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Bacteriological Contamination of Water in Urban Poor Areas: A Case Study of South Lunzu Township, Blantyre, Malawi.

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ABSTRACT
The bacteriological quality of domestic water sources was examined in the peri-urban area of South Lunzu Township in the City of Blantyre, Southern Malawi. The best water quality was the borehole with a mean value of 30 feacal coliforms count per 100ml. Water from the tap was generally of good quality except during the second sampling where the feacal coliform count was as high as 89 per 100ml. In the other sources of water, which are springs, wells and Lunzu River, the quality of water was extremely bad ranging from 730 to 9,500 feacal coliforms per 100ml for springs, 11,000 feacal coliforms for the well and 18,500 feacal coliforms per 100ml for the river. During the rainy season, there was a considerable deterioration of water quality in most of the water sources. The plausible explanation could be the poor sanitation system characterised by unprotected pit latrines and the unhygienic practices, such as stepping on the water source. Moreover, despite the water source, the practice of treating water at household level was very uncommon with only 9.9% of the respondents treating their drinking water. In addition, the hydrogeology of the area which is characterised by fissures and veins puts a threat to the water resources through seepage. Therefore, a combination of improved water supply and effective health education programmes could help in reducing the negative aspects associated with the use of contaminated water.

1 INTRODUCTION

Access to safe clean water and adequate sanitation is fundamental right and a condition for basic health. Lindskog (1987) noted that an adequate supply of clean water is of invaluable importance for any community. Research conducted by the United Nations (1992) revealed that three out of five people in the developing countries had no access to quality drinking water and three out of four had no access to sanitary facilities. Consequently, most of the domestic water supplies in developing countries are contaminated by feacal material due to inadequate sanitary facilities. The presence of pathogenic micro-organisms like viruses and bacteria affect the quality of water and make it unsafe to drink because they cause diseases like typhoid, cholera and dysentery (WHO Guidelines, 1984). In Malawi, only 8.3% of the population is connected to the sewer line while the majority use on-site sanitation or no latrine at all (Malawi Government, 1996). In the city of Blantyre, the problem of waterborne sewerage system to the urban dwellers is disproportionate between the low and high income classes where about only 6% of the urban population is connected to the sewer line. The Malawi Government (1996) noted that the situation is worsened by the frequent blockages and breakdowns of the sewer lines and sewage treatment plants. In addition, Malawi Government (1998) mentions that most of the unplanned settlements or the urban poor areas are established in river catchment areas and either have no latrines, or pit latrines located near water sources. As such, feacal material from the open places contaminate surface water and seepage from pit latrines may affect and pollute ground water. Rajagolapan (1974)

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recognized that contamination may occur at the water source and between the "tap and throat".. This means that constructing an adequate water supply might not be the only change that is necessary. Hence, an improvement of hygiene related behaviour of the consumers must also be enhanced.

The paper will focus on the social characteristics of the people in the area, that is, the sanitation facilities available, hygiene practices as well as the sources of domestic water supply which have a direct bearing on the levels of bacteriological contamination of water in the area.

2 METHODS AND MATERIALS

The study was carried out in South Lunzu Township in the City of Blantyre, Southern Malawi. The township is situated within the Shire Highlands and it is between 1100m to 1200m above the sea level. Seasonal rivers and streams flow through the area from Ndirande Mountain with Lunzu River on the eastern side providing perennial water. In this area there are two seasons, a rainy season lasting from November to April with an average rainfall of 1122mm; and a dry season from May to October with light drizzles between May and July.

The township is characterized by pyroxene granulite gneiss with fractured zones on the eastern side. The deep fractured bedrock provides potential aquifers for ground water, which yields not more than 5 litres per second (Blantyre City Assembly, 1999).

The township has a population of approximately 47,229 people with 6,117 households (Blantyre City Assembly, 1999). The area is not connected to the existing sewer lines and solid waste from the residential area is not collected except in the market area where skips are available.

A household survey was conducted to 160 households from South Lunzu Township. These respondents were sampled at 95.5% confidence interval. Information collected in the survey included among others: characteristics of the households in terms of level of education and occupation, sanitation facilities available within the household such as the type and condition of latrine, and solid waste disposal methods. It was also important to get information on the sources of domestic water supply and some of the hygiene practices done by the respondents in their homes. Results of the survey were cross-tabulated and the Pearson Chi-square test was used to establish the dependency among variables.

