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Full Length Research Article

Detection of Bacteriological Contaminants in Hand-Pump Fitted Borehole Water from a Residential Suburb in Ringim Local Government, Jigawa State

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ABSTRACT
Water from borehole source can be contaminated due to indiscriminate waste disposal. This pilot study was conducted to assess the bacteriological quality of water from five (5) hand-pump-fitted borehole sources present in Sabon Gari quarters in Ringim Local Government Area of Jigawa State. Presumptive, confirmed and completed tests were employed to determine total and faecal coliforms from the water samples using most probable number (MPN) technique. Bacterial isolates were identified by standard microbiological methods. Results obtained indicate that all the water samples across all the dilution strengths tested recorded substantial growth of total coliforms at 37.3°C while faecal coliforms were observed at 44°C after incubation for 48 h. Using the MPN table, the five water samples assayed recorded 50 MPN/100mL, 14 MPN/100mL, 3 MPN/100mL, 5 MPN/100mL and 1 MPN/100mL. Results were also positive for gas and acid production in all samples collected characteristic of presence of *E. coli*. The results obtained in this study show bacterial contamination of the water from the boreholes which may constitute a public health risk. It is therefore recommended that the water pumped from these boreholes should be subjected to adequate treatment to meet World Health Organization (WHO) required standard for potable water meant for drinking.
Keywords: Boreholes, hand pump, most probable number, total coliforms and faecal coliforms.

INTRODUCTION
The utilization of water for numerous daily activities remains undoubtedly the highest need that humans have not got alternatives to as it is inevitable. According to Tya *et al.* (2012), water is certainly one of the most indispensable resources on earth and remains the most needed resource that man needs in his immediate environment. Accessibility and nearness of potable water for human consumption has been pinpointed by Adeleye *et al.* (2018) as vital features that divulge suitable welfare of humans in their environment. The scarcity of water in some remote areas of Nigeria has necessitated the utmost need of constructing hand-pump boreholes which is normally bored into the underground aquifer for domestic, agricultural and industrial use (Palamulen and Akoth, 2015). Many authors (Singh and Mosley, 2003; Bello *et al.,* 2013; Palamulen and Akoth, 2015; Hassan *et al*., 2018; Amoo *et al*., 2018) have submitted that groundwater resources which are supposed to be free from pollution becomes vulnerable to contamination due to indiscriminate disposal of waste materials, poor siting of drainages, proximity of septic tanks to groundwater source and extensive use of environmental contaminating chemicals in the agricultural and industrial sectors.

The importance of bacteriological assessment of water portability has been variously reported (Adetunde and Glover, 2010; Amoo *et al.,* 2018; Bekuretsion *et al.,* 2018; Hassan *et al*., 2018; Onuorah *et al*., 2018; Onuorah *et al*., 2019). For example, the presence of faecal coliforms or *Escherichia coli* in water clearly indicates that such waters have got the presence of water borne pathogens (Okpokwasili and Akujobi, 1996). According to Singh and Neelam (2011), bacteriological analysis of water is a potent tool that is adopted in detecting the presence of microorganisms that might institute health hazards. However, World Health Organization (WHO) has recommended that faecal coliform expected to be found in drinking water should be zero cfu/100mL (Tya *et al.,* 2012).

Ringim is a developing town in Jigawa state, and a major source of household water supply is through community borehole projects by local authorities. Evidently, septic tanks and gutters for disposal of waste are in close proximity to the hand-pump boreholes present in the study area which may leak into the aquifer thereby polluting the groundwater. It is against this backdrop that this study was conducted with a view to ascertaining the portability of the hand-pump borehole water for domestic use by the residents of Sabon Gari quarters in Ringim.

MATERIALS AND METHOD

The Study Area

Ringim is the headquarter of Ringim Local Government Area (LGA) of Jigawa State, Nigeria that has an area of 1,057km^2 with a population around 192,024 recorded during 2006 census (Jigawa State Government, 2017) with farming as the primary occupation during the wet and dry seasons. As shown in Figure 1, Ringim is located at 12.15° North latitude, 9.16° East longitude and about 387 meters elevation above the sea level (Maps, 2019).

