BACTERIOLOGICAL WATER QUALITY ASSESSMENT OF STORED BOREHOLE AND TAP WATER IN MINNA METROPOLIS, NIGERIA

[1]BALA, J. D., [1]ENIOLORUNDA, M. F., [2]ABDULRAHAM, A. A., [1]ADABARA, N. U., [1]KUTA, F. A., [1]ADEDEJI, A. S., AGBOOLA, R. K.

[1]Department of Microbiology, School of Life Sciences, Federal University of Technology, P.M.B 65, Minna, Niger State, Nigeria

[2]Department of Biological Sciences, Federal University, Lokoja, Kogi State, Nigeria

Corresponding Author Email:jerrybrown316@yahoo.com; bala.jeremiah@futminna.edu.ng

+2348037868393

ABSTRACT

The availability of potable water is an important ingredient for preventing epidemic water borne disease and improving the quality of life. This study investigated the bacteriological quality of selected drinking water sources in Minna metropolis. Water samples were collected from borehole and tap water from Bosso and Gidan kwanu campuses of Federal University of Technology, Minna, Niger State, Nigeria. Bacteria isolation was carried out using standard spread plate method and Most Probable Number (MPN) techniques. Data generated from the study were subjected to one-way analysis of variance (ANOVA). Results revealed that the total bacteria counts for the water samples ranges from 4.00 ± 2.00^{a} $x10^{2}$ cfu/mL - 34.50 ± 2.50^{e} $x10^{2}$cfu/mL, faecal coliform count ranges from ***5.00 ± 5.00^{b}*** *$x10^{2}$cfu/mL* ***- 19.00 ± 1.00^{c}*** *$x10^{2}$cfu/mL while the occurrence of coliform ranged from 23.50 ± 19.50^{a} -1100.00 ± 0.00^{f} MPN/100mL which shows that there was significant difference at $p<0.05$.The organisms isolated were identified as Escherichia coli, Pseudomonas sp, Salmonella sp, Shigella sp, Bacillus sp and Klebsiella sp with Klebsiella sp. (31.33%) and Escherichia coli (6.02%) having the highest and lowest frequency of occurrence respectively (31.33%). The physicochemical analysis revealed that not all water samples were within the acceptable standard for drinking water. pH range from (7.59 ± 0.13^{a}-8.79 ± 0.55^{a}),Total hardness range from (51.50 ± 1.50^{a} -171.50 ± 10.50^{c} mg/L) and turbidity range from (0.00 ± 0.00^{a} -14.50 ± 0.50^{d} NTU) . No significant difference between pH while total hardness and turbidity showed significant difference at ($p<0.05$) and the microbial counts exceeded the standard limit. The presence of these organisms in the water sample shows that the water is not potable. Storage tanks should be washed and disinfected regularly to prevent contamination of water.*

KEYWORDS: *Boreholes, Coliforms, Water-borne disease, Pathogenic microbes*

INTRODUCTION

Water is the most essential natural resources needed by every living thing, it is either used for drinking, bathing, food production and recreational purposes (Eboh et al., 2017). According to the World Health Organization 2017, access to safe drinking water is essential to health, a basic human right and a component of

effective policy for health protection. Water is important to sustain life, and sufficient provisions should be made available to consumers (Owolabi et al., 2014). Potable and accessible water supply is important for public health. Due to the important role played by water in sustaining life, it has a great ability for transmitting diseases and illnesses if contaminated (Yakasai et al., 2004). Today, the major challenges in many developing countries include the increase in human population and climatic changes, which have resulted in pollution of available natural water supplies. Availability of water has become a serious problem and it is important to people relying on non-public water supply (Okonko et al., 2008). The growing population has imposed pressure on the provision of safe drinking water, particularly in developing countries (Umeh et al., 2005). However, some of the water provided are contaminated and have consequences on the health and economic standard of the populations (Bala et al., 2016). Unsafe drinking water can carry pathogenic microbes; globally, about 80% of all diseases and death in developing countries are water-related (Ayeni et al., 2011). The numbers of water-borne disease outbreaks that have been reported in Nigeria demonstrates that transfer of pathogens in drinking water remains a notable cause of illness (Nwidu et al., 2008). In assessing quality of drinking water, physical, chemical and bacteriological parameters must be considered. Physical parameters include color, turbidity, while chemical parameters include pH, Electric conductivity (EC), Total suspended soli e.t.c. However, a better understanding of the level of microbial contamination can help us to develop protection program for drinking water systems (st Laurent and Mazumder, 2014). Conformation with microbiological standards is of important concern because of the ability of water to spread diseases within a large population. Even though the standards vary from places, joint effort to ensure global access to safe water, basic sanitation, and improved hygiene is the bedrock for ending of poverty and diseases (Hughes and Koplan, 2005).

