DETERMINING POTENTIAL HEALTH RISKS TO RESIDENTS FROM WATER SOURCED IN MALONI COMPOUND OF LIVINGSTONE DISTRICT IN ZAMBIA

By

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THE UNIVERSITY OF ZAMBIA

LUSAKA

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DECLARATION

I, **Kamunga Mukwasa**, declare that this work is my original work achieved through personal reading and scientific research. This work has never been submitted to the University of Zambia or any other University. All sources of data used, and literature on related works previously done by others, used in the production of this dissertation have been dully acknowledged

Signature …… Date ……

APRROVAL

This dissertation of **Kamunga Mukwasa** has been approved for the partial fulfilment of the requirements for the award of a degree of Master of Science in Public Health by the University of Zambia.

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Signature……..……Date…….

Coordinator

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Signature……...…….…Date…...…….

ABSTRACT

This study is an investigation into the presence of bacteria from water sourced in Maloni Compound of Livingstone District in Zambia. The basic research objective of the empirical study was to investigate the presences of bacteria in water sourced from Maloni Compound of Livingstone District. Furthermore, to examine the potential health risks to the residents arising from the water sourced in Maloni Compound. A mixed research strategy was adopted that made use of questionnaire, interviews guide, observation and standard field sampling sample bottles to collect empirical data. The findings revealed that water in Maloni compound was sourced from submissive boreholes, hand pump fitted boreholes and shallow wells. The study further revealed that residents of Maloni Compound used on site sanitation system namely pit latrine and septic tanks. It also revealed that water sourced from Maloni Compound had the presence of bacteria with relatively high total coliform and faecal coliform contamination, the fact that may have compromised the public health status of the residents of Maloni Compound. The study recommended for the following:

i. There is need for collaboration of various stakeholders up to the consumer level during the planning and implementation stage of urban and peri urban areas, to ensure that the allocation of residential plots is done simultaneously with the provision of necessary services such as water and sewerage reticulation systems.
ii. There is need for SWASCO to directly provide water to existing residents of Maloni and to facilitate decommissioning of all contaminated water sources.
iii. There is need for urban Planners and SWASCO to encourage households to also employ alternative methods in the water sector such as rain water that can be stored and used for flushing toilets.
iv. There is need to formulate policies in water and sanitation, planning and in infrastructure design that will encourage research and development of innovations and technologies that will apply to our local scenario.

DEDICATION

This research is dedicated to my late father **Mr. Job Mukwasa** who unfortunately did not live to see how far the seed he planted in me has grown.

ACKNOWLEDGEMENT

I wish to extend my special thanks to the glory and mercy of the Almighty God for allowing the successful completion of this research report.

Exceptional gratitude is extended to my main supervisor Dr. Chibesa Zacharia Mulenga, the core supervisor Ms. Mutalange Martha and all staff in the School of Public Health who offered critical supervisory support during the shaping of this research document even out of their busy schedules. To them, I say thank you.

Overall and most prominent gratitude is stretched further to my mother Selina Namfukwe, my wife Chanda Bwalya Kapembwa and my children Darlene Kapanzya Mukwasa and Victoria Taizya Mukwasa for giving me the much-needed support and advice on entire studies at the University of Zambia (UNZA), only God will bless them for me and grant them long life. I echo a strong thank you to all the well-wishers and God bless.

Finally, exceptional appreciation is extended to all the study participants that spared their time to provide meaningful information that shaped this document and without them, this study was not going to be possible. I appreciate from the deepest part of my heart.

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LIST OF ABBREVIATIONS AND ACRONYMS

CFU	Coliform Forming Unit
CSO	Central Statistical Office
DHO	District Health Office
GPS	Global Positioning System
LCP	Livingstone City Profile
MMR	Mixed Method Research
MPLs	Maximum Permissible Limits
pH	Hydrogen Potential
SDG	Sustainable Development Goals
SWASCO	Southern Water and Sanitation Company
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
WASH	Water Sanitation and Health
WHO	World Health Organization
WQI	Water Quality Index
ZABS	Zambia Bureau of Standards

CHAPTER ONE:
INTRODUCTION

1.0 Overview

This chapter gives a description of the study. It explains the situation prevailing in the study area that led to the research being conducted. The issues highlighted in this chapter are categorised under the following sub-headings; background, problem statement, aim of the study, research objectives, research questions, justification, scope of the study and conceptual framework. The chapter will end with a conclusion of the issues discussed.

1.1 Background of the study

Water supply and pollution issues are becoming more severe in Zambian urban and peri-urban areas with a large percentage of the population living in such areas depending on shallow wells and hand pump equipped boreholes (Nyambe, 2021). Water is one of the most important requirements for human life, well-being, economic production, and sustainable development. Although safe drinking water is a basic human right, many people still do not have access to safe and adequate drinking water or proper sanitation facilities (Muchanga, 2020). According to the World Health Organization's 2017 report, safe drinking water is water that "does not present any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages". It is also defined as the water that does not represent any significant risk to health over a lifetime of consumption (Fogden and Wood, 2009). 'Safe drinking water' includes treated surface waters, and untreated but uncontaminated waters drawn from protected springs, bore holes, and sanitary wells," (World Health Organization, 1996). In this regard, every effort should be made to achieve drinking-water quality. Water is used in the human body for a number of different functions, such as; a lubricant in the body, body temperature regulation, removing harmful toxins in the body, and transporting nutrients throughout the body. Therefore, without safe drinking water, public health is always at risk and the full economic potential of the community cannot be realized (Allen *et al,* 2018).

Maloni Compound is characterized by a booming population that in turn increases poor sanitation. The poor sanitation is activated by a lack of piped water supply, unplanned sewer system and indiscriminate dumping of waste because most of the residents have limited finance for extending water supply and sanitation services to their unplanned settlement. Sankhla *et al.* (2018) indicated that human health is directly affected by the consumption of

polluted water. Poor water quality has direct negative impacts on the Maloni residents. The research done by the United Nations Human Settlements Programme (UN-HABITAT), in 2009, for example, indicated that, during the rainy season there are usually outbreaks of waterborne diseases like cholera and diarrhoea in Livingstone.

According to WHO (2010), water borne diseases such as cholera, dysentery, and typhoid, among others are quite prevalent especially in densely populated areas such as Maloni compound. WHO (2010) generally stated that, monitoring the quality of drinking water is vital in developing countries owing to poor sanitation. It is from this World Health Organization's perspective that the researcher sought to carry out a study in Maloni Compound to determine the potential health risks to residents from water sourced in Maloni compound in terms of microbial contamination.

According to Greenhalgh (2001), drinking water or portable water is water that is safe enough to be used by human beings with low risk of immediate or long-term harm. The Standards Organization of Nigeria, (2015) describes Drinking Water as; All water either in its original state or after treatment, intended for drinking, cooking, food preparation or other domestic purposes, regardless of its origin and whether it is supplied from a drinking water system. The Standard further adds that Drinking Water is; All water used in any food production undertaking for the manufacture, processing, preservation or marketing of products or substances intended for human consumption. Furthermore, the Kenyan Standard (2015), defines Drinking water as potable water intended for human consumption. Rajagopal *et al*., (2016) concludes that Water that is made fit for human consumption with minimal short or long-term harm is called potable or drinking water.

Martínez-Santos. *et al*. (2017) did a survey of domestic wells and pit latrines in rural settlements of Mali. The survey looked at implications of on-site sanitation on the quality of water supplies. Braul and Kirychuk, (2001) in their study as referenced in Fasae and Omolaja (2014), also recommended a stricter pH range of drinking water between 6.0 and 8.5, largely based on field observations rather than controlled studies. In view of the above, Godwill *et al.* (2015) suggests that there is need for regular quality control monitoring of portable water to minimize the risk of related health consequences due to heavy metal and Microbial contamination.

Davies and Mazumder (2003), said that many drinking water disease outbreaks have resulted from breaches in treatment facilities. Therefore, even with greater treatment intensity, poor

source water quality intrinsically has greater associated health risks. In the Water Sanitation and Health (WASH) era, there is need to expedite the process of addressing these problems for sustainable public health development. It is therefore imperative to determine drinking water quality in unplanned settlements so as to minimize potential and acute health issues associated with consuming poor-quality water. According to WHO (2010), Water quality refers to the chemical, physical, and biological condition of water, usually with respect to its suitability for a particular purpose such as drinking and irrigation, among others. In this context, the focus is on suitability for human consumption based on Zambian standard (ZS 190 of 2010).

1.2 Statement of the Problem

The high incidences of water borne diseases in peri-urban settlements are attributed to people drinking unsafe water due to ineffective quality monitoring (WHO, 2010). This problem has persisted due to inadequate water utility infrastructure: a situation which is more pronounced during the rainy season, when there are usually outbreaks of waterborne diseases like cholera and diarrhoea. It is estimated that almost 900 million people lack access to improved drinking water worldwide, and over 5 million of those people live in Zambia (Peletz *et al.,* 2011). Maloni Compound in Livingstone is one of the compounds in Zambia whose residents depend on hand pump equipped boreholes and shallow water wells. Residents of Maloni, especially Children under the age of five years have continued to experience stomach irritations generally, and persistent diarrheal cases are recorded at the local community health posts (UN-HABITAT, 2009). It is against this background that the researcher sought to carry out a study to determine the potential health risks to residents from water sourced in Maloni Compound in terms of microbial contamination.

1.3 The purpose of Study

The purpose of this study was to assess the potential health risks to residents from the water sourced in Maloni Compound of Livingstone.

1.4 Specific Objectives

i. To investigate the presence of bacteria in water sourced in Maloni Compound of Livingstone.
ii. To examine the potential health risks to residents from water sourced in Maloni Compound of Livingstone.

1.5 Research Questions

i. Does water sourced in Maloni Compound of Livingstone contain bacteria?
ii. What health risks are associated with water sourced in Maloni Compound of Livingstone?

1.6 Significance of the study

Water supply and sanitation is a core development issue for Zambia's economic growth and social development. Lack of safe drinking water supply and sanitation results in poor environmental conditions and poor community well-being which negatively affects the status of public health.

It is therefore expected that results of this study will be beneficial to the government, particularly policy makers in the Environment, Water and Sanitation sector, in attaining Sustainable Development Goal (SDG) number six (6). This aims at ensuring access to water and sanitation for all, thereby complementing on the other hand with SDG number three (3) aimed at ensuring healthy lives and promotion of well-being for all. Through the promotion of good hygiene and sanitation, the status of public health in the community will be enhanced. The study may also benefit the Ministry of Health (MoH) in terms of allocating resources to areas with similar water supply and sanitation conditions to Maloni, especially during the rainy seasons. The local residents may also be equipped with simplified or traditional methods to treat water for drinking at household level. The study is envisaged to provide baseline data for community water planning and reduction of water related health risks, and will provide information that may give insights for further research.

1.7 Delimitations of the Study

The study was conducted in a Compound within Livingstone District where the population is small. Since the study was done in a small compound, results may not be generalised.

1.8 Limitations of the Study

The study was conducted during the Covid-19 pandemic. Therefore, there were disruptions in data collection due to government restrictions aimed at preventing the spread of the pandemic. This resulted in some selected study participants refusing to participate in the study and hence, affected the completion of the study within the planned period.

1.9 Scope of Study

This research will be conducted on sources of drinking water among the residents of Maloni Compound in Southern Province of Zambia. The research will concentrate on determining the potential health risks to residents from the water sourced in Maloni Compound of Livingstone District of Southern province in Zambia.

1.10 Conceptual Framework

This research will determine the quality of drinking water in Maloni Compound in Southern Province of Zambia and the potential health risks. Hence from the scope of the study, the researcher has drawn a conceptual model shown in figure 1.1 below.

