RISK OF BACTERIAL CONTAMINATION OF IMPROVED POINT WATER SOURCES IN LIRA DISTRICT

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DECLARATION

I hereby declare that this research report apart from the literature quoted is my original work and has never been presented before for any award in any institution of learning. Where earlier work of others was cited, acknowledgement has been made.

Signature……

OKABO EDWIN

(CANDIDATE)

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I would like to acknowledge the District Water Officer Lira, the staff of Ministry of Water and Environment upper Nile water Management Zone and water quality department based in Lira, whom through their support I was able to conduct this research and my supervisor Dr.Robinson Isaac Ogwang for his guidance.

APPROVAL

I certify that this research report which has been under my supervision is submitted for examination under my approval.

Signature…………

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Operational Definition

Improved Point Water Sources: For the purpose of this study, improved point water sources refer to water sources that have been protected from contamination and it is accessible from the specific point of production. These includes boreholes, protected springs, and Rainwater harvesting tanks.

Bacterial Contamination: Bacterial contamination refers to the presence of harmful bacteria, such as Escherichia coli (E. coli), fecal coliforms, and other pathogenic microorganisms, in water samples collected from improved point water sources. The presence of these bacteria indicates potential fecal contamination and poses a risk to public health.

Risk Assessment: Risk assessment involves the systematic evaluation of potential hazards and the likelihood of adverse effects associated with bacterial contamination of improved point water sources. It includes the identification of factors contributing to contamination, such as inadequate sanitation practices, proximity to sources of pollution, and environmental conditions.

Water Quality Parameters: Water quality parameters encompass physical, chemical, and microbiological characteristics used to assess the suitability of water for drinking purposes. Key parameters include turbidity, temperature, total coliforms, and E. coli levels.

ACRONYMS

CFU	:	Colony forming unit
DHIMS	:	District Health Information Management System
DWO	**:**	District Water Officer
E-coli	:	Escherichia Coli
FDEAS	:	Final Draft East Africa Standard
MWE	:	Ministry of water and environment
UNICEF	:	United Nation Children Funds
WASH	:	Water Sanitation and Hygiene
WHO	:	World Health Organization.
DW	:	Deep Well
SW	:	Shallow Well
PS	:	Protected Spring
RWHT	:	Rainwater Harvesting Tank

ABSTRACT.

Introduction: Risk of Bacterial contamination of improved point water sources is major health risk in Lira District accounting for 60% of diarrheal diseases. In human being, diarrhea has been known to be caused by drinking of contaminated water. Lira District is reported at 95% safe water coverage while diarrheal diseases have remained high at 60%.

Methods: This was a cross sectional study conducted utilizing quantitative method of data collection from total coliforms water quality test results of water samples collected in Lira District. The data was analyzed using STATA version 15. The data was analyzed using logistic regression to obtain the odd ratio.

Results: The study indicated that 67% of the water sources tested were contaminated with Total coliforms. Deep Wells registered less contaminated water sources at 44%, while protected spring was highly contaminated at 89% followed by Shallow Wells at 72% and Rainwater harvesting tanks at 61%.

Discussion: The results indicated few deep Wells and Rainwater Harvesting Tank was contaminated. The majority of the sampled Shallow Well and protected springs water sources were contaminated. Statistical Analysis showed that the safety of improved point water sources depended on the Water source type or technology, its operation and maintenance and its location in terms of proximity to the contamination source.

The study concluded that the total coliforms count in water samples from different sources were associated with water source protection status and sanitation and hygiene practices. It therefore recommends for improved water source protection, and promotion of good sanitation, and hygiene practices.

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Background of the study.