Water Sample Collection

Water was aseptically sampled from the five (5) sampling points (boreholes) in the study area designated as BHA, BHB, BHC, BHD and BHE (Table 1). Sample collection was done at the beginning of wet season in May, 2019. Adopting the method described by Amoo *et al.* (2018), water samples were collected in clean sterile one (1) litre plastic containers rinsed with de-ionized water before being used (USFDA, 2018) at the point of collection. Each sample bottle was well labeled according to respective sampling location. All the samples were subsequently preserved at 4°C and immediately transported to the laboratory for onward bacteriological analysis.

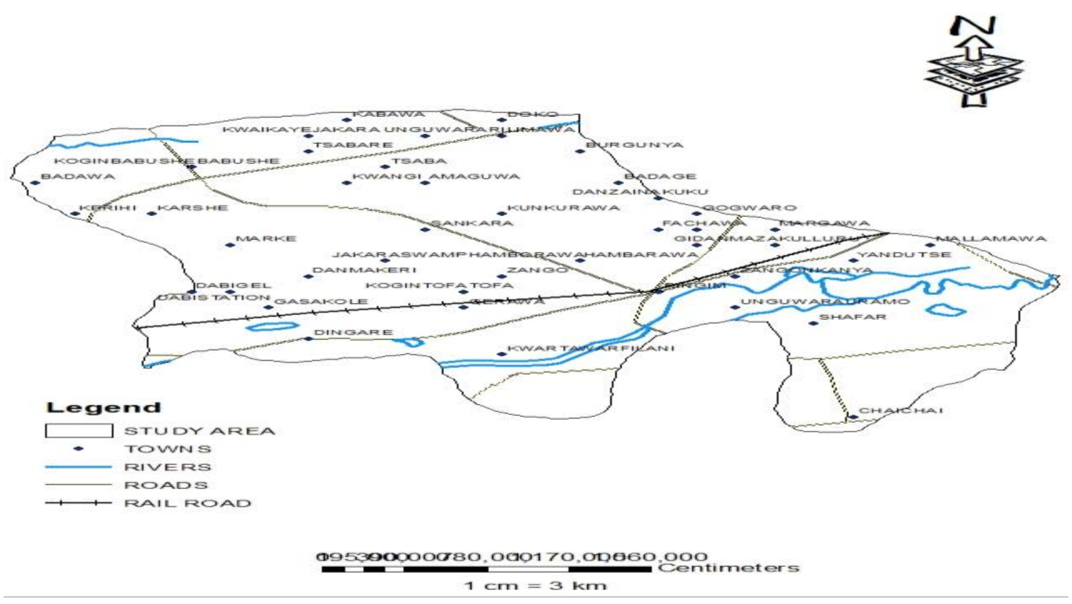

Figure 1: Map showing the study area

Table 1: Location of the assayed boreholes in the study area

Street Name Location	Acronym for Sampling point
HarunaKassim1	BHA
Muttaka Dodo 1	BHB
Muttaka Dodo 2	BHC
Sale Maidodo	BHD
HarunaKassim2	BHE

Physicochemical Analyses of the Water Samples

All the sampled water from each sampling point was subjected to various physicochemical analyses; temperature, pH, turbidity, electrical conductivity (EC), total hardness and nitrite were measured using thomas high-accuracy thermometer, pocket pro pH tester, 2100Q portable turbidimeter, HQ430D laboratory single input multi-parameter meter, SP510 hardness analyzer and EZ7750nitrite analyzer respectively. These parameters were analyzed following the standard analytical methods outlined by APHA (2012).

Determination of Total and Faecal Coliforms in the Water Samples

Tests for determining total and faecal coliforms in the water samples collected were conducted in three stages: presumptive, confirmed and completed tests briefly described below:

Presumptive test

Total coliform was derived by adopting the procedure prescribed by Ochei and Kolhatkar (2008).This was done by employing a three (3) tube assay of the Most Probable Number (MPN) technique and sterilized MacConkey broth. Fifty (50) mL of water was aseptically dispensed into a sterilized test tube containing 50 mL of double strength MacConkey broth, 10 mL of water was dispensed into five (5) sterilized test tubes containing 10 mL single strength MacConkey broth and 1mL of water was dispensed into five (5) test tubes containing 5 mL single strength MacConkey broth. All the test tubes employed contained sterilized Durham tubes for gas entrapment. The test tubes were subsequently incubated at 37.3°C and 44°C for 48 h to estimate total and faecal coliforms respectively. After incubation, the test tubes were examined for acid and gas production. A change in the colour of the broth from reddish purple to yellow was recorded as acid production while the presence of bubbles and gas entrapment in the Durham tubes indicated gas production. The MPN was subsequently determined using appropriate MPN table.

