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Original Paper

An Assessment of the Quantity and Microbiological Quality of Domestic Water Supplied to Residents of Peri-Urban Townships of Lusaka District, Zambia

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ABSTRACT

Introduction: Access to safe and clean water is important and it has been reported that many diarrheal illness recorded in developing counties are due to unsafe and insufficient water.
Aim: The aim of the study was to determine the quantity and microbiological quality of household domestic water supply in Peri-urban areas of Lusaka.
Methods: This was a cross-sectional analytical study. Seven (7) Peri urban areas in Lusaka district were included in the study. Fourteen (14) water samples were collected from each of the Peri-urban areas for bacteriological analysis (faecal and total coliform) using the Colitag ™ test kit and multi-tube fermentation test method. Questionnaires were also administered to 196 households in participating townships to collect information on the quantity of water utilization per household per day.
Results: The study found that 90% of people in the study areas have access to piped water, mostly from boreholes and water kiosks. The quantity of water used per person per day is between 20 to 60 litres. The majority (60.6%) of the water samples examined contained total coliform while about 52.5% contained faecal coliform.
Conclusion: The amount of water supplied to the Peri-urban townships of Lusaka district is highly inadequate and the microbial quality fall below the level of the Zambia bureau of Standards and therefore can serve a vehicle for the transmission of water borne pathogens.

Key words: Water, microbial quality, quantity, Lusaka

1. Introduction

Access to safe and clean water is important as a health and development issue at local, national and regional levels [1]. An estimated 2.5 billion cases of diarrhoea occur among children under five years of age, with more than half of these cases occurring among populations in low-income regions of South-East Asia and sub-Saharan Africa [2].

Zambia‘s population was first comprehensively recorded at 5.7 million in 1980 [3]. Since then, it increased to 7.8 million in 1990, 9.9 million in 2000, and 13.01 million people in 2010 [3]. This gives an annual growth of 2.8 percent between 2000 and 2010; with Lusaka Province having the highest average population growth rate of 4.7 percent yearly [3]. Zambia is one of the most urbanized countries in southern Africa with an average of 35 and 40 percent of the population living in urban township, and an annual urbanization rate estimated at 2.3 percent between 2005 and 2010 [3]. The urban population has continued to rise disproportionately to available resources such as reticulated water supply and sewage system. Similarly, poverty levels have also increased resulting in unplanned settlements that have mushroomed all over the cities [4]. This has led to failure by some urban authorities to provide services

such reticulated water supply and sewage system. The water supply and sewerage infrastructure in most urban township of Zambia were constructed in the 1960's and 1970's and have since received inadequately maintenance that has led to dilapidation [5]. Peri-urban townships in most Zambian towns have grown considerably in recent years, and most have poor water supply and sanitation [6].

Lusaka has over thirty-five (35) unplanned settlements, which are characterized by inadequate shelter, lack of essential services such as water supply and sanitation, and inadequate waste management, making the residents vulnerable to epidemics [5]. Water supply in Lusaka is highly fragmented with just about 30% of the population in peri urban township having access to piped water in their homes and yards [7]. The remaining 70% have to rely on a variety of water sources such as water kiosks, shallow and deep wells whose quality and safety remains uncertain [7]. In the majority of Peri urban settlements, the Lusaka Water and Sewage Company (LWSC) provides water via kiosks, which are mainly supplied from local boreholes. However, water supplied via these kiosks is inadequate and erratic in most cases [7]. The link between the problem of attaining safe and clean water and high incidence of waterborne diseases is a serious problem that affects people world over, but those living in the third world are especially the most impacted [1]. In a study by Zulu and Nyambe (2004), it was reported that 70% deficit of water in the Peri-urban township might be responsible for the diarrheal diseases experienced in these township [8]. The inadequate water supply to the majority of residents in Lusaka has led to self-supply initiatives by most households. The shallow wells in Lusaka are, however, often contaminated as a result of poor sanitation and seasonal flooding [7].

This study was undertaken to assess the quantity and microbiological quality of domestic water supply in Peri-urban township of Lusaka District. The results of the study are important for water and sanitation regulators and service providers, in order to improve water quality and service delivery.

