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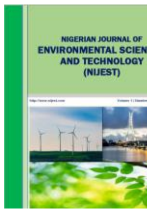

Physicochemical and Bacteriological Analysis of Ground Water Within Makera, Kaduna South, Nigeria

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ABSTRACT

This study examined bacteriological and physicochemical properties of ground water within Makera district, Kaduna South Local Government, Kaduna State. A total of 10 borehole water were sampled from 5 different streets in Makera. The physiochemical parameters were determined by checking conductivity, pH, temperature, turbidity, Alkalinity, hardness, total dissolved solid, colour and odour using standard procedures. Bacteriological analysis was determined using total viable count and most probable number (MPN) technique. This was followed by characterization and antibacterial susceptibility of the isolates. The result obtained shows that conductivity had the values from 0.50 to 1.26mg/l, total dissolved solid ranges from 2.24 to 5.46 mg/l, temperature ranges from 25.7 to 31.9 °C, pH value ranges from 5.65 to 7.5, Alkalinity ranges from 16 to 55mg/l, hardness ranges from 7.6 to 10.4 mg/l. The total viable count ranges from 1.0×10^3 to 4.5×10^3 CFU/ml for dilution of 10^3. The MPN index result revealed that none of the water samples met the standard value of WHO for drinking water which state that, the presence of coliform in drinking water should be zero/100ml. Escherichia coli (90%) was found to have the highest number of isolated organisms followed by Salmonella sp (50%) and Shigella sp (30%). The antibiotic susceptible pattern of isolates in this study indicates that all the isolates were sensitive to gentamycin, tarivid and streptomycin. Ground water in this area is characterized by the present od coliforms indicating bacteriological contamination, as such, not suitable for drinking purpose. This study suggest that the evaluation of ground water quality parameters should be carried out periodically to protect the water resources.

Keywords: Escherichia coli, Salmonella sp, Shigella sp, Most Probable Number, Coliform

1.0. Introduction

Water is essential for life, economic wellbeing and environmental integrity. It played critical and vital role throughout history in the growth and continue to be a factor of importance in the economic growth of all contemporary society (Onyango *et al.*, 2018). Safety and quality of water is always an important issue for healthy living even though many people do not have the access to clean and safe water for drinking and household uses (Khaniki *et al.*, 2010; Acharjee et al., 2014). Ground Water is the primary source of drinking water in both rural and urban areas. The importance of ground water for the existence of human society cannot be over stressed (Wang and Li, 2022). The crisis of ground water is not as a result of natural factors. It has been caused by human action much of which effects health especially in the developing countries and can be traced to the lack of safe and whole some water supply (Mishra, 2023). Continued discharge of industrial waste, domestic sewage and solid waste dump causes the groundwater to become polluted and created health problems as well (Sarker *et al.*, 2021).

Therefore, there is need to properly taken care of it in order to safe guard human, animal and environment. Human and animal wastes are primary source of bacteria in water (Singh *et al.*, 2020). These sources of bacterial contamination include runoff from feed hot, pastures and other areas where animals and industrial wasted are deposited. Bacteria from these sources can sink down underground there by contaminating the ground water (Brian, 2014). Another way bacteria can enter in to ground water is through inundation or infiltration by flood water or by surface runoff. Flood water commonly contains high level of bacteria (Xin *et al.,* 2022). Small depression filled with flood water provides an excellent breeding ground for bacteria. Where ever a well is inundated by flood water or surface runoff bacterial contamination is likely. Shallow well and wells that do not have water tight casings can be contaminated by bacteria infiltrating with the water through the soil near the well especially in coarse textured soil (Brian, 2014).

The physicochemical composition of groundwater is very vital criteria that determine the quality of water. The quality of water is often degraded due to industrial, agricultural and human activities (Akhtar *et al.,* 2021). Even though the natural environmental processes provide by means of removing pollutants from water, there are definite limits. It is up to the people to provide security to protect and maintain quality of water (Saravanan *et al.,* 2021).

