ASSESSMENT OF WATER AND SANITATION ACCESSIBILITY AND PREVALENCE OF WATER-RELATED DISEASES IN BARINGO COUNTY, KENYA

OSIEMO M. MERCY

A Thesis Submitted to Graduate School in Partial Fulfillment for the Requirements of the Award of the Master of Science Degree in Environmental Science of Egerton University

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DECLARATION AND RECOMMENDATION

DECLARATION

I hereby declare that this thesis is my original work and has not been submitted or presented for examination in any other Institution either in part or as a whole.

Signature ……………………………… Date …………………………….

Osiemo Mandere Mercy - NM12/14373/15

RECOMMENDATION

This thesis has been submitted for examination with our recommendation and approval as university supervisors.

Signature ……………………………… Date …………………………….

Prof. George M. Ogendi
Egerton University, Kenya
Department of Environmental Science

Signature ……………………………… Date ……………………………

Prof. Charles M. M'Erimba
Egerton University, Kenya
Department of Biological Sciences

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DEDICATION

To my dear Dad Daniel Osiemo and my mother Stella Moraa Osiemo, thanks a lot for your patience, financial support, and love throughout this academic journey.

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ABSTRACT

Accessibility to potable water is a fundamental right for dignity and well-being. In spite of this observation, over 1.1 billion people lack access to safe drinking water. This is particularly true in the Sub-Saharan Africa and South East Asia regions. The main aim of this study was to Assess Water and Sanitation Accessibility and Prevalence of water-related diseases in Marigat town Baringo County, Kenya. The study employed a Cross-sectional household survey. Stratified random sampling method was used to select household respondents. A structured questionnaire was administered to households' heads to elicit information relating to objectives of the study. Samples of drinking water were collected from water sources (boreholes, rivers, and springs) and at point of use (households) and analyzed for *Escherichia coli* and Total coliform bacteria using the Most Probable Number method. *In situ* measurements of PH and temperature were carried out using a Wagtech International portable meter. Clinical health records from the local health centres were also reviewed to assess the Prevalence rates of some of the water-related diseases. The study findings indicated that there was a significant association between level of education and covering of water storage container ($P< 0.05$). There were significant differences among water sources in terms of *E. coli* ($F_{(2, 21)} = 3.629$, $p < 0.05$) and Total Coliform ($F_{(2, 21)} = 4.041$, $p < 0.05$) during dry season. Similar observations were made during the Wet season for *E. coli* ($F_{(2, 21)} = 4.090$, $p < 0.05$) and Total Coliform ($F_{(2, 21)} = 1.893$, $p < 0.05$). Further, there were significant interactions between the water sources & season *E. coli* ($F_{(2, 42)} = 7.66$, $p < 0.01$) and Total Coliform ($F_{(2, 42)} = 5.494$, $p < 0.05$). Drinking water in large plastic storage containers (herein referred to as skyplast) had the highest *E. coli* and Total Coliform concentrations. Typhoid was the most prevalent water-related disease during the dry season (10%) while Diarrhea (3%) most prevalent during the wet season. All drinking water at abstraction and point of use for Marigat residents are microbiologically contaminated and therefore pose serious health risks to consumers of such water. Thus there is need for Public health awareness campaigns on household water management to curb incidences of water-related diseases. Public health practitioners at county and national levels need to ensure that households have adequate access to potable water and improved sanitation.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
CBO	Community Based Organization
CDC	Center for Disease Control
DWAF	Department of Water Affairs and Forestry
FC	Faecal Coliform
KNBS	Kenya National Bureau of Statistics
KES	Kenyan Shilling
MDGs	Millennium Development Goals
NGO	Non-Governmental Organization
SDGs	Sustainable Development Goals
SID	Society for International Development
TC	Total Coliform
UN	United Nations
UNICEF	United Nations Children's Emergency Fund
USEPA	United States Environmental Protection Agency
WHO	World Health Organizations

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Water and sanitation are essential elements for human survival and well-being (Ahiablame *et al*, 2012). Water and sanitation significantly affect women and children, with children having the highest susceptibility to illness. Poor sanitation and water quality contribute to approximately 1.5 million annual deaths in children below 5 years of age worldwide. This has been observed especially in urban areas where millions of urban poor women lack access to adequate water and sanitation even though this is considered a basic human right (WHO, 2014). About 1 billion people throughout the world don't have access to improved drinking water supplies and 2.5 billion people live without adequate sanitation facilities. In 2012, worldwide, the percentage of those with an adequate supply of water and sanitation was found to be 89% and 86% respectively in urban areas (World Bank, 2015)

Drinking water quality is still an issue of concern for human health in developing and developed countries worldwide. According to the report by WHO, (2014) every year, 4 billion cases of water-related diseases causes at least 3.4 million deaths worldwide, making it one of the leading causes of morbidity and mortality. Most of the victims are children under the age 5 of years, that die of illnesses caused by organisms that thrive in water sources contaminated by raw sewage (WHO, 2014). Inadequacy of water and sanitation and water-related disease prevalence are wide spread especially in Sub-Saharan Africa where utilities lack efficient and transparent management system. The principal challenge for Africa in the urban sphere is to address how its cities respond to the enormous challenges of rapid development, urban expansion, increased demand for services, threats to supply of water, constrained and failing urban planning systems, and institutional practices. The sustainability of human urbanization and growth in economy is threatened by the growing scarcity of water (Vaziri & Tolouei, 2010)

Poor quality of drinking water is associated with the spread of water-related diseases such as cholera, dysentery and Haemolytic Uremic Syndrome (Montgomery & Elimelech, 2007). These diseases are commonly reported in low-income countries as provision of safe water, sanitation and hygiene is sub-optimal (Rana, 2009). In developing countries, accessibility of safe drinking water is still a problem and most people use the available unimproved water sources such as dams and rivers often microbiologically unsafe as a result, the most well-known water-related diseases such as cholera, amoebic dysentery and typhoid are reported from majority of the African countries especially in tropical areas of the region including Rwanda (WHO, 2010).

In Kenya, 80% of the residents live in arid and semi-arid lands (ASALs). The provision of safe drinking water and sanitation are some of the major challenges the livelihoods in the ASALs face and have been recognized as some of the major developmental challenges the country is facing towards the realization of the vision 2030 (GoK, 2007) and in meeting the United Nations Sustainable Development Goals 3 and 6 respectively (WHO, 2016). Approximately, 80% of Kenyans continue to have inadequate access to water, drink unsafe water, and spend much time and money trying to acquire it. As a result, most people suffer and die due to water-related diseases which account for 60% of all diseases in Kenya (Kandji, 2006). On water access, in urban areas, only about 40% of the habitants have direct access to piped water (Herrero *et al.,* 2010). The rest obtain water from kiosks, vendors, illegal connections or from wells. Only about 40 % of those with access to piped water receive water daily (Nyangeri & Ombongi, 2007)

According to a report by National Drought Management Authority, (2014) water sources currently in use in Baringo County include water pans, dams, natural rivers, traditional river wells, springs, boreholes and lakes. Water shortage is prevalent with 76.5 % of the people in Baringo County using unimproved water source (KNBS & SID, 2013). This is caused by the low rainfall received and cyclic droughts and that have hindered development of livestock and farming activities, as people spend many hours daily looking for water. A report on water and sanitation in Kenyan counties revealed that 2.0% of the human population in Marigat sub-counties depend on boreholes, ponds and dams for their domestic water uses (KNBS & SID, 2013). However, these water sources are categorized as unimproved (WHO, 2008). Most of the population does not have access to good sanitation and 5% of the population has access to improved sanitation and this poses a major health hazard among the residents of Baringo County. It is against this background a study was conceived to assess water and sanitation accessibility and prevalence of water-related diseases in the study area.

1.2 Statement of the Problem

Water-related diseases are among the major public health problems in developing countries, Kenya not being an exceptional. Continuous use of unsafe water from unprotected sources such as streams likely to be contaminated coupled with low education awareness has contributed to the escalation of water-related disease prevalence that could lead to high morbidity and mortality in all age groups particularly in children under 5 years of age. Thus this study tried to establish whether there was a link between household hygiene practices, seasonality, and level of education to influence prevalence of water-related diseases in the study area.

1.3 Objectives

1.3.1 General objectives

To assess water, sanitation accessibility and prevalence of water-related diseases in Marigat town, Baringo County during wet and dry season

1.3.2 Specific objectives

1. To determine household access to sources of water and sanitation facilities in the study area
2. To evaluate household water management practices in the study area
3. To determine the occurrence and concentrations of microorganisms in water samples at the source and point of use in the study area in the dry and wet season
4. To characterize the prevalence of water-related diseases in the study area in the dry and wet season

1.4 Research Questions

1. How accessible is water and sanitation and which are the most common sources of water and sanitation facilities in the study area?
2. How do households in the study area manage water and is water in the households contaminated with pathogens?
3. What is the prevalence of water-related disease in the study area?
4. Is there any relationship between water sources, season, point of use and microbial density?

1.5 Justification of the Study

Accessibility to adequate water and sanitation and prevalence of water-related diseases in the urban areas has been a major issue of concern. This study was in line with the United Nations Sustainable Development Goal three, which is geared towards ensuring healthy lives and well-being for all and goal six, whose aim is to ensure availability and sustainable management of water and sanitation for all. This study was also in line with the Kenyan constitution article 42 that states that everyone has a right to a clean and healthy environment which includes the right to have environment protected for the present and future generations through legislative and other measures especially those contemplated in article 69 and have obligations to the environment. This study contributes to the African vision 2025 which ensures equitable and sustainable use of water for socioeconomic development. This study also contributes to the social pillar on water and sanitation target of Kenya's Vision 2030, which aims at ensuring improved water sources in both rural and urban areas. Data from this study is beneficial to the residents within Baringo County, Ministry of Health, and policy makers in addressing water sanitation and accessibility in the urban areas of the county.

1.6 Scope of the Study

The study was confined in Marigat urban centre. The town is located in Baringo County which is an ASAL area. The study was carried out using a cross-sectional survey. There have been reports on the out breaks of water-related diseases such as typhoid and diarrhoea in study area. The study focused on water and sanitation accessibility and Prevalence of water-related diseases (Typhoid and Diarrhoea) during wet and dry season in Marigat Sub-County Health Centres. The study also involved analysis of microbial quality of the drinking water that determined concentration of microorganisms in water samples from both the source and the point of use in the wet and dry season.

1.6.1 Limitation of study

The limitations were as follows:

1. Language barrier from the respondents this limitation mitigated by use of locally educated persons to interpret what the local respondents were saying.
2. Some respondents were unwilling to participate in filling the questionnaires, but this limitation was mitigated by use of the local chiefs to talk to them on the importance of this research to them. The types of questionnaires were designed in such a way to build their confidence.
3. Owing to relatively high illiteracy levels documented in drylands especially in the study area, some respondents faced a challenge while filling in questionnaires this limitation was mitigated by training locally educated people that filled in the information provided by these respondents.

1.6.2 Assumptions of the study

The study assumed that:

1. Households selected provided a true representation of water and sanitation accessibility and prevalence of water-related diseases in the study area.
2. Water-related disease prevalence was explained from the clinical health records reviewed from the health centres within the study area.
3. There was a relationship between independent (Sources of water and sanitation accessibility, microbial quality of the water and household water management practices) and dependent variable (water-related disease prevalence).

1.7 Definition of Terms

Access to sanitation: Refers to a distance not exceeding 200 meters from a home to a sanitation facility

Access to water: This refers to a distance of not more than 200 meters from a home to a public water source.

Agro-ecological zone: are geographical areas exhibiting similar climatic conditions that determine their ability to rained agriculture.

Clean Water: Is water which is pure enough to be consumed or used with low risk of immediate or long-term harm.

Drinking water: Refers to water that is used for domestic purposes including drinking, cooking, and personal hygiene.

Household: Is a group of persons that eat and live together. They may, or may not be related by blood but usually make common provision for food and other essentials for their livelihoods. A household may comprise one or several members.

Improved drinking water source Improved water-source is constructed in such a way that it is protected from outside contamination with fecal waste for instance borehole, protected well, protected spring and household piped water

Unimproved drinking water source: is not constructed fully enough to protect it from fecal contamination, for instance unprotected well, water-vendors, unprotected spring, river water and tanker truck water.

Improved sanitation facilities hygienically separate fecal matter from human contact and includes household connection to a septic systems or a sewer, pour-flush toilets and pit latrines with covered pit.

Unimproved sanitation facility: don't separate fecal matter from coming in contact with human and include uncovered pit latrines, bucket latrines and open places such as bushes.

Kisima points: These are open wells along the river.

Morbidity: This refers to a diseased state, a disability or state of poor health in a population

Mortality: Refers to the total number of deaths expressed in units of death per 1000 people per year

Prevalence: Is the proportion of a population found to have a condition (for this case waterborne disease). It is arrived at by comparing the number of people who have a waterborne disease over the population studied expressed as the number of cases per 10,000 people as a percentage.

Safe water: This refers to water that does not contain any biological or chemical agents directly detrimental to health. This includes untreated but uncontaminated water from protected springs, boreholes and treated surface water.

Sanitation: Is the presence of facilities and services for the safe and adequate disposal of human urine and feces. It is also the maintenance of hygienic conditions, through services such as adequate garbage collection and efficient wastewater disposal.

Water-handling practices: This refers to household water storage, usage and point-of-use treatment

Waterborne disease: Is a disease caused by the ingestion of water that is normally contaminated by human or animal feces or urine that has pathogenic bacteria or viruses including cholera, typhoid

Water-related disease: are diseases that are caused by pathogenic microorganisms that are commonly transmitted in contaminated fresh water. Infection commonly results during bathing, washing, in preparation of food or through consumption of food that is contaminated.

Water quality: is technical term is based upon the characteristic of water in relation to the guideline values of what is suitable for human consumption and also for domestic purposes

Water treatment: this refers to the actor the process of making water more potable or useful, as by purifying, clarifying, and softening it

Water management: refers to the activity of planning, developing, distributing and optimum use of water resource under defined policies and regulations

Water vendors: refers to the formal or informal onward distribution of water from other sources for domestic purposes.

CHAPTER TWO
LITERATURE REVIEW

2.1 Sources of Water Supply

Up to 70% of the Earth's surface is covered by water either surface or ground water is fresh water located in the pore space of soil and rocks. Surface water is water in rivers and lakes naturally replenished by precipitation and groundwater (World Bank, 2011). According to the World Health Organization, in 2010, 89% of the world's population used drinking water from piped connection (54% from a piped connection in their dwelling areas and 35% from other improved drinking water sources such as protected boreholes, shallow wells, springs and rain water collection), leaving 780 million people lacking access to an improved source of water (WHO, 2010). Availability of water in Sub-Saharan Africa is highly variable, 75% of water supply in Africa is from groundwater (UNESCO, 2008). By 2000, about 300 million Africans were living in a water-scarce environment and by 2025; the number of countries experiencing water stress will rise to 18 affecting 600 million people (World Bank, 2011). Demand for water has been increasing for both human and animal needs, partially due to rapid population growth in many developing countries (Huston *et al.*, 2012). As the population increases, development calls for increased allocations of ground water and surface water for domestic and agriculture (WHO, 2007).

