ASSESSMMENT OF THE PREVALENCE AND TRENDS OF WATERBORNE/VECTORBORNE DISEASES: A CASE OF KALUSA VILLAGE, TRADITIONAL AUTHORITY MALENGACHANZI, NKHOTA-KOTA DISTRICT

MSc (ENVIRONMENTAL SCIENCE) THESIS

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UNIVERSITY OF MALAWI
CHANCELLOR COLLEGE

JULY, 2014

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MSc (ENVIRONMENTAL SCIENCE) THESIS

By

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BSc (Environmental Science)-University of Malawi

Thesis Submitted to the Faculty of Science, in partial fulfillment of the requirement for Master of Science Degree in Environmental Science

UNIVERSITY OF MALAWI

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JULY, 2014

DECLARATION

I, Chikondi Precious Chabvuta, declare that this thesis is my own work and that, wherever other people's work has been used, reference has been appropriately made. I further declare that, to the best of my knowledge; it has not been concurrently submitted in candidature to this or any other university for any academic award.

Chikondi Precious Chabvuta

Signature : ________________________________

Date : ________________________________

CERTIFICATE OF APPROVAL

We declare that this thesis is the result of the candidate's own work and that where assistance has been sought, this has been acknowledged and that this thesis has been submitted with our acceptance.

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PREFACE

Water is life, usually ignored and not included in developmental work; without its safe availability, life would cease to exist.

DEDICATION

I dedicate this work to my mum and dad, my best friend Kumbukani Mkawa, my siblings, Tamanda Chabvuta, Pempho Chabvuta, Zaithwa Chabvuta and Annie Chabvuta. Thank you all for your unconditional support throughout the duration of the Masters programme. God bless you.

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ABSTRACT

Water borne diseases are prevalent despite several interventions to reduce these diseases like diarrhoea, dysentery, Malaria and bilharzia which are caused by several factors globally and in Malawi. The general objective of the study was to assess prevalence and trend of water borne diseases with relation to sanitation practices and water quality. The study was conducted in Kalusa village, Group Village Headman Kalimanjira, TA Malengachanzi, Nkhota-kota. There were a total of 12 water sources in the village, only 7 were working. The methodology includes secondary data collection from health centres, GPS mapping to come up with GIS points for water points and toilet facilities, questionnaire, and water quality tests of selected water parameters. Results indicated that the communities attributed that there was an increase in waterborne diseases and the water related vector borne disease Malaria despite several efforts to curb this. A lot of the water points that were perceived as safe water points i.e. tap water were either not functioning or the water is intermittent in distribution. Water contamination leading to a lot of waterborne diseases could be caused by water handling or perhaps this could be researched further. With lack of previous data to compare and contrast the results, perhaps the water is always highly contaminated or perhaps this is a new trend.

Water quality parameters were in the unsafe ranges for consumption according to Malawi standards and no trends were unravelled due to lack of historical data; however, the temporal bacteriological data obtained suggested that water contamination might lead to water borne diseases.

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LIST OF ABBREVIATIONS AND ACRONYMS

3D	3 Dimensional
APHA	American Public Health Association
EC	Electrical Conductivity
FCU	Fecal Coliforms Unit
FGD	Focus Group Discussions
GHI	Gross Household Income
GIS	Geographical Information Systems
HCl	Hydrochloric Acid
KCl	Potassium Chloride
MDG	Millennium Development Goals
NSO	National Statistical Office
PGIS	Participatory Geographical Information Systems
pH	Potential Hydrogen
SMI	Specialty Minerals Inc.
TDS	Total Dissolved Solids

TSS	Total Suspended Solids
UNICEF	United Nations Children's Fund
UV/VIS	Ultraviolet-Visible Spectroscopy
VRBA	Violet Red Bile Agar
WHO	World Health Organization
CFU	Colony Forming Units
MBS	Malawi Bureau of Standards

CHAPTER 1

INTRODUCTION

This chapter is the general introduction which outlines the problem under study, the study significance and the objectives the study sought to achieve. It introduces the topics of waterborne diseases, prevalence of the diseases, the trends and their relation to map out a model of the diseases in 10 years' time. It looks at the research from a global perspective to the local context. Prevalence of waterborne diseases is looked at from the availability of the disease; it's commonness in the areas. Waterborne diseases are defined in this thesis as the diseases that are transferred through water bodies, water channels. Sanitation is defined as the practices and behaviors with the public health of households and communities.

1.1 Background

Water borne diseases are rampant and this sector is facing a lot of challenges including diseases emanating from poor sanitation, water shortage and pollution, and lack of proper sanitation options (Winblad, 2004). Many areas in Africa, Malawi inclusive are affected by water pollution and microbial water-bound contaminants like Cholera (SMI, 2005). The increased demand for safe drinking water supplies have often led to water that is unfit for human consumption. Where river water or wells downstream are consumed there is usually upstream contamination, through human defecation during fishing activities or lack of proper sanitation facilities in households; and human use (washing of clothes, dishes, bathing) which is an important consideration for water quality determination (Winblad, 2004).

Challenges to meeting the Millennium Development Goals (MDG) number 7 targets 1 is to ensure environmental stability and to reduce by half the proportion of people without sustainable stability access to safe drinking water (UNICEF, 2000) including lack of safe water points, and insufficient sanitation facilities for the majority of the rural population.

The majority of the rural population lack access to safe water points or has inadequate water sources like boreholes, protected shallow wells and stand taps in isolated instances. In addition, sanitation facilities are inadequate creating a challenge in meeting MDG target 10 which is targeting to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation Sachs *et al* (2005).
Water can be contaminated in so many ways and it is a huge challenge for the health of human beings which leads to a lot of waterborne disease outbreaks where cholera, diarrhoea and other water related ills can be manifested Costello *et al*, (2009).

1.2 Statement of the Problem and significance

Malengachanzi has more boreholes than other traditional areas in Nkhota-kota. However, this has not effectively improved the situation as most of the boreholes were drilled without considering the geographic variations like slope and groundwater hydrological systems and most of them are no longer functioning (Nkhota-kota district profile, 2010).

Furthermore, sanitation is a neglected aspect of development in countries where spending is limited, and where many other priorities crowd the agenda (World Bank, 2008). The unavailability of safe water is a challenge in most villages in Malawi and this was explored in Kalusa village, TA Malengachanzi, Nkhota-kota against the set standards for the country. The lack of safe water facilities leads to waterborne diseases due to poor sanitation practices; hence, this study was set to explore this by measuring the water quality parameters and their impact on diseases by measuring the prevalence and incidence rates of waterborne diseases; Cholera, Dysentery, Diarrhoea, and Malaria.

1.3 Objectives of the study

1.3.1 General objective: The general objective of the study was to evaluate prevalence and trend of water borne diseases with relation to sanitation practices and water quality

1.3.2 Specific Objectives of the study

Specifically, the objectives of the study are to:

1 Examine the prevalence of common waterborne diseases in the area

2 Map out the trend of prevalence of common waterborne diseases such as cholera, diarrhoea, dysentery and water related insect vector borne Malaria

3 Document available water points and sanitation facilities in the area in order to determine their distribution and accessibility

4 Measure physical and biochemical quality of water from sampled water points in the area

5 Document perceptions regarding the link between waterborne diseases and poor hygiene

1.4 Research Hypotheses

In order to address the specified research objectives, the study answered the following null hypotheses.

1. There are no linkages between prevalence of waterborne diseases and sanitation
2. There are no linkages between location of safe sanitation, its proximity to safe water and the location of sanitation facilities

1.5 Research Variables

In this research, the following were treated as intervening variables.

1. Access/availability of safe water: This was measured using biochemical and physical parameters to determine water points and the distance to the nearest household to come up with the situation on the ground in relation to standards

2. Sanitation infrastructure: Maps of toilets including their types were produced

3. Hygiene behavior: issues to do with hand washing, maintenance of the toilet, distance and location of toilet to the house and water point using a checklist

4. Social Mobilization: What are the community structures and the roles that are given to the community members in terms of management and control of water and sanitation facilities in the area

5. Age: How old a person was determined how well they are conversant in a subject-knowledge, activity profile and predisposition to water and sanitation. The children were categorized into different age groups according to their knowledge. How old the person was determined how they view the problem of water and

sanitation from their point of view. The sex category helped in coming up with the response disparities between men and women

6. Income status: How much money a household gets determined the sanitation facilities in place?

1.6 Organization of the Work

The thesis has 5 chapters. The general abstract gives the concrete synthesis of the study and highlights the study's key findings. Chapter 1 is the general introduction which outlines the problem under study, the statement of the problem and the objectives the study seeks to achieve. Chapter 2 contains the literature review, surveying other studies conducted in relation to the current study including the prevalence of common waterborne diseases, trend of prevalence of common waterborne diseases such as cholera, diarrhoea, dysentery and Malaria, water distribution and accessibility, biochemical and physical quality of water and perceptions regarding the link between waterborne diseases and poor hygiene.

Chapter 3 gives a detailed description of the study area, the technique used in collecting data to achieve the objectives; specifically, assessing the prevalence of common waterborne diseases in the area, mapping out the trend of prevalence of common waterborne diseases such as cholera, diarrhoea, dysentery and Malaria, documenting available water points and sanitation facilities in the area in order to determine their distribution and accessibility, measuring physical and biochemical quality of water from sampled water points in the area, and documenting perceptions regarding the link between waterborne diseases and poor hygiene. It also outlines the statistical packages used for data analysis and subsequent data interpretation.

Chapter 4 discusses the results from each specific objective: prevalence of common waterborne diseases; the trend of the waterborne diseases; is on results from documenting available water points; discusses the results from biochemical and physical results of the available water points; and the communities perception to the link between water and sanitation. Chapter 5, last chapter of the thesis is on conclusions and recommendations.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND RESEARCH

This chapter reviews literature on the theory, concepts and measurement of access to safe water and sanitation, prevalence and incidence of waterborne diseases. In order to understand the social, economic and environmental aspects, it is necessary to define sanitation and safe water, explore the water and sanitation sector in Malawi using sufficient literature on how community setups influence water and sanitation. The first section of this chapter provides background of the study in Malawi and the gaps that are prevalent in this sector. The second section deals with sanitation, safe water and how this is interpreted and assessed in the Malawian perspective. In the fourth section community setups and the influence this has on water parameters and sanitation is explored. The fifth and final section includes an in depth of the theories surrounding the water and sanitation aspect in Malawi.

2.1 Water sector in Malawi

A population's affiliation with water is visible at several levels Tamas, (2003). Water rights, or social and legal rules and obligations relating to the use of water, are often key features of local customs and instruction. Water is often a primary element in struggles and is even the source of conflict in settings where water is threatened Tamas, (2003). Knowledge and skills, concerning water and sanitation, are usually well established, with specific groups or individuals having recognised roles in the management of water.

According to the National Water policy (2007), all people have suitable access to sufficient quantities of water of acceptable quality and the associated water-related public health and sanitation services at any time and within convenient distance. It further mentions that the Ministry is mandated to lead in undertaking the monitoring and evaluation's activities of the implementation plan of this policy. Though this is the case, there is still lack of implementation of the guidelines in the policy.

Practices relating to the use of water and sanitation are part of a local culture, sometimes preserved in religious customs. Winblad, (2004), states that understanding these underlying forces is essential; not only to ensure efficiency, but also to avoid making assumptions excluding specific groups, or putting them at risk hence the literature being reviewed.

In this study, to understand the traditions and practices that lead to how water and sanitation is accessed, semi-structured interviews were used together with Participatory Geographical Information System (PGIS) Mapedza *et al.,* (2003). This is due to the fact that developing strategies and interventions would require a fully integrative understanding of the watershed's biochemical and physical function and the stresses caused by humans.

2.2 Prevalence of waterborne diseases

The literature reviewed focuses on themes related to the objective of assessing the prevalence of waterborne and water related vector borne diseases specifically Cholera, Diarrhoea, Dysentery and Malaria. Waterborne-disease surveillance data are useful for evaluating the adequacy of approaches for providing safe drinking and recreational water Barwick, *et al, (2000)*. Microbial contaminants raise a lot of concern because there are pathogens in rivers that are a primary threat to river water quality. These lower water quality water both for drinking and even irrigation especially in Kalusa Village, TA Malengachanzi, Nkhota-kota which is a watershed area and has both upland and lowland features, and river water is in abundance and where there is a lot of rice farming.

There are also other activities that would alter the quality of water such as agricultural runoff, swimming activities especially for the youth, and even domestic purposes which would be threatened when the water is infested with pathogens Costello *et al, (*2009). In these waters that are naturally flowing is the source of a lot of waterborne diseases. As Nkhota-kota district profile, (2010) states that water related diseases were prevalent in the district though the situation is reported to be improving due to the bringing in of different water interventions.