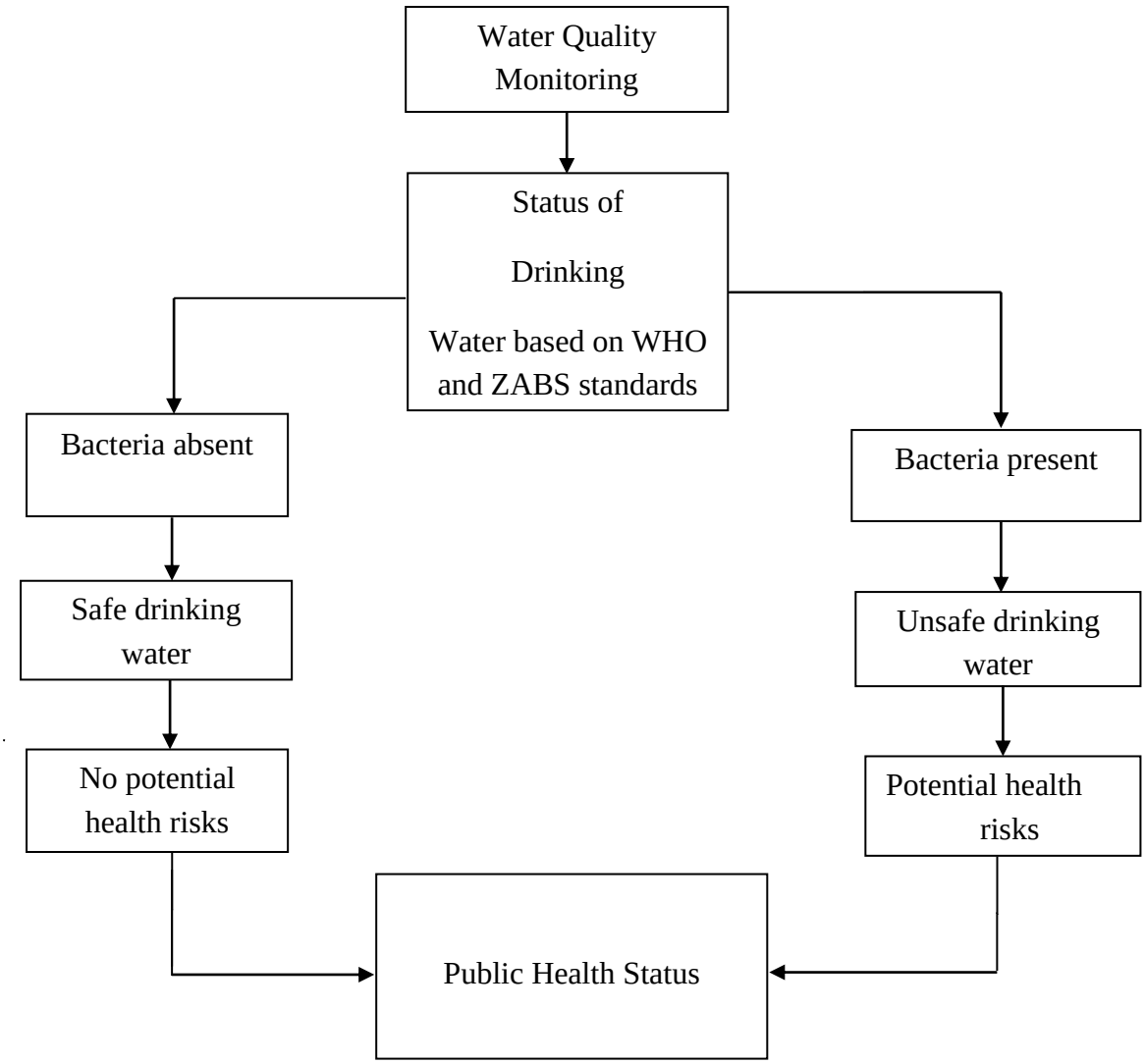

Figure 1: Conceptual framework of the study

The conceptual framework indicates that monitoring of the quality of drinking water basing on the World Health Organization (WHO) and the Zambia Bureau of Standards (ZABS) standard will determine the presence or absence of bacteria. The presence of bacteria in the drinking water implies contamination which has a ripple health risk to humanity. The presence or absence of bacteria in the drinking water reflects the public health status of the community in Maloni Compound of Livingstone District of Southern Province in Zambia.

1.11 Summary

The chapter has given a description of the study. It has also explained in detail the situation prevailing in the study area that resulted in the research being conducted.

CHAPTER TWO:
REVIEW OF RELATED LITERATURE

2.0 Overview

In this chapter, the literature relevant to the study is reviewed, premised on the key theme: determining the potential health risks to residents from water sourced in Maloni Compound of Livingstone in Zambia.

2.1 Global perspectives on water quality and human health risks

Many studies on safe drinking water have been conducted in many places world over and each one of them provides important health knowledge. This section is a review of such studies

Pal *et al.(*2018) did a study that looked at the quality of drinking water as an influential environmental determinant of health. They indicated that contact with unsafe drinking or bathing water can impose serious risks (both acute and delayed) to human health. Globally, the most commonly occurring diseases transmitted through drinking of unsafe water are infectious hepatitis, cholera, bacillary dysentery, typhoid, paratyphoid, salmonellosis, colibacillosis, giardiasis, cryptosporidiosis, and amoebiasis. Contaminated water may also cause many more bacterial, viral, and parasitic diseases. Majority of the diarrheal deaths that occur worldwide are mainly associated with unsafe drinking water, inadequate sanitation, and poor hygiene.

Karpouzoglou *et al.* (2018) explained that peri-urban areas deserve to be a much more visible policy and planning priority, where appropriate institutional and regulatory mechanisms should be designed through which citizen concerns could take a central role in shaping water quality management policies and monitoring plans examined.

Dunn *et al*. (2014), looking at Canada, argued that the Canadian approach to drinking water standards and guidelines resulted in data gaps, urban-rural, and other disparities.

Daud *et al*. (2017) in a study based on Pakistan contends that due to alarming increase in population and rapid industrialization, drinking water quality is being deteriorated day by day. This study focused on various research studies conducted on drinking water quality status of different areas of Pakistan. It took into account the physicochemical properties and pathogenic micro-organisms. It concentrated on the numerical value of the population that had access to unsafe water.

Another study by Baum *et al.* (2014) in the Dominican Republic indicated that water quality was poor due to lack of strategic control of pollutant ridden runoff and human activities.

The above studies were conducted on safe drinking water quality in some countries outside Africa. They are similar to this study in as far as their concentration on the health aspect of the residents in their respective areas. However, these studies were different from this study in as far as their focus is concerned. They for instance focused on deaths resulting from globally occurring diseases transmitted through quality of drinking water while the current study's focus is on determining potential health risks to residents from water sources in Maloni Compound of Livingstone District of Zambia.

2.2 African perspectives on water quality and human health risks

Dahunsi *et al.* (2014) established that groundwater samples from hand pump equipped bore-holes and hand-dug wells of four densely populated towns in Southwestern Nigeria had concentrations of Pb, Ni, Cr, and Cd which were above the minimum permissible limits. Total aerobic plate, total coliform bacteria, and *Escherichia coli* (*E. coli*) were also detected in most of the water samples from the different towns and sources considered.

The presence of coliforms and *E. coli* in the groundwater samples indicated faecal contamination. In this study, the highest mean total aerobic plate count of 136 cfu mL−1 was obtained in the dug-well water sample, the maximum total coliform count of 15 cfu mL−1 was found in the hand-pump water sample. *E. coli* was detected in hand-pump well and hand-dug-well. These biological contaminations were attributable to the closeness of water wells to septic tanks and open-dumps in the area (Dahunsi *et al.,* 2014).

Another study was conducted in Uganda by Bwire *et al*. (2020) that revealed that the quality of water on the surface and subsurface was negatively affected by the various anthropogenic activities which compromised the health of people. It mainly focused on natural surface water in ponds and lakes, unlike shallow wells and boreholes.

Dusabe *et al*. (2019) also conducted a similar study on safe drinking water. They explored the influence of diverse anthropogenic activities on water quality. Their study shows that transboundary human activities may have wide off-site effect on water quality. The study noted that some anthropogenic pollutants from Tanzanian catchments were affecting water quality in Rwanda and surrounding areas. Dusabe *et al*. (2019) suggest sustainable land management in order to sustainably achieve water quality for communities.

As much as we appreciate the work of Dusabe *et al* (2019); Dahunsi *et al* (2014); Bwire *et al* (2020); Pare and Bonzi-Coulibaly (2013) and Dahunsi *et al.* (2014) in detailing the physicochemical and biological status of water, the studies did not emphatically explore the health implications of the findings, thereby creating a gap that the current study will fill. This study aims at assessing the potential health risks to residents from water sourced in Maloni Compound of Livingstone and thereafter determine the Public Health Status of the residents in Maloni compound.

2.3 Zambian perspectives on water quality and human health risks

Silavwe *et al.* (2018) did a study in Peri-Urban Townships in Lusaka District of Zambia that revealed that domestic water supplied to residents was contaminated with faecal coliforms that emanated from unplanned sewer system constructed within the water sources.

Reaver *et al.* (2021) also studied drinking water quality and provision in six low income peri urban communities of Lusaka in Zambia where they noted that, water from shallow wells, kiosks and municipal boreholes had higher specific conductance on average. Using non-parametric tests, they observed strong and moderate evidence that specific conductance was higher in Kanyama for shallow wells and kiosks with respective p-values of 9.1×10^{-4} and 0.017. These statistics were pointing to high turbidity.

A similar study was conducted in Lusaka to observe values of the groundwater parameters (nitrates and microbial contaminants). It revealed that groundwater in Chaisa and Kanyama is characterized by higher concentration of nitrate and microbial contaminants in shallow wells than in boreholes and public taps. The higher amounts of nitrate of up to 50 mg/l and microbial contaminants of up to 31, 025 cfu/100 ml of water in shallow wells are a result of the use of pit latrines for disposal of human excreta in the peri-urban areas (Chandipo, 2015).

These studies are similar and relevant to the current study in a number of ways; firstly, they revealed that the presence of *Escherichia coli* in the drinking water resulted from the sewer system. This is the direction that the current study will take when determining the potential health risks to residents from water sourced in Maloni compound. Secondly the presence of *Escherichia coli* indicated health risks; *Escherichia coli* is one of the bacteria this study will analyse in water sourced in Maloni Compound when determining the potential health risks to the residents; Thirdly these studies assessed the microbial contamination of water; which in some way was determining the quality of water. Additionally, their data analysis and determination of the safety of water were similar to the current study. Like Chandipo (2015)

indicated in his study, the suitability of water for drinking will be determined by comparing the data with the WHO and ZABS permissible limits. This is the direction the current study will take in determining the potential health risks to residents from water sourced in Maloni Compound as suggested by the conceptual framework in chapter one.

Chandipo (2015) subjected water samples to statistical analysis using Analysis of Variance and regression analysis. The current study intends to use a similar statistics package to analysis the water samples from the different sources. Although the studies conducted in Zambia on safe drinking water by Silavwe et al (2018); Reaver et al (2021) and Chandipo (2015) are similar to this study, they did not comprehensively focus on the health dimension. This study will endeavour to determine the potential health risks resulting from the presence of bacteria in water sourced in Maloni Compound.

2.4 Summary

In this chapter, the literature relevant to the study has been reviewed in more detail, premised on the key theme: determining the potential health risks to residents from water sourced in Maloni Compound of Livingstone in Zambia.

CHAPTER THREE:
METHODOLOGY

3.0 Overview

This chapter describes the research methodology that was used in the study. The sub headings in this chapter include: research design, target population, sample size, sampling methods and techniques, methods and tools of data collection, data analysis, data quality and management, ethical consideration, and finally, expected limitations and their respective mitigation strategies.

3.1 Research design

The study used a Mixed Method Research (MMR) approach concurrently. In a concurrent research procedure, the study converged quantitative and qualitative data in order to provide a comprehensive analysis of the research problem. Both qualitative and quantitative data was collected at the same time during the study and was integrated in the overall interpretation of results.

3.2 Study site and Target population

Maloni Compound is found in Livingstone District of Southern Province in Zambia. It is located between 25^{o} 51' 50'' -25^{o}52'17" East and 17^{o} 51'52"-17^{o} 52'19" South (Figure 3.1). It has an approximate areal size of 0.72 Km^2 and a population of about 30,000 people (CSO, 2021). For livelihoods, people in Maloni are dependent upon market purchases, cross border trading, payment in kind for labour, casual agricultural, sale of small livestock, small businesses, working in the nearest lodges and hotels and brewing local beer (Mulandu and Siwila, 2019). It is one of the areas in Livingstone prone to water-related diseases such as cholera, dysentery, and typhoid, among others, as most residents depend on shallow water wells and hand pump boreholes.