According to Haas et al., (2020) bacterial contamination in drinking water significantly contributes to waterborne illnesses, particularly in regions where various water sourcing technologies are being advocated. This poses a significant public health concern as such contamination leads to severe illnesses like diarrhea and intestinal worms. Globally, approximately 1.6 million people die each year from diarrheal diseases due to the lack of access to safe drinking water, with 90% of these deaths occurring among children under 5 years old, predominantly in developing countries (Kelly et al., 2021a) .The United Nations Sustainable Development Goals, specifically Goal 6, aims to achieve universal access to safe drinking water by 2030. To realize this goal, it's imperative that all water sources provided are free from any form of contamination (Ssemugabo et al., 2019a).

With the urgent call for universal and equitable access to safe and affordable drinking water by 2030, it's crucial to confront the persistent challenges presented by bacterial contamination of improved point water sources(Kebede & Gobena, 2004).Indicators for achieving universal and equitable access to safe and affordable drinking water involve several key aspects. These include consistent availability of drinking water from an improved water source, which must be free from fecal, microbial, and chemical contamination. Moreover, the water should adhere to the chemical and physical standards specified in the guidelines provided by the World Health Organization or national authorities for ensuring potable water quality.(Njuguna et al., 2016a).

Ensuring the safety of drinking water supplies depends on a combination of strategies, including catchment protection and prevention of contamination by consumers. Factors influencing the safety of water sources include their protection, site location, and the efficiency of operation and maintenance practices. Many of these factors are within the control of both users and those responsible for implementing safe water projects. (Shaheed et al., 2014)

The Ministry of Water and Environment of Uganda aims to provide safe drinking water to all communities through various means such as piped water systems, deep wells, shallow wells, protected springs, and rainwater harvesting tanks(MWE, MWE Report, 2020). As per the directives from the water quality department of the Ministry, it is mandatory for all established water sources to adhere to the prescribed standards of potable water quality before they are made available to users. Nonetheless, there is presently no defined framework in place for the systematic monitoring of these water quality standards prior to their handover to users.(Larson et al., 2023a)17% of improved point water sources were abandoned in Lira District by communities due to quality issue (Okot-Okumu & Otim, 2015a)this signified water quality problem with the existing improved point water sources considered to be safe for drinking leading to a study on the quality of existing improved point water sources in Lira.

As of June 2020, the national safe water coverage in rural areas of Uganda was recorded at 68%. The primary technological options for water supply in these areas were categorized as follows: Deep Wells at 47%, Shallow Wells at 23.1%, Protected Springs at 20.8%, and rainwater harvesting tanks at 11.3%. Concerning water safety across different technology types, the compliance rates for bacteriological safety were reported as follows: Deep Wells at 81%, Shallow Wells at 55%, and Protected Springs at 37%. These figures represent the proportion of improved point water sources that met the standards for providing safe drinking water based on compliance with bacteriological safety standards (Adomi Mbina et al., 2020).

Improved point water sources in Lira District have been reported at 1,697. These sources are considered to be safe for drinking. The water sources types are Deep Wells, Shallow Wells, Protected Spring and Rainwater Harvesting Tank(MWE, MWE Report, 2020). According to Ministry of Water and Environment sector performance report, 2020, 507,600 people in Lira District have access to safe water. The number of safe water sources is high in Lira District however cases of diarrheal diseases registered within communities still remained high at 60% according to Lira District Health Management Information system, 2020.(Kostyla,2015)

This study has helped in determination of the safety of improved point water sources from bacterial contamination in Lira District. According to national and international water quality standard guidelines for bacterial contamination, total coliforms and Escherichia Coli must not be detected in 100 milliliters of water tested in order for a water source to be considered safe from bacterial contamination (colony forming units per 100ml (CFU/100ml) must be zero)WHO. (2019). The analysis of bacterial water quality was based on analysis of fecal indicators with key organism being total coliforms. Coliforms provide evidence of contamination of water sources.

1.2 Problem Statement

In Lira District, where the government, development partners, and NGOs have collectively constructed 1,697 safe water sources since 2015, the reported 95% safe water coverage has not translated into a significant reduction in diarrheal diseases(Opio, 2020). Despite the Ministry of Water and Environment reporting high safe water coverage in 2020, diarrheal illnesses continue to account for 60% of reported cases in the district. Notably, this discrepancy raises concerns about the actual safety of the improved point water sources and their effectiveness in preventing water-related diseases.