Federal University of Technology Minna is an institution of higher learning with two campuses (Gidan Kwanu and Bosso Campus) in Niger state, North-central of Nigeria. Students live in hostels in both campuses and in the metropolis. Borehole and tap water serves as a source of drinking water and also for domestic purposes on both campuses to students and members of staff living in the quarters. This study is aimed at evaluating the potability of the borehole and tap water supplied to the campuses in Minna metropolis by analyzing its physicochemical and bacteriological properties.

MATERIALS AND METHODS

Study Areas: The study areas were the hostels and staff quarters of Federal University of Technology Minna, Niger state. The institution has her campuses sited at two different locations (Bosso and Gidan Kwanu). The tap water and borehole serves as source of water for domestic purposes like drinking, cooking and washing for students and members of staff living in the quarters of the institution.

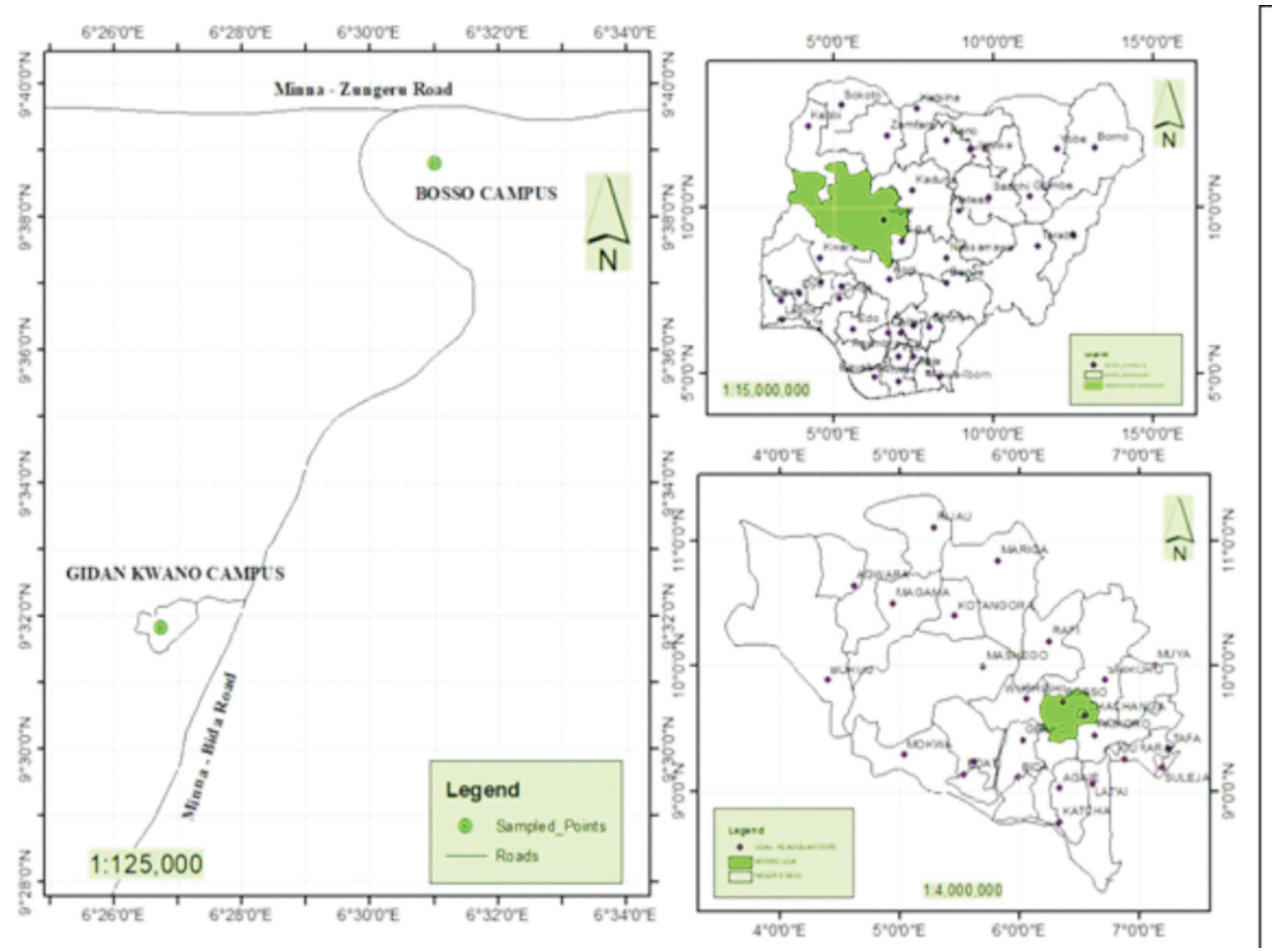

Fig 1. Map of Study Location
Source: Department of Urban And Regional Planning, FUTMinna.

***Collection of samples*:** Ten (10) water samples were collected between 9.00 am and 12.00pm over a period from the two locations in a sterile 200mL bottle with a metallic cork. During the collection, the nozzle of the tap was swabbed with cotton wool soaked in methylated spirit. This helped to disinfect the nozzle of the tap. The tap was allowed to run for 2 minutes and the sterile bottle was used to collect the water and it was corked immediately. This procedure was repeated for collection of water from borehole sources and they were immediately transported to the laboratory in an ice chest for analysis within 6 hours.

Bacteriological water quality determination
Total viable bacterial counts

