

# The Study Of Bacterial Contamination Of Drinking Water Sources: A Case Study Of Mpraeso, Ghana

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## Abstract

The study aimed at determining the presence, type, count and causes of bacterial contamination of water used for drinking and other domestic purposes in Mpraeso. Fifty-four (54) water samples (48 from 8 groundwater wells and 6 from a stream) were collected and analyzed for six months (both during the dry and raining seasons). The results showed that groundwater sources were as polluted as surface water. The detection of bacterial cells in the water sources means that some forms of treatment needed to be done before consumption. The mean count of total coliform and faecal coliform ranged from 299 - 2267 MPN colonies/100 ml water sample and 111 – 1235 MPN colonies/100 ml water sample, respectively. For the groundwater sources, the enterobacteriaceae species detected were *Escherichia coli* (8 wells), *Enterococcus faecalis* (8 wells), *Klebsiella pneumoniae* (6 wells), *Enterobacter cloacae* (5), *Pseudomonas aeruginosa* (3), and *Proteus mirabilis* (3). All these bacterial species were detected in the surface water samples.

## INTRODUCTION

Water is considered as the essence of life and access to safe drinking water is a basic human right essential to all. Although water is necessary for the welfare of humankind and for sustainable development, a large proportion of the world's population do not have access to microbiologically safe sources of water for drinking and other essential purposes (WHO/UNICEF, 2000). Safe drinking water should not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages (WHO, 2006).

Sources of drinking water include piped water, rivers, reservoirs, springs, streams, wells, ponds and rain. Studies have shown that the way water is collected, handled after collection and stored at home cause quality deterioration to such an extent that the water poses potential risks of infection to consumers (Pinfold, 1990; Nala et al., 2003; Ampofo and Karikari, 2006).

Microbial guidelines seek to ensure that drinking water is free of microorganisms that can cause disease. Microbial hazards are said to represent an overall greater threat than chemical hazards, and in developing countries account for 5.7% of the total global burden of disease (Larmie and Paintsil, 1996). The lack of microbiologically safe drinking water and adequate sanitation measures leads to a number of

diseases including cholera, dysentery, salmonellosis, typhoid, and every year millions of lives are lost in developing countries. For the 1.1 billion people who lack access to improved water supplies, and many more with contaminated water, diarrhoeal disease is highly endemic (Clasen et al., 2007). Diarrhoea is a major cause for the death of more than 2 million people per year worldwide, mostly children under the age of five. It is the symptom of infection or the result of a combination of a variety of enteric pathogens (Zamxaka et al., 2004).

Improving access to safe drinking water and sanitation are the ways of achieving the objectives of the United Nations Millennium Development Goals (MDGs). The MDGs target for water is to 'half by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation' (WHO/UNICEF, 2004).

This study was conducted to enumerate the total and faecal coliforms, determine the presence and types of enterobacteriaceae, and assess the causes of bacterial contamination of drinking water sources in Mpraeso, Ghana.

## MATERIAL AND METHODS

The study area, Mpraeso, is the capital of the Kwahu South District of the Eastern Region of Ghana.

Water samples were collected in sterile bottles from each

sampling site (8 wells and a stream) between 0500 and 0700 GMT, when the demand for water was high, from January to June 2008. The collection of samples was done as described by Cheesbrough (1984). Samples collected were labelled, placed on ice packs and sent to the Bacteriology Department of Noguchi Memorial Institute for Medical Research (NMIMR, Legon) for analyses.

The enumeration of faecal and total coliforms was done using the multiple-tube fermentation method (MTF) as described by Prescott et al. (1996). In this study, five tubes per dilution (10, 1, and 0.1 ml) were used; giving a total of 15 tubes inoculated per incubation temperature. In all 30 tubes were inoculated per site. In the presumptive test, five tubes each containing 10 ml of double strength MacConkey Purple (MAC) Broth (Oxoid, CM6a, England) were each inoculated with 10 ml of water sample. Five additional tubes containing 10 ml of single strength MAC Broth were also inoculated with 1 ml sub-samples of water and the remaining five (5) tubes containing 10 ml of MAC Broth was inoculated with 0.1 ml of water sample (a total of 15 tubes). The tubes were then incubated for 24 hours at 37°C and 44°C for total and faecal coliforms respectively. The presumptive coliform numbers were estimated using the MPN index (calculated using the number of 'positive' tubes that displayed gas production in each dilution). The tubes showing gas production at 44°C were further confirmed as faecal coliform by inoculating into Brilliant Green Lactose Bile (BGLB) broth (bioMe'rieux 51001, France). The tubes were then incubated for 48 hours at 44°C. The tubes were again observed for gas production, with the number of positive tubes used to calculate the MPN.

