RESEARCH ARTICLES

Bacteriological status of shallow well water and practices of users in Chipulukusu township, Ndola, Zambia

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In many countries in Africa piped water availability is limited and cannot meet the demands of the growing populations. Most rural areas in Africa resort to underground water which is readily available and is believed to be uncontaminated due to its filtering system as it drains back into the ground. However, it is not always the case due to many factors such as overcrowding, poorly constructed pit latrines and humans that contaminate water. A cross sectional study was conducted to determine bacteriological status of shallow well water and practices of users in Chipulukusu township in Ndola, Zambia. Data was collected using a structured questionnaire and water samples were examined for the presence of fecal coliforms. Data was entered in Epi Info version 7 and analyzed using SPSS version 16. A total of 58 (84.1%) out of 69 households participated in the study. Altogether, 53 (91.4%5) wells were unprotected. All respondents stored their water in wide mouth containers. From a total of 58 households, 34 (58.6%) treated their water with chlorine. The distance between the well and pit latrine for 57 (98.3%) out of 58 households was below 30 m. A total of 47 (81.0%) out of 58 wells contained fecal coliforms. The majority of the wells were contaminated with fecal coliform making water unsafe to use and increases the risk of water borne diseases. Boiling and chlorination will make water fit for drinking.

Introduction

In many countries in Africa (including Ethiopia, Nigeria, Serra Leone and Zambia), piped water availability is limited and cannot meet the demands of the growing populations [1-7]. Rural areas in developing countries resort to readily available underground water [8]. Under ground water at most is believed to be uncontaminated due to its filtering system as it drains back into the ground [9]. However, due to overcrowding, no water and sewage utilities and poorly constructed pit latrines, human waste can reach ground water and contaminate it [10,11].

Every rainy season, Zambia experiences outbreaks of cholera, diarrheal and other water borne diseases [12].

Figure 1 Map of Chipulukusu township showing a population of wells

The majority of households in unplanned settlements and most of the new settlements in Zambia are still not serviced by piped water [3]. Contamination of ground water may occur at different stages during the process from point source, collection and storage of water to consumption [10,13,14].

The risk of micro-organisms contaminating drinking water during collection and storage in the home has previously been reported [1,15,16]. Field investigations carried out in Kitwe, Zambia recognized certain practices and vessel characteristics that are associated with the contamination of household water and diseases resulting after. Use of large-mouth vessels to collect and store water, transferring water from collection vessels to storage vessels and getting water by dipping hand-held utensils rather than via a tap or by pouring have been reported to be associated with contamination of household water [1,17–20]. From the above stated practices, contamination does occur; the open mouth design of the vessel and time from collection to use also favors the survival of the bacteria [21,22].

Chipulukusu is among the largest and fast growing townships in Ndola, having a population of approximately 41,837 with no piped water, sewerage services and utilities [12]. The lack of piped water has made the people of Chipulukusu resort to self-dug shallow wells. These wells are poorly constructed and do not conform to the public health (building and latrine; part xii – provision of latrine accommodation, section 85) regulation Act of the laws of Zambia. There is scanty information on the quality of water at point of collection in Chipulukusu. The aim of the study was, therefore, to determine the biological status of shallow wells and the knowledge, attitudes and practices of users in Chipulukusu in Ndola, Zambia.

Methods

A cross sectional study was carried out from July 2015 to August 2015 in Chipulukusu, Ndola on the Copperbelt province of Zambia. Chipulukusu is situated on latitude 12°57'6.09"S and longitude 28°40'23.58"E at an altitude of 1270 m with a humid sub-tropical climate. The climate of Ndola is characterized by a dry season of 7 months duration from May to October and an average