Population of microorganisms in the water samples was enumerated using standard pour plate method (APHA, 1985). 1mL of the borehole and tap water sample was used of serial dilution using 3 test tubes contains 9mL of distilled water aseptically .1 mL aliquots of the dilutions was aseptically removed with a sterile syringe from the second test tube and dispensed in a petri dish and then already prepared nutrient agar (NA), is poured into the plate containing the aliquots rocked together and allowed to gel. The plates were inoculated on the surface using standard pour plate method. The culture plates were incubated at 37°C for 24-48 hours. Colonies was counted and recorded

Faecal coliform count

Faecal coliform count was determine by 1ml of water sample from the second test tube of serial is introduced into the petri dish and adding Eosin Methylene Blue medium using pour plate method to determine the fecal coliform count

Most Probable Number (MPN) method

The most probable number (MPN) method was used to confirm the coliform counts of the water samples using three tests: presumptive, confirmed, and completed test (Fawole and Oso, 2001).

Presumptive test

Nine test tubes was used for each sample which six was for single strength and three was double strength, 10 mL of lactose broth with methyl red as indicator was dispensed in to the test tubes and Durham tubes were placed in inversely and was sterilized at 121°C for 15 minutes. After which 10 mL of water sample was dispensed to the double strength, 1.0 mL and 0.1 mL of water sample was dispensed in to three test tubes each for single strength was incubation at 37°C for 24 to 48 hours. Positive test tubes were sub-cultured.

Confirmed test

MacConkey agar, *Salmonella shigella* agar and Eosin Methylene Blue agar was prepared and sterilized in an autoclave at 121°C for 15 minutes. Media was left to cool to ambient temperature before dispensing in sterile petri dishes to gel. Positive test tubes from presumptive test was sub cultured on MacConkey agar, *Salmonella shigella* agar and Eosin Methylene Blue agar using streaking method and incubating at 37°C for 24 hours to isolate distinct colonies.

Complete test

Distinct colonies were sub cultured on petri dishes containing nutrient agar and incubated for 24 hours. Using the sterile wire loop, distinct colonies was picked and sub cultured into slant bottles. Gram staining and biochemical tests were done to identify the pure isolates.