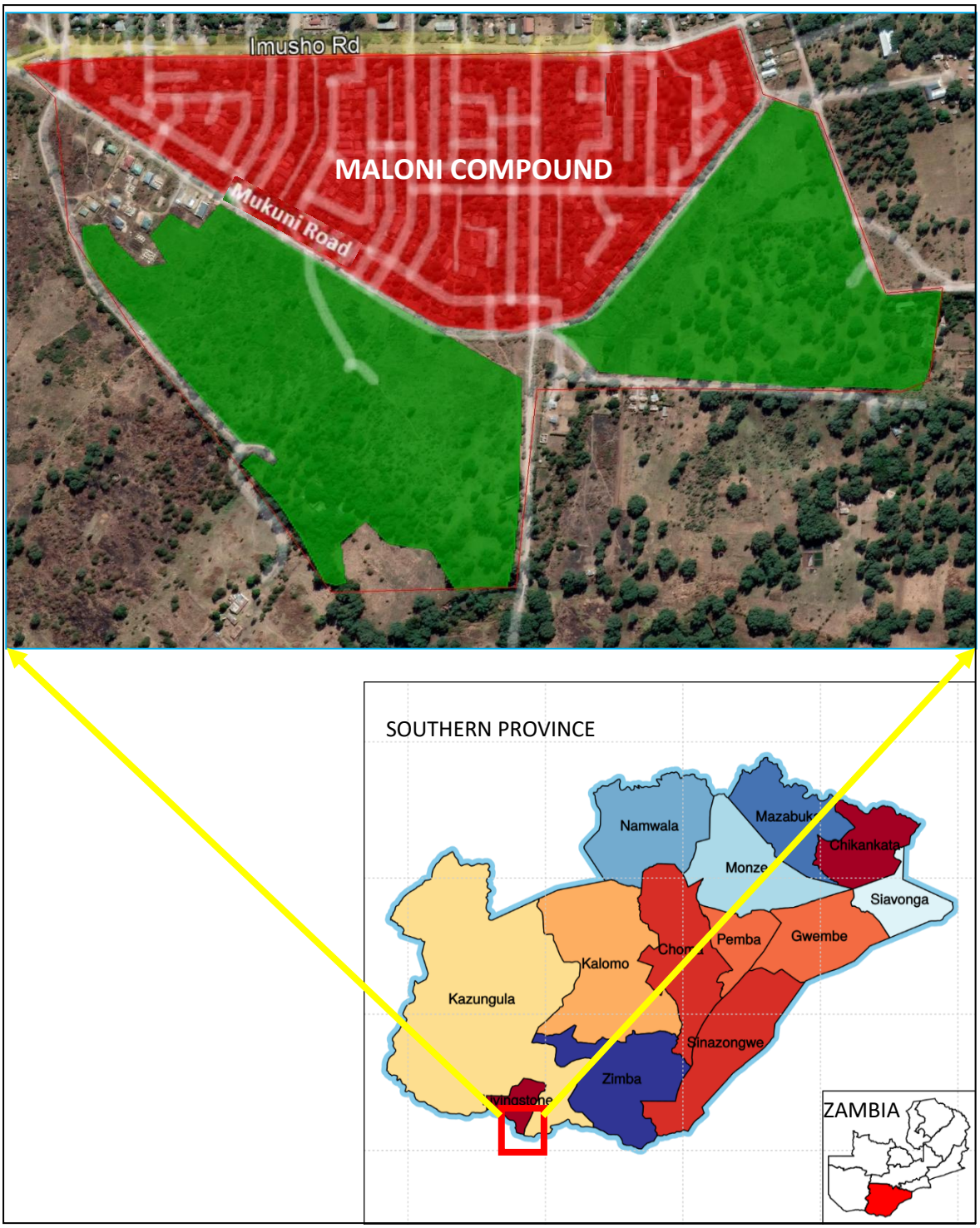

Fig 3.1: Geographical location of the study area

The study primarily targeted Handpumps, Boreholes and shallow wells that were used for domestic water supply in Maloni compound. The secondary target audience was the households that depended on those sources of water so as to understand their experiences.

3.3 Selection of sampling points, sample size and sampling methods

The population in the study was all the water points from different sources in Maloni Compound. Maloni Compound had a total number of 32 water points encompassing boreholes and shallow wells. The boreholes, and shallow wells were grouped into clusters from a total population of 32 water points resulting into 11 clusters. Each cluster was assigned a number from 1 to 3 and any cluster having numbers 1 and 3 was selected randomly resulting into 7 clusters. The selected 7 clusters were the sample size of the study and quantitative data was collected from every drinking water point.

The researcher targeted 24 convenient water points and sampled 10 water users per drinking water point in the selected sample, thereby, making a total population of 240 water users. Out of the 240 water users, 120 were given questionnaires from which qualitative data were collected. A sample of 120 represented 50 percent of the targeted 240 water users which is representative and can be generalised. The 120 water users were selected using a purposive sampling technique because it was necessary to ensure that the right audience was targeted.

3.4 Data collection plan and tools

The study targeted to collect various sets of data based on the objective of the study and in line with the conceptual framework. Table 3.1 clearly tabulates how primary data was collected in line with the objectives of the study.

Table 3.1: Methods and Tools of primary data collection

S/N	Objective	Specific data/information to be collected	Methods and tools	Sources of data
i.	To investigate the presence of bacteria in water sourced in Maloni Compound of Livingstone.	• water samples	Standard Field water sampling using sampling bottles	Sampled Water points in Maloni
ii.	To examine the potential health risks to residents from water sourced in Maloni Compound of Livingstone.	• Residents' perspectives and experiences on health risks associated with depending on the targeted water points	Questionnaire and observation guide	House hold residence in Maloni Compound and Key informants from SWASCO

3.5 Data quality and management

Data quality and management are critical aspects in ensuring trustworthiness of research findings and conclusions (Cresswell, 1994). In order to ensure quality and management on water quality-related data, the following strategies were put in place:

- A blind water sample was included to ensure quality of water analysis in the laboratory
- Operated the pump and let water run for at least two minutes to flush out stagnant water from the pipe and ensured that the sample was taken from underground.
- Rinsed sampling bottles with distilled water and thereafter with water from target source doing the actual sampling.
- Sampled water was closed up tightly, placed in a cooler box and immediately transported to the laboratory for analysis.

The data on research question 2, which concerns health risks associated with water quality, was checked for consistency through triangulation of informants and data checking by informants. Participants were required to inspect the information they provided prior to the end of interviews. The validated data was entered into the google form and kept on google drive.

3.6 Data analysis

Data analysis is very essential for any research because it puts together the meaning of collected data either through use of primary or secondary methods or both (Cresswell, 1994). The data for research question 1 was analysed in two phases. In the first phase water sample parameters were analysed using standard laboratory procedures as provided for in the WHO and ZS 190 of 2010 standards for human consumption. In phase two, the laboratory analysed results were grouped in tabular matrices and graphs and further analysed using descriptive statistics including means, variance and standard deviations in relations to WHO and ZS 190 MPLs.

All socioeconomic and health related data was analysed using thematic analysis. Thematic analysis is a method of analysing qualitative data. It is usually applied to a set of texts, such as interview transcripts (Caulfield, 2020). The researcher closely examined the data to identify common themes – topics, ideas and patterns of meaning that would emerge

repeatedly. Afterwards, patterns of meanings were determined and concluded. The general analytical process was as presented in Figure 3.2.

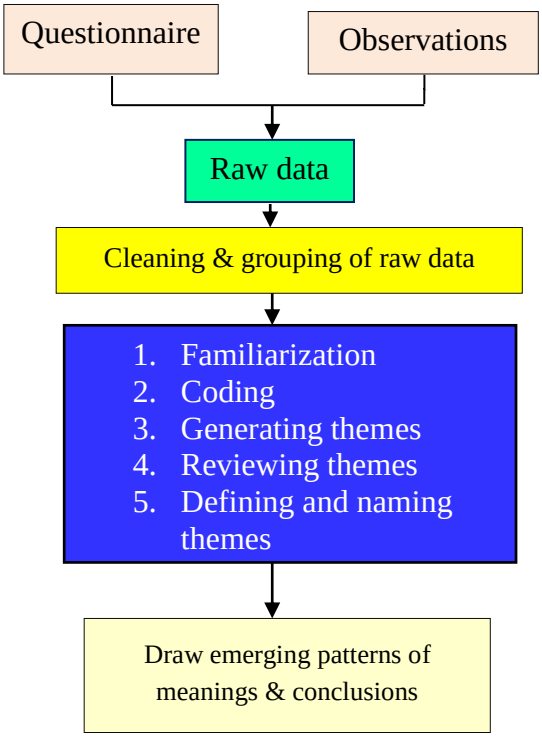

Fig 3.2: Analysis framework for the study

3.7 Ethical Considerations

Consideration of ethics in any research is critical because it acts as influencing factors to which those conducting research should base their reflections on throughout the process (Cresswell, 1994). The proposal was submitted to The University of Zambia Biomedical Research Ethics Committee (UNZABREC) and the Zambia National Health Research Authority (ZNHRA) for ethical clearance and approval, respectively. During data collection, participants were provided with the background of the study for them to make informed decisions on whether to participate or not, and a consent form was given to them to sign. No participant's identity was revealed by name. The data collected was treated with utmost privacy and confidentiality. Participants were also free to choose to participate or withdraw from the study at any time. The participants were informed of no immediate benefits as participation was purely voluntary.

3.8 Justification for the Budget

Data collection was done using the field water sampling bottles and other necessary requirements. Transported samples to the laboratory were analysed. For that reason, there was need for purchase of water sampling gadgets to facilitate sample collection and a cooler box for easy carriage of the samples to the laboratory at controlled temperature. In addition, some stationery such as reams of paper, notebooks and pens were needed for the enumerators and Investigator. Data was collected throughout the day and hence the need to pay the assisting enumerators lunch and transport allowances. Finally, a contingency fund of 10% of the budget was kept for any unforeseen eventualities.

3.9 Potential Pitfalls and Alternative Strategies

The study was conducted during the Covid-19 pandemic. Therefore, there were disruptions in data collection due to government restrictions aimed at preventing the spread of the pandemic. This resulted in some selected study participants refusing to participate in the study and hence, affected the completion of the study within the planned period. To minimize this effect, the researcher and his assistants were provided with personal protective equipment (PPE) such as gloves, facemasks and Alcohol based Hand Sanitiser to promote adherence to national public health guidelines in preventing Covid-19 transmission.

3.10 Deliverables and Dissemination

The research project will result in the writing of a dissertation, which will be submitted to the examination board as part of the requirements for completion of the academic program. The findings will be disseminated to institutions concerned with environment, water, sanitation and health in Zambia among them; Ministry of Local Government, Southern Water and Sewerage Company, Zambia Environmental Management Agency (ZEMA) and Ministry of Health, who are responsible for policy formulation and implementation. The report will also be shared with the academia and the general public through an open access publication on a scientific journal.

3.11 Summary

The chapter has described the research methodology that was used in determining potential health risks among residents from water source in Maloni Compound of Livingstone District in Zambia. The chapter has also discussed the potential pitfalls and their alternative strategies.

CHAPTER FOUR:
PRESENTATION OF FINDINGS

4.0. Overview

Chapter Four presents the findings in the determining of potential health risks to residents from water sourced in Maloni Compound of Livingstone District. In order to show clearly how the objectives of the study have been addressed, the findings are presented under two parts; Part 1 consisting of Qualitative Data and Part 2 consisting of Quantitative Data. Data is presented as Subheadings derived from both the research questions and objectives of the study. The headings that were derived from both the research questions and objectives include: personal data, water and sanitation, potential health risks to residents, and water quality monitoring.

4.1. PERSONAL DATA

The Researcher sought to collect some data on the status of the respondents as this was vital for the study.

4.1.1. Demography of Participants:

The researcher established the demography of the respondents. The objective was that demography might have an influence on the respondent's opinions on determining potential health risks to residents from water sourced in Maloni Compound of Livingstone District of Zambia. It was possible to have certain situations perceived differently depending on the demography of the respondent. The demography includes both male and female participants as can be observed from figure 4.1 below.