Bacteria found in water may not cause disease but can be an indicator of pathogenic organism that can cause diseases such as intestinal infection, dysentery, hepatitis, typhoid fever and cholera (Kristanti *et al.,* 2022). The bacteriological and physicochemical quality of water is a great concern to consumers, public health experts and regulators. The potential of drinking water to transmit microbial pathogens to great number of people causing subsequent illness is well documented in many countries at all altitudes of economic development (Adesakin *et al.,* 2020). There were estimated 4 billion cases of diarrhaea and 2.2 million deaths annually. The consumption of unsafe water has been implicated as one of the major causes of this disease (Xu *et al.,* 2022). According to the United Nation Report, consumable water level are up to 2-7% of the total water content. 1% of the ground water level is threatened either directly or indirectly by pollution (Parihar *et al.,* 2012). Nonpathogenic faecal organisms are best indicators of faecal pollution. However, in all cases faecal coliform contents and E. coli is used as the major tool in the assessment of the health risk borne by pathogen in water (Li *et al.,* 2021).

Therefore, it is of vital to assess both bacteriological and physical standard of borehole water as it is the source of drinking water within Makera community, Kaduna metropolis, to increase awareness and subsequently reduce the incidence of disease transmission. The aim of the study was to examine bacteriological and physicochemical properties of underground water within Makera district, Kaduna South Local Government, Kaduna State.

2.0. Methodology

2.1. Study area

The Makera drain is located in the Kakuri Industrial Area, Igabi Local government on the Far East (Nnamdi Azikiwe) western bye-pass road in Kaduna metropolis, Northern Nigeria (Figure 1). Kaduna is the capital of Kaduna State, it lies within latitudes 100 23’N – 100 38’N of the equator, and longitudes 70 21’E – 70 31’E of the Greenwich Meridian. It is located in the central area of what used to be called the Northern Region of Nigeria. The climate of the study area is of tropical continental type which is characterized by a well-defined wet and dry season. The wet seasons lasts from April to October with its highest peak in August. The dry season persist from October to March during which the harmattan winds usually void of moisture, pervade the large part of the Northern part of Nigeria. The temperature in Kaduna is relatively high throughout the year. The daily ranges are usually higher than the monthly ranges particularly in the dry season when temperatures could drop low as 18℃. The highest temperatures are normally recorded in March and April, which is about 37℃ (Mohammed and Folorunsho, 2015).

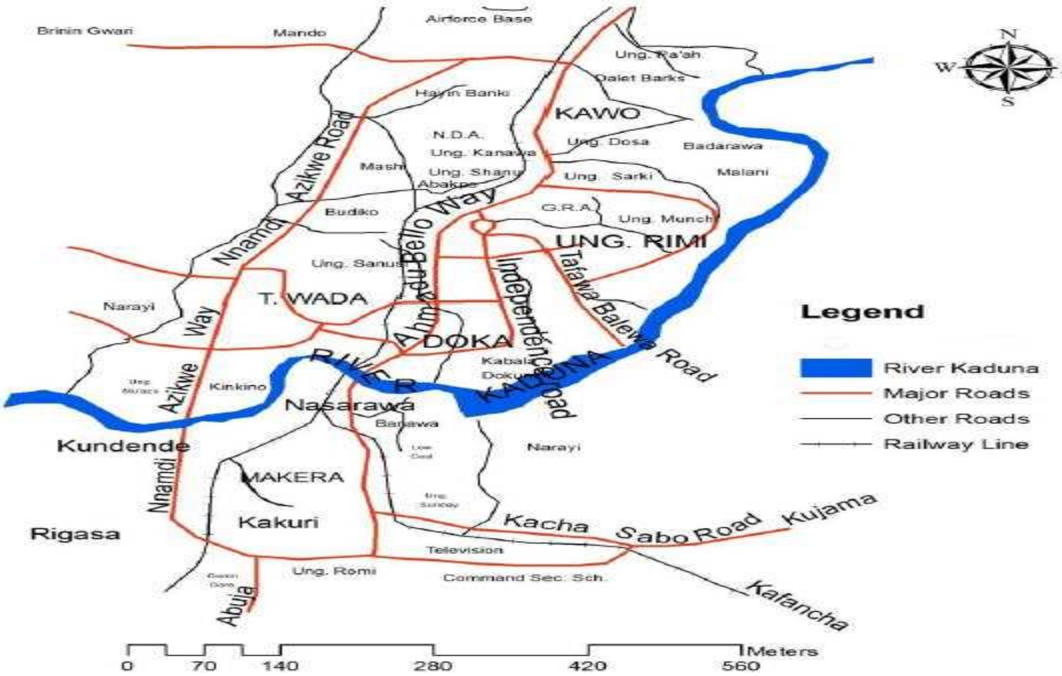

Figure 1: Map of Kaduna metropolis showing major districts including the study area (Abdullahi *et al.,* 2015)

