The microbial quality of drinking water in Manonyane community: Maseru District (Lesotho)

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Abstract

Background: Provision of good quality household drinking water is an important means of improving public health in rural communities especially in Africa; and is the rationale behind protecting drinking water sources and promoting healthy practices at and around such sources.

Objectives: To examine the microbial content of drinking water from different types of drinking water sources in Manonyane community of Lesotho. The community's hygienic practices around the water sources are also assessed to establish their contribution to water quality.

Methods: Water samples from thirty five water sources comprising 22 springs, 6 open wells, 6 boreholes and 1 open reservoir were assessed. Total coliform and Escherichia coli bacteria were analyzed in water sampled. Results of the tests were compared with the prescribed World Health Organization desirable limits. A household survey and field observations were conducted to assess the hygienic conditions and practices at and around the water sources.

Results: Total coliform were detected in 97% and *Escherichia coli* in 71% of the water samples. The concentration levels of Total coliform and *Escherichia coli* were above the permissible limits of the World Health Organization drinking water quality guidelines in each case. Protected sources had significantly less number of colony forming units (cfu) per 100 ml of water sample compared to unprotected sources (56% versus 95%, $p < 0.05$). Similarly in terms of *Escherichia coli*, protected sources had less counts (7% versus 40%, $p < 0.05$) compared with those from unprotected sources. Hygiene conditions and practices that seemed to potentially contribute increased total coliform and *Escherichia coli* counts included non protection of water sources from livestock faeces, laundry practices, and water sources being down slope of pit latrines in some cases.

Conclusions: These findings suggest source water protection and good hygiene practices can improve the quality of household drinking water where disinfection is not available. The results also suggest important lines of inquiry and provide support and input for environmental and public health programmes, particularly those related to water and sanitation.

Key words: Total coliform, E. coli, hygienic practices, households, source water protection.

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Introduction

The rationale for promoting safe drinking water in rural communities in developing countries is the persistently high levels of water related morbidity and mortality[24]. Globally, unsafe drinking water coupled with poor sanitation kill at least 1.6 million children under the age of five every year, 84% of them living in rural areas[26]. If the current trend persists, nearly 1.7 billion rural dwellers will not have access to safe water and improved sanitation by 2015[26].

In Lesotho, a predominantly rural country with nearly 85 percent of the population living in rural areas, traditional drinking water sources such as open reservoirs, springs and open wells are still being used by rural communities[14, 15, 26]. Water from such sources seldom complies with WHO permissible standard limits for drinking water [13, 21]. While available literature[9, 10, 21] point to a rural population having access to safe water supply at 62%. The remaining 38% dependent on these traditional water sources are highly vulnerable to water borne diseases[14,15] . With insufficient information about the contaminants in drinking water sources, little can be done to mitigate the problem. There is therefore a need to check regularly for contaminants threatening water safety of such drinking water sources in order to provide measures capable of mitigating outbreak of water related diseases.

Safe drinking water is defined by WHO[25] as that water having acceptable quality in terms of its physical, chemical and bacteriological parameters. Bacteriological parameters, especially *Escherichia coli* (*E.coli*) and total coliform have been used to

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determine the general quality of drinking water worldwide [2, 9, 16.] The E. coli in particular has been found to be the most specific indicator of faecal contamination in drinking-water [9, 18]. Its presence indicates contamination of water with faecal waste that may contain other harmful or disease causing organisms, including bacteria, viruses, or parasites[27]. Quality water requires guidelines and standards setting permissible limits for each parameter[9, 10]. The World Health Organization guidelines are generally adopted as the international reference point for standards by those countries that do not have their own. The WHO[23], data on faecal coliform bacteria group them into the following risk categories: 0 cfu/ 100ml (conformity); 1–10 cfu/100 ml (low risk); 10–100 cfu/100 ml (intermediate risk); 100–1000 cfu/ 100ml (high risk); and 41000 cfu/100 ml (very high risk).

Drinking water contaminated with E. coli is known to cause stomach and intestinal illness including diarrhoea and nausea, and even lead to death[6]. Total coliform, while not being regarded as a health threat in itself; has been used as an indicator of other potentially harmful bacteria such as E. coli and other viruses and parasites[10, 18, 27].

