PHYSICOCHEMICAL QUALITY AND ANTIBIOTIC RESISTANCE PROFILE OF BACTERIA ISOLATED FROM WELL WATER IN TWO SLUMS IN MINNA, NIGER STATE

MAUDE, A. MOHAMMED & 1JAH, U. J. JOSIAH
Department of Microbiology,
Federal University of Technology, Minna, Nigeria
Email: a.maude@futminna.edu.ng, udemijah@yahoo.com
Phone: +234-803-369-9931, +234-803-589-0201

Abstract
Water plays an indispensable role in sustenance of life and yet, it is one of the major source of transmission of enteric pathogens in developing countries. The aim of this study was to determine the physicochemical and bacteriological qualities of twenty well water samples from two slum communities (Kpakungu and Barikin Sale) in Minna, Niger State using standard methods. The antibiogram of the bacterial isolates was determined using disc diffusion method. Results analysis revealed a significant ($p<0.05$) total viable bacterial counts (TVC) (3.5×10^6 to 9.9×10^6 cfu/mL) and (2.5×10^5 to 4.7×10^6 cfu/mL) from Kpakungu and Barikin Sale well water respectively. The coliform counts and Vibrio cholerae counts for water samples from both slums were higher than World Health Organization (WHO) maximum acceptable limit and Nigerian Standard for Drinking Water Quality (NSDWQ). Similarly, the counts of Salmonella ranged from 1.0×10^2 to 7.10×10^3 cfu/mL in Kpakungu well water. Escherichia (23.7%, 26.9%), Klebsiella (11.3%, 10.3%), Pseudomonas (4.1%, 9.0%), Staphylococcus (5.2%, 14.1%), Streptococcus (8.2%, 7.7%), Micrococcus (1%), Vibrio (3.1%, 1.3%), Salmonella (6.2%) and Bacillus (3.1%, 3.8%) were isolated from both slums. The physicochemical parameters of the well water were within the acceptable limit set by WHO and NSDWQ for drinking water. Interestingly, lead and arsenic were not detected in the water samples. Vibrio cholerae was resistant to most antibiotics tested. Staph. aureus (43%) was resistant to Amoxyl and Ampiclox. Pseudomonas aeruginosa (75%) was resistance to Nalidixic acid while Salmonella typhi showed 83% resistance to Augmentin (AU) and Ampicillin (PN). The results of this study suggest that well water from both slums were contaminated with bacterial pathogen with potential health hazard. Therefore, the need to provide potable water source cannot be overemphasized.

Keywords: Bacteria, slums, physicochemical, water, antibiotics.

Introduction
Water plays an important role in the digestion, absorption of food, transportation of nutrients in the body and elimination of waste products via urine (Aydin, 2007). It is used directly or indirectly in variety of processes. Sources of water include streams, ponds, wells, rivers, taps, oceans and rain water (Musliu *et al*., 2011). Water is the major source of transmission of enteric pathogens in developing countries. This is due to lack of potable water especially in the rural communities (Bolarinwa & Odunola, 2012). According to UNICEF (2004), everyone has the right to have access to potable and safe drinking water. Access to such potable water brings clear health benefits (Adamou *et al*., 2020).

A slum is a densely populated usually urban area marked by overcrowding, poverty, dirty run down houses, limited water, electricity and absence of basic and essential facilities (Adeniran, 2018). United Nations Commission on Human Settlements (UNCHS) defines a slum as "a term used to describe a wide range of low-income settlements and/or poor human living conditions (UNCHS, 2002).

Slum dwellers lack access to potable water. There is therefore the likelihood of outbreak of diseases such as cholera, typhoid, and meningitis. The disease conditions make individuals less productive. There have been cases of death, particularly in slums due to consumption of contaminated water and poor sanitation (Ijah & Stephen, 2006). Also, physicochemical components such as heavy metals and other chemical pollutants poses serious health risk effects with varied symptoms depending on the nature and quantity of the metal ingested (Bello *et al.*, 2013).

In Nigeria, particularly Niger State, there are no guiding principles governing the location, construction and operation of water sources particularly wells. Although, much emphasis has been laid on bacteriological quality of tap and borehole water in Minna, Niger State but less attention is given to wells which could be the major source of water in a particular location and this source is not taken care of. Bacteria including *E. coli*, *Pseudomonas* and *Salmonella* specie have been found to contaminate water sources. These organisms exhibit resistance to commonly used antibiotics and thus, poses problem to public health (Manji, 2012). Therefore, the bacteriological and physicochemical quality of these water sources available in the two slum communities should be assessed.

Furthermore, there is also lack of standard water treatment facilities and inadequate disease outbreak surveillance programme in slum communities. Hence, analysis of well water from time to time is necessary and this will help the government in taking necessary precautions or institute corrective measures against outbreak of diseases in slums. Studies on water quality will also guide policy makers in setting out policies towards establishing a good water source. The study is relevant in assuring whether the quality of the water sources meet regulatory standards because potable water is essential to life. This study could also draw government's attention towards slum dwellers thereby granting them a better life.
The aim of this study was to assess the physicochemical quality, bacterial population and their antibiotic resistance, of well water in two slums in Minna, Nigeria.

Materials and Methods

Study Areas

This study was carried out in Kpakungu and Barikin Sale slums in Minna, Niger State, Nigeria. Niger State is located between latitude 8^0 10′ N and 10^0 30′ N and between longitude 3^0 30′ E and 7^0 30′ E. Minna is located at the north-eastern part of the land that makes up Niger State along the Lagos-Kano railway track (Adeleye *et al.*, 2014). Kpakungu and Barikin Sale are major settlements under Bosso local government area of Niger State and are faced with the problem of over-crowding resulting from massive urban influx. Due to this reason, these areas are forced to grow in an unplanned way. However, access to adequate potable water and good sanitation remain a problem of concern. Their major source of water are wells.

