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Water quality assessment in Bangwe Township, Blantyre City, Malawi

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This study assessed microbial contamination of water in sources (boreholes and open wells) and selected households in four Malawian villages (situated in Bangwe Township, Blantyre city) by analyzing the presence of faecal coliforms using membrane filtration. Additionally, pH, conductivity and temperature of the water sources were also determined. Conductivity ranged from 150.5 to 1575 µS/cm. About 70% of all water sources were above World Health Organization (WHO) and Malawi Bureau of Standards (MBS) limits for conductivity (indicating salty water in the area). Water temperature ranged from 21.5 to 24.7°C and pH from 5.28 to 6.95 with no significant difference ($p > 0.05$) for these physical parameters among the sampling points. Water pH was within MBS range while 60% of water sources were below WHO range. Faecal coliform levels exceeding WHO and MBS safe standards were observed in 79% of all samples analysed in this study. Mean household faecal coliform levels were as follows (village (mean)); Nalivata (437 CFU/100 mL), Mpingwe 1 (172 CFU/100 mL), Mpingwe (266 CFU/100 mL) and Salvation Army (15 CFU/100 mL). All mean faecal coliform counts were above WHO (0 CFU/100 mL) and MBS (0 CFU/100 mL) safe values. The results suggest that the quality of water in the villages often fails to meet one or more WHO and MBS recommended safe levels as such, poses a potential risk to the health of those individuals living in such villages. Local and National Governments should therefore target the provision of safe water to such populations. The findings of this study also highlight the need for improved dissemination of good hygienic practices amongst such communities.

Key words: Boreholes, drinking water, faecal coliforms, health, pollution.

INTRODUCTION

Access to clean and safe water is a worldwide problem affecting more than 1 billion people. In most Less Economically Developed (LEDC) countries urbanization and industrialization do not go in pace with environmental protection, resulting in numerous problems arising from environmental pollution (Farid et al., 2012). Persistent diarrhea in children is a common problem in low and middle income countries due mainly to inadequate supply of potable drinking water (Cabral, 2010; Abba et al., 2009; Fawell and Nieuwenhuijsen, 2003). In Less Economically Developed Countries, grossly contaminated water is also a major source of exposure to faecal contamination and diarrhea pathogens (Moe et al., 1991). In Africa, high levels of poverty mean that access to clean and safe water is often limited. Previous research has shown that many African communities obtain their

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domestic water supplies from unprotected sources (Adelekan, 2010; Dorice et al., 2010; Olaniran et al., 2009), which are prone to contamination by faecal material from human and non-human sources (example latrines and cattle Kraal). This is often further exacerbated by poor waste management, for example environmental assessment of Lake Awba, (Ibadan-Nigeria) revealed contamination of the water column through human and animal waste inputs with coliform counts up to 1 - 2 × 10^4 CFU/100 mL (Tijani et al., 2005). Water-related diseases such as cholera continues to plague many parts of the world, but outbreaks have largely been concentrated in Africa (Naidoo and Patric, 2002). In 2007, various countries around the world registered 178,677 cases of cholera and 4,033 cholera deaths to the World Health Organization (WHO). About 62% of those cases and 5.7% of deaths were reported from the WHO African Region alone (Kirigia et al., 2009). In the Southern African Development Community (SADC) region most of the countries are hit by water shortage problems especially in the dry season. In the rainy season a lot of people suffer from diarrhea diseases including cholera due to poor sanitation. One of the SADC countries where diarrhea diseases are common is Malawi.

