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Assessment of bacteriological quality of borehole water in Wamakko local government, Sokoto state, Nigeria

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Abstract

The increase in human populations together with their daily activities continues to have great influence on the quality of borehole water in Nigeria. In the current study, the major source of drinking water within Arkilla which is the one of the most growing community in Wamakko local government area of Sokoto state, were analyzed bacteriologically to ascertain their portability. A total of three water samples were collected from available boreholes within the major sites of Arkilla area namely; Arkilla layout, Arkilla federal low cost and Arkilla state low cost. They were analyzed for the total bacterial, coliform and faecal coliform counts using the standard plate count and most probable number (MPN) assays. Obtained results were compared with (WHO) standards for drinking water sources. The mean total bacterial count ranged from 5.4×10^4 to 3.7×10^6 cells/ ml, whereas, the total coliform counts of the water samples ranged from 12 -16 MPN/100 ml. The faecal coliform count ranged from 0-1 MPN/100 ml. General bacterial genera encountered were *Escherichia coli*, *Klebsiella* spp. and *Enterobacter* spp. The bacterial load recovered from the studied borehole water samples were above the WHO standard for bacterial loads, and coliform content. Therefore, current results suggest that some of the borehole waters in Wamakko local government area, Nigeria; were not safe for drinking.

Keywords: Bacteriological quality, borehole water, standard plate count, most probable number assay, Wamakko government, Nigeria

1. Introduction

Water is one of the most essential natural resources needed by every living organism (Duru *et al*., 2017; Onyango *et al*., 2018). Whether it is used for drinking, bathing, food production or recreational purposes; portable and accessible water supplies are crucial for public health (Yusuf, 2007; WHO. 2018; WaterLife. 2018). Today the major challenges in developing countries include among others; the unprecedented human populations growth and climatic changes, which have culminated in pollution of available natural water resources (Olaoye and Olaniyan, 2012). According to the United nations medium population projection; over 2,8 billion people in 48 countries will be affected with water stress by 2025 (Hinrichsen *et al*., 1998; WHO. 2018). Against this background, global water security was adopted as one of the top most agenda of international organizations (Aboh *et al*., 2015). According to Amenu, (2014), water was broadly grouped into two sources; surface and underground water. Surface water includes; rivers, streams, ponds and lakes, whereas, underground water includes wells and borehole waters among others.

In Nigeria, borehole water represents the major source of potable water (Getso *et al*., 2018). Due to the acute shortage of water supplies, the last decade has witnessed a rapid increase in sinking of boreholes (Lateef *et al*., 2012). Moreover, Hati *et al*., (2011) reported earlier that the current available underground water sources especially in developing countries were becoming polluted due to; the increasing growth in human populations, industrialization, indiscriminate refuge dumpsites, and climatic changes.

Clean water is priceless and has limited resources that man has begun to treasure only recently after decades of pollution with wastes (Oparaocha *et al*., 2010; Getso *et al*., 2018). According to Chapman and Kimstach, (2014); Obioma *et al*., (2017) groundwater was the most important component of the hydrological cycle, and was an important source of potable water in Africa. Groundwater provides a reasonably constant water supply for domestic use; livestock and irrigation; in addition, it was not likely to dry up under natural conditions thereby buffering the effects of rainfall variability across seasons (Hamil and Bell, 1986; Calow *et al*., 2010). According to Bolaji and Tse, (2009), in many arid and semi-arid areas of Africa; borehole water was a means of coping with water deficiencies especially in areas where rainfall was scarce; or highly seasonal and surface water was extremely limited. Groundwater appeared as vulnerable as surface water; because superficial sources of pollution were being numerous (Deutsch, 2003).

Literatures have shown that water was prompt to contamination regardless of the sources (Oludair and Aiyedun, 2016; Onyango *et al*., 2018). Contaminants such as; bacteria, fungi, protozoans, viruses, heavy metals, nitrates and salts have polluted water supplies, as a result of inadequate treatment and poor disposal of wastes from humans and livestock, industrial discharges; and over-use of limited water resources (Onyango *et al*., 2018; WHO. 2018; WaterLife. 2018).

