ASSESSING CAUSES OF DRINKING WATER SOURCE CONTAMINATION IN KAMPALA CITY: A CASE STUDY OF KATWE AND KISENYI PARISHES

FINAL YEAR PROJECT REPORT

A Project submitted to the department of Mechanical and Civil Engineering in fulfillment of the requirement for the Award of a Bachelor's Degree in Civil Engineering of Kampala International University

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DECLARATION

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APPROVAL

We undersigned, do certify that we have read and hereby recommend for acceptance by Kampala International University this Project Report Titled: **Assessing Causes of Drinking Water Source Contamination in Kampala City: A case study of Katwe and Kisenyi parishes** in partial fulfillment of the requirement for the Award of the Degree of Bachelor of Science in Civil Engineering of Kampala International University.

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We are grateful to Almighty ALLAH who has been with us throughout the all period of our studies.

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DEDICATION

We dedicate this research work to our family who raised us up right away from childhood to date and always ready to encouraged us to pursue our studies till finishing stage.

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LIST OF ABBREVIATIONS

AC	Apparent Color
CAC	Command and control
EC	Electronic Conductivity
EI	Economic Incentive
EPA	Environmental Protection Agency
KCCA	Kampala Capital City Authority
MWE	Ministry of Water and Environment
NEMA	National Environmental Management Authority
PH	Potential Hydrogen
TDS	Total Dissolve Solid
TP	Total phosphorous
TSS	Total Suspended Solid
UNEP	United Nations Environmental Programme
WASREB	Water Services Regulatory Board
WHO	World Health Organization
WSPP	Water Source Projection plan

ABSTRACT

Water pollution is a serious problem for the entire world. It threatens the health and well being of humans, plants, and animals. As the world became more industrial and smaller due to communications and trade, accidental and purposive hazardous dumping have contributed to the problem of sources of water pollution. All water pollution is dangerous to the health of living organisms, but springs and borehole pollution can be especially detrimental to the health of humans. Springs and boreholes are used as primary sources of portable water by populations all over katwe and kisenyi. Another serious consequence of this pollution is the effect of this pollution on the health of the people in this areas. This reseach examines cases which reflect different causes of springs and borehole pollution, the effect of this pollution on health of the residents, and a possible solution to this problems.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The United Nations (UN) set a goal in their Millennium Declaration to reduce the amount of people without safe drinking water by half in the year 2015 (UN, 2000). Safe drinking water for human consumption should be free from pathogens such as bacteria, viruses and protozoa parasites, meet the standard guidelines for taste, odour, appearance and chemical concentrations, and must be available in adequate quantities for domestic purposes (Kirkwood, 1998).

A big number of the residents of katwe and kisenyi are the urban poor with more than 80% of the residents not formally employed and depending on small-scale businesses *(*Katukiza *et al., 2013).* Most of them stay in unplanned and informal settlements occupying very small plots where there is barely enough land for erecting proper sanitation facilities (MWE Report, 2012). Lack of proper sanitation facilities also contributes to the contamination of water sources.

An adequate supply of safe drinking water is one of the major prerequisites for a healthy life, but waterborne disease is still a major cause of death in many parts of the world, particularly in children, and it is also a significant economic constraint in many subsistence economies. The basis on which drinking water safety is judged is national standards or international guidelines. The most important of these are the WHO Guidelines for Drinking Water Quality. The quality of drinking water and possible associated health risks vary throughout the world with some regions showing, for example, high levels of arsenic, fluoride or contamination of drinking water by pathogens, whereas elsewhere these are very low and no problem.

Drinking water treatment as applied to public water supplies consists of a series of barriers in a treatment train that will vary according to the requirements of the supply and the nature and vulnerability of the source. Broadly these comprise systems for coagulation and flocculation, filtration and oxidation. The most common oxidative disinfectant used is chlorine. This provides an effective and robust barrier to pathogens and provides an easily measured residual that can act as a marker to show that disinfection has been carried out, and as a preservative in water distribution.

The basis on which drinking water safety is judged is national standards or international guidelines. The most important of these are the WHO Guidelines for Drinking-Water Quality. These are revised on a regular basis and are supported by a range of detailed documents describing many of the aspects of water safety. The Guidelines are now based on Water Safety Plans that encompass a much more proactive approach to safety from source-to-tap.

The impacts of contamination events to lakes and reservoirs are more severe and persistent than streams and rivers because there is not a natural flushing process as is characterized by the flow in streams and rivers. Contamination is even more persistent in groundwater due to lack of biological degradation. The most biologically active bacteria live within the soil above groundwater supplies.

Drinking water, also known as potable water or improved drinking water, is water that is safe to drink or to use for food preparation, without risk of health problems. Globally, in 2012, 89% of people had access to water suitable for drinking. Nearly 4 billion had access to tap water while another 2.3 billion had access to wells or public taps.1.8 billion people still use an unsafe drinking water source which may be contaminated by feces. This can result in infectious diarrhea such as cholera and typhoid among others.

Access to safe drinking water is indicated by safe water sources. These improved drinking water sources include household connection, public standpipe, borehole condition, protected dug well, protected spring, and rain water collection. Sources that do not encourage improved drinking water to the same extent as previously mentioned include: unprotected wells, unprotected springs, rivers or ponds, vender-provided water, bottled water (consequential of limitations in quantity, not quality of water), and tanker truck water. Access to sanitary water comes hand in hand with access to improved sanitation facilities for excreta, such as connection to public sewer, connection to septic system, or a pit latrine with a slab or water seal.

1.3 Problem statement

According to WHO (2014), approximately 1.1 billion people in the world do not have access to safe water, and another 2.6 billion do not have access to adequate sanitation. In developing countries, an estimated 2.2 million people, most of who are children, die annually due to diarrhea linked to a lack of access to safe drinking water, inadequate sanitation and poor hygiene (WHO 2014).

In Africa, as many as 150 million urban residents representing up to 50 per cent of the urban population do not have adequate water supplies, while 180 million, or roughly 60 per cent of people in urban areas lack adequate sanitation. In urban Asia, 700million people, constituting half the population, do not have adequate water, while 800 million people or 60 per cent of the urban population is without adequate sanitation.(UN-Habitat,2014).

Drinking water quality is an issue for human health in developing and developed countries worldwide. The WHO has stated that every year, 4 billion cases of water related disease cause at least 1.8 million deaths worldwide, making it one of the leading causes of morbidity and mortality. An estimated 99.8% of such deaths occur in developing countries, and 90% are children under the age of five (WHO, 2014). In addition, 88% of these diseases are attributed to inadequate water supply, poor sanitation and hygiene (Lantagne, 2015). Poor quality drinking water has been implicated in the spread of waterborne diseases such as cholera, dysentery, hepatitis A and E, giardias is, and Haemolytic Uremic Syndrome (Montgomery and Elimelech, 2015).

Most drinking water sources in the city are under question as to whether they are safe or perhaps the general public in Kampala is totally at risk due to unsafe water sources. In the past, there have been problems of typhoid and cholera out breaks in most suburbs of Kampala city due to unsafe drinking water. On the 20thof February 2105 the Ministry of Health and Kampala Capital City Authority (KCCA) confirms typhoid outbreak in Kampala city. This has paved way for research necessity to actually find out how drinking water sources are being contaminated and the status of drinking consumed by the public in Katwe and Kisenyi Parishes of Kampala.

1.4 The main objective (Research objective)

The main objective of this research is to assess causes of drinking water source contamination in Katwe and Kisenyi parishes in Kampala City, Uganda.

1.5 Specific objectives

i) To examine the state of existing water sources within Katwe and Kisenyi parishes
ii) To carry out water quality tests which will help to examine the quality of water from each of the selected water source within the two Parishes.
iii) To make recommendations on how to effectively control water source contamination in the two parishes.

1.6 Research questions

The research questions include the following;

i) What is the state of existing water sources within Katwe and Kisenyi parishes.
ii) What are the water quality tests to carry out which will help to examine the quality of water from each of the selected water source within the two Parishes.
iii) What are the recommendations on how to effectively control water source contamination in the two parishes.

1.7 Scope

1.7.1 Content Scope

This research was covered in two zones Katwe and two in Kisenyi II parishes. Different ways of water contamination, impacts of water contamination, possible community attempts to solve the problem of water contamination and proposed improvement strategies was studied.

1.7.2 Geographical Scope

The research was conducted in Katwe and Kisenyi Parishes, they are in Makindye and Central Divisions respectively in Kampala City, Uganda. These parishes were chosen because they are slums where contamination of water sources has been found to be common.