Collection of water Samples

A total of twenty (20) samples of well water, ten (10) each from Kpakungu and Barikin Sale slums were collected randomly. The water samples were collected using a bucket tied to a rope, used by the slum dwellers and then filled into a two hundred milliliter (200ml) sterile screw-top bottle, leaving an inch space for vigorous shaking. The water samples were collected in duplicates for three months (November, February and May). The samples were transported to the laboratory in insulated containers with ice, stored in a refrigerator at a temperature of 4^oC, and analyzed within twenty four hours of collection following the method of Cheesbrough (2009).

Physicochemical Analysis of Water Samples
The water samples were analyzed for pH, temperature, turbidity, total dissolved solids, electrical conductivity, Nitrate, Sulphate, Phosphate, Copper, Iron, Total hardness, Dissolved Oxygen (DO), Chemical oxygen demand (COD), Biochemical Oxygen Demand (BOD), Lead, Chromium, Manganese, Zinc, Nickel, and Arsenic as described by the American Public Health Association (1998) and Winklers method (Ademoroti, 1996).

Enumeration of Bacteria
The water samples were analyzed for total viable bacteria (TVB), Total coliforms, Faecal coliforms, *Salmonella*|*Shigella* and *Vibrio* species.

Total viable bacteria and total coliform bacteria
Total viable bacteria and total coliform bacteria in water samples were obtained using pour plate methods (Cheesbrough, 2009). Each water sample was serially diluted into 10 folds dilution. An aliquot (0.1ml) of 10^{-5} and 10^{-6} dilution factors were aseptically dispensed into seperate sterile petri dishes and 20ml each of Nutrient agar (for enumeration of total viable bacteria) and MacConkey agar (for enumeration of total coliform bacteria) respectively was added. This was properly mixed, allowed to solidify and then incubated at 37^{O}C for 24-48 hours. Discrete colonies which appeared on the plates were counted and the results expressed as colony forming units per milliliter (CFU/ml) of the water sample (Anon, l994).

Faecal coliforms
The water samples were analyzed for faecal coliforms by Membrane Filtration Method (Noble *et al*., 2003). An absorbent pad was soaked with membrane lauryl sulphate broth. The water samples were shaken thoroughly and 100ml of the water samples were filtered simultaneously using 0.45µm pore sized membrane filter with 47mm diameter. The filters were placed on the soaked pad. The plates were inverted and incubated at 44.5^{O}C for 24hours. After incubation, yellow discrete colonies formed were counted and expressed as colony forming units per 100ml (Cfu/100ml) of the water sample.

***Salmonella* and *Shigella* species**
An aliquot (0.1ml) of 10^{-2} and 10^{-3} dilution factors was aseptically dispensed into sterile petri dishes using pour plate method and 20ml of *Salmonella Shigella* agar (SSA) was added. The plates were properly mixed, allowed to solidify and then incubated at 37^{O}C for 24-48 hours for enumeration of *Salmonella* and *Shigella* (Cheesbrough, 2009). Blackish and colorless discrete colonies which appeared on the plates were counted and the results expressed as colony forming units per milliliter (CFU/ml) of the water sample (Anon, l994).

***Vibrio* species**
An aliquot (0.1ml) of 10^{-2} and 10^{-3} dilution factors was aseptically dispensed into sterile petri dishes using pour plate method and 20ml of Thiosulphate citrate bile salt sucrose (TCBS) was added. The plates were properly mixed, allowed to solidify and then incubated at 37^{O}C for 24-48 hours for enumeration of *Vibrio* species (Cheesbrough, 2009). Yellowish discrete colonies which appeared on the plates were counted and the results expressed as colony forming units per milliliter (CFU/ml) of the water sample (Itah *et al*., 1996).

Identification of bacterial Isolates
Bacterial isolates were identified by biochemical tests (Cappuccino & Sherman, 2004). Biochemical tests included coagulase, oxidase, catalase, hydrogen sulphide, indole, citrate, indole, methyl red (MR), voges proskauer, nitrate reduction, spore, motility, starch hydrolysis and carbohydrate fermentation tests. The bacterial isolates were identified by

comparing their characteristics with those of known taxa using the scheme of Cowan and Steel (1995).

Antibiotic Sensitivity Testing of Isolates

Antibiotic sensitivity testing was performed using commercially available antibiotic discs, following Kirby Bauer disc diffusion method (Song, 2011). A loopful of the organism was inoculated in nutrient broth and incubated at 35°C for 6 hours. Sterile cotton swab was used to spread the culture on a dried surface of Mueller-Hinton agar. The anti-microbial disk was placed onto the surface of the inoculated agar plate. The plates were incubated at 35°C for 18 hours. After incubation, each plate was examined for diameter zone of inhibition and measured using a verrnier calliper in millimeter and expressed in percentage (Song, 2011).

Statistical Analysis

The data generated was subjected to statistical analysis using analysis of variance (ANOVA) at 95% confidence limit to determine the significant differences between the values obtained for bacterial counts, as well as physicochemical properties of the water samples (Okunye & Odeleye, 2015).

Results and Discussion

Physicochemical Properties of Water Samples

Table 1 shows the physicochemical qualities of well water samples in Kpakungu and Barikin Sale slums. Temperature, conductivity, total dissolved solids, pH, copper, phosphate, manganese, zinc, sulphate and Arsenic in the wells are within the acceptable limits prescribed by NSDWQ (2007) and WHO (2012). The value for turbidity of water samples from wells in Barikin Sale (3.30 NTU) was within acceptable limit but above limit for well water samples in Kpakungu slum (6.27 NTU) prescribed by NSDWQ (2007). Total hardness of the water was not within acceptable limit prescribed by NSDWQ (2007), but fell within limit (200mg/l) stipulated by WHO (2012). Kpakungu slum recorded 181.55mg/l while Barikin Sale slum recorded 179.20mg/l (Table 1). Similarly, the values for total hardness were not higher than the limits prescribed by NSDWQ (2007) and WHO (2012). The nitrate contents of the well water from both slums were higher than the acceptable values. Kpakungu recorded 83.75mg/l while Barikin Sale recorded 69.31mg/l (Table 1). The heavy metals, chromium and nickel had values above the acceptable limits (Table 1).

