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An Analysis of Alternative Water Sources in BudiriroSuburb Harare

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***Abstract*-The quality of water being used by residents in Budiriro is a major health issue. Water system in Budiriro suburb is centralised through the reticulated water system which is not enough for the residents. The serious water shortage in Budiriro has forced residents to rely on unsafe water sources resulting in the area being endemic to waterborne diseases. This study sought to determine the impact of the quality of the water being used by residents in Budiriro. An analytical cross-sectional study was conducted that combined quantitative and qualitative methods. A structured questionnaire was used to obtain information on alternative water sources A total of 72 samples were collected over a period of four months. Twenty-five (25) borehole water samples, 41 well water samples and 8 from the City of Harare tap water. Data from the questionnaires was captured and analyzed using SPSS (statistical package for social science) in line with the objective Sixteen percent (16%) of the boreholes and 56% of wells sampled did not meet the WHO total and faecal coliform standards of zero per 100ml. Thirty-eight percent (38%) of residents use the water without any form of treatment. Results show that residents are potentially exposed to waterborne diseases. This study concludes that water from alternative sources in Budiriro is of poor quality. The study ascertains the relative importance of the use of different sources of water leading to the development of a distribution planning model for different sources of water to Budiriro residents.**

***Keywords*-Alternative water source, total coliform, physico-chemical parameters.**

I.INTRODUCTION

The provision of potable water to communities and households has been a major developmental goal since the 1990s and has seen many conferences and declarations aimed at effecting changes in water sources and use, like the Dublin conference in 1992 and International Conference of Water and Environment, (1) which advocated for stakeholder participation in water resources managementt. According to United Nations Environmental Programme (UNEP) (18), clean fresh water is critical for meeting basic human needs, from consumption to sanitation, to economic activities and agricultural purposes. Water forms an integral part of the environment and the quality of water at any given locality is a reflection of the state of the environment. Therefore, water quality can serve as an indicator of how well an environment is being managed. The current focus in the world is to get natural resources including water managed at the lowest possible level. This applies even in Budiriro where water is centralised through the reticulated water supply which is not enough for the residents. There is need to have a Decentralised system whereby the community takes ownership of the system. Using locally available water sources can assist in easing the problem thereby combating the scourge of waterborne diseases. This is one of the areas the study sought to address through the development of a planning model on the distribution of water from different sources. Poor water service delivery is a major characteristic of most developing countries especially in Sub Saharan Africa. The high morbidity and mortality rates and incidence of people contracting waterborne diseases in Zimbabwe is of major concern. Major towns and cities in Zimbabwe are upstream of drinking water sources and this has led to huge pollution loads on most systems. Most Urban local authorities have failed to address the high pollution levels. Urban residents in Harare (and other cities in Zimbabwe) frequently experience water cuts, and are exposed to poor quality of drinking water (11). The serious water shortage in Harare forced residents to rely on unsafe water sources

in the period 2008- 2009 resulting in the increase of waterborne diseases that took the lives of many people. Zimbabwe witnessed the worst cholera outbreak which resulted in the deaths of 5000 people out of the 83 631 cases. Budiriro high density suburb was the epicenter of the cholera problem, (22). The study sought to determine the impact of the quality of water being used by residents of Budiriro. Based on this, the study ascertains the relative importance of the use of different sources of water leading to the development of a planning model on the distribution of water to Budiriro residents.

II. MATERIALS AND METHODS

A mixed methods research was conducted in Budiriro High Density suburb of Harare, the capital city of Zimbabwe. A total of 72 samples were collected over a period of four months. The samples were conveniently sampled in the seven areas, from wells and boreholes that were used in the different areas. City of Harare water acted as a control. The samples included 25borehole water samples, 41 well water samples and 8 from the City of Harare tap water. An analytical study design was the best method since analysis of water samples was explicitly done and the quality of water was determined. The study used both quantitative and qualitative data collection techniques. A triangulation of both qualitative and quantitative research methods was used. The different methods were used in order to establish an in-depth knowledge of the residents on the water sources they use.