Figure 1: Map of Uganda showing location of Kampala

(Source: www.infoplease.com/atlas/country/Uganda/html)

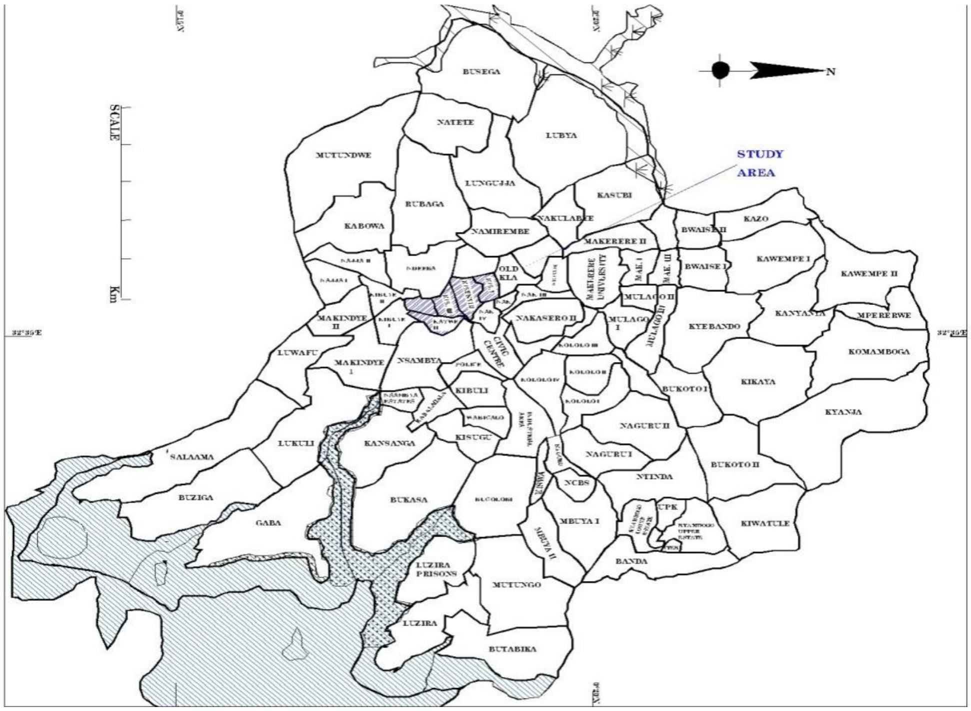

Figure 2: Map of Kampala showing location of Kisenyi and Katwe (Source: Kulabako et al., 2007)

Figure 3: Map of some of the Parishes in Makindye Division inclusive of Katwe I

Figure 4: Map of Kisenyi Parish showing Kisenyi I, II and III

1.7.3 Time Scope

The research was conducted over the period of 13 months in the academic year of 2015-2016 which comprises of examining the state of water sources.

1.8 Significance of the study

i. This research will help in improving the health statues of the residence of this community because it will help in preventing water sources contaminations and control water borne diseases.

ii. This research will help the local community in planning to control any future outbreak of water borne diseases.

iii. This research will help in informing the stakeholders on the water to take and how to treat it for emergency need.

iv. The overall future safety options for drinking water in Katwe and Kisenyi Parishes was identified as suggestive ways forward.

v. Future researchers can also review literature from this study basing on their research interests.

1.9 Project justification

i. This research is important because it will save the lives of the resident of this community by informing them about the quality of the water they take.

ii. This research is important because it will serve as a strategy on water borne disease control.

iii. And also helps in working with the community to tackle difficult water quality problems, such as storm water pollution and urban runoff.

iv. Despite the fact that various studies have been made on contamination of drinking water sources, much research work is still needed, since over the recent past problems associated with contamination of drinking water sources has increased in the two parishes.

v. This directly opens door and renders this research one of great need and urgency otherwise the problem of contamination in the two parishes will persist and end in increased incidences of water borne diseases like cholera, amoebiasis, typhoid fever etc.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature in this chapter describes reviews from different books and scholars basing on the objectives of this research. The research objectives included the examination of; water supply technologies and challenges, water quality test, impacts of contaminated water and suggestive ways forward to improve drinking water contamination from sources. This chapter also reviews the institutional and theoretical framework for water source protection in Uganda.

It is estimated that 31countries, accounting for under 8% of the world population, face chronic fresh water shortages. By the year 2025, however,48 countries are expect to face shortages, affecting more than 2.8billion people 35% of world's projected population. Among countries likely to run short of water in the next 25years are Uganda, Ethiopia, India, Kenya, Nigeria, and Peru. Parts of the large countries, such as China, already face chronic water problems (WHO, 1997).

The presence of lead in drinking water is more prevalent and serious than many people realize. Despite common perceptions, lead is not restricted to inner-city communities, but rather is a problem that affects many water systems across the country. According to an Environmental Protection Agency study released in 1993, more than 800 drinking water systems around the nation contain excessive lead. Today, the EPA estimates that more than 40 million Americans are exposed to potentially dangerous amounts of lead in their drinking water. Recent legislation has helped decrease the problem.

In 1991, the EPA imposed new standards for lead levels in drinking water that are 10 times more protective than levels previously thought to be safe. The new standard allows for a lead level of no more than 15 parts per billion (ppb). Current studies, however, show that lead levels in our drinking water continue to be too high.

Bacteria are the most numerous organisms on the planet. There are literally millions of different types of indicates that lead may be more harmful than previously thought bacteria. They are one celled organisms and are present in everything from water to food, and on objects we touch every day. What's ironic about bacteria is that they are among the smallest organisms on earth, and yet they can cause some of the greatest problems. We come in contact with millions of bacteria every day, and nearly all are harmless. However, some types of bacteria are very harmful, especially those from sewage, even when present in small amounts.

Bacteria are the cause of some serious diseases, such as cholera, that plagued villages and towns centuries ago. Thanks to modem sanitation methods, many of these diseases have been greatly reduced or eliminated in the United States. Unfortunately, less developed countries that do not have effective sanitation systems are still affected by diseases caused by bacteria and viruses from sewage.

All water utilities should deliver to the consumer an adequate supply of high-quality drinking water at a cost commensurate with the needs of each individual water system. To achieve this objective, the water should come from the highest quality source of supply available and be appropriately treated to meet regulatory and water supply industry criteria. Drinking water quality criteria should be based on documented health effects research, consumer acceptance, demonstrated treatment techniques, and effective utility management. The minimum criteria should be as defined by federal, state, and provincial regulations that take into account appropriate health and cost considerations.

2.2 Drinking Water sources

The World Health Organization (WHO) classifies source of water supplies as either improved or unimproved (WHO, 2014). Improved water sources include public standpipes, household connections, boreholes, protected dug wells, protected springs, boreholes and springs connected via a pipe system to a tap, as well as rainwater collection (WHO, 2014). Unimproved water sources include unprotected wells, unprotected springs, vendor-provided water, rivers as well as tanker truck provision of water (Gundry, 2014).

In many developing countries, potable water is collected from communal sources which are either exposed (e.g. unprotected wells, unprotected springs, and rivers) or improved (e.g. protected wells, boreholes and public standpipes) (Sobsey, 2013). The primary source of human pathogens in water sources has been from human waste. Animal waste also carries pathogens that affect people as well as other animals. Discharge of domestic wastes into surface waters allows pathogenic bacteria to be dispersed downstream (Goel, 2014).

Several studies carried out in developing countries investigated the microbiological quality of these improved and unimproved water sources and the results obtained were different depending on the water source. The results of a study carried out in Saudi Arabia, indicated that water collected from traditional sources (wells) showed increases in most of the investigated bacteriological parameters, followed by surface water and bottled or desalinated water. Coliforms were not detected in any samples taken from bottled water, but it was detected in samples taken from desalinated, surface, and well water; of 12.9%, 80%, and 100%, respectively(Alotaibi,2010). Kravitz ,(2011) demonstrated, in their study carried out in Lesotho Highlands, Southern Africa, that based on the estimation of total coliform which is a nonspecific bacterial indicator of water quality, all unimproved and semi-improved water sources were to be considered as not potable. *E. coli*, a more precise indicator of feacal pollution was absent in improved water sources (P<0.001). The study suggests that protection of water sources can improve the microbiological quality of rural water supplies, where disinfection is not feasible. Sobsey (2012) described various interventions strategies to improve the water quality at the source. These improvements can include the building of reservoirs, building protective structures around boreholes and fountains, providing communities with communal taps closer to the dwelling and the treatment of the water source with a disinfectant.

2.3 Impacts of Drinking water source contamination

Water borne diseases caused by poor water quality are the most common impacts of polluted water on communities. There are various forms of waterborne diseases that affect mainly children living in developing countries, according to the World Health Organizations, such diseases account for an estimated 4.1% of the total Daily global burden of disease, and causes about 1.8 million human deaths annually. About 88% of these deaths are due to unsafe water supplies, sanitation and hygiene (WHO, 2014).

2.3.1 Cholera

Cholera is caused by drinking water containing the bacteria *Vibrio cholerae*. It causes an acute intestinal infection, which leads to severe diarrhea and that in turn leads to severe dehydration. It also may be accompanied by vomiting. If not treated, dehydration may lead to death. About 20% of cholera sufferers develop diarrhea to the extent of severe dehydration, while another 80 to 90 percent develop only moderate cases of diarrhea, which is difficult to distinguish from other diarrhea-causing factors. Since cholera may be spread through feacal matter, outbreaks may be difficult to contain in areas of poor sanitation standards. The disease has been reported in mostly developing countries with such sanitation standards (Green, 2015).