Sub-cultures from positive tubes of BGLB broth were streaked on plates of Levine's Eosin Methylene Blue (L-EMB) Agar (Oxoid, CM69, England) and incubated for 24 hours at 37°C. After incubation, the plates were observed for the presence of a green metallic sheen, which indicated the presence of faecal coliforms. Suspected colonies were confirmed as *E. coli* using standard biochemical test methods.

For the other enterobacteriaceae, 10 ml of each water sample was inoculated into the Nutrient Broth tube, mixed gently and incubated for 24 hours at 37°C. After incubation, the tubes were observed for colour change and a loopful of inocula from each Nutrient Broth tube streaked on plates of MAC agar and incubated for 24 hours at 37°C. Isolates from the MAC agar plates were then streaked on plates of

Uriselect 4® Agar (Bio-Rad, 64694) and incubated for 24 hours at 37°C. After comparing the colour changes with a chart provided by the manufacturer, suspected colonies were confirmed using standard biochemical test methods.

## RESULTS

Both total and faecal coliforms were detected in all 54 samples analysed (100%). Generally, the counts of total coliforms (TC) were higher than that of faecal coliform (FC) in all the water sources.

The mean TC and FC levels of surface water were 2134 MPN colonies/100 ml water and 1185 MPN colonies/100 ml water, respectively (Table 1).

The mean TC and FC coliform levels of groundwater ranged from 299 – 2267 MPN colonies/100 ml water and 111 – 1235 MPN colonies/100 ml water, respectively.

### Figure 1

Table 1: Mean bacterial count in drinking water sources, Mpraeso, Ghana

Sampling site	Mean bacterial count (MPN colonies/100 ml water sample) <sup>a</sup>	
	Total Coliform	Faecal Coliform
A (well)	2267	1207
B (well)	1183	637
C (well)	1276	1114
D (well)	1710	1235
E (stream)	2134	1185
F (well)	2000	1887
G (well)	614	174
H (well)	299	111
I (well)	868	570

<sup>a</sup> water samples were collected six times from January to June and count calculated to nearest whole number.

*Escherichia coli* and *Enterococcus faecalis* were detected in all 48 (100%) groundwater and surface water samples analysed (Table 2). *Klebsiella pneumoniae* was detected in 18 (37.5%) of groundwater and 11 (91.7%) of surface water samples. *Enterobacter cloacae* was isolated from 21 (43.8%) and 6 (50%) of groundwater and surface water samples analysed, respectively. *Pseudomonas aeruginosa* and *Proteus mirabilis* were detected in 16 (33.3%) and 14 (29.2%) from groundwater and 5 (41.7%) and 1 (8.3%) from surface water samples analysed, respectively.

**Figure 2**

Table 2: Enterobacteriaceae identified from the water samples, Mpraeso.

Water sources	Bacteria isolated
A (well)	<i>Escherichia coli</i> , <i>Enterobacter cloacae</i> , <i>Enterococcus faecalis</i> , <i>Klebsiella pneumoniae</i> , <i>Proteus mirabilis</i>
B (well)	<i>Escherichia coli</i> , <i>Enterobacter cloacae</i> , <i>Enterococcus faecalis</i> , <i>Klebsiella pneumoniae</i>
C (well)	<i>Escherichia coli</i> , <i>Enterobacter cloacae</i> , <i>Enterococcus faecalis</i> , <i>Klebsiella pneumoniae</i> , <i>Proteus mirabilis</i>
D (well)	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Enterobacter cloacae</i> , <i>Enterococcus faecalis</i> , <i>Klebsiella pneumoniae</i>
E (stream)	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Enterobacter cloacae</i> , <i>Enterococcus faecalis</i> , <i>Klebsiella pneumoniae</i> , <i>Proteus mirabilis</i>
F (well)	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Enterococcus faecalis</i> , <i>Proteus mirabilis</i>
G (well)	<i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Enterobacter cloacae</i> , <i>Enterococcus faecalis</i>
I (well)	<i>Escherichia coli</i> , <i>Enterococcus faecalis</i> , <i>Klebsiella pneumoniae</i>
J (well)	<i>Escherichia coli</i> , <i>Enterococcus faecalis</i> , <i>Klebsiella pneumoniae</i>

## DISCUSSION

Ideally, drinking water is expected to be pristine and indicator organisms must not be detected in any 100 ml water sample (WHO, 2006).