2.2. Collection of water samples

Ten borehole water samples were collected from different street in Makera, two each from Durumin Jamo street, Gambarawa street, Kanfage street, Baban dodo street and Zango street for physiological and bacteriological analysis. The Water samples were collected using fifteen sterile plastic bottles for each sample and were assigned with a code for easy identification and were kept in an ice chest for transporting to the Microbiology Laboratory, Department of Microbiology, Kaduna State University where the samples were stored at below 4 ℃ until further analysis.

2.3. Physicochemical and bacteriological analysis

The physicochemical quality of the water sample was analyzed for conductivity, pH, temperature, turbidity, Alkalinity, hardness, total dissolved solid, colour and odour (Greenberg, 2011; Allamin, 2015). Bacteriological characteristics of the water samples were determined using multiple tube fermentation method (most probable number) for enumeration of total viable count. Lauryl Tryptose Broth (LTB) along with fermentation tubes (Durham tubes) was used. A serial dilution of the water sample to be tested was made and inoculated into LTB growth media. Samples were then incubated at 35˚C for 48 h for the presumptive test for total coliform count. After the positive tubes were transferred to Brilliant green lactose bile broth (confirmation test) and incubated for 48 h at 35˚C, the growth or gas production confirmed the presences of coliform. The pure cultures of the bacterial isolates were subjected to morphological (Gram staining) and biochemical characterization tests (Methyl red, Vosges Proskauer, Catalase Test and Citrate Test) to determine the identity of the bacteria isolates (Greenberg, 2011; Allamin, 2015).

2.4. Antibacterial susceptibility testing

Pure culture of the bacteria isolated from borehole water samples were selected for the antibiotic susceptibility testing against different groups of commercially available antibiotics including septrin (30 μg), streptomycin (30 μg), gentamicin (30 μg), sparfloxacin (10 μg), ciprofloxacin (30 μg), amoxicillin (30 μg), augmentin (10 μg), pefloxacin (30 μg), chloramphenicol (30 μg), and tarivid (10 μg) by the Kirby-Bauer disc diffusion technique. Briefly, the isolates were grown on culture plate, then followed by transferring a few portions of a fresh colony to Muller-Hinton broth and incubating at 37°C for 4 h until the turbidity of the bacterial suspension match that of McFarland's standard (0.5 standards). Muller- Hinton agar (MHA) plates were inoculated by spreading the culture with sterile cotton swab. The antibiotic discs were dropped gently in equal space from each other using a sterile needle. Lastly, incubation of the MHA agar was done at 37°C for overnight and zones of inhibition (if any) were measured as diameter and the interpretation of the results were made as susceptible, intermediate and resistant (Uddin *et al.,* 2019).

3.0 Results and Discussion

3.1. Physiochemical parameters of ground water samples

The physicochemical parameters obtained were temperature, conductivity, total dissolved solid, pH, Alkalinity, hardness, turbidity, colour, odour and test. The temperature value of the water samples collected ranges from 25.7 to 32.6°C which is almost an ambient temperature. This result is in disagreement with of Ayuba (2018) which reported a lower value of 21.6°C to 25.4°C. The high temperature could be due to greater solar radiation, clear atmosphere and higher atmospheric pressure. During winter the temperature remain low due to cool low ambient temperature and shorter photo period. The Conductivity value of water samples obtained ranges from 0.50 to 1.26mg/l. The standard value for conductivity of water must not be more than 2500umhos/cm recommended by APHA (1992). The Conductivity of the water samples obtained were at normal and low levels according to the limits recommended by APHA (1992). The finding differs from that of Hassane *et al.* (2020) which reported that conductivity of all the sample were observed out of recommended limit of WHO. The electric conductance is related to the ionic content of the water samples which is in turn a function of dissolved (ionsable) solids.