2.3.2 Amoebiasis

Amoebiasis or amebiasis refers to an infection caused by the amoeba *Entamoebahistolytica.* This pathogen causes a gastrointestinal infection that may or may not be symptomatic and can remainlatent in an infected person for several years. Amoebiasis causes an estimated 70,000deaths per year worldwide. Symptoms of this disease range from mild diarrhea to dysentery with blood and mucous in the stool, stomach cramps and vomiting and a high fever of 100.4 ºF or above in children under five. Severe amoebiasis infections, known as invasive or fulminantamoebiasis, occur in two major forms. Invasion of the intestinal lining causes ameobicdysentery or amoebic colitis. If the parasite reaches the bloodstream, it can spread throughout the body, normally ending up in the liver where it causes amoebic liver abscesses. When no symptoms are present, the individual is still a carrier and can spread the parasite to others through poor hygienic practices (WHO, 2014).

2.3.3 Typhoid fever

Typhoid fever is an acute life-threatening illness caused by the bacterium *Salmonella typhi*orin some cases *Salmonella paratyphi,* is a related bacteria that causes a less severe illness. This bacterium is deposited by human carriers in water or food and can spread to other people in the area. Typhoid fever is contracted by drinking or eating the bacteria in contaminated food or water. People with the illness can contaminate water supplies through fences which contain high concentrations of the bacteria. The bacteria can survive for weeks in water or dried sewage (Ratini, D.M 2012).

2.4 Water Quality Test

2.4.1 pH

The pH in the general with a low ph (< 6.5) could be acidic, soft and corrosive. Therefore, the water could the leach metal ions such as iron, manganese, copper, lead and zinc from the aquifer, plumbing fixture, and piping. Therefore, water with a low pH could contain elevated levels of toxic metals, have associated aesthetic problems such as a characteristic "blue –green" staining of sink and drains.

Water with a pH >8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can cause aesthetic problems. This problem formation of a scale or precipitate on piping and fixture causing water pressure and interior diameter of piping to decrease. The recommended drinking water value for pH is within range of (6.5-8.5). However, the WHO guidelines for drinking water also state that the acceptable pH range may be broader than 6.5-8.5 where no distribution systems are used. This is because this range is used to minimize technical problems such as inefficient chlorine disinfection in water distribution systems. The apparatuses used for measuring the pH were microprocessor pH meter, assorted glassware and siphon bottle.

2.4.2 Colour

Colour in water is primarily due to presence of coloured organic substances (humic substances), metals such as iron, manganese or highly coloured industrial wastes. Coloured water is aesthetically undesirable to consumers and may adversely affect some industrial processes. Colour is measured by comparison with standard solutions or suspension. The apparent colour is determined by measuring an unfiltered water sample. It is expressed in platinum cobalt units. The apparatuses used include DR/2010 or (NRTL/C England) spectrophotometer, sample cells and assorted laboratory glass ware.

2.4.3 Turbidity

Turbidity occurs in most surface areas due to the pressure of suspended clay, silt, finely divided organic and inorganic matters, algae and micro-organisms. Turbidity is an expression of certain light scattering and light absorbing properties of a water sample and depends in a complex manner, on such factors as the number, size, shape, and refractive index of the participate manner present in the water. Turbidity is expressed in nephelometric turbidity units (NTU). It is generally objectionable to customers, can protect micro-organisms from effects of disinfection, stimulate the growth of bacteria and even increase a significant chlorine demand. There are different methods of measuring turbidity but the most frequently used is the nephelometric method.

2.4.4 Total Phosphorous

The Persulfate digestion method was used to test for TP. A drop of phenolphthalein indicator was added to 50 mL of a suitably diluted portion of thoroughly mixed sample. If a red color developed, sulfuric acid solution was added drop wise to just discharge the color. Then 1 mL H_2SO_4 solution and 0.5g solid $K_2S_2O_8$was added. This mixture was heated in an autoclave for 30 min. and then allowed to cool to room temperature. A drop of phenolphthalein indicator solution was added and neutralized to faint pink color with NaOH, then made up to 100mL with distilled water.

The orthophosphate concentration was determined by the ascorbic acid method where 2.5mL aliquots from the 100 mL above were pipetted into clean, dry test tubes to which 0.4mL combined reagent was added and mixed thoroughly. After at least 10 min but not more than 30 minutes, absorbance of each sample was measured spectrophotometrically at 880 nm, using reagent blank as the reference solution (APHA, 1998).

2.4.5 Total Suspended Solids (TSS)

One liter of well mixed samples was filtered through pre-weighed glasmicrofibre filter papers and dried in a drying oven (Model G90-C, Genlab, Widnes, England) at 103-105^{0}C for at least 1 hour, cooled in a dessicator to balance temperature, and weighed. (APHA, 1998).

2.4.6 E.Coli

E.coli contamination was determined using membrane filtration methodonchromocault agar. Serially diluted samples were filtered through 47 mm mixed cellulose ester membrane disc filters (Michigan, USA) of 0.45 µm pore size and then incubated at 37^0C for 48 hours on Chromo cult TBX agar as growth medium (Appendix I). Dark blue to purple colonies were then counted (APHA, 1998). The dark blue or purple colonies were streaked on MacConkey agar. The colonies which showed bright pink halo, bile precipitant around the colonies, and pink colony growth were considered *E. coli*.

2.5 Strategies for Preventing Drinking Water Source Contamination

2.5.1 Command-and-Control based instruments

Command-and-Control (CAC) based instruments operate by enforcing direct regulations on processes or products, by imposing acceptable levels on the emission of particular pollutants, by issuing restrictions on polluting activities, and by limiting the polluters to operate at particular areas and time (Bernstein 1997). Application of CAC based instruments (direct regulations) heavily relies on setting up of various quantitative and qualitative controls and regulations along with monitoring and enforcement systems to limit polluters' behavior (Kolstad 2000).

2.5.2 Economic incentive based instruments

Economic Incentive (EI) based instruments are also known as market-based instruments. These instruments are shaped by market forces and they aim to change polluter behavior in favour of environmental conservation (Bernstein 2010). In the system of applying these instruments, polluters are not told how much they can pollute or what technology they must use, but their choices have financial consequences and hence this influences the choices they make. With these policies, emission constraints are not specific to a given source; rather they provide equal monetary incentives to all polluters by effectively increasing the marginal costs of production (Eskeland and Jimenez 2012).

2.5.3 Public participation in pollution control

UNEP (2012) has emphasized that public attitude towards environmental pollution is an important component of a sustainable strategy. Chave (2013) points out that the involvement of the public is essential to enable regulators to understand the impact of any proposed measure prior to setting standards for water and effluent, and to ensure that any programs for improvement are attainable within the financial and technical capabilities of the country concerned. The primary reason for community engagement is usually to inform and educate so as to promote public understanding, agreement and perhaps achieve consensus regarding an environmental problem. Bhushan (2004) observed that in many cases where community pressure is absent, regulators and polluters share a privileged partnership.

2.5.4 Public disclosure of information

This involves collecting information on the pollution emitters' environmental performance on a regular basis and disseminating that information to the public (Blackman 2009). This instrument encourages changes in polluters' behavior as it discloses information about pollution among the general public.

2.5.5 Voluntary agreements

These are usually non-legally binding contracts, either between industry (or any other pollution causing agent) and the government or between industry and local community, in which the pollution emitter in question volunteers to reduce its pollution by a certain amount within a specified time (Blackman 2009). By contrast, in developing countries, regulators generally use voluntary agreements to help resolve extensive noncompliance with mandatory regulation (Blackman 2006).

2.5.6 Drinking water quality improvement by hygiene practices

Numerous studies have definitively shown that sanitation and hygiene behaviors are equally important in disease prevention (Macy and Lochery, 1997). Improvements in the quality of water, the disposal of excreta, and the delivery of general hygiene education are all important factors in achieving reductions in diarrhea morbidity and mortality rates (Bartram and Cairncross, 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 implementing innovative, user-friendly, low cost systems (Montgomery and Elimelech, 2007). However, some evidence has linked the standard latrine to contamination of groundwater by bacteria and nutrients. (Montgomery and Elimelech, 2007)

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter focuses on the materials and approaches that were used to achieve the study objectives.

3.2 Research Design

Due to time factor, the research only involved a Qualitative approach. This involved examination of samples taken which was done to find out contamination levels in the different water points.

3.2.1 Sampling technique

The calculation of sample size is dependent on the observations made, the level of precision the researcher is willing to have and the available resources. For this research, the area is too wide therefore, worse case scenario was considered so only four water points were chosen for the study.

3.3 Sources of Data

Primary: laboratory test were done in the samples of water from the two perishes, to know the level of contamination.

Secondary: literature search was done on water point contamination to find out it's possible causes. Levels of contamination were also analyzed, and compared with the recommended levels set by WHO, NEMA and MWE.

3.4.1 Sampling

Water samples were collected from each of the four water points code-named A, B, C and D, those chosen randomly from the study area. Sampling was done twice from each of the wells. The period of sampling comprised of both rainy and dry weather spells. Due to weather changes, the water quality changed. All these points are in use by the communities around them.

Two sample bottles were used for each sample, one for microbiological analysis which was sterilized before usage and the other for the physical and chemical analysis. The bottles were washed and rinsed with distilled water before usage; and also after as a way of decontamination in preparation for the next sampling round.

During the sampling, water was drawn directly from the taps or opening for the boreholes and the hand pumps, and below the water surface level for the wells or unsupported springs. Samples were in 1-litre acid-rinsed and sterilized bottles for chemical and microbiological analysis respectively. The samples were well preserved by storing them in a cool box at 4ºC (with ice packs) before delivery to the laboratory for analysis. The latter was undertaken in the Environmental Biotechnology Laboratory of the Department of Chemistry at Makerere University.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter comprises of the results of the study and their discussion.