Table 1: Physicochemical properties of water samples from wells in Kpakungu and Barikin Sale slums

	Barikin Sale slum	**Kpakungu slum**	**Standards By: NSDWQ**	**WHO**
Turbidity(NTU)	3.30±1.40[a]	6.27±2.50[b]	5.00	25
TDS(mg/l)	355.00±44.18[a]	379.09±51.16[b]	500.00	1000
Conductivity ($\mu s/cm$)	725.00±92.82[a]	802.73±87.34[a]	1000.00	NS
Temp(^{O}C)	28.53±0.39[a]	28.92±0.43[a]	Ambient	NS
Nitrate(mg/l)	69.31±22.74[a]	83.75±11.91[a]	50.00	4.5
pH	6.48±0.46[a]	6.83±0.84[a]	6.50-8.00	6.5-8.5
Sulphate(mg/l)	58.90±12.42[a]	58.91±11.45[a]	100.00	250
Phosphate (mg/l)	1.00±1.13[a]	1.12±0.18[a]	NS	NS
Total hardness (mg/l)	179.20±20.56[a]	181.55±22.09[a]	150.00	200
COD(mg/l)	12.22±4.28[a]	38.18±17.28[b]	NS	NS
BOD(mg/l)	4.50±1.65[a]	14.15±6.37[b]	NS	10.00
DO(mg/l)	6.08±0.43[b]	4.13±0.87[a]	NS	5-7

Heavy metals				
Lead(mg/l)	0.00±0.00[a]	0.00±0.00[a]	0.01	0.01
Chromium (mg/l)	0.10±0.01[a]	0.14±0.05[a]	0.05	0.05
Manganese (mg/l)	0.39±0.64[a]	0.29±0.04[a]	0.20	0.5
Zinc(mg/l)	0.95±0.21[a]	1.26±0.34[b]	3.00	3.00
Nickel(mg/l)	0.10±0.04[a]	0.15±0.040[b]	0.02	0.02
Arsenic(mg/l)	0.00±0.00[a]	0.00±0.00[a]	0.01	0.01
Iron (mg/l)	0.02±0.01[a]	0.04±o.03[a]	0.30	0.30
Copper(mg/l)	0.12±0.04[a]	0.14±0.09[a]	1.00	2.0

Values followed by the same alphabet on the same column are not significantly different at P>0.05

Values are presented as mean (±standard error) of water samples from 20 wells. NS = not stated,TDS= Total dissolved solids, COD= Chemical oxygen demand, BOD= Biological oxygen demand, DO= Dissolved oxygen, Mg/l = Milligram per liter, NTU = Nephelometric tubidity unit.

High values recorded for turbidity may be probably because some wells were left uncovered and received a high level of suspended particulate matter. Turbidity is also influenced by seasons. The rise in turbidity with rains may be due to surface run off introducing both organic and inorganic materials from the soil into the wells (Ijah & Stephen, 2006; Desalegn, 2014). The total hardness of water is a reflection of the presence of magnesium and calcium carbonates in the water. The result obtained in the present study agrees with that of Musliu *et al*., (2011) which recorded hardness of water in the wells of both limestone mined and non – limestone mined areas in Sokoto, Nigeria. This implies that the well water is likely to waste soap and may not easily form lather with detergent. The presence of nitrate in water samples may be due to domestic waste entering the uncovered wells and surface run off from farm lands previously enriched with inorganic fertilizers (Desalegn, 2014; Abu & Wondikom, 2018). Excessive comsumption of nitrate in drinking water has been associated with the risk of methemoglobinemia or blue baby syndrome which could affect infant if untreated (Desalegn, 2014). High value of BOD recorded indicates the high level of contamination of the wells.

Presence of heavy metals may be due to leaching of mineral from the ores. Heavy metals enter into the environment mainly through deposition of atmospheric particulate, disposal of metal enriched sewage sludges and sewage effluents and by-products from metal mining process (Adeniran, 2018). Presence of iron in water sources may be as a result of weathering processes near water sources thereby releasing the element into water. It could also be as a result of corrosion of iron and steels (Itah *et al*., 1996). High concentration could give rise to iron-dependent bacteria which can deteriorate the quality of water by development of slimes and odour (Kangpe *et al*., 2014).

Bacterial counts

The total viable bacterial (TVB) counts in well water in Kpakungu and Barikin Sale slums are presented in Figure 1. Higher bacterial counts were obtained in November ($3.5 \times 10^6 – 9.9 \times 10^6$CFU/ml) than other months for Kpakungu while in Barikin Sale, higher counts were obtained in May ($2.5 \times 10^5 – 4.7 \times 10^6$ CFU/ml) than other months (Figure 1). The counts were significantly different (P<0.05) in the wells between the two slums. This implies that there were high viable bacterial counts in November and May, probably due to scanty rainfall in these months than in February (dry season). This observation is similar to the work of Agwaranze *et al*., (2017) who recorded high viable counts of bacteria in well water in Wukari, Nigeria. The run off into some of the wells in the rainy season and particles from

the environment which gain access into the wells may also be responsible for the increase in bacterial population.