Identification of Isolates

Isolates from the primary cultures incubated at 37^0C were aseptically sub cultured onto a fresh media (Nutrient agar) to obtain pure cultures using spread plate method. The resultant pure cultures were sub cultured into already prepared slant bottles for the purpose of identification and characterization. The various isolates were characterized based on their growth on selective media and biochemical tests including Mannitol salt and starch hydrolysis, Catalase, Indole, Urase, Sugar fermentation, Coagulase tests were used for identification of isolates. The isolates were further identified by comparing their characteristics with those of known taxa using Bergey's Manual of Determinative Bacteriology.

RESULT AND DISCUSSION

The bacteriological examination of ten (10) water samples from tap and borehole water which serves as sources of drinking water for the institution community revealed that water samples were contaminated with bacteria. Both campuses showed that both water sources harbor diverse bacterial contaminants. All the boreholes and tap water samples had coliform count above Nigerian Standards for Drinking Water Quality (NSDWQ) recommended standard of less than 10MPN/100 mL of water. This result agrees with the work of Agbabiaka and Sule, (2010) who reported a similar result on occurrence of coliform in boreholes. Borehole and tap water contamination observed in this study may be due to dirty and contaminated storage tanks, which in most cases serves as a conducive environment for growth of coliform bacteria. The data obtained were subjected to

one way analysis of variance (ANOVA) ($p< 0.05$) which showed significant difference in the microbial counts of the various water sampled. This agrees with the work of Bala (2006) who reported a similar result on occurrence of coliform in well and tap water in Jimeta-Yola, Nigeria. The isolated bacteria such as species of *Escherichia coli, Pseudomonas, Salmonella, Shigella, Bacillus, Klebsiella have been implicated to cause water related diseases such as gastroenteritis, diarrhea, typhoid and cholera as reported by APHA (1998).* In this study, the occurrence of coliform, *Escherichia coli* in the borehole and tap water samples shows faecal contamination and this conforms with the work of Bala (2006). Data obtained from physicochemical analysis of borehole and tap water were subjected to one analysis of variance (ANOVA) ($p<0.05$) which showed that there were significant difference in turbidity, total hardness but shows no significant difference in pH. Some turbidity values of the borehole water and tap water samples did not conform with the values allowed NSDWQ (2007). Turbidity in the borehole and tap water samples may be due to the occurrence of particles such as clay, silt, finely divided organic matter (Adekunle *et al.,* 2007). Table one below shows the different sources of water analyzed.

Table 1 Sources of Water and Location

Key	Source	Location
W1	Tap	Staff Quarters (Bosso)
W2	Borehole	Staff Quarters (Bosso)
W3	Borehole	Boys Hostel (Bosso)
W4	Tap	Girls Hostel (Bosso)
W5	Borehole	New Girls Hostel (GK)
W6	Borehole	Old Girls Hostel (Bosso)
W7	Borehole	New Girls Hostel (Bosso)
W8	Borehole	Old Boys Hostel (Bosso)
W9	Borehole	New Boys Hostel (GK)
W10	Borehole	Staff Quarters (GK)

Table 2 shows the mean total bacterial count. The highest bacterial count recorded was recorded for girls hostel borehole at (34.50 ± 2.50^{e} x10^{2} cfu/mL) while the lowest was from girls hostel tap at (4.00 ± 2.00^{a} x10^{2} cfu/mL).

Table 2: Total bacterial count of water samples

SAMPLE	(x 10^{2}cfu/mL)
W1	5.50 ± 1.50^{a}
W2	24.50 ± 4.50^{d}
W3	7.50 ± 2.50^{a}
W4	4.00 ± 2.00^{a}
W5	34.50 ± 2.50^{e}
W6	12.00 ± 2.00^{b}
W7	12.00 ± 0.00^{b}
W8	13.50 ± 1.50^{b}
W9	15.00 ± 5.00^{c}
W10	14.00 ± 1.00^{b}

Data on the same column with different superscript differ significantly ($p< 0.05$) from each other. Values are ± Standard Error of Mean.

Table 3 shows the mean faecal coliform count. The highest count recorded was for boys hostel's borehole at (**19.00 ± 1.00^{c}** x10^{2}cfu/mL) while the lowest was from quarters tap at (**5.00 ± 5.00^{b}** x10^{2}cfu/mL). No coliform were recorded in boys hostel borehole, girls hostel tap, old girls hostel borehole, new girls hostel borehole, Old boys hostel borehole, New boys hostel borehole, Quarters Gk borehole.