4.2 Sample analysis

Different water sources were identified and samples were taken for laboratory tests.

Table 1: Description allocation of sampling points

SAMPLE DESIGNATION	LOCATION NAME
A.	Katwe (Kiganda or Kinyolo) Spring water
B.	Katwe (Railway) Bore hole water
C.	Kisenyi Tap water (leaking)
D.	Kisenyi Spring water

Sample A

This sample is a spring water source in Katwe. It is not protected with any wall around it. The sample point has algae on surface and the water appearance is unacceptable. There is evidence of site contamination. When it rains, water collects around the ground since it is in the valley. Even according to the water users they have taken a long time without cleaning the area around the spring. Surprisingly, this source of water is used for all domestic activities such as drinking, cooking and washing. There are several pit latrines near this point, the nearest is about 20m upstream of this source.

Sample B

This is a bore hole along Katwe Railway. The drainage around the area is quite good and no contamination may be expected as a result of this. However, the pit latrines are so near within a range of 20-30m and are about 50 feet deep. The population density of this area is also high.

Sample C

This is a tap stand in Kisenyi connected to the NWSC grid. The tap is used for public water sale. Unfortunately, the pipes connecting it are leaking at various points which indicates possible contamination from surface runoff and the surrounding environment.

Sample D

This is a spring water source in Kisenyi. It is protected but it is in the vicinity of many pit latrines. According to the information got from the users, these pits are unlined. This implies possible contamination of the well by feacal matter.

4.3 Laboratory measurements

Water samples were picked from the field and taken to Makerere University, Environmental Biotechnology laboratory for analysis. Laboratory tests were carried out to find out the presence of nutrients, stabilizing factors and micro-organisms to enable determine the level of contamination. The standards of analysis of water was properly observed and followed. The following parameters were analyzed:

4.4 Indicator organisms

An indicator organism is a micro-organism whose presence is evidence that the water has been polluted with feaces of human or other warm-blooded animals.

Coliform bacteria, as typified by Escherichia coli (E.coli) and feacal streptococci (enterococci) that reside in the human intestinal tract are excreted in large numbers in feaces, averaging about 50 million per coliforms per gram. Most pathogenic bacteria and viruses causing enteric diseases in humans originate from feacal matter.

4.4.1 pH

The pH in the general with a low ph (< 6.5) could be acidic, soft and corrosive. Therefore, the water could the leach metal ions such as iron, manganese, copper, lead and zinc from the aquifer, plumbing fixture, and piping. Therefore, water with a low pH could contain elevated levels of toxic metals, have associated aesthetic problems such as a characteristic “blue –green” staining of sink and drains.

Water with a pH>8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can cause aesthetic problems. This problem formation of a scale or precipitate on piping and fixture causing water pressure and interior diameter of piping to decrease. The recommended drinking water value for pH is within range of (6.5-8.5). However, the WHO guidelines for drinking water also state that the acceptable pH range may be broader than 6.5-8.5 where no distribution systems are used. This is because this range is used to minimize technical problems such as inefficient chlorine disinfection in water distribution systems. The apparatuses used for measuring the pH were microprocessor pH meter, assorted glassware and siphon bottle.

4.4.2 Colour

Colour in water is primarily due to presence of coloured organic substances (humic substances), metals such as iron, manganese or highly coloured industrial wastes. Coloured water is aesthetically undesirable to consumers and may adversely affect some industrial processes. Colour is measured by comparison with standard solutions or suspension. The apparent colour is determined by measuring an unfiltered water sample. It is expressed in platinum cobalt units. The apparatuses used include DR/2010 or (NRTL/C England) spectrophotometer, sample cells and assorted laboratory glass ware.

4.4.3 Turbidity

Turbidity occurs in most surface areas due to the pressure of suspended clay, silt, finely divided organic and inorganic matters, algae and micro-organisms. Turbidity is an expression of certain light scattering and light absorbing properties of a water sample and depends in a complex manner, on such factors as the number, size, shape, and refractive index of the participate manner present in the water. Turbidity is expressed in nephelometric turbidity units (NTU). It is generally objectionable to customers, can protect micro-organisms from effects of disinfection, stimulate the growth of bacteria and even increase a significant chlorine demand. There are different methods of measuring turbidity but the most frequently used is the nephelometric method.

4.4.4 Total Phosphorous

The Persulfate digestion method was used to test for TP. A drop of phenolphthalein indicator was added to 50 mL of a suitably diluted portion of thoroughly mixed sample. If a red color developed, sulfuric acid solution was added dropwise to just discharge the color. Then 1 mL H_2SO_4 solution and 0.5g solid $K_2S_2O_8$was added. This mixture was heated in an autoclave for 30 min. and then allowed to cool to room temperature. A drop of phenolphthalein indicator solution was added and neutralized to faint pink color with NaOH, then made up to 100mL with distilled water.

The orthophosphate concentration was determined by the ascorbic acid method where 2.5mL aliquots from the 100 mL above were pipetted into clean, dry test tubes to which 0.4mL combined reagent was added and mixed thoroughly. After at least 10 min but not more than 30 minutes, absorbance of each sample was measured spectrophotometrically at 880 nm, using reagent blank as the reference solution (APHA, 1998).

4.4.5 Total Suspended Solids (TSS)

One liter of well mixed samples was filtered through pre-weighed glasmicrofibre filter papers and dried in a drying oven (Model G90-C, Genlab, Widnes, England) at 103-105^{0}C for at least 1 hour, cooled in a dessicator to balance temperature, and weighed. (APHA, 1998).

4.4.6 E.Coli

E.coli contamination was determined using membrane filtration methodonchromocault agar. Serially diluted samples were filtered through 47 mm mixed cellulose ester membrane disc filters (Michigan, USA) of 0.45 µm pore size and then incubated at 37^{0}C for 48 hours on Chromo cult TBX agar as growth medium (Appendix I). Dark blue to purple colonies were then counted (APHA, 1998). The dark blue or purple colonies were streaked on MacConkey agar. The colonies which showed bright pink halo, bile precipitant around the colonies, and pink colony growth were considered *E. coli*.

4.5 Data analysis

The T-test using MiniTAB was used to analyze the laboratory results. The results were then compared with the WHO and Ministry of Water and Environment guidelines.

4.6 Results

The following results were achieved from the two seasons when sampling and analysis were done. Table 2 represents January and Table 3 April results respectively.

Table 2: Table of Results for Feb, 2016 Raining Season

Sample	pH	EC (mS/cm)	TDS (mg/L)	TSS (mg/L)	TP (mg/L)	Turbidity (NTU)	Apparent colour (PtCo)	E.coli (CFU/100mL)
Kisinye Spring water	5.8	0.68	0.48	0.17	0.36	1.65	7	0.67
Borehole water Katwe	5.79	0.72	0.52	6.21	1.04	6.08	38.82	0.91
Tap water leaking Kisenyi	5.60	0.36	0.25	0.12	0.56	0.56	2.4	1
Katwe Spring water	8.43	0.85	0.63	24.03	0.98	8.09	46.03	18

Table 3: Table of Results for May 2016 Dry season

Sample	pH	EC (mS/cm)	TDS (mg/L)	TSS (mg/L)	TP (mg/L)	Turbidity (NTU)	Apparent colour (PtCo)	E.coli (CFU/100mL)
Katwe Spring water	5.9	0.62	0.31	0	0.03	0	3	0
Borehole water Katwe	5.64	0.68	0.34	5.32	0.5	5.462	30.82	0
Tap water leaking Kisenyi	5.37	0.18	0.09	0	0.04	0	0	0
Kisenyi Spring	5.91	0.49	0.24	21.35	0.522	7.38	41.37	10

These results were compared with the minimum standard guidelines for drinking water set by the Water Services Regulatory Board (WASREB), Uganda's Ministry of Water and Environment (MWE) and the World Health Organization (WHO). These water quality guidelines are shown in tables 4, 5 and 6 below:

Table 4: Quality requirements for drinking water: WASREB standards

No.	Characteristic	Unit	Drinking water
1	Colour	True colour units	15+
2	Taste &odour	Mg/l	Shall not be offensive to customers
3	TSS	Mg/l	0
4	Turbidity	NTU	5
5	TDS	Mg/l	1500 max
6	TP	Mg/l	30
7	E.Coli	In 250ml	0
8	Ph		6.5 to 8.5

Table 5: Recommended MWE values of the following tested parameters.

pH	EC	Turbidity	TSS	Alkalinity	E.Coli	TN	TP
6-8.5	2500	15	0	700	0	5	5

Table 6: Recommended WHO values of the following tested parameters

Parameter	Lab Results: 10/05/2016 Dry season				Recommended value
	A	B	C	D	
pH	5.8	5.79	5.60	8.43	6.5-8.5
Colour (p_tC_o)	7	38.82	2.4	46.03	10
Turbidity (FAU)	1.65	6.08	0.56	8.09	10
EC (s/cm)	0.68	0.72	0.36	0.85	2500
TSS(g/l)	0.17	6.21	0.12	24.03	100
TDS (mg/L)	0.48	0.52	0.25	0.63	500
E.coli CFU/100Ml	0.67	0.91	1	18	0
TP	0.36	1.04	0.56	0.98	10

Parameter	Lab Result: 10/05/2016 Raining season				Recommended value
	A	B	C	D	
pH	5.9	5.64	5.37	5.91	6.5-8.5
Colour (p_tc_o)	3	30.82	0	41.37	10
Turbidity (FAU)	0	5.46	0	7.38	10
EC (s/cm)	0.62	0.68	0.18	0.49	2500
TSS(g/l)	0	5.32	0	21.35	100
TDS (mg/L)	0.31	0.34	0.09	0.24	500
E.coli CFU/100Ml	0	0	0	10	0
TP	0.03	0.5	0.04	0.522	10

4.7.2 EC

The EC results which were obtained for only two times are highly unlikely to be used for analysis and drawing conclusions. This is because they are not consistent with what was supposedly expected due to not using an appropriate scale. However, what we have is in acceptable ranges for all points.