Kenya is among the water scarce country of Africa. Its water storage per capita has deteriorated with time to critical levels of $8m^3$ (Futi *et al.*, 2011). Majority of its population relies on communal water sources that are either exposed or improved (Sobsey, 2002). Surface water sources are limited covering only two percent of Kenya's total surface area. Rainfall is unevenly distributed throughout the country. To respond to water scarcity rain water harvesting technique also provides a solution, especially in rural and drought prone areas (NWP, 2007). According to Herrero *et al.*, 2010, urban areas, only about 40 % of the inhabitants have direct access to piped water. The rest obtain water from kiosks, vendors, illegal connections or from wells. Only about 40% of those with access to piped water receive water 24 hours per day (Herrero *et al.*, 2010). On average, most of the major towns receive water 6 hours per day, a level which is unacceptable by the Water Sector Regulatory Board (Joyce *et al.*, 2010). According to the Water Sector Regulatory Board, in 2009/10 only 76% of drinking water samples complied with standards for bacteriological quality, a level which is unacceptable by the regulator. Twenty-four percent of the population within Baringo

County uses improved water sources while the rest of the population relies on unimproved water sources (KNBS & SID, 2013). Marigat urban centre being an ASAL, water scarcity in the area especially in the dry season is high. Unlike big dams which collect and store water over large areas, small scale water harvesting technique loose less water to evaporation because the water is collected locally and stored in water pans (Futi *et al.,* 2011).

2.2 Sanitation Accessibility

Worldwide it is estimated that about 2.5 billion people do not have access to adequate sanitation facilities (WHO, 2010). Lack of access to adequate sanitation and hygiene are implicated in 88% of diarrheal diseases in both developed and developing countries, out of which 2.2 million people die annually from diarrhea (Tumwine, 2005). Sanitation and hygiene behaviors are equally important in disease prevention. Proper disposal of wastes especially faecal matter is an important factor in achieving reductions in diarrhea morbidity and mortality rates. Improving sanitation in both the urban and rural communities should include safe disposal of human waste through encouraging the use of a pit latrine, safe disposal of children's stool in latrines, ensuring proper use of latrines, hand washing stations with soap and adequate water for hand washing near the latrines (UNICEF, 2010).

A simple pit latrine, one of the most basic forms of household sanitation, offers an inexpensive alternative to a sewage system. One of the major challenges with sanitation is developing and employing innovative, user-friendly, and systems that are of low cost (Montgomery & Elimelech, 2007). However, some evidence has linked the standard latrine to contamination of groundwater by bacteria and nutrients. Additionally, besides absence of adequate sanitation facilities especially toilets, poorly constructed latrines without lids to prevent flies from visiting the toilets and picking faecal matter on their appendages to contaminate foods and cooking utensils is also a major problem faced in the prevention of water borne diseases. This is because most families do not have good toilets facilities; the hygiene and sanitation officers of the rural municipalities do not do regular checks in homes to identify defaulters who do not have good toilet facilities or with toilets too close to households and judicious sanctions meted on them. In the hinterlands some inhabitants used pig fence as their toilets, others used rivers as their toilet thus polluting water thereby causing water borne infections for those using it downstream (Meinhardt, 2007)The ventilated improved pit latrine improves on the standard design by allowing odour to escape, preventing flies from entering, and in many cases sealing the pit to prevent groundwater contamination (Montgomery & Elimelech, 2007).

Proper education should be provided to people from rural communities to promote the correct hygiene practices and these communities should be informed on the transmission risk and the causes of waterborne diseases (Banda, 2006). Information about hygiene behaviour provided through home visits, health education classes, awareness campaigns or hygiene promotion programs has been shown to be an effective instrument (O'Reilly *et al.*, 2007). However, a study on population's knowledge and hygiene practices conducted in rural communities indicated that they lacked knowledge on safe disposal of fecal matter in the households (Banda, 2006).

According to Baringo County Annual Development Plan 2015/2016 most of the population within Baringo County do not have access good sanitation. Household use bushes to relieve themselves constituting 49% while 46% uses pit latrines. There is no sewerage plant in all the towns and trading centers in the county posing a major health pollution hazard among the residents.

2.3 Water Accessibility

Worldwide more than 1.1 billion people lack access to safe water (WHO, 2010). The United Nations set a goal in their millennium declaration to halve the number of people without access safe drinking water by 2015. Although most countries face challenges of providing adequate water supplies for domestic use, this problem is critical among the developing countries. Whereby it is estimated that in 50 percent of the developing countries, the majority of the populations have no access to adequate safe and clean water. Furthermore, UN Population Division (2004) reported that of 117 countries with data available in developing nations, majority of the population lack access to safe drinking water (UN, 2007) .

Although the problem of lack of access to safe water supply exists among many regions of the world, Sub-Saharan Africa is experiencing its devastating impact. UN-HABITAT Report (2011) indicated that an estimated 150 million Sub-Sahara African urban dwellers do not have access to safe drinking water supplies. Even in areas where there is water, its quality is often poor leading to exposure to water borne diseases. It is also estimated that in Sub-Sahara Africa, more than 300 million people lack access to safe drinking water supply (Yongsi, 2010).

The adverse effects of a lack of water services extend beyond the unequivocal consequences. Collection of water, which is primarily the responsibility of women and children, represents an additional burden. Up to 6 hours each day may be spent in search of water to meet household needs. Time spent in search of water is very long forcing children to miss school and women to forgo potential opportunities such as small business endeavors, such as growing and selling vegetables. A lack of water or inadequate water may prevent people from practicing proper hygiene habits, such as washing their hands before eating or after visiting a latrine. Water scarcity may also limit the ability to grow and water vegetables, thus depriving individuals of essential nutrients needed to fight diseases. In addition, the long-term consequences of diarrheal diseases have been linked to secondary health impacts, e.g. malnutrition and reduced cognitive function in children (WHO, 2005)

Furthermore, in Kenya according to UNIHABITAT (2007) urban poor people get their water by queuing for hours to collect water from stand pipes or illegal connections. Others buy their water from vendors who can charge up to twenty-time more for water than the price paid by their neighbors forcing the people to get water from unprotected water sources such as streams which are often contaminated with fecal material, domestic and industrial wastes. Such polluted water results in an increased public health risk of waterborne diseases outbreaks (Mahvi, 2007).

Baringo County has a population size of 555, 561 people and twenty-four percent of the population within Baringo county had access to improved water sources while the rest of the population relied on unimproved water sources. Twenty-six percent of the population have access to safe water, 28.5% lower than the national population (54.1) who have access to safe water. Water from vendors especially in urban centers and small market centers constitute a small percent. The distance covered to domestic water sources was reported to be normal at 4km thus this indicate that water situation in the county is dismal (KNBS & SID, 2013).

2.4 Microorganisms Occurrence and Concentration in water

Microorganisms are widely distributed in nature and their abundance and diversity may be used as indicators for the suitability of water. Microorganisms that cause diseases via drinking water are generally pathogens and can be classified in diminishing size as helminths (>100 µm), protozoa (5-100 µm), bacteria (0.5- 1.0 µm) and viruses (0.01-0.1 µm). They originate from either human or animal faeces and if they are not removed by water treatment and disinfection, may cause outbreaks of waterborne diseases (Gray, 2008)**.** Thus bacteriological assessment for coliforms are normally earned out by the public health authorities to ascertain the quality of water to ensure prevention of further spreading of pathogens through water agencies (Swistock & Sharpe, 2005)

Various pathogenic microorganisms have been suggested as indicators of faecal pollution and microbiological quality of domestic water. However, indicator bacteria are frequently used to assess the microbiological quality of water, providing an easier, more rapid and reliable indication of the microbiological quality of water supplies and thus the recommended indicator bacteria for the assessment of the microbiological quality of water includes: total coliform, faecal coliform and *E. coli* bacteria of which can be found in contaminated food or water specifically of faecal origin and can be found in very large numbers (up to 10^9 organisms per gram) in faeces of humans, other mammals and birds (Potgieter, 2007).

Another alternative to counting *E. coli* is to identify and enumerate the total coliform count in the water sample. Total coliforms are characterized by their ability to ferment lactose in culture at 35° to 37°C, and include *E. coli,* Citrobacter, *Enterobacter,* and *Klebsiella*. General coliforms they not only originate from faeces of warm-blooded animals, but also from vegetable matter and soil. Under certain conditions, coliforms may persist and grow using the available organic carbon from non-metallic components in construction materials. Therefore, presence of small numbers of coliform, particularly in untreated groundwater, may be innocuous and may not indicate presence of fecal contamination (Alotaibi, 2009)

Although bacterial pathogens such as the coliform organisms are less or comparably resistant to disinfection, Enteroviruses and cysts of some parasites are more resistant. Therefore, the absence of coliforms from disinfected water does not necessarily indicate absence of enteroviruses, and the cysts of *Cryptosporidium*, *Giardia*, amoebae, and other parasites (Potgieter, 2007)

2.5 Household Water Management

Household-level approaches to water treatment and safe storage options are referred also to as managing water at the "point-of-use" (POU) (WHO, 2007) By preventing disease, household water management and storage practices can contribute to poverty alleviation and development (UNICEF, 2008). Their widespread use, has the potential to save millions of lives until the infrastructure to reliably deliver safe water to the greater population has been created. Household water treatment and safe storage (HWTS) interventions can lead to improvements in drinking water quality and reductions in diarrhoeal disease making a difference to the lives people relying on water from polluted rivers, lakes, in some cases, unsafe wells (WHO, 2010)

Due to distances and unavailability of piped water to households in many rural communities, people are forced to store their drinking water. However, storing water can provide a number of opportunities for water contamination. Transmission of microorganisms in the household can occur through several routes. The most important transmission routes include water, food, and person-to person contact, unhygienic behaviour, storage conditions at the POU (Potgieter, 2007). In rural households' water storage containers are often not cleaned and exposed to faecal contamination as a result of children placing their hands into the water, unhygienic handling of the water storage containers, and the use of dirty utensils to withdraw water (CDC, 2010).

A review on drinking water contamination between the source of water and the point-of-use in households of rural areas in developing countries, published by Gundry et al. 2004, indicated that water from the household storage was more contaminated than water from the water source. The results showed that 12% of source samples were contaminated while, in household storage, more than 40% of samples were contaminated. The review found that samples of stored water contaminated with *V. cholerae* resulted in cholera cases. Human faecal contamination from children and adults who do not wash their hands after using the toilet can contribute to secondary contamination of household stored drinking water (Potgieter, 2007).

According to a study by Potgieter, 2007, *E. coli* can survive for 10 minutes, *Klebsiella spp* for 2.5 hours and *Shigella sonnei* for up to 3 hours on unwashed hands which can contaminate water and food in the household. Consequently, washing hands practices with soap at critical times: after visiting the toilet, after cleaning a child who has defecated and before eating or preparing food were shown to be effective in the reduction of diarrhoeal diseases(Cairncross *et al.,* 2010). Study in rural Bangladesh indicated the effectiveness of washing hands with soap in reducing childhood diarrhoea, compared to households where people prepared food without washing hands. Children living in households where hands were washed before preparing food had less diarrhoea (Odds Ratio (OR) = 0.30; 95%, confidence interval (CI) = 0.19–0.47). The same trend was shown in households where residents washed hands with soap after defecation (OR = 0.45; 95% CI = 0.26–0.77. Hoque (2003) showed that soap, ash and soil were equally effective hand washing reagents. However, washed hands should not be dried with dirty cloths since, recontamination of hands occurs (Potgieter, 2007).

Study by Montgomery and Elimelech, 2007, indicated that improving the quality of household water by point-of-use treatment and safe storage in improved vessels reduces diarrheal and other water-related diseases in most communities and households of both developing and developed countries by 6-90%, depending on the technology and local conditions. Several technologies to improve the microbial quality of household water and reduce water-related disease have been developed and this includes physical and chemical treatment methods (World Health Organization, 2007). The physical methods, include boiling, heating (fuel and solar), settling, filtering, exposing to the UV radiation in sunlight. The chemical methods include coagulation-flocculation and precipitation, adsorption, ion exchange and chemical disinfection. However, many of these treatments are not suitable for conditions in rural communities (Potgieter, 2007).

Of the above household water treatment and storage interventions, boiling, sedimentation, solar disinfection, filtration, chlorination, and the combined treatments of chemical coagulation-filtration have been proven to improve quality of water by reducing bacteria and viruses in water samples in developing countries (Lantagne *et al.*, 2006)

2.6 Prevalence of Water-related Diseases

Although water-related diseases have been eliminated in developed nations, the burden of these diseases remains a major concern in many developing countries, particularly in tropical regions (Gleick, 2002). Worldwide, it has been shown that water-related diseases are responsible for over 2-3 million deaths a year mainly due to lack of safe drinking water (WHO/UNICEF, 2009). Water-related diseases are caused by enteric pathogenic organisms such as bacteria, viruses and protozoa, which may cause diseases such as cholera, dysentery, and E, giardiasis and schistosomiasis (UNICEF, 2008). More importantly, vulnerable groups, such as children, women, people with low immune system such as AIDS patients, and elderly, are the most impacted. Water-related diseases constitute a cause for concern in both developing and developed countries worldwide. It is estimated that the number of people who die each year from diarrhea, malaria and typhoid equals to the size of the population of Norway. Nearly 2,900,000 people, mostly children, die from diarrhea alone each year (Sijbesma *et al.*, 2009). Additionally, 1.8 million people die every year from diarrheal diseases whilst 3,900 children die every day from water borne diseases. Moreover, the global health burden associated with these conditions is overwhelming, with an estimated 4000-6000 children dying each day from diseases associated with lack of access to safe drinking water (Moe & Rheingans, 2006). Drinking water quality provision in many rural areas is substandard. The impact of water-related in South Africa is significant with about 43,000 South Africans dying each year from diarrheal disease. Enormous cost therefore arises from the annual public and private direct health care (Kahinda *et al.,* 2007).

A study carried out in Bamendakwe municipality indicated that out of two thousand one hundred and twenty-four people that were consulted from March to June 2013, one thousand two hundred (56.5%) were cases of water-related diseases. Also a study conducted by the pacific institute estimated that if no action is taken to address the scarcity of water, poor sanitation and hygiene as many as one hundred and thirty-five million deaths will occur by 2020 (Gleick, 2002). Waterborne diseases, such as diarrhea, remains the second leading cause of death among children under five globally. Worldwide, it is estimated that 140 million people develop dysentery each year, and about 600,000 die. In the United States of America, water-related disease outbreaks have been caused mainly by contaminated wells and water storage reservoirs(WHO/UNICEF, 2009)

Furthermore, it is estimated that nearly one in five children’s death, that is about 1.5 million each year is attributed to diarrhea, thus, killing more young children than AIDS, Malaria and Measles combined. It is also estimated and reported that diarrhea kills 1.8 million and causes approximately 4 billion cases of illness annually, of which 88% is attributable to unsafe water. The Center for Disease Control (2007) reported that Typhoid fever is still common in the developing world where it affects about 21.5 million persons each year (WHO/UNICEF, 2009). Diarrheal epidemics have been common in many world regions. For example, a four-year epidemic in Central America, at the beginning of 1968, led to more than 500,000 cases and more than 20,000 deaths. Since 1991, dysentery epidemics have occurred in eight southern African countries of Angola, Burundi, Malawi, Mozambique, Rwanda, Tanzania, Zaire, and Zambia. Currently, the island nation of Haiti is in a cholera epidemic which has reportedly killed more than 4,000 people and infected 217, 000 people (Tuite, 2011).