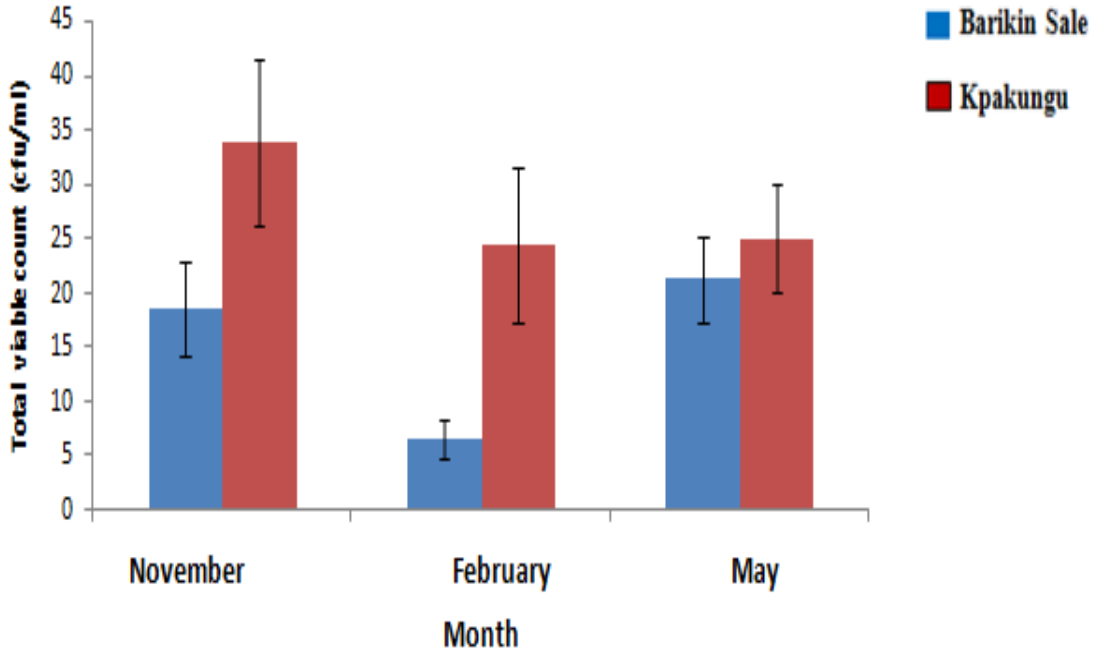

Figure 1: Total viable bacterial counts in well water samples analysed

The total coliform counts (TCC) in well water samples in Kpakungu and Barikin Sale slums are presented in Figure 2. Higher counts were obtained in November while the least counts were obtained in February in the two slums. There was however, no significant difference ($P>0.05$) in coliform counts in the wells of the two slums. The total coliform counts were high during the rainy season as a result of surface run off, since most of the wells were lowly elevated and not properly covered. The coliform counts were found to exceed 10-25 coliforms per 100ml recommended by NSDWQ (2007) and zero TCC per 100ml stipulated by the WHO (2012). The finding agrees with the earlier report by Gambo *et al.*, (2015) that, coliforms in most well water exceeded 10-25 coliforms per 100ml due to the fact that most of the wells had no proper covers/lids, thereby exposing them to contamination with animal droppings, dead animals, nasal droplets, rain splash, seepage splash, sewage, formites and coliforms carried by wind (Oyedum *et al.*, 2016).

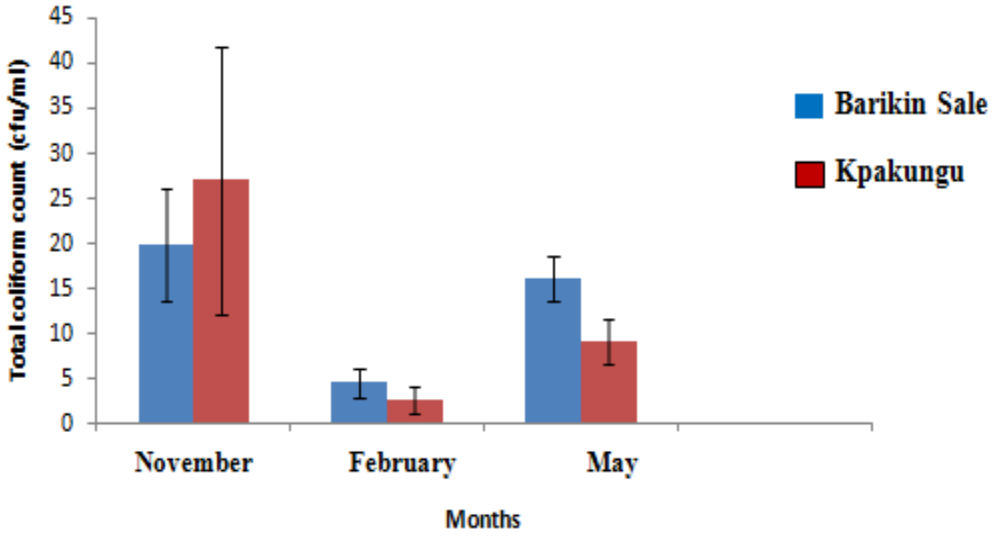

Figure 2: Total coliform counts in well water samples analysed

The results (Figure 3) of faecal coliform counts (FCC) revealed that highest counts were obtained in May (124 – 404 CFU/100ml), for Kpakungu slum, while Barikin Sale slum (32 – 316 CFU/100ml), had highest counts in November. No faecal coliforms were detected in February for Barikin Sale slum. It was however, observed that there were significant differences ($P<0.05$) in the counts recorded. The faecal coliform counts (FCC) in the wells were high in both slums and exceeded the permissible limit of zero faecal coliform per 100ml of water stipulated by NSDWQ (2007) and WHO (2012). The presence of these bacteria may be attributed to leacheates from waste dump site (Aboh *et al.*, 2015), indiscrimate defeacation, untreated sewage that seep into wells, seapage from soakaway into wells located near it and animal droppings. Oyedum *et al.*, (2016) reported that location of wells too close to pit latrine, soakaway or refuse dumps could pollute groundwater.

