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Microbial Quality of Household Drinking Water in the Sunyani Municipality of Ghana

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Abstract
The health risk associated with the microbial contamination of drinking water has been a major challenge in most households in the developing world. This challenge stems from the fact that water management systems are either inadequate or non-existent. In this study, the microbial quality of household drinking water in the Sunyani Municipality of Ghana was assessed. Thirty water samples were collected from the various households from eight communities for bacteriological analysis using the multiple tube method. The results were recorded as Most Probable Number (MPN) of coliform per 100 ml of water and compared with World Health Organization Guidelines for Drinking water quality. From the study, the mean total coliform of water ranged from 1.75 x 10^3 to 8.5 x10^6 cfu/100 ml. Out of the 30 water samples, twenty-two (73.3%) were positive with coliforms. The commonest source of drinking water standpipe had fifty percent of samples contaminated with coliforms. All four samples collected from the borehole were contaminated with coliforms. Out of the 22 coliform-positive samples, 59.1% of them showed positive for faecal coliform, out of which 50% of samples tested positive for the presence of *Escherichia coli (E. coli).* The study recommends intensive community education on proper water management systems as well as encouraging proper household hygiene practices.
Keywords: Total coliforms, *E. coli*, Most Probable Number, water quality

1. Introduction

Water has long been considered as an elixir of life. Its usefulness stems from the fact that it is a universal solvent capable of dissolving most substances. Public health challenges associated with the consumption of water of poor quality has been a subject of much study (Anstiss & Ahmed 2006). The supply of safe water is important to protect the health of people in a community (WHO, 1997). An approximately 884 million people still lack access to drinking water from improved sources (EAWAG, 2010). They rely on other sources of collecting water of dubious quality. Many more people collect water from poorly functioning municipal water systems that may deliver unchlorinated water, contaminated with human or animal faecal waste, which may contain bacteria that can cause cholera, dysentery, typhoid fever and other waterborne diseases.

The quality of drinking water may be ascertained by microbiological examination. Water may become contaminated at any point between collection, storage or handling in homes (Tambekar *et al*. 2005). This places water handling and hygienic practices at the household level a matter of utmost importance (Addo *et al.* 2014).

The urban population in Ghana using an improved water supply declined from 86% in 1990 to 79% in 2006 and further down to 59% in 2009. About 60% of households in the Sunyani Municipality have access to treated piped water from the Ghana Water Company Limited. Out of this, 48% have a pipe connection to their households whereas the remaining 52% obtained water from either public or private commercial standpipes. However, less than 30% of people with a pipe connection in their homes have water supply everyday.

The majority of households who do not have access to water have resorted to drilling rope pump wells to gain access to potable water. Those who cannot afford the cost of drilling rope pump well tend to buy water from those who have it. The siting of these wells close to septic tanks can cause contamination of water. This is because seeping of septic tank effluent into the groundwater may cause diseases such as cholera when the water is used for drinking purposes. The contamination of drinking water by pathogen causing diarrhoeal diseases is the most important aspect of drinking water quality (Fawell & Nieuwenhuijse 2003).

The problem arises as a consequence of contamination of water by faecal matter, particularly human faecal matter, containing pathogenic organisms. Detection and enumeration of pathogens in water are not appropriate under most circumstances in view of the difficulties and resources required so *E. coli* are used as indicators of faecal contamination. The assumption is that if the indicators are detected, pathogens including viruses could also be present and therefore appropriate action is required (Fawell & Nieuwenhuijse 2003).

The presence of these indicator organisms in household source of water in Ghana has been documented (Addo *et al*. 2013).

The purpose of this study therefore was to assess the microbial quality of household source of drinking water in the Sunyani Municipality of Ghana.