2.3 Trends in waterborne diseases

When there are many activities taking place like farming, settlements, and domestic use of water, there is bound to be water contamination. When this happens, the water bodies become more ideal for parasitic infections that cause waterborne diseases to boom Fenwick, (2006). As the population of Malawi is increasing, so is the demand for water resources, and hence more activities due to the demand in the water sector that are leading to high rates of alteration leading to waterborne diseases. According to Chikopa, (2010), when there is a lot of overcrowding of people which usually results in scarcity of clean water, there is bound to be poor sanitation. In his study conducted in Zomba watershed, he found that water related diseases were prevalent, with Malaria being the dominant disease, followed by diarrhoea, and cholera is quite low. Chikopa, (2010) states that there seems to be a decrease in cholera cases each year which would be attributed to more people aware of the infections, or there are now improved practices in Malawi. But this could all be speculation or could be unique to his area of study as Chikopa, (2010), did not indicate as to the reasons why Malaria and Diarrhoea were on the rise and cholera is on the decline. The trend of these waterborne infections seems to be increasing in Chikopa's study and in all related literature like news articles and other unpublished studies that were consulted in the literature review.

Could this trend also be true for Nkhota-kota? Or is Nkhota-kota unique from this conclusion? If it is, is there is a reason why the cases are following a certain trend. Normally, a decline in prevalence is expected due to the various interventions like increase in availability and access of safe water and sanitation or just increased awareness that could have been introduced in the area, but this could also not be reflective as it was eluded during the situation analysis stage where the communities and the district profile clearly attributed that there is an increase and prevalence in waterborne diseases respectively.

2.4 Availability and access of water points and sanitation facilities

The future generations' needs cannot be met without the present generation not benefitting from the same resources (Winblad, 2004). Sanitation approaches that can come in as interventions must be resource minded hence agreeing with Weitz, (2009) which argued that all characteristics of a community have to be incorporated into interventions. Similarly, (Winblad, 2004) states that there can be no parity as long as half the world's population goes without even basic sanitation and safe water. Focus also has to be put on coping and transformative strategies that the communities have to water and sanitation practices that are either detrimental to the communities' health or those that are positive and improving how the communities access the water and sanitation facilities.

This study is expected to illustrate how the environmental health indicators and using standard statistical methods can offer a basis for a better understanding of the linkages between environmental risk factors and population health, especially as a tool for environmental health decision making.

2.5 Issues on quality of water and disease outbreak

The literature review is focusing on few water quality parameters that are linked to sanitation, but also are giving the water quality situation of the area. The parameters that were looked at in this study are pH, total coliform bacteria, electral conductivity, nitrates, phosphates and turbidity. Total coliform bacteria determine the quality of water because according to WHO staff, (1997), the detection of E.Coli which is a coliform bacterium signifies that the water has fecal pollution and hence can cause waterborne diseases. The WHO guidelines also state that the parameters recommended for minimum monitoring include pH and turbidity and these two parameters are used to supplement the determination of *E.Coli* and other microbial activities WHO Staff, (1997). Electral Conductivity is related to the amount of dissolved solids in the water; it is a measure of purity of water which is free from waterborne causing contaminants. Nitrates and phosphates are an indication of contamination of water because they indicate human or animal contamination Geokocekuos *et al,* (2011). Though this is the case, there has been construction of boreholes to ensure that there are more water sources that are safe for water consumption.

Though the number of water sources would were on the increase, if there is an indication of human/animal contamination, then it is not safe for consumption. In his study, Tsirizeni, (2004), indicated that though the number of boreholes is increasing, there was an upsurge in the prevalence of waterborne diseases which would be caused from a lot of factors for instance, the water points being congested, especially the safe water points, low water yield for some boreholes, and the majority being that cholera and other water borne diseases are high especially in the rainy season.

Tsirizeni, (2004), continues to state that there is increase in the number of waterborne diseases due to poor sanitary handling of the water from the collection point to the households which is attributing to the increase in waterborne diseases. The study clearly showed that though there are many efforts by government and other non-state actors to improve the water quality and hence reduce waterborne diseases, the water still gets contaminated, either through runoff; of collapsed toilet structures; poor handling of food that become a nuisance in terms of wastes, having dirty pails to carry the water; or even dirty hands to carry the water which in the end would lead to poor waste management.

The gap in the literature is the link of water variables to sanitation, and coming up with trends of how these diseases are progressing or decreasing after several interventions hence this study is set to explore the biochemical and physical parameters stated previously in order to come up with clear indications of whether the water that is used for drinking is safe water and if whether the diseases are on the increase or on the decline and if there is any relationship with sanitation practices. Further to that, there is no available data and statistics for the area for water quality parameters that is why it is important to carry out this study to come up with data for the water points in the area.

2.6 Perceptions by communities and institutions on waterborne diseases

As far as culture is concerned, water and sanitation are known to be regarded lowly in terms of putting the issue as an important one because it is not seen as a problem to have no toilets in a compound or to use the river for defecation as the situation analysis pointed out for the area Bianchi *et al*, (2000). Apart from culture and practices, gender roles also influence the perceptions on water quality, sanitation and hygiene practices.

It has to be emphasized that traditional gender division of labour often assigns specific roles for women and men in the family and the wider community. The gender division of labour is one of the key ways in which economic tasks are structured. This division of labour when combined with gender ideas defines specific spaces for women and men in society Bianchi *et al,* (2000). Women more often are allocated the bulk of the unpaid family and community work while men do tasks that are considered productive and remunerated. This gender division of labour is thought to have specific influences on women's participation in water and sanitation sector.

Though women may play an important role in water collection and accessing safe sanitation means, they do not generally work on the forefront and for this reason women have frequently been ignored in water and sanitation development Oxfam, (1995).

As far as coping and transformative options are concerned, women and men respond differently to situations Asowa-Okwe, (1994). While there is absence of literature on the gendered coping mechanisms of safe water and sanitation, there are a few studies on coping strategies under other situations exist, for instance how gender roles influence the coping methods in times of drought.

In summary, none of the studies reviewed make comparisons of the gender dimensions in connection to water and sanitation atrocities in Kalusa, Malengachanzi area. Further apart from Manda (2009), who does not look at gender considerations in resource allocation and mostly in water and sanitation aspects, his studies consider water and sanitation from largely a sociological viewpoint, a natural science based angle or a perspective is not embedded in the research. To add to that, before developing any strategies for development, there was need to understand the economic, environment and the community because as the literature shows, ignoring one leads to the detriment of the ecosystems health and becomes more expensive. This work thus built on these gaps to present a descriptive picture of the situation of the water and sanitation sector and practices in a gender perspective in Kalusa village, TA Malengachanzi, Nkhota-kota.

Theoretical Framework

From the literature explored, the theory was adapted from Einsberg *et al,* (2007). This theory uses a systems theory structure to mix and examine unequal evidence from a variety of disciplines. The goal was to identify knowledge gaps and define research directions as well as to develop relevant study designs and approaches so that knowledge about environmental change can be incorporated appropriately into the study. The literature explores the theory which explains the environment, transmission, and disease. This theory has also been used by Strachan *et al*, (2013); Chen *et al,* (2013); and McFarlen *et al,* (2013) among others. Independent variables included the proportion of the population with access to improved water source and the proportion of population with access to improved sanitation, as defined by the WHO/UNICEF Joint Monitoring Programme (UNICEF, 1997). The following are detailed definitions of improved access to water and sanitation: Access to safe drinking water is measured by the percentage of the population using improved drinking- water sources.

Improved drinking water source is a source that, by nature of its construction, adequately protects the water from outside contamination, in particular from faecal matter (UNICEF, 1997). Common examples include piped household water connection, public standpipe, borehole, protected dug well, protected spring and rainwater collection.

Access to sanitation is measured by the percentage of the population using improved sanitation facilities. Improved sanitation includes sanitation facilities that hygienically separate human excreta from human contact. Access to basic sanitation is measured against the proxy indicator: the proportion of people using improved sanitation facilities (such as those with sewer connections, septic system connections, pour-flush latrines, ventilated improved pit latrines and pit latrines with a slab or covered pit). Shared sanitation facilities are otherwise-acceptable improved sanitation facilities that are shared between two or more households. Shared facilities include public toilets and are not considered improved. Other covariates included in the analyses are: Gross Household Income (GHI), adult literacy rate and deaths (1 000's) attributable to waterborne diseases, Gender and Age.

Conceptual Framework

From the literature, the problems that are being addressed in this study are access to safe drinking water, hygiene and sanitation. The independent variables are drinking water quality, water access, and access to safe sanitation practices, and hygiene.

There was need to measure all these factors without ignoring the other as the literature stipulated. Gender has to be taken into account when dealing with access to resources like water and sanitation and hygiene. It was important to look into all the four before reframing the planning problem, creating an integrative knowledge base, and institutionalizing multi-stakeholder participation in decision making. Also, there was need to fully integrate understanding of the watershed's biochemical and physical function and the stresses that are caused by humans to the watershed. Also, in this community, there have been intervention to help curb the problems of water and sanitation and hygiene, were these done with proper gender analysis and cultural adaptation plans in place? To ensure the data is holistic, there was collection of information from the district hospital and even the nearby hospitals in order to determine the health problems of the area, and if they were water or sanitation-hygiene related. The aspect of gender was also highly integrated in the data collection in order to start addressing the missing link in most of the literature on water and sanitation.

CHAPTER 3

RESEARCH METHODOLOGY

AN OVERVIEW OF THE STUDY AREA, MATERIALS AND METHODS

3.1 Site Description

Kalusa village is bordered by Kalimanjira, Chiula, Makuzi villages and it is in Group Village headman Kalimanjira, TA Malengachanzi, Nkhota-kota. Nkhota-kota district is one of the nine districts in the central region of the Republic of Malawi. It is located on the west coast of Lake Malawi. Nkhota-kota district borders Nkhata Bay District to the North, Mzimba District to the North West, Kasungu District to the West, Ntchisi District to the South West and Salima District to the South. It also shares an international boundary with the Republic of Mozambique to the East. (Figure 1). Nkhota-kota lies on 12.9167° S, 34.3000E°.

It has a total population of 303, 659, with Malengachanzi having a population of 77,842 (NSO, 2002).

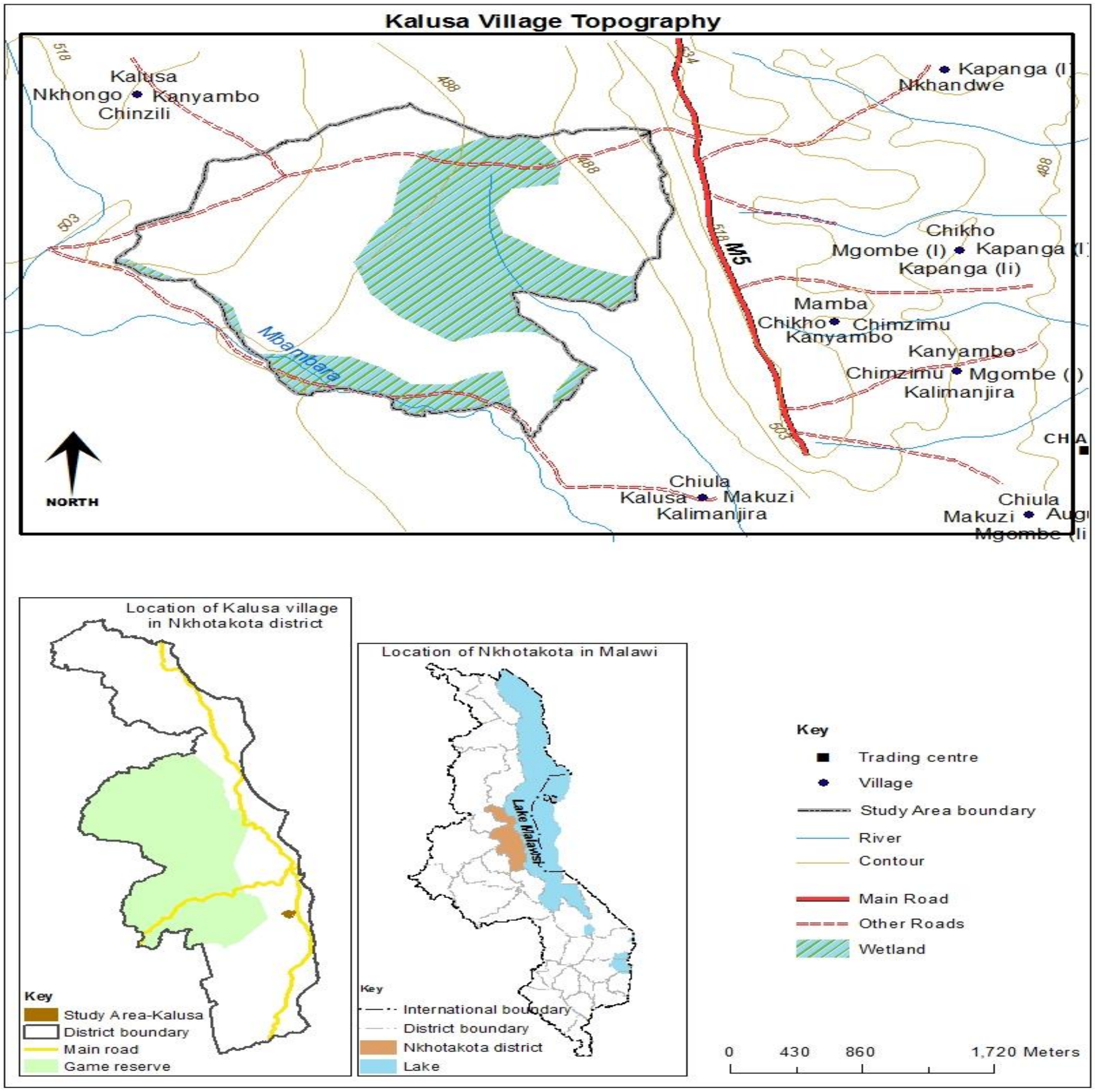


Figure 1: Shows Nkhota-kota highlighting Malengachanzi and Kalusa

3.2 Topography and Climate

According to Nkhota-kota district profile (2009), the land surface is flat with a slight slope towards the lake. The shore primarily consists of sandy beaches punctuated by marshes. The elevation ranges from 493 to 1638 above sea level. The altitude averages to 1065.5 meters above sea level. The overlying sediments are alluvial and colluvial deposits, which according to the borehole-test records are more than 30 meters thick as stated in the Nkhota-kota district profile, (2009). Nkhota-kota has a tropical type of climate and consists of two main seasons. These are the wet season from November to April and the dry season from May to October, steady rains falls within the months of December, January, February and March (Nkhota-kota district profile, 2010). On average, the district receives annual rainfall of about 1400 mm but might fall as low as 860 mm to as high as 1600 mm.