Globally, groundwater sources are considered to be of better microbial quality than surface water; however, the results obtained from this study showed that groundwater sources are as polluted as surface water sources. Nogueira et al. (2003) reported that untreated water sources were more heavily contaminated with both total and faecal coliforms than treated water sources.

The presence of *E. coli* in the water samples collected from the ground and surface water sources emphasizes that there has been faecal contamination of the drinking water sources. *E. coli* is the only member of total coliform found exclusively in the faeces of humans and other animals, and its presence in water indicates not only recent faecal contamination of the water but also the possible presence of intestinal disease-causing bacteria, viruses, and protozoa (Health Canada, 2006).

In addition, recent studies have recorded the occurrence of pathogenic strains of *E. coli*, which include *E. coli* O157:H7, and *E. coli* O111 (Vaccari et al., 2006; WHO, 2006). The symptoms of illness associated with these strains are bloody and non-bloody diarrhoea that were accompanied by abdominal cramps (Vaccari et al., 2006; FAO/WHO, 2008). This means that there was the possibility of the occurrence and subsequent detection of these pathogenic strains in the

water in the study area if a more sensitive method of microbial analysis had been employed in this study.

Additionally, the detection of other bacterial species further demonstrates the level of faecal contamination of the ground and surface water sources in the study area.

Expectedly, diarrhoeal-related diseases are among the top ten reported causes of outpatient visit in the district (Kwahu South District Assembly, 2006). High incidence of diarrhoea is associated with the drinking of contaminated water, and people who are at particularly high risk include the very young and the very old, as well as immunocompromised individuals, such as those suffering from HIV/AIDS (Howard et al., 2006; Mahvi and Karyab, 2007).

Additionally, visitors who drink from contaminated water sources are also vulnerable to diarrhoea-related diseases. Diarrhoea is a major killer among the poor, especially in developing countries, and each year an estimated number of 2.2 million people, most of whom are under 5 years of age, die from diarrhoea-related diseases (WHO/UNICEF, 2000).

A number of factors could be attributed to the high level of contamination of surface water in Mpraeso. Firstly, human settlements at Mpraeso appeared to be uphill and close to the streams (site E), and the probability of domestic wastes being washed into these bodies of water during the rainy season is high. Rainfall is one of the most important causes of degradation of source water quality. A study in Ghana by Obiri-Danso et al. (2005) revealed that overland wastes move into rivers during periods of heavy or extended precipitation and this subsequently leads to higher indicator bacteria numbers recorded during the rainy season compared with the harmattan period (dry season).

Furthermore, lack of proper and permanent disposal sites for both solid and liquid wastes in the district may result in the use of streams as receptacles for these untreated wastes. In addition, the residents resort to insanitary practices such as defecating or urinating into open space, gutters and polythene bags, which ultimately find their way into bodies of water.

The detection of bacteria of faecal origin in groundwater in the study area could be attributed to the fact that the groundwater (wells) have similar features: they lack proper physical barriers like concrete sanitary seals, concrete plinths, concrete aprons, well linings, sanitary covers, lockable sanitary lids, et cetera which could prevent overland runoff containing human, animals and domestic

wastes from contaminating the water sources. The WHO (2006) reported that groundwater is less vulnerable to contamination due to the barrier effect, and that once the protective barrier is breached direct contamination may occur. Chapman (1996) noted that due to the relatively slow movement of water through the ground, once polluted, a groundwater body could remain so for decades, or even centuries.

Furthermore, the groundwater sources are constructed downhill and close to sanitation facilities as well as surface water. Consequently, runoff of human and domestic wastes and seepage of contaminants from the streams may pollute the water.

Usually, the users brought their own jugs, pans, and old/rusted cooking oil containers with which to fetch water into a bucket or water vessel. Others also fetched water by putting their buckets directly into the groundwater. This manner of fetching water could lead to introduction of microorganisms into the water sources.

To reduce the level of bacterial contamination of drinking water sources, there is the need for stakeholders to educate inhabitants, particularly women and children, on causes, modes of transmission and prevention of water- and sanitation-related diseases, in addition to modes of storing water in proper storing facilities with narrow necks, proper handling of stored water, the treatment of collected water and hand-washing, etc to help reduce the consumption of contaminated water. Also, residents of the area must endeavour to cultivate better sanitation habits and ensure that their surroundings and water sources are not indiscriminately polluted, especially by passersby.

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