Environment and Pollution; Vol. 5, No. 2; 2016
ISSN 1927-0909 E-ISSN 1927-0917
Published by Canadian Center of Science and Education

# Risks of Domestic Underground Water Sources in Informal Settlement in Kabwe – Zambia

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Received: April 13, 2016 Accepted: May 21, 2016 Online Published: September 29, 2016

doi:10.5539/ep.v5n2p1 URL: http://dx.doi.org/10.5539/ep.v5n2p1

**Abstract**

Informal settlements are a hot spot for disaster risks worldwide. They are characterised by limited provision of basic services. Water being a critical life support resource is not adequately provided. Residents usually rely on unsafe water sources of hand dug wells. Pit latrines are a major facility for sanitary purposes. Further, informal settlements high population density residing in poor housing units is a common characteristics. Risks of underground water pollution are high due to the proximity of sanitation facilities to unprotected shallow wells increasing the possibility of feacal contamination by ecoli and coli form. This paper presents a case of Makululu informal settlement in Zambia. A total of 385 respondents were identified at random while purposive sampling identified key informants. Water samples collected from 12 hand dug wells located close to pit latrines were tested for coli form and ecoli. Testing was done before and after the rainy season to analyse the relationship between pit latrines and wells as well as the relationship with rainfall distribution pattern to ascertain levels of risks. Water was tested to determine the levels of contamination based on the presence of ecoli and coli form. Laboratory results indicated that 90 percent of water consumed in Makululu informal settlement is highly contaminated by faecal coliforms.

**Keywords:** coliform; informal settlement; pit latrines, ecoli

## 1. Introduction

The Global Report on Disaster Risk Reduction (2009), stated that by 2008, half of the world's population was living in urban areas and by 2010; it was projected that 73% of the world's urban population and most of its largest cities will be in developing countries. The challenge is that, many governments have been incapable of ensuring that there is safe land for housing, adequate infrastructure and services, and a planning and regulatory framework to manage the associated environmental and other risks. Flooding is claimed to be the most common hazard that affect more people than any other disaster and is a hot in informal settlements (Pelling and Wisner, 2009). Floods account for approximately forty percent of natural disasters and may become more frequent and severe due to climate change and global warming (Reacher, *et al.,* 2004).

Informal settlements typically occupy land deemed unsuitable for residential or commercial use. They are located in the low lying flood prone area. Gilbert and Gugler, (1992) and UNEP, (2007b) gives the characteristics of an informal settlement as settlements created through a process of unassisted self-help and tend to have two or more of the following characteristics when they are initially created: 1. most houses are self-built by the families occupying them using initially temporary building materials, 2. the settlements are illegal in some way, 3. the settlements are subserviced, and lastly are mostly occupied by people living in situations of poverty. However, these descriptive characteristics are not exhaustive but there are other conditions such as environmental, institutional or political and physical conditions.

Further, there is lack of involvement by and collaboration with the residents of the informal settlements about disaster risk management. These recent events have prompted an emphasis [that] has moved away from physical control and engineering construction (structural measures) towards reducing human vulnerability through non-structural approaches and partnership with risk reduction organizations and local authorities (Paton, 2006, Van Riet and Van Niekerk, 2012).

We cannot survive without water - but it has to be clean water because many life-threatening diseases are carried in contaminated water. The biggest cause of contamination is human waste that has not been disposed of correctly - usually because of inadequate sanitation, poor drainage systems and poor waste management services. The resultant diseases are spread through poor hygiene putting entire communities at risk. Common diseases include cholera, dysentery, diarrhoea, malaria, bilharzia and typhoid.

*1.1 Background of Makululu Settlement*

Makululu Settlement is an unplanned (Informal) settlement located in Kabwe district of Central Province Zambia lying between latitude 14° 27' S and longitude of 28° 27'E. It is lies along the Great North Road 139 kilometers North East of Lusaka. Kabwe is the provincial headquarters of the Central Province, figure 1. Kabwe has experienced a rapid population growth in the last decade from 176,758 in 20 00 to 230,000 (CSO, 2011). Geographically, the area is situated on wetland near to the Lukanga Swamp hence flood prone. The smaller western part drains in towards the Lukanga Swamps whereas the remaining surface flows into the catchment area of the Lukanga River System.