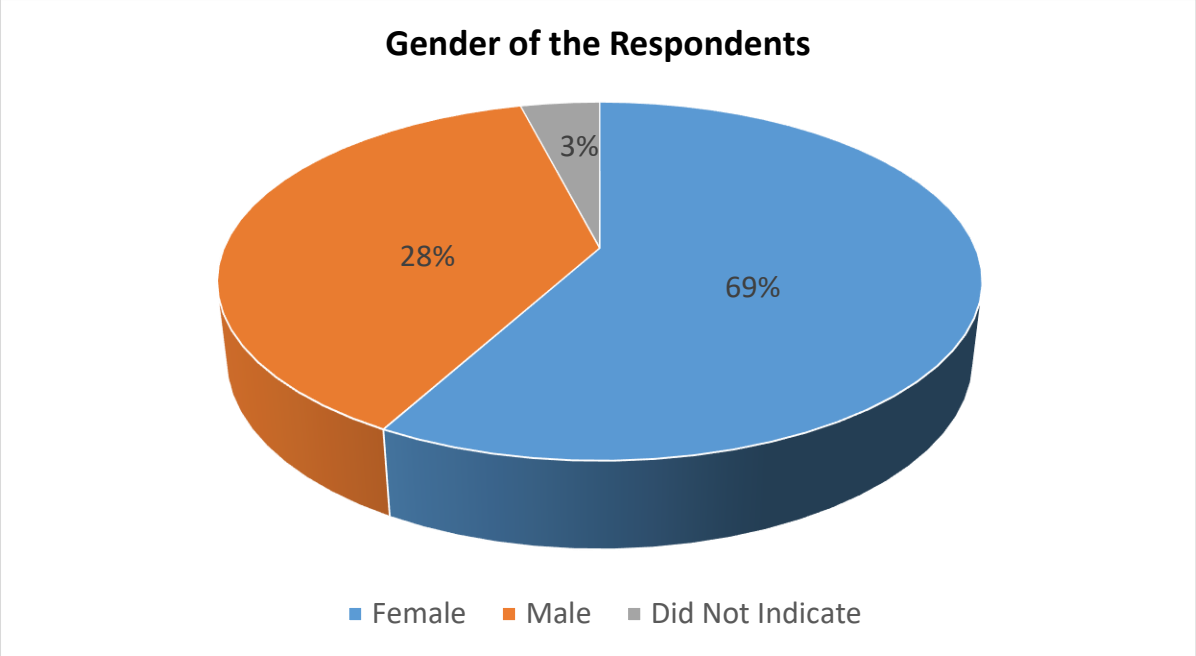

Fig 4.1: Participants Gender.

Fig 4.1 shows the demography of the participants that took part in the study. The Figure indicates that 83 respondents representing 69 percent were female, 33 respondents representing 28 percent were male and 4 respondents representing 3 per cent did not indicate their gender. The demographic status in this study indicates that there was unequal distribution of opinions by gender.

4.1.2. Level of Education of Participants:

The researcher established the levels of education of the respondents. The objective was that the level of education might have an influence on the respondent's opinions on determining potential health risks to residents from water sourced in Maloni Compound of Livingstone District of Zambia. It was possible to have certain situations perceived differently depending on the levels of education of the respondent. The levels of education in this study included Tertiary Education, Secondary Education and Primary Education.

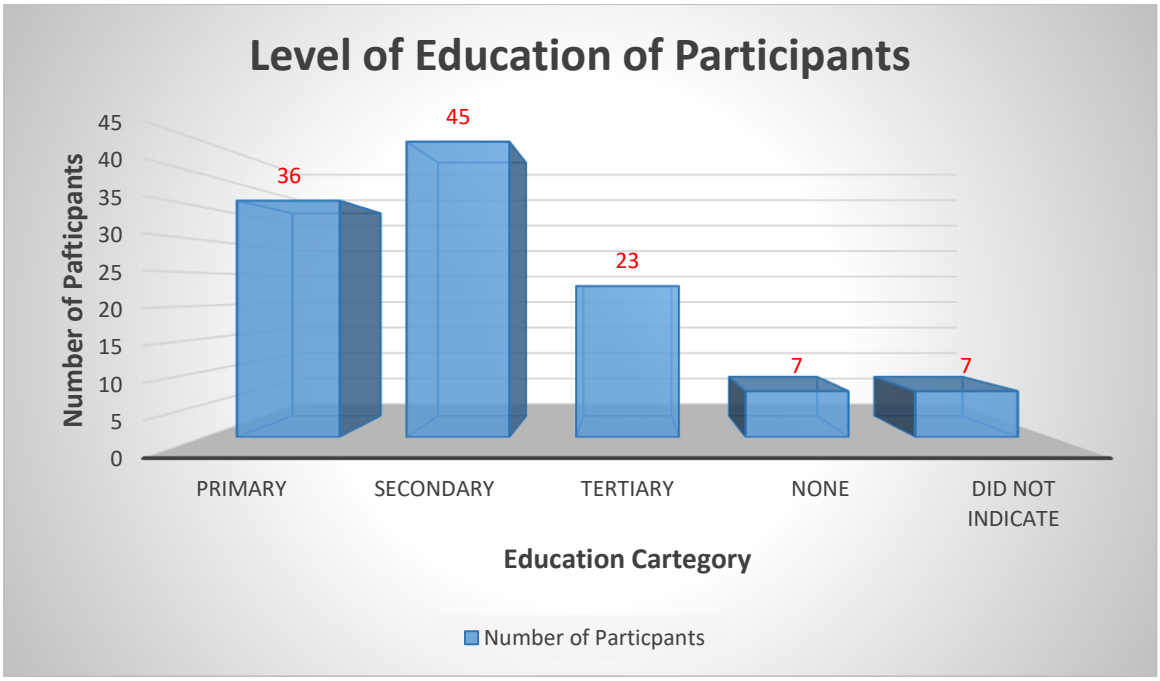

Fig 4.2: Participant's Level of Education.

Fig 4.2 shows the levels of education of the respondents that took part in the study. According to Fig 4.2, 45 of the respondents had secondary level of education, 36 of the respondents had primary level of education, 28 respondents had tertiary level of education and 7 respondents had none. Fig 4.2 also shows that 7 respondents did not indicate their level of education. The level of education in this study indicated the levels of understanding of the language and questions raised in the questionnaire.

4.1.3. Marital Status of Respondents:

The researcher sought to establish the marital status of the respondents. The objective was that marital status might have an influence on the respondent's opinions on determining potential health risks to residents from water sourced in Maloni Compound. It was possible to have certain situations perceived differently depending on the marital status of the respondent. The marital status in this study included the options of; 'married', 'single', 'widow' and 'widower'.

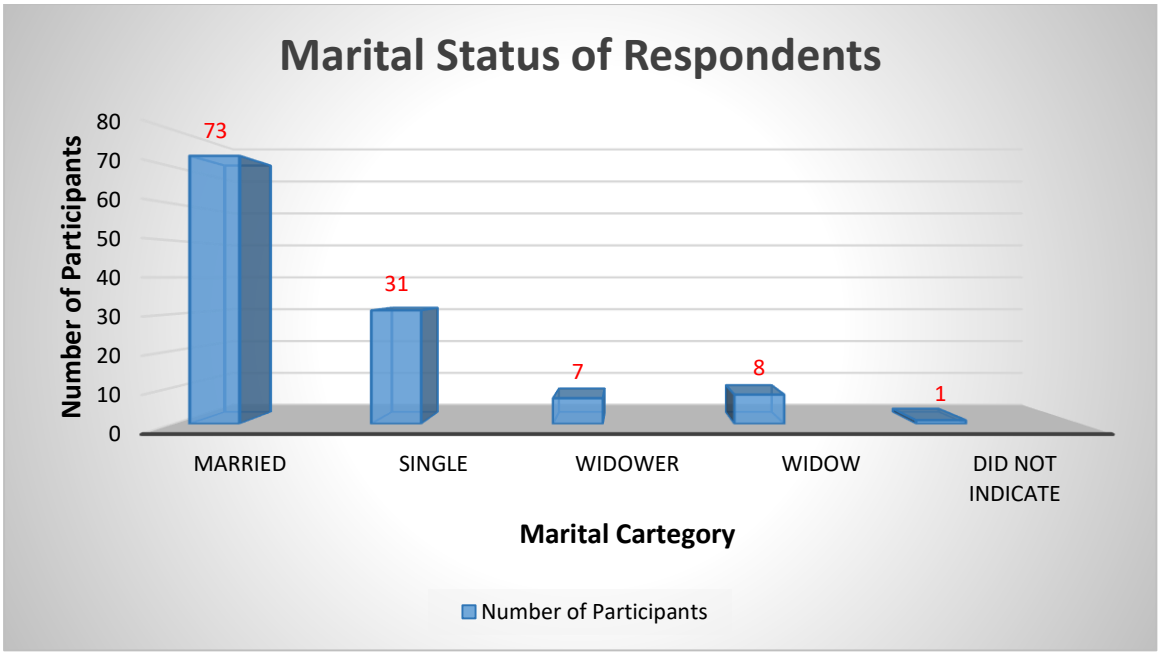

Fig 4.3: Marital Status of Respondents.

Fig. 4.3 shows the marital status of the participants that took part in the study. According to Fig 4.3, 73 of the participants were married, 31 of the participants were single, 8 of the participants were widows and 7 of the participants were widowers. Fig 4.3 also shows that 1 participant did not indicate the marital status. The marital status had a bearing on the levels of maturity and responsibility in taking care of drinking water and the general sanitation surrounding the drinking water.

4.2.1. WATER AND SANITATION:

The researcher sought to establish the water points from the respondents with the aim of determining sanitation surrounding drinking water. The objective was that water points might have an influence on the respondent's opinions on determining potential health risks to residents from water sourced in Maloni Compound of Livingstone District. It was possible to have certain situations perceived differently by the respondents, depending on the water points. The water points in this study included shallow wells and Boreholes.

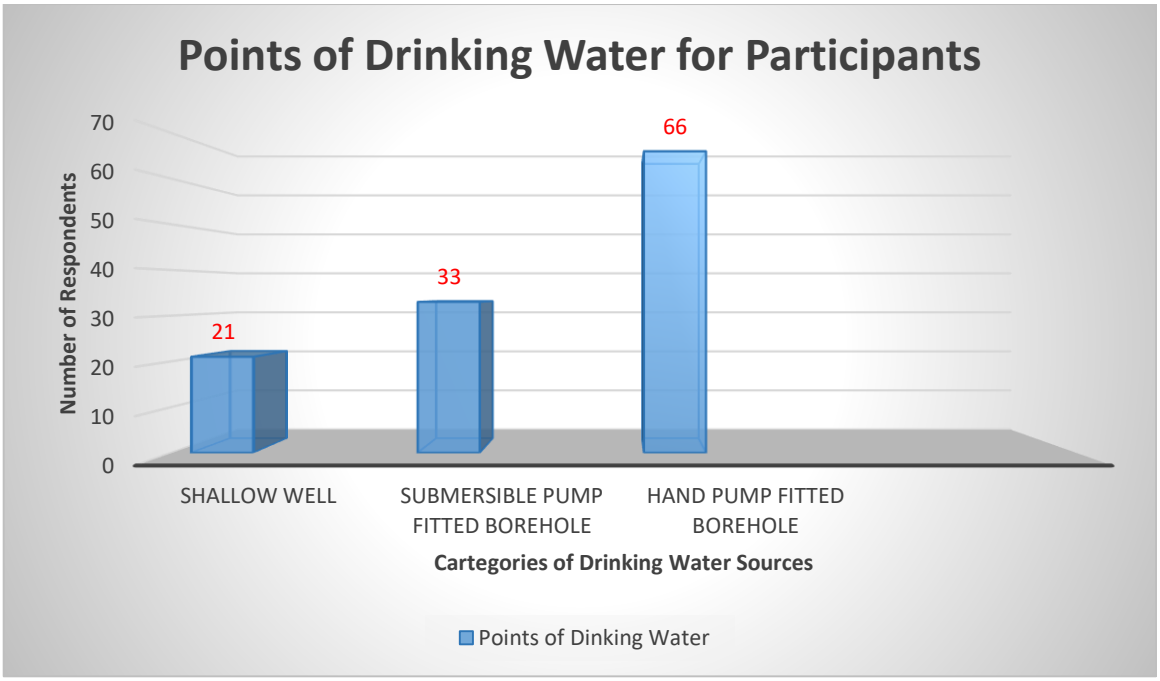

Fig4.4: Points of Drinking Water for Participants.

Fig. 4.4 shows the responses on the water points from which Maloni Compound residence draw their drinking water. According to Fig 4.4, 66 of the respondents indicated Hand pump fitted boreholes 33 of the respondents indicated Submersible pump fitted boreholes and 21 of the respondents indicated Shallow Wells. The water points in this study indicated risk status of drinking water drawn from each particular point.