The persistence of diarrheal diseases, especially among children under five, is a critical public health issue(Ongom, 2017). Even with Uganda reporting that 7.9% of illnesses in children under 5 years were attributed to diarrhea in 2020, and acute diarrhea cases in individuals above five years ranked as the fourth leading cause at 3.2%, the problem persists (Khattak et al., 2020). The study investigated the safety of improved point water sources in Lira District, exploring factors contributing to contamination. Understanding these factors is crucial for identifying interventions to mitigate the high prevalence of diarrheal diseases and associated mortality.

Globally, diarrhea remains a significant threat to child health, causing 525,000 deaths annually in children under five (WHO 2016). In Uganda, diarrheal diseases accounted for 12,103 deaths in 2020, making up 5.3% of the total mortality rate (Omara, 2020). Despite the emphasis on safe water sources, the study recognizes the need to search the causes of the bacterial contamination of these improved point water sources in Lira District, providing insights and recommendations to address the persistent health challenges and contribute to achieving the broader goal of universal and equitable access to safe drinking water by 2030(UNICEF, 2015).

1.3 Goal and Objectives

1.3.1 Overall goal

To determine whether the existing improved point water sources considered to be safe for drinking are free from bacterial contamination.

1.3.2 Specific Objectives

1- To establish the level of safety of different types of improved point water sources being used in Lira District.

2-To determine the risk factors associated with bacterial contamination of improved point water sources being used in Lira District.

1.4 Research Questions

What is the level of contamination of different types of improved point water sources being used in Lira District?

What are the risk factors attributed to the contamination of point water sources in Lira District?

1.5 The justification of the study

Almost all communities in Lira District are accessing a safe water source reported at 95% however, the unsafe water related diseases of diarrhea is at 60% according to Lira District Health Management Information systems data, 2020. This indicated unsafe water related diseases burden in the community in terms of lives lost, cost of treatment, loss of productive days is still high in Lira District.

The study was conducted to determine the safety of improved point water sources being used and identified the factors which are causing the contamination of the point water sources being provided to the communities resulting into high morbidity and mortality from diarrheal diseases. According to World Health Organization report, 2020, 829,000 people die each year from diarrhea as a result of unsafe drinking water.

The justification for this study lies on the reported high safe water coverage in Lira District and the persistent prevalence of diarrheal diseases, particularly among vulnerable populations such as children under five. Despite significant investments in improving water infrastructure, the high burden of diarrheal illnesses suggests that there may be underlying factors contributing to water contamination. Understanding the safety of improved point water sources and identifying contamination factors is crucial for informing targeted interventions aimed at reducing the incidence of waterborne diseases and improving public health outcomes in the community.

1.6 The significance of the Study

The study ought to contribute to the reduction of diarrheal morbidity and mortality by ensuring that water sources provided to the communities by government of Uganda and their partners are free from contamination.

It will also save the resources being deployed within the communities in areas of clean, safe water in the name of eradicating unsafe water related diseases within communities while some of the point water sources are turning to be unsafe for consumption. These point water sources cost between Uganda shillings 10,000,000 to 24,000,000 depending on the types, however this resource being deployed have not cut down the diarrheal diseases within communities in Lira District.

1.7 Contributions

Policy

This study contributes to policy decisions making regarding water sources infrastructure design, management and public health interventions in Lira District, by identifying factors contributing to improved water source contamination and the persistence of diarrheal diseases despite reported various safe water sources interventions, policymakers can refine existing point water source construction design and location policies guidelines and allocate resources more effectively to address the root causes of waterborne illnesses.

Practice

The findings of this study offer practical insights for improving water quality management practices in Lira District and beyond, by understanding the specific factors contributing to bacterial contamination of improved point water sources, practitioners can incorporate interventions such as water treatment, good sanitation practices, alongside provision of point water sources and community education programs to mitigate the risk of waterborne diseases and promote public health.