Malawi faces a number of public health challenges that are currently leading to a lot of premature deaths, of which diarrhea diseases rank highly (Young and Briscoe, 1987). The most periodic diarrhea disease especially in peri-urban areas of Malawi such as Blantyre is cholera. This is due to a number of factors including the use of contaminated water, poor sanitation, improper waste management and unhygienic practices in food preparation (Clasen, 2008). Malawi registered its first cholera outbreak in 1973 (Khonje et al., 2012). Due to its easy transmission via contaminated water and food, cholera is referred to as a disease of the poor (WHO, 2008). Cholera outbreaks occur mostly during the rainy season and any other times, often after prolonged water shortages in the city of Blantyre. The relationship between human health and seasonal patterns is not a new concept and has been widely reported by others (Emch et al., 2010; Shar et al., 2010; Lipp et al., 2002). With no safe supply of potable water, many Malawians resort to drinking water from swamps and unpurified wells (MSF, 2007). Consequently cholera outbreaks especially in the rainy season have resulted in countless preventable deaths (Muula, 2009). The Blantyre District Health Office (DHO) compiles the number of cases and deaths of cholera. The highest number of cholera cases between 1998 and 2007 was recorded in 2001/2002 in which there were 3610 people affected by cholera and deaths. Bangwe Clinic has consistently registered the highest number of cholera cases. From 2004 to 2005 and November 2007 to December 2007 Bangwe clinic registered 263 and 85 cholera cases, respectively, which was the highest level recorded by both peri-urban and rural clinics in Blantyre. Despite so much global attention and commitment towards making the Water and Sanitation targets of the Millennium Development Goals (MDGs) a reality, available figures seem to speak on the contrary as they reveal a large disparity between the expected and what currently exists especially in developing countries (Dada, 2011). Therefore, water and sanitation in less economically developed countries remains an extremely important area of research. In this study levels of faecal coliforms were investigated in water sources and also amongst households in four selected villages in Bangwe Township, Blantyre.

Faecal coliforms were selected for use in this study as they have been extensively used as indicators of drinking water quality and historically led to the public health protection concept (Nikaeen et al., 2009). The other advantage is that faecal coliforms can be found in all faecally impacted sources of water including ground water. The presence of faecal coliforms in ground water is not a new concept as supported by work carried out by Bahram et al. (2012) who found alarming levels of coliforms in tube wells of Khorramdarreh County, Iran. While nonpoint sources of pollution that contribute faecal bacteria to surface waters have proven difficult to identify (Hagedorn et al., 1999), in this study it was envisaged that point sources of pollution which were to be identified, would be dealt with through the health surveillance team of the area.

MATERIALS AND METHODS

Study area and sampling campaign

The study was conducted in Bangwe Township, located to the east of Blantyre city (Figure 1) and is one of the most populous townships in the city having a population of 170, 350 people distributed in 33 villages and 41,456 households. It has a total area of 1020 hectares. In this study a total of four villages in the township were randomly sampled which were Nalivata, Mpingwe 1, Mpingwe and Salvation Army. In each of these villages a total of 36 households were sampled.

Sample collection

Water samples were collected from 10 sources (boreholes and open wells because these are the most significant sources) and from households (storage containers) in selected villages. The samples were collected in the rainy season because previous research had suggested that this is the period when diarrhea diseases in Malawi are highest. Samples were collected in autoclave sterilized bottles by grab method. They were immediately put in a cooler box filled with ice.

Sample analysis

For the water sources, faecal coliforms, pH and electrical conductivity were determined in accordance with standardized methods (APHA, 2005). For the household water samples, only faecal coliforms were determined. pH and electrical conductivity

