Physico-chemical and Bacteriological analyses of Domestic water sources in Orhionmwon Local Government Area, Edo State, Southern Nigeria

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ABSTRACT

The physicochemical and bacteriological qualities of water samples sourced from five communities in Orhionmwon LGA were determined using standard methods. Bacteriological enumeration was carried out the membrane filter technique and isolates identified using routine cultural and biochemical procedures. A total of 50 samples comprising of 25 wells and 25 ground water (borehole) samples were examined. The physicochemical parameters ranges include; pH{well water samples (5.64±0.19-6.56±0.06), ground water (borehole) samples (4.46±0.05-5.76±0.08)}, Electrical conductivity {well water samples (46.00±6.00 µS/cm-66.67±31.80µS/cm),ground water (borehole) samples (8.00±1.22µS/cm - 22.00±12.00µS/cm)}. The mean heterotrophic bacterial counts of the well water samples were highest in Ogan with counts of 8.24±1.09 × 10^2cfu/100ml.The mean coliform counts for both the well and ground water (borehole) samples were highest in Igbanke community with counts of 2.34 ± 0.25 × 10^2 cfu/100ml and 2.02±0.52 ×10^2 cfu/100ml respectively. Eight bacterial genera were isolated from the water samples namely, *Klebsiella, Pseudomonas, Proteus, Acinetobacter, Alcaligenes, Enterobacter, Citrobacte*r and *Escherichia*. Citrobacter freundii had the highest number of haemolytic isolates (83.33%). Pefloxaxin was the most active antibiotic against all the bacterial isolates as it was active against 97.62% of the isolates. For the respective water samples, the heterotrophic and coliform counts fall short of the WHO standards.

Key words: Borehole, Ground water, Haemolysin, Orhionmwon LGA, Serum resistance, Well water,

INTRODUCTION

Water is one of the most important natural resources. In 2015, Goal 6 of the sustainable development goals (SDGs) which deals with the need for all to have access to clean water and good sanitary services has been accepted by all UN States (UN, 2018).However, safe drinking water is not available to all and contaminated sources of drinking water is a major health risk. Bain *et al*. (2014) estimated that 1.8million people globally use a source of drinking water which is faecally contaminated and that drinking water is more contaminated in rural areas than in urban areas.

In Nigeria, about 66.3 million people have no access to safe drinking water (Ighalo and Adeniyi,2020).Water may be obtained as municipal pipe borne water, natural sources like rivers,streams and rain water (Niyi and Felix, 2007).In rural areas, only about 42.00% of

Nigerian population have access to safe water and open defaecation is still practiced by people (WHO/UNICEF, 2015).Reports of domestic water sources in Nigeria harboring potentially pathogenic bacteria and inadequate physio-chemical parameters abound in literature. Naturally occuring substances such as iron, barium, manganese, selenium, hydrogen sulphide and salt may be present at detrimental levels. Prolonged exposure to physio-chemical parameters and heavy metals above WHO standards maybe associated with different kinds of illnesses (Esemikose and Akoji, 2014). Coliform counts higher than the WHO(2008) standard of <10 per 100ml of drinking water as well as presence of bacteria such as *Escherichia coli*, *Klebsiella* spp., *Salmonella* spp. *Pseudomonas* spp., *Aeromonas* spp. and *Vibrio cholera* have been reported in domestic water samples(Adegboyega *et al*., 2015). Gambo *et al* (2015) reported that all the well water samples from the study location analysed in Kaduna had high coliform counts and none of them met the WHO standard of <10 coliforms/100ml of water .

Some of these bacteria that have acquired putative virulence factors such as genes for enterotoxin production, invasiveness as well as hemolysin production can be pathogenic to man. Bacteria with high resistance to common antibiotics such as ampicillin and cotrimozaxole have previously been reported in water sources (Ogunleye *et al*., 2016; Ogu *et al*., 2017).Waterborne diseases remain a major global public health issue and a great environmental concern and outbreaks are common in African countries (Manetu and Karanja, 2021).Waterborne diarrhea illness affects approximately 4 billion causing about 1.8 million deaths annually globally (United Nations,2014).