Literature

This study adds to the existing body of literature on water quality and public health by providing empirical evidence from a specific context, Lira District. By documenting the challenges and successes in ensuring safe water access and addressing waterborne diseases, the study enriches the literature on the effectiveness of water infrastructure investments.

Methodology

The methodology employed in this study, including water sampling techniques, bacterial analysis methods, and data analysis approaches, contributes to the methodological toolkit for assessing water quality and its impact on public health outcomes. By documenting the process of assessing water safety and identifying contamination factors, this study provides a framework for future research in similar settings.

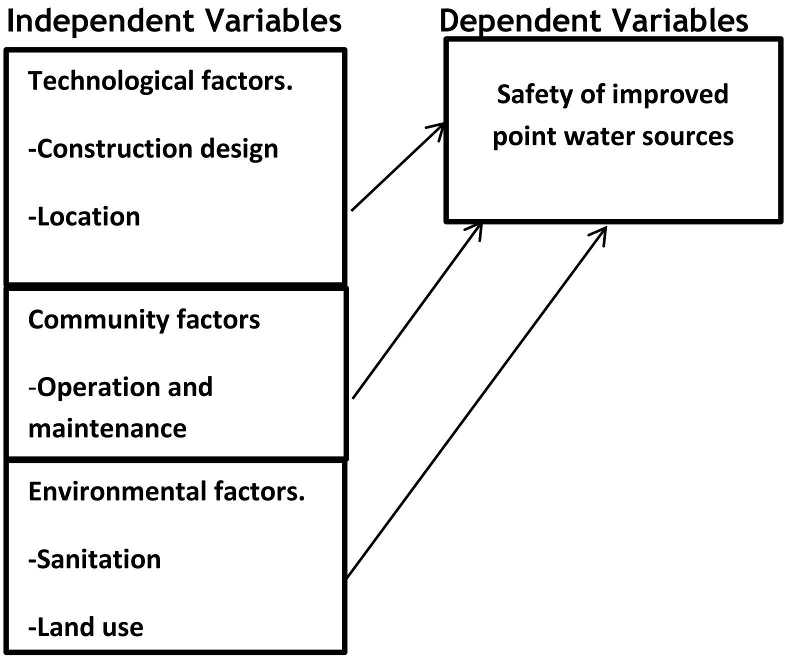
Knowledge

This study advances the understanding of the complex interactions between water quality, public health, and socioeconomic factors in Lira District. By generating new knowledge about the prevalence of diarrheal diseases, the safety of improved point water sources, and the factors contributing to water contamination, the study contributes to building a more comprehensive understanding of the challenges and opportunities in ensuring universal and equitable access to safe drinking water.

1.8 Conceptual framework

The high percentage of safe water coverage in Lira District has not impacted on the prevalence of poor water related infections like diarrhea in Lira District an indication that some of these safe water sources actually are not safe for drinking, several risk factors have been identified to be associated with the contamination of these point water sources.

The conceptual framework for this study is built on information obtained from existing literature, aiming to explain the relationship between safe water coverage, water contamination, and the prevalence of waterborne infections, such as diarrhea, within Lira District. According to (Okurut, 2018)Highlighted is the divergence between reported safe water coverage and the persistent occurrence of water-related diseases, indicating that not all purportedly "safe" water sources adhere to required drinking water quality standards. This incompatibility stresses the significance of investigating the multitude of risk factors associated with water contamination, as identified in existing literature. Technological factors, encompassing the design and maintenance of water infrastructure, can significantly impact the susceptibility of water sources to contamination. Concurrently, community factors, such as hygiene practices and waste disposal methods, exert a significant influence on the microbiological quality of water sources. Additionally, land use practices, including agricultural activities and urban development, have the potential to introduce pollutants into water sources, further jeopardizing their safety. By integrating these insights into a conceptual framework, this study endeavors to search into the nature of water contamination in Lira District and to propose targeted interventions aimed at enhancing water quality and improving public health outcomes.