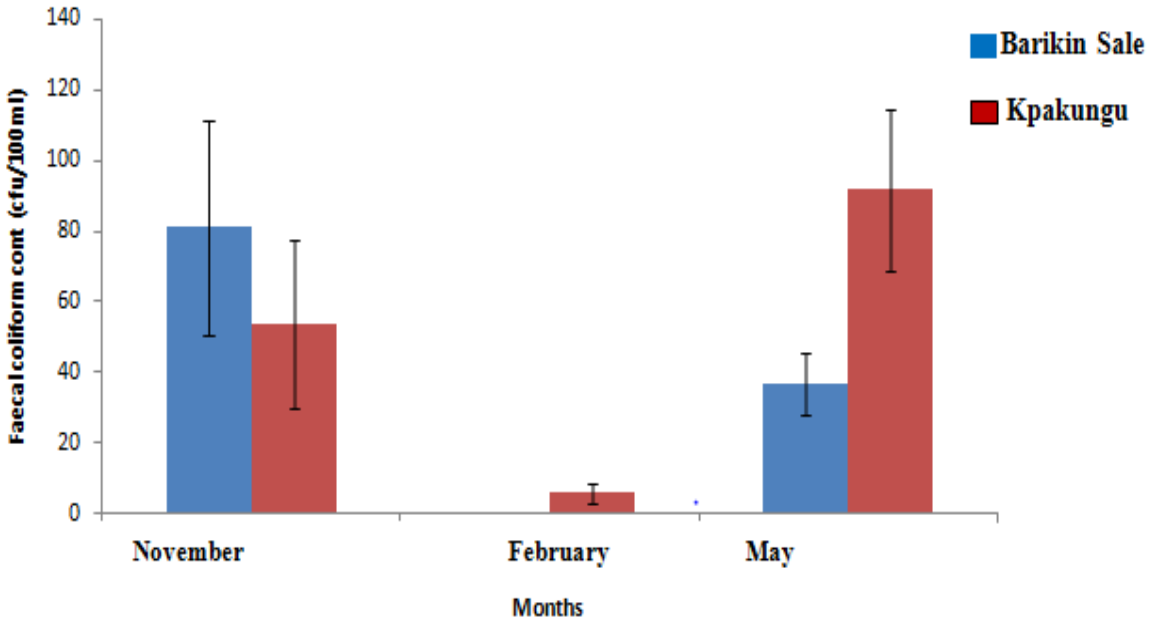

Figure 3: Faecal coliform counts in well water samples analysed

Salmonella-Shigella (Table 2) were only detectected in May ($1.0 \times 10^2 - 7.1 \times 10^3$ CFU/ml) for Kpakungu slum, while Barikin Sale slum had no *Salmonella* and *Shigella* throughout the period of sampling probably because the organisms were not present in the samples. It could also be due to the fact that the number of the organisms was too few to be detected. The detection of *Salmonella* in water samples obtained from wells in Kpakungu slums agrees with the report of Musliu *et al*., (2011), which isolated *Salmonella* from wells in Sokoto, Nigeria. Presence of *Salmonella* in water has serious public health implications as this organism is the cause of dreadful zoonotic diseases and is intolerable under any circumstance (Folorunso *et al*., 2014; Agwaranze *et al*., 2017).

Vibrio cholerae were only detected in the water samples in Kpakungu slum ($3.0 \times 10^2 - 6.1 \times 10^3$ CFU/ml) and Barikin Sale slum (1.0×10^2-1.5×10^5 CFU/ml) in May only. This may be as a result of contamination by flies and human activities (Ferdous *et al*., 2018). Umoh *et al*., (2009) isolated *Vibrio cholerae* from well water in Katsina, Nigeria. Ferdous *et al*., (2018) also isolated the organism from water in Bangladesh.

Identification of Bacterial Isolates

The bacterial isolates were identified as species of *Escherichia, Klesbsiella, Pseudomonas, Staphylococcus, Streptococcus, Salmonella, Vibrio, Micrococcus* and *Bacillus*. These organisms have been isolated from drinking water sources by other investigators (Adabara *et al*., 2011; Oyedum *et al*., 2016; Auta *et al*., 2017).

The results (Table 2) revealed that *Escherichia coli* were more frequently isolated in both slums, and constituted 23.7% for Kpakungu slum and 26.7% for Barikin Sale slum, followed by *Bacillus substilis* (15.5% for Kpakungu and 16.7% for Barikin Sale slums) and *Klebsiella pneumoniae* with 11.3% for Kpakungu and 10.3% for Barikin Sale slum. The present finding agrees with the report of Kolo & Garba (2010), who recorded high occurrence of pathogenic bacteria in well water in Minna, Nigeria. Detection of *Escherichia coli* indicates recent pollution because the organism cannot survive for long period outside of their natural habitat which is the intestinal tract of animals (Auta *et al*., 2017). The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination and suggests that other disease-causing bacteria, viruses; protozoa may likely be present (WHO, 2014). Folorunsho *et al*., (2014) reported the presence of species of *Bacillus* in well water and attributed its source to soil being swept into water by rain.

The differences in the frequencies of occurrence of the isolates may be due to the relative abundance of these organisms in the environment which might have been influenced by the type of materials that harboured the organisms or contaminate the water sources (Galadima *et al*., 2011). Contamination of water sources have been reported by researchers as a medium of disease outbreak and spread in developing countries and rural areas (Okunye & Odeleye, 2015; Agwaranze *et al*., 2017).

Table 2: Frequency of occurrence of bacterial isolates in wells in Kpakungu and Barikin Sale slums

	Frequency of occurrence (%)	
Bacterial isolates	**Kpakungu slum**	**Barikin Sale slum**
Escherichia coli	23 (23.7)	21(26.9)
Bacillus subtitis	15(15.5)	13(16.7)
Klebsiella pneumoniae	11(11.3)	8(10.3)

Bacillus lichiniformis	10(10.3)	4(5.1)
Streptococcus faecalis	8(8.2)	0(0)
Salmonella typhi	6(6.2)	0(0)
Staphylococcus aureus	5(5.2)	11(14.1)
Streptococcus pyogenes	4(4.1)	6(7.7)
Pseudomonas aeruginosa	4(4.1)	7(9.0)
Vibrio cholerae	3(3.1)	1(1.3)
Staphylococcus epidermidis	3(3.1)	3(3.8)
Bacillus cereus	3(3.1)	3(3.8)
Bacillus megaterium	1(1.0)	0(0)
Micrococcus roseus	1(1.0)	0(0)
Micrococcus luteus	0(0)	1(1.3)
Total	97	78

Numbers in parenthesis represent percentage frequency of occurrence

$$\%\text{frequency of occurrence} = \frac{\text{Number of isolate}}{\text{Total number of isolate}} \times 100$$

Antibiotics Resistance Profiles of Bacterial Isolates

Table 3 shows percentage resistiance to antibiotics by some bacteria isolated from water samples in Kpakungu slum. The results revealed that Reflacin (PEF) showed the least efficacy against *E.coli* and *Klebsiella pneumoniae*, (44% and 48% for respectively). *Pseudomonas aeruginosa* showed high rate of resistance (75%) to Nalidixic acid (NA) while For *Salmonella typhi*, Augmentin (AU) and Ampicillin (PN) showed the least efficacy against the bacteria, having 83% resistance each. *Vibrio cholerae* showed 100% resisitance to Reflacin and Tarivid while for *Staphylococcus aureus*, Amoxil (AMX) and Ampiclox (APX) showed the least efficacy among other antibiotics. *Streptococcus faecalis* showed 57% resistance to Amoxil (AMX) (Table 3).