In Lesotho the quality of water in rural communities has mostly been analysed at a macro level. There is less information at micro level about the quality of water from community water sources and the strategies communities use to address associated challenges. The objective of this study was to assess, at micro level the E.coli and total coliform counts in water samples from different drinking water sources in Manonyane community. A household analysis was conducted to assess the community's perception towards the quality of its water and practices aimed at protecting its sources. The study was planned to provide information that could assist in working out a model for safe drinking water supply to the community.

Methods

Study area

The study was conducted in the administrative area of Manonyane Community Council in Maseru District. The community council has a population of 22 491[3] and is divided into nine administrative wards.

Geologically the study area is dominated by exposed sedimentary rocks of the Triassic- Jurassic age of the karoo super group capped by basalts of the Drakensberg formation[19]. The terrain of the study area is mostly hills and valleys. In general accelerated erosion, mass wasting and sedimentation characterise the study area[5]. Most settlements and drinking water sources are located at the foothills.

The study was cross-sectional and conducted from September to October 2009 before the onset of the rain season. Water samples were collected in 27 randomly selected household clusters of the nine administrative wards of Manonyane. Once in the sampled household cluster, water sources used by the community as the source of drinking water were identified with the assistance of members of the communities. The set of water samples taken were as follows: 13 samples from unprotected springs, 9 samples from protected springs, 6 samples from open wells, 6 samples from boreholes, 1 sample from open reservoir. The strategy was to capture all types of water sources used by the community. A protected spring was defined as a spring that was properly covered by stone masonry or completely covered by a concrete block (figure 1d).

Water samples were collected in 500 ml sterile bottles that were fitted with screw caps, labeled and kept in a cooler box before being transported to the laboratory for analysis. The samples were analyzed within six hours of collection.

Water quality analysis was based on the most probable number of colony forming units (cfu) per 100 ml for the total coli form and E. coli. Descriptive statistics were used to summarize and compare the quality of water under various conditions, with results of the statistical analyses displayed graphically and in tabular form. The Pearson's correlation coefficient between the mean total coliform and E. coli counts was calculated at $p<0.05$ indicating statistical significance.

Relevant sanitary conditions and practices around each water source were assessed during samples collection. Eighty randomly selected households were interviewed in the selected villages to establish the water sources types' usage.

Results

The usage of water sources by house holds was high with 71% (n = 80) indicating using at least two sources for their domestic water purposes in a year, 12% indicating three sources and 15% just one source. Among the households using one source, private owned sources, boreholes and permanent springs accounted for more than 60% of the water sources. The majority of households (71%) using two sources combined springs with open wells. Springs (figure. 1) constituted water source for more than 85% of the respondents in summer. This however dropped to 68% in the dry season as some of the springs dried up.

On-site water source inspections revealed that 57% of the water sources (N=35) lacked some form of protection (figure 1 a, b, c). Livestock faeces as well as animals themselves were observed adjacent to some of the water sources (figure. 1). Evidence of washing clothes close water sources was recoded at five water sources.

Other potential risks included pit latrines located near and mostly upstream of water sources and grave yards in the vicinity of sources of drinking water. About 34% of the springs were however protected with some having water tapes connected to them. Water containers used by households to draw water from the source point ranged from small aluminum metal containers to plastic buckets.

More than 80% of the respondents rated their drinking water safe for consumption and indicated colorless, odourless; as well as absence of illness after drinking as indicators for judging the quality of the water. However, 60% of respondents reported having at least some concerns with safety of their water. More than 9% of the households reported at least one household member having suffered some water related illness in the past two years.

Figure 1: Common water sources used by households in Manonyane

a = unprotected spring, b = open well, c = poorly protected spring and d = concrete covered protected spring

Microbiological quality of drinking water from different sources

The microbiological test results showed the presence of total coliform and E. coli in 97% and 71% of the water samples respectively. The variations in the number of colony forming units per 100 ml among the water sources were however wide depending on the nature of protection accorded to the water source. Generally, the average total coliform and E. coli density was relatively high in unprotected water sources compared to protected ones. Results of the means, ranges, and standard deviations of the analyzed parameters are given in table 1.