1.8.1 Technological factors.

Construction design.

The deep and shallow Wells were found with cracked and worn-out apron which can provide access of contaminated surface water to the underground water. Some of them had contaminated water logged on the apron which is a risk to the underground water.

Some rain water harvesting tank was receiving water from rusted iron roof and none of them had filter clothes on the inlet.

All the protected spring were without fence in the water storage area providing access for the animals to create holes on the water storage area, and the diversion channels were found to be non-functional allowing surface run off water to access protected water storage.

1.8.1.2 Location

All the shallow Wells and Protected spring were found to be located near swamps or streams which are contaminable by the surface run off water during rainy season. While some of them were located within the buffer zone of the stream.

1.8.2. Community factors.

Operation and maintenance

Most of the Water sources were not fenced which allow access by the contaminant like animals with the surrounding not kept clean promoting contamination of underground water from surface run off. Some of the spout was seen clogged with sediments and dirt's. And community was not taking action to protect the water sources. Some of the drainage of protected spring was blocked causing water logging at the access point of the protected spring and a reverse flow of contaminated water, community were not cleaning the spout of these water sources providing a breeding place for the bacteria.

1.8.3 Environmental factors.

Sanitation

The surrounding of these hand pump water sources was untidy and wet which were a breeding ground for the bacteria and some sources were located less than 30 meters from the pit latrine. This can be the source of contamination for the improved point water sources especially deep and shallow Wells.

Land use.

Most of the protected spring and shallow Wells were located in the farm land which can easily be contaminated by the pesticides.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter contains existing literature on safe water, water quality and contamination put forward by different researchers. Several scholars, researchers, and organizations have made tremendous contributions through studies and information sharing in these areas of safe drinking water and water quality; some are cited and referred below.

2.1 Water Quality

Water quality is a concern worldwide, as access to clean and safe water is important for human health and overall well-being. International efforts like the United Nations' Sustainable Development Goal 6 (SDG 6) are committed to achieving universal access to safe water and sanitation by the year 2030 (Ssemugabo et al., 2019b). Nevertheless, persistent challenges remain, particularly concerning contamination from pollutants like pathogens, chemicals, and heavy metals. International research emphasizes the significance of monitoring various water quality parameters such as turbidity, pH, dissolved oxygen, and microbial contamination. These assessments are crucial for determining the suitability of water for different purposes and for mitigating the health risks associated with inadequate water quality (Robinah Nantege, D. K. 2022)

In regions like Sub-Saharan Africa, where access to safe water is limited, maintaining water quality poses a significant challenge. Research conducted in the region underscores the influence of factors like insufficient sanitation infrastructure, industrial pollution, and agricultural runoff on water quality (Khan,2021). Moreover, alterations in precipitation patterns and temperatures due to climate change can also impact water availability and quality, further complicating existing challenges (Guillemin et al., 1991).Regional efforts concentrate on enhancing water quality through strategies like improved water treatment, pollution management, and community awareness campaigns promoting hygiene and sanitation practices (Nayebare,2022).

At the national level, countries such as Uganda have introduced policies and initiatives to tackle water quality issues. The implementation of national water quality monitoring systems by entities like the Ministry of Water and Environment is aimed at evaluating and regulating water quality across various water sources (Batura, 2022). Yet, obstacles like resource constraints, technical expertise shortages, and enforcement deficiencies impede the efficient monitoring and control of water quality (Chalchisa et al., 2018).

National regulations governing water resource management and pollution control play a crucial role in protecting water quality and ensuring safe water access for all.

In Lira District, ensuring water quality is essential for public health and sustainable development. Local studies have identified various factors affecting water quality, including contamination from agricultural runoff, inadequate sanitation practices. Additionally, socio-economic factors such as poverty and limited education contribute to poor water quality by affecting hygiene practices and water management behaviors (Walekhwa et al., 2022a)This study aimed to assess water quality in Lira District by examining key parameters such as microbial contamination, turbidity, and chemical pollutants. By identifying sources of contamination, the study sought to inform interventions to improve water quality and promote safe water access in the district.