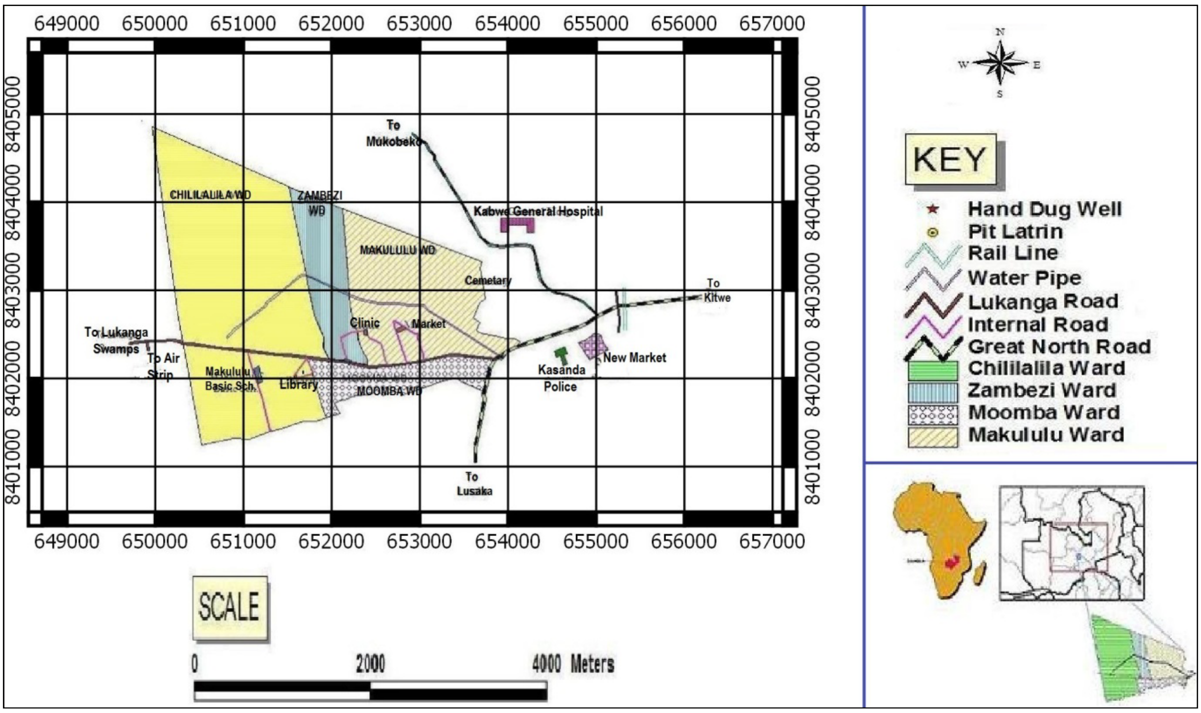



Figure 1. Map showing Makululu Compound in Kabwe district

Source: Malungu M. 2011

Map1.Shows the geographical and political boundaries respectively. It is located in Bwacha constituency. Makululu Settlement comprise of four wards namely; Makululu, Chililalila, Zambezi, and Moomba. The total population of Makululu is 28, 410 (CSO, 2011:25). Further, Makululu had estimated housing units of 6,641. It is a high density and unplanned settlement.

1.1.1 Socio-economics

Kabwe was established as a lead and zinc mining town around 1902 and ended in 1994 when the mines were closed. Therefore, prior that period, the mines were the major employers. Other key industries included the Zambia Railways whose headquarters was based in Kabwe till privatisation which has seen the company relocate its head offices to Lusaka. The other one was the Mulungushi Textiles which later became Zambia China Mulungushi Textiles and now closed. There have been some efforts to revamp the mining activities with the coming of Sable Zinc though at a small scale. However, the closures of these main companies has resulted in Kabwe having high unemployment for the majority of the residents.

Hydrology and drainage system.

1.1.2 Geomorphology

The relief of the district is gently undulating plateau dissected by dambo. Kabwe district lies on the watershed between the Kafue and Lunsemfwa rivers which forms the Luangwa river basin on the Luano valley. The watershed approximately follows the line of the Great North Road from Lusaka to the Copperbelt (Dalal-Clayton, 1980). The quality of water from open shallow wells is a great risk to the health of the people. Several efforts have been put in place to reduce the exposure to such disaster risks. The ZCCM-IH Copperbelt Environment Project has been working in Kabwe and Makululu in particular.

## 2. Problem of Water Quality in Makululu Informal Settlement

Like many informal settlements, Makululu comprise of poor housing units made of mud, with poor sanitation and water supply. Lack of access to safe water and sanitation provision makes Makululu prone to water borne illnesses which include cholera, diarrhoea and dysentery. These can be attributed to socio-economic, political and environmental vulnerabilities. Socio-economic conditions and settlement formation" describes the drivers and pressures which lead to the formation and maintenance of informal settlements.

With the rapid urbanization and rapid expansion of slum settlements in sub-Saharan Africa, on-site sanitation and underground water are used in some urban areas because they are affordable options in the absence of government-supplied services. However, the congestion in the urban slums does not allow for adequate distance between the wells and the pit latrines, which allows micro-organisms to migrate from feacal contents into the underground water sources. Furthermore, poor sanitary practices (for example, disposal of human excreta) lead to contamination of water and consequently water-borne diseases.

The current and likely future impacts of climate change are considered among the most important issues faced by human beings. A review of climate change impacts on urbanization by the International Institute of Environmental Development (Huq *et al.,* 2007) found that floods are already having very severe impacts on cities, smaller urban centres and rural areas in many African countries

The key underlying causes of flooding could be established to include;

- Increased occupancy in flood prone area
- Inadequate maintenance of flood defences such as drainages
- Increased urbanisation in catchments
- Ineffective land zoning and building regulations resulting in poor standard houses.
- And finally community vulnerability due to poverty and lack sustainable employment opportunities.

These underlying causes and many others makes Makululu Settlement exposed to high risk of underground contamination and unsafe water resulting in outbreaks of cholera and diarrhoea collapsing of houses and submerging of houses leading to loss of property. It is therefore imperative that an analysis of the quality of water is assessed to understand the risks residents faced by residents of informal settlements.

### *2.1 Aim of This Study*

The aim of the research was to assess the quality of water from by residents of Makululu informal settlement of Makululu Settlement in Kabwe district of the Central Province of Zambia.