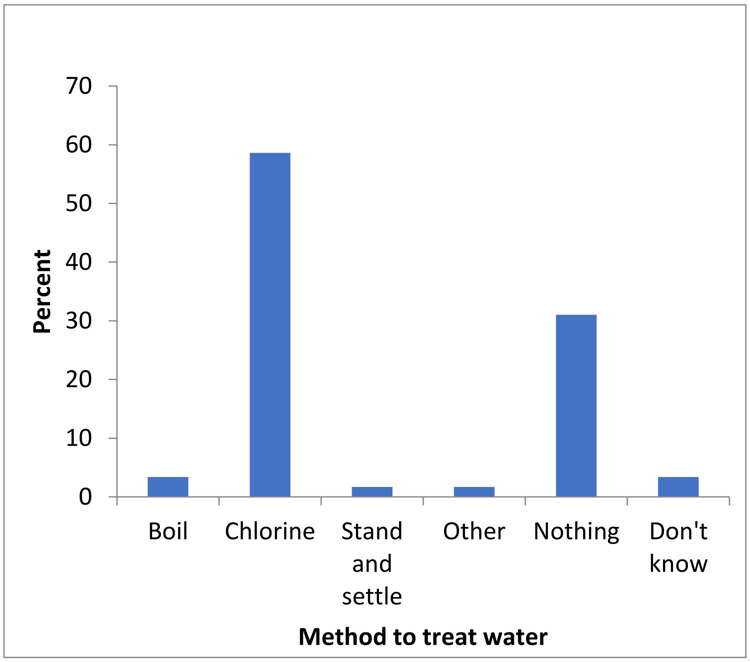

Figure 2 Methods used to treat water

rainfall of 1232.8 mm.

Chipulukusu township is divided into 14 zones based on population distribution and density. The areas of interest were zones exclusively using well water for their consumption or zones not supplied by piped water. From the criteria, zones 3 and 3B were selected as sampling sites. A total of 84 wells were enumerated in the study area and Geo-tagged for easy location and identification. Assuming a rate of contamination of 50+5% (as no estimate was available) and a 95% confidence level, a sample size of 69 wells were to be sampled. Wells were randomly selected using a simple random sampling technique. Figure 1 shows the distributions of wells in the study area. Since the wells were individually owned by households, the oldest person aged 18 years or older found at the household was requested to participate in the survey.

The proposal was reviewed and approved by the Tropical Diseases Research Centre Research Ethical Committee and the Clinical Science Department, Public Health Unit, Michael Chilufya Sata School of Medicine, Copperbelt University, Ndola, Zambia.

A structured questionnaire comprising socio-demographic characteristics and water quality variables was administered to residents. Water was aseptically collected (150 ml) in sterile reusable bottles from each well using a collector (container) for a particular well. These samples were transported to the laboratory in cooler box with ice packs within three hours after collection. By use of membrane filtration techniques, 100 ml of water was then filtered through the membrane (1.45 µm, 47 mm GN-6 Metricel) connected to a vacuum pump [23]. Filtration was done in triplets, and after every set, all components of the filtering apparatus were sterilized in an ultraviolet chamber for 30 minutes. The membranes were placed on the selective m-FC agar plates then incubated at 44±0.5°C for 24 hours. Coliforms greater than 100 were considered too numerous to count (TNTC). The distance between the wells and the pit latrine was measured as well.

Data collected from the laboratory and questionnaires were entered in Epi info version 7.0 and exported to SPSS version 16.0 for analysis. Correction and editing was done after running the frequencies and checking for out of range responses. Data was summarized using frequencies.

Results

A total of 58 (84.1%) out of 69 households participated in the study. Table 1 shows distributions for socio-demographic factors of the sample. The majority of the participants were aged below 50 years (75.9%), married 38 (65.5%), Protestant by faith 45 (77.6%) and 51.7% had attained primary level of education. In terms of occupation, the majority (46.6%) were traders/businessmen or women with most (96.6%) of the respondents earning an income below the minimum wage of ZMK522.00 (U$D 66.03).

A large proportion of the participants lived as a nuclear family (63.8%) with family size ranging from 2 to 10. The majority (77.6%) of the respondents had lived in the area for less than 25 years.

