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Original Research Article

Bacteriological Quality of Borehole Water Samples Distributed in Federal College of Education Katsina, Katsina State, Nigeria

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ABSTRACT

Waterborne diseases are still emerging global concerns, hence the need for continuous assessment of drinking water quality to ensure safe consumption. This study focuses on determining the bacteriological properties of borehole water samples distributed within Federal college of Education (F.C.E) Katsina, Katsina State, Nigeria by assessing the bacterial and coliform counts of the water distributed and the characterization of the bacteria present. The bacteriological quality of the water samples was analyzed using standard methods. A total of 20 samples were collected from ten different sites within college community. A total of six (6) bacteria isolates were identified using the bioMerieux vitek 2 system. They include Acinetobacter baumannii, Pseudomonas aeruginosa, Pseudomonas florescens, Chromobacterium violanceum, Dermacoccus nishinomiyaensis and Kocuria kristinae. The total bacterial counts and total coliforms were 0.56 – 2.31 × 10^2 cfu/mL and 6.50 – 34.00 cfu/100mL respectively. Faecal coliforms were absent in all the samples analyzed. Analysis of variance (ANOVA) revealed significant differences in the values of the bacterial counts obtained and no significant differences in the faecal coliform counts at $P \leq 0.05$. The water quality within the college community fell within the permissible standards of the WHO. More so, the bacterial isolates demonstrated complete susceptibility to Ciprofloxacin and Gentamicin which could serve as drug of choice for the treatment of these pathogens. The study recommends continuous surveillance of the water supplies and regular disinfection of the water in other to keep up with quality of the water supplies.

1. INTRODUCTION

Water is an abundant gift of nature and a necessity that is ineluctable. Safe drinking water is a basic need for everyone and an index of development; however poor water quality in line with waterborne diseases pose tremendous threat to public health in many developing countries, especially Nigeria (Abubakar and Said,

2022). Drinking water is said to be potable when it poses no health risk; however potable water is now an essential commodity as all inhabitants on earth are confronted with water bankruptcy (Agbabiaka *et al.,* 2021). Over one billion people in the world are inaccessible to safe potable water (WHO, 2010).

In this part of the world, water remains the most abused resource in the environment. Most surface water are heavily polluted due to anthropogenic activities, massive increase in population and industrialization all around the world (Kolawole and Afolayan, 2017). This is also a consequence of a corresponding rapid increase in environmental pollution and the demand for safe and potable water. More so, most communities are now depending on groundwater sources for safe drinking water as the type of our waste affects the treatment of water, which therefore necessitates that population growth is monitored and groundwater quality is imposed to continuous surveillance, which is pertinent and key to sustainable development (Adegboyega *et al.,* 2015).

Bacteria isolated from drinking water may not only possess virulent characteristics and antibiotic resistance but also express resistance to commonly used disinfectants in the treatment of water (Khan *et al.,* 2016). Apart from these, most water-borne disease outbreaks emerge from the consumption of unsafe water. In Katsina State, waterborne disease like cholera causes significant loss of lives. A total of 5796 cases were recorded with 182 deaths in a cholera outbreak in year 2021 and 767 cases in 2022 (Suleiman *et al.,* 2022; UNICEF, 2022).

In light of these prevailing circumstances and the rapid increase in outbreaks worldwide, it becomes essential that thorough investigation should be conducted in this part of the world in other to ascertain the quality of the water distributed and the features of these pathogens. The study aims at determining the bacteriological quality of selected borehole water distributed in F.C.E Katsina, Katsina state, Nigeria.

2. MATERIALS AND METHODS

2.1. Study Area

Federal College of Education (F.C.E) Katsina is located in Batagarawa local government area of Katsina State, Nigeria. Its geographical coordinates are between Latitude 12°55'50.4" North and Longitude 7°36'08.7" East as shown in Figure 1. The average annual temperature is 35 ^{o}C, wind speed is estimated at 5 km/h and humidity level is 11%. Batagarawa was established in 1991 and has an area of 433 km^2 with a population projection of 337,900 as at the year 2022 (NBS, 2022). The Hausa tribe are the major ethnic group and activities includes rearing of animals and cultivation of grains such as maize, millet and guinea corn.