With respect to colour, odour and test analyzed, the water samples shows that all the samples were colourless, odourless and tasteless respectively. This is in agreement with Chindo *et al.* (2013) which reported colourless, odourless and tasteless water. The occurrence of odor was associated with the presence of inorganic or organic contaminants of water, related to taste, a strong odor from water for consumption will obviously cause rejection on the part of the consumer. The normal water should be colourless, odourless and tasteless for drinking water as recommended by WHO (2011). The hardness of the water sample obtained ranges from 7.6 to 10.4 mg/l which does not exceed the standard value of 100 mg/l recommended by WHO, which means the water is safe for drinking. This differ from results of Madhusmita *et al.* (2016) that reported a high value of hardness (118.3-326.3mg/l) which may be due to evaporation of water, addition of calcium and magnesium salts by means of plant, living organisms and also due to regular addition of large quantity of sewage and detergent from the nearby residential localities (Verma, 2012).

The turbidity of the water samples obtained shows that all the samples were cleared which did not exceed the standard value set by WHO (5.0 NTU) which means the water is safe for drinking. The study is an agreement with the work of Akinyemi *et al.* (2013) who reported that in Borehole water, turbidity usually does not exceed 5.0 NTU. The Alkalinity of the water samples obtained ranges from 16 to 55 mg/l, Durumin Jammo street sample has the lowest Alkalinity (26mg/l), while Zango street sample has the highest Alkalinity (55 mg/l). This result is in agreement with the work of Akintola (2014) that reported a higher value of 57 mg/l. The pH value obtained from this study shows the water samples to be slightly acidic ranges from 5.65 to 7.5 and it is below the lower permissible limit (6.5-8.5) recommended by WHO (2011). It may be reasonable presumed that low pH of the water is likely caused by organic contamination, which lead to a decrease in pH (acidic) (Abraham, 2012). Agbabiaka *et al.* (2012) in their study recorded similar low pH, though, slightly higher (5.94) than the values for water samples obtained in this study.

Table 1: Physiochemical parameters of Ground water samples collected from different street in Makera Kaduna South Kaduna state

Sample	Physical Appearance	Tempt. ^{0}c	Conductivity Mg/L	TDS Mg/L	pH	Alkalinity Mg/L	Hardness Mg/L	Turbidity	Odour	Taste
A	Colourless	32.0	0.9	5.46	5.65	16	7.6	Clear	Odourless	Tasteless
B	Colourless	31.9	0.62	3.31	6.00	49	10.4	Clear	Odourless	Tasteless
C	Colourless	32.1	0.50	2.24	5.80	44	8.8	Clear	Odourless	Tasteless
D	Colourless	32.6	1.26	4.63	6.91	50	7.6	Clear	Odourless	Tasteless
E	Colourless	25.7	1.00	2.33	7.5	55	9.8	Clear	Odourless	Tasteless

Key: A = Durumin Jammo street, B = Gambarawa street, C = Kanfage street D = Baban dodo street, E = Zango street.

3.2. Total viable count

The results of total viable count as presented in Table 2 indicates that the number of bacterial population ranged from 1.0×10^3 CFU/ml (sample obtained from Durumin Jammo street) to 4.5×10^3 CFU/ml for sample collected from Zango street, which is exhibited in dilution of 10^{-3}, while the result that was exhibited in dilution of 10^{-4} ranged from 1.0×10^3CFU/ml sample obtained from Zango street to 8×10^2CFU/ml for sample collected from Durumin Jammo and Baban dodo streets. The total viable count shows that all the samples do not exceed the limit of 100 viable count, they are within the acceptable limit of 100 count/100ml. The result of this study is in agreement with the work of David *et al.* (2015) who reported that in Borehole water viable count usually does not exceed standard value, and low viable count determined the purity of Borehole water.

Table 2: Total viable count of ground water samples collected from different street within Makera Kaduna South Kaduna.