Water samples were collected from the traditional domestic water sources that included a borehole, a well, and two springs (which have been characterized as ground water sources), from piped water and four points along Lunzu River (surface water sources). Four sets of water samples were collected - two during the dry season and two during the wet season. The samples were analysed for indicator bacteria that is feacal coliforms and feacal streptococci using the Membrane Filtration Method (APHA, 1975). Each of the methods for feacal coliform and feacal streptococci has a relative standard deviation of 5%. The results were compared to the drinking water standards set by the World Health Organisation (WHO) and the Water Department.

3 RESULTS

3.1 Sanitation Facilities

In the peri-urban area of South Lunzu, the on-site sanitation system was the best alternative to other forms of sewage disposal. Although 100% of the respondents mentioned that they had a latrine, there were observable differences on the type and nature of the latrine. There were four categories of latrines which were identified. The traditional type was the one where a hole was dug in the ground 2-3 metres deep and the hole of this type of latrine was not lined at all. The other one was similar to the traditional type but was sealed at the mouth with concrete and a cover provided. The third category included those latrines, which were known as ventilated improved pit latrines (VIPs'). These were the latrines, which were also 2-3 metres deep, but they were lined with concrete from the bottom to the top but with spaces to allow for seepage. These latrines usually had brick wall superstructures, a cover on the hole and had pipes inserted outside for ventilation. The other type which was identified was the water closet. These were toilets found inside the dwelling house but they were connected to a septic tank which was lined from the bottom. These depend on the availability of piped water. However, with the intermittent supply of water in the area, each household where they had a water closet, they also had a traditional latrine.

Table 1 shows the distribution in terms of the type of latrine available. The majority of the respondents, about 58.8% had traditional pit latrine with 35.6% having a slab on the floor. Small proportions of the respondents, about 5% had ventilated improved pit latrines, which were believed to be environmentally friendly. These ventilated improved pit latrines were found in area 5 within the township where "Habitat for Humanity", a non-governmental organisation had built and was selling these low cost houses to the local inhabitants.

A very small proportion of the respondents, 0.6% indicated that they had a water closet. The few numbers of water closets' in the area could be attributed to the non-existence of a sewer line as well as the unreliable and expensive piped water supply in the area which serves such a system.

Table 1: Percent Distribution of Respondents by Type of Latrine ($n = 160$)

Type of Latrine	Percentage
Traditional	58.8
Ventilated Improved Pit	5.0
Slab Only	35.6
Water Closet	0.6
Total	100

3.1.1 Condition of Latrine

Observation of the latrines within the households was appropriate in order to determine the condition the latrine. There was a noticeable difference when one observed the condition of the said latrines among the households. Four categories were identified namely: slab, superstructure, ventilation and roof to explain the condition.

As shown in Table 2, there were variations in the condition with 69.4% of the respondents' reporting having a good slab and about 10% had no slab at all. Slabs play a significant role with respect to hygiene. It is easier to sweep and cover a latrine which has good slab than the one without.

To avoid nuisance from odour coming from the latrines, they ought to be well ventilated. However, the table shows that up to 45.6% of the respondents had poor ventilated latrines although 48.8% were observed to have had good ventilated latrines. It should be mentioned here that poorly ventilated latrines not only are uncomfortable to the users but they also attract flies which are the major carriers of diseases.

Provision of privacy and preservation of dignity are necessary attributes that every latrine should have. However, when latrines were assessed in this respect, it was observed that only 63.7% of the latrines fulfilled this requirement. The other latrines had superstructures' which were poor while others had none at all.

A roof is important for protection during high temperatures and heavy rains. The table below shows that 55% of the respondents had good roofing on their latrines with 45.0% having poor and no roof.

Table 2: Percent Distribution of Respondents by Condition of Latrine ($n = 160$)

Condition of Latrine	Slab %	Super-structure %	Ventilation %	Roof %
None	12.5	4.4	5.6	22.5
Poor	18.1	31.9	45.6	22.5
Good	69.4	63.7	48.8	55
Total	100	100	100	100

3.2 Water Supply

The challenge in the peri-urban area was not only in terms of sanitation facilities. Equally of concern was the availability of piped water supply systems which were not common because of high cost of installation as well as monthly bills. For instance, Blantyre Water Board charged Mk180.00 for the first 10m3 of water (BWB, 1999) whilst for a household water connection, the Board charged not less than Mk3, 000 as connection fee. As shown in Table 3, 84.4% of the respondents did not even think of having household piped water system because it was just too expensive. However, only 11.9% indicated that they could afford individual connections.