The variation in values may be because of change of weather and contents of the rocks consisting the aquifers from which the ground water flows and higher pH may also be due to temperature variation. January was generally in the dry weather unlike April which was rainy.

4.7.3 TDS

From tables 5 and 6, the TDS of the water ranges from 0.09 to 0.63 for all the sources. The values are higher in January. However, all these values are acceptable when compared with the recommended standards.

4.7.4 TSS

Except for the Kisenyi spring and Katwe tap in April, all the TSS values are unacceptable for drinking by the given standards. These values range from 0 unto a maximum of 28.03.

Total solids is a measure of the amount of dissolved, suspended and colloidal impurities total solids do not have a standard acceptance value, what is normally recommended is the concentration to be as low as possible (Clescer et al, 1998)

4.7.5 Turbidity

As for TSS, except for the Kisenyi spring and Katwe tap, all the TSS values are unacceptable for drinking by the given standards. The acceptable value is five yet these values range from over this limit up to a maximum of 8.09.

This is an indication that there are suspended matters in the water showing that there was a lot of contamination by materials to these water points. It should be noted that these water points are ground water sources where ground water contamination is very likely.

4.7.6 Apparent Colour

Colour for the Kisenyi spring and Katwe tap are below fifteen, all the other values are above and are unacceptable. As for turbidity, this indicates that there was a lot of contamination by materials to these water points.

4.7.7 E.coli

E.coli contamination was determined using membrane filtration method on chromocault agar. Serially diluted samples were filtered through 47 mm mixed cellulose ester membrane disc filters (Michigan, USA) of 0.45 µm pore size and then incubated at 370C for 48 hours on Chromocult TBX agar as growth medium (Appendix I). Dark blue to purple coloniess were then counted (APHA, 1998). The dark blue or purple colonies were streaked on MacConkey agar. The colonies which showed bright pink halo, bile precipitant around the colonies, and pink colony growth were considered E.coli.

Table 7: Tables of comparison: 10/05/2016 Result Analysis

Katwe spring water	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Apparent color	E.ColI (ml)
Test results (lab)	5.8	0.68	0.48	0.17	0.05	1.65	7	0.67
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	68.23%	0.02%	0.09%	0.17%	0.500%	16.50%	70%	0%

Borehole water katwe	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Apparent color	E.ColI (ml)
Test results (lab)	5.79	0.72	0.52	6.21	1.04	6.08	33.52	0
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	68.11%	0.03%	0.10%	6.21%	10.40%	60.80%	33.5%	0%

Table 8: Tables of comparison

Tap water kishenye	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Apparent color	E.ColI (ml)
Test results (lab)	5.60	0.36	0.25	0.12	0.56	0.4	0	0
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	65.88%	0.01%	0.05%	0.12%	5.60%	4.00%	0%	0%

Spring water katwe	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Apparent color	E.ColI (ml)
Test results (lab)	8.43	0.85	0.63	24.03	0.98	8.09	46.03	18
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	99.41%	0.03%	12.60%	24.03%	9.80%	80.90%	46.03%	0%

4.8 Charts of comparison: 10/05/2016 Result Analysis

Kisenye spring water:
The chart below shows the contamination levels in katwe spring water where the PH and apparent color, the apparent color take the high percentage which shows the water is not

in good condition to Drinking.

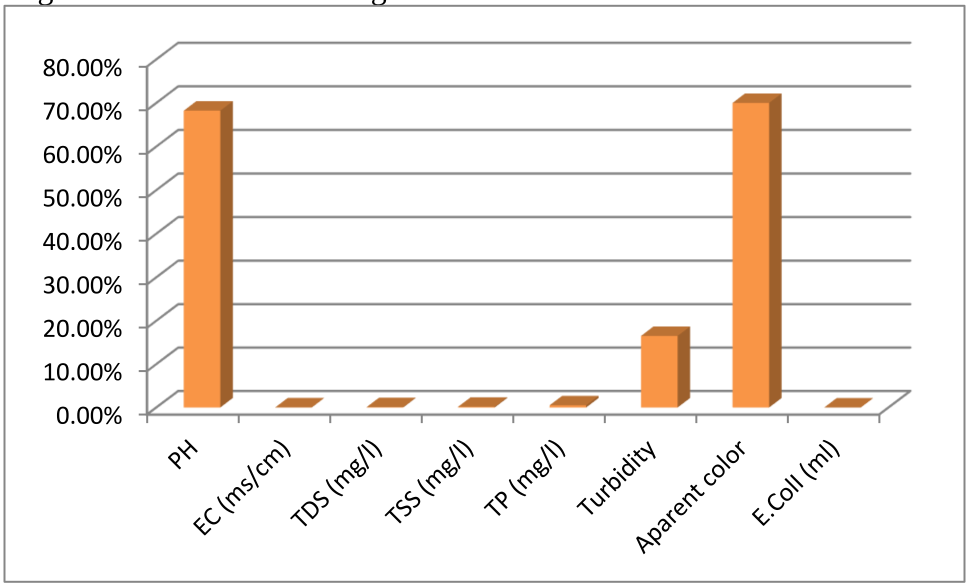

Figure 5: chart representative katwe spring water

Katwe borehole:

The chart below shows the analysis representative of borehole from katwe which shows the water has high capacity of PH that means the water is hard which is not good to drink for the purpose of health also Turbidity are the range of un acceptance because the value is too high to present from the recommendation of WHO and the apparent color is ok.

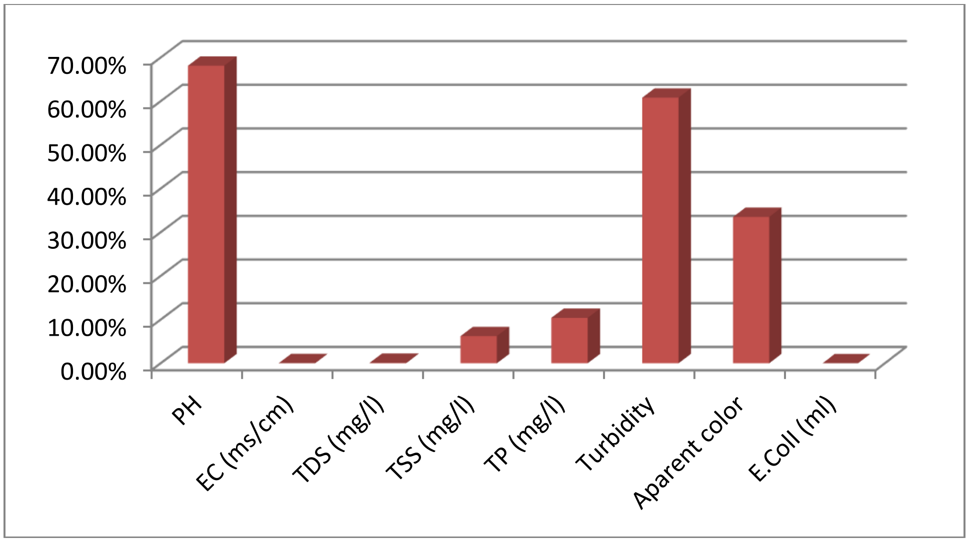

Figure 6: Chart representative Katwe borehole

Tap water kishenye:

The level of contamination of Tap water from kishenye is very low which the water is acceptable for the drinking and other domestic use as if we look at the Turbidity and total phosprone they are all in well percentage.