2.2. Sample Collection

Water samples were obtained from 10 (ten) selected borehole water sources within the Federal College of Education Katsina, Katsina State, Nigeria. The sampling points include; A (College administrative block), B (School of languages), C (School of Education), D (School of vocation and technology), E (School of sciences), F (Microteaching laboratory), G (School of Arts and social sciences), H (Student hostel), I (Staff quarters) and J (Gymnasium) as shown in Figure 2. The sampled points were chosen based on the accessibility and frequent usage of the water. A total of 20 water samples were collected from storage tanks and distribution taps using standard methods as described by Ogah and Ukaegbu (2019). All samples collected were properly sealed and transferred to the laboratory in coolers with ice block for proper analysis.

2.3. Sanitary Surveillance of Sampled Points

The sampling points were observed, evaluated and recorded during the course of investigation based on the physical appearance and activities surrounding the sampling points in order to investigate any point source pollution. The parameters include; any leakage from the tap handle, accumulation of water near tap stand, closeness of potential contaminants to sampled point, observable leakage within pipes.

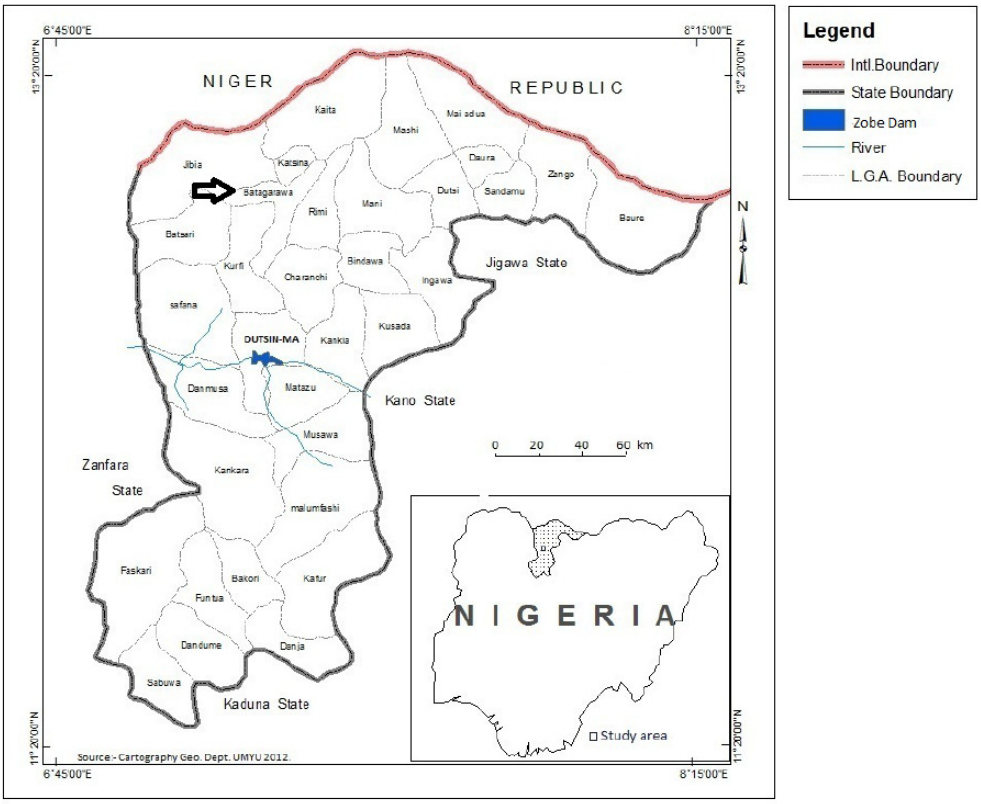

Figure 1: Map of Katsina State indicating Batagarawa local government area

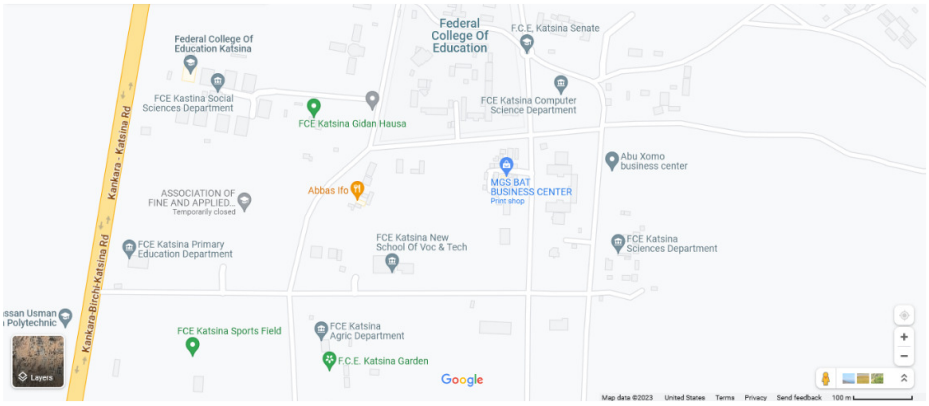

Figure 2: Geographical map of the sampling points.

2.4. Bacteriological Analysis

The total bacterial count was determined using standard pour plate technique (APHA, 2005). Total and faecal coliform bacteria were enumerated using the technique of membrane filtration. Aliquots of 100 mL from each sample was filtered using 0.45 µm paper filters. The filters were placed on mEndo-LES agar plates and incubated in an inverted position at 37 ˚C for 24 hours for the estimation of total coliforms and also placed on mFC agar plates incubated at 44.5 ºC for 24 hours for faecal coliforms. Red colonies with or without a characteristic metallic sheen were confirmed as total coliforms while dark blue colonies on mFC media were confirmed as feacal coliforms (Brian and Pinedo, 2015). Pure cultures of bacteria were characterized using