Confirmed test

Confirmed test was conducted in accordance with the procedure established by Majula *et al.* (2011). This was done by aseptically transferring a loopful of culture from positive test tubes in the presumptive test into plates containing sterilized Violent Red Blue Agar (VRBA) and test tubes containing sterilized peptone water. The plates and test tubes were subsequently incubated as described previously for total and faecal coliforms respectively. The production of gas and emergence of red colour indicating indole production in peptone water employed were recorded as a positive result for the presence of *E. coli* while growth of pink colonies with metallic sheen and bleaching at center on VRBA confirmed the presence of coliforms.

Completed test

Completed test was carried out as prescribed by WHO (2012). This was done by streaking positive results from the confirmed test on sterilized Eosin Methylene Blue (EMB) agar with a view to obtaining discrete colonies. The plates were subsequently incubated at 37.3°C for 48 h. Development of green metallic sheen colonies on EMB was recorded as a completed test for further identification of coliforms or faecal coliforms (*Escherichia coli*) as established by Adetunde and Glover (2010).

Gram Staining
In other to conduct morphological identification of the bacterial isolates, gram staining was done according to the procedure recommended by Olutiola *et al.* (1991).

Biochemical tests for the identification of coliforms
After gram staining, all the assayed water samples from the sampling points came up as gram negative rods thereby prompting the need to further confirm their possible identities through the conduct of appropriate biochemical tests recommended by Barrow and Feltham (1993). Biochemical characterization was carried out to identify bacterial isolates by conducting the following tests: catalase, indole, methyl red and vogesproskauer (Cheesebrough, 2006); citrate, oxidase, urease, nitrate reduction and gelatin (Ochei and Kolhatkar, 2008); mannitol, lactose and triple sugar iron (Hemraj *et al*. 2013); oxidation fermentation and glucose (Aryal, 2018)

Statistical Analysis
Most Probable Number (MPN) analysis which is based on the random spreading of microorganisms per volume in any given sample as described by Aryal (2018) was adopted in analyzing data generated from the presumptive, confirmed and completed tests. Data generated from physicochemical and bacteriological analyses were subsequently summarized in tables and compared with WHO permissible standards.

RESULTS AND DISCUSSION
Results of the physicochemical analyses of the sampled boreholes as presented in Table 2 show that temperature of borehole water samples measured during water sample collection, for BHA, BHB, BHC, BHD and BHE are 34°C, 33°C, 31°C, 33°C and 32°C respectively. Even though WHO has not recommended any temperature standard for potable water, Palamuleni and Akoth (2015) reported that it does enhance the total quality of water in terms of its biological and physicochemical attributes. The total hardness of the water samples that ranged from 105.8 to 48.6 mg/L fell below the permissible limit recommended by WHO. It can be observed that pH values ranged from 7.8 to 7.2. Interestingly, the pH values recorded in this study fell within the recommended limits set by WHO. Similar findings were reported by Amoo *et al.* (2018) who conducted water quality assessment of selected boreholes in a geological location similar to the area of this study.

Table 3 presents results for determining the presence of coliforms in the water samples. All the samples demonstrated substantial growth of total and faecal coliforms suggesting microbiological contamination of the borehole water under study.