### *2.2 Objectives of The Study*

To achieve its aim, the objectives of the research are to:

Test the quality of water from shallow wells before and after the rainy season

Identify interventions that can be applied to manage flooding in an integrated way

## 3. Informal Settlements and Access to Safe Water

The United Nations Environment Programme (UNEP, 2007b) estimates that 72 per cent of all Africa's urban population lives 'under slum conditions'. One of the most pressing issues facing the world today is the rapid urbanization and its impact on communities, cities, economies and policies. Most informal settlements receive little attention in form of public services from the government such as paved roads, safe water, sewerage and waste collection services. Olaniran and Babatolu, (1996), argue that poor people and poor communities are vulnerable to disaster risks and are primary victims of natural disasters.

Due to high poverty levels, settlers in peri urban informal settlements found themselves in disaster-prone areas and often live in crowded, makeshift houses which increase their vulnerability. Vulnerability refers to exposure susceptibility of a community to disaster risks. A community is more vulnerable if it is likely to be badly affected by an event beyond its control. "Natural hazards by themselves do not cause disasters – it is the combination of an exposed, vulnerable and ill prepared population or community with a hazard event that results in a disaster"

(ISDR, 2009:1).

One may wonder how people settle in peri urban areas and live under slum conditions and yet the government and local authorities does so little to improve their conditions. The complexity of urban governance in peri urban is both a weakness and strength (Wisner and Pelling, 2009). They further argue that it is a weakness in that decision-making takes a long time and implementation may be flawed in the case of top-down urban improvement projects. However, on the side it is a strength meaning that, there is a depth of commitment to the community and knowledge of social relations among informal leaders. Community members are committed to improve their living conditions but often disappointed by low commitment from the government and other stakeholders.

### *3.1 Water and Sanitation in Informal Settlements*

The World Health Organisation estimates that 2.2 million people die annually from diarrhea diseases and that 10% of the population of the developing world are severely infected with intestinal worms related to improper waste and excreta management. In Kenya for instance, diarrheal diseases are among the major illnesses affecting children of the slum residents. Where ground water is used as a source of domestic water, use of pit latrines is not recommended because the two are incompatible unless the water table is extremely low and soil characteristics are not likely to contribute to contamination of ground water.

Where they coexist, although it is difficult to give a general rule for all soil conditions, the commonly used guideline is that the well should be located in an area higher than and at least 50 m from the pit latrines and should be at least 2 m above the water table. Available evidence shows that increased lateral separation between the source of pollution and ground and surface water supply reduces the risk of fecal pollution.

### *3.2 Total Coliform*

Total coliforms are defined as all aerobic and facultative anaerobic "gram-negative, non-spore-forming, rod-shaped bacteria capable of growth in the presence of bile salts or other surface-active agents with similar growth-inhibiting properties, oxidize-negative, fermenting lactose at 35-37°C with the production of acid, gas, and aldehyde within 24- 48 hours (Dufour *et. al,* 2003)." Total coliforms have been used in the past as indicators of water contamination. However, because coliforms have the ability to survive and multiply in natural waters, their effectiveness as indicators of fecal contamination is compromised. Additionally, studies have shown that there is no direct correlation between the presence of pathogens and the presence of total coliforms (Low, 2001). Instead, total coliforms can be better used to assess treatment methods; their presence in filtered or disinfected water reveals inadequate treatment (WHO Ch. 20, 2004). Total coliforms will be used in the course of this research to indicate the effectiveness of ceramic water filters at removing bacterial contamination.

Table 1. World health organisation (WHO) guidelines for maximum permissible value for drinking water

| | **WHO Guideline** |
|---|---|
| **Parameter** | **(Maximum Permissible value for drinking water)** |
| pH | 6.5- 8.5 |
| Turbidity (NTU) | 5.0 |
| Total Dissolved Solids (mg/l) | 1000 |
| Total hardness (as mg $CaCO_3$/l) | 500 |
| Nitrates (as $NO_3$ -Nmg/l) | 10.0 |
| Lead (mg/l) | 0.01 |
| Residual Chlorine (mg/l) | 0.5 |
| **Bacteriological Results** | |
| Total coliforms (#/100ml) | 0 |
| Feacal coliforms (#/100ml) | 0 |

Source: World Health Organisation. (1997). *Guidelines for Drinking Water Quality*

Table 1, shows the required standard parameters and values for drinking water supply. The challenge is that these guidelines are mostly used in water processing and treatment supply by the municipality. Informal settlements in most cases are not provided with treated water hence get water with a high risk of contamination above the stated WHO guidelines. The presence of indicator organisms (*total coli* or feacal coliform bacteria) in water indicates recent contamination of the water source with fecal matter and hence possible presence of intestinal pathogens. According to World Health Organization (WHO) guidelines, coliform bacteria should not be detectable in any water intended for drinking. However, the congestion in informal settlements (slums) does not allow for adequate distance between the wells and the pit latrines, which allows micro-organisms to migrate from fecal contents into the underground and surface water sources after the rainy season.

## 4. Methodology

### *4.1 Research Design*

The research design for this study was both qualitative and quantitative. Qualitative data was collected by reviewing literature, conducting interviews through focused group discussions and consultations with members of the communities in Makululu and key stakeholders. Quantitative data was obtained by testing water samples from sources of water, wells and communal water stand taps.

### *4.2 Research Instruments*

Administered Questionnaires were used for household interviews while self administered questionnaires were used for stakeholders.