In Nigeria, cases of waterborne diseases such as typhoid fever,diarrhea and cholera still abound (Nwabor *et al*., 2016).Other waterborne diseases include respiratory tract and skin infections such as legionellosis, cellulitis and otitis externa. Those with access to safe drinking water in Orhionmwon LGA of Edo State with a population of approximately 118,054 is 35,416 (about 30.00%) as published in a field study by Idogho *et al*., (2013).This same report also indicated a widespread occurrence of water and sanitation related diseases in Edo State such as schistosomiasis,typhoid fever,cholera and diarrhea. The majority of people depend on borehole water which is either piped into tanks in the homes of those that can afford it or bought from water vendors/tankers or harvested rain water in hand dug wells.Water can become contaminated at source or during storage so care must be taken to avoid transmission of waterborne diseases at both events (Mintz *et al.*, 1995).

This study was designed to assess the physicochemical and bacteriological qualities of water samples obtained from wells and boreholes in five different communities in Orhionmwon LGA in Edo State, Nigeria.The need to study the bacteriological quality of

these water sources therefore becomes imperative as such data will not only help to raise awareness but also aid in developing preventive measures against water-borne infectious diseases.Most members of the aforementioned communities rely greatly on the availability of water from the wells which has been dug for over 10 years.

MATERIALS AND METHODS

Study Area/Design

The study was conducted in Orhionmwon LGA of Edo State, Nigeria with headquarters in Abudu. The local government is located in the rainforest belt of Nigeria between Longitude 5.9841^{o}or 5^{o}59'3"E and Latitude 6.2535^{o}or 6^{o}15'13"N.The state is bound by Kogi State to the East and to the North, Ondo State to the West and Delta State to the South with a landmass of 17,820 km^{2}.Most of the inhabitants are farmers.