The study population consisted of the residents of Budiriro high density suburb in Harare. According to the City of Harare Department Statistics (6), Budiriro has a population of 138146. The study was conducted from October 2018 to January 2019. The sample size had 237 households (37 per area) and 72 water samples. The sample size was calculated using the following formulae developed by cochrain (1963).

$$n = \frac{Z^2 p(1-p)}{e^2} \quad \text{----------(1)}$$

Where n=sample size, Z= Z statistic for the confidence interval at which the data is going to be tested The 95 % confidence level will be used and therefore Z=1.96. p is the estimated proportion of an attribute that is present in the population (assumed to be 0.5) and e is the degree of accuracy expressed as a proportion (0.1). The study used a degree of accuracy of 10% instead of the convectional 5%. According to (12), if there are resource limitations researchers can use a larger degree of accuracy (e). Based on the formulae above, a sample size of 237 participants were selected.

1. Subjects & selection method:
The study population consisted of the residents of Budiriro high density suburb in Harare. Budiriro has a population of 138146. The District housing data base was used as the sampling frame and seventy- two (72) water samples were collected from the seven phases in Budiriro high density area.

2. Procedure Methodology
A questionnaire was used to obtain information on alternative water sources, knowledge on the sources, perceived safety of the sources and the preferred sources. The decision to use a questionnaire was fundamentally based on understanding that it is probably one of the democratic approaches to obtain public opinion if the sampling is appropriate and a true representation of the population. The questionnaire was administered from October 2018 to January 2019. The sample size had 237 households. Data from the questionnaires was captured and analyzed using SPSS (statistical package for social science). in line with the objective. A total of 72 samples were collected over a period of four months. The samples were conveniently sampled in the seven areas, from wells and boreholes that were used in the different areas. City of Harare water acted as a control. The samples included 25borehole water samples, 41 well water samples and 8 from the City of Harare tap water. Written consent was obtained from the participants from each household.

3. Ethical considerations
This paper is part of a lager study which was endorsed by the City of Harare, Zimbabwe, approved by the Africa University Research Ethics Committee and the Medical Research Council of Zimbabwe (MRCZ number: A/2325). All study participants gave written informed consent for participation in the study. It was also fully explained that participation was voluntary, not compulsory.

4. Statistical analysis
In order to ensure the quality of the data, each completed questionnaire was manually checked before it could be coded on MS Excel 2007. The data was analyzed using the Statistical Package for Social Science (SPSS 20). The software was used to calculate frequencies, measures of central tendency and proportions.

III.RESULTS

Table 1 Sample characteristics.
The demographic characteristics of the study sample are summarized in Table 1. A total of 237 households participated in the survey.

Characteristics of the study sample

Sample characteristics	n	%
Area and number of household		
Total sample size	237	100
Budiriro 1	33	13.9
Budiriro 2	25	10.5
Budiriro 3	18	7.7

Budiriro 4	37	15.6
Budiriro 5	62	26.2
CABS	37	15.6
Ngungunyani	25	10.5
Other variables		
Gender of main respondent, female	165	
Mean age of main respondent	38	
Highest Level of education, main respondent		
Never attended school	3	1.2
Primary		2.4
Secondary	61	24.6
Tertiary	95	38.3

The mean age of the respondents was 42, and the majority had competed tertiary education. Fifty-six percent (56%) of the main respondents were female.

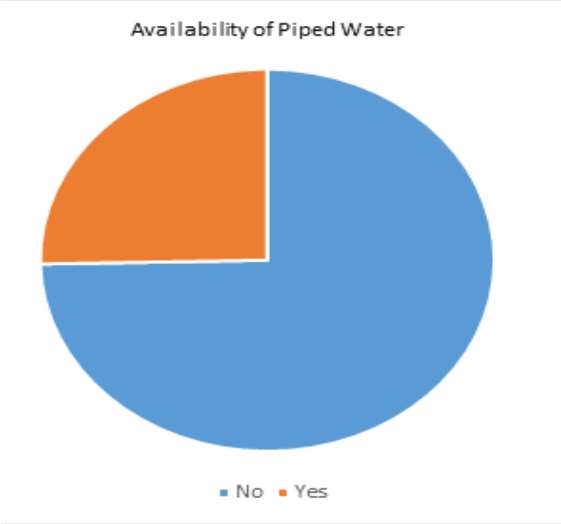

Figure 1. Availability of piped water in Budiriro area.

According to figure 3 above, most of the respondents (74.6%) responded that the piped water was not always available in their homesteads.