### *4.3 Sampling*

A cross-sectional study design was used and a sample of 385 households was selected through multistage sampling technique as follows: all the four administrative blocks (wards) were picked. 385 were randomly respondents were interviewed. Respondents were also concentrated on households surrounding the wells.

Key stakeholders interviewed included local Councilors, the Environmental Health Technologist from Makululu Health Centre, Public Health department of Kabwe Municipal Council, Regional Coordinator, Disaster Management and Mitigation Unit, Kabwe, Area Development Committee (ADC) members, Zambia Consolidated Copper Mine – Investment Holding, Copperbelt Environment Project (ZCCM-IH CEP) and Neighbourhood Health Committee members.

### *4.4 Data Collection*

#### 4.4.1 Household Interviews

385 questionnaires were administered in Makululu compound. In each ward, about 100 households were involved. Respondents were randomly sampled as the area is an informal settlement without defined pattern of housing units. The information required was on quality and types of water and sanitation facilities, vulnerability to flooding, coping strategies, challenges being faced in coping with flooding.

#### 4.4.2 Key Stakeholder Interviews

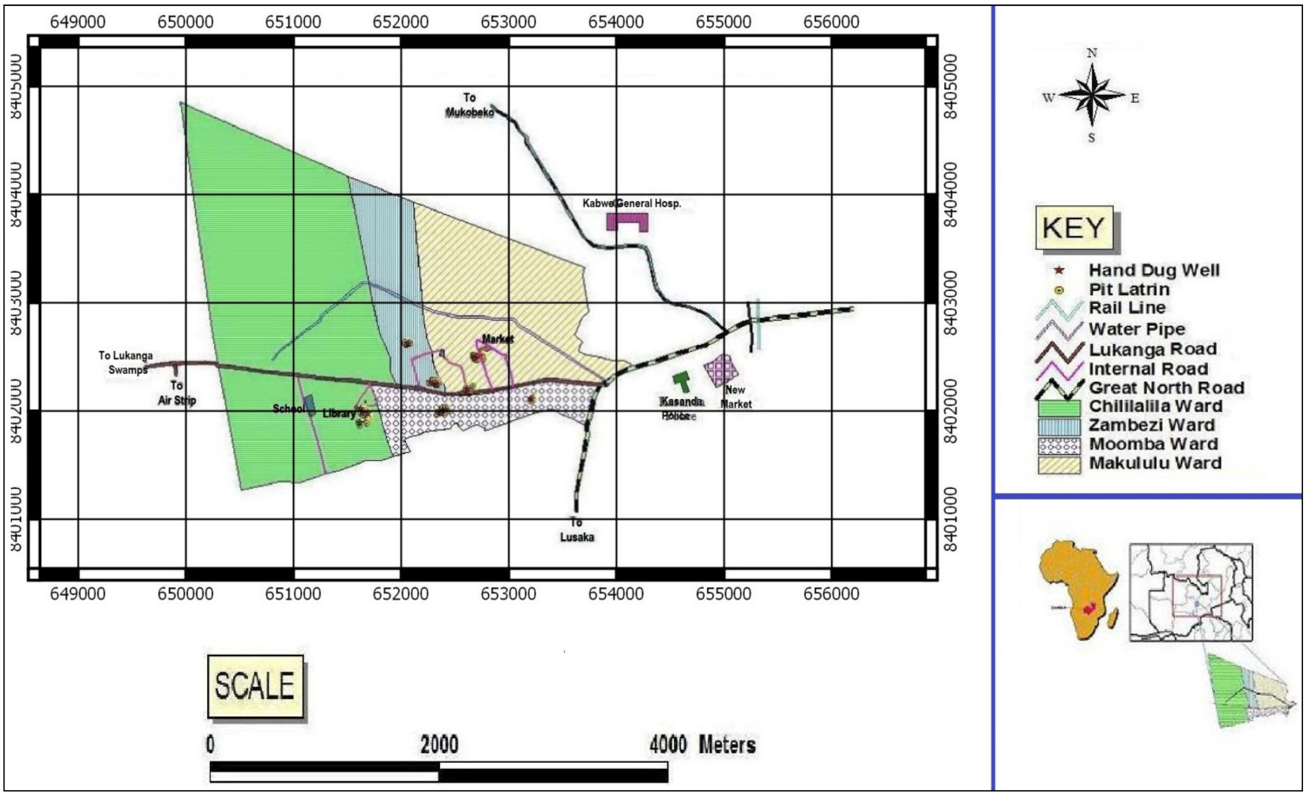
These included Makululu Health Centre, a facility located in the compound. The Kabwe Municipal Council was also consulted to provide the legal framework and plans the local authority has to improve provision of basic services and upgrading of the settlement to a legal status. The mine conglomerate project, by Zambia Consolidated Copper Mine – Investment Holding, Copperbelt Environment Project (ZCCM-IH CEP) had been having intervention in Makululu on lead pollution and improvement of the life of the community. Lastly, the Regional Coordinator of the Disaster Management and Mitigation Unit (DMMU) in Kabwe.

#### 4.4.3 Secondary Data

Desk review involved review documents about informal settlement. The Kabwe state of the Environment Report 2010, Mapping and Upgrading of Makululu Settlement plan. Town and country planning Act Cap 282, Summary reports on water and sanitation. Kabwe Environment Reports from the Kabwe Environmental Library.