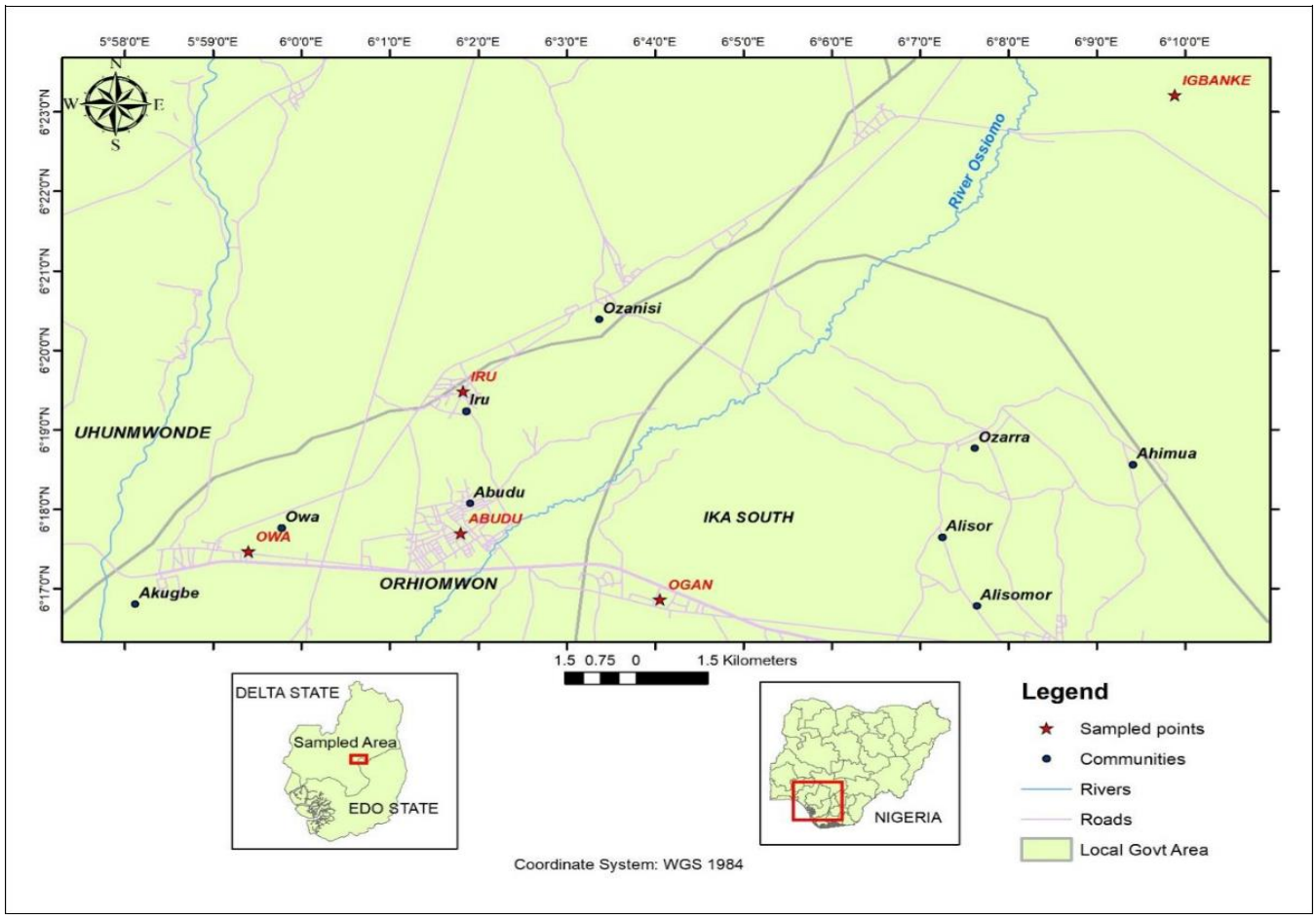

Fig 1: Map of Orhionmwon LGA showing the sampling locations

Sample Collection

Fifty (50) water samples were collected from five (05) communities (10 samples from each community comprising of five (05) wells and five (05) boreholes) in Orhionmwon Local Government Area, Edo State. They were collected into sterile plastic containers and

transported to the laboratory on ice pack coolers and refrigerated in cases when they were not analyzed immediately.

Physicochemical parameters

The hydrogen ion concentration (pH) of each sample and temperature were measured using a HACH digital pH/temperature meter respectively. Total alkalinity was determined by titrimetric method using standardized sulphuric acid, phenolphthalein and methyl orange indicator. Electrical conductivity of each water sample was also determined using a portable conductivity meter.The turbidity of the water samples were determined using the spectrophotometric method as described by APHA (1993) and phosphate by the method of (Radojevic and Bashkin, 1999).The total suspended solid,total dissolved solid, chloride,hardness, nitrate,calcium,magnesium,dissolved oxygen (DO), biological oxygen demand (BOD)and chemical oxygen demand (COD) values for the water samples were also determined using the methods described by Ademoroti (1996).

Bacteriological analyses

The method employed for bacteriological evaluation was the membrane filtration technique. One hundred (100) ml of water was passed through a membrane filter (0.45milipore diameter) using a membrane filtration apparatus. The membrane filter was then placed on nutrient agar and Macconkey agar and then incubated for 37^{o}C for 24 hours after which the bacterial colonies were counted. Enumeration of the total heterotrophic bacteria counts of the water samples was done on nutrient agar while coliform counts was done on Maconkey agar plates. The tentative identities of purified bacterial cultures was ascertained using conventional bacteriological techniques previously stated by Enabulele *et al.* (2022).

Haemolysin production

Haemolysin production was done using the method described by Martinez-Martinez *et al*. (1999).All bacterial isolates were grown in sheep's blood agar at 37^{o}C for 24 hours.The presence of clear zones around the colonies was taken as positive for haemolysin production.

Determination of serum resistance

The serum resistance was performed by the method described by Kumar and Mathur (1997) using pooled human serum from healthy individuals. The test bacteria was grown in Nutrient broth and incubated overnight at 37^{o}C. Equal volumes of pooled

serum from healthy individuals and the bacterial suspension were mixed and incubated in a water bath at 37^0C.Viable counts were performed at 0 and 3 hours. If more than 90% of the initial counts survive after 3 hours it is resistant, counts reduced to less than 1% is sensitive while between 1 and 90% is intermediate.