Table 3: Percentage Distribution of Respondents by Affordability of Individual House Water Connection ($n = 160$)

House Water Connection	Percentage
Cannot Afford	84.4
Can afford	15.6
Total	100

When respondents were asked on their ability to afford individual piped water connection based on their occupation, the study revealed that 28.4%, 46.1% and 25.5% of the respondents who are employed, unemployed and have self-employment, respectively, could not afford individual connections. Table 4 shows the distribution of respondents on the level of affordability of piped water by their occupation.

An analysis of the Pearson Chi-square test showed that there was correlation between occupation and the level of affordability and the result was statistically significant (2 = 0.501, P¿.05). Basically, it was noted that 46.1% of those who could not afford an individual connection were unemployed. This implied that there was a high likelihood of affording an individual connection among those who were employed unlike those without employment.

Table 4: Percentage Distribution of Respondents by Occupation by Level of Affordability of Piped Water ($n = 160$)

Occupation	Affordability of Piped Water	
	Yes ($n = 19$)	No ($n = 141$)
Employed	31.6	28.4
Unemployed	31.6	46.1
Self-employed	36.8	25.2
Total	100	100

3.2.1 Sources of Domestic Water

Due to the high tariffs of piped water provided by the Blantyre Water Board, people had other sources of water supplies such as springs, wells, borehole and from Lunzu River. Water from these sources was used for all domestic endeavours, which included drinking, cooking, washing and bathing.

Table 5: Percentage Distribution of Respondents by Source of Domestic Water ($n = 160$)

Source of Water	Drinking	Cooking	Bathing	Washing
Tap water	83.1	81.9	76.2	74.4
Groundwater	8.8	8.7	8.8	8.7
Surface water	8.1	9.4	15	16.9
Total	100	100	100	100

Table 5 indicates that nearly 83.1% used tap water, 8.8% used ground water and 8.1% used surface water for drinking. Although 83.1% of the respondents mentioned that they used tap water, the piped water system in the area was unreliable. According to the Blantyre Water Board, there were frequent breakdowns coupled with low pressure in the pipes resulting into intermittent water supplies. As such, respondents were asked on the alternative sources of water for domestic use. Table 6 shows that about 88.7% mentioned that they used spring water which was available throughout the year, while some opt for well water, others had no choice but to use water from Lunzu River.

3.2.2 Treatment of Water

Having seen that people used other sources of water other than piped water, it was important to know whether the water was treated at household level. There are several ways that water can be made safe at household level which include boiling, filtering with a cloth or adding chlorine tablets.

Table 6: Percentage Distribution of Respondents by Supplementary Source of Domestic Water ($n = 160$)

Supplementary Source	Percentage
Spring(s)	88.7
Open well	2.5
River	4.4
Private Tap	4.4
Total	100

Table 7 indicates that 90.1% of the respondents did not treat their water in any way regardless of the water source. Nevertheless, 9.9% of the respondents did treat their water either by boiling, filtering with a clean cloth or chlorinating with chlorine tablets. These respondents mentioned that they usually treat their water during the rainy season because of a high risk of waterborne diseases.

Table 7: Percentage Distribution of Respondents by Treatment of Water ($n = 160$)

Treatment of Water	Percentage
Do no treat	90.1
Boiling	6.8
Filter with cloth	0.6
Add chlorine tablets	2.5
Total	100.0

As observed above, most households did not treat drinking water, as such it became imperative to find out the common diseases in the area. The study revealed that people in the area suffered from a number of diseases which included cholera, dysentery as well as diarrhoea. Table 8 shows the most common diseases prevalent in the study area.The use of clean potable water should ensure reduction of water-related illness and dramatically improve the quality of life. It is important to note that water is so basic to human health and prosperity hence the need to have access to potable and clean water.

It should be mentioned that during the survey many, which was done during the dry season, many children had scabies and rashes. Apparently, these children indicated that they used to bath in Lunzu River. This disease is associated with low quantities of bathing water especially when river have small loads.

Table 8: Percentage Distribution of Respondents by Common Diseases in the Study Area ($n = 160$)

Common Diseases	Percentage
Malaria	55.0
Diarrhoea	23.1
Scabies/Rashes	11.7
Cholera	8.8
Typhoid	1.8
Coughing	0.6
Total	100.0

3.3 Hygiene Practices

Based on personal observations, it was noted that no hygiene practices were observed at most of the water sources. For instance, those drawing from the spring and the well, each person used her own container to draw water from the point. These containers were either washed or not depending on the choice of the user. In addition, those washing and cleaning utensils were not advised to do their washing away from the source. It was also observed that stepping on the source was unavoidable (due to overcrowding) especially at the spring and the well, thus further polluting the water sources.