#### 4.4.4 Water Quality Testing

A total of 12 samples was selected from the Makululu (Figure 2). Four samples were taken from three wards while in one ward, Zambezi had three samples. In addition 2 samples were taken from the communal water taps supplied by the water utility company, Lukanga Water and Sewerage Company. This number for water samples was determined by geographical locations and the water availability after the sampling before the rainy season. Wells were defined as water sources being hand-dug.




Water samples were collected aseptically with sterile sampling bottles. The samples were transported within 2 hours of collection in a cool box containing ice packs to the, University of Zambia, Environmental Engineering Laboratory in Lusaka for analysis. The parameters to be analysed included; Total coliform and feacal coliform coliforms (#/100ml), pH, Total Dissolved Solids (mg/l), Residual Chlorine (mg/l), Total hardness (as mg $CaCO_3$/l), Turbidity (NTU), Nitrates (as $NO_3$ - Nmg/l) and Lead (mg/l). Further, Distances between pit latrines and wells was measured to ascertain the proximity between of pit latrine to the nearest hand dug well.

*4.5 Water Sample Analysis*

After the analysis, feacal contamination of the water was determined through isolation of indicator organisms, total coliforms, and then fecal coliforms, through Multiple-Tube Fermentation (MTF) technique. Probability tables (McCrady tables) were used to determine the Most Probable Number (MPN) estimates of the coliform organisms per 100 ml of water. Analysis of data was generally descriptive, involving determination of frequencies.

## 5. Results and Discussions

*5.1 Water and Sanitation*

The provision of quality water is the main challenge facing the Kabwe Municipal Council not to only to informal settlement but to formal settlements as well. The Lukanga Water and Sewerage has been mandated to provide water in the entire Kabwe district. However, due to the pressure in unplanned status the company supplies water using communal taps in Makululu. The study found that there were 50 water stand taps in Makululu. The table below shows different types of domestic water sources (Table 2).

Table 2. Water and sanitation facilities

| Sn | Water and Sanitation Facilities | Total |
|---|---|---|
| 1 | Protected wells | 60 |
| 2 | Unprotected wells | 335 |
| 3 | Boreholes | 12 |
| 6 | Pit Latrines | 4445 |
| 5 | VIP | 20 |

Source: Makululu Health Centre Records 2015

Most people (61%) said they used shallow wells as the major source of domestic water, whereas 8 % used water from both the well and communal tap and 25% used tap water from the communal taps provided the water utility company Lukanga Water and Sewerage Company. The shallow wells often had no concrete slab and often the aperture was not covered at all or was poorly covered with a loose lid that was not lockable, whereas the communal taps were the piped system (Plate 1b). Those who used communal taps reported they use the water mainly for cooking as it was with a cost while water from the wells was used for other domestic chores. Tap water was mainly from water kiosks where water was being sold to the residents. Problems of unreliability were mentioned as hindering use of tap water from the kiosks as some respondents said that sometimes the kiosk near their house could remain closed for longer hours even whole day.

Plate 1. Sources of water in Makululu

1a. Hand dug Well 1b. Communal Water Tap Stand 1c. Unprotected well

Water wells can be classified as being either being protect or unprotect (Plates 1a and 1c). After the rainy season and heavy down pours water levels are so high that some of these get submerged with flood waters.

*5.2 Sanitation*

Findings on the sanitary facilities in Makululu revealed that 99 % of the households use pit latrines and the rest use the bush, open defecation. Only adults and older children of 10 years and above usually used pit latrines, whereas the rest defecated indiscriminately. Further, 52 % of the households share the sanitation facilities with other households if located closer to their residence plot. 70 % of the households indicated that their due to limited space of the plots, pit latrines were located within the radius of 30 metres from water sources. Further, 98 % indicated that they bury their pit latrines when full and build new ones.

Most of the pit latrines (95%) in the community were traditional, whereas ventilated improved pit latrines (VIP latrines) (5%) were found at the school, clinic and the market.

*5.3 Distance between Pit Latrine and Well*

The wells were very close to the pit latrines. In many circumstances (38%), the distance between the wells and the pit latrines was estimated to be less than 15 m (the commonly used guideline is that the distance should be at least 50 m). Most wells were situated at a distance between 12m and 20m from the pit latrines while Moomba had the highest located 28.30m (Table 3).

Table 3. Distance between Pit latrines and Wells

| **Wards: Well** | **Distance (m)** |
|---|---|
| Moomba : 1 | 28.30 m |
| Moomba : 2 | 13.91 m. |
| Chililalila : 1 | 12.65 m. |
| Chililalila : 2 | 13.54 m |
| Makululu : 1 | 9.93 m |
| Makululu : 2 | 15.92 m |
| Zambezi : 1 | 13.01 m |
| Zambezi : 2 | 20.90 m |

Source: Field data, 2015

## 6. Water Analysis Results

A total of 14 water samples were analysed in the laboratory at the University of Zambia, School of Engineering, Environmental Laboratory for possible both total and faecal coliform contamination before the rainy season in October 2011 and after the rainy season March, 2012 (see Table 4a and 4b and Figure 2). Two samples were from the communal water stands. The testing was based on the following; pH, Turbidity, Nitrates, total dissolved solids, residue chlorine, total and feacal coliform respectively.

***Chililalila ward***

In Chililalila ward, before the commencement of the rainy season in October, 2011, water from the wells was within the WHO parameters with the exception of nitrates and biological results for feacal higher than WHO guideline of 0. The water samples after rainy season from three well was beyond the permissible value 10mg/l recording 26.85 mg/l, 12.84 mg/l and 33.65mg/l in after the rainy season in 2012 compared with 2.48 mg/l, 10.0 mg/l and 20.86 mg/l.