Table 1 Distributions for socio-demographic factors of the sample

Factor	n (%)
Age (years)	
<50	44 (75.9)
50+	14 (24.1)
Marital status	
Single	14 (24.1)
Married	38 (65.5)
Widowed/widow	6 (10.3)
Religion	
Catholic	8 (13.8)
Protestant	45 (77.6)
Islam	5 (8.6)
Education level attained	
Below primary	10 (17.2)
Primary	30 (51.7)
Secondary	18 (31.0)
Occupation	
Trade/business	27 (46.6)
Housewife/unemployed	22 (37.9)
Retiree	2 (3.4)
Student	3 (5.2)
Other	4 (6.9)
Income (ZMK)	
<522	96 (96.6)
522+	2 (3.4)
Family type	
Nuclear	37 (63.8)
Extended	21 (36.2)
Length of stay (years)	
<25	45 (77.6)
25+	13 (22.4)

Table 2 shows distributions of water and sanitation-related factors. Most (91.4%)

households had unprotected wells and all households stored their water in wide mouth containers.

Table 2 Distributions of water and sanitation-related factors

Factor	n (%)
Source of water	
Protected well	5 (8.6)
Unprotected well	53 (91.4)
Toilet use	
Shared with people outside family	42 (72.4)
Not shared with people outside family	16 (27.6)
Disposal of fecal waste of young children	
Child used latrine	9 (15.5)
Thrown into garbage	7 (12.1)
Buried	31 (53.4)
Left in open	1 (1.7)
Did not know	10 (17.2)

In terms of method of water treatment, 58.6% used chlorine (Figure 2). All respondents used a pit latrine with the majority (72.4%) of the participants indicating that they shared a toilet with anyone in the community. Fecal waste of the youngest children in about half of families (53.4%) was disposed by burying. Almost two thirds (62.1% or 36/58) denied suffering from diarrhea 6 months prior to the interview and 39 (67.2%) of 58 respondents indicated to not have had diarrhea in last 2 month before the study. A total of 47 (81.0%) out of 58 wells contained fecal coliforms. Out of 58 households, 57 (98.3%) had <30 m between the well and pit latrine.

Discussion

The households of Chipulukusu solely depended on pit latrine for the disposal of fecal waste. During rainy seasons, runoff water entered the pit latrines and also contributed to the groundwater contamination. The distance between the well and pit latrine of less than 30 m was observed in most households (81.0%). Thus, contravening the Public Health Act of 1995 which states that the minimum distance between the pit latrine and the nearest well should not be less than 30 meters. The small sizes of the plots contributed to the close proximity of the wells and latrines.

All respondents reported to store water in wide mouth container. These results are similar to the results found in a study done in Samara, Zaria, State Nigeria [7]. It was stated in another study that narrow mouth containers significantly reduced contamination with *E. coli* [1]. Therefore, it was possible that water stored in wide mouth containers was contaminated. The majority of the respondents denied to have suffered from diarrhea in 6 months and 2 months prior to the study. This could be attributed to the high response rate on chlorine usage [3].

The microbiological examination revealed that a large proportion of the wells were contaminated by *E.coli*, indicative of fecal contamination. This could be as a result of the poor means of waste (fecal) disposal, proximity of the pit latrine toilets and the well and runoff water during the rainy season. This exceeds the guidelines recommended by WHO international standards which state that no sample should contain fecal coliform or *E.coli* and there should be no total coliform/100 ml of water. Other studies conducted in Nigeria showed similar results with well water samples reported to have high MPN value [4].

Most of the wells were contaminated with fecal coliform making water unsafe to use and increased the risk of water borne diseases. Boiling and chlorination remain the best means of treating water.

The study might have had limitations in that the information given by participants might have been biased due to fear of their wells being declared unsafe. In addition, the fecal coliform count, *E.coli* isolation and drug sensitivity were not determined. Furthermore an association between the measured well to pit latrine distance and total fecal coliform count was not determined. These limitations provide prospects for future work.

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