4.2.2. Protection Status of Drinking Water Points:

The researcher sought to establish the protection status of drinking water from the respondents with the aim of determining safety of drinking water. The objective was that the protection status of the water sources might have an influence on the respondent's opinions on determining potential health risks to residents from water sourced in Maloni Compound of Livingstone District. It was possible to have certain situations perceived differently by the respondents depending on the protection status of the water sources.

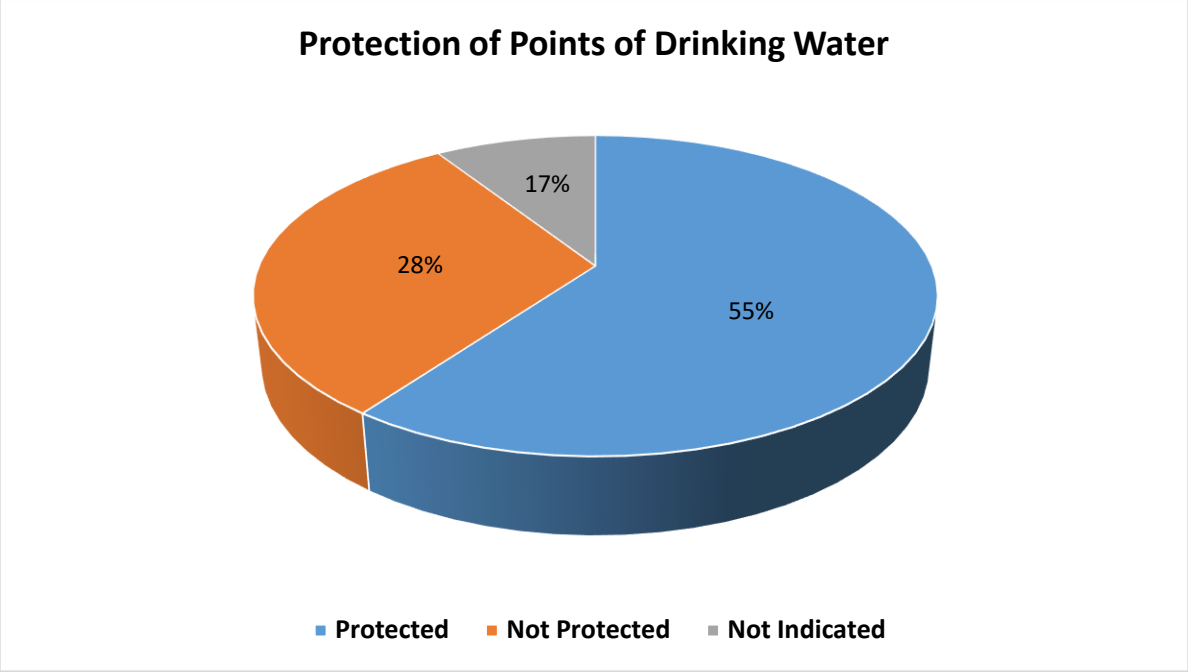

Fig4.5: Protection of Points of Drinking Water.

Fig 4.5 shows the protection status of the sources of drinking drawn from Maloni Compound in Livingstone District. According to Fig 4.5, 66 of the respondents representing 55 percent drew their drinking water from points that were protected against contamination from the surroundings, while 34 of the respondents representing 28 percent drew drinking water from points that were not protected against contamination from the surroundings. Fig 4.5 also shows that 20 of respondents representing 17 percent did not comment on whether their points of drinking water were protected or not.

4.2.3. Type of Toilet used for Disposal of Excreta:

The researcher sought to establish the types of toilets used for disposal of excreta in Maloni Compound in Livingstone District. The objective was that the type of toilet might have an influence on the respondent's opinions on determining potential health risks to residents from water sourced in Maloni Compound of Livingstone. It was possible to have certain situations perceived differently by the respondents, depending on the type of toilet used for disposal of excreta.

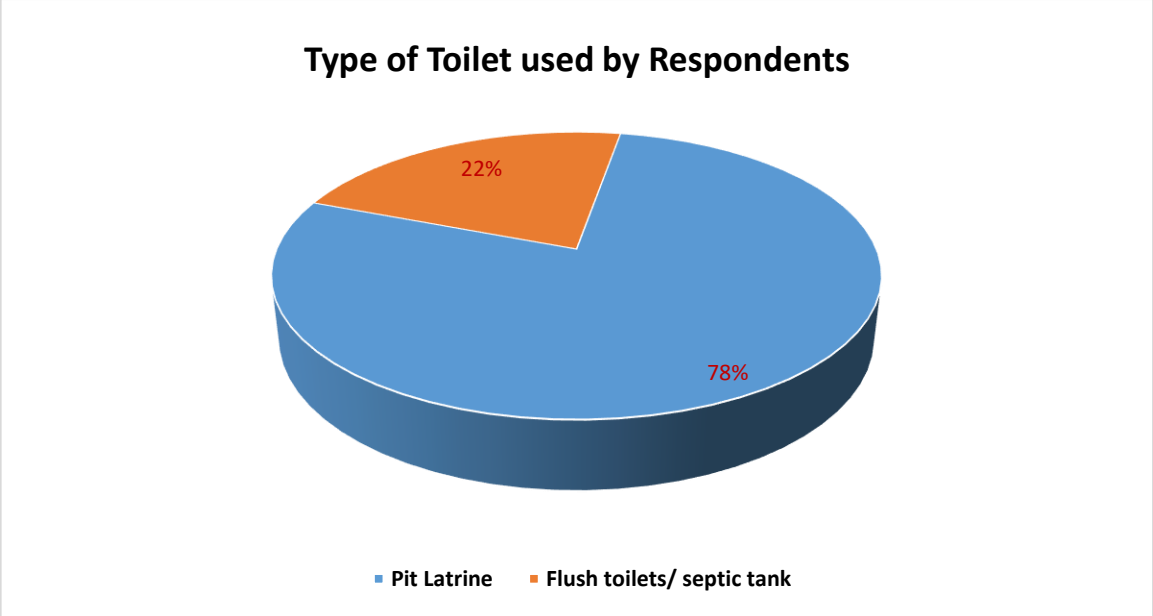

Fig 4.6: Type of Toilet used by Respondents.

Fig 4.6 shows the responses on the types of toilets used by residents of Maloni Compound in Livingstone District. According to Fig 4.6, 78 percent of the participants indicated 'Pit latrine' 22 percent of the participants indicated Flush toilets/ septic tank.

4.3. POTENTIAL HEALTH RISKS TO RESIDENTS:

The researcher sought to establish the potential health risks to residents from drinking water sources of Malone Compound in Livingstone District. The objective was that the protection status of the water sources might have an influence on the respondent's opinions on determining potential health risks to residents from water. It was possible to have certain situations perceived differently by the respondents depending on the protection status of the water sources.

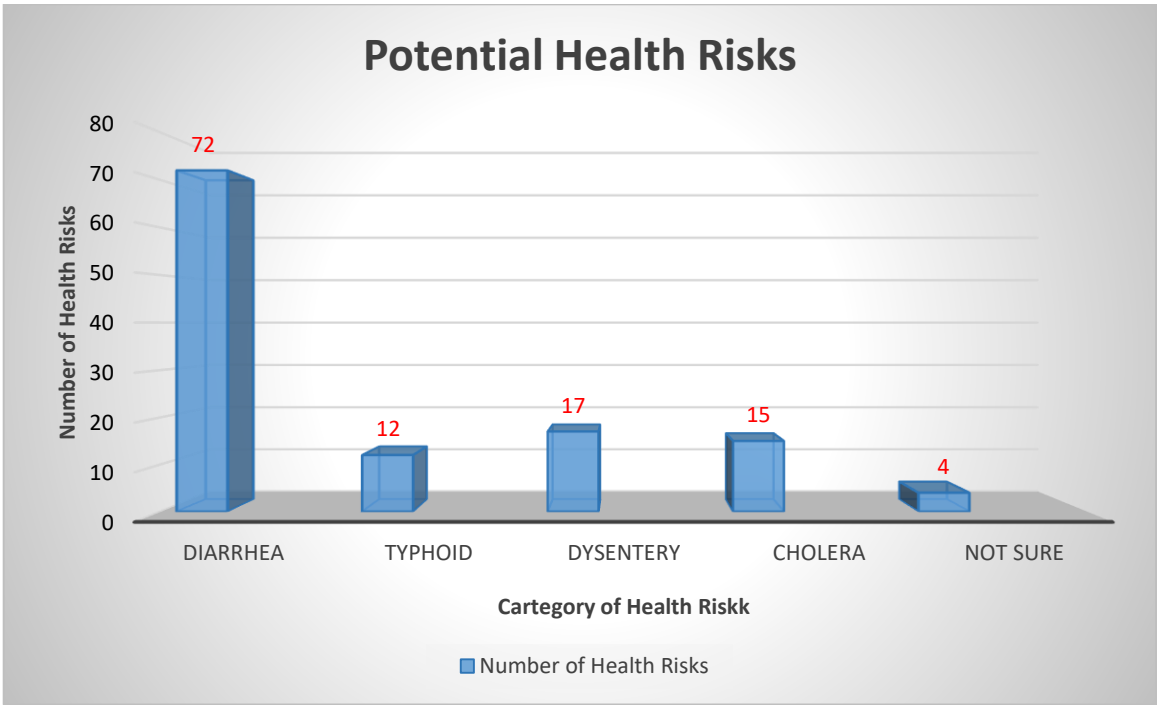

Fig 4.7: Potential Health Risks to Residents of Maloni.

Fig 4.7 shows the potential health risks to residents of Maloni Compound. According to Fig 4.7, 72 respondents indicated 'Diarrhoea', 12 respondents indicated 'Typhoid', 17 respondents indicated 'Dysentery', 15 respondents indicated 'Cholera' and 4 respondents were not sure.

4.4 WATER QUALITY MONITORING

4.4.1 Water Quality Monitoring:

S/N	Category of Response	Number of Respondents	Monitoring Organisation	Total Number of Respondents
1	Yes	23	SWASCO	23
2	No	64	N/A	64
3	Not Sure	33	N/A	33
Total				**120**

Table 4.1: Drinking Water Quality Monitoring.

Table 4.1 shows responses of the respondents on who was responsible for water quality monitoring in Maloni Compound. According to Table 4.1, 23 respondents indicated SWASCO, 64 respondents indicated no water quality monitoring and 33 respondents said that they were not sure.

Figure 4.8 below indicates the understanding of respondents regarding Water Treatment at Household Level.

4.4.2 Water treating at household level before drinking:

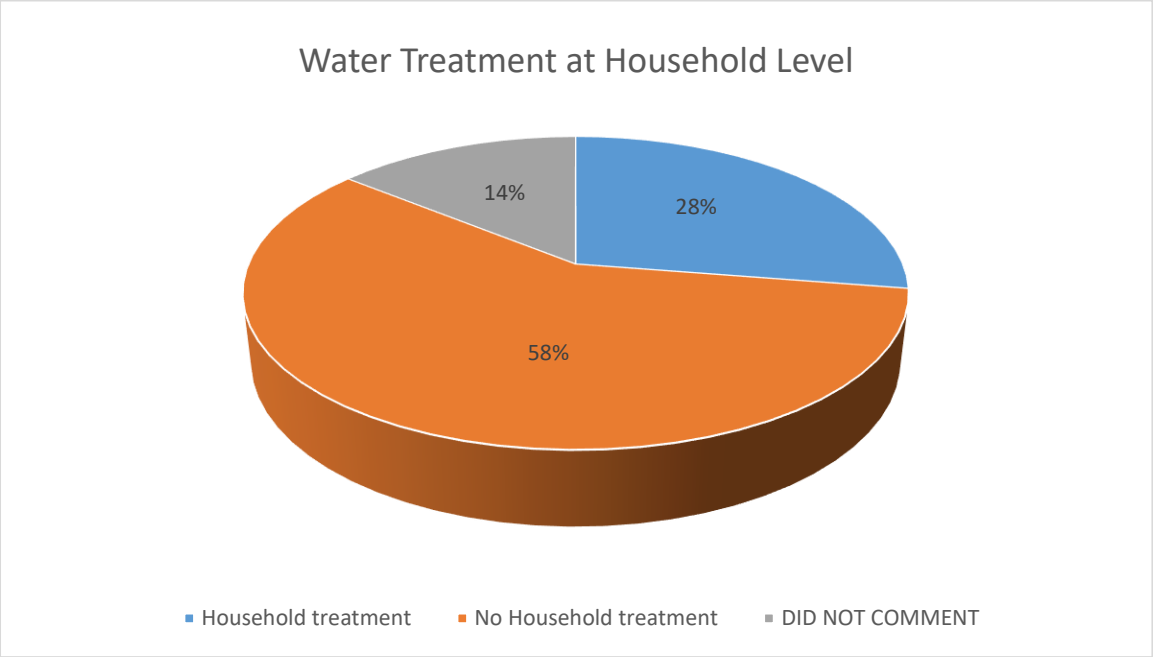

Fig 4.8: Water Treatment at Household Level.