3.3 Population Characteristics

In Kalusa village, TA Malengachanzi, the population is 77,842 (NSO, 2008). The population is comprised of farmers and fishermen; cassava, maize, rice are the staple crops. The communities are either served by boreholes, gravity piped water supply and shallow or unprotected wells. About 45% of the district's population has no access to potable water even though number of boreholes had been increasing Nkhota-kota district profile, (2010).

The community is comprised of Chewa and two other tribes, Tonga and Tumbuka tribes Nkhota-kota district profile, (2010). In terms of gender distribution, there are more women than men by a ratio of 56:44 according to Nkhota-kota district profile, (2010).

3.4 Economic Activities

The community has both farmers and fishermen and a few people are business people. The small businesses are fish selling, rice selling, a few hawkers. Most people earn an income less than K50, 000 per year. This perhaps explains why there are non-functioning water points that are not maintained and drilled in the wrong points and why there are few water points servicing the large population. Income determines if people can afford more water points and more improved sanitation services.

3.5 Materials and Methods

3.5.1 Sampling and sample preparation

Secondary data from health centres accessed by the community were accessed to analyze the trends for the past 10 years on how these diseases are progressing in the location. Afterwards, maps and frequencies were developed from these.

3.5.2 Water Sampling

The World Health Organization (WHO) Drinking Water Guidelines for Microbiological Parameters is defined as the percentage of drinking water samples with E.Coli or with fecal streptococci higher than the guideline value of 0/100 ml water over a given time period (World Health Organization, 2000). The rate was calculated from the following diseases where drinking water is recorded as the main mode of transmission. These include gastroenteritis, campylobacteriosis cholera, cryptosporidiosis, giardiasis, paratyphoid, salmonellosis, shigellosis, typhoid, primary amoebic meningoencephalitis, hepatitis A, legionellosis, leptospirosis, vero/ shiga-toxigenic, and Escherichia coli (Khan *et al*., 2007). In this study more focus was put on gastroenteritis, cholera, and Malaria as the focus diseases though there are more waterborne or water related diseases in the area as recorded by the district health records.

Samples were collected from the water sources that are functional and are used in the communities. There are a total of 12 water sources in the village according to the focus group discussions, only 7 are working and this includes Mambala River as one of the sources for water.

Samples were collected at the end of the rainy season due to the hospital data that had indicated that this season was peak for water borne diseases in the area. The samples were collected in triplicates and were put in 1 liter plastic bottles that were cleaned with nitric acid and then rinse with deionized water to remove any contamination. The bottles were carried in a cooler box with ice blocks which had a temperature of 4^{o}C.

The samples were analyzed for electrical conductivity, TDS, pH, temperature, turbidity, nitrates, phosphates and bacteriology as described in literature (APHA, 1989).

3.5.3 Household Sampling

Out of the population of 858, a sample of 160 respondents was selected by simple random sampling of households, systematic random sampling was used to come up with 1 household per 5 households apart. A questionnaire was constructed and administered. The questionnaire for this study consisted of questions on socio-economic, socio-demographic, health, time allocation, and satisfaction with various variables that are being tested in this study. This was developed after answering the first objectives in order to address the gaps that were identified in the previous objectives.

Focus Group Discussions (FGDs) were planned for various groups of women, men and mixed groups to help clarify some contentious issues emerging as well as to generate additional information. The focus groups were focusing on ranking diseases to get the prevalent diseases. The ranking was done using bean/maize seed and placed in a circle representing each disease. The disease most prevalent was the one with more bean/maize seed in it, and interventions came based on the ranking. Four focus group discussions were conducted and each group had 6-8 participants.

The communities were given flipcharts where they developed the roles and responsibilities for each sex as separate entities of the community documented and used to assess the roles, responsibilities and the control in terms of water points and sanitation and also how the community views the issue of sanitation in their context as separate genders.

3.5.6 Geographical Information System

To analyze the availability and access of water points and sanitation facilities in the area the method was informed by the first two objectives of assessing the prevalence of common waterborne diseases in the area and mapping out the trend of prevalence of common waterborne diseases such as Cholera, Diarrhoea, Dysentery and water related insect vector borne Malaria. Participatory GIS was done to map distribution of water and other related natural resources like forests and wetlands.

To come up with the locally made map that would inform the mapping, firstly, all participating members (of different age groups to allow equal and inclusive participation) labeled on a 3D model map of their village on the ground. They decided on the legend by using different locally available materials such as ash for water and leaves for forests. The advantage of this step was that it allowed for participation through visualization. The old people were important at this stage because they provided historical trends and village boundaries. Participants were given marker pens of different colours. This allowed the young literate ones to show case their skills in mapping. The third stage was ground-truthing of the natural resources on the flip chart by using Google Earth maps and Bing Maps aerial.

The data for the points was in the default file format of Garmin GPS Database Version 2 (.gdb). This file carried facility information for 219 locations spreading across an area bounded by:-Northern limit of 8556514.51123 easting. (13.05408o S); Southern limit of 8551607.77959. (13.09844o S); Western limit of 636586.45252 long. (34.25972oE); Eastern limit of 642504.88142 long, (34.31454o E). Laboratory Result data provided in an Excel sheet had seven locations of Water Points.

Some base map layers were required to process map(s) that would display and illustrate plotted data points of the said area had to be sourced. These are:-Malawi district map layer – National Spatial Data Centre (NSDC); River layer- NSDC; Roads layer- NSDC; TA boundary layer- NSDC; Malawi Digital Elevation Model (DEM)– Surveys department; Google Earth views of the locality.

Geographical Information System tools that have been utilized in coming up with the map products include Map Source, ArcView, and Idrisi Taiga. Map Source program was used to open the provided prime data (the captured GPS data values) in gdb. format and make it ready for being read in Excel where data base files were created for Arcview. Processing the data in ArcView, it was possible to visualize the geographical locations. Apparently nature of the results demanded information on influence of location altitude. This brought the deed to use Idrisi program. Idrisi is a program mostly dealing with raster analytical functionality and covering the spectrum of GIS and remote sensing needs from database query, to spatial modeling, to image enhancement and classification. Therefore the DEM for Malawi provided an appropriate input, since from it Idrisi processed contours of the said area.

Availability of Malawi DEM could make things better for seeking a solution for elevation issues of our study area. As stated, Idrisi program was used to process the DEM image into contours for the whole study area. Area of study was clipped off from the DEM and processed for contours. These contours have been used in the maps.

In brief, GIS was used to map the areas that are water sources for the communities and the distances were noted and a map of the water point areas were developed from the GIS. GIS was used to come up with a land use map of water points and sanitation facilities of the area in order to determine the distances from the households to proper water points and all other water points in the area including rivers and lakes, wells, boreholes. The distances between the toilets and water points and the distances to the households were also being recorded.

3.6 Sample Preparation

The water samples were refrigerated for the time they were transported and the analyses were done on the day of collection of the water. Blank solutions were prepared for each of the parameter.

3.7 Analytical Methods

The analytical methods were adapted from APHA, 1989:

3.7.1 Determination of Nitrates NO^{3-}

Reagents

a) Standard NO_3^- solutions

721.8 mg of anhydrous potassium nitrate, KNO3 were dissolved and diluted to 1000 mL with distilled water; 1.00 mL = 100µg NO_3^- .From this stock, working standard solutions of 1.00, 3.00, 5.00 and 7.00 mg/L NO_3^- were prepared and 1 mL of 1N HCl added.

Procedure

To 50 ml filtered sample, 1ml of 1N HCl was added and mixed thoroughly. Using the Wagtech T90 UV/Vis spectrophotometer, standards and sample nitrate absorbance were measured at 220 nm and the concentrations calculated from the standard curve.

3.7.2 Determination of Phosphates PO_4^{3-}

Reagents

a) Vanadate-molybdate reagent

Solution A; 25.00 g of ammonium molybdate, $(NH_4)6Mo7O_24.4H_2O$ were dissolved in 400 ml distilled water

Solution B; 1.25 g of ammonium metavanadate, NH_4VO_3 were dissolved in 300 ml hot water, cooled and then 330 ml concentrated HCl added.

Solution A was then poured into a room temperature cooled Solution B and diluted to 1L.

b) Standard phosphate solution

219.500 mg of anhydrous potassium dihydrogen phosphate, KH_2PO_4 were dissolved in distilled water and diluted to 1000 mL mark; 1 mL = 50 µg $PO4^{3-.}$

From the stock solution, 1.0, 3.0, 5.0, 7.0 and 10.0 mg/L PO_4^{3-} were prepared and vanadate-molybdate reagent added.

Procedure

To a 50 ml volumetric flask, 35 ml of sample was placed and 10 ml vanadate-molybdate reagent was added and diluted to the mark with distilled water. The sample was measured for phosphate 10 minutes after adding the vanadate-molybdate reagent against a blank sample at 470 nm using a T90 UV/Vis spectrophotometer, Wagtech Projects (China). Phosphate concentration of samples was calculated from the standard calibration curve.

3.7.3 Determination of Total Suspended Solids (TSS)

Total suspended solids (TSS) were determined by filtering 50 milliliters of sample through a filter paper. The filter paper containing solids was dried at 103℃ at constant mass cooled in a desiccators and weighed on an oetling R41 (mark II) analytical balance. TSS was calculated by the formula (APHA, 1989).

TSS (mg/l) = ((A-B)/V x 1000 where

A= weight of filter + dried residue, (mg)

B= weight of filter, (mg)

V= volume of sample, ml (APHA, 1989)

3.7.4 Determination of turbidity of water samples

To determine turbidity of water, standard solutions of aqueous hexamethylenetramine (solution A) and hydrazine sulphate (solution B) were prepared by dissolving $(CH_2)6N_4$ (10.00 g) and $N_2H_4H_2SO_4$ (1.00 g) in 50 ml de-ionised water respectively. The standards and samples in triplicates with de-ionised water as a blank were run on a Jenway 6405 uv/vis spectrophotometer at 580 nm using 1 cm cell. Turbidity of the water samples was calculated from the calibration obtained by using standard solutions for turbidity in FTU (APHA, 1989).

3.7.5 Determination of EC, pH, TDS and Temperature

Water temperature and pH were determined in-situ with a MARTINI pH 55 digital meter. The meter was calibrated with pH 7.00 ± 0.02 and pH 4.01 ± 0.02 buffer solutions prior to use. Electrical conductivity and TDS were determined on site with a MARTINI EC 59

EC/TDS digital meter. The meter was calibrated with a 1413 μs/cm conductivity KCl calibration solution before use.

3.7.6 Bacteriological analysis using standard plate count

Dilution solution was prepared in order to determine fecal coliform bacteria. This was done by making sterile Petri dishes in triplicated with sample number dilution factor and date. Dilution ringer's solution was prepared by dissolving one tablet of ringer solution in 500 mL of de-ionized water. Nine milliliter of dilution factor, the mixture was also thoroughly shaken. This also gave a dilution factor of 10^{-2}. Then the Violet Red Bile Agar (VRBA) was prepared by weighing 38.5 g of Violet Red Bile Agar powder and dispersed in 1L of de-ionized water and then the mixture was heated to boil with constant swirling to prevent overheating. After it dissolved completely, it was then allowed to cool to 47^{o}C.