Table 3: Faecal coliform count of water samples

SAMPLE	($x10^2$cfu/mL)
W1	5.00 ± 5.00^{b}
W2	0.00 ± 0.00^{a}
W3	19.00 ± 1.00^{c}
W4	6.00 ± 6.00^{b}
W5	0.00 ± 0.00^{a}
W6	0.00 ± 0.00^{a}
W7	0.00 ± 0.00^{a}
W8	0.00 ± 0.00^{a}
W9	0.00 ± 0.00^{a}
W10	0.00 ± 0.00^{a}

Data on the same column with different superscript differ significantly ($p< 0.05$) from each other. Values are ± Standard Error of Mean.

Table 4 shows the mean total coliform count. The highest total coliform count recorded was for quarters borehole and old boys hostel at (1100.00 ± 0.00^{f} MPN/100mL) while the lowest was from new girls hostel borehole at (23.50 ± 19.50^{a} MPN/100mL).

Table 4: Total coliform count of water samples

SAMPLE	(MPN/100mL)
W1	51.00 ± 42.00^{b}
W2	1100.00 ± 0.00^{f}
W3	26.00 ± 17.00^{a}
W4	210.00 ± 00.00^{d}
W5	23.50 ± 19.50^{a}
W6	106.50 ± 13.50^{c}
W7	180.00 ± 30.00^{d}
W8	1100.00 ± 0.00^{f}
W9	112.50 ± 37.50^{c}
W10	780.00 ± 320.00^{e}

Data on the same column with different superscript differ significantly ($p< 0.05$) from each other. Values are ± Standard Error of Mean.

The percentages of organisms characterized and identified are shown in table 5 below.

Table 5: Frequency of occurrence of bacterial isolate in the water samples

S/N	Organisms	Number of occurrence	Percentage of occurrence
1	*Bacillus* sp	13	15.66
2	*Salmonella* sp	10	12.05
3	*Escherichia coli*	5	6.02
4	*Pseudomonas* sp	14	16.87
5	*Klebsiella* sp	26	31.33
6	*Shigella* sp	15	18.07
	Total	83	100

Table 6 shows the shows the physiochemical parameters of stored borehole and tap water samples.

Table 6: Physiochemical Parameters of water samples

SAMPLES	pH	TOTAL HARDNESS (mg/L)	TURBIDITY(NTU)
W1	8.12±0.10[a]	51.50±1.50[a]	6.50±0.50[c]
W2	8.02±0.20[a]	151.50±0.50[b]	6.00±0.00[c]
W3	8.42±0.07[a]	127.00±1.00[b]	2.00±0.00[b]
W4	8.76±0.45[a]	60.50±1.50[a]	14.50±0.50[d]
W5	8.79±0.55[a]	136.50±1.50[b]	2.50±0.50[b]
W6	7.59±0.13[a]	171.50±10.50[c]	0.00±0.00[a]
W7	8.26±0.45[a]	171.50±2.50[c]	0.00±0.00[a]
W8	7.68±0.14[a]	173.00±12.00[c]	0.00±0.00[a]
W9	7.82±0.39[a]	180.50±11.50[d]	0.00±0.00[a]
W10	8.40±0.04[a]	141.50±11.50[b]	0.00±0.00[a]
NSDWQ	8.5	150	5

KEY: (NSDWQ): Nigerian standards for drinking water quality

Data on the same column with different superscript differ significantly ($p< 0.05$) from each other. Values are ± Standard Error of Mean.

CONCLUSION

From the study, it can be concluded that the water supplied to the study area is not potable as the types and numbers of microorganisms isolated from the stored borehole and tap water sample shows that the water samples are contaminated and contaminant numbers exceeded the standard unit recommended by Nigerian Standards for Drinking Water Quality (NSDWQ) which makes the water unsafe for drinking and may be liable to cause diseases that is related to water while the physiochemical parameters of some samples analyzed are not within the recommended range neither. High turbidity levels of some samples may be due to the presence of high number of dissolved solids.

RECOMMENDATIONS

i. The periodic washing and disinfection of storage tanks should be done regularly to prevent the growth of algae.

ii. Water should not be stored in storage tank for too long

iii. Water should be treated in the storage tanks with disinfectants like chlorine before discharge for public consumption.

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