Table1: Total coliform and E. coli loads in water samples

Parameter tested		Test results from different water source				
		Unprotected spring	Protected spring	Open well	Borehole	Open reservoir
Total coliforms (cfu/100ml)	Minimum	1.46×10^2	1.6×10	0	8	-
	X	1.51×10^3	2.073×10^2	1.2747×10^3	3.883×10^2	-
	SD	1.102×10^3	2.285×10^2	1.2567×10^3	4.878×10^2	-
	Maximum	2.42×10^3	6.49×10^2	2.420×10^3	1.046×10^3	2.42×10^3
E. coliforms (cfu/100ml)	Minimum	0	0	0	0	-
	X	1.22×10^2	2.75×10	1.678×10^2	1.17×10	-
	SD	1.21×10^2	6.45×10	3.372×10^2	1.76×10	-
	Maximum	3.87×10^2	2.06×10^2	7.70×10^2	4.1×10	4.00×10^2

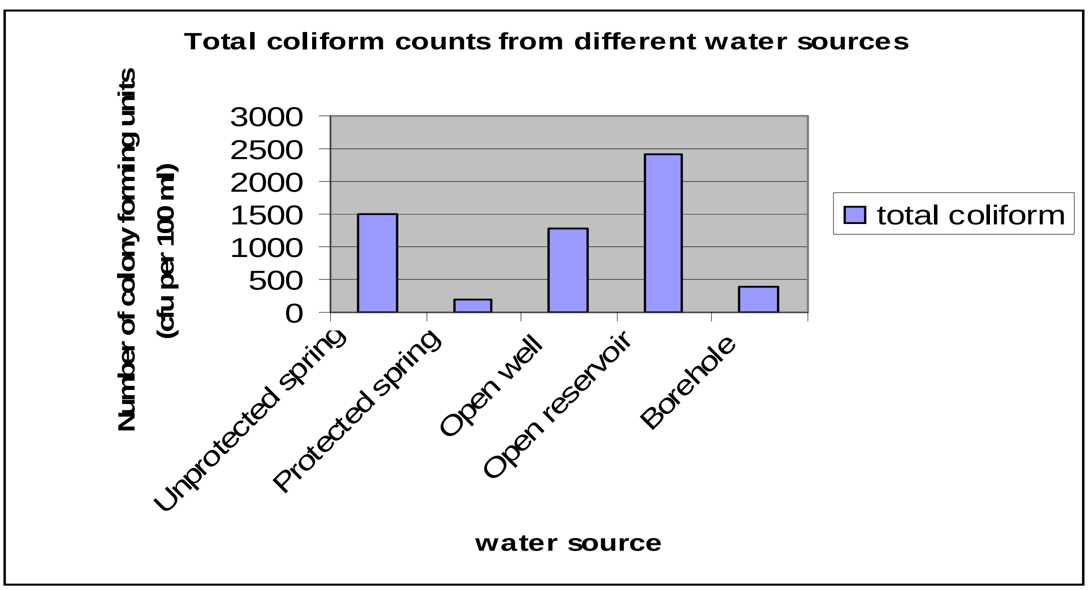
X: Mean SD: Standard Deviation

Of the thirty five water samples tested, total coliforms were detected in 97% of the water samples. The number of cfu/100 ml from all the water sources except one open well exceeded the no risk WHO guidelines of zero cfu/100 ml in drinking water.

The range counts (in cfu/100 ml) from unprotected spring, protected spring, open well, borehole and open reservoir water samples were $1.46 \times 10^2 – 2.42 \times 10^3$, 1.6×10 - 6.49×10^2, 0 - 2.420×10^3, 8 - 1.046×10^3 and 2.42×10^3 respectively (table 1). The mean values were significantly high for unprotected water sources compared to those from protected sources.

Wide variations of total coliform were observed within similar water sources but different levels of protection. In samples from unprotected water sources more than 50% of the water was of high risk by WHO standards. Generally, unprotected springs, open wells, and the open reservoir had more than 50% of their sources with more than 300cfu/100ml counts than those from protected sources (figure 2).