The agar was inoculated with water samples by pipetting water samples (10^{-1} mL and 10^{-2} mL) into sterile Petri dishes using sterile pipette. Approx. 25 mL of Agar (at around 47C) was poured into the Petri dishes and thoroughly mixed with the water samples using sterile rod. The Petri dishes were then incubated at 44.5C for 18-24 hours. After 18 hours and before 24 hours, the colonies were identified and counted. The number of colonies was calculated by using the following formula:

Equation 1 Number of Colonies

$$Colonies/100mL = {N(100)}\big/{Df}$$

Colonies/100mL= N x 100/Df where

N= Number of colonies

Df= dilution factor

3.8 Analysis of Data

Data cleaning, editing and coding was done before analysis and Statistical Package for Social Scientists (SPSS) was used. Water quality data was analysed using excel package to come up with percentages, graphs and figures.

This was done to come up with factor analysis which is a multivariate method in multiple regressions that was used to reduce a large number of scaled items to a smaller number known as factors. Trend in the data was analyzed using simple linear regression of the form:

Equation 2 Regression line

$$y = mx + C$$

Where y is the dependent variable, x is time, m is the slope and C is a regression constant (Myers, 1990). The regression analyses were done using R, the free statistical computing software.

CHAPTER 4

RESULTS AND DISCUSSION OF THE STUDY

This chapter presents the description of the prevalence of waterborne diseases, availability of water points, water quality trends of water borne diseases and perception of communities. Lastly, the chapter presents the data analysis used to obtain the results and discussions.

4.1 Trends for Waterborne diseases

The results of temporal trends in waterborne diseases are from 10 year records at hospitals namely Mpamantha and Chididi where the Malengachanzi community goes to for medical assistance.

4.1.1 Malaria trends

Figure 2 and 3 showing the temporal trends in Malaria from Chididi and Health Centres respectively. The Malaria trend is decreasing over time. It can be seen from the figures that a constant pattern where it increases and decrease according to season in Malaria for the past 10 years from Chididi which is a private hospital. Mpamantha which is a public hospital shows that there is an increasing trend in Malaria with time. Malaria is an example of a waterborne disease that is caused by a vector, mosquitoes that breed or live near water. Malaria causes over 1 million deaths a year alone (World Health Organization, 2006). According to Addisie (2012), Stagnant and poorly managed waters provide the breeding grounds for Malaria-carrying mosquitoes. In Kalusa village, there is stagnant water available which were observed in the area despite efforts to curb the disease. This perhaps is increasing the trend of Malaria or the trend could be increasing due to other factors like climate change or not using mosquito nets.

Malaria trend

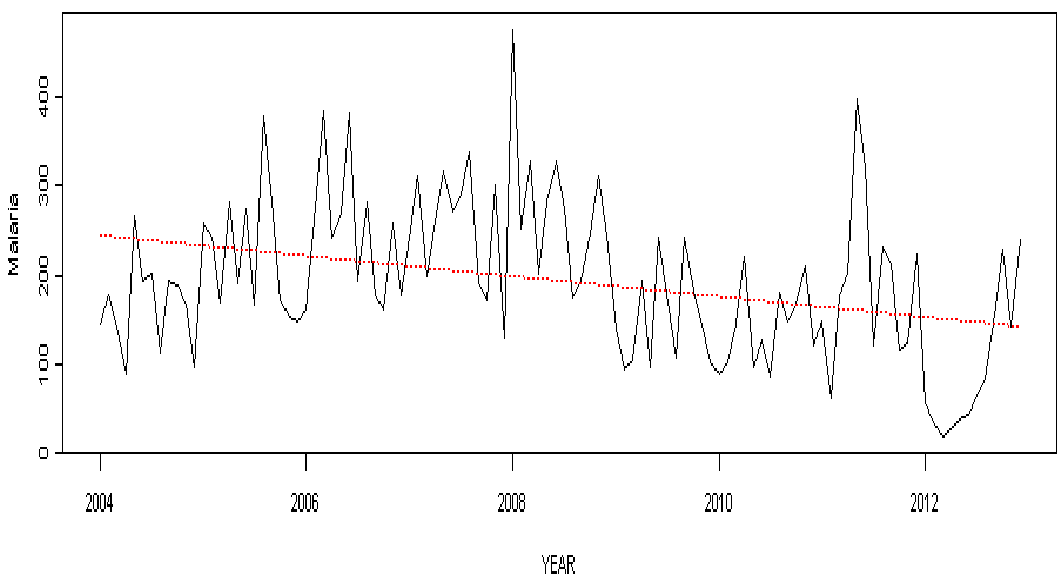


Figure 2: Shows the trend of Malaria from Chididi Health Centre

$y = mx + C$ as in Equation 1

Malaria trend

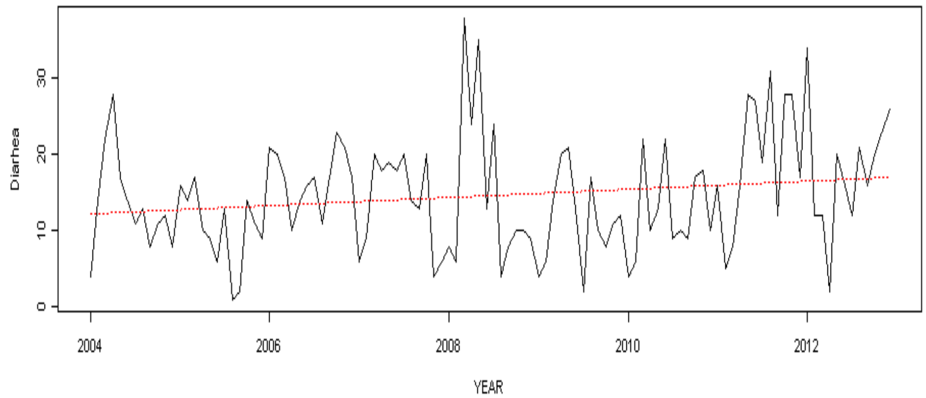


Figure 3: Shows the trend of Malaria from Mpamantha Health Centre

4.1.2 Diarrhoea Cases over time

Both hospitals show that there is an increasing trend of diarrhoea with time. This is the case despite so many efforts to curb waterborne diseases like cholera in the area. Although cases of diarrhoea are high, the high number of victims could be due to poor hygienic conditions or some social economic factors of the community. For instance, in Brazil, there were dramatic differences in diarrhoea prevalence across socioeconomic groups that persisted over time (Sastry and Burgard, 2005).

Diarrhoea Trend

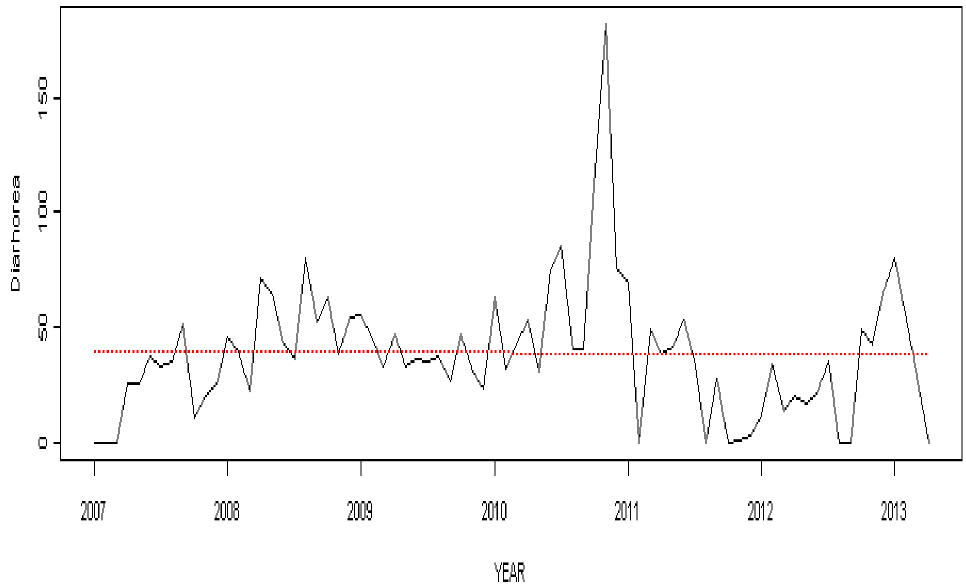


Figure 4: Shows the Trend of diarrhoea disease in Mpamantha

4.1.3 Bilharzia

Trend of Bilharzia

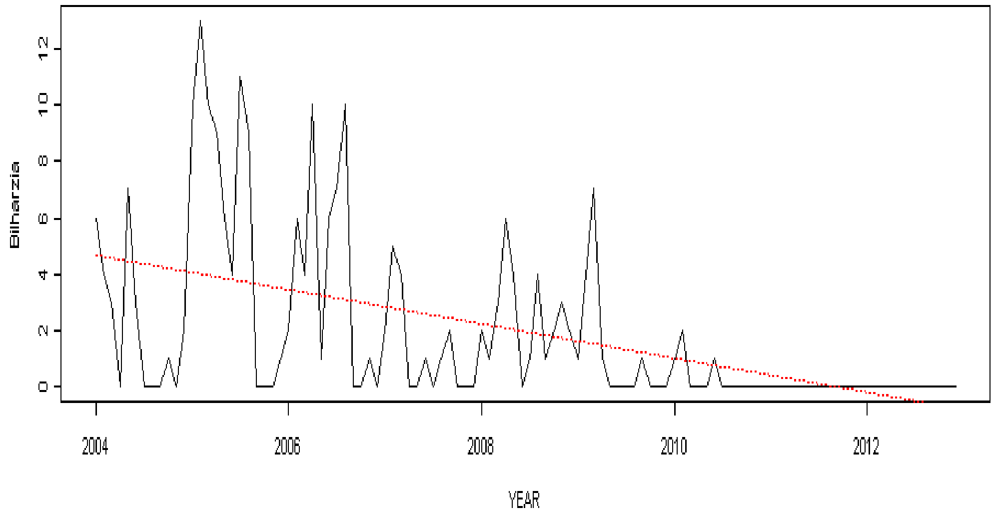


Figure 5: Shows the trend of Bilharzia from Chididi hospital

Simple linear regression: Y=mx +C, other things being equal.

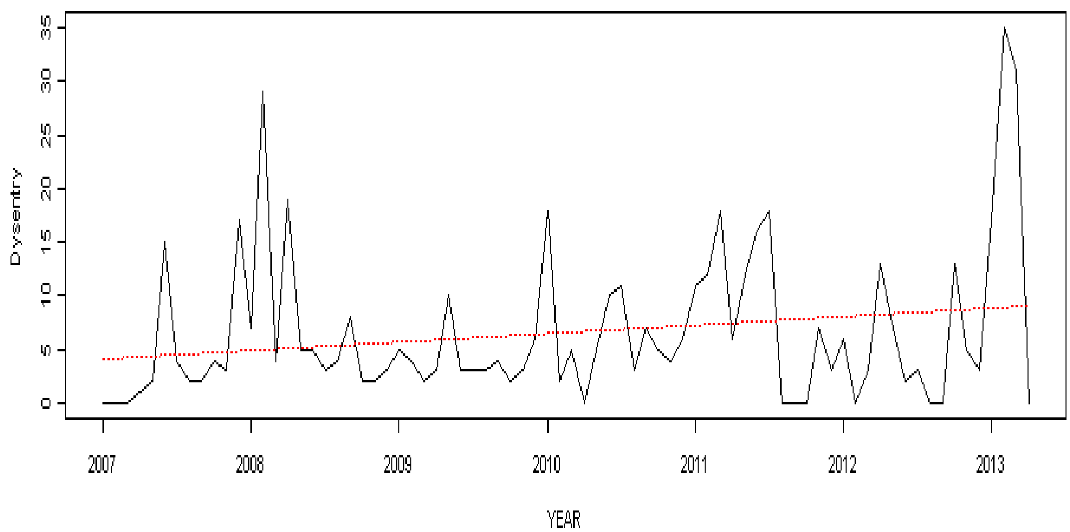
Bilharzia is decreasing in the area and this could be attributed to the high levels of awareness on the disease. It could also mean people are not reporting the diseases to the hospitals. According to Nkhota-kota district profile, (2010), the district in general had proposed to increase awareness campaigns for the high occurrence diseases like Malaria, cholera, bilharzia and sleeping sickness. Hence it could be concluded that education is acting as a vital instrument for easy diagnosis of signs and symptoms of bilharzia for early treatment hence the decrease in this disease.

Bilharzia is on the decline in the area according to the graph in figure 5 over time. This could be due to a lot of awareness programs on this disease which has sensitized communities that bilharzia is a disease and not a hereditary infection. It could also be due to medications that are now readily available to curb this disease because according to Nkhota-kota district profile, (2010), the disease has declined over time due to a lot of educational programs and a lot of treatment of the disease over time.

4.1.4 Dysentery

Figure 6 shows the trend of dysentery for the 10 year period 2007-2013.