***Makululu Ward***

Outstanding findings indicated that total coliform and feacal contamination was very high in well 1 recording as high 1440/100ml. Like in Chililalila, Nitrates were on average lower than the recordings before the rainy season in 2011.

Table 4a. Water Samples Chililalila Ward: October 2011 and March, 2012

| **Parameter** | **TAP - Water Kiosk** | | **Well 3** | | **Well 2** | | **Well 1** | | **WHO Guidelines** |
|---|---|---|---|---|---|---|---|---|---|
| | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** | |
| pH | 7.68 | 8.37 | 7.27 | 8.26 | 7.72 | 8.50 | 7.49 | 8.72 | **6.5- 8.5** |
| Turbidity (NTU) | 0.28 | 0.66 | 5.64 | 2.20 | 5.0 | 0.83 | 2.41 | 1.52 | **5.0** |
| Total Dissolved Solids (mg/l) | 238 | 198 | 424 | 285 | 1000 | 268 | 394 | 263 | **1000** |
| Total hardness (as mg $CaCO_3$/l) | 136 | 234 | 480 | 560 | 500 | 526 | 442 | 512 | **500** |
| Nitrates (as $NO_3$ -Nmg/l) | 1.56 | 8.40 | 2.48 | 33.65 | 10.0 | 12.84 | 20 .86 | 26.85 | **10.0** |
| Lead (mg/l) | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | 0.4 | <0.01 | **0.01** |
| Residual Chlorine (mg/l) | Nil | Nil | Nil | 0.4 | 0.5 | Nil | Nil | Nil | **0.5** |
| **Bacteriological Results** | | | | | | | | | |
| Total coliforms (#/100ml) | 0 | 0 | 300 | 0 | 0 | 466 | 0 | 22 | **0** |
| Feacal coliforms (#/100ml) | 0 | 0 | 90 | 0 | 0 | 102 | 0 | 3 | **0** |
| **Water Samples Makululu Ward: October 2011 and March, 2012** | | | | | | | | | |
| **Parameter** | **Well 1** | | **Well 2** | | **Well 3** | | **Well 4** | | |
| | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** | |
| pH | 7.47 | 8.39 | 7.38 | 8.29 | 7.02 | 8.37 | 7.42 | 7.42 | **6.5- 8.5** |
| Turbidity (NTU) | 26.90 | 0.50 | 16.00 | 0.85 | 13.70 | 0.85 | 1.58 | 1.58 | **5.0** |
| Total Dissolved Solids (mg/l) | 364 | 98 | 287 | 91 | 231 | 90 | 493 | 93 | **1000** |
| Total hardness (as mg $CaCO_3$/l) | 372 | 344 | 274 | 290 | 385 | 240 | 660 | 260 | **500** |
| Nitrates (as $NO_3$ -Nmg/l) | 25.40 | 28.45 | 9.15 | 14.36 | 21.44 | 26.40 | 24.50 | 10.70 | **10.0** |
| Lead (mg/l) | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | **0.01** |
| Residual Chlorine (mg/l) | Nil | Nil | Nil | Nil | >1.0 | Nil | Nil | Nil | **0.5** |
| Bacteriological Results | | | | | | | | | |
| Total coliforms (#/100ml) | 1,440 | 50 | 0 | 66 | 0 | 900 | 1,720 | 88 | **0** |
| Feacal coliforms (#/100ml) | 290 | 12 | 0 | 20 | 0 | 180 | 440 | 22 | **0** |

***Moomba ward***

In Moomba ward, all the samples had the presence of total coliforms with the highest value of 3,600/100ml before the rainy season 2011 while the highest after the season 2012 was 3300 /100ml recorded (Table 4b).

***Zambezi Ward***

The test results showed that the presence both total and feacal coliforms in large volumes in all the wells sampled. Nitrates results were slightly above or below in some two wells. Well number three had the highest of $NO_3$ – 28.70 mg/l.

Table 4b.

| Zambezi ward Water Samples | | | | | | | WHO Guidelines |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Well 1** | | **Well 2** | | **Well 3** | | |
| | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** | |
| pH | 7.12 | 8.33 | 7.02 | 8.41 | 7.04 | 8.54 | **6.5- 8.5** |
| Turbidity (NTU) | 12.00 | 5.33 | 103.00 | 1.35 | 20 .30 | 1.15 | **5.0** |
| Total Dissolved Solids (mg/l) | 331 | 235 | 269 | 220 | 485 | 240 | **1000** |
| Total hardness (as mg $CaCO_3$/l) | 320 | 266 | 260 | 386 | 420 | 364 | **500** |
| Nitrates (as $NO_3$ -Nmg/l) | 7.39 | 8.80 | 12.94 | 9.72 | 17.48 | 28.70 | **10.0** |
| Lead (mg/l) | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | **0.01** |
| Residual Chlorine (mg/l) | Nil | Nil | Nil | Nil | Nil | Nil | **0.5** |
| **Bacteriological Results** | | | | | | | |
| Total coliforms (#/100ml) | 3,300 | 2800 | 2.400 | 3100 | 3,600 | 2400 | **0** |
| Feacal coliforms (#/100ml) | 2,000 | 1200 | 2,100 | 1800 | 2,100 | 1080 | **0** |