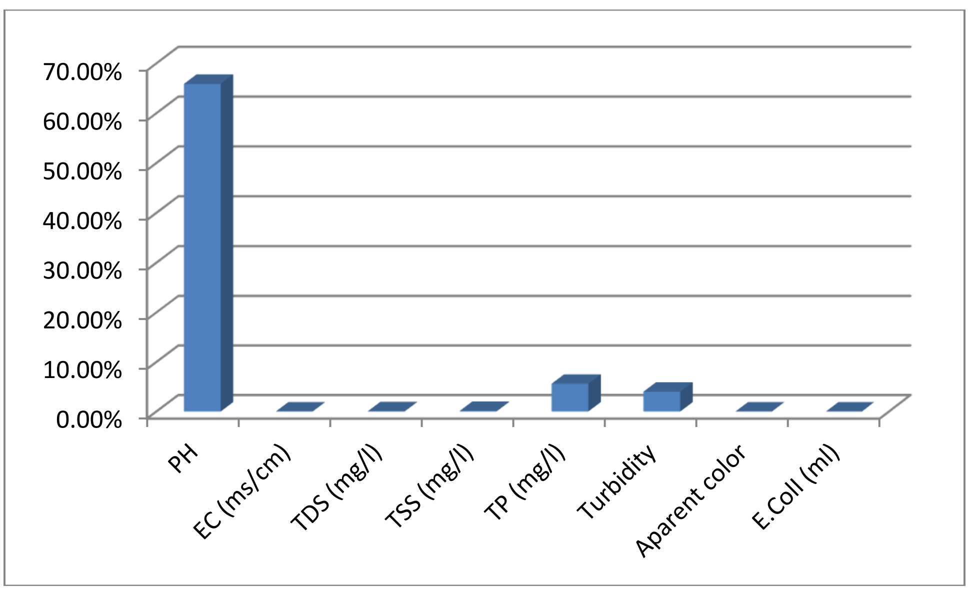

Figure 7: Chart representative Kisenyi tap water

Spring water katwe:

This result shows the percentage of ph, TDS, TSS,TP, Turbidity and Apparent color which the ph take the high percentage followed by Turbidity which shows the spring are at risk and this occur due to nearer to the pit latrine which the soil consume the liquid particle from the human west, it make the spring to get the high level of contamination and source of contamination come due to unprotected spring site the Area has a lots of garbage.

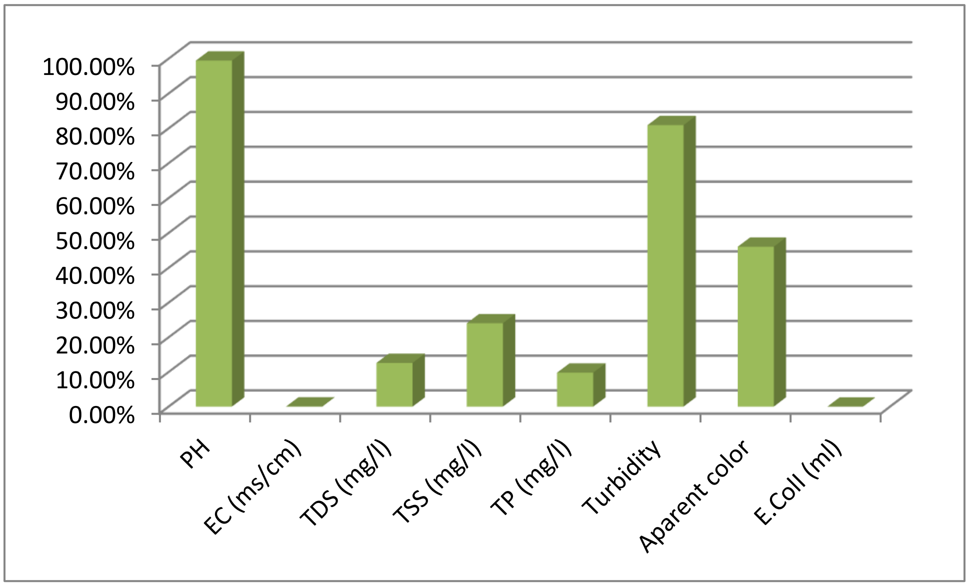

Figure 8: Chart representative kisenyi spring water

10/05/2016 Result Analysis combine results

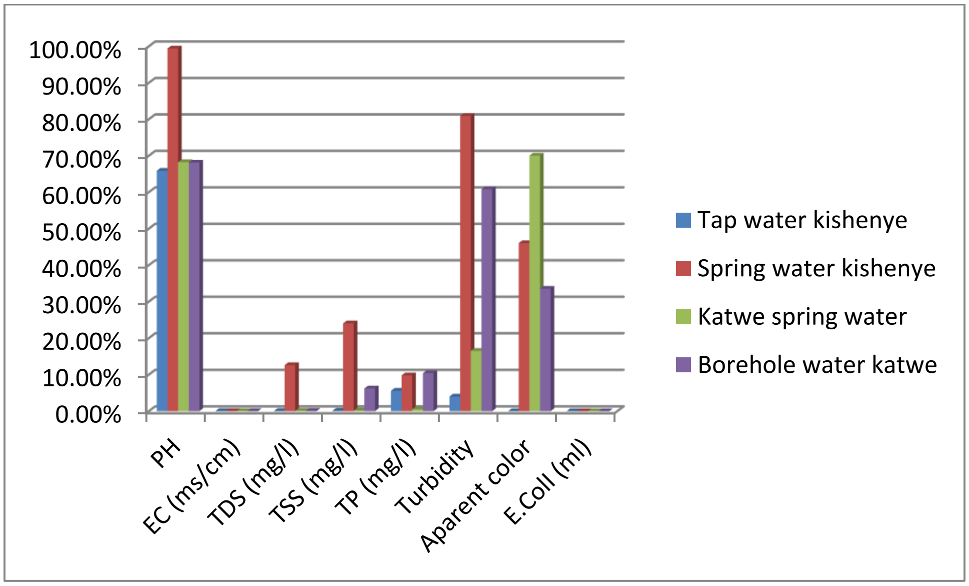

Figure 9: Dry season

Table 6: Tables of comparison 10/05/2016 Analysis

Tap water kishenye	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Aparent color	E.Coli (ml)
Test results (lab)	5.37	0.62	0.31	0	0.03	0	3	0
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	63.17%	0.02%	0.06%	0%	0.300%	0%	30.00%	0%

Spring water katwe	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Aparent color	E.Coli (ml)
Test results (lab)	5.91	0.49	0.24	21.35	0.522	7.38	41.37	10
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	99.52%	0.01%	0.04%	21.35%	5.22%	73.80%	41.73%	0%

Table 7: Table of comparison 10/05/2016 Analysis

Spring water kisenye	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Aparent color	E.Coli (ml)
Test results (lab)	5.9	0.62	0.31	0	0.03	0	3	0
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	69.41%	0.02%	0.06%	0%	0.300%	0%	30%	0%

Borehole water katwe	PH	EC (ms/cm)	TDS (mg/l)	TSS (mg/l)	TP (mg/l)	Turbidity	Aparent color	E.Coli (ml)
Test results (lab)	5.64	0.68	0.34	5.32	0.5	5.462	30.82	0
UNBS maximum standard	8.5	2500	500	100	10	10	10	0
Percentage variation	66.35%	0.02%	0.06%	5.32%	5.00%	54.62%	30.82%	0%

10/05/2016 chart Analysis

Tap water spring

Compared results of two different season of dry and rainy season the result shows the pH has change from 60% to 63% which shows the acidic of water. Therefore, water with a low pH could contain elevated levels of toxic metals, have associated aesthetic problems such as a characteristic “blue –green” staining of sink and drains. The result also shows the change of color this was happen due particle which dron in to pipe during rainy season

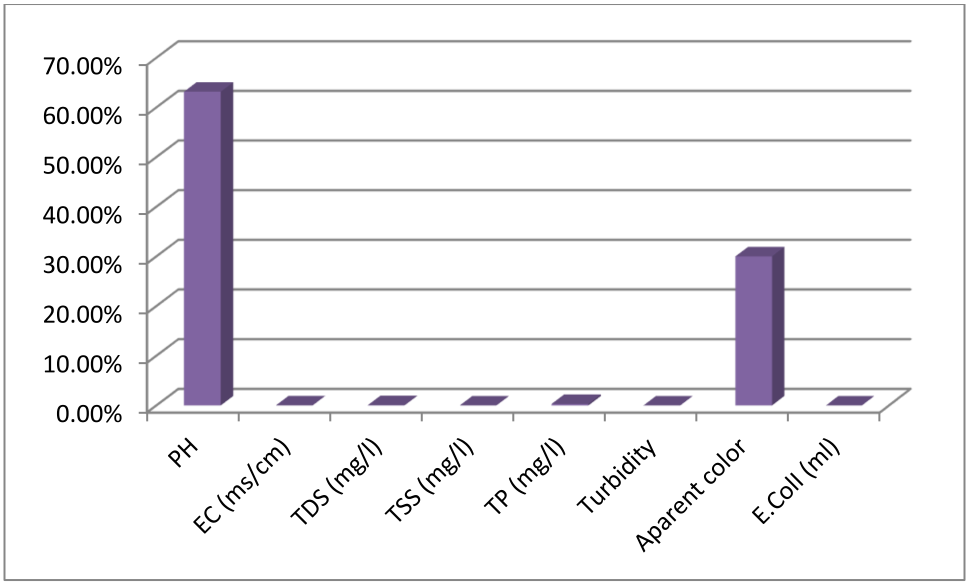

Figure 10: Tap water spring

Spring water katwe:

The spring water in katwe are not safe at all if we look the level of Ph, Turbidity and Apparent color 96%of ph and 71% of Turbidity shows the high contamination in the source but the E.coli are in the acceptable range also total phosphorone is also accepted if we consider the two results we find out the high risk of water in that spring.

