and botanical environment. It can be an opportunistic pathogen in humans, affecting people with immunocompromised system, and is becoming increasingly important as a hospital – derived (nosocomial) infection [28, 29, 30]. Their presence in water sources could therefore lead to severe health issues.

Some studies on the bacteriological quality of water carried out in different locations in Nigeria had reported the presence of some bacterial genera, using cultural and molecular techniques. Eniola *et al*. [31] in a study implicated *Proteus vulgaris* and *Staphylococcus aureus* to be among the bacterial contaminants that influenced the quality of borehole water in storage tanks. A study conducted by Onuorah *et al*. [32] showed that *P. vulgaris* (46.7%) and *S. aureus* (13.3%) were among the prevalent bacterial species in borehole water in Ogbaru Communities, Anambra State, Nigeria. However, this study utilized a cultured dependent molecular method to identify bacterial species rarely reported by phenotypic identification alone. Furthermore, it has also presented a more reliable and

thorough approach, collaborating the findings of earlier researchers on microbial quality of domestic water sources.

5.0 Conclusion

This study had revealed that the physical and chemical parameters influencing water quality, except for pH, were within the limits for WHO guideline values.

The antibiotic susceptibility assay indicated that the majority of bacterial isolates were responsive to the convectional antibiotics tested. Therefore, this antibacterial drugs maybe vigorous in managing any outbreak caused by the bacterial species isolated in this study.

The molecular analysis was able to characterize some important bacterial isolates, including *Staphylococcus haemolyticus* strain SH1 (with accession number, MK886483.1), *Escherichia coli strain* Rizhao 4981(with accession number, MN314234.1) and *Klebsiella pneumoniae* strain CP27 (with accession number, PP346491.1), to their species and strain level.

Regular treatment of hostel water sources is therefore required maintain water of excellent quality and as well prevent microbial growth in water channels.

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