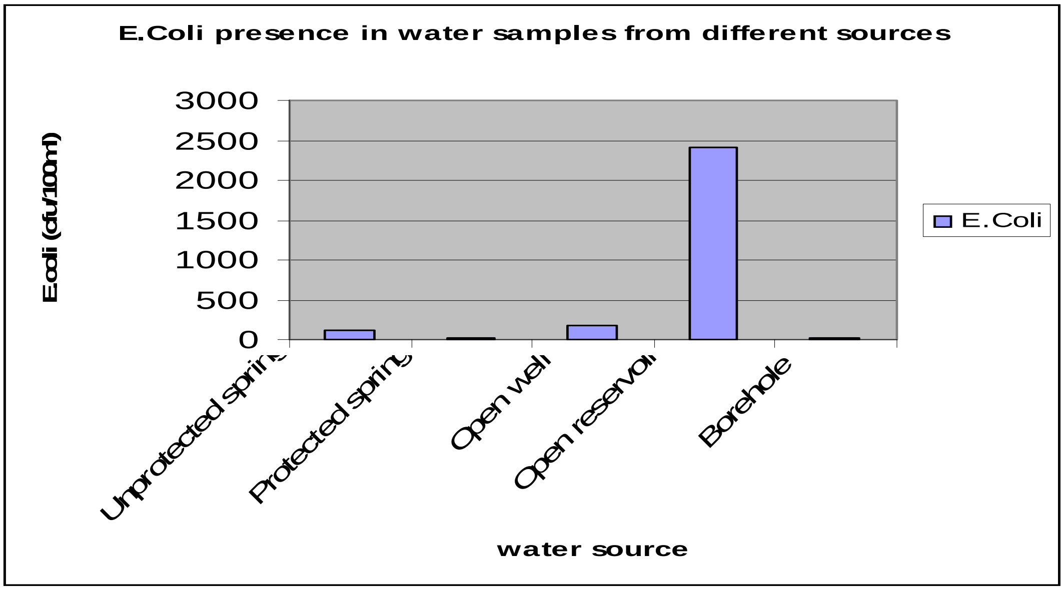
Figure 2: Total coliform count results from different water sources



The E. coli was detected in 71% of the water samples. The number of cfu counts ranged from 0 - 3.87×10^2, 0 - 2.06×10^2, 0 - 7.70×10^2, 0- 4.1×10 for samples from unprotected springs, protected springs, open wells and boreholes, respectively. For the sample from open reservoirs the cfu was 4.00×10^2.

There was a significant difference ($p < 0.05$) in E. coli counts between water samples from different sources, with the highest count (400cfu/100ml) having been recorded in an open reservoir water sample. Figure 3 shows the variations in E. coli counts for water samples from different water sources. Variations were significant (p< 0.05). More than 38% of the samples from unprotected springs (n= 13) had more than 200cfu/100ml compared to 11% (n=9) in protected springs. Open wells had about 16% of their samples (n=6) exceeding 200cfu/100ml. More than 40% of the protected springs had samples with 0cfu/100ml while 50% had 2 to 5 cfu/100ml. Boreholes equally had 60% of the samples (n=6) with no E. coli while the those samples with E. coli the counts were less than 25cfu/100ml. The open reservoir had its sample exceeding 220cfu/100ml (figure 3).

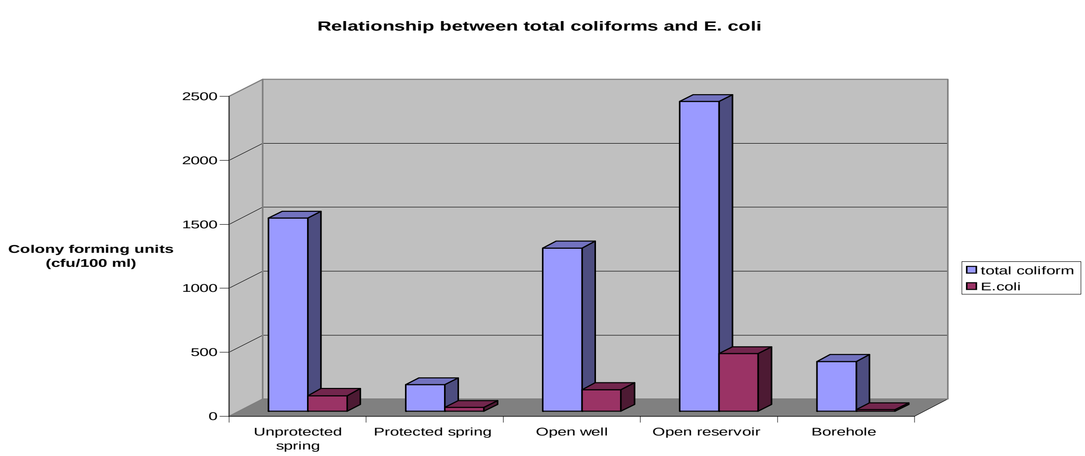
Figure 3: E. coli presence in samples from different water sources