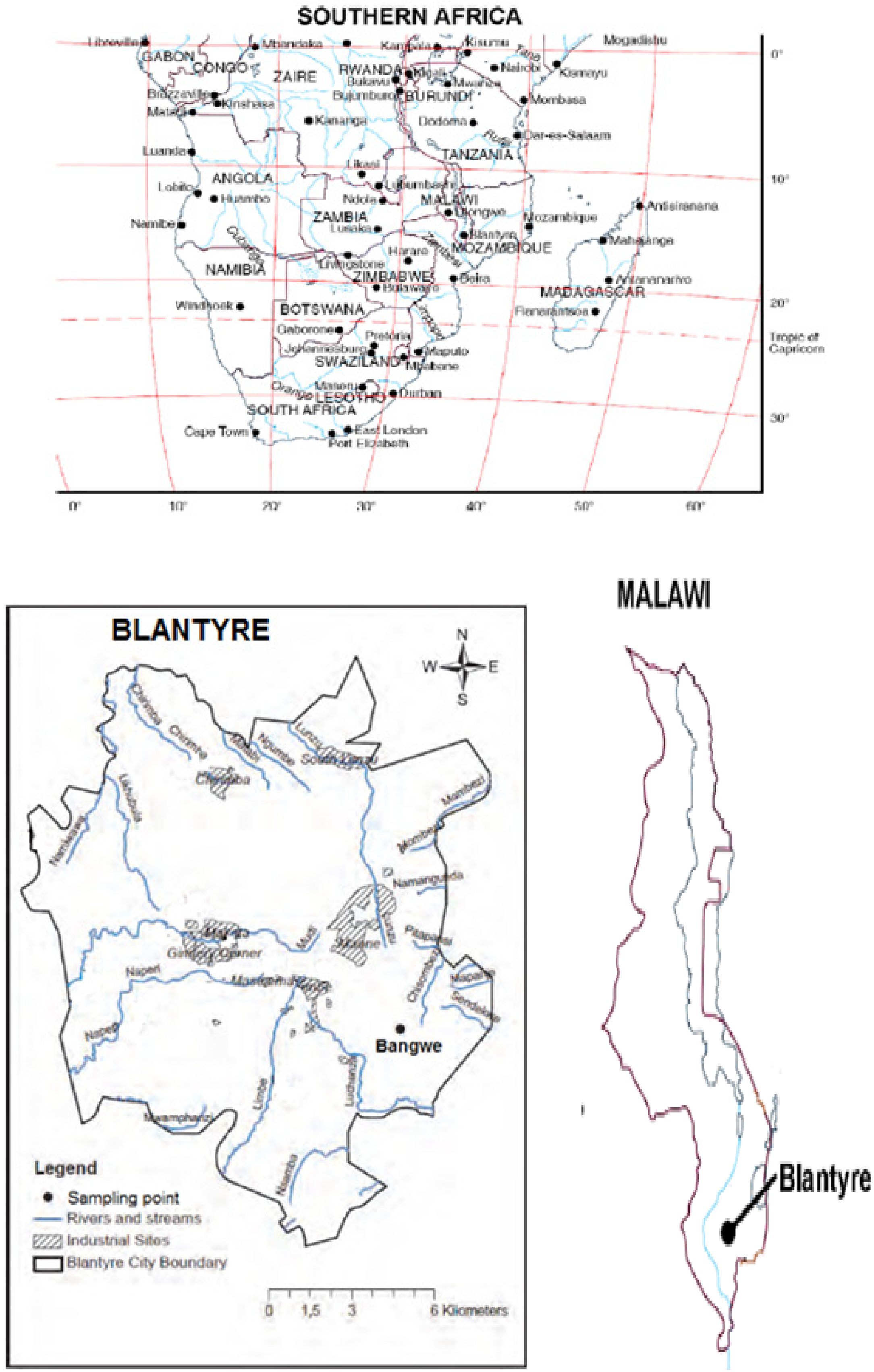

Figure 1. Map of Southern Africa, Malawi and study area.

Table 1. Water quality with respect to water source type and location.

Sample site no.	Water source location	CFU/100 mL	Electrical conductivity (µS/cm)	Temperature (°C)
1	Salvation Army*	100	1575	21.8
2	Mpingwe 1*	3	403	21.5
3	Mpingwe School**	618	170	22.2
4	Mpingwe Nalivata**	752	346	22.5
5	Mpingwe Mapundi**	684	470	22.5
6	Mpingwe - Chiwere**	50	150.5	22.9
7	Mvula - Bangwe School*	20	1297	22.6
8	Mvula - Market**	1400	754	24.7
9	Mvula - Nalivata Market*	35	829	22.7
10	Mvula - Mwamadi*	2	936	22.6

* Borehole. **Open Well

were determined by a Horiba pH/Conductivity Meter model D-24. Faecal coliforms were determined by the membrane filtration method from American Public Health Association (2005). A sample of water was passed through a 0.45 µm membrane filter. The coliform bacteria retained on the membrane were then placed in Petri dishes containing membrane lauryl sulphate broth (MLSB) and incubated for 24 h at 37°C. At the end of the incubation period, the filter was examined with a microscope. All yellow coloured colonies on the filter were enumerated and expressed in terms of colony forming units (CFU) per 100mL. This was calculated from the formulae below;

Colonies/100 mL = (100 mL x colony count)/sample volume used.