Parts of the world have made encouraging progress in meeting the improved water target, but serious disparities remain. Lack of access to improved drinking water is still a major problem in many parts of Asia and Sub-Saharan Africa (Moe & Rheingans, 2006). Invariably, global health statistics indicate that Africa and South Asia contain the most severely affected areas by water-related diseases (UNEP, 2012). High morbidity associated with water-related diseases therefore characterizes these areas. Diarrhea, schistosomiasis, trachoma, ascariasis, and hookworm disease are all wholly attributable to unsafe water supply. What is more, water-related diseases continue to be a public health problem in developing countries lacking access to adequate drinking water (Walton, 2011).

2.7 Research Gaps

1. Access to safe drinking water is an important component to human health. Lack of access to safe water may be associated with lack of awareness and low income levels thus these households depend on unimproved water sources such as rivers and unprotected boreholes.

2. Consumption of unsafe water may be attributed to the high incidences of water-related diseases in the world today.

3. In ASAL areas, access to water is a major problem. People are forced to travel long a distance to look for water. This water is often stored in storage containers over a long period of time. This might lead to re-contamination, thus increasing the prevalence water-related diseases.

4. Most households in ASAL areas have been found out to lack access to an improved sanitation facility. Household use in Baringo County use bushes to relieve themselves constituting 49% while 46% uses pit latrines thus might result in contamination of the available water sources such as rivers in the region due to surface run-off thus increasing the spread of water-related diseases.

5. There have been reports of high prevalence of water-related diseases as a result of consumption of unsafe water from unimproved sources such as water vendors and rivers present in the region.

6. Low literacy levels in ASAL areas like Baringo County may lead to poor household water handling practices which might lead to contamination of drinking water thus leading to high prevalence of water-related diseases.

2.8 Theoretical Framework

This study has a relationship with the Health Belief Model which explains the behaviors on health (Becker, 1974). This model is spelled out in six terms of constructs which represent perceived threats and net benefits i.e. perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action and self- efficacy. Perceived susceptibility this mainly refers to one's opinion of chances of getting a certain condition. This involves defining the population(s) at risk and heightening perceived susceptibility if found to be too low. A population that consumes water from unprotected sources are exposed to microorganisms in this water. Thus this study determined the effects of these microorganisms in the immune system of consumers as well as revealed if they are aware of their susceptibility. Perceived severity refers to one's opinion of how serious a condition is and its consequences. This construct involves specification of consequences of the risk and the condition. Based on this construct, this study assessed consequences of water-related diseases that threatens well-being of people and with many effects on the quality of life. Perceived benefits this refers to one's belief in the efficacy of the advised action to reduce risk or seriousness of impact. As such, this study believes that when the people are aware of the effects of microorganisms on their health they will participate actively in reducing their exposure to these microorganisms i.e. through practice of conventional household water treatment and practice of good sanitation and hygiene. Perceived barriers, involve identifying and reducing barriers by putting in place the recommended action. Thus this research will therefore create awareness about water-related diseases and highlight some of the causes of water-related diseases in line with Cues to action construct. Knowledge would help them to prevent incidences of water-related diseases in line with the sixth construct (self-efficacy).

2.9 Conceptual Framework

There is an association between sanitation facilities, sources of water and accessibility, household water management practices and prevalence of water-related diseases. The more the presence of well-constructed and managed pit latrines and improved water sources the lesser the incidences of water-related diseases. High personal hygiene reduces incidences of water-related diseases such as hand washing after visiting the toilet with soap reduces the risk of diarrhea. Household water storage is also a common practice in most developing countries due to lack of direct supply of water in their households. Thus households where there is poor management of water storage facilities means that there is high prevalence of water-related diseases. Public awareness as an intervening variable has an indirect impact on dependent variable, in that some communities' people poorly dispose wastes due to lack of information on the impact of wastes in their health and thus high risk of them contracting water-related diseases. Climate is also indirectly linked to water-related diseases thus forms an intervening variable. Low rainfall means that there is less amount of water to maintain good personal hygiene hence the high prevalence of water-related diseases. High population growth rate, leads to an increase in demand for water and sanitation facilities thus it may lead to an increase in water-related diseases as the people will not have adequate access to improved water and sanitation facilities. Some legal frameworks have an indirect impact on the dependent and independent variables. EMCA Act 2012 establishes criminal sanctions for those discharging toxic wastes in aquatic environment in contravention of water pollution control standards and liable to imprisonment. Article 42 of the New Constitution also ensures that every human being is entitled to live in a clean and healthy environment. A failure to adhere to this law may lead to a dirty environment thus high prevalence of water-related diseases. In addition, Public Health Act 2012 makes it an offence for any landowner to allow accumulation of wastes that may endanger human health.

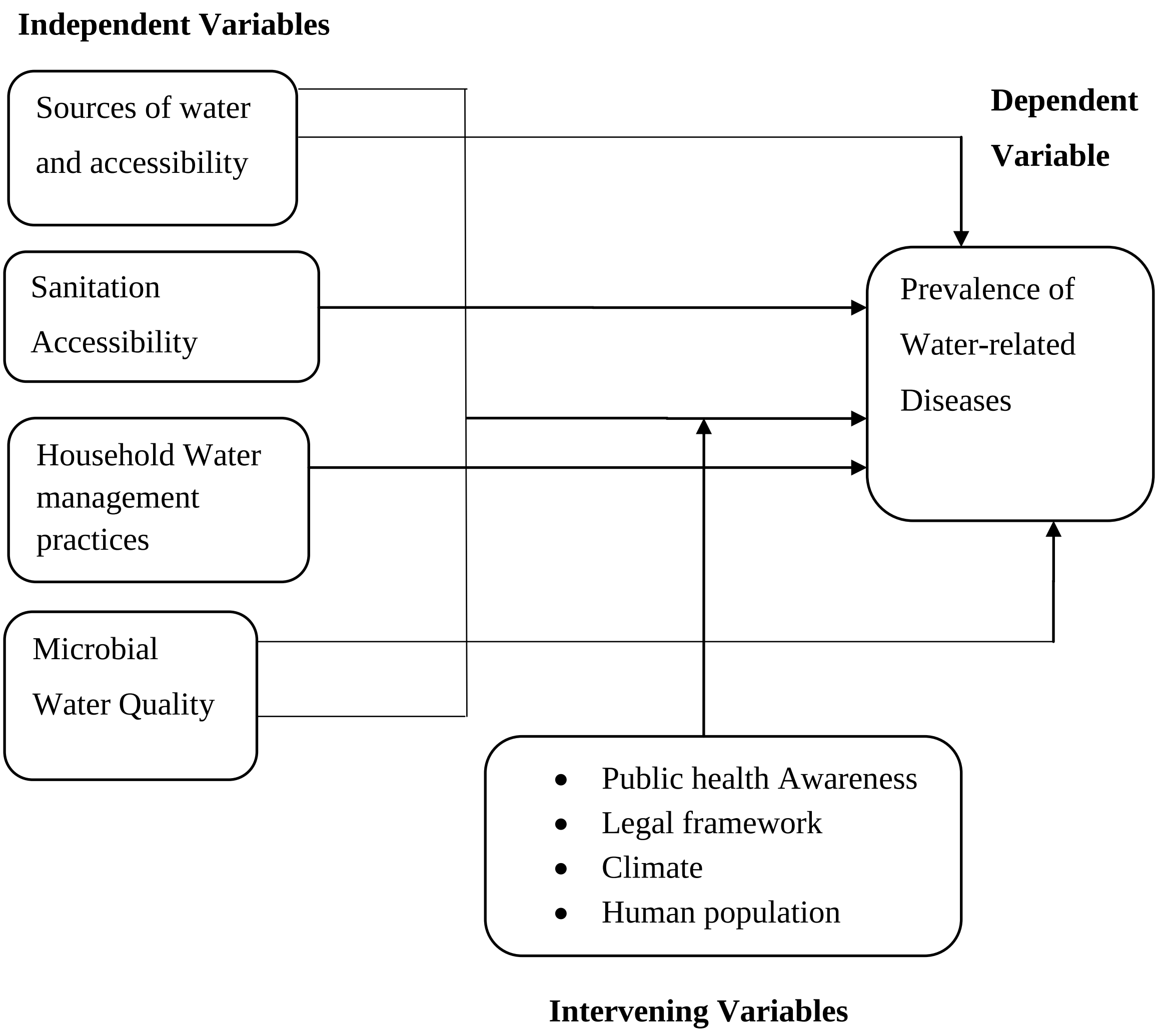

Figure 2.2. Conceptual Framework depicting interaction amongst study variables

CHAPTER THREE
MATERIALS AND METHODS

3.1 Research Design

The research design adopted was a cross-sectional household survey and microbial analysis of drinking water samples both at the source and point of use. Cross-sectional household survey was used, whereby the population was examined at one particular point and time (Kumar, 2011). This survey was used to identify the various sources of water, sanitation facilities and household water management practices within the study area.

3.2 Study Area

The study was conducted in Marigat town, Baringo, County Kenya. This town is located in the water-scarce ASALs of Kenya, in agro-ecological zones V and lies between latitude 0° 12′ and 1° 36′N, longitude 35° and 36′ and 36° and 30′E. The area experiences erratic rainfall with an annual average ranging from 150 to 450 mm and temperature between 25-30°C. The wettest months are between April to July and driest months between December-February. The town is about 1.678km^2 and the main economic activities include Business and agriculture According to KNBS & SID, (2013), Marigat town have a population size of 6661 and 1200 households. Water sources currently in use include dams, natural rivers, traditional river wells, springs, boreholes and lakes (KNBS & SID, 2013).

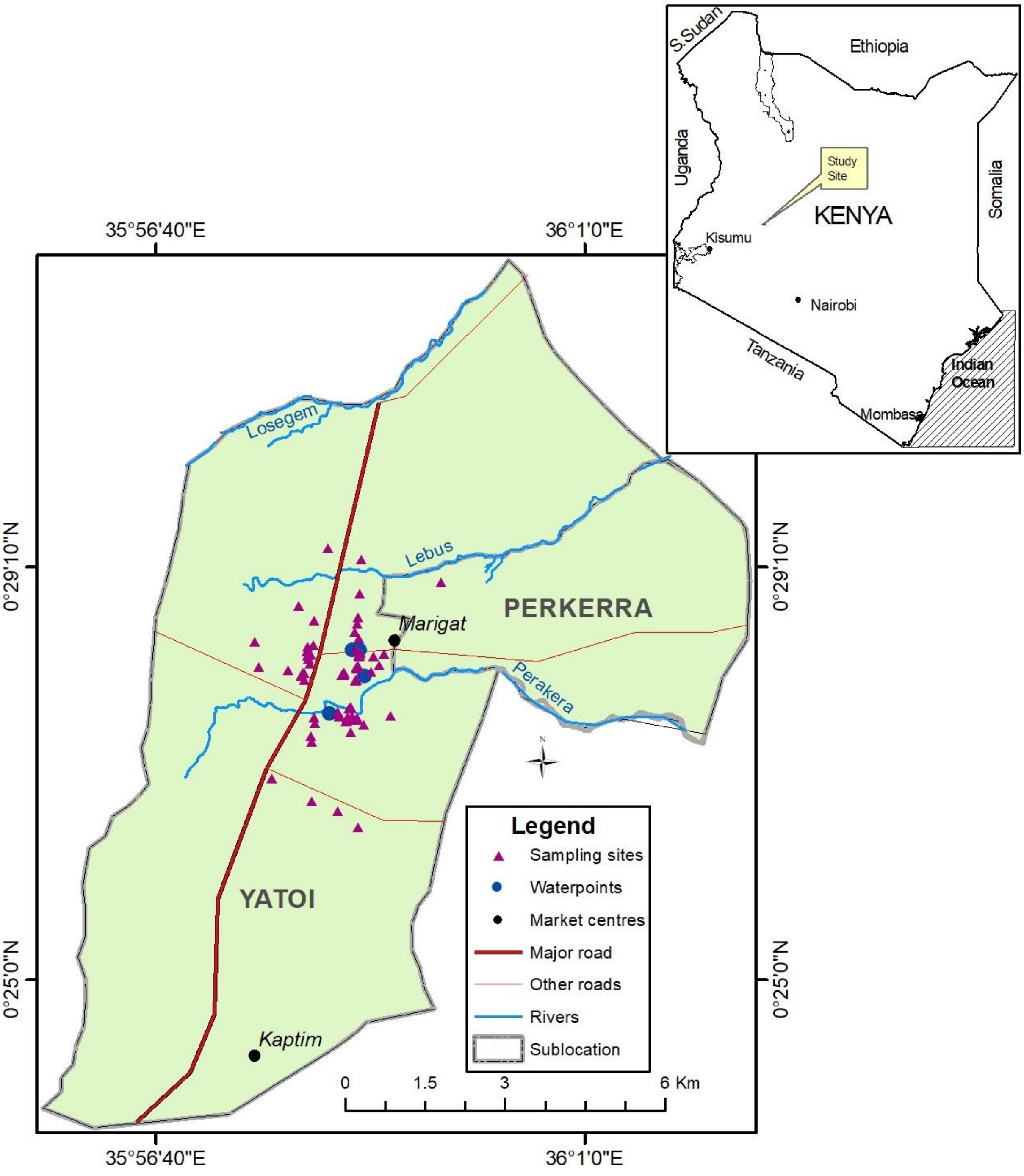

Figure 3.1. Map of the Study Area (Modified and adapted from Topographic Maps of Kenya 1: 50,000)

3.3 Sampling Frame

The sampling frame consisted of 100 households randomly selected from households that relied on boreholes and river water for household use. The respondents consisted of household heads and if absent members of the household that were 18 years and older were interviewed on the main sources of water and types of sanitation facilities and household water management practices

3.4 Pilot Study

A pilot study was done in Mogotio Sub-county, Baringo County. Whereby 10% of the households were chosen in the same way as the main study that gave the researcher the opportunity of verifying whether the respondents understood the questions and whether all questions were relevant. The purpose of the pilot study was to enable the researcher to ascertain the reliability and validity of the instruments and to familiarize with administration of the questionnaires therefore improve the instruments and procedures.

3.5 Validity

In this research, content validity was used as a measure of the degree in which data collected using the questionnaire represented objectives of the study. The instrument was verified by the supervisors who as experts in research, helped to improve content validity of the instrument.

3.6 Reliability

Reliability was determined by administering 10 questionnaires to 10 respondents. This was carried out twice within Mogotio town. Then an average response was scored out of the issued questionnaires; in what known as Cronbach's alpha calculation. A value of 0.7 was achieved, that was useful in modifying the questionnaire before a final set of questions were produced

3.7 Ethical considerations

Before data collection, approval was sought from the County Government of Baringo and the National Council for Science and Technology (NACOSTI) in Kenya, both who issued the researchers with permits to conduct the study. Permit number (NACOSTI/P/19/28617/27715). The researchers thereafter gained informed consent from the respondents to participate in the study.