Relationship between total coliforms and E. coli counts

The correlation between total coliform and E. coli counts was positive and significant (r = 0. 817, p< 0.05). Total coliform counts were significantly (p < 0.05) higher than those of E.*coli*. The general trend was that while densities of *E. coli* were lower than those of total coliform for all the water sources, the trend in the number of cfu of *E. coli* increasing as those of total coliforms increased was observed to be significant (figure. 4). The number of water samples from protected sources with total coliform of more than 100 cfu/100ml was significantly less (56% versus 95%, p < 0.05) and *Escherichia coli* (7% versus 40%, P < 0.05) compared with unprotected sources. Samples from borehole sources had the least microbial loads, being absent in 50% (n=6) of the samples.

Figure 4: Relationship between total coliform and E. coli counts



Discussion

The presence of coliforms in drinking water is enough grounds for assuming that a potential health hazard existed because of the possible presence of pathogens[1]. The results of this study reveal that average bacterial density in drinking water was relatively high, especially from unprotected water sources, compared with that from protected sources. The presence of E. coli in water suggests enteric pathogens and faecal pollution[8] and has been reported to be the causative agent of diarrhoea, urinary tract infection, haemorrhagic colitis, and haemolytic uraemia syndrome in similar studies elsewhere [1,6]. These results provide insight into the potential health risks found in water in Manonyane community.

The number of total coliform and E. coli counts found in unprotected water sources suggest though not conclusively that poor source water protection and poor sanitation conditions and practices are potential reasons for the high presence of microbiological contaminants. The big difference in the microbial counts from water samples of similar protection status might be indicative of widely varying hygiene behaviours in the households. This assertion is supported by the cleaning behaviours and habits of the household members at or near the water sources. Some washed their laundry close to water sources while others used dirty containers to collect water from the source.

Contamination of water was also potentially tied to livestock and human faeces that created a diffuse source of faecal contamination to water sources, poor hygiene and sanitation practices that include laundry activities close to water sources by households; and water sources being very near or down slope of latrines. This implied the risk of contamination was very high.

In a few cases there was a decrease in the numbers of total coliforms and E. coli. This was linked to the protection of the water sources and hygiene practices by the household members using the sources.

Based on these findings, it is prudent to recognize the link between water quality, environmental quality, sanitation and public health. These observations suggest the need for focused interventions on source water protection and sanitation practices as this could lead to improvements in water quality at source.

Challenges associated with access to safe and reliable sources of drinking water are not unique to Manonyane alone as they have been highlighted elsewhere in the literature. Inadequate drinking water supplies, poor sanitation and none protection of water sources are especially highlighted as acute for most rural communities in developing countries that rely on raw water for drinking. Water quality monitoring and surveillance studies of different water sources elsewhere show that surface drinking water sources faecally contaminated because of exposure to unhygienic conditions[15]. Comparing the results of this study with a similar study conducted in the villages of Lesotho Highlands by Kravitz[13], sanitation was found to be a serious problem compromising the quality of domestic water as well as contributing to outbreak of water-borne diseases.

These findings demonstrate the need to come up with source water protection strategies and policies for rural communities where water treatment is not available. Public awareness regarding the significance of protecting water resources as well as monitoring its quality and human health effects are also important and recommended. An integrated approach incorporating policies, plans and activities that prevent or minimize release of pollutants into the sources of drinking water could be the starting point for Manonyanyane.

Conclusion

The majority of the water sources in this study were grossly polluted. The effects were attributed to poor source water protection, poor sanitation and low level of hygiene practices, and lack of monitoring and healthcare awareness. The potential risk of infection of water consumers calls for prompt intervention to mitigate the potential health impact of water-borne diseases in the community. A proper sanitary survey and implementation of water and sanitation projects in the community is recommended.

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