Trend of Dysentery



Simple linear regression: Y=mx +C, other things being equal

Figure 6: Shows the trend of Dysentery from Mpamantha

Dysentery is on the rise just like diarrhoea due to the presence of waterborne infections like coli forms which are being brought about due the increasing population and also all efforts to curb the disease are not leading to any success. This could be attributed to factors like climate change, hygiene practices and geormophological reasons in the way the toilets are constructed. This disease also is not seasonal; it is present throughout the year which perhaps means that sources of contamination are not influenced by rains but by other factors. Nkhota-kota generally has weather variations, and weather variations have different impacts on the transmission of dysentery (Zhang, *et al.*, 2007).

4.2 Prevalence of waterborne diseases

From the focus group discussions, and the responses from the questionnaire, the communities attributed that there was an increase in waterborne diseases and the water related vector borne disease Malaria. According to the communities, this was due to poor quality water due to a lot of non-functional safe water points in the community.

Table 1 shows frequencies of causes of waterborne diseases by the community

Cause of waterborne diseases	**Number**	**Percentile**
Not Using Water guard	12	12%
Lack of safe water points	13	13%
Non-functioning water points	45	45%
Poor water handling	30	30%
Total		100%

Out of the 6 boreholes only 2 were functioning representing a 33% of functioning boreholes. According to observations, a lot of the water points that were perceived as safe water points i.e. tap water were either not functioning or the water was intermittent in distribution, only 1 of the three communal water taps in the area was working representing 33% functioning water taps. Probed further, the responses were that the constructions of these safe water points were done without consultation with the communities to come up with safe water points that were close to the geological rock that would provide the water.

4.3 Availability of water points

Figure 7 shows the location of water points in the area marked as red dots that are used as sources of drinking water by the date the research was conducted. According to WaterAid, (2007), 50 litres per person per day is recommended and this is backed by government using a distance of 500 meters as signifying adequate access to water. Access to water is defined as the availability of 20 litres per capita per day at a distance no longer than 1,000 metres (Manda, 2007).

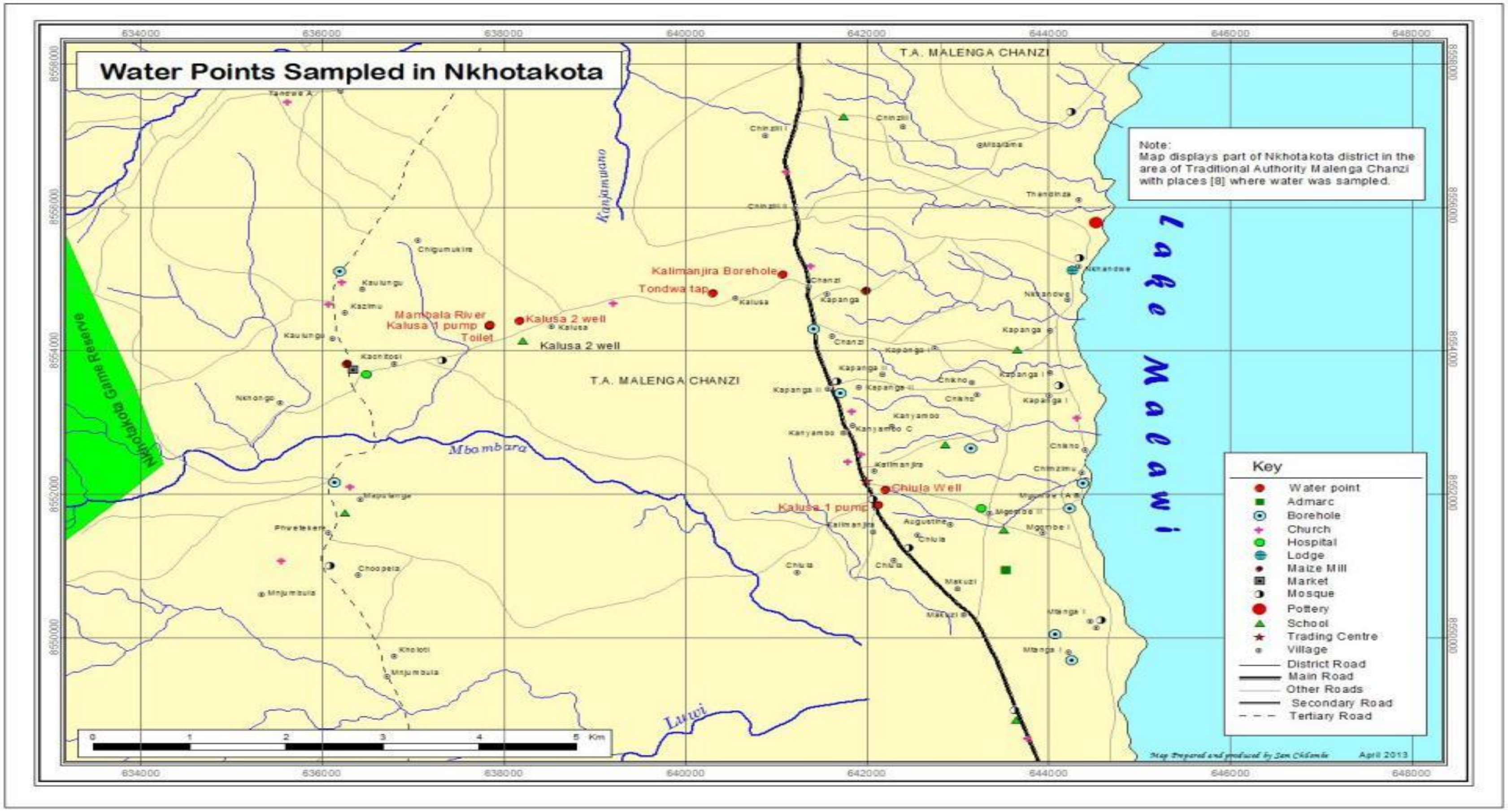


Figure 7: Shows Water Points in Kalusa village

Figure 7 is a map showing Kalusa village with its water points sampled and these water points are the places that the people draw their drinking water from. With respect to the literature reviewed, the distances between households to water points and to toilets was not the recommended one. Basic access is the availability of drinking water at least 20 liters per day per person, a distance of not more than 1 kilometer from the source to the house and a maximum time taken to collect round trip of 30 minutes Adissie, (2012). This is not the case because according to the map, water can be collected for a minimum of 3 kilometers and a maximum of 10 kilometers to a safe water point. This also affects the level of contamination the water can have even if there was less microbiological contamination at source.

The bacteriological quality of drinking water suggestively declines after collection in many settings, and the longer it takes for households to collect water, the extent of contamination after water collection varies considerably between settings, but is fairly greater where fecal and total coliform counts in source water are low Wright, *et al*, (2004). Perhaps longer distances increase chances of bacteriological contamination. For Tsirizeni, (2004), in his study found that longer distance between collection point and household increase the chances of water contamination keeping all factors constant. Possibly this would also explain the recommendation by the government to have a minimum of 500 meters between a household and a water point which would reduce drudgery but also reduce chances of contamination. According to Adissie, (2012), if the distance is more people resort to nearby water sources which are usually contaminated. Several studies have documented increased concentrations of fecal coliforms during household storage.

VanDerslice and Briscoe (1993) also states that most contamination happens after the water source and hence even if water source is improved and there is safe water, chances of contamination are high due to handling. So it could be that the water contamination leading to a lot of waterborne diseases could be caused by water handling or perhaps this should be researched further.

4.4 Water Quality

To answer objective 4, the following Tables 2 and 3 describe the documented water points and their microbiological, chemical and physical parameters.

Table 2 Physical and chemical results

Sampling Site	TDS (ppm)	EC	TSS	pH	Alkalinity	Temperature	Turbidity	Phosphates	Nitrates
Kalusa1 Pump	37.0	74.67	4.000 ± 2.828	5.600	0.457333	27.9	2.019 ± 0.000	0.454 ± 0.122	0.018
Mambala River	1.0	2.67	7.500 ± 3.536	5.633	0.620667	27.8	3.057 ± 0.401	0.274 ± 0.031	-0.0605
Masika BH	28.0	56.33	1.500 ± 0.707	5.867	0.373333	28.1	1.359 ± 0.134	0.267 ± 0.000	0.02
Kalusa 2Well	13.3	26.33	4.500 ± 0.707	5.533	1.000667	27.4	3.434 ± 0.133	0.454 ± 0.000	0.152
Tondwa Tap	49.7	99.33	10.000 ± 1.414	5.700	0.767333	27.6	2.113 ± 0.133	0.403 ± 0.010	0.5345
Kalimanjira BH	43.3	86.00	9.000 ± 1.414	5.767	2.140667	28.5	1.453 ± 0.267	0.367 ± 0.000	0.784
Chiula Well	106.7	213.33	5.500 ± 0.707	6.200	2.140667	28.0	3.906 ± 0.000	0.583 ± 0.000	3.271

The Table 3 shows the microbiological results based on the results found from the water points sampled:

Table 3 Microbiological results (in Arithmetic and Geometric means)

Site name	Arithmetic mean (Fecal CFU/100ml)	Geometric mean(FCU/100ml)	Arithmetic mean E. Coli(CFU/100ml	Geometric mean(FCU/100ml)	Depth
Kalusa II - Pump well	33±58	5	0±0	1	5 meters
Mambala river	3167±4210	1423	233+404	9	4 meters
Masika school borehole	0±0	1	0±0	1	5 meters
Kalusa II-Open well	333±577	10	33±58	5	-
Tondwa Tap water	33±58	5	0±0	1	-
Kalimanjira borehole	367±550	46	67± 58	22	12 meters

According to literature, the Microbiological Parameters are defined as the percentage of drinking water samples with *E. coli* or with fecal streptococci higher than the guideline value of 0/100 ml water over a given time period World Health Organization, (2000). From the laboratory results, it shows that Kalimanjira borehole, Tondwa tap, Kalusa II open well, Mambala river, and Kalusa II pump well are contaminated with coliform counts and are a potential source of the increasing trends of waterborne disease in the area.

Only Masika school borehole has no coliform count and this could be attributed to the presence of *ScleroCaryabirreaSubspCaffra* commonly known as Marula trees around the borehole and the absence of a toilet facility in the 500m radius of it hence it is safe water for the school going children. According to JøkerDorthe and Erdey, (2003), the *ScleroCaryabirreaSubspCaffra* has a high antibacterial element and this tree is usually used for treatment of dysentery and diarrhoea. This could explain the lack of coliform in the water that was from the borehole. Though the area was geormophologically similar to the open well and the Kalimanjira borehole, the presence of the tree species perhaps serves as a control of diarrhoeal diseases. The community complained of smell of roots in the water, but in terms of all other factors, the water was safe for consumption.

Mambala River, Kalusa II open well and Kalimanjira borehole at the high level were also found with E.Coli counts and this serves as an indicator of presence of dysentery and diarrhoea. According to Malawi Bureau of Standards, (2004) safe water has no E.coli at 95% and 4% in algal petri dishes, but the water from these three water points showed presence of E.Coli which is detrimental to the health of the community. Many studies have indicated a public health threat. Based on the survival study of *E. coli* in the environment, it can be bracketed its survival in water at a temperature of 15-18°e of between 4 and 12weeks Edberg, *et al,* (2000).

Hence it is advised that the people treat the water after collecting from the water source. Also the type of vegetation surrounding a water point should be seen critically. Probably more *ScleroCaryabirreaSubspCaffra* trees could be planted around water points, in order to enhance the anti-bacterial properties.

4.4.1 Phosphates, Nitrates and their relation to waterborne diseases

The presence of phosphates and nitrates is influenced by pH and alkalinity. Changes in pH also influence the availability of plant nutrients, such as phosphate and nitrate, among others in the water. The acceptable range in Malawi according to the Malawi Bureau of Standards, (2004) is between 6.0-10.0 mg/l. The water samples according to Table 3 had ranges below the standards which perhaps indicate that there is absorption of it by bacteria, phytoplanktons and macrophates which are present in the water Tandwe, (2012). Conceivably, in most water bodies that are contaminated, the trend is usually the same as literature suggests. The lower levels of both nitrates and phosphates indicate the presence of other organisms that are feeding on it which could explain the presence of coliform bacteria and *E. Coli* in the water samples. The presence of coliform count is an indicator of diarrhoea, dysentery and in some instances cholera.

The nitrate concentration in Mambala River could lead to high spawning grounds for Malaria due to its high nitrification of NO_3 into NO_2 and NH_3 by denitrification bacteria Tandwe, (2012). This is also the same and Ndenga *et al*, (2012) found that the habitats with high anopheles mosquito presence had greater abundance of mosquito aquatic stages and tadpoles and two times more levels of nitrate in water. Though this is the case, there is still more research needed to verify the presence of nitrates and phosphates in relation to presence of anopheles mosquitoes which is a vector for Malaria. With lack of previous data to compare and contrast the results, perhaps the water is always highly contaminated or perhaps this is a new trend. But with health records which show the constant trend of waterborne diseases, possibly this could be the way the water safety is all the time or perhaps not.

4.4.2 EC, pH and Temperature

The EC threshold levels were 70-150 ms/m as in Table 2 and there was high coefficient of variation in the water samples with only Kalusa 1 pump, Tondwa tap and Kalimanjira Boreholes falling within the range and Chiula going beyond the normal range reported the highest EC, while Mambala river reported the lowest EC, and Masika BH and Kalusa 2 well were also below the set standards.