Table 3: Percentage resistance of some bacterial isolates to antibiotics from Kpakungu slum

Bacteria	**Antibiotics %**									
	CN	AU	CPX	SXT	S	PN	CEP	OFX	NA	PEF
E. coli	6	11	22	28	0	0	17	11	39	44
Klebsiella pneumoniae	9	27	0	0	18	36	18	18	18	48
Pseudomonas aeruginosa	9	27	0	0	18	36	18	18	75	48
Salmonella typhi	0	83	0	50	17	83	33	0	17	17
Vibro cholorae	0	0	0	0	0	50	25	100	75	100
	CN	APX	RD	AMX	S	NB	CH	CPX	E	LEV
Staphylococcus aureus	0	43	14	43	0	23	0	0	0	0
Streptococcus faecalis	0	14	0	57	0	29	14	0	0	14

CN= Gentamycin (10µg), AU= Augmentin (30µg), CPX= Ciproflox (10µg), SXT= Septrin (30 µg), S= Streptomycin (30µg), PN=Amplicilin (30µg), CEP= Ceporex (10µg), OFX=Tarivid (10µg), NA= Nalidixic acid (30µg), PEF= Reflacine (10µg), AMX= Amoxil (30µg), APX= Ampliclox (30µg), RD= Rifampicin (10µg), NB= Norfloxacine (10µg), E= Erythromycin (10µg), CH= Chloramphenicol (30µg), LEV= Levofloxacin (10µg).

Table 4 shows percentage resistance to antibiotics by bacterial isolates from water samples in Barikin Sale slum. Augmentin (AU) showed the least efficacy against *E.coli*, having 30% resistance. Reflacin (PEF) showed highest rate of resisitance against *Klebsiella pneumoniae* (57% resistance) while *Pseudomonas aeruginosa* showed 44% resistance to Nalidixic acid (NA). *Vibrio cholerae* was highly resistant to almost all the antibiotics except Augmentin (AU), Streptomycin (S), Ampicilin (PN) and Nalidixic acid (NA) with zero resitance (Table 4). For *Staphylococcus aureus*, Norfloxacine (NB) showed the least efficacy against the bacteria (89% resistance) while Norfloxacine showed the least efficacy against *Streptococcus faecalis* (50% resistance). The two organisms (*S. aureus* and *Strep. faecalis*) showed no resistance to gentamycin, streptomycin, ceporex, tarivid, Nalidixic acid and reflacine (Table 4).

The data from this investigation suggests that antibiotic resistance among bacteria is common and significant with many strains of pathogens, showing resistance to almost all test antibiotics. The findings agree with various reports that resistance is highest to most commonly used antibiotics (Sikarwar & Batra, 2011; Manji *et al*., 2012; Nmema, 2013; Abu & Wondikom, 2018).

Table 4: Percentage resistance of some bacterial isolates to antibiotics from Barikin Sale slum

Bacteria	Antibiotics (%)									
	CN	AU	CPX	SXT	S	PN	CEP	OFX	NA	PEF
E.coli	0	30	5	5	5	0	15	10	25	10
Klebsiella pneumonia	0	43	0	0	14	29	43	43	43	57
Pseudomonas aeruginosa	0	11	11	0	0	11	11	0	44	0
Vibrio cholera	100	0	100	100	0	0	100	100	0	100
	CN	APX	RD	AMX	S	NB	CH	CPX	E	LEV
Staphylococcus aureus	0	22	27	33	0	89	0	0	0	0
Streptococcus faecalis	0	0	0	0	0	50	0	0	0	0

CN= Gentamycin (10µg), AU= Augmentin (30µg), CPX= Ciproflox (10µg), SXT= Septrin (30 µg), S= Streptomycin (30µg), PN=Amplicilin (30µg), CEP= Ceporex (10µg), OFX=Tarivid (10µg), NA= Nalidixic acid (30µg), PEF= Reflacine (10µg), AMX= Amoxil (30µg), APX= Ampliclox (30µg), RD= Rifampicin (10µg), NB= Norfloxacine (10µg), E= Erythromycin (10µg), CH= Chloramphenicol (30µg), LEV=Levofloxacin (10µg).

The resistance of *Salmonella typhi* to Ampicillin agrees with the study of Brooks *et al*., (2006) who also recorded high level of resistance to Ampicilin. High degree of resistance by *Staph. aureus* to Augmentin was also reported by Nmema (2013). Similarly, high resistance of *Staph. aureus* to septrin (cotramazole) was also reported by Chijioke *et al*. (2016) in Ondo north, south and central Nigeria. Reflacin and ceporex resistance by *Klebsiella pneumoniae* agrees with the work of Sikarwar & Batra (2011). Okhonlaye & Oluwatosin (2018) also reported high resistance of *Klebsiella pneumoniae* to multiple antibiotics in Ondo north and south of Nigeria. Resistance to high concentration of Nalidixiic acid in *Pseudomonas aeruginosa* agrees with the report of Levy (2001). Augmentin resistance by *E. coli* was reported in the work done by Manji *et al*. (2012). Generally, various factors contribute to the resistance of bacteria to different antibiotics. These include enzymatic degradation of antibacterial drugs, alteration of bacterial protein that are antimicrobial

target, change in membrane permeability to antibiotics. Resistance could be due to the production of enzymes such as extended spectrum Beta lactamases (ESBLS) by the organism that inactivate the antibiotics or probably because the organism generated different types of hybrid plasmids (Sikarwar & Batra, 2011). Misuse of antibiotics also results to the emergence and survival of resistance strains of bacteria (Abu & Wondikom, 2018). The implication of these findings is that there will be high cost of chemotherapy.