RESULTS AND DISCUSSION

Water sources quality

Table 1 shows the faecal coliform count, electrical conductivity and temperature of the water sources.

The results in Table 1 reveal that faecal coliform counts for the water sources ranged from 2 to 1400 CFU/100mL. The most contaminated water source was the open well at Mvula Market (Site 8) which may be due to both market activities and also the number of people using the water source. There were significant differences ($p < 0.05$) in faecal coliform levels present in boreholes and open wells, with open wells containing significantly higher levels of contamination (Open well faecal coliform results were in agreement with a study by Pritchard et al. (2007) in Blantyre, Mulanje and Chiradzulu districts, Malawi). All sampling points had faecal coliform counts above World Health Organisation (WHO) (2006) and Malawi Bureau of Standards (MBS) (2005) drinking water standards (0 CFU/100mL). The water conductivity ranged from 150.5 to 1575 µS/cm. The highest value of conductivity at Salvation Army is attributed to rocks in the area and also farming activities (use of fertilizers) because the borehole in this area is located at a slope of a mountain and also there are a lot of gardens in the area. About 70% of the water sources were above WHO conductivity limit (400 µS/cm) and all samples were above MBS conductivity limit (150 µS/cm). This means that the water in the area tastes salty. The water temperature ranged from 21.5 to 24.7°C. There were no significant differences ($p > 0.05$) in water temperature of the sampling points. The presence of high levels of faecal coliforms in water sources agrees with the studies conducted elsewhere for example el-Abagy (1988) found faecal coliforms in drinking water from different sources in greater Cairo, Egypt. The introduction of sewage into the drinking water system is the main source of bacterial contamination (Rehman et al., 2012). For the physical parameters, during the rainy season temperature and conductivity are higher but pH is low which is related to the continuous load of faeces' from human and animal sources to aquatic systems (Mazari-Hiriart et al., 2008; Parveen et al., 1999) which is the case with our data.

Water sources pH

Figure 2 shows the pH of the water sources. The water pH ranged from 5.28 to 6.95. There were no significant differences ($p > 0.05$) in the water pH levels among the sampling points. The water pH was within the MBS range (5 - 9.5) while 60% of the water sources were below WHO range (6.5 - 8.5). The pH was generally conducive for the survival of faecal coliforms because most pathogens will breed properly at a pH range of 5.8 to 8.4 (Lambert, 1974).

Faecal coliform counts for the sampled villages

Table 2 shows mean and range of the faecal coliform counts of water in thirty-six randomly selected households for each of the four sampled villages (Nalivata, Mpingwe 1, Mpingwe and Salvation Army). Table 3 shows the frequency of the feaecal coliform counts within a specific range. In Nalivata only 6% of the