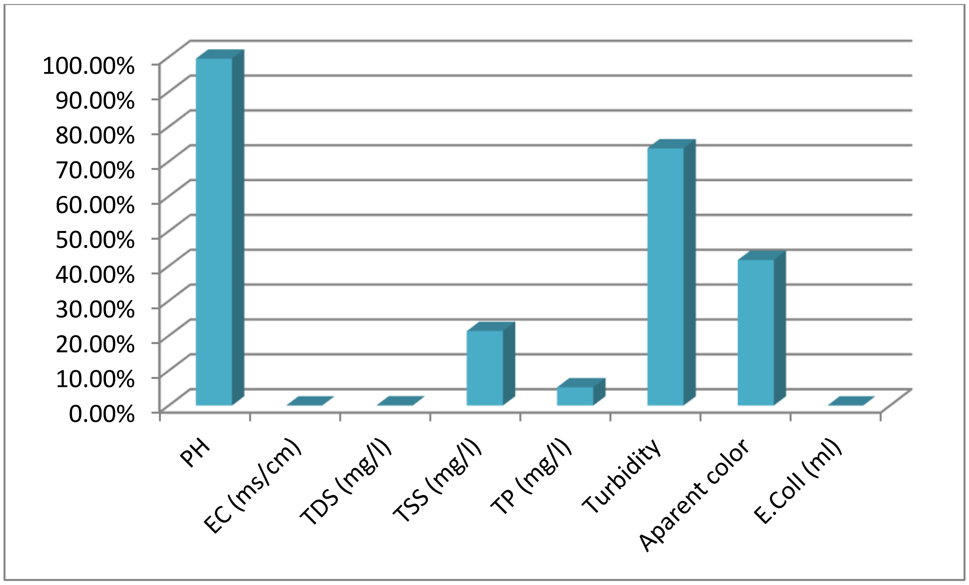

Figure 11: Spring water katwe:

Kisenye spring water:

The chart below shows the contamination levels in katwe spring water where the PH and apparent color, the apparent color take the high percentage which shows the water is not in good condition to Drinking as the same results to Feb.

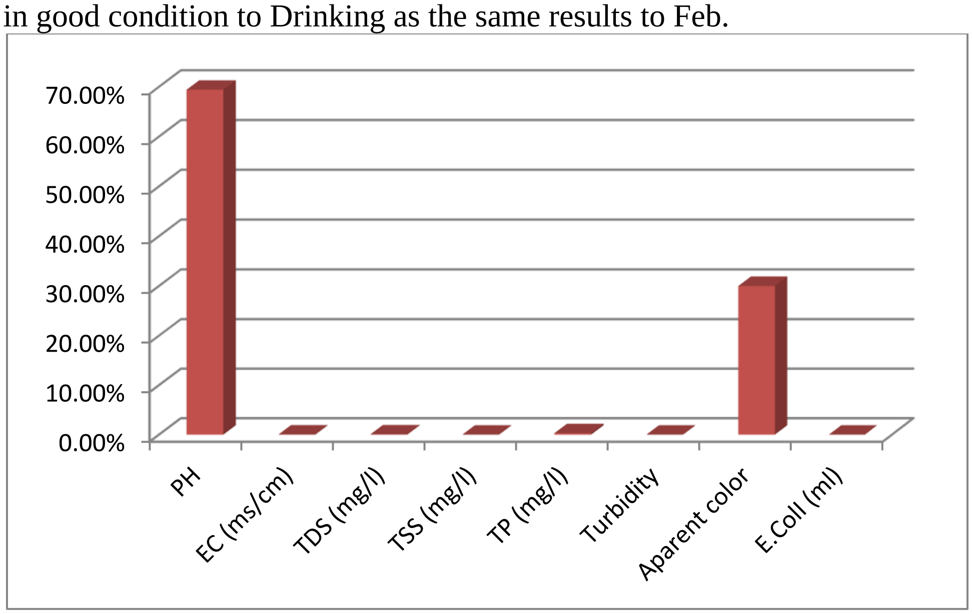

Figure 12: Kisenye spring water

Borehole water katwe

The chart below shows the analysis representative of borehole from katwe which shows the water has high capacity of PH that means the water is hard which is not good to drink for the purpose of health also Turbidity are the range of un acceptance because the value is too high to present from the recommendation of WHO and the apparent color is ok, but compare to the result of Feb, the percentage of turbidity and apparent color change due to weather change.

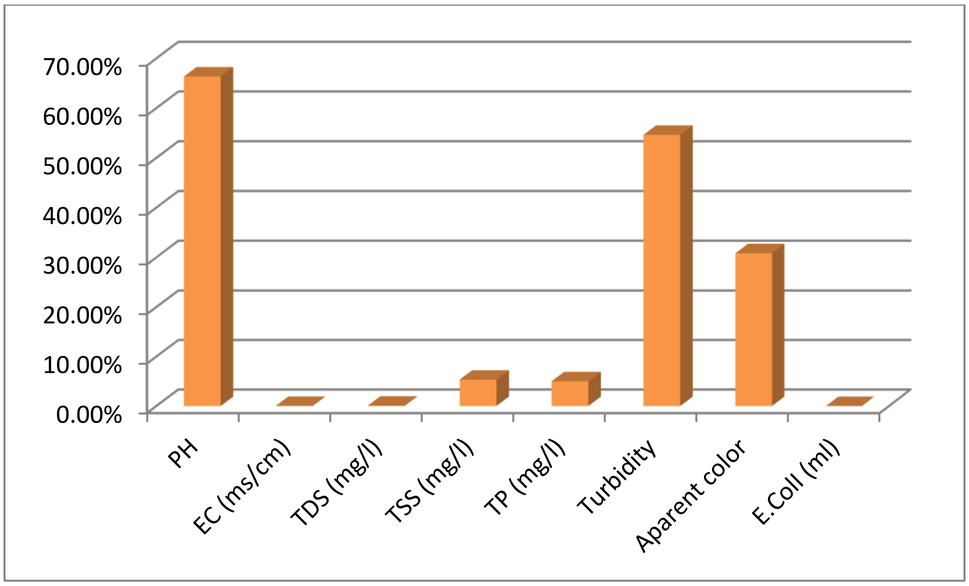

Figure 13: Borehole water katwe

10/05/2016 Analysis combine results

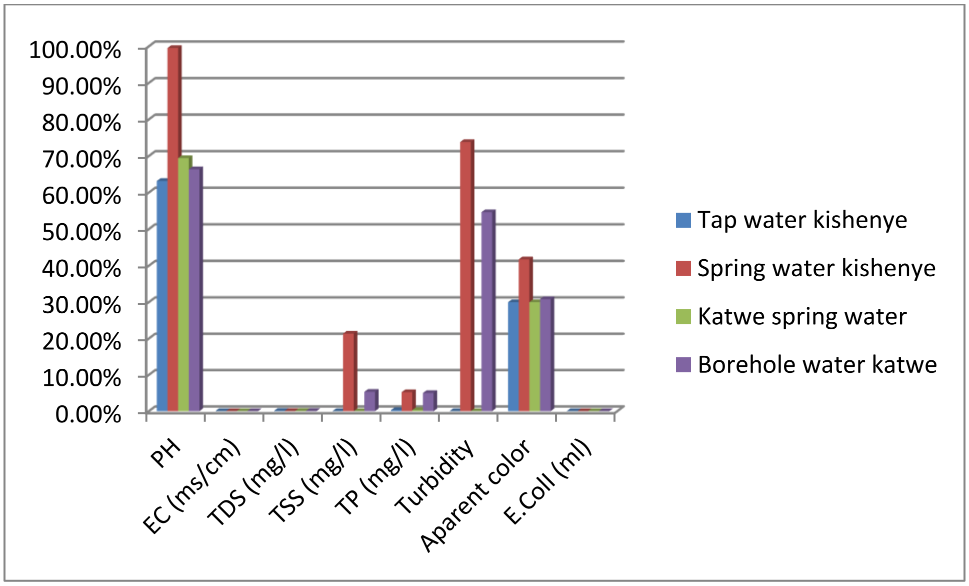

Figure 14: Raining season

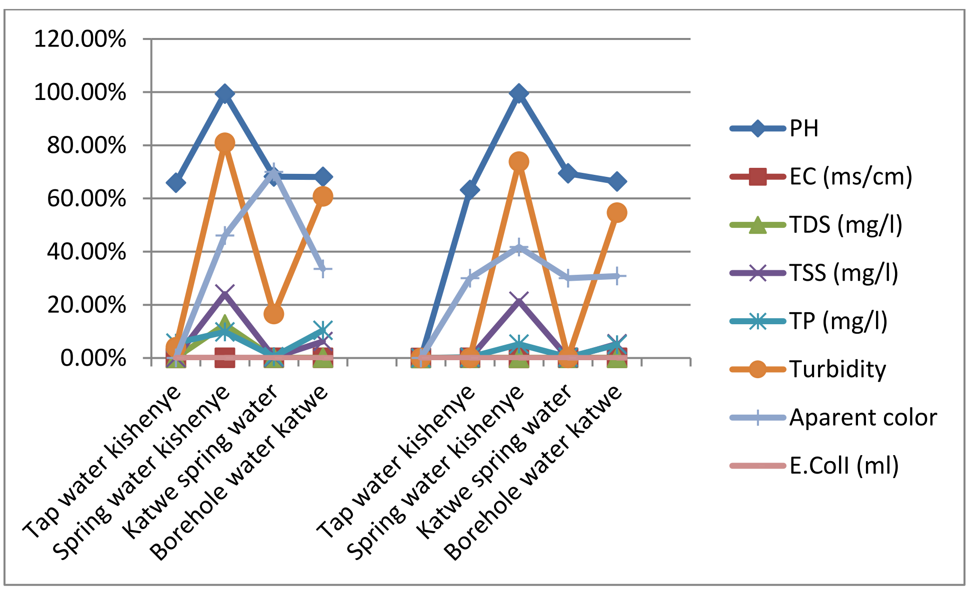

Figure 15: Comparison results of dry and rainy season

CHAPTER FIVE

CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

5.0 Introduction

This chapter present discussion and the summary of the findings as present in chapter four, conclusions and recommendation plus areas for further research

5.1 Conclusion

5.1.1 Lab measurements (pH, EC and Temperature)

As observed from tables 5 and 6, the pH of the water is generally unacceptable when compared with the recommended standards except for the Kisenyi spring in January. All the values are below the minimum acceptable 6.5.The temperature results were with acceptable range for all water points for both sampling times.