High conductivity signifies high mineral salt content meaning Chiula well water is saline whilst the ones falling below the set standards are that the water does not have conductivity which correlates with its TDS which is also very low. These results highly correlate with the activities around these water points. The communities practice rice farming, they also do laundry around the water points which could perhaps explain the low TDS and high conductivity.

This could possibly explain the possibility of having unsafe water for consumption because in a similar study, low conductivity was an indicator of primeval or background conditions (Wetzel, 1983). In another study done in Ethiopia, TDS and EC were described as measures of the total ions in solution and ionic activity of a solution respectively (Addisie, 2012). As TDS and EC increase, the corrosive nature of the water increases hence leading to water that is unsafe for consumption.

4.4.3 TSS and TDS

According to Table 2, on Total Dissolved Solids (TDS), the MBS regulations state that the standard for Malawi on TDS is 450-1000 mg/liter and all the samples were below the standards. According to literature, TDS alone is not an indicator of polluted water because when found in water, the TDS levels change in the gut system of a human being and hence cannot cause infection. Another point is that low TDS could be attributed to reverse osmosis. The pH threshold levels are 5.0-9.5 according to Malawi Bureau of Standards, (2004) and according to the water points sampled, all water points were falling within the accepted range, but just like TDS, pH alone cannot be used to determine the presence of pollution or activity in the water.

Total suspended solids (TSS) throughout the water points were falling within the threshold of Malawi standards which is 10 mg/l; but TSS is also affected by other factors so not to be taken as a measure of good quality water in isolation. TSS correlates with turbidity, and the threshold levels for turbidity are 0.1-1 NTU. In all water samples turbidity levels were high though the TSS was falling within the normal range. The coefficient of variation was not high in all the samples which meant that the water was polluted but it was not significant.

4.4.4 Alkalinity

Alkalinity levels depend on pH. In water with moderate to high alkalinity, pH is neutral or slightly basic (7.0 to 8.3) and does not change widely (Wurts and Borborow, 1992). With the data from Table 2, it shows that perhaps the alkalinity is not as significant because of its dependency on pH. The more alkaline the water was, the higher the phosphate levels and the higher it would lead to presence of anopheles mosquito, a vector for Malaria. Kalimanjira borehole and Chiula well are more prone to having higher levels of Malaria than the other areas. This would explain the reason of having an increasing trend in Malarial cases in this area. The high population of the village uses Kalimanjira Borehole, which is a breeding ground and hence leading to spread of mosquitoes that are Malaria causing.

4.5 Structure of Communities

The community that was interviewed was diverse like most Malawian villages; some of the characteristics of the communities were that it had both farmers and fishermen. The characteristics of the community determined the levels of knowledge on issues of water quality and sanitation but also on issues of responsiveness to problems that were present.

How other social economic factors were linked with the utilization, availability, access, gender categories and prioritizing of safe water and sanitation. Figure 8 is a graph showing age groups of the community which would determine the link with water related diseases.

Age group of population

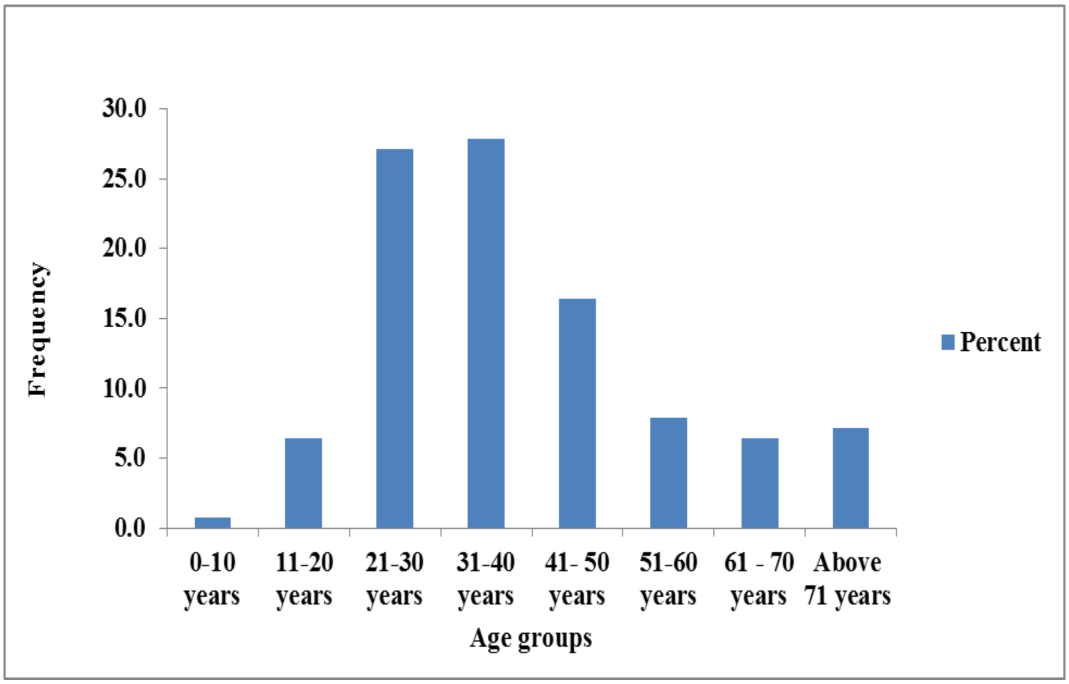


Figure 8: Shows the Age Group of the population sample interviewed

The larger population was in the productive and reproductive age of between 21-40 years old. Perhaps this is a sign that most people are in the reproductive age of the population which would probably mean the population is expected to double due to having a large group in the reproductive years. This age group is also more productive and has demand for water and its uses for their livelihoods. It was also noted during literature review and in focus group discussions that the productive group was the one that was more prone to waterborne diseases than other groups. Because of the prominence of water, the effects of gender by age may influence decisions about water and may have far reaching consequences on human well-being (Crow and Sultana, 2002).

4.5.1 Household Waste Management Practices

Table 4 shows the waste management practices in Kalusa village of TA Malengachanzi with an explanation. These percentages are derived from the interviewed population of 160 respondents from SPSS analysis:

Table 4 shows household waste management practices

Not Applicable	Throw in dump behind house	Burn	Compost	Throw in Bush
2.9%	75.7%	2.9%	5.7%	12.9%

Household waste is managed mostly by throwing in a waste pit behind the house by 75.7% of the population whilst 12.9% throw behind the bush by their responses, but with observations, there were more households without a waste pit as Figure 9 shows.

Waste Management Practices

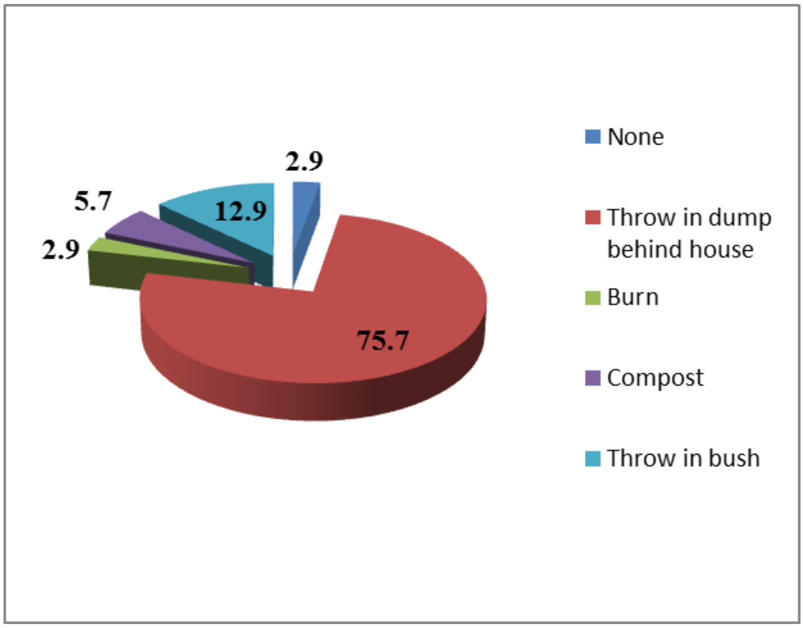


Figure 9: Shows waste management practices

Sanitation is essential to promote health and prevent diseases. It is described in terms of personal hygiene, toilet facilities and surrounding environment (Water Aid, 2009). The condition of toilets was not hygienic due to scarcity of water and problem of awareness created among the existing households which was attributed to during the focus group discussions.

The local communities' awareness toward sanitation is good due to access to sanitation and hygienic education. The reasons for those who did not have toilets included adoption of the habit of open defecation; toilets were warped during rainy season, absence of space or land for toilet and lack of labour and money.

There is a connection between education and method of waste management practice, 45% of the respondents went to primary school and hence able to throw their waste in a dump behind their houses. 10% responded that they throw their waste in the bush and it was not because of the level of education attained, this could be due to the awareness levels that are leading to hygienic practices in the area. Though there is a rise in hygiene related diseases which would quickly be attributed to what is consumed and with the variables present like age and education, this is disputed in Tadesse, (2008) who found out that demographic features such as age, education and household size have an insignificant impact over the choice of alternative waste disposal means, and he found that the supply of waste management options significantly affects waste disposal choice. Hence it could be concluded that since the only viable and common means that the community is aware of is throwing in a rubbish pit behind the house, this is affecting the other options that the community can venture into.

4.5.2 Hygiene practices and behavior

The hygiene practices in the community include hand washing, throwing wastes in rubbish pits as shown in Figure 9. Explaining further, Figure 10 shows hand washing practices that are some of the practices and behaviors of the community in relation to water borne disease prevention.

Hand washing as a hygiene practice

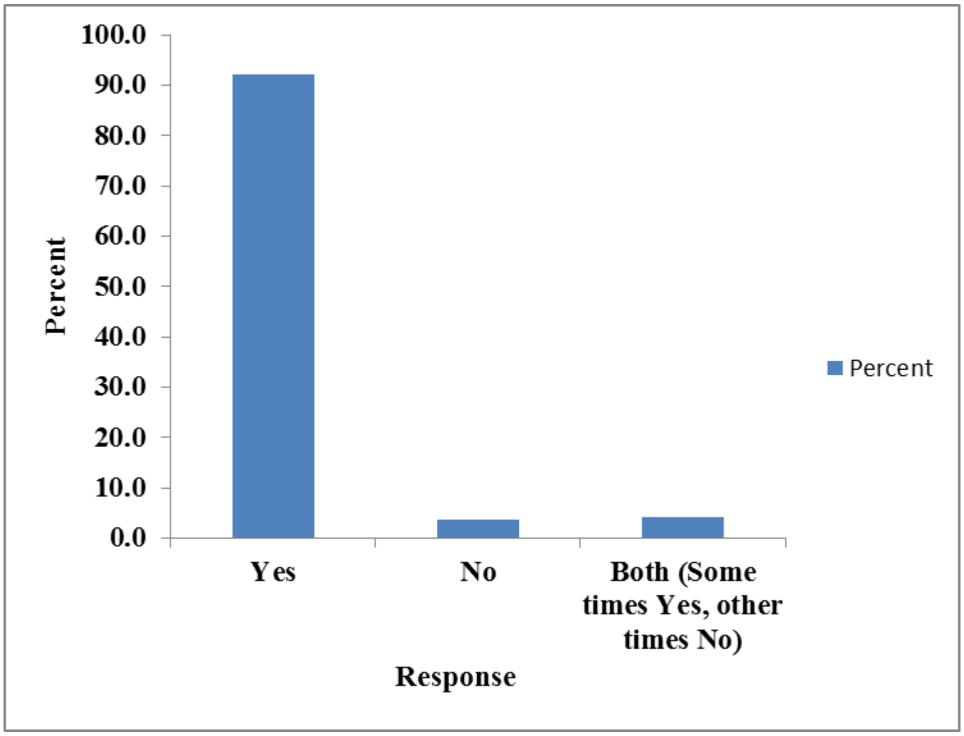


Figure 10: Shows hand washing after visiting the toilet

90% of the respondents attributed to hand washing as a hygiene practice after visiting the toilet. It is in this line that it is not the hygienic practices that are leading to increase in waterborne diseases but it is the quality of the water from the water points as evidenced by the water quality parameters in the water sampled. Curtis, (2003) studied and found that health is low on people's list of motives, and hands are washed to remove dirt, to rinse food off after eating, to make hands look and smell good, and as an act of motherly caring but not usually washed after visiting the toilet. This study suggests differently in that due to education, 90% of the respondents do wash their hands after visiting the toilet in Malengachanzi area, probed further the reasons were education and also it is a religious duty expected of everyone.

4.5.3 Water Source Problems

There are several water source problems as Figure 11 depicts long distance to a protected water source, scarcity of potable water, congestion, low water yield and inadequate water points.