2. Methodology

2.1 Profile of the Study area

Sunyani Municipality is one of the 22 administrative districts in the Brong Ahafo Region of Ghana. It lies between Latitudes 7^0 20' N and 7^0 05'N and Longitudes 2^0 30'W and 2^0 10'W. The Municipality has a total land area of 829.3 square kilometres. The Municipality falls within the wet Semi-Equatorial climatic zone of Ghana. The mean monthly temperatures vary between 23^o C and 33 ^{o} C with the lowest around August and the highest being observed around March and April. The population of the Sunyani Municipality was 101, 145 according to the 2000 Housing and Population Census. Currently with a growth rate of 3.8%, the estimated population is 147, 301. The Municipality has an average household size of 4.

2.2 Household Data Collection

Thirty households were randomly selected from eight communities in the Sunyani Municipality. Within each household, domestic water used for drinking purposes was collected for bacteriological analysis. The source of the drinking water was also assessed. The collected water samples were transported on ice and were analysed within three hours of collection.

2.3 Laboratory analysis (Inoculation and Incubation)

2.3.1 Total and Faecal coliform

The Most Probable Number (MPN) method was used to determine total and faecal coliforms in the water samples. Serial dilutions of 10^{-1} and 10^{-4} were prepared by picking 1 ml of the sample into 9 ml distilled water. One milliliter aliquot from each of the dilutions were inoculated into 5 mls of MacConkey Broth and incubated at 35 ^{o}C for total coliforms and 44 ^{o}C for faecal coliforms for 18-24 hours. Tubes showing colour change from purple to yellow and from light wine to very deep wine after 18-24 hours were identified as positive for both total and faecal coliforms. Counts per 100 milliliters were calculated from the Most Probable Number tables.

2.3.2 *Escherichia coli* (Thermotolerant Coliforms)

From each of the positive tubes identified a drop was transferred into a 5 milliliters test tube of trypton water and incubated at 44 ^{o}C for 24 hours. A drop of Kovacs reagent was then added to the tube to trypton water. All the tubes showing a red ring colour development after gentle agitation denoted the presence of indole and recorded as presumptive for Thermotolerant coliform (*Escherichia coli*). Counts per 100 millilitres were calculated from the Most Probable Number.

3. Results

3.1 Presence of bacteria in household source of water

A total of 30 water samples from eight (8) randomly selected communities were assessed for coliform contamination. Using the MPN Index calculations, the number of Total coliforms present in the water samples was determined as summarized in Table 1.

Table 1 MPN Index of water samples contaminated with Coliforms

Community	Water facility	Total Coliforms/100ml 1	2	Mean
Abesim	1.Voltic (bottled)	0	0	0
	2.Sachet	1.0x10^4	3.0x10^5	1.55x10^5
	3.Stand pipe	0	0	0
	4.Rope pump well	1.5x10^6	2.0x10^5	8.5x10^6
	5.Stand pipe	0	0	0
New Dormaa	6.Stand pipe	0	0	0
	7. Rope pump well	2.4x10^6	2.3x10^6	2.35x10^6
	8.Stand pipe	0	0	0
	9.Borehole well	1.7x10^5	2.1x10^6	1.14x10^6
Yawhima	10.Rope pump well	7.0x10^4	1.5x10^4	4.25x10^4
	11.Rope pump well	0	0	0
	12.Bore hole well	1.8x10^6	2.3x10^5	1.02x10^6
	13.Stream	2.4x10^6	2.1x10^6	2.25x1010^6
Kotokrom	14.Open shallow well	2.30x10^5	2.3x10^5	2.3x10^5
	15.Borehole well	1.8x10^5	1.7x10^4	9.85x10^4
	16.Rope pump well	4.0x10^4	4.0x10^4	4.0x10^4
Newtown	17.Stand pipe	1.8x10^3	3.5x10^4	1.84x10^4
	18.Stand pipe	0	0	0
	19.Rope pump well	4.1x10^5	2.5x10^5	3.3x10^5
	20.Borehole well	1.5x10^6	2.2x10^5	8.6x10^5
Baakoniaba	21.Stream	2.9x10^5	2.7x10^6	1.5x10^6
	22.Standpipe	2.2x10^3	1.3x10^3	1.75x10^3
	23.Standpipe	0	0	0
	24.Rope pump well	3.0x10^5	2.1x10^6	1.2x10^6
Zongo	25.Standpipe	1.2x10^3	1.1x10^3	1.15x10^3
	26.Standpipe	1.6x10^3	4.2x10^3	2.9x10^3
	27.Open shallow well	7.2x10^5	5.0x10^5	6.1x10^5
Penkwase	28.Open shallow well	9.3x10^5	9.0x10^5	9.15x10^5
	29.Standpipe	3.5x10^3	0	1.75x10^3
	30.Standpipe	1.5x10^3	0	7.5x10^2