cultural, cellular, biochemical and identified using the bioMerieux vitek 2 system as described by Pincus (2013). Pathogenicity were determined among bacterial isolates based on their ability to produce certain enzymes such as haemolysin, lecithinase, lipase, proteinase and beta-N-acetylglucosamidase using the methods of Edberg et al. (2009) and Horn et al. (2016).

2.5. Antibiotic Susceptibility Testing of the Isolates

Antibiotic susceptibility test was performed using the automated bioMerieux vitek 2 system as described by Pincus (2013) and results were interpreted using standard reference values of the Clinical and Laboratory Standard Institute (CLSI, 2016).

2.6. Statistical Analysis

All the data generated in this study were analyzed descriptively by analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS version 23.0).

3. RESULTS AND DISCUSSION

The sanitary inspection of the sampled points was determined, and the findings obtained were recorded. Sampled points A, B, C and F were free from all analyzed parameters while others were positive for one or two of the parameters tested as presented in Table 1. Sanitary surveillance of the sampled points revealed that some of the sites were in close proximity to potential contaminants, poor drainage and leakage of infrastructure. However, four (4) points were devoid of these parameters and these contributes a little extent to the quality of the water. Eniola *et al.* (2015) reported that poor water infrastructure and unsatisfactory sanitary conditions at water distribution systems contributes greatly to the deterioration of water quality at consumers end resulting to a post-treatment contamination of water. It is therefore important to note that the environmental conditions and the quality of the channel in which water is being discharged greatly influences the microbial quality of water and it becomes necessary to maintain clean hygienic practices at all points of water supplies.

Table 1: Sanitary surveillance of the sampling points

Parameters checked	Sampling points									
	A	B	C	D	E	F	G	H	I	J
Any leakage from the tap	-	-	-	-	-	-	-	+	-	-
Accumulation of water near tap stand	-	-	-	+	-	-	-	+	+	+
Closeness of potential contaminants to sampled area	-	-	-	+	+	-	+	-	-	+
Leakage between sampled area and source	-	-	-	-	-	-	-	-	-	-

Key: + = Yes, - = No A, B, C, D, E, F, G, H, I and J = College administrative block, School of languages, School of Education, School of vocation and technology, School of sciences, Microteaching laboratory, School of Arts and social sciences, Student hostel, Staff quarters and Gymnasium respectively.