Antibiotic susceptibility test

This was done using the disc diffusion methodusing the following antibiotic-impregnated disc ampiclox (APX), gentamycin (CN), pefloxaxin (PEF), erythromycin,(E), septrin (SXT), ciprofloxacin(CPX), rocephin (R), amoxacillin (AM), zinnacef (Z) and streptomycin (S).The plates were incubated at 37ºC for 24 hours after which the zones of inhibition were measured and interpreted as resistant (R), or sensitive (S) as described by the Clinical Laboratory Standards Institute (2017).

Statistical analysis

Mann-Whitney unpaired sample T test was used to ascertain if the differences in the heterotrophic bacterial and coliform counts of the different water samples; well water and ground water (borehole) water was significant (α=0.05). This was conducted with the aid of SPSS software version 22.

RESULTS

The pH of the well water samples ranged from 5.64 ± 0.19 (Ogan) - 6.56 ± 0.06 (Owa) while that of the ground water (borehole) samples ranged from 4.46 ± 0.05 (Igbanke) – 5.76 ± 0.08 (Owa) (Table 1 and 2).The temperature of the well water and ground water (borehole) samples ranged between 26.50 ± 0.39^{0}C (Iru) to 29.20± 0.51^{0}C (Ogan) and 27.93± 0.44^{0}C (Abudu) to 31.20 ± 0.37^{0}C (Owa) respectively.

The Electrical Conductivity (EC) had a range of 46.00± 6.00 µS/cm (Owa) to 66.67± 31.80 µS/cm (Abudu) for the well water samples and 8.00±1.22µS/cm (Iru) to 22.00±12.00µS/cm (Owa) for the ground water (borehole) water samples (Table 1 and 2). The BOD had a range of 2.55± 0.93 mg/l (Abudu) to 3.40± 1.38 mg/l (Owa) and 0.84± 0.19mg/l (Abudu) to 4.14± 0.45 mg/l (Igbanke) for the well and borehole samples respectively .The dissolved oxygen (DO) values ranged from 4.12±0.22 mg/l (Abudu) to 6.62±0.73mg/l(Igbanke) for the well water samples and 5.70±0.36mg/l(Iru) to 8.64±0.23mg/l(Igbanke) for the ground water (borehole) samples.The nitrate values ranged from 1.32±0.32mg/l(Iru) to 3.34±2.07mg/l (Abudu) and 1.04±0.05mg/l (Abudu) - 2.05±0.48mg/l (Owa) for the well and ground water (borehole) samples respectively. The COD had values ranging from 20.67±0.78mg/l

(Abudu) - 29.60±4.71 mg/l (Ogan) and 14.20±2.20mg/l (Ogan) – 23.60±1.78mg/l(Iru) for the well and ground water (borehole) samples respectively.

Table 1: Physicochemical parameters of well water samples in Orhionmwon L.G.A., Edo State

Parameter	Abudu	Iru	Owa	Igbanke	Ogan	NSDWQ Limit	WHO Limit
pH	5.93±0.15	6.10±0.07	6.56±0.06	5.96±0.04	5.64±0.19	6.5-8.5	6.5-8.5
Tempt. (°C)	27.80±0.78	26.50±0.39	28.96±0.44	28.80±0.58	29.20±0.51	27	< 35
EC (µS/cm)	66.67±31.80	64.00±16.00	46.00±6.00	64.00±14.35	46.00±6.78	1000	1000
Turb. (NTU)	1.00±1.00	0.00±0.00	8.80±2.33	0.60±0.60	0.80±0.37	5.0	1.0-5.0
TSS (mg/L)	2.67±1.33	0.00±0.00	2.80±1.88	7.20±1.11	5.60±0.87	< 10	< 10
TDS (mg/L)	35.33±16.85	33.98±8.42	28.62±3.97	33.92±7.61	24.38±3.59	500	500
Alkalinity (mg/L)	44.00±24.44	58.60±5.65	54.80±15.56	32.80±5.57	20.80±5.08	100-200	120
Chloride (mg/L)	11.77±2.35	11.30±1.73	12.71±1.41	16.94±1.73	14.12±2.23	250	250
Hardness (mg/L)	44.00±24.44	62.40±8.30	50.00±11.88	40.80±4.76	57.60±15.01	150	100-500
Phosphate (mg/L)	0.45±0.28	0.21±0.02	0.38±0.05	0.36±0.02	0.40±0.12	5	5
Nitrate (mg/L)	3.34±2.07	1.32±0.32	1.64±0.21	2.08±0.36	2.10±0.44	50	40-50
Calcium (mg/L)	14.43±9.66	18.43±4.51	18.44±4.95	17.47±3.16	22.44±5.87	75	200
Mg (mg/L)	1.95±0.56	4.02±1.16	1.07±0.24	0.97±0.27	0.49±0.00	20	20
DO (mg/L)	4.12±0.22	6.02±0.45	6.12±1.48	6.62±0.73	4.94±0.55	1-5	1-10
BOD(mg/L)	2.55±0.93	3.06±0.14	3.40±1.38	2.56±0.73	3.28±0.53	10	10
COD(mg/L)	20.67±0.78	26.80±2.67	21.20±1.11	23.20±2.54	29.60±4.71	10	30