Having the knowledge and actually doing it are two different things. Respondents were asked on some of the hygiene practices which they did in their homes. It was interesting to note that 4.4% of the respondents did not wash their hands before and after eating food; 8.1% did not wash their hands after visiting a latrine; 49.4% did not wash their hands after handling childs' excreta, 50.6% did not wash their hands even when they saw that they were dirty. Such practices could be routes of some diseases even when water supply and sanitation systems were clean and safe.

3.4 Bacteriological Quality of Water

As may be expected bacteriological water quality in South Lunzu Township was not uniform. Of interest were the variations between the ground water and surface water sources on one hand and between the dry season and the wet season on the other.

Table 9 indicates the values of bacteriological contamination based on feacal coliform counts and feacal streptococci counts of the samples from surface water both during the dry season and the wet season. The upstream of Lunzu River registered up to 6,100 feacal coiliforms/100ml during the dry season and as high as 18,500 feacal coliforms /100ml during the second wet season sampling. The lower middle section of the river registered exceptionally highlevels of feacal counts ranging between 10,500 to 17,000 /100ml at the onset of the rainy season but the levels lowered to 400feacal coloforms/100ml towards the end of the rainy season. All in all, the results show high levels of both feacal coliforms and feacal streptococci with the highest levels during the wet season in the surface water sources.

Table 10 indicates the values of bacteriological counts of the samples from ground water both during the dry season and the wet season. The ground water pollution had variations depending on the nature and position of the water source. For instance, Msopa well had exceptionally very high values of feacal pollution because it was located on a fractured joint formed from the weathered clay rock particles which allows for free movement of water. In addition, settlements surround the well within a radius of 5-10 metres and during the wet season, mud and other debris got drained into and around the well hence introducing a lot of pollutants into the water source. Worth mentioning is the borehole which was the only ground water source depicting low pollution during both seasons although it still needs regular sanitary checks.

(no value refers to the breakdown of the borehole during the first wet season sampling)

For treated piped water, feacal coliform count is supposed to be 0 and 0-50 when compared to the WHO and Water Department standards respectively. However, the tap water in South Lunzu Township registered 89 feacal coliforms counts per 100ml during the dry season and 2 feacal coliform/100ml during the wet season which was considered to be highly polluted for treated water.

4 DISCUSSION

The provision of sanitation facilities and the use of clean potable water should ensure the reduction of water-related illness and dramatically improve the quality of life. In most cities throughout the world, providing access to piped water and sanitation for the urban poor continues to be a challenge for a number of reasons. UNEP (1999) noted that some of the challenges include difficulties with land tenure, irregular crowded street patterns and the prohibitive high cost of installing household connections for poor families. However, these two basic facilities are in inadequate supply especially in urban squatter settlements. As a consequence, ground water and surface water sources are being grossly polluted resulting into outbreaks of diarrhoea, cholera and dysentery, which continue to claim many lives.

The results during all the seasons indicated

Table 9: Levels of Feacal Coliforms (FC) and Feacal Streptococci (FS) in Surface Water

Sample Site	Organism Type and Levels Registered for Surface Water/100ml							
	Dry Season				Wet Season			
	Sample 1		Sample 2		Sample 1		Sample 2	
	FC	FS	FC	FS	FC	FS	FC	FS
Upstream	6,100	520	2,900	1,040	16,000	15,500	18,500	1,400
Middle	4,200	380	2,500	1,400	8,500	6,000	12,200	500
Lower Middle	1,100	230	4,600	6,500	17,000	10,500	400	0
Downstream	5,200	640	750	1,420	15,500	12,000	3,000	1,600
Drinking Water Stds								
WHO	0							
Water Department	0-50							

Table 10: Levels of Feacal Coliforms and Feacal Streptococci in Ground Water

Sample Site	Organism Type and Levels Registered for Ground Water/100ml							
	Dry Season				Wet Season			
	Sample 1		Sample 2		Sample 1		Sample 2	
	FC	FS	FC	FS	FC	FS	FC	FS
Borehole	2	0	0	0	no value	no value	30	0
Nkhumbe Spring	270	10	190	50	730	204	2,000	0
Namilango spring	1,070	200	530	220	9,500	7,000	3,000	0
Msopa well	5,200	640	3,500	530	4,250	2,650	11,000	250
Tap Water	0	1	89	0	0	3	2	0
Drinking Water Stds								
WHO	0							
Water Department	0-50							