Conclusion

The results of this study indicate the presence of pathogenic bacteria and heavy metals in the water samples analyzed. Thus the water does not meet the standard stipulated for drinking water by regulatory agencies and may serve as source of transmission of diseases. The wells were exposed to air borne particles harboring many microorganisms and animal faeces. Antibiotics resistance study revealed alarming patterns of antibiotic resistance among the bacterial pathogens. Antimicrobial resistance increases health costs and causes low productivity. It is therefore necessary to prevent faeces of animals and man from being carried by wind or surface runoff into the open wells. Water drawing containers and ropes should be clean in order to avoid contamination by faeces of man and animals. This can be achieved by hanging on a poll after every use. There is also the need to keep the surroundings of the wells tidy as this will lessen the level of contamination of the water. Potable water supplies should be provided to the slum dwellers in order to reduce their dependence on wells. There should be regular enlightenment campaigns in slums on the sources, implications and prevention of water contamination.

References

Aboh, E. A., Giwa, F. J., & Giwa, A. (2014). Micrbiological Assessment of Well Water in Samaru, Zaria, Kaduna State, Nigeria. *Annals of African Medicine*, 14, 32-38.

Abu, G. O., & Wondikom, A.C. (2018). Isolation, Characterization and Antibiotic Resistance Profile Studies of Bacteria from an Excavated Pond in Port Harcourt Metropolis, Nigeria*. Journal of Applied Science and Environmental Management*, 22(8), 1177–1184.

Adabara, N. U., Mawak, J. D., Momohjimoh, A., Bala, J. D., Abdulrahaman, A. A., Oyedum, U. M., & Jagaba, A. (2011). A relative bacteriological assessment of public borehole and well water in Bosso town, North-Central Nigeria. *International Journal of Biomedical and Advance Research*, 02(10), 416-420.

Adamou, H., Ibrahim, B., Salack, S., & Adamou, R. (2020). Physico-chemical and bacteriological quality of groundwater in a rural area of Western Niger: a case study of Bonkoukou. *Journal of Water and Health*, 18(1), 77- 90.

Adeleye, B., Medayese, S., & Okelola, O. (2014). Problems of of water supply and sanitation in Kpakungu Area, Minna, (Nigeria). www.glocalismjournal.net

Ademoroti, C. M. O. (1996). *Standard methods for water and effluents analysis.* Foludex Press Ltd, Ibadan, Pp 29-118.

Adeniran, A. (2018). Assessment of water quality in slum area, Ibadan*. Hydrology Current Research,* 9(1), 291- 296.

Agwaranze, D. I., Ogodo, A. C., Nwaneri, C. B., & Agyo, P. (2017). Bacteriological examination of well water in Wukari, Nigeria. *International Journal of Scientific Research in Environmental Science*, 5(2), 42-46.

American Public Health Association, APHA (1998). *Standard Methods for the Examination of Water and Wastewater.* Clesceri L.S, Greenberg A.E, & Eaton A.D (20theds.) APHA, Washington, DC.

Anon (1994). The microbiology of drinking water. Report on Public Health and Medical Subjects. Methods of Examination of Water and Associated Materials, London. *Water Related Diseases Report*, 20, 80-91.

Auta, K. I., Mohammed, S. S. D., & Abubakar, M. I. (2017). Assessment of bacteriological quality of well water around Dogon Dawa district in Birnin Gwari Local Government, Kaduna State. *Science World Journal*, 12(4), 38-42.

Aydin, A. (2007). The microbial and physico-chemical quality of groundwater in West Thrace, Turkey. *Journal of Environmental Studies*, 16 (3), 377–383.

Bello, H. S., Isa, M. A., Shettima, A., & Allamin, I. A. (2013). Physicochemical changes and bacteriological contamination of drinking water from wash bores in Jere, Borno State, Nigeria, *Journal of Microbiology and Biotechnology Research,* 3 (3), 126-131.

Bolarinwa, O., & Odunola, A. (2012). Consumers willingness to pay for improved water services in Ilorin metropolis of Kwara State. *Nigerian Journal of Economics and Sustainable Development*, 3 (9), 30-31.

Brooks, J. T., Ochieng, J. B., Kumer L., Okoth, G., & Shapiro, R. L. (2006). Surveillance for bacterial diarrhea and antimicrobial resistance in rural western Kenya, 1999-2003.*Clinical Infectious Disease*, 43, 393- 401.

Cappuccino, J. G., & Sherman, N. (2004). *Microbiology-A Laboratory Manual*. Pearson Education, Singapore, Pp. 24-31.

Chessbrough, M. (2009). *Medical Laboratory Manual for Tropical Countries.* New York, Cambridge University Press, pp. 481 – 483.

Chijioke, A. N., Vivian, N. N., & Christian, U. O. (2016). Prevalence and antibiotic susceptibility pattern of *Staphylococcus aureus* isolated from various clinical specimens in South East Nigeria. *Journal of Clinical Microbiology*, 3(2), 159-162

Cowan, L. L., & Steel, K.J. (1995) *Manual for Identification of Medical Bacteria*. Cambridge University Press, Cambridge.

Desalegn, A. (2014). Bacteriological and physicochemical quality of well water sources. . *Research Journal of Chemistry and Environmental Science,* 2 (5), 13-27.

Federal Republic of Nigeria, FRN (2012). *Nigerian Poverty Profile Report 2010*.The National Bureau of Statistics, Abuja.

Ferdous, J., Sultana, R., Rashid, R. B., Tasnimuzzaman, M., Nordland, A. Begum, A. & Jensen P. K. M. (2018). A Comparative Analysis of *Vibrio cholerae* contamination I point of drinking and source water in a low income urban community, Bangladesh. *Frontiers in Microbiology*, 9, 489- 492.