Fig 4.8 shows responses on water treatment at house hold level. According to Fig 4.8, 70 of the respondents representing 58 percent indicated that water was not treated at household level before consumption and 33 of the respondents representing 28 percent said water was treated at household level. Fig 4.8, also shows that 17 of the respondents representing 14 percent did not indicate anything on this segment.

4.5 Drinking Water in Maloni Compound

This section is a presentation of quantitative data derived from the research questions and objectives. The data is presented through the headings and subheadings generated from research questions.

4.5.1 Types of Water Sources

Water Source	**Number**	**Percentage**
Submersible pump fitted borehole (Private Self-erected Borehole)	16	50%
Hand pump fitted boreholes (Communal)	10	31%
Shallow wells	6	19%
Total	32	100%

Table 4.2: Types of water source in Maloni Compound

Table 4.2, shows the frequency and percentage distribution of different main water sources. The first source of water supply for Maloni Compound in Livingstone District is Submersible pump fitted borehole (self-erected borehole water) (16) representing 50% of the total water sources in Maloni Compound. The second source of water is Hand pump fitted boreholes (communal borehole) (10) representing 31% of the total water sources and the least is private open well water (6) representing 19% of the total water source.

4. 6. Presence of Total Coliforms (Bactria) in entire sample

Bacteria status	Count	Percentage
Absent of total coliforms	10	31.25
Present of total coliforms	22	68.75
Water quality		
No potential health risks	10	31.25
Potential health risks	22	68.75
Total samples	32	

Table 4.3: Status of bacteria in drinking water in Maloni Compound

Table 4.3, shows the status of bacteria in water sourced in Maloni Compound of Livingstone District. A total of 32 water samples were collected from the three-water points of the cluster sample collectively. These water samples were examined for the presence of total coliforms.

In the end, the levels of the two parameters were determined so that the quality of the water in each water source and collectively could be determined. According to Table 4.3, 22 water samples indicated the presence of total coliforms and 10 water samples indicated the absence of total coliforms. The prevalence rates for the total coliforms levels and the corresponding water quality state for the entire sample was also indicated. According to Table 4.3, the majority (68.75 %) of the water samples examined contained total coliforms while about 31.25% did not contain any total coliforms.

4.7.1 Water Source and the Presence of Total Coliforms (Bacteria)

Water Source	Number		Percentage
	Collected	Bacteria Present	
Submersible pump fitted borehole (Self-erected Boreholes)	16	10	63%
Hand pump fitted boreholes (Communal hand Pumps)	10	6	60%
Shallow Wells	6	6	100%
Total Samples	32	22	69%

Table 4.4: Prevalence of bacteria in water sourced from Maloni Compound

Table 4.4 shows a comparison of bacteria levels by water points in Maloni Compound. According to Table 4.4, self-erected boreholes had 63% bacteria contamination, Hand pump fitted boreholes had 60% bacteria contamination and shallow well had 100% bacteria contamination levels.

4.7.2 Water Source and Quality of Water

Water Source	Number of water sample collected	Absence of total coliforms		Presence of total coliforms	
		Number	Percent	Number	Percent
Submersible pump fitted borehole (Self-erected borehole)	16	6	37%	10	63%
Hand pump fitted boreholes (Communal hand Pumps)	10	4	40%	6	60%
Shallow well	6	0	0%	6	100%
Total	32	10		22	

Notes: Pearson chi-square (2) = 3.85; Pr.0.05

Table 4.5: Quality of water sourced from Maloni Compound

Among the water points sampled, Hand pump fitted boreholes (communal hand pumps had more) (40%) safe water samples followed by Submersible pump fitted borehole (Tap) (37%) and then the least was shallow wells (0%) safe water. A Test to see whether there is an

association between the area and quality of water, revealed a significant relation of the two variables at 5% level of significance with a Pearson Chi-Square Test value of 3.85, with 2 degrees of freedom and a p-value of 0.05 (Table 4.5).

4.8. Summary

The chapter has presented the findings as observed and obtained from the field. These findings were presented under two parts; Part 1 consisting of Qualitative Data and Part 2 consisting of Quantitative Data. This was done in order to show clearly how the objectives of the study were addressed. Data was presented as Subheadings derived from both the research questions and objectives of the study. The headings that were derived from both the research questions and objectives include: personal data, water and sanitation, potential health risks to residents, and water quality monitoring.

CHAPTER FIVE:
DISCUSSION OF FINDINGS

5.0 Overview

The study aimed at determining potential health risks to residents from the water sourced in Maloni Compound of Livingstone District. Chapter four presented the research findings in relation to the research questions. The findings were presented under two parts: Part 1 consisting of Qualitative Data and Part 2 Quantitative Data. This chapter will discuss the research findings to address the following research questions:

i. Does water sourced in Maloni Compound of Livingstone contain bacteria?
ii. What health risks are associated with water sourced in Maloni Compound of Livingstone?

5.1 Demography of Participants:

The demography represented in Chapter Four indicated 83 female respondents representing 69% of the target population while 33 respondents representing 28% were male. The researcher observed that the demographic distribution in terms of gender balance was equivalent. The demography had an influence on the respondent's opinions on Determining Potential Health Risks to residents from water sourced in Maloni Compound of Livingstone District. The female participants were more involved in sourcing water and it was possible for them to make informed responses on the topic at hand. While it was true that few males were involved in sourcing water for drinking, their involvement made it possible to have a balanced distribution of opinions on the topic under discussion, because the male perceived certain situations differently from their female counterparts.

5.2 Level of Education of Participants:

The level of education in this study was important as it depicted the level of participants' understanding of the topic under study. According to the data presented, the majority (45) of the respondent were clustered around secondary education, followed by those that have gone through the primary level (36) and the lowest was (23) tertiary level. The findings also indicated that only 7 of the 120 participants had not passed through any level of education. The implication of the finding was that 68 participants went through secondary school and were in a better position to interpret the questionnaire and also make informed responses on the topic at hand. The level of education of the participants in this study had an influence on

respondent's opinions on Determining Potential Health Risks to residents from water sourced in Maloni Compound of Livingstone. Those above primary level of education perceived the situation differently from those below the primary levels of education. They had a deeper understanding of the topic under discussion and as such they made informed responses.

5.3 Marital Status of Respondents:

The marital status of the participants was important to the researcher as it reflected the levels of responsibility. The findings in this study revealed that the majority (73) of the participants were married. This meant that married people were capable of taking responsibility in terms of caring for surrounding areas within the water sources. It also indicated the levels of maturity and responsibility in taking care of drinking water and the general sanitation surrounding the drinking water. Marital status had an influence on respondents' opinion on determining potential health risks to residents from the water sourced from Maloni Compound in Livingstone District.

5.4 Water and Sanitation

In order to determine the status of water and sanitation in Maloni Compound, a survey was conducted to find out what types of water sources are accessed by the residents of Maloni Compound in Livingstone District. Figure 7 in Chapter 4, shows the results from the study as follows; submersible pump fitted boreholes (self-raised borehole), hand pump fitted boreholes (communal hand pumps) and shallow wells.

The results from the study show that none of the households of Maloni Compound was connected to SWASCO. All respondents interviewed representing 120 households confirmed that they were not getting any services from SWASCO. Hence the results show that residents in Maloni Compound have on-site connections to water on various other sources. This implies that the residents provide their own water for their daily usages. The SWASCO informant interviewed confirmed that SWASCO was not providing water services in most of the households in the area. This is in line with the statistics given by SWASCO (2018) which indicated that SWASCO had only less than 3,000 households connected to the conventional system, and these were mainly in the areas near Linda Compound. The failure of SWASCO to facilitate for water in the area has led to individual property owners installing onsite water facilities (submersible and hand pump fitted boreholes). During the study, the SWASCO informant revealed that Maloni Compound was among the areas selected for the

implementation of the Livingstone Water Supply, Sanitation and Drainage Project (LWSSD). He further explained that;

> *The water sanitation project was established under the laws of Zambia as a company limited by guarantee as an entity to implement the Livingstone water supply, sanitation and drainage project funded by Johnny Levers. The project is for duration of five years and it comprised of the implementation of the Water Supply, Sanitation and Drainage Project. The objective of the project was to expand access to, and improve the reliability of, water supply and sanitation, and improves drainage services in Maloni Compound in order to decrease the incidence of water-borne and water-related diseases and generate time savings for households. In so doing, the Public Health Status of the residents will be ensured.*

According to the information released during the interview, it is expected that residents will be connected to SWASCO metered water once the projects are completed. Therefore, there is need to conduct further studies in the area that will analyse how the residents will respond to the metered water from SWASCO since most households have boreholes.

The researcher sought to find out the water sanitation status of Maloni Compound in a quest to determine the potential health risks to the residents. The study showed that SWASCO was not providing sanitation services to Maloni Compound. This was confirmed during an interview with the SWASCO informant (25th August, 2022) who acknowledged that the utility company had challenges providing sanitation services because of the treatment plants that were already overwhelmed, and that sanitation projects were very expensive because most of the sanitation systems had to be run by gravity. This is also shown in a report by UNESCO *et al.,* (2004) who noted that centralized networks are very cost-intensive in terms of construction, operation and maintenance.

The study earlier indicated that residents in Maloni compound use on-site sanitation options. According to the results, 78 percent of the respondents used pit latrine and 22 used flush toilets. The majority of households were found to be using pit latrines which are viewed as not ideal and therefore not convenient sanitary facilities in urban areas. The users of flush toilets were also found to be connected to boreholes, this was in line with the study conducted by done Tipping *et al.,* (2005) who states that a little more than half of the households with piped water also have flush toilets, which are often connected to septic tanks rather than to sewers. It was observed during the study that most of the pit latrines were more temporary in

nature as most of the houses with pit latrines were occupied by care takers who were only occupying the houses until the landlords were ready to occupy them. The study observed also that most houses that used pit latrines did not have running water but sourced their water from either hand pumps fitted borehole, shallow well or neighbours' submersible pump fitted boreholes.

Due to the absence of a sewerage system in Maloni Compound, most of the sanitation facilities in the area are connected to septic tanks, which is common for areas with on-site sanitation. However, more often than not, this arrangement has potential health risks to the residents and causes a negative impact on the environment. The study revealed that there was an increased concentration of total coliforms (bacteria) in groundwater near onsite sanitation systems. Further, literature reveals that the safe distance between on-site sanitation units and groundwater supply sources should not be less than 30 meters (Bulaya *et al*, 2017). For Maloni Compound, most households occupy plots measuring 30x20 metres, with over 50 percent of the households using boreholes. This makes the threat of ground water contamination real.

While respondents revealed that water quality monitoring was done in Maloni Compound, most of them indicated that water quality monitoring fell below the ZABS (2010) and WHO (2010) guidelines for drinking water. For example, the high percentages of total coliforms give a direct indication that interventions on reducing the bacteria content was not done (i.e., Table 4.1 in Chapter 4). This failure to make intervention may be due lack of knowledge of high total coliform content in the drinking water sourced from Maloni Compound.

5.5 Drinking Water Sources in Maloni Compound

The findings indicate that most of the people 81 percent in the study areas have access to water, mostly from submersible and hand pumps fitted boreholes. This finding agrees with Chaisa (2014), who showed that the source of domestic water supply for about 90 percent of these peri urban areas is piped water.