Key: Tempt. = Temperature, Turb. = turbidity, EC = electrical conductivity, TSS = total suspended solids, DO = dissolved oxygen, TDS = total dissolved solid, COD = Chemical oxygen demand, Mg = magnesium, BOD = biological oxygen demand,; NSDWQ= Nigerian Standard for drinking water quality, WHO =World Health Organization

Table 2: Physicochemical parameters of Ground water samples in Orhionmwon LGA, Edo State

Parameter	Abudu	Iru	Owa	Igbanke	Ogan	NSDWQ Limit	WHO Limit
pH	5.27±0.12	5.50±0.17	5.76±0.08	4.46±0.05	4.50±0.03	6.5-8.5	6.5-8.5
Tempt. (ºC)	27.93±1.44	29.60±0.93	31.20±0.37	30.20±1.36	30.60±0.24	27	< 35
EC (µS/cm)	16.67±6.67	8.00±1.22	22.00±12.00	14.00±2.45	16.00±2.45	1000	1000
Turb. (NTU)	1.00±1.00	0.40±0.40	0.60±0.24	0.40±0.24	0.00±0.00	5.0	1.0-5.0
TSS (mg/L)	0.33±0.33	0.00±0.00	0.00±0.00	2.00±0.63	0.60±0.40	< 10	< 10
TDS (mg/L)	9.03±3.43	4.44±0.71	11.90±6.30	7.60±1.22	8.60±1.22	500	500
Alkalinity (mg/L)	8.67±0.67	10.80±1.02	8.80±0.80	8.00±0.89	4.80±0.49	100-200	120
Chloride (mg/L)	11.77±2.35	12.71±1.41	14.12±0.00	14.12±0.00	15.53±2.64	250	250
Hardness (mg/L)	7.33±0.67	8.80±1.02	9.20±1.02	9.60±0.40	8.80±0.80	150	100-500
Phosphate (mg/L)	0.19±0.07	0.14±0.02	0.20±0.02	0.26±0.01	0.25±0.01	5	5
Nitrate (mg/L)	1.04±0.05	1.76±0.68	2.05±0.48	1.64±0.44	1.25±0.38	50	40-50
Calcium (mg/L)	1.33±0.27	1.29±0.32	2.08±0.32	1.76±0.16	1.92±0.19	75	200
Mg (mg/L)	0.97±0.00	1.56±0.24	1.07±0.28	0.87±0.10	0.97±0.27	20	20
DO (mg/L)	5.74±1.37	5.70±0.36	7.54±0.29	8.64±0.23	5.80±0.60	1-5	1-10
BOD(mg/L)	0.84±0.19	2.76±0.09	2.68±0.59	4.14±0.45	3.00±0.73	10	10
COD(mg/L)	16.33±0.88	23.60±1.78	19.60±1.50	18.00±2.94	14.20±2.20	10	30

Key: Tempt. = Temperature, Turb. = turbidity, EC = electrical conductivity, TSS = total suspended solids, DO = dissolved oxygen, TDS = total dissolved solid, COD = Chemical oxygen demand, Mg = magnesium, BOD = biological oxygen demand,; NSDWQ= Nigerian Standard for drinking water quality, WHO =World Health Organization