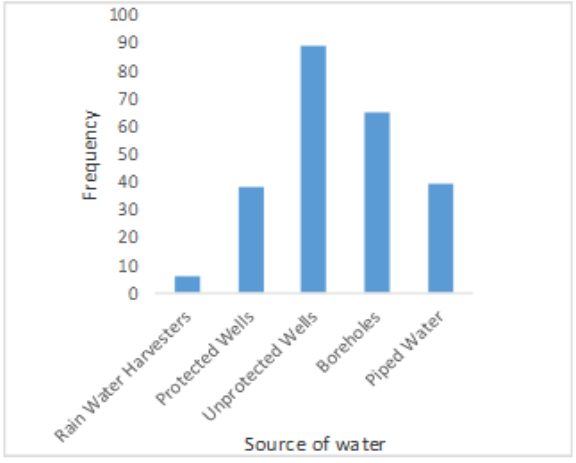

Figure 2 above shows frequencies of residents of Budiriro.

who depend on sources such as municipal piped water, boreholes, protected wells, unprotected wells and rain water harvesters n=237 (100%). The water sources are ranked on availability and accessibility, of the water used by residents across Budiriro is from municipal piped water n=39 (16%)unprotected wells, n=89 (38%) from boreholes, n=65 (28%) from protected wells and n= 6 (2%) from rainwater harvesters. The main water source is hand dug wells which is always available and has the highest frequency of n 89.

Table 2 Results of total coliform in Budiriro Area wells.

Sampling Area	Total coliform count (cfu/ 100ml)					Total
	None	1 to 10	>10 to 100	>100 to 1000	>1000	
Budiriro1	1	1	1	4	0	7
Budiriro 2	0	0	0	7	0	7
Budiriro 3	0	0	0	6	0	6
Budiriro 4	1	0	1	3	0	5
Budiriro 5	1	1	2	1	0	5
Cabs	0	0	0	5	0	5
Ngunguny ani	0	1	0	4	0	5
Total	3	3	4	30	0	40

From the result of the analysis on Total coliform count (TCC), it was observed that 36 of the tested samples have detectable amount of TCC, with concentration ranging from 0-1000 cfu/100ml for wells (table 4), as against the WHO (2011) acceptable limit of 0cfu/100ml for potable water.

Table: 3 Results of E. coli monitoring in Budiriro Area for Wells.

Sampling Area	E. coli counts (cfu/ 100ml)					Total
	None	1 to 10	>10 to 100	>100 to 1000	>1000	
Budiriro1	2	2	3	0	0	7
Budiriro 2	3	2	1	1	0	7
Budiriro 3	3	1	0	0	2	6
Budiriro 4	3	1	1	0	0	5
Budiriro 5	2	1	1	1	0	5
Cabs	3	0	0	2	0	5
Ngungunya ni	2	3	0	0	0	5
Total	18	10	6	4	2	40

Table 5 above show that E coli counts were recorded in 16% of the water samples collected from some areas in Budiriro. This is an indication of feacal contamination

Table 4 Laboratory water quality results for boreholes using Chemical analysis.

Suburb	pH	Hardness	Sulphate	Nitrate
WHO guidelines 2008	6.5-8.5	500 mg/L$CaCO_3$	250 mg/LSO_4^{2-}	50 Mg/LNO_3
Budiriro1	6.73	164.03	2	4.5
	7.04	116.5	12.67	2.58
Budiriro 2	7.12	170.9	1.25	4.1
	6.91	130	19.41	1.7
Budiriro 3	7.2	138.4	65.23	0.8
	7.29	164.8	12.62	3.0
Budiriro 4	7.3	146.5	29.27	0.8
	7.1	102.8	21	21.6
Budiriro 5	7.47	150.2	18.4	40.2
	6.88	187.2	498.39	25.44
Cabs	6.84	122.53	14	11.17
	7.47	150.2	18.3	40.2
Ngunguny ani	6.9	143.5	17.2	7.6
	7.10	100.79	21.0	21.6

IV. DISCUSSION

This study provides a comprehensive description of quality of alternative water sources used by residents of Budiriro. Water sources in the study area, were highly contaminated with E. coli. This study analyzed the level of E. coli bacteria in water samples because testing for all known pathogens is complicated and an expensive process. Besides, E. coli bacteria are considered as the best microbial quality indicator of drinking water for public health protection (7). The E-Coli levels were above the Zimbabwean standard of 0 CFU/ 100Ml. The figure is also above the WHO allowable limit of 0cfu/100ML.