2. Methods

The study was cross-sectional analytical and was aimed at assessing the quantity and microbiological quality of domestic water supply in Peri urban township of Lusaka District.

Site selection

Lusaka has seven (7) constituencies from which one Peri urban area was selected and included in the study. The selection of Peri urban townships was done by listing all townships in each constituency and through a raffle one area was selected. The peri urban townships randomly selected were Kanyama from Kanyama Constituency, Kalikiliki from Munali Constituency, Garden from Mandevu Constituency, Bauleni from Lusaka Central Constituency, Chunga from Matero Constituency, Jack from Kabwata Constituency, and Misisi from Chawama Constituency (figure 1).

Water Sample collection and microbiological analysis

All the water samples were collected in pre-labelled sterilized (auto-claved) 500 ml glass containers. Fourteen (14) water samples were collected from each Peri-urban area amounting to a total of 98 water bottles. The water samples were collected according to the WHO protocol on water sampling [9].

The water samples were transported to the laboratory for analysis within 6 hours of collection and were analysed for total and faecal coliforms using the Colitag ™ test kit (Neogen, USA) and multi-tube fermentation test method and procedures are as described by Nakaonga *et al* (2017) [10]. The Colitag™ test kit (Neogen, USA) is qualitative test that uses a selective and differential medium to detect total coliforms and *Escherichia coli (E. coli)* in water samples in 16-48 hours [10]. The multi-tube fermentation test method is a quantitative microbiological test carried out through multiple tube fermentation technique, where by most probable number (MPN) of coliform and E. coli was determined and categorized according to their number [10].

Semi-Structured Interviews

Information was collected using a semi-structured questionnaire from 196 households in the participating townships. Semi-structured interviews were also conducted at the water utility company Lusaka Water and Sewerage Company (LWSC).

The qualitative data from Lusaka Water and Sewerage Company was grouped into themes and discussed. The quantitative data was analysed using Stata version 11 and Statistical Package for Social Sciences (SPSS) Version 23, determining the mean, median, standard deviations, and t-tests.

3. Results

Domestic water sources

The first source of water for households in the peri-urban Townships was piped water which accounted for 90% which was divided into communal taps and piped water within house, 65% and 25%, respectively. The second source was groundwater representing 10%, of which included protected open wells (1%), public borehole (6%) and borehole within yard (3%) (Figure 2).

Water availability and consumption

The average quantity of water used by a typical household in the study was 91.42 litres per day with a median value of 100 litres per day, and ranged from 40 to 220 litres per day. The daily water consumption per capita on average was about 17 litres/person/day and ranges from 2.5 to 100 litres/person/day (Table 1).