| Water Samples Moomba Ward: October 2011 and March, 2012 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Well 1** | | **Well 2** | | **Well 3** | | **WHO Guidelines** |
| | **2011** | **2012** | **2011** | **2012** | **2011** | **2012** | |
| pH | 7.12 | 8.33 | 7.02 | 8.41 | 7.04 | 8.54 | **6.5- 8.5** |
| Turbidity (NTU) | 12.00 | 5.33 | 103.00 | 1.35 | 20 .30 | 1.15 | **5.0** |
| Total Dissolved Solids (mg/l) | 331 | 235 | 269 | 220 | 485 | 240 | **1000** |
| Total hardness (as mg $CaCO_3$/l) | 320 | 266 | 260 | 386 | 420 | 364 | **500** |
| Nitrates (as $NO_3$ -Nmg/l) | 7.39 | 8.80 | 12.94 | 9.72 | 17.48 | 28.70 | **10.0** |
| Lead (mg/l) | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | **0.01** |
| Residual Chlorine (mg/l) | Nil | Nil | Nil | Nil | Nil | Nil | **0.5** |
| **Bacteriological Results** | | | | | | | |
| Total coliforms (#/100ml) | 3300 | 2800 | 2400 | 3100 | 3600 | 2400 | **0** |
| Feacal coliforms (#/100ml) | 2000 | 1200 | 2100 | 1800 | 2100 | 1080 | **0** |

Source: Field data

Source: Field data 2011

### *6.1 Water Contamination*

For most ordinary members of the community, the quality of water is measured by the water clear appearances. However, the water testing results given above indicate that much of the water contains fecal and total coliforms which makes it unsafe for consumption above 100/100ml of the tested water samples. This is against the standard WHO guidelines of 0/100ml. Findings further revealed that risks of contamination by biological factors are high before the rainy season as compared to during and after the rainy season.

Water sources in Zambezi ward are highly contaminated with 3300/100ml of total coliform and 2000/100ml of feacal coliform. Chililalila ward on the other hand had the lowest levels of contamination around 466/100ml, 300100ml, 102100ml and 90/100ml before and after the rainy season ( Figure 2).

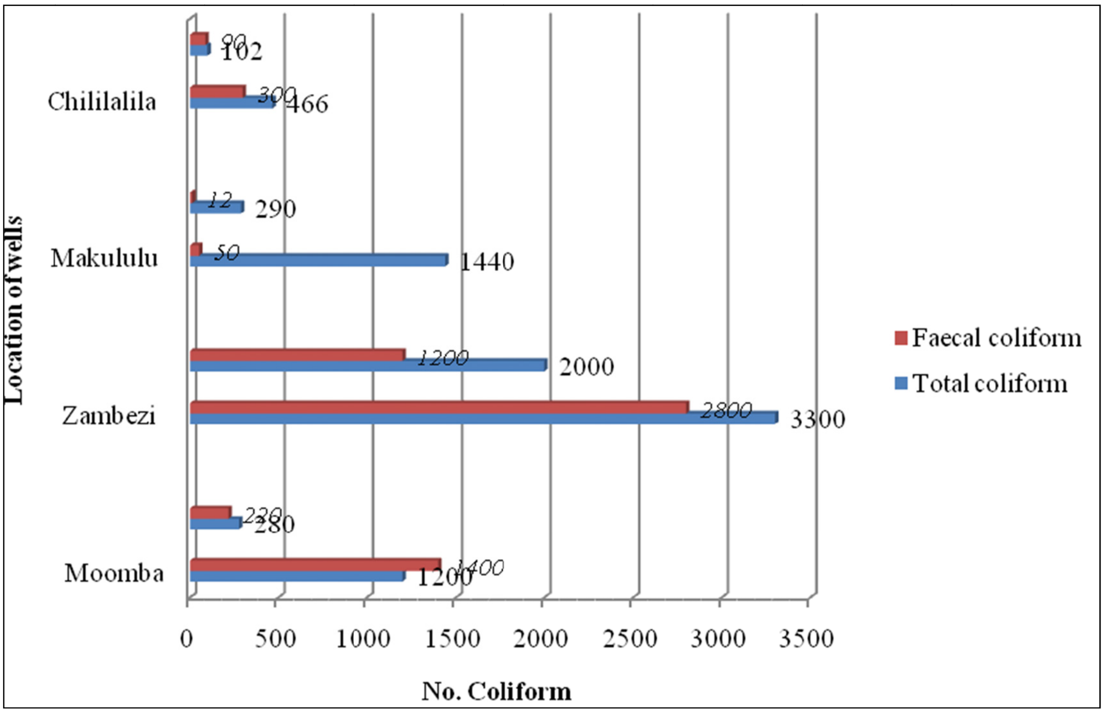


Figure 2. Presence of coliform – before and after rain season 2011-2012

Source: UNZA Environmental Laboratory, 2011/2012

However, despite the evidence of the presence of coliform, people in the community have different perceptions about the quality. In Makululu, (45%) perceives the water good, (36%) as poor, 10 did not know and lastly 9 said the water quality was very good for domestic consumption.

*6.2 Health and Sanitation*

PHAST–Participatory Hygiene and Sanitation Tool for the community project a Japanese International Cooperation Agency (JICA) project. 20 Neighbourhood Health Committees trained by the Environmental Health Technologist. The methodology involves use of pictures under the participatory rapid appraisal tools (PRA). The method is ideal as for the community whereby most of the members are of low education caliber.