The mean total heterotrophic bacterial counts of the water samples were from 3.20 ±0.56 $\times 10^2$cfu/100ml (Iru) – 8.24 ±1.09 × 10^2cfu/100ml (Ogan) for the well water samples and 1.28±0.22 × 10^2cfu/100ml(Iru) - 4.36 ±1.31 × 10^2cfu/100ml (Igbanke) for the ground water (borehole) samples (Table 3). The mean coliform count ranged from 0.48 ±0.25 $\times 10^2$cfu/100ml (Iru) – 2.34 ±0.25 $\times 10^2$cfu/100ml (Igbanke) for the well water samples and 0.66 ± 0.25 $\times 10^2$cfu/100ml (Iru) – 2.02±0.52 $\times 10^2$cfu/100ml (Igbanke) ground water (borehole) water samples.The observed differences between the mean heterotrophic

bacterial and coliform counts obtained for the respective well water and ground water (borehole) samples was significant ($P< 0.05$).

Eight bacterial genera were isolated namely *Klebsiella*, *Pseudomonas*, *Proteus*, *Acinetobacter*, *Alcaligenes*, *Enterobacter*, *Citrobacter* and *Escherichia* (Table 4). *Klebsiella pneumonia* (60.00%) followed by *Pseudomonas aeruginosa* (32.00%) were the most frequently isolated species.

Haemolysin production and serum resistance were assayed for all the isolates some of which were positive (Table 5). All isolates of *E.aerogenes*, 6(83.33 %) of *C. freundii* and 9(66.67%) of *P. aeruginosa* produced haemolysin while none of the isolates of *P.vulgaris* and *A. faecalis* produced hemolysin. All (100%) isolates of *Proteus* sp. and *Escherichia coli* were resistant to serum while 90.90% *A. faecalis*, 77.78% of *P. aeruginosa* and *E. aerogenes* were also resistant. *Acinetobacter* sp. and *C. freudii* had the least percentage (50.00%) of resistant isolates. Most of the bacterial isolates were sensitive to pefloxacin and ciprofloxacin as the percentage of sensitive isolates were found to be 82(97.62%) and 81(96.43%) respectively (Table 6). They were least sensitive to ampiclox, zinnacef and amoxicillin with 1(1.19%), 19(22.62%) and 29(29.76%) respectively. Multiple antibiotic resistance patterns were exhibited by some of the isolates from the well and ground water (borehole) samples.

Table 3: The mean heterotrophic and coliform count of the wells and Ground water (borehole) samples in Orhionmwon LGA, Edo State

Location	**Mean heterotrophic count ×10^{2}cfu/100ml**		**Mean coliform count ×10^{2}cfu/100ml**	
	Wells	Ground water (Borehole)	Wells	Ground water Borehole
Abudu	3.44±0.13	2.64±0.44	0.74±0.13	0.84±0.22
Iru	3.20±0.56	1.28±0.22	0.48±0.25	0.66±0.25
Owa	4.80±1.44	1.64±0.52	1.38±0.39	0.94±0.46
Igbanke	4.70±0.86	4.36±1.31	2.34±0.25	2.02±0.52
Ogan	8.24±1.09	2.24±0.34	2.20±0.77	1.28±0.19

Table 4: Frequency of occurrence of bacterial isolates from well and ground water (borehole) samples in Orhionmwon LGA, Edo State

Organisms		**Occurrence (%)**	
	Well samples	**Ground water (Borehole) samples**	**Total (%)**
	n=25	n=25	
Klebsiella pneumoniae	15(60.00)	15 (60.00)	30 (60.00)
Alcaligenes faecalis	(24.00)	5(20.00)	11 (22.00)
Pseudomonas aeruginosa	(32.00)	1(4.00)	9 (18.00)
Klebsiella oxytoca	6(24.00)	2(8.00)	8(16.00)
Enterobacter sp.	(8.00)	5(20.00)	7 (14.00)
Citrobacter freundii	(12.00)	3(12.00)	6 (12.00)
Escherichia coli	(12.00)	3(12.00)	6 (12.00)
Acinetobacter sp.	(12.00)	1(4.00)	4 (8.00)
Proteus mirabilis	(8.00)	0(0.00)	2 (4.00)
Proteus vulgaris	(4.00)	0(0.00)	1 (2.00)