5.5 Drinking Water quality in Maloni Compound

The projects by the water utility company are very cardinal because not only do the results of this study indicate a deficit in the quantity of drinking water supply, the findings also show that all the water samples collected either had faecal or total coliforms, or both. This may further be explained by the findings that indicate that 100% of the water used from the shallow wells was of very poor quality and most of the water used from submersible pump

fitted boreholes (63%) was of poor quality. The pollution of this source of water is because of the on-site sanitation most commonly used in Maloni Compound of Livingstone District, which may lead to cross-contamination of the water sources. The findings also indicate that even water from Hand pump fitted boreholes is contaminated, with about 60% being of poor quality. These results are in conflict with the standards set by the WHO (2008) that domestic water should contain zero faecal and total coliform. This could be as a result of having on-site sanitation facilities that are close to water sources. The problem of on-site sanitation facilities in Maloni Compound is further compounded by the fact that most of the residents (70%) do not treat their water either with chlorine or by boiling before use in the home. This lack of treatment of the contaminated water may be responsible for the high prevalence of diarrheal diseases in Maloni Compound of Livingstone District. This also is in line with the findings by Chege and Agha (1999), who indicated that the lack of treatment of the contaminated water may be responsible for the high prevalence of diarrheal diseases in low-income urban neighbourhoods of Zambia.

CHAPTER SIX:
CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

This chapter presents the conclusions and recommendations of this study. The recommendations can be adopted to address the situation in Malone Compound and other residential areas in similar circumstances. They can also inform future developments and give guidance to government policies on planning for water and sanitation in peri-urban areas.

6.2 Conclusions

The study was aimed at investigating the presence of bacteria in drinking water in relation to the prescribed standards by WHO and ZABS. The standards of WHO and ZABS state that drinking water should not contain any bacteria (WHO, 2011). The researcher also examined the potential health risks associated with the quality of water sourced in Maloni Compound of Livingstone District of Southern Province in Zambia.

The study revealed that water in Maloni compound was sourced from boreholes, and shallow wells. The study further revealed that residents of Maloni Compound used on site sanitation systems, namely pit latrines and septic tanks. It also revealed that water sourced from Maloni Compound had the presence of bacteria with a relatively high total coliforms and faecal coliforms contamination, compromising the public health status of the residents of Maloni Compound. The study also revealed that this status was facilitated by the incapacity of SWASCO to meet the current demand for its services.

Section 6.3 below recommends measures that can be adopted to improve the situation in Maloni Compound.

6.3 Recommendations

In order to improve water and sanitation service delivery in planned urban areas and to reduce unsustainable methods of on-site water and sanitation, there is need for collaboration between different institutions in order to develop technologies, systems and policies that will improve water and sanitation provision. The study therefore recommends the following;

1. Water and Sanitation Stakeholders

v. There is need for collaboration of various stakeholders up to the consumer level during the planning and implementation stage of urban and peri urban areas, to ensure

that the allocation of residential plots is done simultaneously with the provision of necessary services such as water and sewerage reticulation systems.

2. SWASCO and Urban Planners

vi. There is need for SWASCO to directly provide water to existing residents of Maloni and to facilitate decommissioning of all contaminated water sources.

vii. There is need for urban Planners and SWASCO to encourage households to also employ alternative methods in the water sector such as rain water that can be stored and used for flushing toilets.

3. To Central and Local Government

viii. There is need to formulate policies in water and sanitation, planning and in infrastructure design that will encourage research and development of innovations and technologies that will apply to our local scenario.

6.4 Concluding Remarks

The study set to investigate the presence of bacteria in the water sourced from Maloni Compound of Livingstone District in Zambia. It also sought to examine the potential health risks associated with the quality of water sourced in Maloni Compound. The constructions of the research were that the absence of bacteria in the water sourced in Maloni Compound as stipulated by WHO and ZABS standards indicate safe drinking water and consequently no potential health risks. The presence of bacteria in water sourced in Maloni Compound indicated unsafe drinking water and as a consequence, an indication of potential health risks (see the Conceptual Framework on page 5).

The findings in this research indicate that drinking water sourced from Maloni Compound contained bacteria. The researcher fulfilled objectives of the research raised in chapter one (1) of this study. Since the study findings indicated the presence of bacteria in drinking water sourced from Maloni Compound, there is need to conduct a further study that will focus on the specific bacteria responsible for diarrhoea cases among residents of Maloni Compound of Livingstone District of Southern Province in Zambia.

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APPENDICIES

Appendix A: Participant Information Sheet

INFORMATION SHEET

DETERMINING POTENTIAL HEALTH RISKS TO RESIDENTS FROM WATER SOURCED IN MALONI COMPOUND OF LIVINGSTONE DISTRICT IN ZAMBIA

INFORMED CONSENT TEMPLATE FOR INTENDING RESEARCHERS

Title of the proposed study:
DETERMINING POTENTIAL HEALTH RISKS TO RESIDENTS FROM WATER SOURCED IN MALONI COMPOUND OF LIVINGSTONE DISTRICT IN ZAMBIA

Investigators: KAMUNGA MUKWASA
P.O. Box 60682, Livingstone
Cell: 0968061671

Background and rationale for the study:
Maloni Compound is characterized by a growing population that in turn increases poor sanitation. The poor sanitation is activated by lack of piped water supply, unplanned sewer system and indiscriminate dumping of waste because most of the residents have limited finance for extending water supply and sanitation services to their unplanned settlement. Human health is directly affected by the consumption of polluted water. Polluted water has direct negative impacts on the Maloni residents.

It is therefore expected that results of this study will be beneficial to the government because it will show the public health status of the residents of Maloni compound. The study may also benefit the Ministry of Health (MoH) in terms of allocating resources to Maloni Compound especially during the rainy seasons. It may also suggest the use of simplified traditional methods of treating water for drinking at household level. The study is predicted to provide information for community water planning and reduction of water related health risks.

Purpose:

The purpose of the research is to collect data on determining potential health risks to residents from water sourced in Maloni compound of Livingstone District of Zambia. The aim is to detect the presence of bacteria in drinking water and to find out health risks associated with the quality of drinking water in Maloni Compound of Livingstone District of Zambia.

Procedures:

The investigator will administer the questionnaire to the participants in their respective households for qualitative primary data collection. The involvement of participants will be at the point of responding to the questionnaire.

Who will participate in the study?

The 120 sampled residents (water users) of Malone Compound in the sampled clusters will participate in the study. These need to have been residents of Maloni Compound for at least one year and are adult (18 years and above) members of a household who may provide information on their perception about potential health risks from the drinking water sourced in Maloni compound. Each participant is expected to take between 20 to 25 minutes to answer the questions.

Risks/Discomforts:

Participants are likely to experience a discomfort that they risk having their identities disclosed in the study. As they interact with the researcher in answering the questionnaire, they also risk contracting Covid-19 if national Public Health guidelines such as social distancing are not observed.

Benefits:

It is anticipated that the community will have improved water quality monitoring and supply that will lead to improved public health status among residents of Maloni Compound. The study is also envisaged to provide information that may give insights for further research.

Alternatives:

Participants will be informed that participation in the study is not mandatory; they may decide to stop at their will if they so wish. If such a situation occurs, the investigator may decide to closely observe the activities of the residents in order to collect the qualitative data.

Cost:

In this study, there will be no cost for the participants since the information will be sourced from participant's households.

Compensation for participation in the study:

Participants will not be taken away from their households and this setting reduces risks in terms of contracting diseases and injury. in case of the unfortunate circumstances happening, the investigator will provide resources to facilitate treatment of such health-related outcome.

Reimbursement:

In this particular study, participants will not need to travel. Instead, the investigator will have to follow the research participants in their respective households.

Questions:

The investigator will travel to the specific households where participants will be found and if participants have study-related questions, the investigator will answer such questions within those places.

Questions about participants rights:

Participants who have questions about their rights as research participants can ask the investigator during the time of engagement and their queries will be addressed.

Statement of voluntariness:

Participation in this study is voluntary and participants may take part on their own free will. Participants also have a right to withdraw from the study at any time without a penalty.

Confidentiality:

The results of this study will be kept strictly confidential, and used only for research purposes. My identity will be concealed in as far as the law allows. My name will not appear anywhere on the coded forms with the information. Paper and computer records will be kept under lock and key and with password protection respectively.

The interviewer has discussed this information with me and offered to answer my questions. For any further questions, I may contact the Chairperson, UNZABREC on the following details;

+260 1 256067 or email: unzarec@unza.com

Appendix B: STATEMENT OF CONSENT/ASSENT

STATEMENT OF CONSENT/ASSENT

..... has described to me what is going to be done, the risks, the benefits involved and my rights regarding this study. I understand that my decision to participate in this study will not alter my usual medical care. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Name.…….Signature / Thumb print of participant ……. Age ..……..Date (DD/MM/YY)……

Name of Witness …… Signature / Thumb print of Witness …… Date (DD/MM/YY)…….

Name:…… Signature print of parent or guardian for minors……..…… Date(DD/MM/YY)……

Name……..Signature of Interviewer ……. Date (DD/MM/YY)……...

If you have any further questions please contact the University of Zambia Biomedical Research Ethics Committee

Telephone: +260977925304
Telegrams: UNZA, LUSAKA
Telex: UNZALU ZA 44370
Fax: + 260-1-250753
E-mail: unzarec@unza.zm

Ridgeway Campus
P.O. Box 50110
Lusaka, Zambia

Assurance No. FWA00000338 IRB00001131 of IOR G0000774

Appendix C: PARTICIPANT RECRUITMENT PROCEDURE

Good day.

I am a student at the University of Zambia carrying out an academic research entitled: Determining the potential health risks to residents from water sourced in Maloni compound of Livingstone District in Zambia.

The study is envisaged to provide baseline data for community water planning and reduction of water related health risks.

The study seeks to recruit participants who will provide information about their source of drinking water. Participation is voluntary and no payment will be made in any form. The research is taking place in Maloni Compound in Livingstone District of Zambia.

To be eligible to participate in this study, you must meet the following criteria:

1. Be an adult aged 18 years and above
2. Be a resident of the study area for at least 1 year.

Do you meet the criteria stated above? Yes ☐ No ☐

Are you willing to participate in the study? Yes ☐ No ☐

If the participant meets the inclusion criteria and agrees to participate in the study, proceed to consent.

Appendix D: Research Questionnaire

QUESTIONAIRE FOR RESIDENTS OF MALONI

A. PERSONAL DATA

LEVEL OF EDUCATION: ☐ Primary, ☐ Secondary, ☐ Tertiary, ☐ None

MARITAL STATUS: ☐ Married, ☐ Single, ☐ Widow, ☐ Widower

SEX: ☐ Male, ☐ Female.

NUMBER OF HOUSEHOLD MEMBERS: ☐

OCCUPATION: ☐ Employed, ☐ Trader, ☐ Farmer, ☐ Other

B. WATER AND SANITATION

1. Where is your main source of drinking water?
   i. Personal shallow well? ☐ Yes, ☐ No.
   ii. Communal shallow well? ☐ Yes, ☐ No.
   iii. Personal Borehole? ☐ Yes, ☐ No.
   iv. Public Hand pump Borehole? ☐ Yes, ☐ No.
2. Is the water source protected against contamination from the surrounding?
   i. If yes, is the well properly covered on top? ☐ Yes, ☐ No.
3. Do you use Pit latrine or a soak-away for your toilet?

   Pit latrine ☐

   Soak-away ☐

   For any of the above give a reason……

3. Do you have a regulated sewer systems for waste water? ☐ Yes, ☐ No.

C. POTENTIAL HEALTH RISKS TO RESIDENTS

4. In your view, what are the potential health risks to residents resulting from water sourced in Maloni Compound?
   i. ……
   ii. ……
   iii. ……
   iv. ……

v. ……

D. WATER QUALITY MONITORING

5. Is the quality of water from this source monitored? ☐ Yes, ☐ No, ☐ Not sure

i. If yes, Name the organizations that monitor the quality of water from this source.

……

ii. How often is the quality of water from this source monitored?

3 Months ☐ , 6 Months ☐ , 9 Months ☐, 12 Months ☐

6. Do you treat the water at home before drinking? ☐ Yes, ☐ No.

i. If yes, how? ☐ Chlorine, ☐ Boiling, ☐ Others (…….)

ii. Are there any health risks for drinking untreated water?

Yes ☐, No ☐

If yes: Name the health risks associated with drinking untreated water

i. ……

ii. ……

iii. ……

iv. ……

v. ……

End of Interview.

thank you for your time.