Plate 1*:* Types of water sources in the study area (a) Borehole 1 GPS (X) 0831618 (Y) 0052263 elevation 1047M, (b) Borehole 2, GPS (X) 0831711 (Y) 0051777 elevation 1034m, (c) Well GPS (X) 0831060 (Y) 0051067, elevation 1038m (d) River GPS (X) 0831474 (Y) 0050898 elevation 1039m

3.8 Sampling Procedure

The study applied stratified random sampling technique that was used to select the household heads respondents from the study area (details provided in appendix 1). Using this technique, the population was handled into groups whereby, the total population was divided into clusters and probability sample drawn from each. This was done proportionately, where the sample size chosen was proportionate to the size of the population. This stratified random sampling technique was preferred for this study as it ensured inclusion in the sample of the group, which would be omitted entirely by using other methods in sampling simply because of their small numbers in the population (Mugenda, 2003).

The sample size which was 100 was determined using the formula for determining sample size for estimating proportions (Kothari, 2004) as follows:

$$n = \frac{Z^2 \times p \times q}{e^2}$$

Where;

n is the required sample size,

Z is Z statistic for a level of interval (at 95% Z= 1.96),

P is the population proportion with characteristic of interest (0.1)

q is (1-p), = 0.9

e is acceptable error which is 0.05

$$100 = \frac{1.962 \times 0.1 \times 0.9}{0.05^2}$$

3.9 Sample Collection

Data was collected using 100 structured questionnaires containing both open and closed ended questions relating to the objectives of the study. Data collected from the questionnaires included: types of water sources, sanitation facilities and household water management practices. Prevalence of water-related diseases data (period prevalence) was acquired from two governmental health centres; Marigat sub-county health centre and Marigat mission health centre to validate data obtained from the questionnaires. The checklist combined a number of information of the patients including age, gender and the name of the disease the patient suffered from was obtained during the wet and dry season. The prevalence rates of diseases were calculated using the following formula.

$$\text{Prevalence rate} = \frac{\text{All persons with a specific Condition at one point in time}}{\text{Total population}} \times (100)$$

(*Equation 1*)

Ten replicate water samples were collected from the point of use (at the household level) and 4 replicate samples from water sources during the wet and dry season using sterilized 250ml glass sampling bottles. The bottles were first washed in dilute hydrochloric acid and then thoroughly rinsed with distilled water and finally autoclaved. Sampling was carried out during the wet and dry seasons. At the water sampling site, each bottle was rinsed three times with sampled water before it was finally filled, capped, labeled and placed in a cool box. The samples were stored at 4^{o}C then transported to Egerton University Biological Science Department Laboratory for analysis that commenced immediately within 24 hours of sampling.

In the Laboratory, *E.coli* and total coliform (TC) concentrations were determined using the Most Probable Number method that utilizes the Chromocult broth media. This media is a selective chromogenic medium for simultaneous determination of *E. coli* and TC, twenty-seven grams of the media was dissolved in 1000ml distilled water then gently heated to dissolve the media completely. The media was sterilized by autoclaving at 121°C for 15 minutes, cooled to 40-50° C in a water bath, then mixed gently, and 1ml poured in the Petri dishes. Serial dilutions were carried out up to 10^{-3}, by picking 1ml of the sample into 9ml of distilled water. 1ml of the aliquot from each of the dilutions was inoculated into 5 ml of media. The Petri dishes were inverted and then incubated at 35°C for 24 hours. After the set time, the Petri dishes were removed from the incubator and examined for bacteria colony growth. A 10-15X magnifier microscope was used to count the colonies. The colonies which indicated a red color was enumerated as positive colonies for total coliform and dark blue colonies were enumerated as positive colonies for *E. coli,* and both were reported as Colony Forming Units per 100ml (APHA, 2017). In-situ measurement of physical parameters for PH and temperature were carried out using a Wagtech International portable meter

3.10 Data Analysis

Statistical analysis was performed using SPSS version 22. Data was analyzed using both descriptive and inferential statistics. Descriptive statistics was used to show distribution of various sources of water and sanitation facilities, to indicate the time taken by the people to have access to the water sources. Descriptive statistics was used to evaluate household water management practices and chi-square tests used to indicate association between level of education and water treatment. Descriptive statistics was used also to determine concentration of microorganisms in both the water sources and at the point of use and one-way ANOVA used to compare mean concentration of microorganisms among the water sources and point of use. Two-way ANOVA was performed to compare whether they existed any significant interactions among water sources, point of use and season on microbial density. Prevalence rates was used to characterize prevalence of water-related diseases in the study area.

Table 3.1. Data Analysis Summary Table

RESEARCH QUESTIONS	RESEARCH VARIABLES	STATISTICAL TOOL
i) How accessible is water and sanitation and which are the common sources of water in the study area?	Water sources Sanitation facilities	Descriptive statistics
ii) How do households in the study area manage water?	Household water management practices	Descriptive statistics Chi square
iii) Is water in households contaminated with pathogens?	occurrence and concentration of microorganisms	Descriptive statistics One-way ANOVA
iv) What is the prevalence of water-related diseases in the study area?	Water-related diseases	Prevalence rates
v) Is there any relationship between season, water source, point of use and microbial density?	Water sources, season, point of use, and microbial density	Two-way ANOVA

CHAPTER FOUR

RESULTS

4.1 Household Access to Water Sources

Out of the 100 households evaluated, 74% used water from river and borehole. The rest (26%) got their water for household chores from other sources as indicated in Figure 4.1.

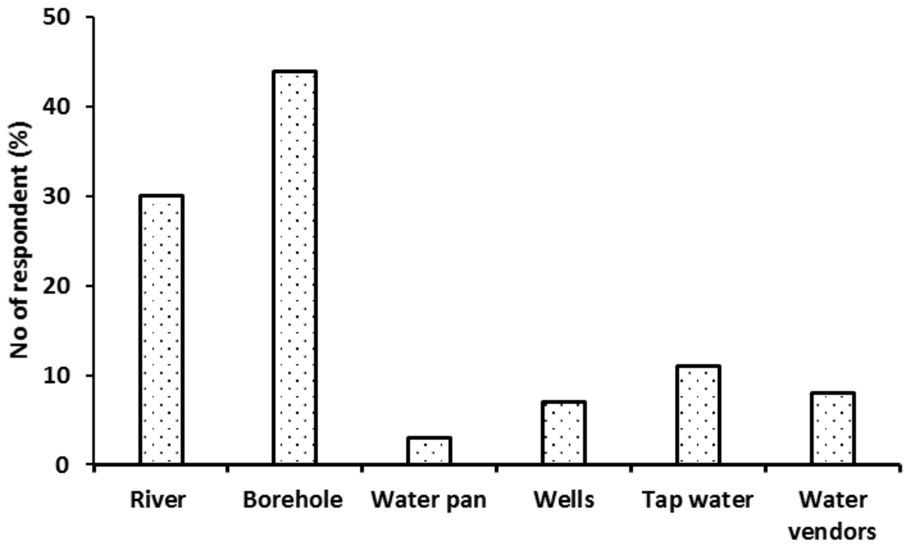

Figure 4.1. Household water sources

Approximately 75% of the respondents in the study area covered distances exceeding 15 meters to the point of water collection (Fig. 4.2). Those close to the water sources (distance of 1-5m) formed 15% of the total respondents.

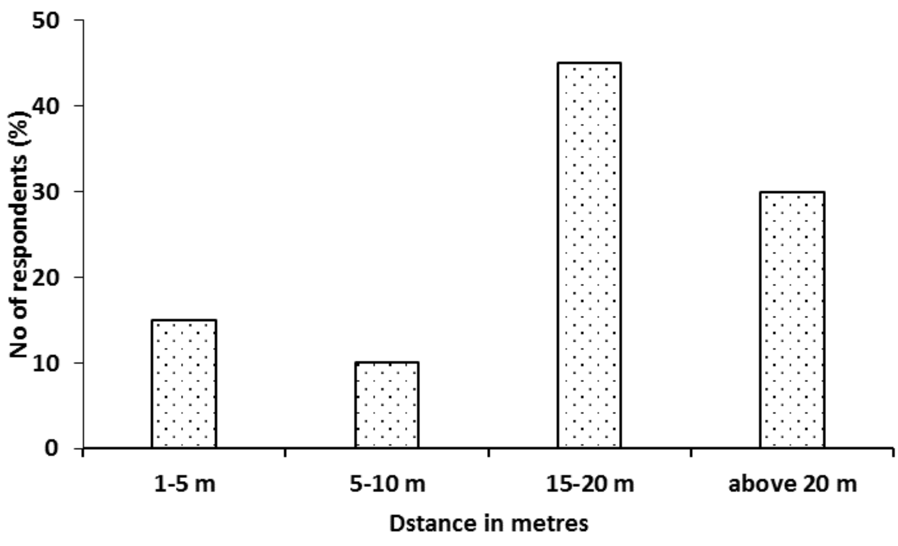

Figure 4.2. Distance (m) covered per household to access water

About 46% of the respondents in the study area took more than 15 minutes to reach the water sources (Fig. 4.3). Majority were those who took between 10 to 15 minutes and about 19% took below 10 minutes to reach the water sources.

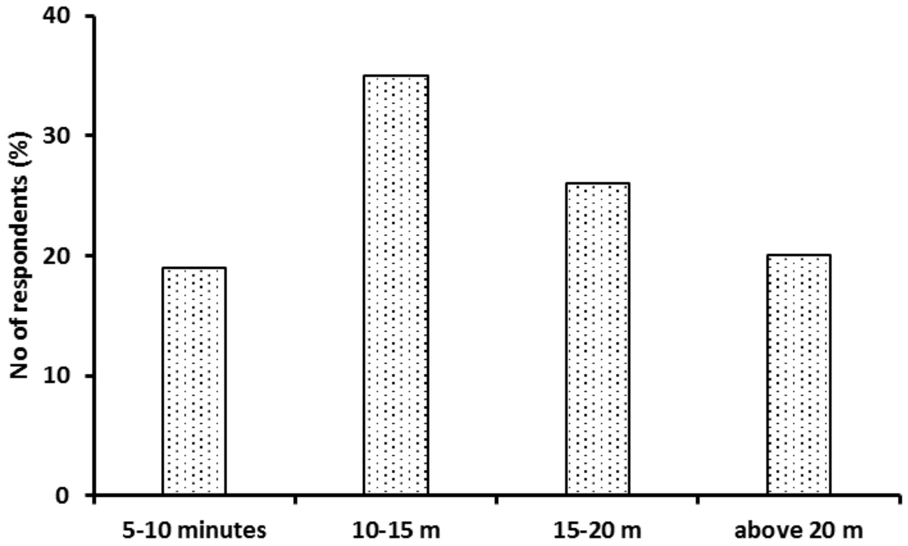

Figure 4.3. Time taken per household to fetch water from the nearby water sources

4.1.1 Household Access to Sanitation Facilities

Out of the 100 respondents interviewed 70% relied on pit latrines as their source of sanitation facility, 27% used bushes and rest relied on buckets as shown in Figure 4.4.

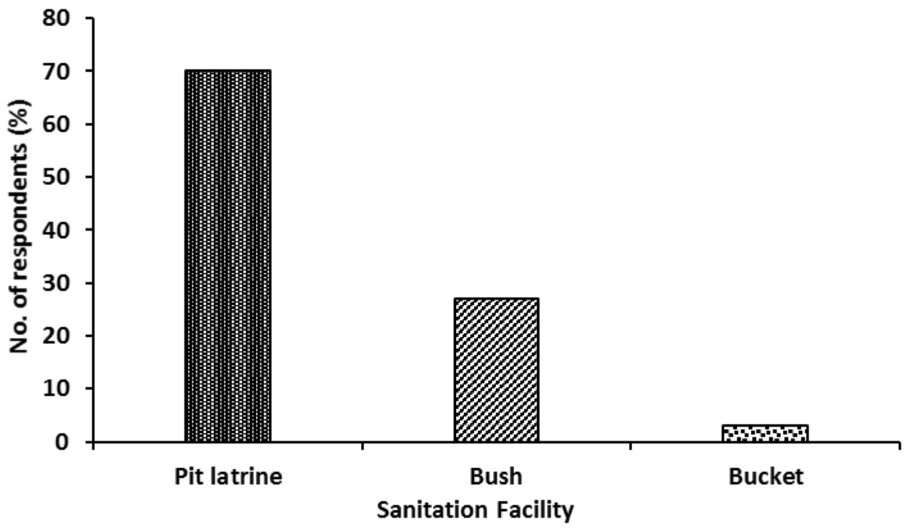

Figure 4.4. Types of sanitation facilities

The maximum distance covered by the households to access sanitation facilities exceeded 20 meters. Out of the total individuals interviewed, 79% of the respondents covered a distance exceeding 15 meters to access sanitation facility. Those close to the sanitation facility with a distance less than 5 meters formed 17% of the total respondents (Fig.4.5).

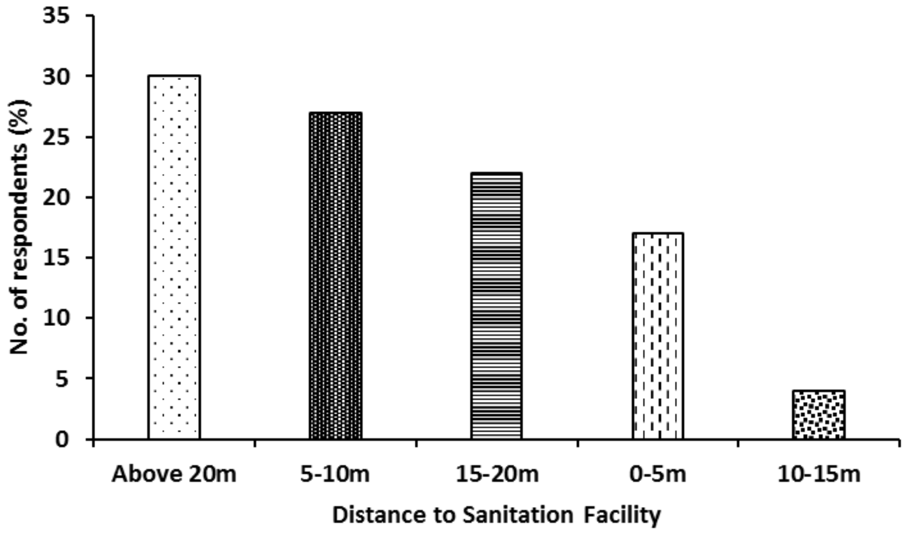

Figure 4.5. Distance covered to the sanitation facilities

4.2 Household Water Management Practices

4.2.1 Water Collection and Storage Facilities

When containers of varied capacity were considered (Plastics, Clay pots & Jerry cans), 34% used plastic containers of 20L & below with only 10% using 100L containers. Clay pots were used by 24% of the respondents while 22% used Jerry cans (Fig. 4.6).