Hamil and Bell, (1986) stated that pathogenic bacteria can survive long period underground and may have a life span of about 4 years. Reports from previous research works showed that the majority of borehole waters in Nigerian communities were microbiologically unsafe for drinking; which therefore placed the community at risk of waterborne diseases (Hati *et al*., 2011; Bello *et al*., 2013; Okoro *et al*., 2017). The most frequent bacteria associated with waterborne diseases were the enteric bacteria such as; *Escherichia coli*, *Shigella* spp. and *Salmonella* spp.; which according to WHO. (2018) have been associated with the estimated 80% of diseases affecting developing countries.

About 842 000 people were estimated to die each year from diarrhoea caused by unsafe drinking-water, sanitation, and hand hygiene. More than 240 million people worldwide were affected by schistosomiasis, an acute and chronic disease caused by parasitic worms contracted through exposure to contaminated water (WHO. 2018). Therefore, this study aimed to assess the bacteriological quality of borehole water in Wamakko local government, Sokoto state, Nigeria.

2. Materials and methods

2.1. Study design and sampling site

This was an experimental laboratory study carried out in Microbiology department, Sokoto State University, Sokoto, North-Western Nigeria in August 2018. Water samples were obtained from Wamakko local government (latitude 120 'N and 13058N, longitudes 040 8' E and 6054E) as clear in Fig. 1.