Appendix E: Research Budget

S/N	Research Items	Tentative Budget		
		Quantity	Unit Price (K)	Total (K)
A	**Proposal Development**			
1	Note Pad	1	15.00	15.00
2	Transport cost for survey	1	200.00	600.00
3	Pen	1	3.00	3.00
4	Ream of Paper	1	75.00	75.00
5	Ruler	1	10.00	10.00
6	Water resistant Marker	3	30.00	90.00
7	Printing and binding of the Research Proposal	1	75.00	75.00
Sub-total				**K280.00**
B	**Data Collection**			
1	Transport to facilitate Primary data collection	3	300.00	900.00
2	Printing of Letter of Consent	3	5.00	15.00
3	Printing of Sample label tags	1	1.00	1.00
4	Photocopying of Sample label tags	30	2.00	60.00
5	Ethanol 70% v/v	1	700.00	700.00
6	Alcohol wipes or pads or cotton wool	1	450.00	450.00
7	Sterile 500 ml sampling bottles	30	20.00	600.00
8	Aluminum foil	3	100.00	300.00
9	Permanent or water-resistant marker	3	15.00	45.00
10	Cooler box with ice packs	1	600.00	600.00
11	Blow lamp	1	100.00	100.00
12	Matches/ lighters	2	10.00	20.00
13	Sterile gloves	3	150.00	450.00
14	Transportation of samples	300	3.00	900.00
Sub-total				**K5,141.00**
C	**Data Analysis and report writing**			
1	Laboratory analysis	24	1,360	32640
2	Post laboratory analysis and report production	3	500	1500
Sub-total C				**K34,140.00**
Total Expenditure				**K39,281.00**
Contingency @ 10%				**3,928.10**
Grand Total				**K43, 209.10**

Appendix F: Research Timeframe

Phase	Activities	Study Timeframe (2022)																																	
		February				March				April				May				June				July				August				September				October			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Research Proposal development	Developing a research proposal																																				
Primary and secondary data collection	Collection of data																																				
Processing of data	Analysis and presentation of data																																				
	Discussion of findings																																				
Report writing	Compiling and submitting draft report																																				
Final dissertation submission	Submitting Final dissertation.																																				

Appendix G: Introductory Letter

THE UNIVERSITY OF ZAMBIA
SCHOOL OF PUBLIC HEALTH

Telephone: +260-1-290258
Fax: +260-1-290258
E-mail assistantdeanpgsoph@unza.zm

P O Box 50110
Lusaka, Zambia

12th May, 2022

The Director
Livingstone District Health Office
Livingstone

Dear Sir/Madam,

SUBJECT: INTRODUCTORY LETTER – Kamunga Mukwasa

Reference is made to the above subject matter.

Am writing to introduce Mr. Kamunga Mukwasa who is pursuing his Second year MPH – Environmental Health programme in the School of Public Health. Mr. Mukwasa would like to collect data for his study entitled ***"Determining the potential health risks to residents from water sourced in Maloni Compound, Livingstone".***

This mail serves to introduce Mr. Mukwasa and request that he be granted authority to collect data in the district.

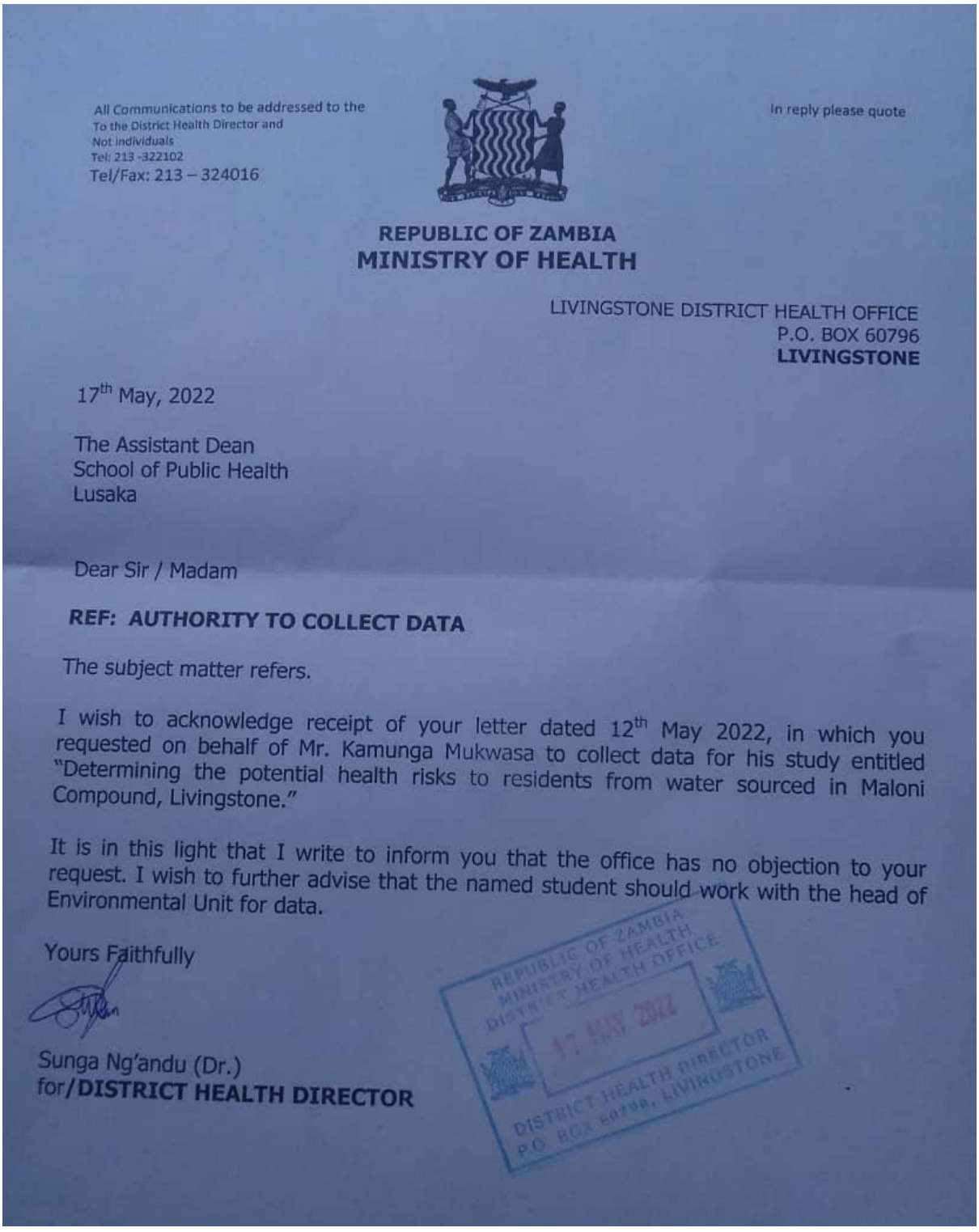
Your positive response will be highly appreciated.

Doreen C Sitali (PhD)
ASSISTANT DEAN (PG), SCHOOL OF PUBLIC HEALTH

Cc Assistant Registrar – School of Public Health

UNIVERSITY OF ZAMBIA SCHOOL OF PUBLIC HEALTH ASSISTANT DEAN POSTGRADUATE P.O. BOX 50110 RW, LUSAKA. 12 MAY 2022

Appendix H: Authorisation Letter



All Communications to be addressed to the
To the District Health Director and
Not individuals
Tel: 213 -322102
Tel/Fax: 213 – 324016

In reply please quote

REPUBLIC OF ZAMBIA
MINISTRY OF HEALTH

LIVINGSTONE DISTRICT HEALTH OFFICE
P.O. BOX 60796
LIVINGSTONE

17th May, 2022

The Assistant Dean
School of Public Health
Lusaka

Dear Sir / Madam

REF: AUTHORITY TO COLLECT DATA

The subject matter refers.

I wish to acknowledge receipt of your letter dated 12th May 2022, in which you requested on behalf of Mr. Kamunga Mukwasa to collect data for his study entitled "Determining the potential health risks to residents from water sourced in Maloni Compound, Livingstone."

It is in this light that I write to inform you that the office has no objection to your request. I wish to further advise that the named student should work with the head of Environmental Unit for data.

Yours Faithfully

Sunga Ng'andu (Dr.)
for/**DISTRICT HEALTH DIRECTOR**

REPUBLIC OF ZAMBIA
MINISTRY OF HEALTH
DISTRICT HEALTH OFFICE
17 MAY 2022
DISTRICT HEALTH DIRECTOR
P.O. BOX 60796, LIVINGSTONE

Appendix I: UNZABREC Feedback

UNIVERSITY OF ZAMBIA
BIOMEDICAL RESEARCH ETHICS COMMITTEE

Telephone: +260 977925304 Ridgeway Campus
Telegrams: UNZA, LUSAKA P.O. Box 50110
Telex: UNZALU ZA 44370 Lusaka, Zambia
Fax: + 260-1-250753 E-mail: unzarec@unza.zm
Federal Assurance No. FWA00000338 IRB00001131 of IORG0000774 NHRAR-REC No 2021-05-0002

12th July, 2022

Your REF. No 2859-2022

Mr. Kamunga Mukwasa,
University of Zambia,
School of Public Health,
P.O Box 50110,
Lusaka.

Dear Mr. Mukwasa,

RE: DETERMINING POTENTIAL HEALTH RISKS TO RESIDENTS FROM WATER SOURCED IN MALONI COMPOUND OF LIVINGSTONE (REF. NO. 2859-2022)

The above-mentioned research proposal was presented to the Biomedical Research Ethics Committee on 11th July, 2022. The proposal is **approved**. The approval is based on the following documents that were submitted for review:

a) Study proposal
b) Questionnaires
c) Participant Consent Form

APPROVAL NUMBER : REF. 2859-2022
This number should be used on all correspondence, consent forms and documents as appropriate.

i. **APPROVAL DATE : 12th July 2022**
ii. **TYPE OF APPROVAL : Standard**
iii. **EXPIRATION DATE OF APPROVAL : 11th July 2023**
iv. After this date, this project may only continue upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the UNZABREC Offices should be submitted one month before the expiration date for continuing review.
v. **SERIOUS ADVERSE EVENT REPORTING**: All SAEs and any other serious challenges/problems having to do with participant welfare, participant safety and study integrity must be reported to UNZABREC within 3 working days using standard forms obtainable from UNZABREC.
vi. **MODIFICATIONS**: Prior UNZABREC approval using standard forms obtainable from the UNZABREC Offices is required before implementing any changes in the Protocol (including changes in the consent documents).

vii. **TERMINATION OF STUDY**: On termination of a study, a report has to be submitted to the UNZABREC using standard forms obtainable from the UNZABREC Offices.

viii. **NHRA:** You are advised to obtain final study clearance and approval to conduct research in Zambia from the National Health Research Authority (NHRA) before commencing the research project.

ix. **QUESTIONS**: Please contact the UNZABREC on Telephone No. +260977925304 or by e-mail on unzarec@unza.zm.

x. **OTHER**: Please be reminded to send in copies of your research findings/results for our records. You are also required to submit electronic copies of your publications in peer-reviewed journals that may emanate from this study. Use the online portal: unza.rhinno.net for further submissions.

Yours sincerely,

Sody Mweetwa Munsaka, BSc., MSc., PhD
CHAIRPERSON
Tel: +260977925304
E-mail: s.munsaka@unza.zm

Appendix J: NHRA Feedback

NATIONAL HEALTH RESEARCH AUTHORITY
Paediatric Centre of Excellence, University Teaching Hospital, P.O. Box 30075, LUSAKA
Chalala Office Lot No. 18961/M, Off Kasama Road, P.O. Box 30075, LUSAKA
Tell: +260211 250309 | Email: znhrasec@nhra.org.zm | www.nhra.org.zm

Ref No: NHRA0000007/04/08/2022 **Date: 4th August, 2022**

The Principal Investigator,
Kamunga Mukwasa,
University of Zambia,
Lusaka, Zambia

Dear Mr. Mukwasa,

Re: Request for Authority to Conduct Research

The National Health Research Authority is in receipt of your request for ethical clearance and authority to conduct research titled **"Determining Potential Health Risks to Residents from Water Sourced in Maloni Compound of Livingstone District in Zambia".**

I wish to inform you that following submission of your request to the Authority, our review of the same and in view of the ethical clearance, this study has been **approved** on condition that:

1. The relevant Provincial and District Medical Officers where the study is being conducted are fully appraised;
2. Progress updates are provided to NHRA quarterly from the date of commencement of the study;
3. The final study report is cleared by the NHRA before any publication or dissemination within or outside the country;
4. After clearance for publication or dissemination by the NHRA, the final study report is shared with all relevant Provincial and District Directors of Health where the study was being conducted, University leadership, and all key respondents.

Yours sincerely,

Prof. Godfrey Biemba,
Director/CEO,
National Health Research Authority