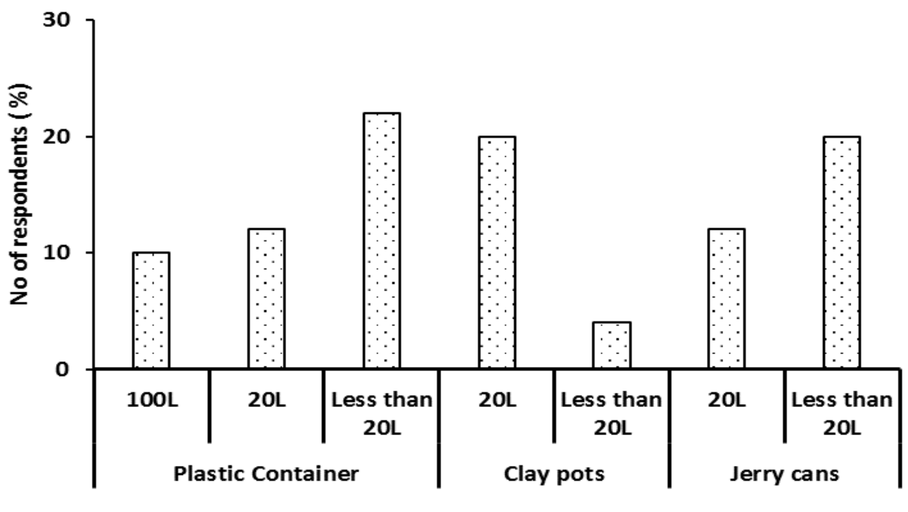

Figure 4.5. **Household water collection and storage facilities**

4.2.2 Household Hygiene Practices

Those who cleaned their water containers on daily basis formed 28% of the respondents. About 54% cleaned their containers between 2 - 7days. Only 11% cleaned their utensils on monthly basis. Those who did not clean their utensils at all comprised 7% of the total respondents (Fig. 4.7)

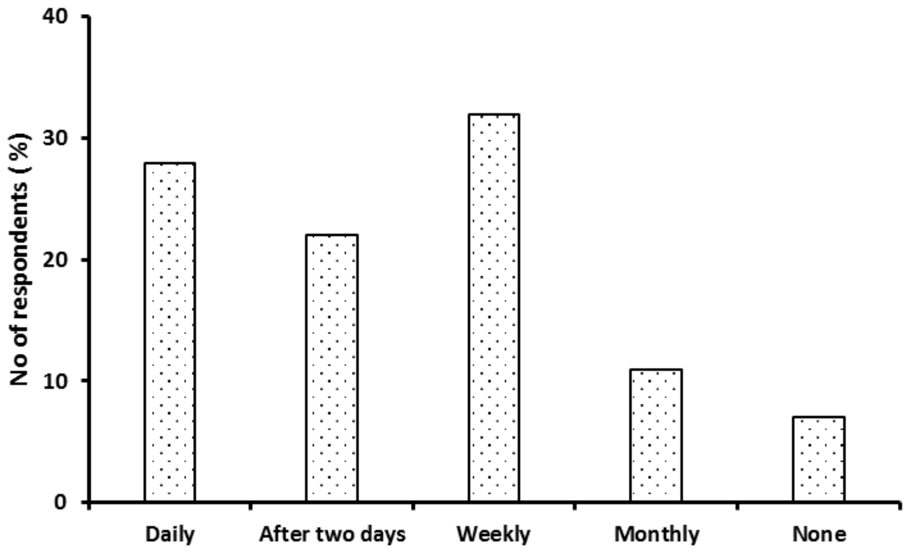

Figure 4.7. Household Frequency of cleaning containers

Majority of the respondents (66%) cleaned their drinking water storage containers using soap & water while 34% used other materials such as sand, mud & ash to clean the drinking water storage container (Fig. 4.8).

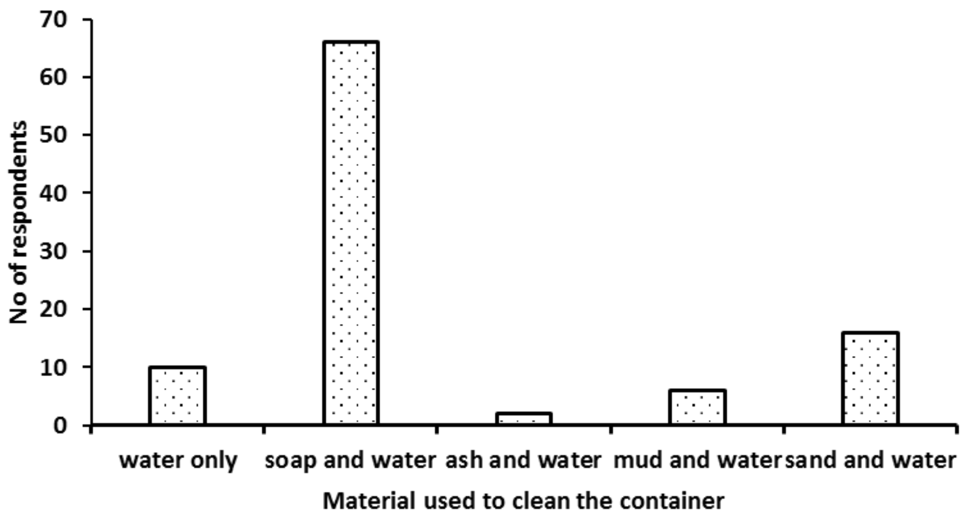

Figure 4.8. Material used to clean the container

Majority of the respondents (45%) used a tin to transfer water from the water storage container & 38% tilted the container in order to pour out water (Fig. 4.9)

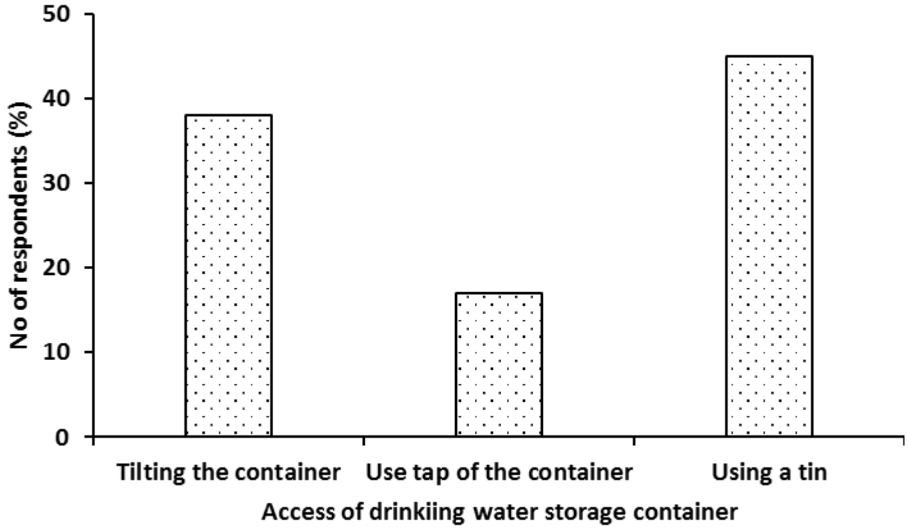

Figure 4.9. Access of drinking water storage container

Boiling, chlorination & filtration were some of the water treatment practices observed during the study. About 52% of the respondents used conventional methods of drinking water treatment (Boiling and chlorination) while 38% did not treat their drinking water at all (Fig 4.10). Filtration was less practiced as a means of treating drinking water.

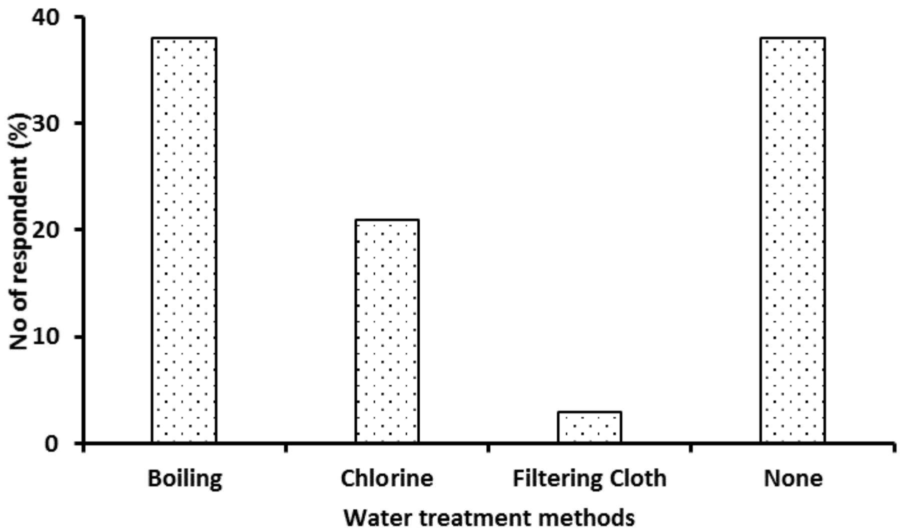

Figure 4.10. Household water treatment

Chi square test was performed to determine whether water management practices among respondents was dependent on the level of education. As represented in table 4.1, the results show that there is a significant association between level of education & covering of water storage container. 90.5% of the respondents in primary level covered their drinking water storage container, 97.5% in secondary level, 100% both in tertiary college and university level.

Table 4.1. Covering of drinking water containers among the respondents stratified by the level of education

Education level	Covering of drinking water storage container		P
	Yes	No	X=14.538
Primary	19 (90.5%)	2 (9.5%)	P=0.013
Secondary	35 (97.5%)	1 (2.8%)	
Tertiary college	23 (100%)	0 (0.0%)	
University	16 (100%)	0 (0.0%)	

4.3 Spatial and seasonal variation in microbial drinking water quality at the point of use and water sources

The physical and chemical parameters results on mean values at the source and point of use during the dry and wet season as compared to standards acceptable by WHO are shown in Table 4.2.Temperature and pH were within the range recommended by WHO at the source and point of use during dry and wet season.

Table 4.2. Physical parameters at the source and point of use

Point of use	Temperature	pH	Source	Temperature	pH	WHO (pH)
Borehole	25.75 ± 0.94	6.42 ± 0.49	**Borehole**	27.7 ±1.4	6.95 ± 0.4	6.5-8.5
River	28.37 ± 0.37	7.25 ±0.17	**River**	27.6 ± 0.6	7.47 ± 0.3	
Well	30.9 ± 0.1	7.38 ± 0.05	**Well**	24.6 ± 3.6	7.29 0.1	

In Marigat town, the main sources of water for human consumption were borehole, river, and well. Out of 10 households that were sampled during the wet season, 50% relied on borehole water, 40% on well and the rest relied on river water. Among the sources of water used at the household level during the wet season, 90% were faecally contaminated. During the dry season, 60% of the households used borehole as a source of water and 40% on river water. All these samples from these households were faecally contaminated. During the dry season at the point of use, *E. coli* and T.C for Borehole and Well water were below 1000cfu/100ml while River water was above 1000cfu/100ml as shown in Figure 4.11. One-way ANOVA indicated that there was a significant difference in CFUs among the point of water use in terms of *E. coli* ($F_{(2, 21)} = 3.629$, $p < 0.05$) and TC ($F_{(2, 21)} = 4.041$, $p < 0.05$).

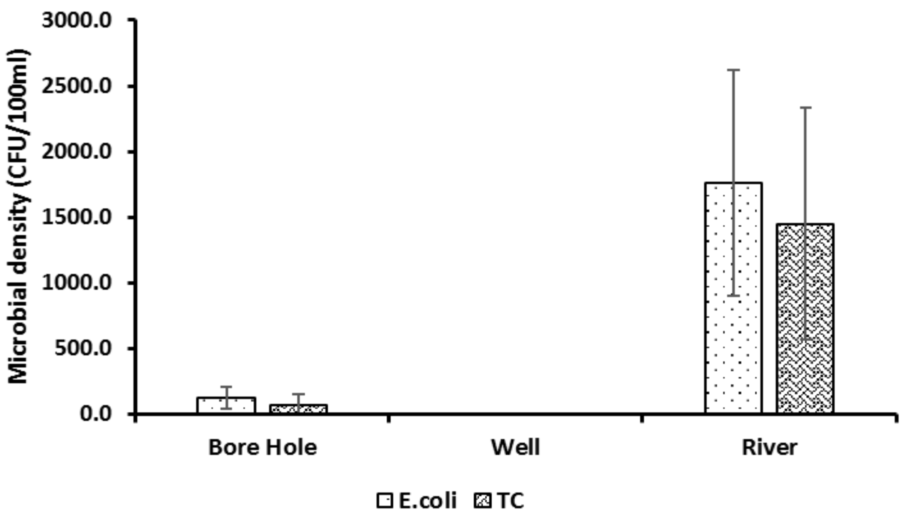

Figure 4.11. Concentration of Microorganisms at the point of use in dry season. Vertical bars are standard Error bars, n = 10

During the wet season at the household level concentrations of *E. coli* and T.C for Borehole and well water was above 1000cfu/100ml while river water was below 1000cfu/100ml as shown in Figure 4.12. A One-way ANOVA indicated that there were significant differences amongst the water sources in CFUs for *E. coli* ($F_{(2, 21)} = 4.090$, $p < 0.05$), TC ($F_{(2, 21)} = 1.893$, $p < 0.05$). A Two-way ANOVA indicated that there was a significant interaction between the point of water and season for *E. coli* ($F_{(2, 42)} = 7.66$, $p < 0.01$) and TC ($F_{(2, 42)} = 5.494$, $p < 0.05$) as shown in Table 4.3.

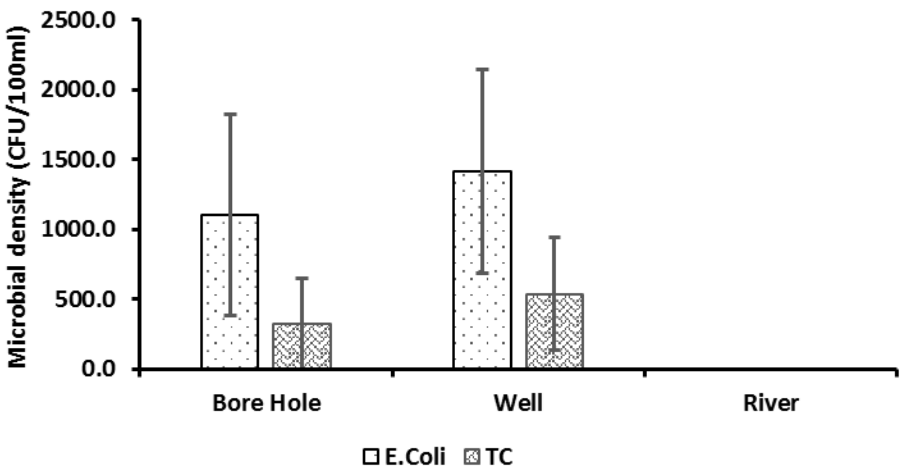

Figure 4.12. Concentration of Microorganisms at the point of use in the wet season. Vertical bars are standard Error bars, n = 10

The concentrations of the selected of microorganisms in Borehole and well water was below 500cfu/100ml but not for *E. coli* in river water (Figure 4.13). One-way ANOVA indicated that there was no significant difference among the water sources in terms *E. coli* concentrations ($F_{(2, 9)} = 0.020$, $p > 0.05$) and TC ($F_{(2, 9)} = 1.196$, $p > 0.05$).