A household questionnaire was used to identify the main alternative water sources in the seven areas of Budiriro. It was found that the supply of City of Harare water was erratic hence residents in all the seven areas use boreholes, unprotected wells, rain water harvesters and protected wells as their sources. Due to erratic supply of Municipal water, residents resort to use of alternative sources as their main water source for domestic purposes. The planning model on the distribution of different water sources will be developed to serve as tool for efficient distribution of water in a manner that can improve the provision of quality water to the residents. Results from this study revealed that water shortages cause residents to resort to alternative water sources to meet their domestic needs which concurs with the findings of Chioreso, (5).

The quality of alternative water sources has become a major concern to many, because most people depend on these sources for their livelihood. In this study, 16% of the boreholes and 56% of wells sampled did not meet the WHO total and faecal coliform standards of zero per 100ml. Coliform bacteria are clustered into two categories. Total and faecal coliforms based on their origins and features. Total coliforms are a group of bacteria generally found in the environment such as in water and soils as well as in human and animal feces; while, faecal coliforms are found only in animal and human faeces. They are often used to distinguish and approximate the level of faecal contamination of water; although, they are not often considered as dangerous to human health but used to show the presence of a health threat. For instance, the existence of fecal coliforms and E. coli in drinking water shows recent contamination of water by human or animal feces and may indicate the possible presence of other diseases causing organisms such as certain bacteria, viruses or parasites. These pathogens can cause diarrhea, cramps, nausea, and headache and therefore may pose a special health risk mainly for infants and children. Part of the questionnaire required respondents to list their preferences on which source of domestic water they can use so that decisions on the development of a planning model would be made. This approach was expected to raise community participation in the improvement of the quality of water that they use thereby developing a planning model.

E. coli was detected in 56 % of the wells and 16% of boreholes with Budiriro 1 and 2 the most affected. The result agrees with the distribution of waterborne and diarrhoeal diseases as reported in the DHIS 2 of 2017. The microbial levels observed in Budiriro gives an indication of contamination of well and borehole water by faecal matter. According to WHO, (20), these conditions make the water unsuitable for human consumption, predisposing significant health risks to humans. Thirty-eight percent (38%) of water used by residents in Budiriro is from unprotected water sources and they do not treat it before use.

The presence of E. coli in drinking water denotes that the water has been contaminated by faecal matter and therefore presents a potential health risk to households that use the water untreated (Nkansah et al, 2010). According to WHO, (19), E. coli is present in very high numbers in human and animal faeces and its presence provides conclusive evidence of recent faecal pollution and should not be found in drinking water. A study by Amenu et al. (23) investigated the microbial water quality of rural households in Lemu and Siraro districts of Oromia Regional State, Ethiopia, the study finds that 54.9% of the samples from unprotected wells were contaminated with E. coli; In another study in a study in Kersa district of Eastern Ethiopia they found that more than 78% of sampled water from wells were contaminated with E. coli (10). In a study on quality of drinking water of Kalama region in Egypt, 30% of samples from public waters were contaminated with Coliform bacteria. Other studies showed that 67% of water samples from open water sources in India were contained by Total Coliforms

and/or faecal Coliform bacteria (15). Thus its presence in wells and boreholes poses a health risk to residents.

These results show that many residents from Budiriro area were potentially exposed to waterborne diseases. This is supported by the cholera and typhoid outbreaks of 2018. High levels of faecal and total coliforms in Budiriro could be because most of the wells that are not protected and at times too shallow. The existence of many blocked sewers could be attributing to the causes of ground pollution of wells and boreholes.

Microbial indicators were present in the borehole and wells sampled in all the seven areas of Budiriro. Significant numbers of total coliforms were recorded in the wells that were sampled. Total coliform numbers ranged from 5 to numerous to count coliforms cfu/100ml which far exceeded the WHO standards of zero total coliform counts in drinking water. This could be due to water withdrawal practices were a rope tied to a tin is used. This could introduce total coliforms by users and contamination of wells with organic materials from the environment. Similar studies by Ifabiyi, (9) and Akinbile and Yusoff, (2) are in agreement with the afore going sentiments that high values of total coliform counts in wells is as a result of contamination during water withdrawal. This was also noted that most of the wells in the areas are not lined inside and they are 20cm above ground surface and not covered so there could be high chances of contamination by plants.