Sources of Water problems against population

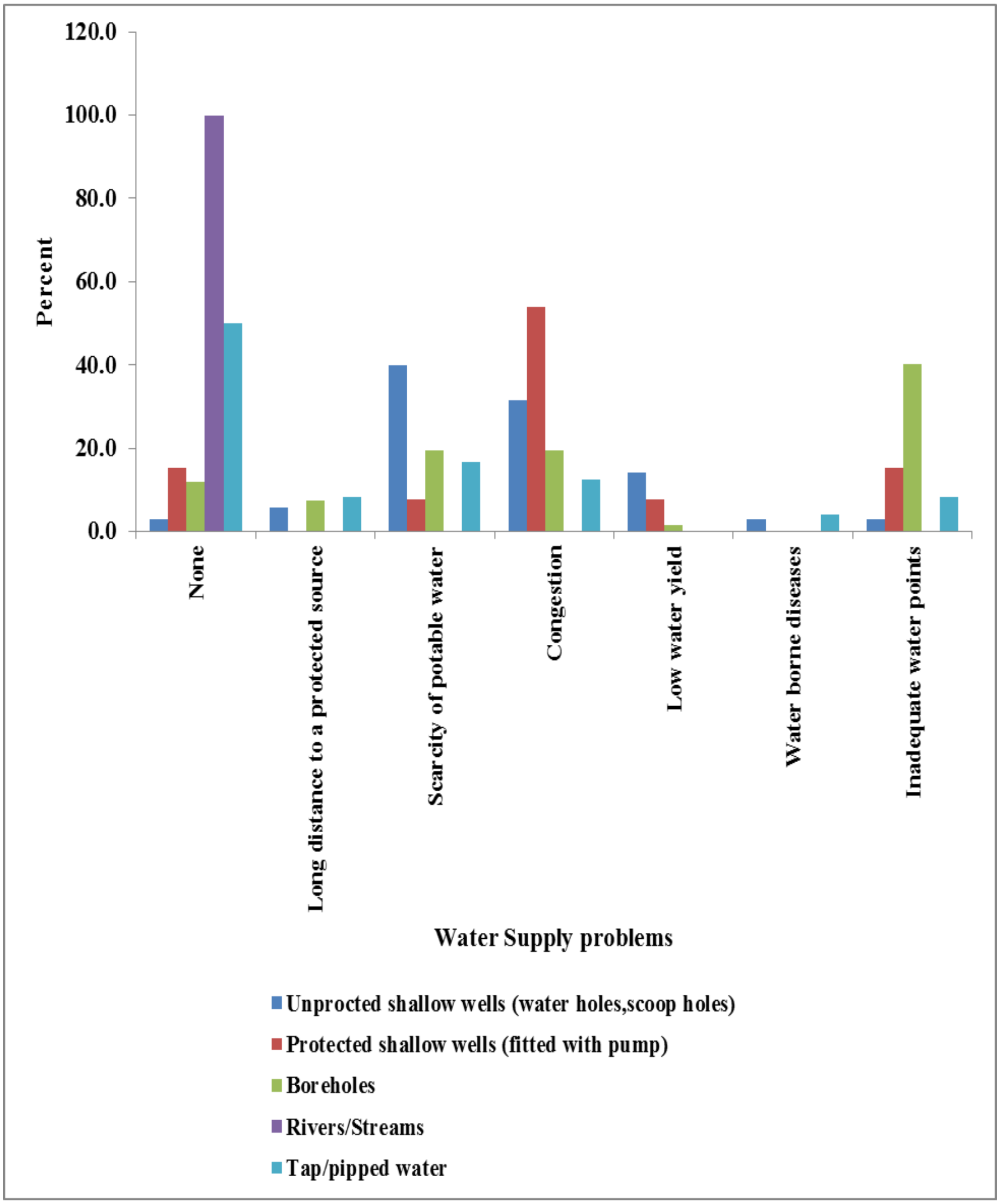


Figure 11: Shows source of water problem against population

There were people who were still dependent on unimproved water sources such that the problems associated beside queuing time was also a problem to access water hence people obligate to found alternative unhealthy water sources. People use other means of water collection i.e. rivers and streams, unprotected shallow wells due to the erratic water availability. Distance from the source to the house, quality of the water, adequacy from the source and waiting time were significant at P values less than 0.05. This means there was a relationship between reluctance and these variables. Because when the distance from improved sources increased people prefer to collect water from nearby unimproved sources. Sometimes households prefer to collect water from unimproved sources because they believed the water sources could be cleaned manually.

An important outcome of the study was the development of data for possible intervention for safe water and sanitation sector. The debate for safe water centres on availability, quantity, distance, time taken to access the facility and types of facilities (Manda, 2009). According to WaterAid, (2007), 50 litres per person per day is recommended and this is backed by government using a distance of 500 meters as signifying adequate access to water. Access to water is defined as the availability of 20 litres per capita per day at a distance no longer than 1,000 metres (Manda, 2009).

4.5.4 Water source in the sub villages of Kalusa

Figure 12 shows the source of water problems in the villages

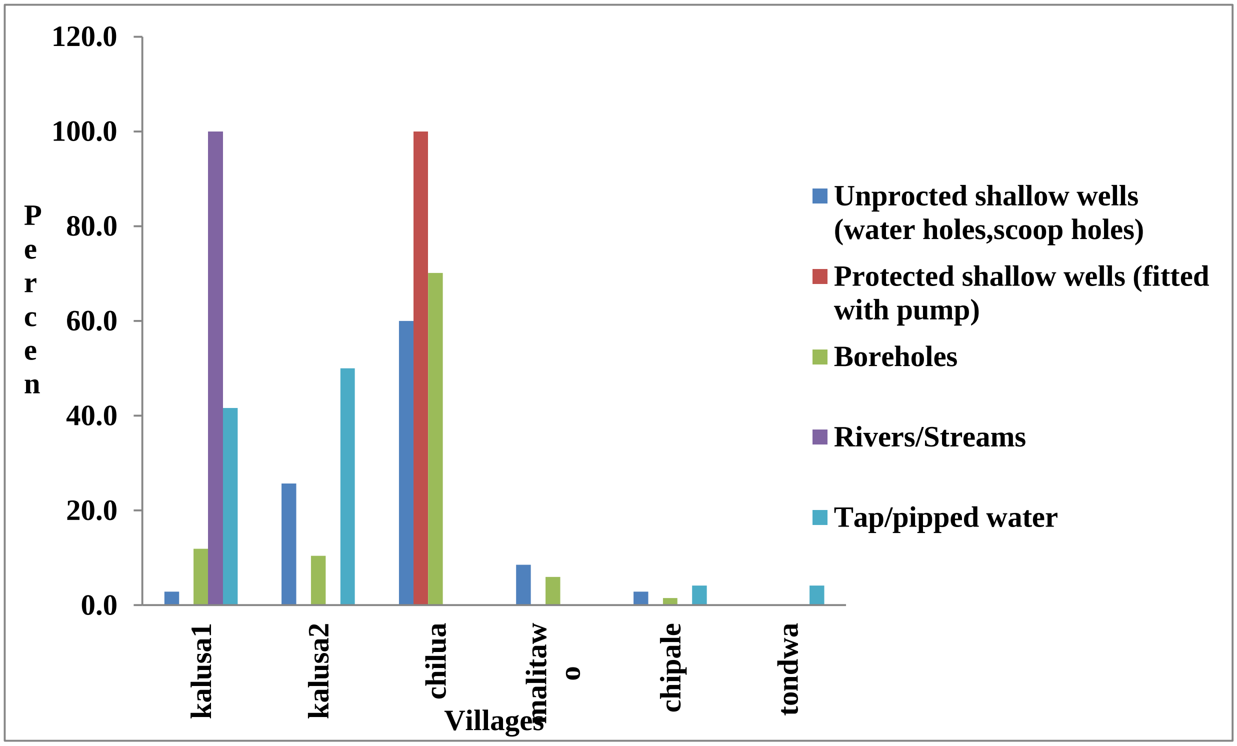


Figure 12: Shows source of water against villages

Among the villages in Kalusa, Chiula had the highest access to protected shallow wells (fitted with pump) but though this was the case, there was still presence of E.Coli in the water which would mean the increase in diarhoeal cases is from the source and not from the hygiene practices.

Common Water Supply Problems

Figure 13 shows the common water supply problems that the community faces.

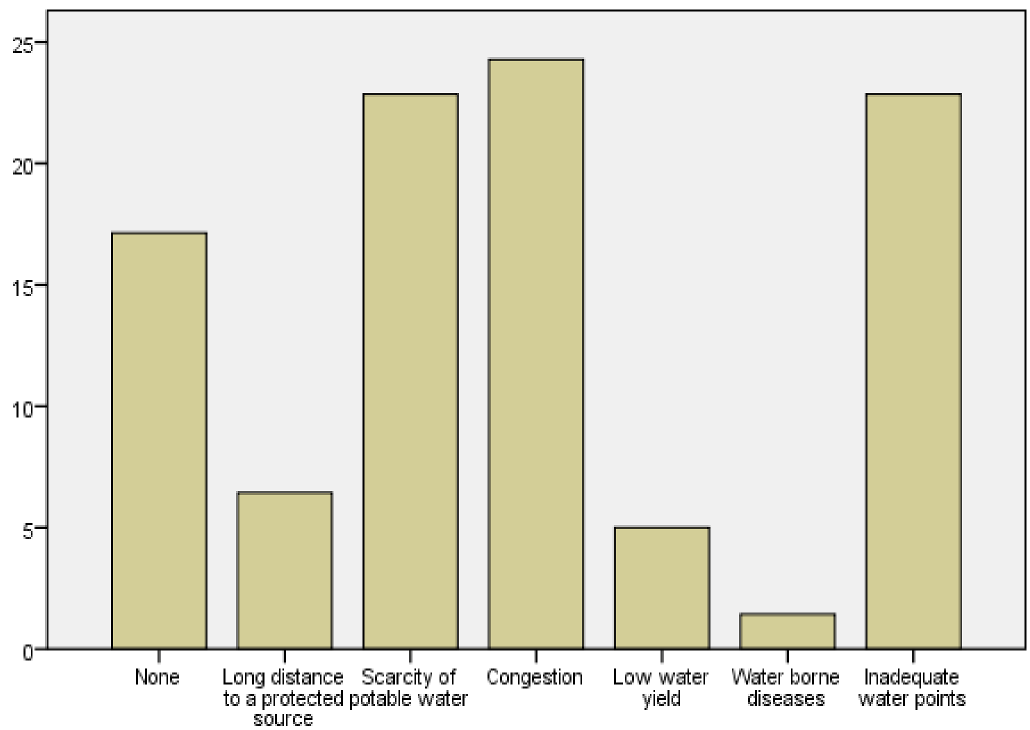


Figure 13: Shows Common water problems

The highet percentage attributed the congestion at safe water points as a main water supply problem. The water problem is a trigger for the use of unsfae water or even the reason for not following water purification at household level due to the drawing of water from what the community perceives as a safe water point. But in cases of people congestion go to the water points as highlighted by the Figure 7. 35% of the population get their water from unprotected water points which defeats the whole purpose of having improved water in the community. There is need to ensure that the availabe water points are being regularly checked and monitored of water quality and that there is safe drinking water for the community which is a basic human right.

4.5.5 Gender and Water source problems

According to the focus group discussions, there is no significant relationship between the gender and the water source problems. The problems are affecting both genders though women are the custodians of water collection, and children are the ones that are affected by water borne diseases more than adults, the women and men are vulnerable to the waterborne diseases. Figure 14 is showing the sources of drinking water:

Sources of water problems against sex of respondents

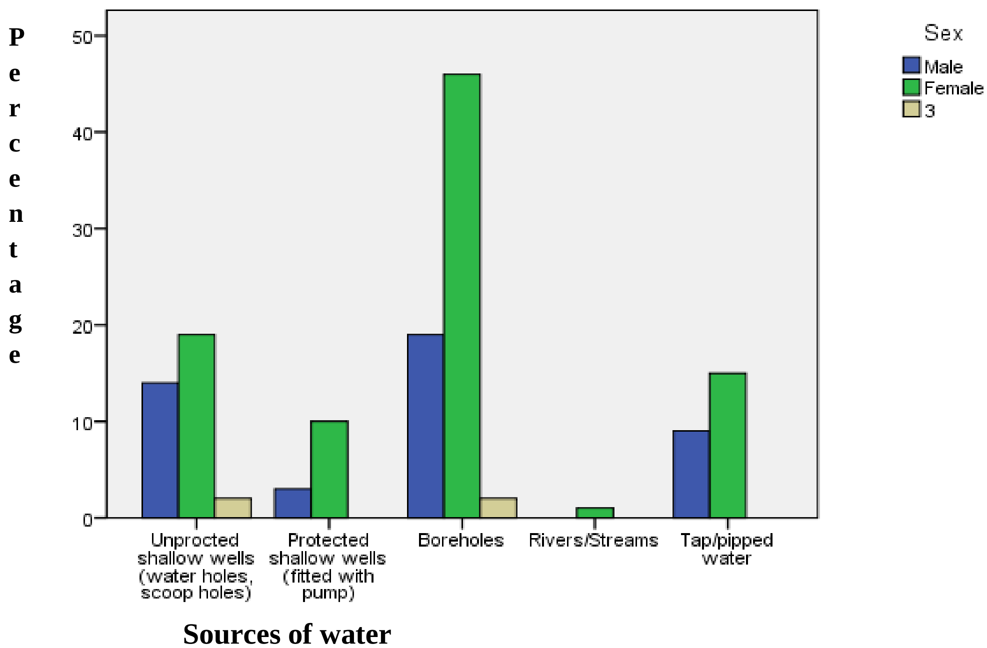


Figure 14: Shows sources of drinking water against gender

Most females draw water from the boreholes which are contaminated as this study has assessed. Though there is drawing of water from unprotected water points, there is still availability of pathogens that are causing waterborne diseases. During the focus group discussions, women are the ones that handle water at household level. Men come in contact with water due to fishing or when bathing but 68% of the respondents attributed women having the responsibilty of water from source to household.