Key: n=No of samples

Table 5: Hemolysin production and serum resistance of bacteria isolates from well and ground water (borehole) water samples in Orhionmwon LGA , Edo State

Bacterial isolates	**Number tested**	**Haemolysin No/ (%)** positive	**Serum resistance N/ (%)**	
			Intermediate	**Resistance**
Klebsiella sp.	38	12(31.58)	17 (44.74)	21 (55.26)
Pseudomonas aeruginosa	9	6 (66.67)	2(22.22)	7(77.78)
Proteus mirabilis	2	1(50.00)	0(0.00)	2(100.00)
Acinetobacter sp.	4	1 (25.00)	2(50.00)	2(50.00)
Proteus vulgaris	1	0(0.00)	0 (0.00)	1(100.00)
Alcaligenes faecalis	11	0(0.00)	1(9.00)	10(90.90)
Enterobacter aerogenes	7	7 (100)	2(28.57)	5(71.43)
Citrobacter freundii	6	5 (83.33)	3(50.00)	3(50.00)

Escherichia coli	6	2 (33.33)	0(0.00)	6(100.00)

Table 6: Antibiotic sensitivity pattern (%) of bacterial isolates from domestic water samples

	Antibiotic sensitivity (%)									
Isolates (n)	**APX**	**CN**	**PEF**	**E**	**SXT**	**CPX**	**R**	**AM**	**Z**	**S**
K. pneumoniae (30)	0.00	20(66.70)	29(96.70)	25(83.30)	25(83.3)	28(93.30)	20(66.70)	18(60.00)	7(23.30)	25(83.30)
K.oxytoca (08)	0.00	7(87.50)	8(100.00)	6(75.00)	6(75.00)	8(100.00)	7(87.50)	2(25.00)	0(0.00)	7(87.50)
Pseudomonas aeruginosa (09)	0.00	5(55.60)	9(100.00)	6(66.70)	5(55.60)	8(88.90)	7(77.80)	0(0.00)	1(11.10)	6(66.70)
Proteus sp.(03)	0.00	3(100.00)	3(100.00)	3(100.00)	2(66.70)	3(100.00)	3(100.00)	0(0.00)	0(0.00)	3(100.00)
Acinetobacter(04)	0.00	3(75.00)	4(100.00)	2(50.00)	3(75.00)	4(100.00)	3(75.00)	1(25.00)	1(25.00)	3(75.00)
Alcaligenes faecalis (11)	0.00	8(72.70)	11(100.00)	10(90.90)	7(63.60)	11(100.00)	6(54.50)	1(9.09)	1(9.09)	7(63.60)
Citrobacter freundii (06)	1(16.60)	6(100.00)	6(100.00)	5(83.30)	6(100.00)	6(100.00)	5(83.30)	0(0.00)	2(33.30)	6(100)
Enterobacter aerogenes (07)	0.00	3(42.90)	6(85.70)	6(85.70)	4(57.10)	7(100.00)	3(42.90)	3(42.90)	2(28.60)	6(85.70)
E. coli (06)	0.00	3(50.00)	6(100.00)	3(66.70)	4(66.70)	6(100.00)	3(50.00)	0(0.00)	5(83.30)	5(83.30)
Total	1(1.19)	58(69.04)	82(97.62)	67(79.76)	62(73.81)	81(96.43)	57(67.86)	25(29.76)	19(22.62)	68(80.95)

Key: APX-Ampiclox, CN-Gentamycin, PEF-Pefloxaxin, E-Erythromycin, SXT-Septrin, CPX-Ciprofloxacin, R-Rocephin, AM-Amoxacillin, Z-Zinnacef, S-Streptomycin

DISCUSSION

Water samples from the four of the five communities had pH values below the stipulated standard of 6.50-8.50 by the World Health organization (2011) and Nigerian Standard for Drinking Water (2015).This is in line with the report of Ogunleye *et al.,*(2016) and Adediji and Ajibade (2005) who observed low values in the pH of the well water samples.None of the ground water (borehole) samples fell within the stipulated range of 6.50-8.50.They all had values lower than that from the well water samples. The low pH could be as a result of leaching of metallic ions around the soil surrounding the wells and also the CO_2 produced from respiration of organisms in the water (Edema *et al.,* 2001).