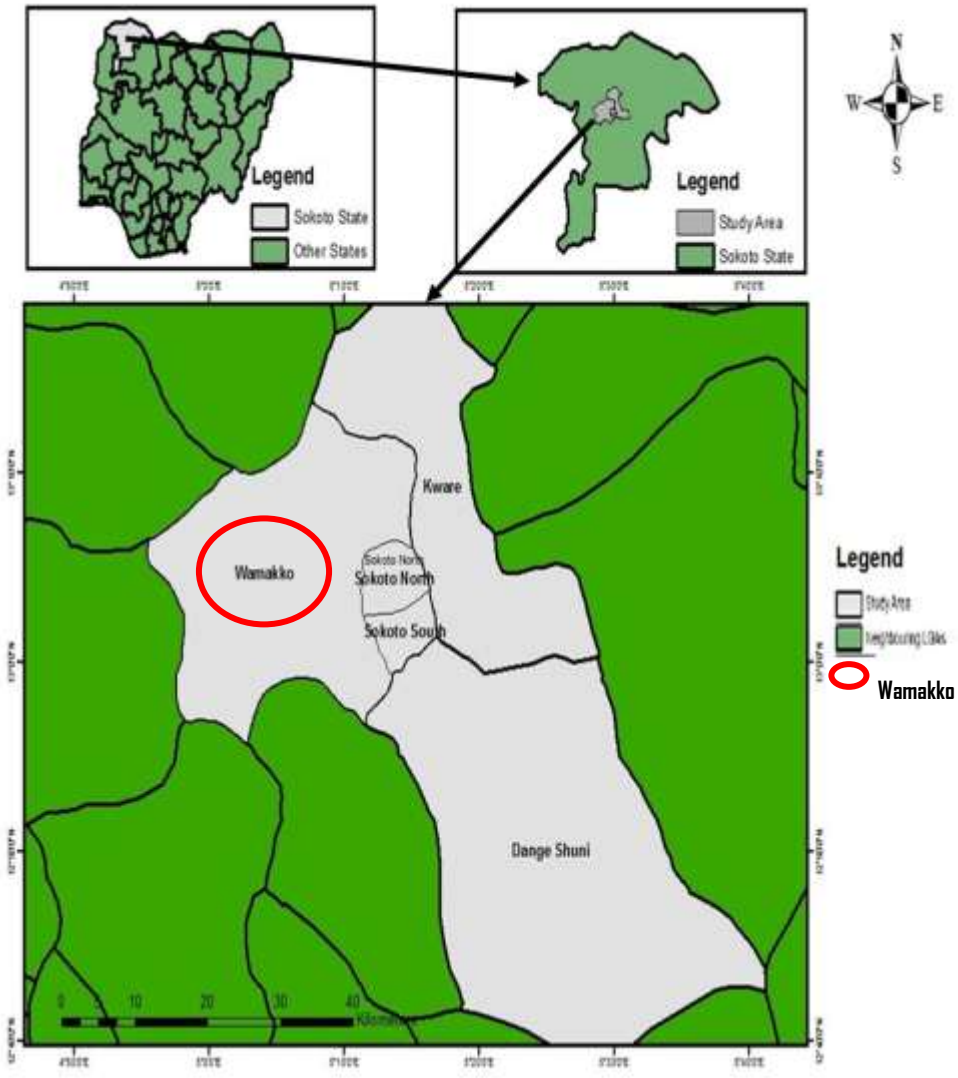

Fig. 1: Map of Sokoto state, showing the sampling site circled in red (Kwoji *et al*., 2017)

2.3. Determination of bacteriological quality

2.3.1. Enumeration of total bacterial count

Surface spread plate method was used as described by Ibe and Okplenye, (2005); Kalpana *et al*. (2011); to enumerate total bacterial counts of the collected borehole water samples. Serial dilutions of the water sample were made by aseptically transferring 1 ml of the water sample into 9 ml of sterile dist. water; to make dilutions that range from 10^{-1} - 10^{-6}. Thereafter, an aliquot of 0.1 ml from each dilution was aseptically plated on Nutrient agar plates (Hi-media) in duplicates then spread aseptically using a sterile spreader. Plates were incubated at 37˚C for 24 h before counting the colonies.

2.3.2. Most probable number (MPN) for coliform counts

2.3.2.1. Presumptive test

Coliform counts of borehole water samples were determined using the three tube analysis of Most Probable Number (MPN) techniques; as described earlier by Cheesbrough, (1991); Ibe and Okplenye, (2005); Kalpana *et al*., (2011) using sterile MacConkey broth. The first set of three tubes had sterile 10 ml double strength lactose broth; whereas the second and third sets had 10 ml single strength broth. All tubes contained Durham tubes before sterilization. The three sets of tubes received, 1 ml, 0.1 ml and 0.01 ml quantities of water samples, respectively. The experiment was conducted in duplicates (One set up of tubes for estimation of total coliform bacteria; whereas, the second set was for estimation of faecal coliform). Tubes were then incubated at 37˚C for 24-48 h for the estimation of total coliforms; and at 44.5˚C for 24-48 h for faecal coliforms, and thereafter were examined for acid and gas production. Acid production was detected by color change of the lactose broth from reddish purple to yellow, and gas production was checked for by the entrapment of gas in the Durham tubes. Positive tubes were noted and then MPN was determined.

2.3.2.2. Confirmative tests

A loopful of samples from positive tubes were inoculated onto a Petri plates containing Eosine Methylene blue agar (EMB) using streaking method; and then plates were incubated at 37˚C for 24- 28 h. This selective and differential agar medium inhibits Gram positive bacteria, but allows growth of Gram negative coliforms. Coliforms produced large pinkish colonies; with dark centers and green metallic shines. This confirmative test was carried out to determine if the coliforms were of faecal origin or not. Presence of typical colonies at 37˚C confirmed the presence of coliforms; and those at 44.5˚C confirmed the presence of *E. coli* as referenced by Cheesbrough, (1991); Ibe and Okplenye, (2005); Kalpana *et al*., (2011).