Table 2: Physicochemical parameters recorded from the sampling points

	BHA	BHB	BHC	BHD	BHE	WHO
pH	7.8	7.4	7.2	7.7	7.3	≥7 to ≤9.2
T (^{0}C)	34	33	31	33	32	No standard
TH (mg/L)	105.8	87.3	65.4	68.7	48.6	150 to 500
EC (µS/cm)	585	570	462	465	420	1000
Tu (NTU)	3.04	2.15	0.16	1.05	0.05	5
Nitrite(mg/L)	0.06	0.03	0.01	0.01	0.01	50

Note: T= Temperature; TH= Total Hardness; EC= Electrical Conductivity; Tu= Turbidity

Table 3: Water assay results for all the sampling points in SabonGari Quarters

Sample	Growth			Acid Production			Gas Production		
	50mL	10mL	1mL	50mL	10mL	1mL	50mL	10mL	1mL
BHA	Yes	Yes	Yes	+	+	+	+	+	+
BHB	Yes	Yes	Yes	+	+	+	+	+	+
BHC	Yes	Yes	Yes	+	+	+	+	+	+
BHD	Yes	Yes	Yes	+	+	+	+	+	+
BHE	Yes	Yes	Yes	+	+	+	+	+	+

Note: + = Positive

In terms of acid production by the total and faecal coliforms that grew in the water samples, all recorded positive results across the dilution strengths employed (Table 3). These results indicate the presence of total and faecal coliforms in all the water samples as indicator organisms have been implicated by Ochei and Kolhatkar (2008) as having the ability of producing acid when incubated at the afore-indicated temperature ranges employed in this study. Again, the detection of gas in all the Durham tubes employed in this study indicates the presence of total and faecal coliforms in all the water samples assayed (Table 2).

The quantification of the coliform bacteria present in the water samples assessed in this study through the employment of most probable number (MPN) table is depicted in Table 4.

It can be seen that the MPN values ranged from 1-50mL across the five sampling points (Table 4). Samples from BHE (1 mL) and BHA (50mL) recorded the lowest and highest MPN/100mL respectively. The variations observed in the total and faecal coliforms present in the study area may be due to different sources and proximity of pollutants responsible in each sampling point. For instance, physical inspection of BHA during sampling revealed its proximity to drainages and septic tanks that might have potentially contributed to the pollution level recorded in this study. Again, the incessant flooding experienced in the study area prior to water sampling might be held responsible for the presence of coliform bacteria in the groundwater of that locality. The results obtained in this study are in concord with the reports of Adetunde and Glover (2010); Kamanula *et al*. (2014). These authors implicated the location of the boreholes assayed in their respective studies and some environmental factors as determinants of pollution level that groundwater is exposed to these days.

The results of the biochemical tests conducted (Table 5) confirmed the presence of *E. coli*. The gram negative rod tested positive to catalase, OF, indole and MR tests but negative to VP, citrate and TSI.

Table 4: MPN Values for the water samples collected from the sampling points

Sample	**Ratio**	**MPN Values (MPN/100mL)**
BHA	1:5:2	50mL
BHB	1:3:2	14mL
BHC	1:1:0	3mL
BHD	1:1:1	5mL
BHE	0:1:0	1mL

Key: MPN= Most Portable Number

Table 5: Biochemical Screening of Gram Negative Rods Detected in Borehole water Samples

	CA	OF	MR	VP	GL	LA	MA	GE	NR	UR	CI	OX	IN	TSI	Identity
BHA	+	+	+	-	+	+	+	-	+	-	-	-	+	-	*E. coli*
BHB	+	+	+	-	+	+	+	-	+	-	-	-	+	-	*E. coli*
BHC	+	+	+	-	+	+	+	-	+	-	-	-	+	-	*E. coli*
BHD	+	+	+	-	+	+	+	-	+	-	-	-	+	-	*E. coli*
BHE	+	+	+	-	+	+	+	-	+	-	-	-	+	-	*E. coli*

Key: + = Positive; - = Negative; CA= Catalase; OF= Oxidation Fermentation; MR= Methyl Red; VP= Voges-Proskauer**;** TSI = Triple Sugar Iron; GL= Glucose; LA= Lactose; MA= Mannitol; GE= Gelatin; NR= Nitrate reduction; UR= Urease; CI= Citrate; OX= Oxidase; IN= Indole

CONCLUSION AND RECOMMENDATIONS

The findings of this study have detected the presence of *Escherichia coli* in all the sampled borehole water hence not fit for human consumption. It is recommended that the water from these boreholes should be treated with disinfectants before use for domestic purposes most especially drinking. Routine monitoring and assessment of the borehole water quality in the study area is important to avert public health crisis.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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