2.2 Safe Water Access and Contamination

Globally, access to safe drinking water is a fundamental human right, yet millions worldwide lack this basic necessity(Sasakova, 2018). The World Health Organization (WHO) and UNICEF Joint Monitoring Programme report that around 2.2 billion people lack access to safely managed drinking water services. This issue is compounded by rapid urbanization, population expansion, and insufficient infrastructure in numerous low- and middle-income nations (Gizachew et al., 2020a).Waterborne diseases, including diarrhea, cholera, and typhoid fever, remain substantial health threats, especially in areas with limited access to safe water and sanitation facilities.

According to (Viban et al., 2021a) In Sub-Saharan Africa, ensuring access to safe water remains a pressing concern due to rapid population growth, insufficient infrastructure development, and inadequate sanitation practices. Regional initiatives, such as the African Water Facility and the African Minister's Council on Water, aim to address these challenges through capacity building, infrastructure development, and policy advocacy (Poulin, C. P. 2020) However, disparities in access persist, with rural and marginalized communities facing the greatest barriers to safe water access.

In countries like Uganda, efforts to improve safe water access have been prioritized by the government and various stakeholders (Ssemugabo et al., 2019b). The Uganda National Water Policy emphasizes the importance of sustainable water sources management, infrastructure development, and community participation in achieving universal access to safe water. Despite progress in expanding water infrastructure, challenges such as inadequate funding, limited technical capacity, and contamination of water sources persist (Gebrewahd et al., 2020a).

In Lira District, access to safe water is essential yet remains a significant challenge. Despite efforts to improve water infrastructure, including the construction of boreholes and piped water systems, the prevalence of waterborne diseases like diarrhea persists (Ssemugabo et al., 2019c). According to (Gwimbi et al., 2019) factors contributing to water contamination, such as inadequate sanitation practices, agricultural runoff. However, gaps in water quality monitoring and enforcement hinder efforts to ensure the safety of drinking water sources. This study aimed to address these gaps by investigating the safety of improved point water sources in Lira District and identifying strategies to mitigate waterborne disease transmission. By maximizing community engagement and employing effective water quality testing methods, the study sought to inform evidence-based interventions to improve safe water access and public health outcomes in Lira District.

2.3 Risk Factors Associated with Bacterial Contamination of Improved Point Water Sources

Globally, the risk of bacterial contamination in improved point water sources is a significant global concern, particularly in regions where access to safe water is limited (Larson et al., 2023). Studies from (Kanyerere et al., 2012) have identified various risk factors contributing to waterborne diseases associated with bacterial contamination. These factors include inadequate sanitation infrastructure, agricultural runoff, industrial pollution, and improper waste disposal practices. Additionally, climate change-induced extreme weather events, such as floods and droughts, can worsen contamination risks by affecting water quality.

In regions like Sub-Saharan Africa, where access to safe water remains a challenge, the risk of bacterial contamination in improved point water sources is particularly common(Walekhwa et al., 2022b). Regional studies have highlighted the role of factors such as unregulated land use practices, population density, and limited access to water treatment facilities in increasing contamination risks (Bain et al., 2014).Additionally, socio-economic factors, including poverty and inadequate hygiene practices, contribute to the persistence of waterborne diseases despite efforts to improve water infrastructure.