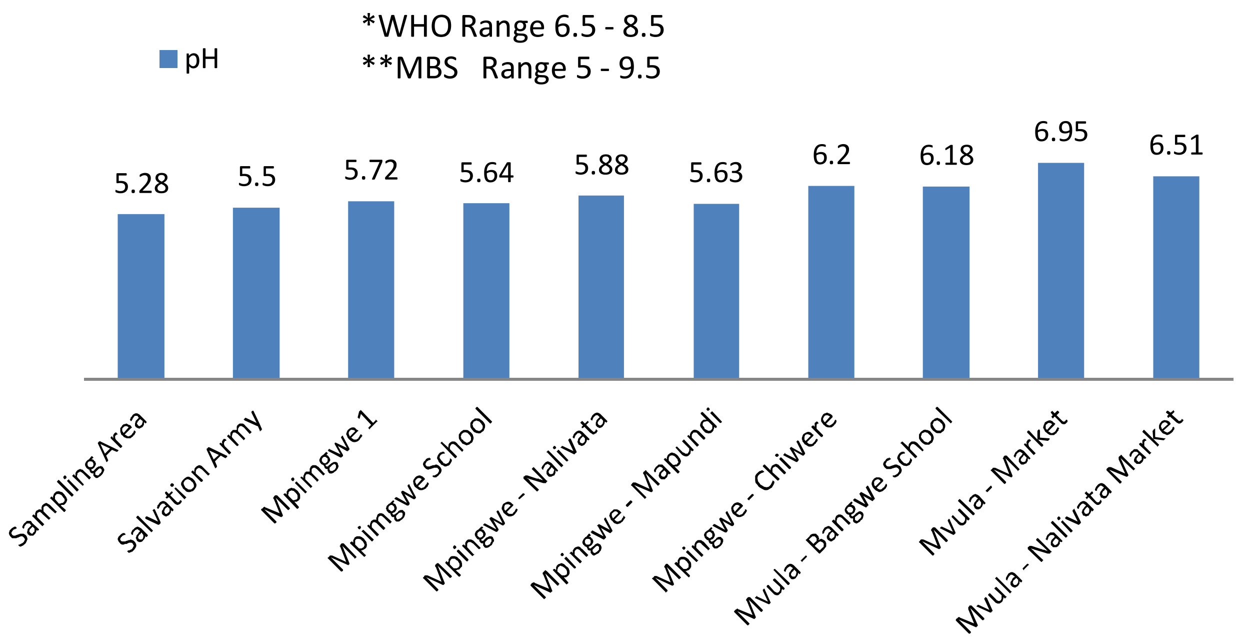

Figure 2. Mean levels of pH for the water sources. *World Health Organisation; **Malawi Bureau of Standards.

Table 2. Household water sample faecal coliform mean and range values (n = 36).

Factor	Faecal coliform count (CFU/100mL)			
	Nalivata (A)	Mpingwe 1 (B)	Mpingwe (C)	Salvation Army (D)
Mean	437	172	266	15
Range	0 - 930	0 - 916	0 - 934	0 - 90

Table 3. Frequency of faecal coliforms within a specific range (n = 36).

Range	Frequency of feaecal coliform count (CFU/100 mL)			
	Nalivata (A)	Mpingwe 1 (B)	Mpingwe (C)	Salvation Army (D)
0 - 200	13	27	23	36
201 - 400	0	0	0	0
401 - 600	10	4	3	0
601 - 800	10	3	7	0
801 - 1000	3	2	3	0

samples complied with MBS (0 CFU/100mL) and WHO (0 CFU/100mL) guideline value while 94% of the samples did not comply. In Mpingwe 1 only 36% of the samples complied with MBS and WHO standards with the rest of the samples (64%) above standards. In Mpingwe only 19% of the samples complied with WHO and MBS standards while 81% did not comply with standards. At Site D (Salvation Army), 31% of the samples complied with standards while 69% did not comply. The mean levels show that the order of contamination (from highest polluted households to least polluted) were; Nalivata, Mpingwe, Mpingwe 1 and Salvation Army. While the water sources are contaminated with faecal coliforms, additionally the handling of water after being collected is also likely to be contributing to pollution. What`s more, utensils used in water collection and storage could also be routes for the transfer of faecal contamination. A study done by Battu and Reddy (2009) revealed that water samples obtained from mobile vendors in Jeedimetla municipality, Hyderabad, India revealed high levels of