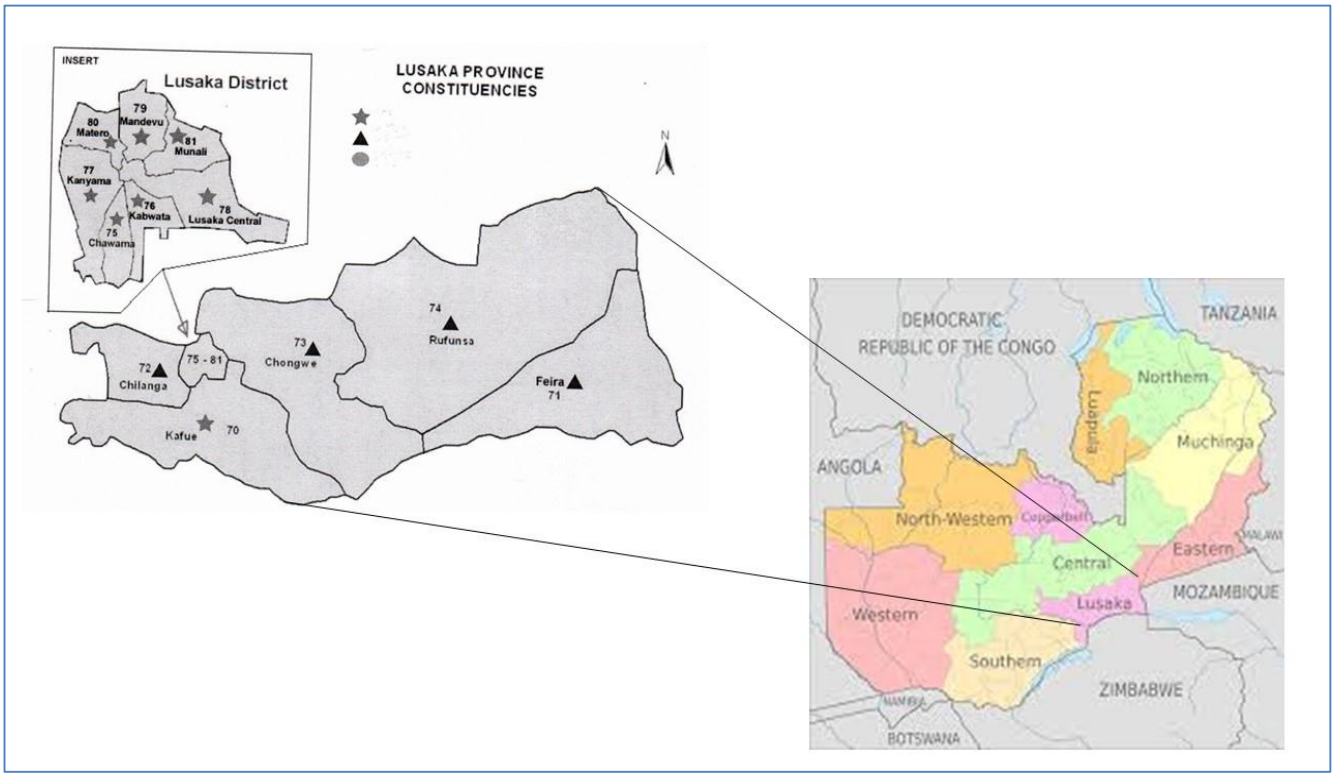

Figure 1: Map of Lusaka showing all constituencies

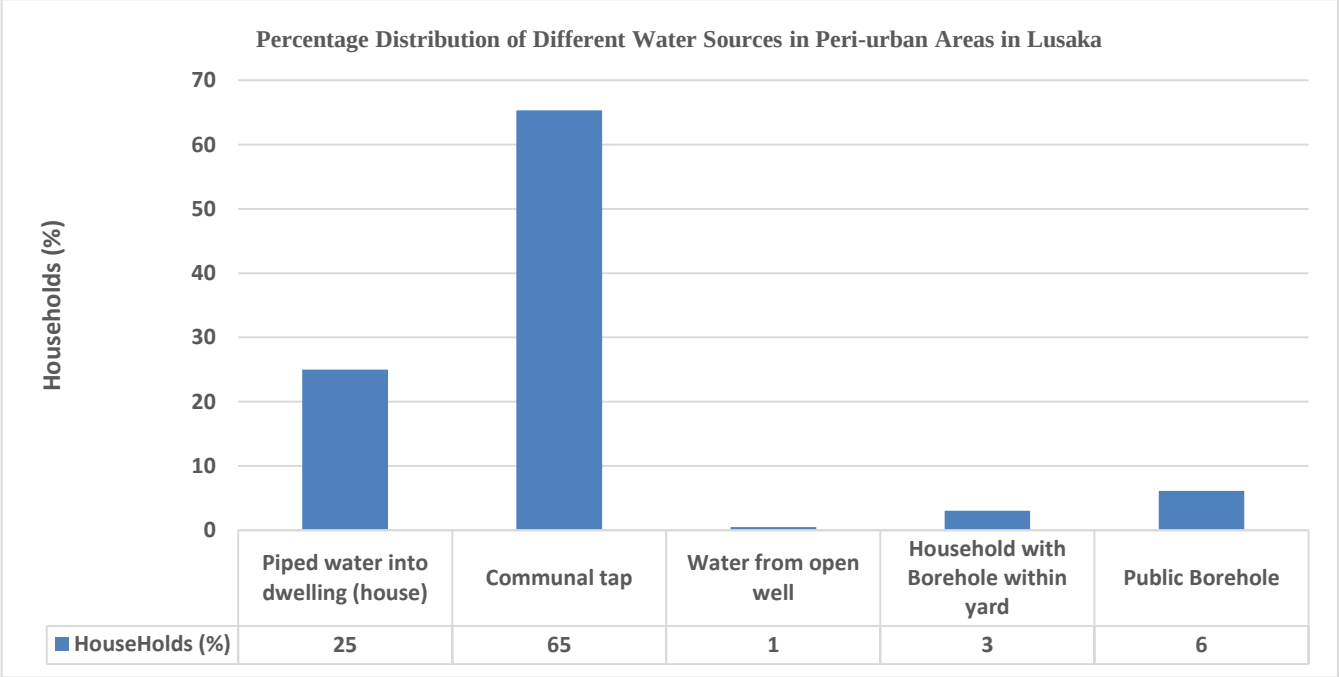

Figure 2: Percentage Distribution of Different Water Source

Table 1: Residential water consumed and capita daily water consumption in peri-urban areas of Lusaka District

Variables	Mean	Standard Deviation	Median	Minimum	Maximum
Quantity of residential water consumed (Litres/day)	91.43	46.67	100	40	220
Per capita daily water consumption (Litres/person/day)	16.95	11.86	16.67	2.5	100

Table 2: Microbiological quality of water from the seven townships

S/N	Township	Number of Samples [%]			
		Total samples collected	Total Coliforms (above 3cfu/100ml)	Faecal Coliforms (above 1cfu/100ml)	Satisfactory Samples
1	Kalikiliki	14	12 [85.7]	11 [78.6]	3 [21.4]
2	Garden	14	5 [35.7]	2 [14.3]	12 [85.7]
3	Kanyama	14	7 [50.0]	6 [42.9]	8 [57.1]
4	Jack	14	7 [50.0]	7 [50.0]	7 [50.0]
5	Bauleni	15	15 [100.0]	12 [80.0]	3 [20.0]
6	Misisi	14	10 [71.4]	10 [71.4]	4 [28.6]
7	Chunga	14	4 [28.6]	4 [28.6]	10 [71.4]
	TOTAL	**99**	**60 [60.6]**	**52 [52.5]**	**47 [47.5]**

Table 3: Sources and quality of water

Source of Water	Quality of water		TOTAL
	Satisfactory [%]	Unsatisfactory [%}	
Piped Water	44 [49]	46 [51]	90
Open Well	0 [0]	1[100]	1
Borehole	3 [38]	5 [52]	8
	47 [47.5]	52 [52.5]	99