2.3.2.3. Completed test

The completed test was carried out by subculturing colonies which grew from the confirmed test on nutrient agar slants; and tubes of lactose broth then incubated at 37°C for 24 h. After incubation period; lactose broth was checked for the production of gas, and Gram stain was done on colonies growing on nutrient agar slants. After Gram staining; if the bacterium is Gram-negative; non-spore-forming rods and produced gas in the lactose broth tube, then it was considered positive for presence of coliforms in this water sample (Ibe and Okplenye, 2005; Cheesbrough, 2006).

2.3.3. Gram's staining, cell shape and biochemical tests

Pure bacterial isolates were then characterized using Gram staining; microscopical examination of cell shape, and biochemical assays such as; Catalase,

Coagulase, Urease, Indole, Methyl Red and sugar fermentation tests. Identities of the isolates were matched with reference standards for confirmation; as described by Bergey's Manual of Determinative Bacteriology (Holt *et al*., 2002).

3. Results

In the current study, total bacterial counts of the borehole water samples ranged from 3.7×10^6 - 5.4×10^4 cells/ ml. The highest bacterial counts were recorded in sample 3; whereas, sample 1 had the least bacterial counts (Table 1). Moreover, the total Coliform counts ranged from 12 - 16 MPN/100/ml. Highest coliform counts were detected in sample 3 (16); while sample 1 had the least coliform counts (12) as clear in Table 2. Total faecal counts of the borehole water samples ranged from 0 - 1 MPN/100/ml. A single faecal colony was recovered from sample 3; whereas, samples 1 and 2 had no faecal bacteria (Table 3). The morphological and biochemical characteristics of the bacterial isolates revealed the identity of *E. coli*, *Kleibsiella* sp., and *Enterobacter* sp. as shown in Table 4.

4. Discussion

Over the years, polluted water has been identified to play a vital role in the transmission of diverse human ailments (WHO. 2018). Because humans on daily basis depend on water for drinking and domestic activities; it is pertinent to ensure that the available water supplies are protected from contamination due to human activities. Also drinking water sources are expected to be monitored by private and governmental agencies, to ensure that they meet international standards of potable water. One of the major bacteriological indices for water pollution was to test for water borne pathogens; as indicators of its contamination, such as faecal coliforms analysis. The WHO standards for total and faecal coliforms were 1 - 10/100 ml and 0/100 ml, respectively (WHO. 2003; 2006; 2017). In this study, some borehole water samples used as major drinking water sources in Wamakko local governments were analyzed, to ascertain their bacteriological quality and safety.

Results of the current study revealed out that borehole water samples analyzed had total bacterial counts higher than the standard counts (1.0×10^2 cells/ ml), which was reported by WHO. (2018). This was in agreement with previous study of Bello *et al*., (2013); who reported a higher bacterial load in some borehole water samples collected from Ijebu-Ode, South western Nigeria. Similarly, Okoro *et al*., (2017) reported higher total heterotrophic bacterial counts in borehole water sources in Nsukka Urban area, Enugu state, Nigeria. Borehole water samples from Arkilla federal low cost had the highest bacterial, total and faecal coliforms loads compared to other sampling sites. This might be attributed to the poor sanitary system around boreholes from where the samples were collected. Moreover; samples collected from Arkilla state low cost had the least bacterial coliform counts, which might be due to the difference in hygiene practices by people in the surrounding environment. However, both samples collected from Arkilla layout and Arkilla state low cost had no faecal counts. This was in agreement with the results of Bello *et al*. (2013); who reported no faecal coliforms in water samples of some boreholes and wells in Ijebu-Ode, South western Nigeria. In general, the absence of faecal coliforms in borehole water means that it was accurately dug to get clean water. This borehole perhaps might not be located close to a toilet or suck away system; had consistent washing and disinfection of the water tank, and might also had a water purifier which increased water quality (Okoro *et al*., 2017; Obioma *et al*., 2017).