Folorunso, O. R., Adetuyi, F. I., Lasinde, E. A. O., & Onibi, G. E. (2014). Microbiological Assessment of well water at different duration of storage. *Pakistan Journal of Biological Sciences*, 17, 198-205.

Galadima, A., Garba, Z. N., Leke, L., & Al Mustapha, M. N. (2011) Domestic water pollution among local communities in Nigeria, causes and consequencies. *European Journal of Scientific Research*, 52 (4), 592-603.

Gambo, J.B., James, Y., & Yakubu, M. B. (2015). Physicochemical and Bacteriological Analysis of Well Water at Crescent Road Poly Quarters, Kaduna. *International Journal of Engineering and Science*, 4 (11), 11-17.

Garba, Z. N., Hamza, S. A., & Galadima, A. (2010). Arsenic level specification in fresh water from Karaye Local Gorvernment, Kano State, Nigeria. *International Journal of Chemistry*, 20(2), 113-117.

Ijah, U. J. J., & Stephen, E. (2006). Microbiology and physicochemistry of River Kaduna, Nigeria Receiving Water Discharged from Hydroelectric Power Dam. *Journal of Environmental Sciences,* 10 (1), 17-26.

Itah, A. Y., Etukudo, S. M., & Akpan, E. J. (1996). Bacteriological and chemical analysis of some rural water supplies in Calabar, Nigeria. *West African Journal of Biological and Applied Chemistry,* 41, 1-10.

Jafari, R. A., Fazlara, A., & Govahi, M. (2006). An Investigation into *Salmonella* and Fecal coliform contamination of drinking water in broiler farms in Iran*. International Journal of Poultry Science*, 5, 491-493.

Kangpe, N. S., Egga, E. S., & Mafuyai, G. M. (2014). Physico-chemical and Microbiological Assessment of some Well water from Mista- Ali town, Bassa L.G.A., Plateau State, Nigeria. *Asian Review of Environmental and Earth Science*, 1(2), 39-42.

Kolo, P. S. N., & Garba, S. A. (2010). Occurrence of pathogenic bacteria in well water in Minna, Niger State, Nigeria. *Book of Abstract, 23rd Annual Conference of Biotechnology Society of Nigeria*, University of Nigeria, Nsukka, Pp. 11-12.

Levy, S. B. (2001). Antibiotic resistance. Consequences of inaction .*Clinical Infectious Diseases* 33, 5124-5129.

Manji, P. L., Antai, S. P., & Jacob, I. O. (2012). Incidence of *Saphylococcus aureus*, coliforms and antibiotic resistant strains of *Escherichia coli* in rural water supplies in Calabar South local government area. *Journal of Public Health and Epidemiology,* 4 (9), 230-237.

Mohammed, S. A., Shahla, L., & Gulam, M. S. (2012). Bacteriological quality of drinking water in Lahore, Parkistan. *Biomedical*, 26, 66-69.

Musliu, A., Ijah, U. J. J., & Mungadi, A. G. (2011). Bacteriological and physicochemical assessment of well water in limestone mined areas of Sokoto, Nigeria. *Journal of Science and Technology Research*, 10 (3), 98-103.

Nigerian Standard for Drinking Water Quality, NSDWQ (2007). Standard Organization of Nigeria, Abuja, Nigeria.

Nmema, E. E. (2013). Peculiar pattern of antibiotic resistance in bacteria isolated from various Sources in South-east Nigeria and the implications in health and economy. *Journal of Applied Science and Environmental Management*, 17(4), 529-534.

Noble, R. T., Leecaster, M. K., McGee, C. D., Weis, S. B., & Ritter, K. (2003). Comparison of total feacal coliform and *Enterococcus* response for ocean recreational water quality testing. *Water Resources*, 37(7), 1637-1643.

Okhonlaye, O. A., & Oluwatosin, O. M. (2018). Occurrence of Multidrug Resistant *Staphylococcus aureus* and *Klebsiella pneumoniae* Isolated from Clinical and Environmental Samples in Ondo State, Nigeria. *Journal of Advances in Microbiology*, 10(2), 1.

Okunye, O. L. & Odeleye, F. O. (2015). Bacteriological investigation of well water samples from selected market location in Ibadan Nigeria. *International Journal of Pharmaceutical Science Invention*, 4(5), 32-36.

Oyedum, U. M., Adabara, N. U., & Oloruntimilehin, B. J. (2016). Asurvey of bacteriological quality of well water from various Locations in Bosso town, North Central, Nigeria. *FUTA Journal of Research in Sciences*, 12(2), 280-286.

Sikarwar, A. S., & Batra, V. H. (2011). Prevalence of antimicrobial drug resistance of *Klebsiella pneumoniae* in India. *International Journal of Bioscience*, *Biochemistry and Bioinformatics*, 1(3), 211-215.

Song, J. (2011). Antibiotic susceptibility report (Antibiogram). *Journal of Antimicrobial Chemotherapy*, 28 (3), 15-19.

Umoh, J. U., Adesiyin, A. A., Adekeye, J. O., & Nadarajah, M. (2009). Epiemiological features of an outbreak of gastroenteritis and cholera in Katsina, Northern Nigeria. *Journal of Hygiene*, 91, 101 – 103.

United Nations Commission on Human Settlements Habitat, UNCHS (2002). *National Trends in Housing Production Practices* Volume 4: Nigeria. HS/313/93 E, Nairobi, Kenya.

Winn, W. J. R., Allen, S., Janda, W., Koneman, E., Procop, G., & Schreckenberger, P. (2006). *Koneman's Color Atlas and Textbook of Diagnostic Microbiology*, (6th edition). United States of America, Lippincott Wiilliams and Wilkins. Philadelphia, Pp. 212-301.

World Health Organization, WHO (2014). *Guidelines for Drinking-Water Quality*. Microbial Fact Sheet. p. 229-31. Retrieved at: http://www.who.int/water/gdwq3rev/en. 23g dwq3_11.pdf G .Accessed in April 2019.