The total bacterial counts of the water samples within ranged from 0.56×10^2 cfu/mL to 2.31×10^2 cfu/mL in sample J and B, respectively. Total coliform counts ranged from 6.50 cfu/100 mL – 34.00 cfu/100 mL in samples A and E respectively. All samples were totally free from faecal coliforms as presented in Table 2. A total of six (6) different bacterial species were isolated from all samples analyzed, they are; *Acinetobacter baumannii, Pseudomonas aeruginosa, Pseudomonas florescens, Chromobacterium violanceum, Dermacoccus nishinomiyaensis* and *Kocuria kristinae*. The distribution of each isolates from various sampled points is shown in Table 3. Three (3) bacterial isolates which include *Acinetobacter baumannii, Pseudomonas aeruginosa* and *Pseudomonas florescens* produced haemolysin, proteinase and lecithinase, *Chromobacterium violanceum* was the only beta-N-acetylglucosamidase producer while all the bacterial isolates were negative to lipase as presented in Table 4.

Table 2: Bacteriological analysis of the water samples

Sampled points	Total bacterial count ($x10^2$CFU/ml)	Total coliform count (CFU/100ml)	Faecal coliform count (CFU/100ml)
A	0.60 ± 0.20^{d}	6.50 ± 2.5^{d}	0.00 ± 0.00^{a}
B	2.31 ± 0.20^{a}	29.50 ± 1.5^{b}	0.00 ± 0.00^{a}
C	0.56 ± 0.12^{e}	22.50 ± 2.5^{b}	0.00 ± 0.00^{a}
D	1.40 ± 0.56^{ab}	18.50 ± 2.5^{bc}	0.00 ± 0.00^{a}
E	0.60 ± 0.12^{d}	34.00 ± 6.0^{a}	0.00 ± 0.00^{a}
F	1.02 ± 0.70^{bc}	10.00 ± 1.0^{cd}	0.00 ± 0.00^{a}
G	1.33 ± 0.21^{b}	14.50 ± 2.5^{c}	0.00 ± 0.00^{a}
H	0.71 ± 0.11^{c}	14.80 ± 2.5^{c}	0.00 ± 0.00^{a}
I	1.28 ± 0.28^{b}	29.50 ± 0.5^{ab}	0.00 ± 0.00^{a}
J	0.56 ± 0.55^{e}	12.50 ± 3.5^{c}	0.00 ± 0.00^{a}

Key = Mean ± Standard error, ANOVA, DMRT (Duncan multiple range test) (n = 10). A, B, C. D, E, F, G, H, I, J = College administrative block, School of languages, School of Education, School of vocation and technology, School of sciences, Microteaching laboratory, School of Arts and social sciences, Student hostel, Staff quarters and Gymnasium respectively. Values with different superscripts within same column are significantly different and those with the same superscripts have no significant difference at $p \leq 0.05$.

The total bacterial counts in the water samples ranged from $0.56 – 2.31 \times 10^2$ cfu/mL with fifty percent (50%) of the sampled points having count within the limit of 100 cfu/ml permitted for potable water (NSDWQ, 2007) while other sampled points were slightly above this standard. However similar counts were reported by Agbabiaka *et al.* (2021). All the borehole water samples were bereft of faecal coliforms, however, the total coliform counts of the samples ranged from 6.50 – 34.00 cfu/100ml and did not conform to the WHO standards of zero coliform counts in 100 mL sample. These however could be attributed to contamination from the soil and the poor sanitary conditions going around certain sampled points.

Bacterial species isolated from the water samples include *Acinetobacter baumannii, Pseudomonas aeruginosa, Pseudomonas florescens, Chromobacterium violanceum, Dermacoccus nishinomiyaensis* and *Kocuria kristinae.* These organisms could be pathogenic or may cause opportunistic infections as they were positive for certain extracellular enzymes responsible for the contribution of virulence in bacteria. They include haemolysin, proteinase, lipase, lecithinase and beta-N-acetylglucosamidase. These was observed in all the *Acinetobacter baumannii, Pseudomonas aeruginosa* and *Pseudomonas florescens* isolated. These findings are similar with that of Agbabiaka *et al.* (2021) and Horn *et al.* (2016) who provided answers regarding potential pathogenicity of heterotrophic bacteria in water. This implies that they have potential to cause human illnesses.