5.1.2 State of the Drinking water sources

From the results of the risk assessment method carried out, katwe (kiganda) spring water are not safe from on-site contamination by having a lots of gabages around the spring. The level of contamination is always high during the rainy seasons because of the increased amount of storm water which washes many organic matter sites with a high number of feascal organisms.

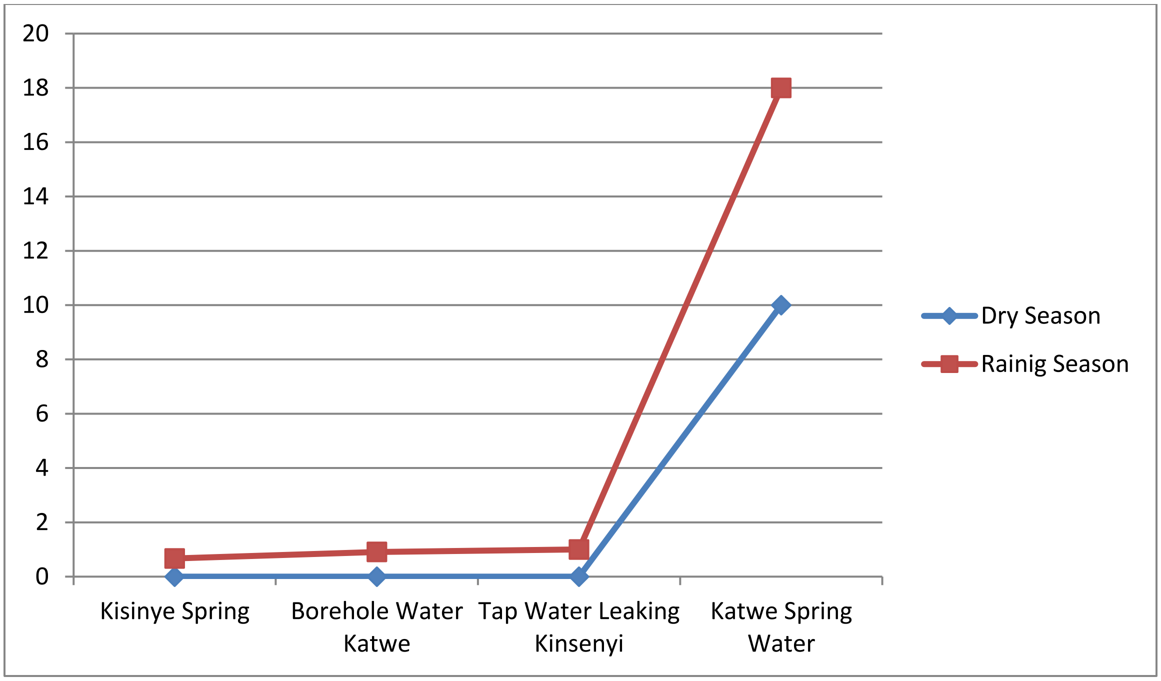

Figure 20: Comparison results of dry season and raining season of E.coli

The state of surrounding of the borehole was fair except a few place where poor drainage is, pit latrine are about 10m close to the bore holes with a depth of about 50 feet rending the aquifer from the water is obtained susceptible to contamination.

5.2 Recommendation of findings

5.2.1 Protection of Springs

Springs are susceptible to contamination by surface water, especially during rainstorms. Contamination sources include livestock, wildlife, crop fields, forestry activities, septic systems, and fuel tanks located upslope from the spring outlet. Changes in color, taste, odor, or flow rate indicate possible contamination by surface water. To protect springs the following measures can be taken.

1. Diverting all surface water away from the spring as far as possible. Do not allow flooding near the spring.
2. Constructing a U-shaped surface drainage diversion ditch or an earth berm at least 50 feet uphill from the spring to divert any surface runoff away from the spring. Be careful

not to dig deep enough to uncover flowing groundwater. Prevent pounding in the diversion ditch.

3. Constructing an earth beam adjacent to the spring or a second U-shaped diversion ditch lined with concrete tile for added protection.
4. Fencing an area at least 100 feet in all directions around the spring box to prevent contamination by animals and people who are unaware of the spring's location.

5.2.3 Spring Disinfection

1. It will help in improving the health statues of the residence of this community because it will control water borne diseases.
2. It will save lives of the residence of Katwe and Kisenyi.
3. Regular cleaning products do a good job of removing soil, but only disinfectants or disinfectant cleaners (also known as antibacterial cleaners) kill the germs that can cause many illnesses.
4. It will reduce the occurrence and prevent outbreak of water born diseases within the community.

At the end we recommend chlorination because Chlorine disinfectants can reduce the level of many disease-causing microorganisms in drinking water to almost immeasurable levels.

5.2.4 Provision of Improved Sewage Disposal System

We include the location of toilets at appropriate distance away from spring sources to prevent contamination of the springs, 30-50m away, depth 3m (WHO, 2015).

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(Source: www.infoplease.com/atlas/country/Uganda/html

APPENDICES

APPENDIX 1: PROPOSED PROJECT WORKPLAN

Project scheduling (2015/2016)

Month Year	**Sept 2015**	**Oct 2015**	**Nov 2015**	**Dec 2015**	**Jan 206**	**Feb 2016**	**March 2016**	**April 2016**	**May 2016**	**June 2016**	**July 2016**	**Aug 2016**	**Sept 2016**
Activities													
Conception													
Identify Problems													
Reviewing Literature													
Writing of Proposal													
Supervisor's Corrections													
Presenting Proposal													
Collection of raw data													
Analyzing of data finally													
Presenting final project													
Submitting final report													

ANNEX 2: ESTIMATED PROJECT BUDGET

	ITEM	UNIT	QUANTITY	RATE(UGX)	AMOUNT(UGX)
1.	Stationery	lump sum		100,000	100,000
2.	Transport to site	Trips	25	9,500	237,500
3.	Internet access	Hour	20	1,000	20,000
4.	Data collection and expenses	Day	25	15,000	375,000
5.	Printing and binding	lump sum		180,000	180,000
6.	Water testing	-	-	600,000	1,500,000
7.	Miscellaneous	lump sum			250,000
	Grand Total				**2,662,500**

APPENDIX 2: LABORATORY WATER TESTS RESULTS

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COLLEGE OF NATURAL SCIENCES

DEPARTMENT OF BIOCHEMISTRY AND SPORTS SCIENCE

DEPARTMENT OF BIOCHEMISTRY AND SPORT SCIENCE

10/05/2015

Client: Sambo Muhammad &Abdulkadir Abdullahi
Sample Matrix: Water
Number of Samples: 4

Table of Analysis Results

Sample	pH	EC (mS/cm)	TDS (mg/L)	TSS (mg/L)	TP (mg/L)	Turbidity (NTU)	Aparentcolour (PtCo)	E.coli (CFU/100mL)
Katwe Spring water	5.8	0.68	0.48	0.17	0.36	1.65	6	0.67
Borehole water Katwe	5.79	0.72	0.52	6.21	1.04	7.08	38.82	0.91
Tap water leaking Kishenyi	5.60	0.36	0.25	0.12	0.56	0.56	2.4	1
Spring water Kisenyi	8.43	0.85	0.63	28.03	0.98	8.09	52.03	18

Analysis By

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COLLEGE OF NATURAL SCIENCES
DEPARTMENT OF BIOCHEMISTRY AND SPORTS SCIENCE

10/05/2016

Client: Sambo Muhammad &Abdulkadir Abdullahi
Sample Matrix: Water
Number of Samples: 4

Table of Analysis Results

Sample	pH	EC (mS/cm)	TDS (mg/L)	TSS (mg/L)	TP (mg/L)	Turbidity (NTU)	Apparent color (PtCo)	E.coli (CFU/100 mL)
Katwe Spring water	5.9	0.62	0.31	0	0.03	0	3	0
Borehole water Katwe	5.64	0.68	0.34	5.32	0.5	5.462	30.82	0
Tap water leaking Kishenyi	5.37	0.18	0.09	0	0.04	0	0	0
Spring water Kisenyi	5.91	0.49	0.24	21.35	0.522	7.38	41.37	10

Analysis By

John Omara