Out of the 30, 22 samples representing 73.3% were positive for coliforms. The commonest source of drinking water, standpipe, had 50% out of the total 12 samples collected being contaminated with coliforms. More than 80% of the samples collected from Borehole and Open-shallow wells as well as the Streams had coliform contaminations (Table 2).

Table 2 Percentage ratios of water samples contaminated with Coliforms

Water source	Number of samples collected	Number of samples contaminated	Percentage contamination (%)
Standpipe	12	6	50
Rope pump well	7	6	85.7
Borehole well	4	4	100
Stream	2	2	100
Open shallow well	3	3	100
Bottled water	1	0	0
Sachet water	1	1	100
Total	**30**	**22**	**73.3**

The samples positive for coliforms were also tested for faecal contamination and presence of *E. coli* (Table 3).Out of the 22 coliform-positive samples, 13 showed faecal contamination representing 59.1% (Table 3). 50%

of the samples showed positive for the presence *E. coli* which was determined based on the formation of a pink colony (Table 3).

Table 3 Coliform-positive water samples contaminated with faecal coliform and pathogenic *E. coli*

Community	Water facility	Faecal Coliforms/100ml 1	2	Mean	Pathogenic *E. coli*
Abesim	Sachet water Rope pump	0 3.1x10^3	0 2.4x10^3	0 2.75x10^3	Absent Absent
New Dormaa	Rope pump well Borehole well	0 1.0x10^4	0 3.0x10^5	0 1.55x10^5	Absent Absent
Yawhima	Rope pump well Bore hole well Stream	1.8x10^3 5.0x10^3 7.0x10^5	3.5x10^4 3.2x10^5 1.2x10^6	1.84x10^4 1.63x10^5 9.95x10^5	Absent Present Present
Kotokrom	Open shallow well Borehole well Rope pump well	9.0x10^4 0 3.2x10^3	9.0x10^5 0 1.6x10^3	4.95x10^5 0 2.4x10^3	Present Absent Present
Newtown	Standpipe Rope pump well Borehole well	0 2.1x10^3 6.2x10^4	0 1.3x10^3 3.2x10^5	0 1.7x10^3 1.9x10^5	Absent Present Present
Baakoniaba	Stream Standpipe Rope pump well	1.0x10^4 0 0	3.0x10^3 0 0	6.5x10^3 0 0	Present Absent Absent
Zongo	Standpipe Standpipe Open shallow well	9.0x10^2 0 2.1x10^4	1.1x10^3 0 1.9x10^3	1.0x10^3 0 1.15x10^4	Absent Absent Present
Penkwase	Open shallow well Standpipe Standpipe	2.3x10^5 0 0	2.3x10^5 0 0	2.3x10^5 0 0	Present Absent Absent

Out of the six (6) coliform-positive standpipe samples, only one (16.7%) showed faecal contamination whereas borehole and open shallow wells recorded 75% and 100% faecal contamination respectively. With the exception of the standpipe and sachet water samples, the other four water sources tested positive for the presence of *E. coli* (Table 4).