According to ObiriDaso, Adjei, Stanley, and Jones, (14) the upper part of wells should be above the ground surface in order to prevent contamination. The results from this study indicated that residents in Budiriro were at risk of waterborne diseases outbreak. Basing on the City Health Report for the period January to December 2018, Budiriro recorded 513 diarrhoeal cases. Apart from these cases, other waterborne, water related and water washed diseases that were experienced include 235 typhoid cases and 84 dysentery cases. This indicated the effects of bacteriological contamination in Budiriro area. The fact that 70% of the respondents in the study indicated that they did not treat water from the alternative sources can be a good pointer to the recent cholera outbreak in Budiriro whose epi centre in Glenview recorded the second highest number of cases according to City of Harare reports.

1. pH

The results of the physico-chemical analysis of the water samples from the 72 boreholes and wells showed that the pH of the water samples ranged from 6.66 to 7.47. The measured pH values indicate that all the 70 boreholes and wells had values that were within the Zimbabwean recommended range of 6.5-8.5 for drinking water, and did not appear to pose any problem to the water. This is in line with the World Health Organisation (20) which suggests that the optimum pH required in drinking water should be in the range 6.5-8.5.

2. Sulphate

The sulphate levels of the water samples ranged from 0 to 498.39 mg/LSO42. Samples from Budiriro 5 exceeded the maximum permissible limit according to the guidelines for drinking water quality (20). Sulphate is a combination of sulphur and oxygen. Sulphate gets into the ground through the solution of rocks containing sulphur and mine drainage waste. (16) concurs with this notion There were high levels of sulphate in boreholes in Budiriro and these results were similar to those from a study carried out by Bashir, et al, (4) in Pakistan. The effect of sulphate depends largely on the body mass of an animal, the smaller the animal, the greater the effect. This this also true for people. Water with elevated levels of sulphate can cause diarrhoea and dehydration. Infants are often more sensitive to sulphate than adults. The presence of sulphate in drinking water can also result in a noticeable taste, the lowest taste threshold. concentration for sulphate

3. Nitrate

Nitrate concentrations ranged from 0.8 to 40.2 in all areas of Budiriro. The water samples were below the WHO standard limit according to the guidelines for drinking water quality (20). Although high level of concentration was recorded in CABS and Budiriro 5 areas which recorded 40.2 Mg/LNO3 this could have been due to underground leaching. Self and Waskom, (17) posit that due to its high mobility, nitrate can leach into groundwater. Nitrogen is present in soils which are normally fixed by nitrogen fixing bacteria. The primary health concern regarding nitrate and nitrite is the formation of methaemoglobineamia, so called “blue-baby” syndrome. The acceptable concentration of nitrates in drinking water is 50 mg/l as nitrogen (WHO, 2008)

4. Hardness

Hardness does not pose a health risk but may affect the taste of water as well as influence the lathering ability when used for washing. Hardness is referring to total concentration of calcium and magnesium in water; It also measure the capacity of water to precipitate soap (3). Total hardness of water depends mainly upon the amount of divalent metallic cations of which Ca2+ and Mg2+ are more abundant to ground water Nkansah, Owusu-Boadi and Badu, (13). The effect arises because the dictations destroy the surfactant properties of the soap by forming a solid precipitate Ameyibor and Wiredu, (1991). The average hardness of the water samples ranged from100.79 to 187mg/LCaCO3 with Mbare recording the highest of 1038 and Mabvuku the lowest of 100.79 The acceptable limit of hardness is 500mg/LCaCO3 WHO, (20).

V. CONCLUSION

This study concludes that water from alternative sources in Budiriro is of poor quality. This is evidenced by the high contamination levels of Total Coli forms (TC) and Faecal Coli forms (FC) which was beyond the acceptable standards stated by WHO. In Budiriro, wells, boreholes and water harvesters are the optional sources due to the inability of City of Harare to supply residents with treated water.The water from these sources is not fit for human consumption as proved by the findings of this study. The presence of faecal coliform and E. coli suggests that there is faecal contamination of wells and boreholes. That made them unsuitable for human consumption according to the guidelines for drinking water quality (20). The planning model on the distribution of different water sources will determine the use of water according to use. This model will mitigate on the control of waterborne diseases and reduce the City of Harare water budget since the water will be available in the locality compared to water from Morton Jaffraywmg&rosuvastatin 20mg.

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