According to Zwarteveen (1997), in most systems studied there is lack of acknowledgment of women's specific water needs, because mostly women use the water for domestic consumption unlike men. Zwarteveen (1997) backs up this finding that women are in contact with water more hence more likely to be infected with waterborne diseases more than men. Education level has no significance difference on the waste management practices because most of the people throw waste in a bush are in lower secondary education as shown in Figure 15.

Figure 15 shows the relationship between education and waste management practices

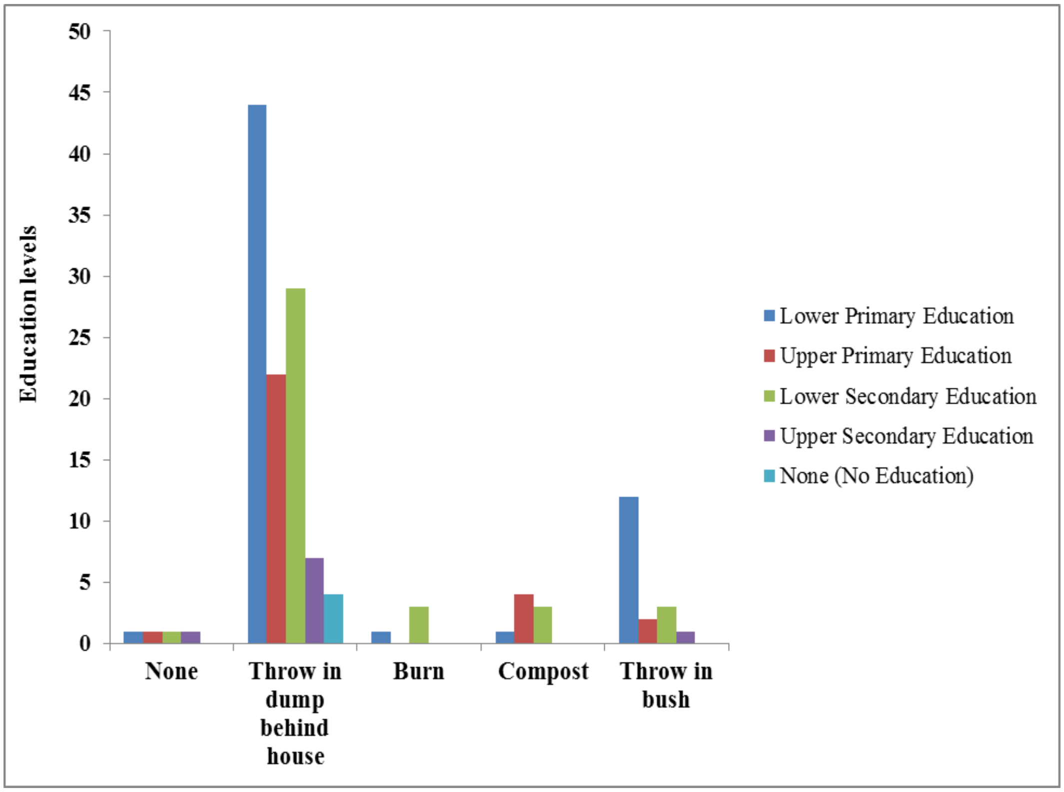


Figure 15: Shows a relationship between education and waste management practices

On water treatment, there are the following methods available:

Table 5 Shows Treatment of water

Treatment of water after collection	Frequency
Do not treat water	57%
Boil Water	30%
Use water guard/chlorine	13%

57% of the respondents do not treat their water in any way as Table 5 shows that 30% boil the water, 13% just use the water without thinking of any other filtration of it. As literature has suggested, more pathogens are present in water after the water source. According to World Health Organization (2006), pathogens can be present through various natural chemical contaminants, biological sources, microbial activity, and from corrosion.

Hence even though the water sources have contamination, for the safe water point's contamination could be available after the water source if the water is not treated. Perhaps more contamination happens with handling of water than the water source itself.

Table 6 Shows Correlation of results

Correlations	Significance level (P-value)	Correlation	Confidence Interval
Functionality of water points and diseases prevalence	0.456	0.087	99%
Disease prevalence and availability of latrines	0.492	-0.81	99%
Disease prevalence and hand washing	0.58	-0.16	99%
Treatment of water and disease prevalence	0.109	0.136	99%
Sources of drinking water and disease prevalence	0.88	-0.13	99%
Income and sources of drinking water	1	0.001	99%

Table 6 depicts the relationship among the variables in the research which correlates the variables to accept or reject the hypotheses. Functionality of water points and diseases prevalence, Treatment of water and disease prevalence, and Income and sources of drinking water showed a positive correlation meaning that if water points are functioning properly, disease prevalence will decrease. Also it means if income of the household increases, the sources of drinking water are safer for households but this is not significant. Also it means if water is treated, the diseases prevalence will go down.

Another important relationship is that, if there are no pit latrines, disease prevalence will be high shown by the strong negative relationship in correlation of the two variable. Sources of drinking water and hand washing are not highly correlated with disease prevalence but are negatively correlated.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusion and recommendations from the study results and the recommendations derived from the study.

5.1 Conclusion

Firstly, an important outcome of the study was the development of data for possible intervention for safe water and sanitation sector.

Secondly, policy makers may use information on the access to clean drinking water and sanitation as perhaps one of the most significant Millennium Development Goals because of its relations to human health and the aptitude of people to carry out useful occupation. It is also linked to gender and as well as their role in collecting water for families and communities.

The study has shown that prevalence of diseases namely diarrhoea, dysentery, and Malaria is perhaps increasing due to contamination of water sources as evidenced by the results. Water quality parameters are in the unsafe ranges for consumption and no trends were unravelled due to lack of historical data; however, the temporal bacteriological data obtained suggests water contamination that might lead to water borne diseases.

In summary, the most important outcome of this study was the assessment of the prevalence and trends of waterborne diseases in Kalusa village, Malengachanzi. The presence of vegetation that is antibacterial like the *ScleroCaryabirreaSubspCaffra* close to water points perhaps leads to decrease or no presence of bacterial diseases due to its antibacterial properties.

The study rejects the null hypothesis that are no linkages between location of safe sanitation, its proximity to safe water and the location of sanitation facilities because there are linkages on location of the toilets played a role in the presence of coliform bacteria and *E.Coli* in some areas like Kalimanjira Borehole which was close to the water point.

5.2 Recommendations

The following are recommendations made out of this study;

- Researchers should further examine the influence of driving forces like land use, on the state of the water and, subsequently, on health of the population.
- Policy makers need to constantly be checking on parameters of water to be able to back evidence of water quality parameters over a time period.
- For the communities, conceivably hygiene practices for consumption should be encouraged to reduce incidences of water borne diseases.
- Vegetation with anti-bacterial properties should be planted around water points in communities.

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APPENDICES

Appendix 1: Questionnaire for Households in Kalusa Village for examining the linkage of sanitation and water by using the Ecosystems Approach principles

1. Official Details
2. Name of Interviewer: ____
3. Date of interview: ____

A. LOCATION DETAILS

1. Traditional Authority:_______________________________
2. Group Village Head:________________________________
3. Village of residence: _______________________________
4. GPS coordinate: Easting________________ Northing______________________

B. RESPONDENT PROFILE

5. Age or calculate from date of birth:

   (Below 10; (2) 11-19; (3) 20-29; (4) 30-39 (5) 40-49 (6) 50-above
6. Tribe
   (1)Yao; (2) Chewa; (3) Ngoni (4) Tumbuka (5). Any other (please specify) __________________________

7. Marital status

   (1) Single; (2) Married; (3) Divorced (4) Widowed (5) Separated

8. How many are you in your household?

   __ Male: Female___________

9. Religious belief:

(1) Christian; (2) Moslem; (3) Other (please specify)______________________

10. Education level

(1) Can't read and write (2) Basic primary school (3) Primary School Leaving Certificate (4) Malawi School Certificate of Education (5) Other (specify)_______________________

11. Main Economic activity

    (1) Farming; (2) Employment; (3) Fishing; (4) Selling forest products (firewood, game, cane products, fruits, curios, etc.); (5) Selling locally manufactured products; (6) Tour guide; (7) Other (specify)____________

12. Annual income (in Malawi Kwacha based on main economic activity as shown above)

(1) Less than K10,000; (2) K10,000-K20,000; (3) K20,000-K30,000; (4) K30,000-K40,000; (5) K40,000-K60,000; (6) K60,000 and above

13. Who is responsible for fetching water?

A. Husband 2) wife 3) child 4) Husband + wife 5) wife + child 6) others

14. Is there alternative water source in the vicinity?

A. Yes 2) No

15. How many times do you collect water per day from improved water sources?

A. One 2) two 3) three 4) four and above

16. How many times do you collect water per day from traditional water sources?

A. One 2) two 3) three 4) four and above

17. How long you spent average time to fetch water from the source to house from traditional water source?

A. 15min 2) 30min 3) 1hrs 4) 2hrs and above

18. How long you spent average time to fetch water from traditional water source?

A. 15min or less 2) 30min 3) 1hrs 4) 2hrs and above

19. What is the average distance in meters from the source to the house?

A. 7.1 traditional 7.2 Improved

20. Is the distance convenient in your perception?

A. Not at all 2) somewhat convenient 3) convenient 4) very convenient

21. What type of material used for water collection?

22. How many liters it holds?

23. How much water did you collect yesterday?

24. Were you satisfied?

A. Not at all 2) somewhat satisfied 3) partially satisfied 4) Fully satisfied 5) Over satisfied

25. For what purposes you used for?

26. How much liter?

27. How many times per week did you collect water from unprotected springs?

A. Once 2) twice 3) three times 4) four and above

28. From hand dug wells?

A. Once 2) twice 3) three times 4) four and above

29. From rivers?

A. Once 2) twice 3) three times 4) four and above

30. Protected springs? 1) Once 2) twice 3) three times 4) four and above

31. Hand pumps?

A. Once 2) twice 3) three times 4) four and above

32. Public taps?

A. Once 2) twice 3) three times 4) four and above

33. If unimproved source, why not improved sources?

A. Income 2) distance 3) presence of alternative source 4) quality 5) adequacy 6) waiting time 7) interest 8) others

34. Do you pay water fee for improved sources?

1) Yes 2) No

35. If no, are you willing to pay for improved source?

A. Yes 2) No

Water quality and sanitation perception questions

36. What does water quality mean to you?

37. Do you perceive that the water you consume is safe?

A. Not safe at all 2) somewhat safe 3) partially safe 4) safe 5) highly safe

38. What is the main indicator of the water quality?

Color 2) test 3) odor 4) disease attack 5) others specify

39. Is the taste, odor and color of water the same as the unimproved source?

A. Yes 2) no 5.

40. If no, what is the difference detected?

41. What do you think the major cause of water quality problem?

A. Animal wastes 2) human wastes 3) flood 4) others

42. What treatment measures do you use for unsafe water?

A. Not at all 2) boiling 3) sedimentation 4) others specify (done by projects)

43. How many times your family sick due to water related disease last year?

A. None at all 2) twice 3) three times 4) more than three

44. Have you participated in any educational and awareness activities about sanitation and hygiene parallel to water supply? 1) Yes 2) No

45. Do you have a latrine? 1) Yes 2) No 74

46. If yes, when you dig a latrine (in relation to the constructed water source)?

A. and less than 1 year 2) 2years ago 3) three and more

47. If yes, who teaches you to dig a latrine?

A. Own self 2) sanitary 3) water use &sanitation committee 4) not at all

48. If yes do you use it? 1) Yes 2) No

49. If yes, who use the latrine?

A. Man 2) wife 3) child 4) all families 5) except child

50. If not for what is the reason

51. If no, why don't have a latrine?

52. Where do you defecate?

A. Public toilet 2) neighbor 3) open field 4) own toilet

53. Do you wash your hand after defecation?

A. Yes 2) No 18. If no why not? 19. Do you wash with Soap or other material?

54. When do you wash your hands?

Thank you for your participation in the survey. Your responses are highly appreciated