Sample	Dilution 10^{-3}	Dilution 10^{-4}
A	1.0×10^3	3.0×10^2
B	3.0×10^3	8.0×10^2
C	1.8×10^3	5.0×10^2
D	3.0×10^3	1.1×10^3
E	1.1×10^3	2.0×10^2
F	4.0×10^3	1.8×10^3
G	1.5×10^3	8.0×10^2
H	2.2×10^3	5.0×10^2
I	4.3×10^3	1.6×10^3
J	4.5×10^3	1.0×10^3

Key: A and B =Durumin jamma street, C and D = Gambarawa street, E and F = Kanfage street, G and H = Baban dodo street, I and J = Zango street.

3.3. Most Probable Number Index per 100ml of water samples

The result of MPN test of water samples shows that the MPN index value ranges from 2MPN index/100ml (sample obtained from Gambarawa street) to 17MPN index/100ml for sample collected from Gambarawa street (Table 3). From the MPN index result, none of the water samples met the WHO standard for drinking water which states that the presence of coliform in drinking water should be zero/100ml (Bridson, 2000). All the 10 water samples collected from different street in Makera Kaduna South Kaduna shows all the MPN index result of the water samples exceeded the standard value.

Table 3: Most Probable Number Index per 100ml of ground water samples collected from different street within Makera Kaduna South Kaduna.

Samples	MPN Index per 100ml
A	4
B	5
C	2
D	17
E	11
F	14
G	6
H	4
I	7
J	12

Key: A and B = Durumin Jammo street, C and D = Gambarawa street, E and F = Kanfage street, G and H = Baban dodo street, I and J = Zango street.

3.4. Presumptive organisms of ground water samples

The result obtained shows that *Escherichia coli* occurs in 9 out of 10 samples, followed by *Salmonella* sp in 5 out of 10 samples and *Shigella* sp was the least found which occurs in 3 out of 10 samples (Table 4). Coliforms bacteria have been widely used as indicator of the microbiological quality of ground water (Baker, 2008), thus the presence of coliforms is an index of bacteriological quality of water. *E. coli* (90%) has the highest number of occurrences among the bacteria from the water samples, followed by *Salmonella* sp (50%) and *Shigella* sp (30%). This finding is in agreement with the work of Hirsch *et al.* (2010), which reported that

E. coli was found to be the most frequent occurring organism in water, followed by *Salmonella* sp and *Shigella* sp in water samples. The presence of these organisms in water sample indicates that they are responsible for causing typhoid fever and diarrheal disease (Begaud *et al.*, 2003).

Table 4: Presumptive organisms of ground water samples collected from different street within Makera Kaduna South Kaduna.

Sample	**E. Coli**	**Salmonella**	**Shigella**
A	+	+	-
B	+	-	-
C	+	-	-
D	+	-	-
E	+	-	+
F	+	+	+
G	-	+	-
H	+	+	-
I	+	+	-
J	+	-	+
Total Number of occurrences	9	5	3
Percentage occurrence (%)	90%	50%	30%

Key: + = Present, - = Absent, A and B = Durumin Jammo street, C and D = Gambarawa street, E and F = Kanfage street, G and H = Baban dodo street, I and J = Zango street.