Results of this study also revealed that borehole water samples collected from Arkilla federal low cost contained faecal coliforms, in agreement with those findings of Kumarasamy *et al*., (2009); Onwughara *et al*., (2013). Presence of faecal coliforms in the water sources indicated their

Table 1: Total bacterial count detected in borehole water samples

Sample no.	Water sample	TBC (cells/ ml)
1.	ASL	$3.7x10^6$
2.	ALO	$4.9\ x10^5$
3.	AFL	$5.4\ x10^4$
Standard	WHO limit	$1.0\ x10^2$

Where; TBC= total bacterial counts, ASl= Arkilla state low cost, ALO= Arkilla layout, AFL= Arkilla federal low cost

Table 2: Total coliform count detected in borehole water samples

Sample no.	Water sample	**TC** (MPN/100/ ml)
1.	ASL	12
2.	ALO	15
3.	AFL	16
Standard	WHO limit	0

Where; TC= Total coliforms, ASl= Arkilla state low cost, ALO= Arkilla layout, AFL= Arkilla federal low cost

Table 3: Faecal coliform count detected in borehole water samples

Sample no.	Water sample	**FC** (MPN/100/ ml)
1.	ASL	0
2.	ALO	0
3.	AFL	1
Standard	WHO limit	0

Where; FC= Faecal coliforms, ASl= Arkilla state low cost, ALO= Arkilla layout, AFL= Arkilla federal low cost

Table 4: Morphological and biochemical characteristics of the bacterial isolates recovered from borehole water samples, collected from Wamakko local government area, Sokoto state

Morphological characteristics				**Biochemical characteristics**				
Gram reaction	**Shapes**	**Catalase**	**Coagulase**	**Urease**	**Indole**	**Methyl red**	**Lactose fermentation**	**Probable organisms**
G-	Rod	_	_	_	+	+	AG	*E. coli*
G-	Rod	_	_	+	-	-	AG	*Klebsiella* sp.
G-	Rod	_	_	_	_	_	AG	*Enterobacter* sp.

Where; G- = Gram negative, + = positive, - = negative, AG= acid and gas

pollution from sewage or from animals wastes. Thus, their presence in the borehole water samples suggested that they did not meet the permissible standards set by international water regulatory agencies. According to WHO. (2017), total microbial counts should not be more than 1.0×10^2 cells/ ml, and zero MPN count per 100 ml of a water sample. Moreover, Biiton, (1994); Okoro *et al*., (2017) added that diverse unfriendly environmental human activities in the vicinity of underground water; and poor borehole construction, contributed greatly to their pollutions and poor water qualities.

Further analysis of the bacteriological quality of water samples collected in this study, revealed the presence of three dominant bacterial genera, namely; *E. coli*, *Klebsiella* sp., and *Enterobacter* sp. These isolates have been reported by earlier researchers in borehole water samples within many Nigerian communities (Bello *et al*., 2013; Ehiowemwenguan *et al*., 2014; Okereke *et al*., 2014; Adogo *et al*., 2016; Adebawore *et al*., 2016). The most frequent bacterium isolated in this study was *E. coli*; whose presence indicated the possible occurrence of faecal contamination, which could be linked to gastrointestinal disorders (Kuta, 2008; Onwughara *et al*., 2013). *E. coli*, *Klebsiella* sp. and *Enterobacter* sp. were all Gram-negative rod shaped bacteria belonging to the Enterobacteriaceae family. They were capable of causing several illnesses such as; watery and bloody diarrhea, dysentery, and urinary tract infections (WHO. 2018). They can also cause bacteremia when introduced into the bloodstreams. In addition, some strains of *E. coli* were capable of producing enterotoxins in the human small intestine which can also cause diarrhoea (Obioma *et al*., 2017).

Conclusion

The bacteriological load of borehole water is one of the major parameters for ascertaining its portability and usefulness. The levels and quality of bacterial isolates recovered from the studied borehole water samples were above the WHO standard for total bacterial loads and coliform counts. Therefore, these results suggested that some of the borehole waters in Wamakko local government area were not safe for drinking.

Conflict of interest

The authors declare no conflict of interests.

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