Table 3: Frequency distribution of bacterial isolates from various sampling points

Sampling points	Isolates					
	Acinetobacter Baumannii	*Pseudomonas Aeruginosa*	*Pseudomonas florescens*	*Chromobacterium violanceum*	*Dermacoccus nishinomiyaensis*	*Kocuria kristinae*
A	-	+	-	+	-	+
B	+	+	-	+	-	+
C	-	-	+	+	+	+
D	-	-	+	+	-	-
E	+	-	-	-	+	-
F	-	-	-	+	-	-
G	-	+	-	+	-	-
H	+	+	-	+	-	+
I	-	+	-	+	+	-
J	+	+	+	+	-	-

Key: + = Present, - = Absent A, B, C, D, E, F, G, H, I and J = College administrative block, School of languages, School of Education, School of vocation and technology, School of sciences, Microteaching laboratory, School of Arts and social sciences, Student hostel, Staff quarters and Gymnasium respectively.

Table 4: Virulence characteristics of the isolates

Isolates	Haemolysin	Proteinase	Lipase	Lecithinase	Beta-N-acetylglucosamidase
AB	+β	+	-	+	-
PA	+β	+	-	+	-
PF	+β	+	-	+	-
CV	-ɣ	-	-	-	+
DN	-ɣ	-	-	-	-
KK	-ɣ	-	-	-	-

Key: + = Positive, - = Negative, +β = Beta haemolysis, -ɣ = gamma haemolysis, AB = *Acinetobacter baumannii,* PA = *Pseudomonas aeruginosa,* PF = *Pseudomonas florescens,* CV = *Chromobacterium violanceum,* DN = *Dermacoccus nishinomiyaensis* and KK = *Kocuria kristinae.*

The number of bacterial isolates either resistant, intermediate or susceptible to a particular antibiotic were determined and calculated in percentage and the concentration of the antibiotic used was also recorded in Table 5. Antibiotic susceptibility test revealed that most of the bacterial species demonstrated complete resistance to Ampicillin and Cefazolin (100%) and were highly susceptible to Ciprofloxacin and Gentamicin (100% and 83.3%) respectively. This agrees with reports Adesoji and Ogunjobi (2013) and Flores-encarnacion *et al.* (2016). This is therefore a clear indication that antibiotic resistance has emerged among heterotrophic bacteria in water to the first generation antibiotics. Analysis of variance (ANOVA) revealed significant differences in the values of the total bacterial counts obtained and no significant differences in the faecal coliform counts at $P \leq 0.05$. This indicates that the bacterial and total coliform counts greatly differ in water samples at different sampled points while the faecal coliform counts remains the same for all the sampled points analyzed.

Table 5: Antibiotic susceptibility pattern of the isolates

Antibiotics	Drug concentration (µg)	No. of Isolates %		
		Resistant	Intermediate	Susceptible
Ampicillin	25	100.0	0.0	0.0
Piperacillin	10	0.0	50.0	50.0
Cefazolin	10	100.0	0.0	0.0
Ceftazadime	10	33.3	33.3	33.3
Ceftriaxone	30	16.7	33.3	50.0
Meropenem	5	0.0	33.3	66.7
Gentamicin	10	16.7	0.0	83.3
Ciprofloxacin	10	0.0	0.0	100.0
Nitrofurantoin	200	50.0	33.3	16.7
Levofloxacin	5	0.0	33.3	66.7

4. CONCLUSION

The quality of the water distributed is satisfactory and falls within the acceptable standards for drinking water quality recommended by world health organization (WHO). However, poor water infrastructure and unsatisfactory sanitary conditions at certain sampled points seems responsible for the slightly high bacterial counts. Nevertheless, Ciprofloxacin and Gentamicin are possible drugs of choice for the treatment of infections caused by these pathogens. We recommend regular disinfection and cleaning of storage tanks, water treatment and continuous surveillance in other to keep up the standards of the water quality. More so there seems to be potential industrial microorganisms within the soil sites based on certain bacterial species isolated which should serve as future prospects.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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