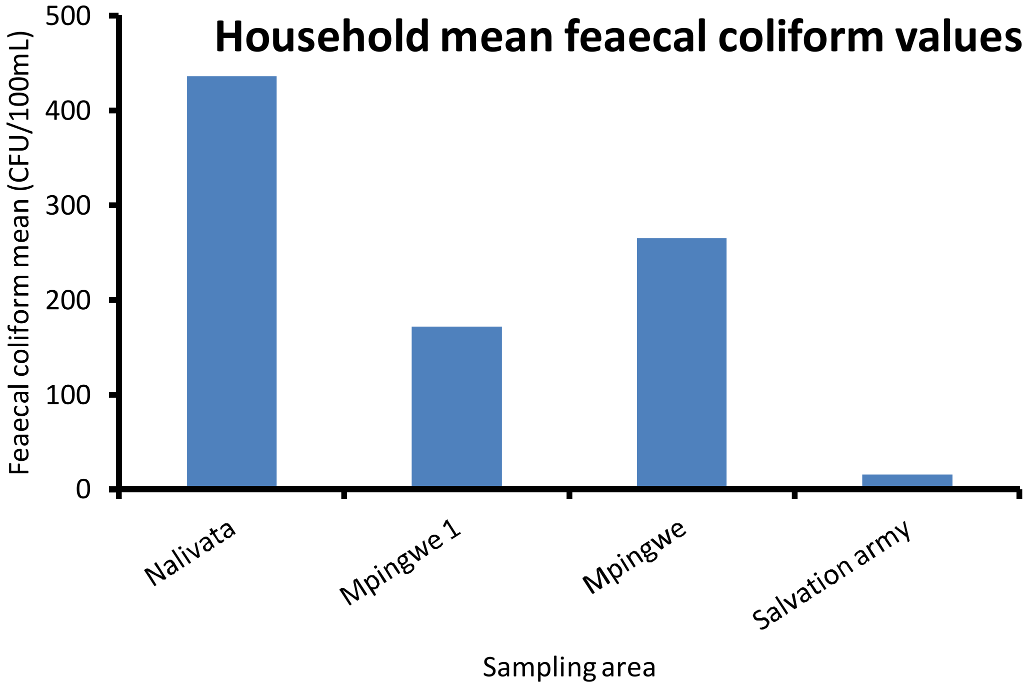

Figure 3. Household mean faecal coliform plot.

coliforms of up to 1500 CFU/100mL mainly attributed to storage utensils and the handling process. Tambekar et al. (2011) states that factors responsible for reduction in potability of household water, include withdrawal without hand washing, poor domestic hygiene, dipping hands in water, placing water dipper on lid and non-washing of containers. Table 3 shows that 69% of the total samples had faecal coliform counts within the range of 0 - 200 CFU/mL. It is clearly seen that Salvation Army had the lowest household water sample faecal coliform counts. This is further supported by the plot of mean coliform counts in the graph (Figure 3).

Figure 3 shows the household mean faecal coliform values. When the villages were compared to check if there are significant differences in the levels of faecal coliform counts the results were as follows; Mpingwe 1 had significantly higher ($p < 0.05$) levels of faecal coliforms as compared to Nalivata; there were no significant differences ($p > 0.05$) in faecal coliform counts between Mpingwe 1 and Mpingwe; Mpingwe had significantly higher ($p < 0.05$) levels of faecal coliforms as compared to Nalivata; Nalivata, Mpingwe 1 and Mpingwe had significantly higher ($p < 0.05$) levels of faecal coliforms as compared to Salvation Army.

The contamination of water samples in households and also at sources clearly highlights why Bangwe township in Blantyre, Malawi is hardly hit by cholera cases especially in the rainy season. It is important that the water should be treated before being used. Cairncross et al. (2010) propose diarrhoea risk reductions of 48, 17 and 36%, associated respectively, with hand washing with soap, improved water quality and excreta disposal. Cholera was largely eliminated from industrialized countries by water and sewage treatment over a century ago (Gaffga et al., 2007). This is also supported by Prüss et al. (2002) who states that the disease burden caused by diarrhea-related illnesses can easily be controlled. There are other factors like high urbanization and high overcrowding (Osei and Duker, 2008) which also encourage diseases like cholera because access to safe drinking water becomes a challenge. In that case there is need for the government to provide the necessary resources to the growing population. This may include household treatment devices since there is significant evidence that household water treatment devices/-systems (HWTS) are capable of dramatically improving microbial contaminated water quality (Mwabi et al., 2012). Good sanitation facilities do not only prevent the loss of life but they also help to save money as shown by a Safe Water System Project (water treatment with bleach, safe storage, and behavior-change communications) at a school in rural Kenya (Migele et al., 2007).

Conclusion and recommendations

This study shows that water sources of four sampled villages in Bangwe Township are subject to levels of faecal contamination in excess of WHO and MBS safe levels. Additional contamination at household level could also result from the contamination of household utensils and water storage facilities. The factors may contribute to continued diarrhoea outbreaks in such areas. The findings of this study highlight the importance of the provision of good sanitation facilities (by national and local government), combined with improved education in order to promote good hygienic practices within such households.

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