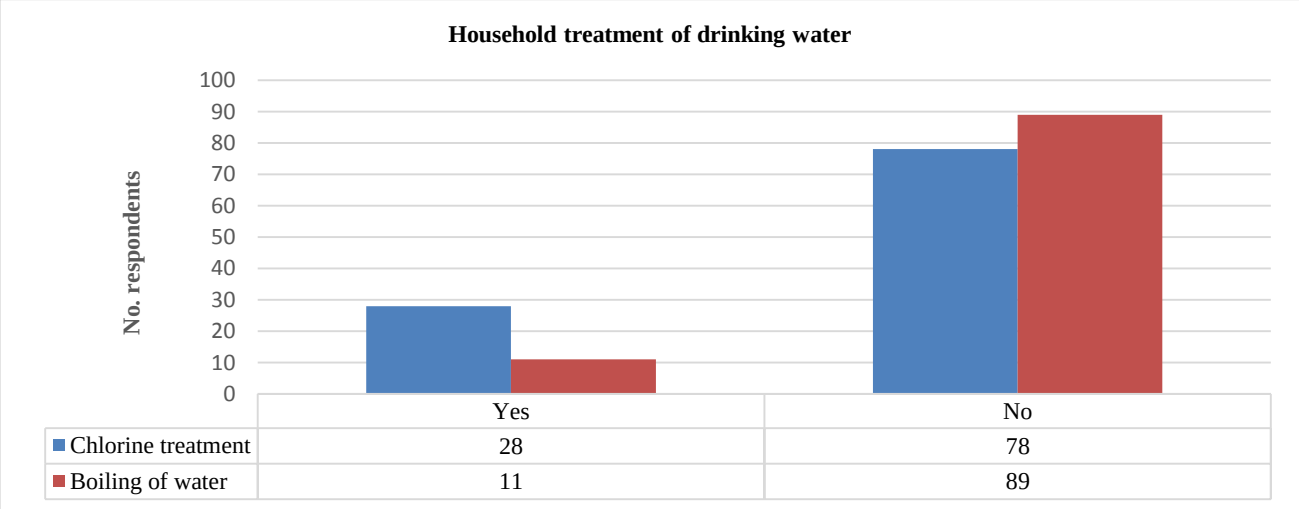

Figure 3: Treatment of drinking water at household level

Microbiological water quality

Results of the microbiological quality of the water samples collected from all the townships included in the study revealed that 60.0% and 52.5% were contaminated with total and faecal coliforms, respectively. Bauleni Township had the highest contamination of total (100%) and faecal (80%) coliforms, while Chunga Township and Garden Township recorded the least total coliforms (28.6%) and faecal coliforms (14.3%), respectively (Table 2). It was further observed that only 47.5% of the water samples from all Peri-urban townships were safe for human consumption. The least and most satisfactory results of the quality of water for human consumption were recorded in Bauleni (20%) and Garden (85.7%) Townships, respectively (Table 2).

Regarding the microbiological quality of water from the different sources, the study revealed that only 49% (44/90) of piped water, 38% (3/8) of borehole water and 0% (0/1) of open wells were satisfactory for human consumption (Table 3). On the treatment of water after collection from the available sources, only 11% and 28% of respondents treated their drinking water using chlorine and boiling, respectively (Figure 3).

4. Discussion

The research aimed to study the quantity and the microbiological quality of water that is supplied to residents of Peri-urban townships in Lusaka district. The study revealed that majority (90%) of Peri-urban households used piped water which was mostly sourced from communal pipes (65%). The quantity of water used per household ranged from 40 to 220liters per day with the mean and median values being 91.42 and 100 litres per day, respectively. Microbiological quality results of the water collected from Townships revealed that 60.0% and 52.5% were contaminated with total and faecal coliforms, respectively. Responses from the residents revealed that only 11% and 28% treated their drinking water using chlorine and boiling, respectively.

Quantity of water supply

The findings of the study indicated that 90% of the residents in the Peri-urban areas of Lusaka district have access to piped water of which 65% of the households fetched from communal taps. The percentage of households with piped water within the homes or yards was 25% this result is lower than that determined in a prior study which was at 30% [7]. It is gratifying to note that the overall supply of piped water has increased significantly to 90% as it was reported in a study by Mulenga (2011) that 70% of the population living mostly in the over 35 informal settlements relied on a variety of water sources, water kiosks, shallow wells and deep wells to meet their needs. The provision of piped water by the relevant utility company therefore entails that the residents of the peri-urban townships are able to receive adequate treated water for their daily use.

Despite the increase in provision of piped water, the quantity supplied to residents of the peri-urban Lusaka district is still low at 20 to 60 litres compared to the recommended daily supply of 150 to 200 litres of water per person per day [11]. The findings are in conformity with the assertions by Zulu and Nyambe (2004) that a 70% deficit of water supply was recorded in the peri-urban areas of Lusaka, and the workers further postulated that the deficiency might contribute to the reported diarrheal diseases.

As indicated in the African Ministers Council on Water (AMCOW) Country Status Report, 2010, for any Water Supply Sector to be effective, there is need for well-defined institutional frameworks and adequate municipal funding [12]. The LWSC indicated that they had a budget and organizational capacity for improvement of domestic water supply and sanitation in Lusaka, and is working with donor agencies such as the European Union (EU), the World Bank and The Millennium Challenge Account, to set up water supply and sanitation projects. Despite this indication, some infrastructure is lacking such as meters for the tap-off points for water supply to the peri urban areas, which are essential for the company to determine actual water supplied to the peri-urban areas.