Makululu Health Centre is Located right in the middle of the settlement. The health centre carters for the population of 29,010 of which 4500 are under the age of five. In addition, the records indicate that there are 7906 households in Makululu. These are catered for by 3 health facilities which include; the cholera centre, the Health centre and a health post. This is in 8 zones Makululu compound.

The major sources of water in Makululu include; shallow wells, communal taps provided by the Lukanga water and Sewerage Company. These wells are categorized as being protected wells, unprotected wells and hand dug shallow wells.

Makululu Health Centre Environmental Health Technologist (EHT) attributed poor sanitation especially human excreta usually from pit latrines as the main causes of cholera and dysentery in Makululu. The only health care facility is Makululu Health Centre which has a catchment population of 29, 010.

The challenge with the water and sanitation in Makululu has been the coexistence of pit latrines and shallow wells. However, where these facilities coexist, although it is difficult to give a general rule for all soil conditions, the commonly used guideline is that the well should be located in an area higher than and at least 15 m from the pit latrines and should be at least 2m above the water table. Available evidence shows that increased lateral separation between the source of pollution and groundwater supply reduces the risk of fecal pollution. With the rapid urbanization and rapid expansion of slum settlements in sub-Saharan Africa, on-site sanitation and underground water are used in some urban areas because they are affordable options in the absence of government-supplied services.

Further, the congestion in urban slums do not allow for the adequate distance between wells and pit latrines which in turn allows the migration of micro – organisms from fecal contents into underground water sources.

Poor sanitary practices (for example, disposal of human excreta) in Makululu lead to contamination of water and consequently water-borne diseases especially after the rainy season.

## 7. Discussions

### *7.1 Water and Sanitation*

The major sources of water for domestic use is from wells (61%) poses a great risk of water borne illnesses. The categories of wells which include some being unprotected, shallow and others poorly covered makes contamination very easy especially after the rainy season. Research finding showed that most of the wells dries in October and only become filled up after the rainy season. Although, some water stands (taps) have been installed in the area, not many residents have access to them. Some residents argued that the cost was too high for them to afford while others said they use the tap water specifically for cooking. These are some the reasons for annual outbreaks of water borne illnesses.

The trends of disease outbreaks of cholera, diarrhoea and typhoid as reported by the health authorities relate the prevalence of water borne diseases to rainy season. The trends of diarrhoea related cases showed that the number of reported diarrhoea cases is high starting from October decreasing towards the peak of the season. The Health personnel attributed this to the pathogens for diarrhoea is active in the hot season. On the other hand, the trend for Malaria cases increase as the rainy season progresses to March. This is attributed to the growth of grass and accumulation of stagnant water.

### 7.2 Pit Latrines and Hand Dug Wells Contamination

On the sanitation part, this poses a great challenge. Due to the high concentration of houses on small plots, the distance between pit latrines and wells is an unacceptable. The standard distance of 50m between the two facilities is not feasible for the high density informal setup of Makululu. The average distance of between 10m and 20m apart makes the water easily becoming contaminated. The chances of risk of contamination of the water sources are high as coliforms migrate from the pit latrines to the wells as the water table rises. The World Health Organization (WHO) guidelines, dictates that coliforms bacteria should not be found in any water intended for drinking. The laboratory analysis results of water samples showed that almost all of them had total and fecal coliforms present in water sources with as much as 3,600mg/l in Zambezi ward instead of the WHO standard of 0 mg/l. The presence of nitrates was on the increase as the rainy season progresses above the standard 10mg/l. The increase can be attributed to the raising water table due to flood waters carrying all sorts of organic matter.

## 8. Conclusion and Recommendations

It is evident that most of the sources of domestic water in Makululu are contaminated with fecal matter and do not meet the WHO guidelines for drinking water quality. This poses a health hazard to the residents of as they are at risk of water-borne diseases. The risk of underground is highest before the rainy season due to the concentration of faecal, total coliform and nitrates in the wells. During the rainy season, the concentration of contaminants reduces due to the increase of water from rains diluting most of the contaminants. The results of this study also suggest that tap water may be safer, but additional sampling is needed. The ideal intervention in the long-run may therefore be provision of adequate piped water to all slum dwellers. However, this may take some time, and simpler interventions could be put in place in the mean time. Basic sanitary improvement may be worthwhile at the moment. Covering the shallow wells and possibly installing hand pumps or mechanical pumps at the wells could improve the situation. Basic treatment of the water at the community or household level by chemical disinfection using chlorine, filtration using simple household filters, and boiling should also be promoted.

### *8.1 Recommendations*

The following interventions would help in reducing improving the risks and impact of flooding in Makululu compound.

- Makululu need to be upgraded to township status with basic services such as water and sanitation provided by the local authority.
- Unprotected wells need to be discouraged by burying them and be replaced with communal taps and VIP toilets or the flush toilets.
- Basic treatment of the water at the community or household level by chemical disinfection using chlorine, filtration using simple household filters, and boiling should also be enhanced and encouraged as a stop gap measure.

- Community based Disaster Risk Reduction (DRR) and Water and Hygiene Sanitation Education (WASHE) activities training programmes should be enhanced through neighborhood committees facilitated by Mulungushi University, Kabwe Municipal Council, Civil Society Organisations and the Makululu Health Centre personnel.

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