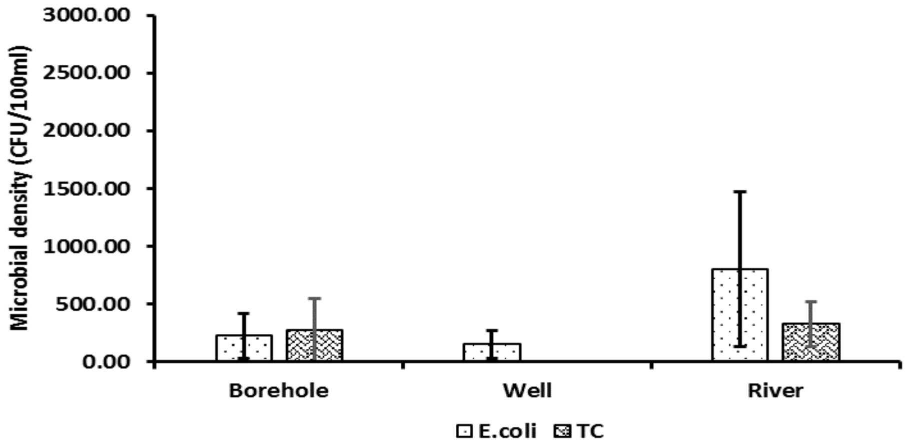

Figure 4.13. Concentrations of microorganisms at the water source in the dry season. Vertical bars are standard Error bars, n = 4

During the wet season, concentrations of E. *coli* and TC varied minimally (Figure 14). A One-way ANOVA indicated that there were no significant differences among the water sources in terms *E. coli* concentrations ($F_{(2, 9)} = 0.055$, $p > 0.05$) and TC ($F_{(2, 9)} = 0.002$, $p > 0.05$). Two-way ANOVA indicated that there were no significant interactions between source of water and season for *E. coli*, ($F_{(2, 18)} = 0.016$, $p > 0.05$), TC, ($F_{(2, 18)} = 0.402$, $p > 0.05$) as shown in Table 4.3.

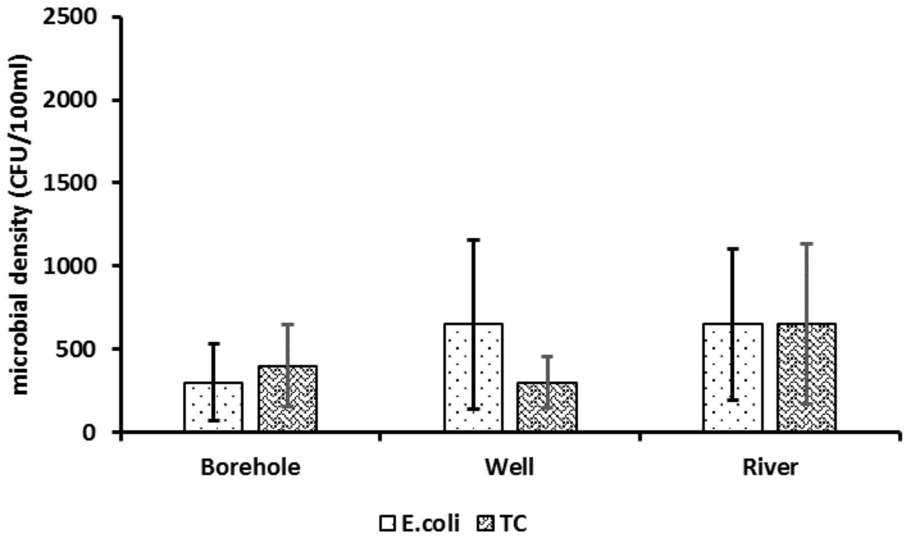

Figure 4.14. Concentrations of E. coli & TC at the water source in the wet season. Vertical bars are standard Error bars, n = 4

Table 4.3. Summary of two-way ANOVA on the relationship between the source of water, point of use & season. Significant p values are in bold.

Source of water	**DF**	**F**	**P**
TC	(2,18)	0.016	**P >0.05**
E. coli	(2, 18)	0.402	**P > 0.05**
Point of use			
TC	(2, 42)	7.66	**P < 0.01**
E. coli	(2,42)	5.494	**P < 0.05**

During the wet season among the household water storage containers used, skyplast and clay pots recorded the highest amount of *E. coli* concentrations in both Borehole, Well & River water as shown in Figure 4.15

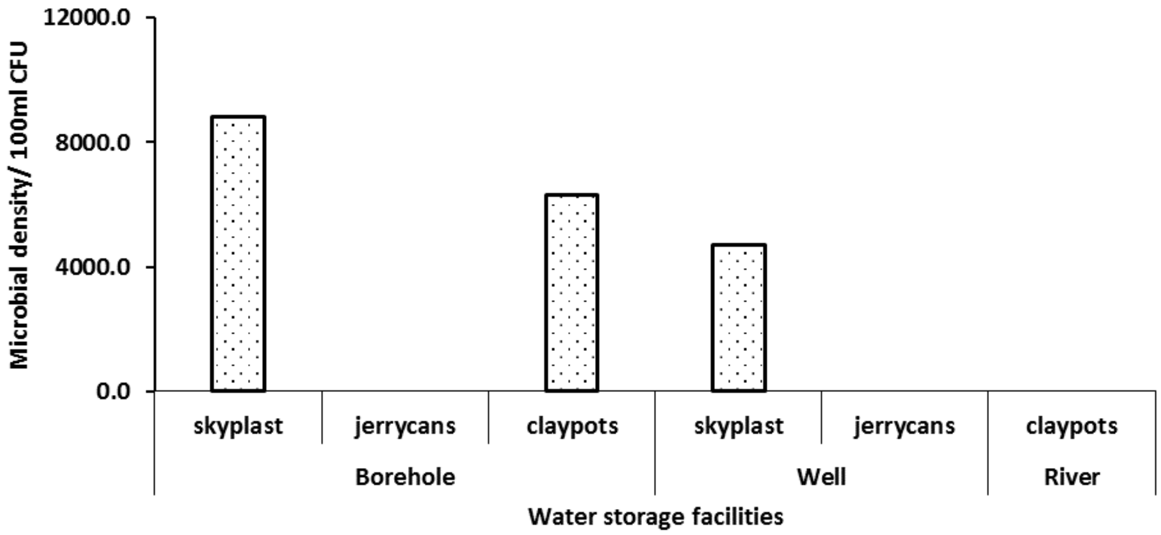

Figure 4.15. Concentrations of *E. coli* in the household water storage containers in wet season

In the dry season, skyplasts recorded the highest amount of *E. coli* concentrations in the river water while jerry cans and clay pots had the same amount of *E. coli* concentration in Borehole water as shown in Figure 4.16

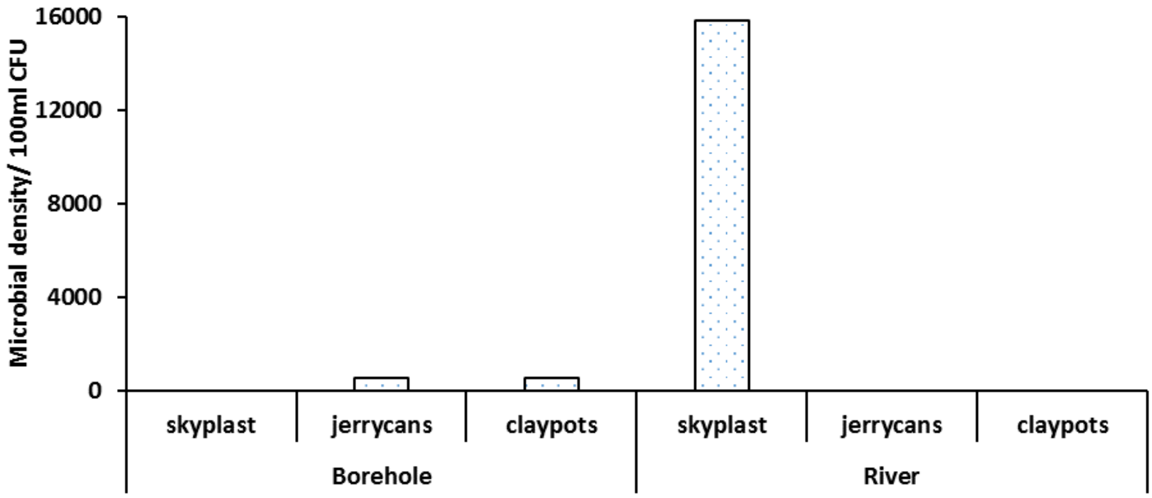

Figure 4.16. Concentrations of *E. coli* in water storage containers during the dry season

In the wet season skyplast and clay pots recorded the highest amount of TC in both Borehole & well water respectively as shown in Figure 4.17

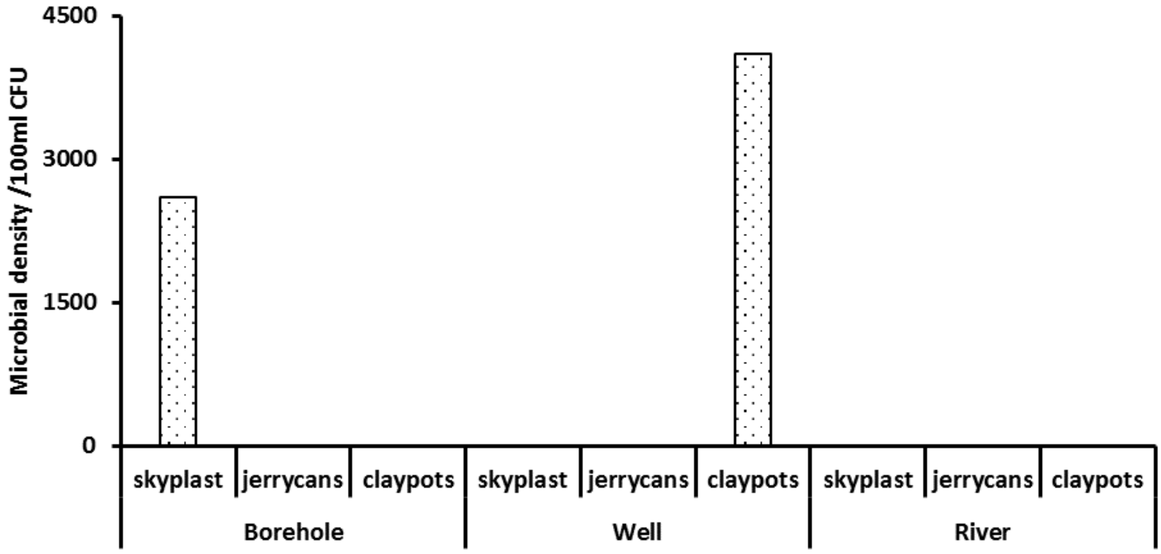

Figure 4.17. Concentrations of TC in water storage containers during the wet season

During the dry season skyplast had the highest amount of TC in Borehole water while in river water jerry cans had higher amount of TC as shown in fig 4.18.

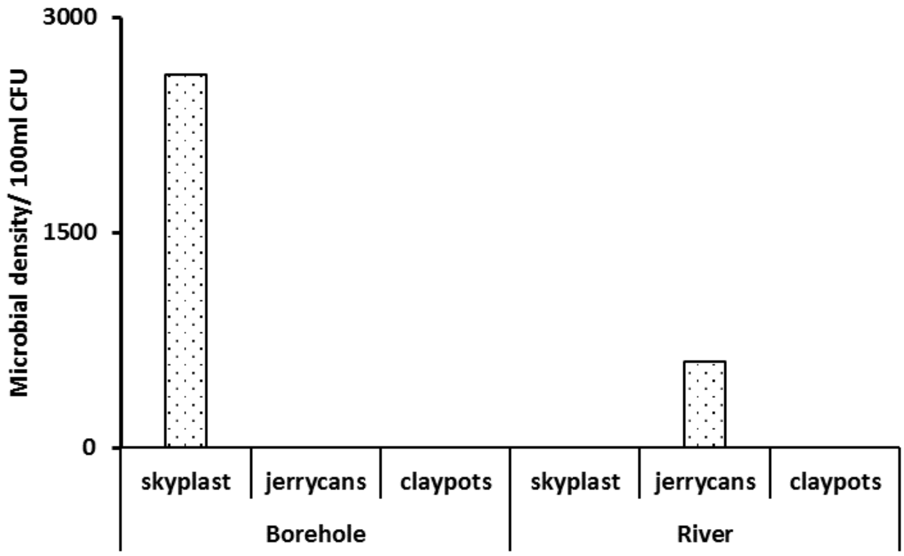

Figure 4.18. Concentrations of TC in water storage containers during the dry seas

4.4 Prevalence of water-related diseases

Clinical records from Marigat health centres were reviewed to identify patients with water-related diseases. The prevalence rates of water-related diseases based on Season is presented in Figure 4.18- 4.19. Typhoid recorded 669 cases and thus was the most prevalent water-related disease during the dry season (10%) as shown in (Fig. 4.19).

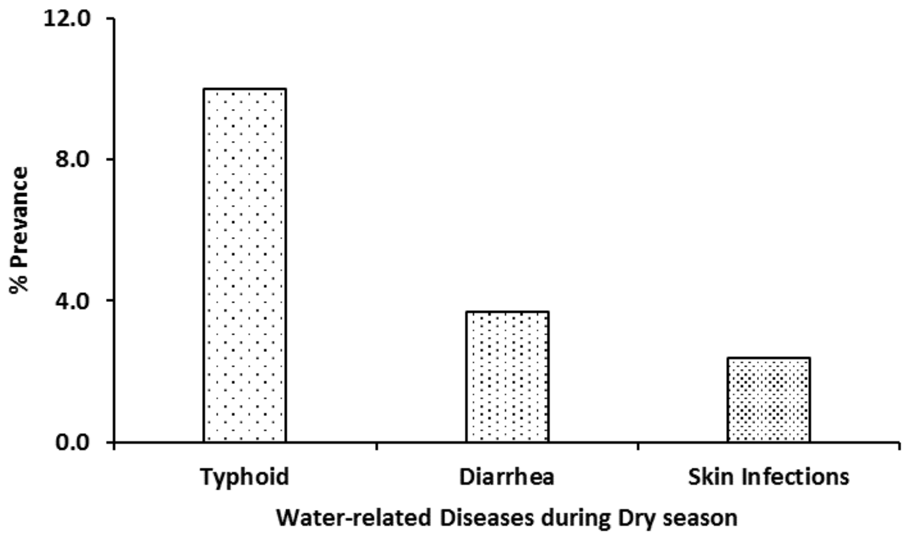

Figure 4.19. **Water-related diseases during dry season**

Diarrhoea recorded 194 cases thus the most prevalent during the wet season (3%) (Fig. 4.20).