Water quality

The water samples collected from the study site either contained faecal or total coliforms, or both and 52.5% of all the water tested were not safe for human consumption. The highest contamination was recorded in open well (100%) while borehole and tap water were 52% and 51%, respectively. Ineffective chlorination from the source, ineffective dozers along the distribution line or leaking pipes along the line of distribution could lead to contamination of tap water [13]. The results of the study are consistent with those of other studies conducted in Zambia where 48.5% and 100% contamination of borehole water reported in Chalala Township, Lusaka district [10] and Mulenga Township, Kitwe District, respectively [14]. A study by Banda *et al* (2014) reported that in St Bonaventure *E. coli* was isolated in 10.9 % of the borehole water and pollution was attributed to septic tank siting resulting in contamination of ground water [15]. Other studies have attributed contamination of borehole water to the following; improper disposal of sewage and wastewater from domestic activities, discharges from septic tanks and latrines close to some of the bore holes [15, 16]. The Zambia Bureau of Standards (ZABS) requires that water used for drinking and other household activities should be free of faecal coliforms [17], therefore provision of unsafe water to peri-urban townships is breach of the local water quality standards.

The microbiological quality of water from studies in Lusaka district and other towns in Zambia are not in conformity with the Zambia Bureau of Standards (ZABS) that requires drinking water or for household use to be free of faecal coliforms [17]. The consistently high microbial contamination levels of household water recorded in several studies conducted in Zambia raises concern on the public health risks associated with its consumption and use. This therefore further highlights that there has been very little action taken towards the provision of safe water to the residents of peri-urban townships. Contaminated water serves as vehicle for the transmission of pathogenic bacteria such as *Vibrio cholerae, Shigella dysentriae, Salmonella typhi*, therefore predisposing the users to diarrheal infections caused by the pathogens [18]. Therefore, coupled with efforts to increase the supply of water,

the local authority and water utility companies ought to ensure the water is safe for human consumption as well.

The problem of the use of unwholesome water in the peri urban areas of Lusaka is further compounded by the fact that 78% and 89% of the residents neither treat their water with chlorine nor by boiling, respectively. The provision of unsafe water which is contaminated with faecal coliforms and the lack of its treatment may contribute to the high prevalence of diarrheal diseases in low-income urban neighbourhoods of Zambia [19]. Disinfection of drinking water has proven to reduce and prevent cases of waterborne diarrheal diseases. In a study conducted in Kitwe district by Quick *et al* (2002), Diarrheal disease risk for individuals in intervention households was 48% lower than for controls [20]. Disinfection of water is a useful tool for preventing waterborne diseases in families in developing countries who lack access to potable water [20].

Considering the huge financial investments required in the provision of piped water to households in Peri-urban townships of Zambia, there is need for more research to develop affordable but sustainable interventions to increase the availability of potable water in households. Further research on the social and economic dynamics of water supply in the Peri-urban townships will help highlight challenges faced by the communities and the water utility companies in accessing and providing potable water, respectively.

Conclusion

The study concludes that 90% of residents of Lusaka's Peri urban areas receive water from the local utility company, either from the main network or from the water kiosks that are operated in their residential areas. The quantities of domestic water received by the residents, 20 – 60 litres per person per day, is not adequate for domestic use. The study also revealed that 60.0% and 52.5% of the water was contaminated with total and faecal coliforms, respectively. Therefore, the residents of peri-urban townships of Lusaka district received inadequate quantity and poor microbial quality water for use in their homes.

Recommendations

From the study some recommendations have been drawn which will help better provide more and cleaner water to residents of peri-urban townships of Lusaka district.

Short term

The water utility company should ensure that the online chlorine dozers are always operational and water leaks are attended to promptly to prevent the contamination of piped water. Routine sampling of water for microbiological analysis should be increased so that efforts being made to treat the water are tested to being effective or not. All stakeholders in water provision which includes water utility company, local authority and ministry in charge of water affairs, should actively participate in independently monitoring the quality of water. The local authority together with the water utility company needs to urgently implement the Water and Sanitation programs planned for Lusaka's peri urban areas to address the problem of on-site sanitation that has contributed to the contamination of the domestic water in these areas.

Long term

The water utility company should improve/increase the quantities of domestic water supplied to the peri urban areas in order to increase the quantity of water accessed per person per day to meet the minimum requirement of 150 – 200 litres. Therefore construction of reticulated systems should be planned for in order to achieve the goal. The central government through the ministry of finance needs to increase funding allocation to water infrastructure.

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