(no value refers to the breakdown of the borehole during the first wet season sampling)

that surface water in South Lunzu Township was contaminated. The surface water was contaminated mainly by run-off and soil erosion from the urban poor area. Renwick, (1985) observed that some trace substances both organic and inorganic have the tendency to travel attached to particles rather than being dissolved which could explain the higher levels of feacal coliform counts during the rainy season. In addition, Lunzu River is passing through Maone Waste Water Treatment Works, Kachere and Nkolokoti Townships. As such, the high pollution levels in the river could be attributed to the raw sewage being discharged in the river (since the waste water treatment was not functioning) and also run-off and sub-surface flow from the two townships. During the wet season, the level of contamination was extremely high in the surface water samples. This could be explained in terms of the increased surface erosion which tend to shield some micro-organisms. Organic turbidity could also serve as a source of nutrients, which might have contributed to bacterial growth. Moreover, the high levels of contamination in the river could be attributed to the washing of clothes which included napkins not to forget the people involved in brick making along the river who had no sanitary facilities but used the river as a disposal system.

Generally, ground water sources were heavily polluted throughout the study period, except for the borehole, indicating considerable contamination by feacal material from the environment. This was the case because during the household survey it was revealed that the majority of the residents used the traditional pit latrines, which unfortunately were located in very close proximity to the ground water sources. In South Lunzu Township, it was found that the water sources were on an average distance of less than 10 metres from the nearby pit latrines. UNEP, (1999) recommends that pit latrines should be located at least 40 metres away from a ground water source. Furthermore, the geology of the area is characterised by fissures and fractured pegmatite veins in the base-

ment aquifers, which make ground water vulnerable to contamination (BCA,1999). These fissures and veins facilitate recharge processes and seepage from nearby latrines and septic tanks. This had resulted in 6.47% of the total cholera cases which occurred in the City of Blantyre being reported from this township (Chilowa, 1998). Similarly, a recent survey done in Kenya in the towns of Migosi and Manyatta had confirmed that wells too close to the pit latrine sanitation system increased feacal contamination of the ground water systems especially during the rainy season. In Migosi, pit latrines were located at an average distance of 20.5metres from the useable wells while in Manyatta they were as close as 11.5metres. Unacceptable high levels of feacal coliforms that did not meet either the Kenyan or the WHO standards for drinking water had been reported. Consequently, diseases such as cholera, typhoid and dysentery have occurred with severe outbreaks during the rainy season (UNEP, 2000).

The quality of piped water was supposed to be better than the water from the other sources. However, the results showed that even tap water was contaminated with coliforms. The contamination in the tap water could be attributed to the frequent breakdowns which occur in the pipes. As a result, during repairs, there was possibility of pollutants getting into the system.

Provision of safe potable water supply by itself will not necessarily prevent infection. It is apparent that improvements in sanitation and personal habits should accompany the efforts to improve water supply. Education in simple applied hygiene is essential. The survey revealed that the hygiene practices prevalent in the area had contributed to the deterioration of water at household level. The practice of washing hands after visiting a latrine, or after changing baby napkins was not done by all the respondents. Such practices could be routes of some diseases even when water supply and sanitation systems were clean and safe. A study done by Lindskog and Lindskog (1987) acknowledged that although water supplies are probably a necessary condition for achieving public health, quality of sanitary facilities, personal hygiene are equally important to reduce water related diseases. Therefore, it is apparent that improvements in sanitation and personal hygiene should accompany the efforts to improve water supply.

5 CONCLUSION

The analysis of bacteriological contamination in all the water sources showed that water in South Lunzu Township was greatly polluted. This could be attributed to the geological formation in the area which has fissures and veins. This meant that there was easy penetration of bacteria and nutrients into the water sources. Coupled with this was the close proximity of these water sources to the pit latrines and septic tanks. Thus, the distance between the water source and the sanitation facilities gives insufficient time to attenuate or eliminate pathogens. In addition, the surface water source, Lunzu River was receiving raw sewage discharged by the incapacitated Maone Wastewater Treatment Works. When rivers have excessive amounts of waste, the natural process of self-purification cannot keep pace with the input of pollutants, so water quality deteriorates.

Although lack of sanitation facilities and the geology of the area had been attributed to the pollution of the water sources, the institutional set-up governing the provision of services in the area was equally to blame. The Blantyre Water Board's tariffs were very high and unaffordable by most of the residents. The Blantyre City Assembly's sewer line served only a small proportion of the population. Consequently, people tend to source water from unprotected places which was a threat to their health and lives. The inadequate sewer lines had forced residents to use pit latrines and septic tanks which unfortunately were poorly constructed and maintained. As a result, seepage from these places had polluted ground water and surface water sources.

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