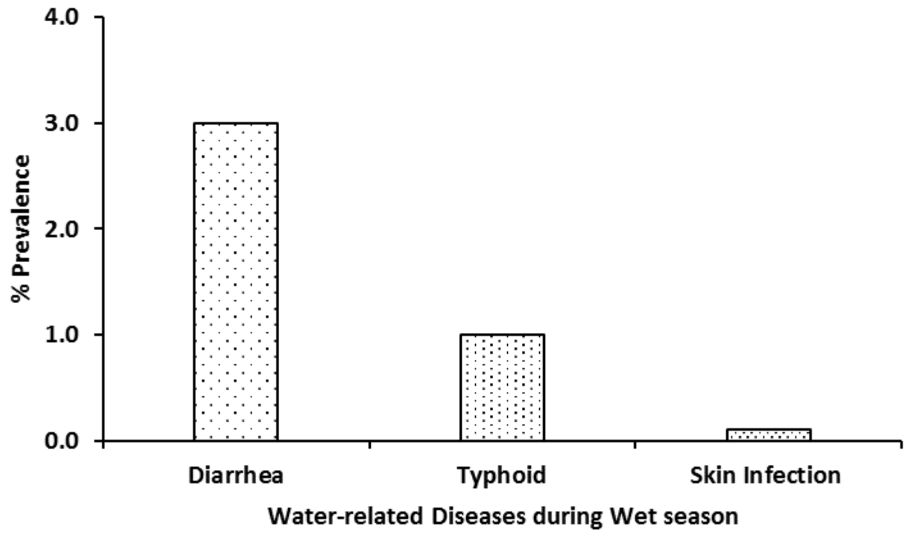

Figure 4.20. Water-related diseases during wet season

CHAPTER FIVE

DISCUSSION

5.1 Household Access to Water Sources and Sanitation Facilities

Access to safe water and sanitation facilities can reduce the risk of illness and death from water-related diseases (CDC, 2010). The United Nations (UN) General Assembly recognizes human right to water, "everyone has the right to sufficient, continuous, safe, acceptable, physically accessible and affordable water for personal and domestic use"(UN, 2010) . According to WHO, 2013, a large number of people in developing countries mostly live in extreme conditions of poverty and the main factors responsible for this situation include lack of priority given to these sectors; due to inadequate financial resources, inadequate water supply and sanitation services. In many developing countries, potable water is collected from communal sources which are either exposed or improved (WHO, 2013).

It is approximated that globally in urban areas, more than 100 million urban dwellers are forced to defecate in the open, into waste paper and plastic bags because public toilets are not available or are too distant and expensive (WHO/UNICEF, 2014). These settlements lack systems for disposal of sewage, excreta, silage and solid wastes, which may cause health and environmental dangers. Specifically, Human waste disposal is a major problem, which renders informal settlements an unhygienic living place for the residents (WHO/UNICEF, 2014). Ozkan *et al.*, (2007) had reported that absence of adequate and safe water supply and sanitation systems were responsible for various kinds of sicknesses such as diarrhea along with other waterborne diseases in rural areas of Turkey (Ozkan *et al.,* 2007).

According to a study carried out by Bhavnani, (2014) in Ecuador unimproved water sources and unimproved sanitation are the major risk factors of diarrhea. The study showed that unimproved water sources and unimproved sanitation increased the adjusted odds of diarrhea (Bhavnani, 2014). Based on this study, majority of the respondents used water from Perkerra River and Bore hole, and almost a third of the study respondents relied on bush as their type of sanitation facility thus higher incidences of water-related diseases. The task of collecting water falls to women in most developing countries. In rural Africa women often walk ten miles or more every day to fetch water (Sobsey, 2002). In this study, 75% of the respondents in the study area covered distances exceeding 15 meters to the point of water collection. This study is supported by a study carried out by Gundry *et al.*, (2004) that reported deterioration of microbiological quality of the water after collection (Gundry *et al.,* 2004).

5. 2 Household Water Management Practices

Due to distances and unavailability of piped water to dwellings or inside the households in many communities, people are forced to store their drinking water (Potgieter, 2007). According to a report by Seino *et al.,* 2007, inadequate storage could result in an increase in numbers of some microorganisms such as heterotrophic bacteria and total coliform over time (Seino *et al.,* 2007). In this study more than half of the respondents cleaned their drinking water storage containers weekly, monthly and others never cleaned it. Consequently, biofilm formation inside the household's water storage containers could, due to improper cleaning practices, facilitate the survival and the growth of potential pathogenic disease causing microorganisms (Potgieter, 2007). A study however, looking at the impact of tank material on water quality in household water storage systems in Bolivia indicated that cleaning frequency may contribute to microbial water quality. Although there was no statistically significant association, storage containers that were reported to be cleaned 3 or more times per year have less *E. coli* than containers cleaned less frequently (p = 0.102) (Schafer, 2010). In addition, studies have indicated poor storage conditions and inadequate water storage containers as factors contributing to increased microbial contamination compared to the source of water. Higher levels of microbial contamination and decreased microbial quality were associated with storage vessels having wide openings (e.g., skyplast and pots), vulnerability to introduction of hands, cups and dippers that can carry faecal contamination, and lack of a narrow opening for dispensing water (Seino *et al.,* 2007). Notably, a study by Quick *et al.,* (2002) indicated that there was a significant reduction in diarrhoeal in the community after disinfection and safe storage of drinking water at the point of consumption ($p < 0.001$; OR: 0.52, 95% CI: 0.3, 0.9) (Quick, 2002). In this study the concentrations of *E. coli* and TC were much higher in households that used Clay pots and skyplast as their main water storage containers as shown in Figure 4.3.5-4.3.8 during wet and dry season due to their wide openings. As represented in table 4.2, there was a significant association between level of education and covering of water storage container P= 0.013 thus high health risks to the households that did not cover their drinking water storage containers.

Approximately almost a half of the respondents used a tin to draw water from a drinking water storage container. Water must be stored and drawn in a safe manner, otherwise water may be contaminated. The latter happens when there is a communal mug on top of the covered container. When drawing water from the storage container, people dip this mug into water and may then touch the water with dirty hands. In this way, bacteriological quality of drinking water may significantly decline at these households. Proper lid for the storage container and daily cleaning of the container may prevent the contamination of household stored water (Tambekar *et al.,* 2008)

Point of Use drinking water treatment can reduce risks of disease until the longer-term goal of universal access to piped, treated water is achieved. By preventing disease, household water can contribute to poverty alleviation and development (UNICEF, 2008). Their widespread use has the potential to save millions of lives until the infrastructure to reliably deliver safe water to the greater population has been created. Household water treatment can lead to dramatic improvements in drinking water quality and reductions in diarrhoeal disease making an immediate difference to the lives of those who rely on water from polluted rivers, lakes and, in some cases, unsafe wells or piped water supplies (WHO, 2010). Inadequate or no treatment of drinking water remains a major problem in both urban and rural communities, as a means of waterborne disease prevention aggravating the risk of water contamination regardless of the quality of water being used at the households (Sobsey, 2003). More than a quarter of the study households (38%) did not treat their drinking water before consuming thus higher health risks of the respondents.

5.3 Concentration of Microorganism at the Source and Point of Use

According to a report on drinking water quality guidelines by WHO, (2011), access to safe drinking water is essential for human health as well as a basic human right. According to the United Nations third World Water Development Report, more than 600 million people in most parts globally, are forced to live without safe water and sanitation services. Our study findings indicate that the residents of Marigat are among this global statistic of persons with inadequate access to potable water. Inadequate access to safe drinking water can result in water-related illnesses to health illnesses among consumers of such contaminated water. Based on this study findings, *E. coli* concentrations and TC exceeded the WHO drinking water guidelines of 0cfu/100ml (WHO, 2013)

Among the sources of water used at the household level during the wet season, 90% were faecally contaminated thus higher prevalence of water-related diseases. During the dry season, the majority of water samples drawn from households irrespective of the water source were faecally contaminated. This, therefore, indicates that drinking water used in these households was not suitable for human consumption and thus higher chances of contraction of water-related diseases. According to a study by Addo *et al. (*2014) on water handling and hygiene Practices on the Transmission of diarrhoeal diseases and soil-transmitted helminthic infections, water may become contaminated at the time between collection and storage where handling and hygienic practices matter most (Addo *et al.,* 2014). This is study is consistent with other study by Addo *et al*. (2013), on sanitation and its impact on the bacteriological quality of water. In a study by Addo and others (2013), Out of the 30 water samples, all the total coliform values recorded were significantly higher than the World Health Organization recommended guidelines for drinking water. In Sub-Saharan Africa where the majority of people practice open defecation, fecal contamination of surface water is a major issue of concern (Addo *et al.,* 2013). Also this study is consistent with that of Kurui et al. (2017) in Baringo County, who found that Total Coliforms densities were high at the water pans water samples during the dry season (Kurui et al., 2017).

With increasing poor sanitation conditions, fecal contamination of the water samples can also be attributed to unsanitary handling of the water during collection and distribution in various households (WHO, 2013). Besides, studies have indicated poor storage conditions and inadequate water storage containers as factors contributing to increased microbial contamination compared to the source of water. In this study higher levels of microbial contamination were associated with storage vessels having wide openings (e.g., skyplast and pots), vulnerability to introduction of hands, cups and dippers that can carry faecal contamination, and lack of a narrow opening for dispensing water similar observations have been made in another study by Seino *et al.* (2007) on bacterial quality of drinking water stored in containers by boat households (Seino et al., 2007). The concentrations of *E. coli* and TC were much higher in the households that relied on sky-plasts and clay pots as their main water storage containers. Consequently, biofilm formation inside the household's water storage containers could, due to improper cleaning practices, facilitate the survival and the growth of potential pathogenic disease-causing microorganisms (Potgieter, 2007). A study, however, looking at the impact of tank material on water quality in household water storage systems in Bolivia indicated that cleaning frequency might contribute to microbial water quality. Although there was no statistically significant association, storage containers that were reported to be cleaned 3 or more times per year have less *E. coli* than containers cleaned less frequently ($p = 0.102$)

5.4 Prevalence of Water-related Diseases

Water-related diseases account for 4.1% estimated cases of global disease burden and cause about 1.8 million deaths annually with 88% attributed to unsafe water supply, sanitation, and poor personal hygiene. According to a report on drinking water by WHO, (2017) 884 million people lacked access to even basic drinking water service, including 159 million people that were dependent on surface water such rivers. The latter group is therefore at a higher health risk of contracting water-related diseases and more so if they live in places where people practice open defecation (WHO, 2017).

Cholera diarrhea and typhoid are among the most widely known illnesses that are linked to the consumption of faecally contaminated food and water. The results on water quality results from this study agree with the clinical data drawn from local health centers that showed the prevalence of water-related diseases. Typhoid was the most prevalent water-related disease during the dry season, and diarrhea was most prevalent during the wet season. Poor personal hygiene at the household level and poor household water handling practices could explain the high prevalence of diarrhoeal and typhoid diseases in the study area. According to the study findings of Mazari-Hiriart *et al.*, (2005), the intensity and effects of water-related diseases depend on the volume of contaminated water ingested by an individual and the individual's immune status, with the children being the most susceptible (Mazari-Hirriat, 2005). The result of this study are consistent with those of Adenyinka, (2014), that revealed that diarrhea is the most prevalent waterborne disease in communities located along River Ase in Southern Nigeria (Adeyinka *et al.*, 2014). The high incidence of diarrhoeal diseases during the wet season could be attributed to high level of microbial contamination caused by surface run-off as much fecal matter is washed into ponds and river (Onyango & Angienda, 2010)

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSIONS AND RECCOMENDATIONS

6.1 Summary of Findings

This study aimed at Assessing Water and Sanitation Accessibility and Prevalence of Water-related diseases in Marigat Urban Centre Baringo County, Kenya. In relation to the first objective that sought to find out types of water sources and sanitation facilities, 74% used water from Perkerra River & Borehole. The rest (26%) got their water for household chores from other sources. Forty six percent of the respondents took more than 15 minutes to reach the water sources. Thirty two percent of the respondents covered a distance exceeding 15 metres to access pit latrines, whereas 20% practiced open defecation. Those close to the sanitation facility with a distance less than 10 metres constituted 44% of the total number of respondents.

In relation to the second objective that sought to assess household water management practices, 34% used plastic containers of 20L & below with only 10% using 100L containers, 46% used Clay pots and Jerry cans. Those who cleaned their water containers on daily basis formed 28% of the respondents. About 54% cleaned their containers once in every two to seven days. Only 11% cleaned their utensils on monthly basis and 7% did not clean their utensils at all. 45% used a tin to transfer water from the water storage container & 38% tilted the container in order to pour out water. About 52% of the respondents used conventional methods of drinking water treatment (Boiling and chlorination) while 38% did not treat their drinking water at all. There was a significant association between level of education & covering of water storage container ($P < 0.05$).

In relation to the third objective that sought to assess concentration of microorganisms at the point of use and source of water during both the dry and wet season, there was significant differences among the point of water sources during both seasons ($P < 0.05$). There was also significant interaction between the point of water sources and season in terms of *E. coli* and TC ($P < 0.01$) TC ($P< 0.05$) respectively. There were significant differences among the various sources of water ($P< 0.05$) and no significant interactions between source of water and season in terms of *E. coli* concentrations and TC ($P > 0.05$).

In relation to the fourth objective that sought to assess the prevalence of waterborne diseases in the study area during both the dry and wet season, Typhoid was the most prevalent waterborne disease during the dry season (10%) and Diarrhoea recorded the highest prevalence during the wet season (3%).

6.2 Conclusions

The results of this study confirms that poor household water management practices led to the deterioration of the microbiological quality of the drinking water. In summary:

1. In this study the residents lack adequate access to water sources and sanitation facilities thus high incidences of water-related diseases.
2. Based also on this study, the respondents practice inappropriate household water management practices, they are not well sensitized on the proper treatment of water from various water sources as well as its protection and preservation for onwards consumption which is the main reason for high incidences of water-related diseases in the study area.
3. Water used from various water sources for consumption is inadequate and not potable. Water from Perkerra River, Well and Borehole used by the respondents indicated unacceptable levels of *E. coli* and total coliform in both seasons mainly due to poor sanitation practices and hygiene and thus water from these sources is unsafe for human consumption and could increase the health risk associated with water-related diseases.
4. The clinical records reviewed from health centres in Marigat town showed that the prevalence of water-related diseases was high especially diarrhoea and typhoid during wet and dry season respectively. This is an indication that there are poor water and sanitation facilities, Poor health promotion and personal hygienic behavior is also a major contributing factor as well in the study area.

6.3 Recommendations

Based on the findings of the study, the researcher recommends that, to reduce incidences of high prevalence of water-related diseases in the study area:

1. The government should ensure potable water is availed to the residents to improve the welfare of residents and reduce the prevalence of water-related diseases within the study area.

2. The government should increase access to proper sanitation to improve the health status of the residents and reduce incidences of water-related disease in the study area.

3. The government together with ministry of health should promote public awareness campaigns on appropriate water management practices.