Table 4 Percentage ratios of coliform-positive water samples contaminated with faecal coliforms and *E. coli*

Water source	No.of coliform-positive samples	No. of samples contaminated with faecal coliform	Percentage contamination (%)	No. of samples contaminated with *E. coli*
Standpipe	6	1	16.7	0
Rope pump well	6	4	66.7	2
Borehole well	4	3	75	2
Stream	2	2	100	2
Open shallow well	3	3	100	3
Sachet water	1	0	0	0
Total	**22**	**13**	**59.1**	**11 (50%)**

4. Discussion

One of the most crucial effects on health is the quality of water irrespective of the usage, including drinking, food production, and domestic or recreational purposes. In addition to supporting public health, resources that ensure water safety often promote personal and socioeconomic development (WHO, 2011).

Most infectious diseases such as diarrhoea, cholera, dysentery and typhoid are transmitted principally through contaminated water. In 2008 alone, an estimated number of 2.5 million people lost their lives due to diarrhoeal diseases (WHO, 2011a). This burden of waterborne infections and mortalities among children under five is greater than the combined affliction of HIV/AIDS and malaria (Liu *et al.,* 2012).

Generally, the greatest microbial risks are associated with consumption of water that is contaminated with faecal

matter of humans or animals. In this study, a total of 30 water samples from randomly selected communities were initially assessed for coliform contamination. The result indicated that majority of the water samples, representing 73.3%, were positive for coliforms. As coliforms are considered to be part of soil microbiota, the 73.3% coliform-positive samples is suggested to be a reflection of the source of the water samples. This is consistent with other studies by Addo *et al*. (2013), in which 10 different bacterial species were found in household drinking water in some households in Ghana. Out of the 30 water samples, 16 were untreated water fetched from Streams, Rope pump, Borehole and Open shallow wells. All the total coliform values recorded were significantly higher than World Health Organization recommendation for the presence of coliform in drinking water. This states that in 90% of samples examined throughout any year for treated water, coliform bacteria shall not be detected or MPN index of coliform or microorganism shall be less than 1.0. None of the samples shall have an MPN index of 10. From the study, the mean total coliform count per 100 ml ranged from 1.75×10^3 to 8.5×10^6. Additionally, the coliform count recorded in the positive samples was very high especially in the untreated water. This is consistent with other studies suggesting that the average coliform count in raw water or contaminated piped water approximately ranges 10^2 - 10^6 per litre (Wright *et al*, 2003).
Due to issues relating to difficulty and sensitivity of detecting specific pathogens in water samples, *E. coli* has been used as an indicator organism to assess faecal contamination in drinking water. From this study, 50% of the coliform-positive samples had *E. coli* present, in which majority of these samples were taken from Streams, Rope pump, Borehole and Open shallow wells. This result primarily indicates contamination of these water sources with faecal pollution with the possible presence of pathogens such as *Clostridium perfringes, Shigella spp., Vibrio cholerae,* enteropathogenic *E. coli, Campylobacter jejuni,* and enteric viruses (Water Pollution Control Federation, 1992). In sub-Saharan Africa where the number of people engaged in open defecation is still rising, faecal contamination of surface water and for that matter untreated water sources is a major issue of concern (WHO, 2013). With increasing poor sanitary conditions, faecal contamination of the water samples can also be attributed to unhygienic handling of the water during collection and distribution in various households.
According to the WHO Guidelines for Drinking water Quality (4th Ed. 2011), all water intended for drinking should have a zero maximum contaminant level (MCL) of *E. coli* or Thermotolerant coliform bacteria in any 100ml sample of that particular water.

5. Conclusion

Out of the thirty (30) water samples from the eight (8) communities randomly selected, 22 samples representing 73.3% was positive for coliforms. The commonest source of drinking water which was stand pipes had 50% out of the 22 samples contaminated with coliforms. More than 80% of the samples collected from the borehole, open-shallow wells and the streams had coliforms contamination. It is therefore estimated that 50% of the water samples involved in this study is of less quality for drinking. Proper hygiene and intensive education must be strengthened in the various communities to reduce the incidence of waterborne diseases from contaminated drinking water.

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