Water with low pH could lead to eye and gastrointestinal afflictions, skin irritations and could also directly affect the taste of the water, giving it a sour taste (WHO,1996).The DO concentration was within the acceptable range of the (WHO,2011) but fell below that of (NSDWQ,2015).Higher values of dissolved oxygen was also reported for well water samples in Illorin(Kolawole and Afolayan,2017) and Elemile *et al*., (2011) in Kwara State, Nigeria. All other parameters namely temperature, turbidity, electrical conductivity, phosphate total suspended solids, total dissolved solids, biochemical oxygen demand and oxygen demand fell within the WHO standards for water.

The total heterotrophic plate counts (HPC) has been used for a long time to access the quality of water supplies. However, HPC greater than 500cfu/ml would indicate a decrease in water quality that should trigger further investigation(Verhille,2013).The range of mean heterotrophic plate count in this report was lower than values recorded for well and borehole water samples from Zaria (Adesakin *et al.*, 2020).Although counts from the water samples were lower than 500cfu/ml, the range of the mean coliform counts in this study were comparatively higher than the acceptable standards of 10 cfu/100ml prescribed by (SON,2007) with respect to drinking water.

The presence of coliforms in the water samples is an indication of faecal contamination of the water sources. The high coliform count observed is in agreement with the report of Ukpong *et al*., (2013) in Calabar, Nigeria which did not meet the WHOr permissible limit. Most wells arefound at lower elevation compared to the fields used for open defecation. Hence, fecal matter produced by animals and man can inevitably reach the water sources through run-offs and increase the contamination.The higher counts in the wells more than the borehole water samples could be as a result of shallowness of the wells, human activities around the wells such as washing of clothes, plates, contamination from the buckets and ropes used in obtaining water from the wells. This corroborates the findings of

Allamin *et al*., (2015) who observed higher counts in the wells than the ground water (borehole) water samples analysed from Kaduna metropolis.

Some of the isolates from this study such as *Esherichia coli*, *Enterobacter* sp., *Pseudomonas* sp., *Klebsiella* sp. and *Proteus* sp. have also been isolated from both well and borehole water samples by others (Ibe and Okplenye , 2008; Ogunleye *et al*., 2016) previously. The presence of *E. coli* in the water samples could mean the pollution of the water source with faecal matter either from sewage disposal or from human activities. The majority of isolates obtained in this study are known opportunistic pathogens. Some such as *E. coli*, *Klebsiella pneumoniae*, *Enterobacter* spp., *Proteus* spp., *P. aeruginosa* e.t.c could contaminate and cause wound infections (Enabulele *et al*.,1996), urinary tract infections (Ibadin *et al.,* 2018). Diarrheargenic strains of *E. coli* could cause diarrhea .

Haemolysin production and serum resistance test were carried out as a measure of bacteria virulence. The number of hemolytic strains varied amongst the species isolated.All the strains of *E. aerogenes* were hemolytic. Organisms with alpha or beta hemolytic ability are able to lyse red blood cells or other nucleated cells in the blood thereby enabling it to invade and cause disease.The serum resistant attribute of an organism is the ability of the organism to evade serum killing and this attribute could enhance their pathogenic potential. All the isolates of *Escherichia coli* , *Proteus vulgaris* and *Proteus mirabilis* were resistant to the bacteriocidal action of blood serum.Serum is composed of a number of proteins and also the complement system which are important components of the immune system.

The antibiotic susceptibility pattern showed that the bacterial species isolated from this study were most susceptible to perfloxacin and ciprofloxacin with 97.62% and 96.43 % respectively. The isolates were least sensitive to ampiclox and zinnacef with 1.19% and 22.62% respectively. Similar results were reported by Odonkor and Addo (2018) where *E.coli* strains from wells, ground water, streams and dams were most sensitive to cefotaxime, gentamycin and ciprofloxacin and least sensitive to the penicillin and ampicillin.Sources of contamination of water bodies by antibiotic resistant bacteria could be human or animal wastes, runoffs from pharmaceutical companies and livestock farms such as poultry farms. Thus siting of such facilities near domestic water sources should be discouraged. There is also need to get people aware of the need for disinfection of water from such sources such as boiling before consumption.

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