6.4 Suggestion for Further Research

- A study to examine the relationship between water quality in household water storage vessels and prevalence of waterborne diseases in Baringo County is suggested. We need to understand the Spatio-temporal variations in micro-organism concentrations in various storage containers and also relate it with the frequency of cleaning these vessels.

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APPENDICES

APPENDIX 1: Questionnaire on Knowledge, Attitudes and Practices (KAP) on Water Usage and Water-related Disease Prevalence in Marigat Urban Centre Baringo, County

INFORMED CONSENT

Hello. My name is Osiemo Mercy and I am a Masters student from Egerton University from the department of Environmental Science. I am conducting a research on water and sanitation accessibility and Prevalence of Waterborne Diseases in Marigat urban Centre Baringo County. I will appreciate your participation in this survey. The information you will give will help to know the types of water sources and sanitation facilities you use, accessibility to these sources and prevalence of water-related diseases. The questionnaire will take 10-15 minutes to fill. Participation in this survey is voluntary and you can choose not to answer any individual question or all the questions. However, I hope that you will participate in this survey since your views are important.

You will not have to financially support this survey.
At this time, do you want to ask me anything about the survey? You may leave the interview in between if you want to.
May I begin the interview now?

……………………
Signature

QUESTIONNAIRE:

1.0. PERSONAL DETAILS (tick in the brackets)

1.1. Gender

a) Male ☐

b) Female ☐

1.2. Age (Please tick in the space provided)

a) 11- 20 ☐
b) 21 – 30 ☐
c) 31 – 40 ☐
d) 41 – 50 ☐
e) 51 – 60 ☐

1.3. Demographic information

a) Who is the head of the household? …………….

b) What is the size of your family? Males ……… Females ……….

c) Total number of children under 5 years …………………

d) What is the occupation of the household head? …………………………

e) What are the main income sources to your household? ………………………………….

1.4. Education level (tick in the brackets)

a) Primary level ☐

b) Secondary level ☐

c) Tertiary colleges ☐

d) University ☐

e) Others specify …………………………………….

2.0 Sources of water

2.1. What is the main source of water for cooking and drinking in your household chores?

a) Water pans/dams ☐

b) Bore hole ☐

c) Rivers ☐

d) Tap water ☐

e) Water vendors ☐

f) Others explain

……………………………………………………………………………………………

……

2.1.What is the main source of water for livestock use in your household?

a) Water pans/dams ☐

b) Bore hole ☐

c) Rivers ☐

d) Tap water ☐

e) Water vendors ☐

f) Others explain……………………………………………………………………

2.2 How long does it take you to walk from your homestead to the water source and back?

a) 10 minutes ☐
b) 30 minutes ☐
c) 1 hour ☐
d) 1 hour 30 minutes ☐
e) Other Specify ……………………

2.3 What is the distance from your homestead to the water source?

a) 5-10m
b) 10-15m
c) 15-20m
d) More than 20m
e) Other specify……………………….

2.4. Do livestock drink water from the same point that you use to fetch water?

a) Yes ☐
b) No ☐

2.5. If No, how long does it take your livestock to their watering source?

a. 10 minutes ☐
b. 30 minutes ☐
c. 1 hour ☐
d. 1 hour 30 minutes ☐
e. Other Specify ……………………………

3.0 Water handling

3.1 What container do you use to store drinking water in the household?

a) Plastic container ☐
b) Clay pots ☐
c) Jerrycans ☐

3.2 Where is your drinking water storage container located in the house?

☐

a) At the door of the living room

b) In the kitchen ☐

c) In the corner of living room ☐

3.3 State the size of the container you use for storing drinking water in your household?

a) Wide mouth ☐

b) Medium mouth ☐

c) Very small mouth ☐

d) Other specify

………………………………………………………………………………………

………………………………………………………………………………………

….

3.4 Do you cover your drinking water storage container?

a) Yes ☐

b) No ☐

3.5 If yes, what do you use to cover the drinking water storage container?

a) Lid of the container ☐

b) Clean cloth ☐

c) Other specify …………………………………….

3.6 How often are the storage containers cleaned?

a) Daily ☐

b) After two day ☐

c) Weekly ☐

d) Monthly ☐

e) Yearly ☐

f) Never ☐

g) Others specify …………

…………………………………………………….

3.7 What do you use to clean your water vessels?

a) Water only ☐

b) Soap and Wate☐

c) Ash and Water☐

d) Mud and Wate☐

e) Sand and water☐

f) Other specify…………………………………………………………………

3.8 How is the drinking water from the storage container accessed?

a) Tilting the container to pour the water ☐

b) Using the tap in the container ☐

c) Using a tin to fetch the water from the container ☐

d) Others specify ……………………………………………………

4.0 Household Water treatment

4.1 Do you treat your drinking water before use at home?

a) Yes ☐

b) No ☐

4.2 If yes, how do you treat your water?

a) Boiling ☐

b) Chlorine ☐

c) Solar ☐

d) Filtering by cloth ☐

5.0 Hygiene and sanitation

5.2 Do you wash your hands with soap in a designated hand washing place?

a) Yes ☐
b) No ☐

5.3 If no, where do you usually wash your hands with soap?

a) At the water source ☐
b) In the latrine ☐
c) Near the latrine ☐
d) In the kitchen area ☐
e) Others specify ……………….

5.4 How often do you wash your hands?

a) Before mealtime ☐
b) After mealtime ☐
c) Before cooking ☐
d) After using the toilet. ☐
e) Other specify …………………...

5.5 What materials do you use to wash your hands?

a) Water only ☐
b) Soap and Water ☐
c) Mud and water ☐
d) Ash and water ☐
e) Other specify......................................

5.6 Do you have any of these facilities in your household?

a) Pit latrine ☐
b) VIP latrine ☐
c) Bucket latrines ☐
d) Others…………………..

APPENDIX 2: A CLINIC RECORD CHECKLIST ON INCIDENCES OF WATER-RELATED DISEASES IN HOSPITALS

Health record collection form on prevalent water-related diseases

1. Are there any reported cases of water-related diseases for the past six months in this hospital?
   a. Yes ☐
   b. No ☐
2. If yes, please specify?

Incidences of Water-related Diseases in Hospitals

Name of Disease	Children		Adults (18-50yrs)	Aged above 60yrs	
	Male (0-5 yrs.)	Female(0-5yrs.)		Male	Female
Cholera					
Skin Infections					
Typhoid fever					
Diarrhoea					

THANK YOU VERY MUCH FOR YOUR PARTICIPATION AND ASSISTANCE

APPENDIX 3: HOUSEHOLD DISTRIBUTION

Household code	GPS	Family size
HH1	(x) 0831611 (y)0052141 1024 m	2 children Household head father
HH2	(x)0831611 (y)0052147 1025 m	5 children Household head father
HH3	(x)0831606 (y)0052158 1045m	3 children Household head mother
HH4	(x)0831583 (y) 0052156 1045m	4 children Household head father
HH5	(x) 0831583 (y)0052138 1045m	No child House head mother
HH6	(x) 0831579 (Y) 005117 1043m	1 child House head father
HH7	(x) 0831579 (y) 005122 1045m	No child Household head mother
HH8	(x) 0831590 (y) 0052123 1043m	3 children Household head father
HH9	(x)0831578 (y) 0052101 1043m	No child Household head father
HH10	(x) 0831585 (y) 0052065 1042m	2 children Household head father
HH11	(x) 0831572 (y) 0052066 1042m	No child House head mother
HH12	(x) 0831571 (y) 0052053 1043m	3 children Household head father
HH13	(x)0831583 (y) 0052053 1043m	5 children Household head father
HH14	(x) 0831587 (Y) 0052052 1043m	No child House head father

HH15	(x)0831582 (y) 0052051 1043m	No child Household head mother
HH16	(x) 0831577 (y) 0052052 1043m	6 children Household head mother
HH17	(x) 0831571 (y) 00552015 1042m	No child Household head mother
HH18	(x) 0831580 (y) 0051991 1042m	1 child Household head father
HH19	(x) 0831558 (y)0051979 1043m	1 child Household head father
HH20	(x) 0831534 (y) 0051981 1045m	5 children Household head mother
HH21	(x) 0831549 (y) 0052268 1051m	No child Household head father
HH22	(x) 0831544 (y) 0052271 1050m	4 children Household head father
HH23	(x) 0831540 (y) 0052262 1050m	7 children Household head father
HH24	(x) 0831539 (y) 0052258 1048m	7 children Household head father
HH25	(X) 0831545 (Y) 0052254 1048m	5 children Household head father
HH26	(x) 0831514 (y) 0052279 1055m	9 children Household head father
HH27	(x) 0831481 (y)52290 1056m	5 children Household head father
HH28	(x) 0831412 (y) 0052308 1056m	12 children Household head father

HH29	(x) 0831413 (y) 0052312 1055m	10 children Household head father
HH30	(x) 0831437 (y) 0052193 1054m	6 children Household head mother
HH31	(x) 0831437m (y) 0052200 1054m	7 children Household head father
HH32	(x) 0831442 (y) 0052201 1055m	9 children Household head father
HH33	(x) 0831425 (y) 0052206 1055m	4 children Household head father
HH34	(x) 0831413 (y) 0052160 1053m	2 children Household head mother
HH35	(x) 0831409 (y) 0052165 1053m	No child Household head father
HH36	(x) 0831482 (y) 0052138 1054m	1 child Household head mother
HH37	(x) 0831474 (y) 0052145 1053m	No child Household head mother
HH38	(x) 0831469 (y) 0052144 1054m	6 children Household head mother
HH39	(x) 0831486 (y) 0052143 1053m	1 child Household head mother
HH40	(x) 0831484 (y) 0052145 1053m	3 children Household head father
HH41	(x) 0831483 (y) 0052146 1053m	5 children Household head father
HH42	(x) 0831478 (y) (0052148 1053m	3 children Household head mother
HH43	(x) 0831512 (y) 0052099 1046m	1 child Household head mother

HH44	(x) 0831553 (y) 0052081 1040m	4 children Household head mother
HH45	(x) 0831543 (y) 0052082 1042m	1 child Household head mother
HH46	(x) 0831542 (y) 0052082 1043m	No child Household head mother
HH47	(x) 0831542 (y) 0052080 1043m	3 children Household head father
HH48	(x) 0831531 (y) 0052080 1043m	3 children Household head father
HH49	(x) 0831571 (y) 0052079 1040m	No child Household head mother
HH50	(x) 0831590 (y) 0052066 1039m	9 children Household head father
HH51	(x) 0831589 (y) 00552011 1039m	10 children Household head father
HH52	(x) 0831584 (y) 0052018 1039m	1 child Household head mother
HH53	(x) 0831558 (y) 0051688 1032m	No child Household head mother
HH54	(x) 0831560 (y) 0051696 1033m	7 children Household head father
HH55	(x) 0831560 (y) 0151700 1033m	3 children Household head father
HH56	(x) 0831553 (y) 0051698 1033m	No child Household head mother
HH57	(x) 0831552 (y) 0051693 1033m	4 children Household head father

HH58	(x) 0831538 (y) 0051686 1033m	1 child Household head mother
HH59	(x) 0831543 (y) 0051693 1033m	6 children Household head father
HH60	(x) 0831543 (y) 0051695 1033m	No child Household head mother
HH61	(x) 0831416 (y) 0051158 1041m	2 children Household head father
HH62	(x) 0831421 (y) 0051158 1036m	1 child Household head mother
HH63	(x) 0831427 (y) 0051159 1035m	8 children Household head father
HH64	(x) 0831434 (y) 0051159 1034m	5 children Household head father
HH65	(x) 0831432 (y) 0051160 1036m	No child Household head father
HH66	(x) 0831399 (y) 0051081 1036m	1 child Household head father
HH67	(x) 0831393 (y) 0051066 1035m	4 children Household head father
HH68	(x) 0831423 (y) 0051047 1035m	2 children Household head mother
HH69	(x) 0831424 (y) 0051047 1036m	1 child Household head father
HH70	(x) 0831406 (y) 0051014 1036m	4 children Household head mother
HH71	(x) 0831401 (y) 0051015 1036m	3 children Household head father

HH72	(x) 0831403 (y) 0050974 1036m	1 child Household head mother
HH73	(x) 0831405 (y) 0050972 1036m	7 children Household head father
HH74	(x) 0831420 (y) 0050987 1036m	5 children Household head mother
HH75	(x) 0831426 (y) 0050966 1036m	6 children Household head father
HH76	(x) 0831430 (y) 0050967 1036m	8 children Household head father
HH77	(x) 0831439 (Y) 0050982 1036m	3 children Household head mother
HH78	(x) 0831447 (y) 0050981 1036m	7 children Household head father
HH79	(x) 0831457 (y)0050983 1036m	3 children Household head mother
HH80	(x) 0831454 (y) 0050983 1036m	2 children Household head father
HH81	(x) 0831458 (y) 0050994 1036m	No child Household head mother
HH82	(x) 0831458 (y) 0051001 1036m	1 child Household head father
HH83	(x) 0831459 (y) 0051010 1036m	No child Household head father
HH84	(x)0831459 (y) 0051015 1036m	No child Household head mother
HH85	(x)0831463 (y)0051012 1036m	1 child Household head mother
HH86	(x) 0831475 (y) 0050997 1037m	12 children Household head father

HH87	(x) 0831474 (y)0051002 1037m	6 children Household head father
HH88	(x) 0831474 (y) 0051010 1038m	6 children Household head father
HH89	(x)0831473 (y) 0051012 1038m	3 children Household head mother
HH90	(x) 0831491 (y) 0050999 1039m	2 children Household head mother
HH91	(x) 0831499 (y) 0051009 1038m	1 child Household head father
HH92	(x) 0831501 (y) 0051012 1038m	No child Household head mother
HH93	(x) 0831486 (y) 0050991 1038m	9 children Household head father
HH94	(x) 0831487 (y)0050986 1038m	15 children Household head father
HH95	(x) 0831485 (y) 0050983 1037m	10 children Household head father
HH96	(x) 0831487 (y) 0050979 1037m	No child Household head mother
HH97	(x) 0831486 (y) 0050977 1037m	6 children Household head father
HH98	(x) 0831498 (y) 0050988 1037m	No child Household head mother
HH99	(x) 0831492 (y) 0050952 1039m	9 children Household head father
HH100	(x) 0831498 (y) 0050940 1039m	5 children Household head father

APPENDIX FOUR: RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MISS. MERCY MANDERE OSIEMO
of EGERTON UNIVERSITY, 0-20115
Egerton, has been permitted to conduct research in *Baringo County*

on the topic: *ASSESSMENT OF WATER AND SANITATION ACCESSIBILITY AND WATERBORNE DISEASE PREVALENCE IN MARIGAT URBAN CENTRE BARINGO COUNTY, KENYA*

for the period ending:
31st January,2020

Permit No : NACOSTI/P/19/28617/27715
Date Of Issue : 31st January,2019
Fee Recieved :Kshs 1,000

Applicant's Signature

Director General
National Commission for Science, Technology & Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

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TEL: 020 400 7000, 0713 788787, 0735 404245
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Website: www.nacosti.go.ke

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