3.5. Antibiotic susceptibility profile of the isolates

Susceptible pattern of the isolated organisms; *E. coli*, *Salmonella* sp and *Shigella* sp was carried out, by which Gentamycin, Tarivid and Streptomycin are effective on *E. coli* while it shows resistant to Pefloxaxin, Ciprofloxacin and Septrin and shows intermediate to Chloramphenicol, Sparfloxacin, Amoxacillin and Augmentin. *Salmonella* spp showed susceptibility to Gentamycin, Tarivid and Streptomycin. It showed resistant to ciprofloxacin and intermediate to Septrin, Chloramphenicol, Ciprofloxacin, Amoxicillin and Augmentin. *Shigella* spp showed susceptibility to Gentamycin, Tarivid and Streptomycin. It showed resistant to ciprofloxacin and intermediate to Septrin, Chloramphenicol, Ciprofloxacin, Amoxicillin and Augmentin (Table 5, 6 and 7). The test towards the ten negative discs showed that *E. coli* had an antibiotic susceptible index of 0.3 of the ten antibiotics. Among the antibiotics used, the organism was susceptible to gentamycin, tarivid and streptomycin and it is resistant to septrin, ciprofloxacin and pefloxacin while it shows intermediate to chloramphenicol, sparfloxacin, amoxacilin and augmentin. *Salmonella* and *Shigella* both showed the same susceptibility pattern with susceptible index of 0.3 of the ten antibiotics. The organisms were susceptible to gentamycin, tarivid and streptomycin and are resistant to ciprofloxacin and pefloxacin while it shows intermediate against septrin, chloramphenicol, sparfloxacin, amoxacilin and augmentin. Although antibiotic resistant is common, antibiotics are still indicated in the management of diarrhea. Antibiotics shorten the duration of diarrhea, decrease stool output and may mitigate complications (Obi *et al.*,2004). The antibiotic susceptible pattern of isolates in this study indicates that 100% of the isolates were sensitive to clinically relevant antibiotics gentamycin, tarivid and streptomycin.

Table 5: Antibiotic susceptibility pattern of the *E. coli* isolate

Antibiotics	Abbreviation	Quantity	Zone of Inhibition	Effectiveness
Septrin	SXT	30ug	15.5mm	R
Chloramphenicol	CH	30ug	14.5mm	I
Sparfloxacin	SP	10ug	17.5mm	I
Ciprofloxacin	CPX	30ug	17mm	R
Amoxacillin	AM	30ug	18mm	I
Augmentin	AU	10ug	17mm	I
Gentamycin	CN	30ug	17.5mm	S
Pefloxacin	PEF	30ug	17.5mm	R
Tarivid	OFX	10ug	18mm	S
Streptomycin	S	30ug	16.5mm	S

Key: I= intermediate, S= susceptible, R= Resistant

Table 6: Antibiotic susceptibility pattern of the *Salmonella* sp isolate

Antibiotics	Abbreviation	Quantity	Zone of Inhibition	Effectiveness
Septrin	SXT	30ug	17.5mm	I
Chloramphenicol	CH	30ug	15.5mm	I
Sparfloxacin	SP	10ug	16.5mm	I
Ciprofloxacin	CPX	30ug	15mm	R
Amoxacillin	AM	30ug	15.5mm	I
Augmentin	AU	10ug	15.5mm	I
Gentamycin	CN	30ug	16.5mm	S
Pefloxacin	PEF	30ug	17.5mm	R
Tarivid	OFX	10ug	18mm	S
Streptomycin	S	30ug	17.5mm	S

Key: I= intermediate, S= susceptible, R= Resistant

Table 7: Antibiotic susceptibility pattern of the *Shigella* sp isolate

Antibiotics	Abbreviation	Quantity	Zone of Inhibition	Effectiveness
Septrin	SXT	30ug	17mm	I
Chloramphenicol	CH	30ug	16.5mm	I
Sparfloxacin	SP	10ug	17.5mm	I
Ciprofloxacin	CPX	30ug	16.5mm	R
Amoxacillin	AM	30ug	17.5mm	I
Augmentin	AU	10ug	16.5mm	I
Gentamycin	CN	30ug	17.5mm	S
Pefloxacin	PEF	30ug	17.5mm	R
Tarivid	OFX	10ug	17mm	S
Streptomycin	S	30ug	16.5mm	S

Key: I= intermediate, S= susceptible, R= Resistant

4.0 Conclusion

The physicochemical parameters (conductivity, total dissolved solid, pH, Alkalinity, hardness, turbidity, colour, odour and test) of the borehole water samples in the study area were all within the acceptable limits by WHO standard for drinking water. The total viable count shows that all the samples do not exceed the limit of 100 /100 ml count, hence, they are within the acceptable limit. The result of MPN revealed that the MPN index value ranges from 2MPN index/100ml to 17MPN index/100ml. Thus, none of the water samples met the WHO standard for drinking water which states that the presence of coliform in drinking water should be zero/100ml. About three species of bacteria were identified in the water samples, these includes *E. coli, Salmonella,* and *Shigella* sp. It is recommended that the study of this kind be carried out periodically to assess the suitability of drinking water for inhabitants of the community.

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