At the national level, Uganda have implemented various measures to address the risk of bacterial contamination in improved point water sources. National water quality monitoring programs, such as those conducted by the Ministry of Water and Environment, aim to assess and mitigate contamination risks (Agensi et al., 2019b). However, challenges such as inadequate funding, technical capacity, and enforcement mechanisms hinder effective monitoring and control of water quality. National policies and regulations governing water resource management play a crucial role in addressing contamination risks and promoting safe water access (Viban et al., 2021b)

In Lira District, the risk of bacterial contamination in improved point water sources is a pressing concern despite efforts to improve water infrastructure. Local studies have identified several risk factors contributing to contamination, including inadequate sanitation practices, agricultural runoff, and limited access to water treatment facilities (Gizachew et al., 2020b). Additionally, socio-economic factors such as poverty and limited education exacerbate contamination risks by affecting hygiene practices and water management behaviors (Amatobi & Agunwamba, 2022). This study aimed to assess and mitigate these contamination risks by investigating the safety of improved point water sources in Lira District and identifying strategies for improving water quality and public health outcomes. The study sought to identify interventions to reduce the risk of bacterial contamination and promote safe water access in Lira District.

CHAPTER THREE: METHODOLOGY

3.1 Research design

This was a cross-sectional quantitative study design used to pick water samples from different types of point water sources in the communities in Lira District and tested at the laboratory to determine their safety from bacterial contamination at that particular point of time.

3.2 Area of Study

The study, the risk of bacterial contamination of improved point water sources was conducted in Lira District. Lira District is located in Northern Uganda; the District has a population of 660,361 according to Uganda National Population and Housing Census, 2014 conducted by Uganda Bureau of Statistic with the main economic activities being petty trading and agriculture (UNBS, 2014). The rural communities in Lira District rely mainly on point water sources of Shallow, Deep Wells, Protected Spring and Rainwater Harvesting Tanks for their drinking water (MWE, MWE Report, 2020)

The people who live in Lira District rely on subsistence farming for their livelihood, most of the settlement is concentrated in a small area leaving other land for farming the land ownership is communal. The areas have water bodies ranging from swamp, wetlands and streams.

The main source of drinking water is protected spring, deep well, shallow well and few households and institutions like health centers and schools rely on rainwater harvesting tank. The most common latrine in this area is pit latrine which is not lined and they are buried immediately they a full then a new one is constructed, they are usually between 5 -15 meters deep.

Lira District has 479 deep Wells, 538 Shallow Wells, 605 Protected Springs 605 and 70 Rainwater harvesting tanks established within communities. Lira District has the safe water coverage of 95% according to Ministry of Water and Environment water atlas 2020; however, the suitability of this water source depends on biological, physio-chemical properties of the water. The district has eight sub-counties of Amach, Agali, Barr, Ogur, Agweng, Itek, wiodyek and Aromo, the point water sources are distributed within villages in these sub-counties.

3.3 Source of Information

The study collected the data from the primary source. The data was the test results of total coliforms from the water samples collected from different water sources and tested at the Ministry of Water and Environment regional laboratory located in Lira City. The laboratory issued a certificate of result for the water samples tested.

Observation was made and recorded at the water sources during water sample collection.

3.4 Study population and Sampling Technique.

The study population was the Deep Wells, Shallow Wells, protected springs and rainwater harvesting tanks located within the communities, where water samples were picked and tested for total coliforms. The sampled water sources were picked from the data base of Lira District Water Office shared with the researcher. Deep Wells, Shallow Wells, protected springs and Rainwater harvesting tank water sources were sampled from each of the eight sub-counties picking from different villages and parishes. The judgment sampling method was used to pick the sample water sources from each sub-county and a total of 72 improved point water sources were sampled. The use of judgment sampling to select sample water sources from different villages from each sub-county allows for targeted selection of water sources functioning and used by the community since the data base presented by Lira District water office did not provide functionality status and usability of these improved water sources.

3.4.1 Sample size

Given choice of the study population, including Deep Wells, Shallow Wells, Protected Springs, and Rainwater Harvesting Tanks, reflects the diversity of improved point water sources within the communities in Lira District. By sampling nine improved point water sources in different villages and parishes from each sub-county, the study ensures representation across the entire District, thereby enhancing the generalizability of the findings to the broader district population. With a total of 72 improved point water sources sampled, the study achieved a sufficient sample size to provide statistically meaningful insights into the prevalence of total coliforms and assess the overall water quality status in Lira District.

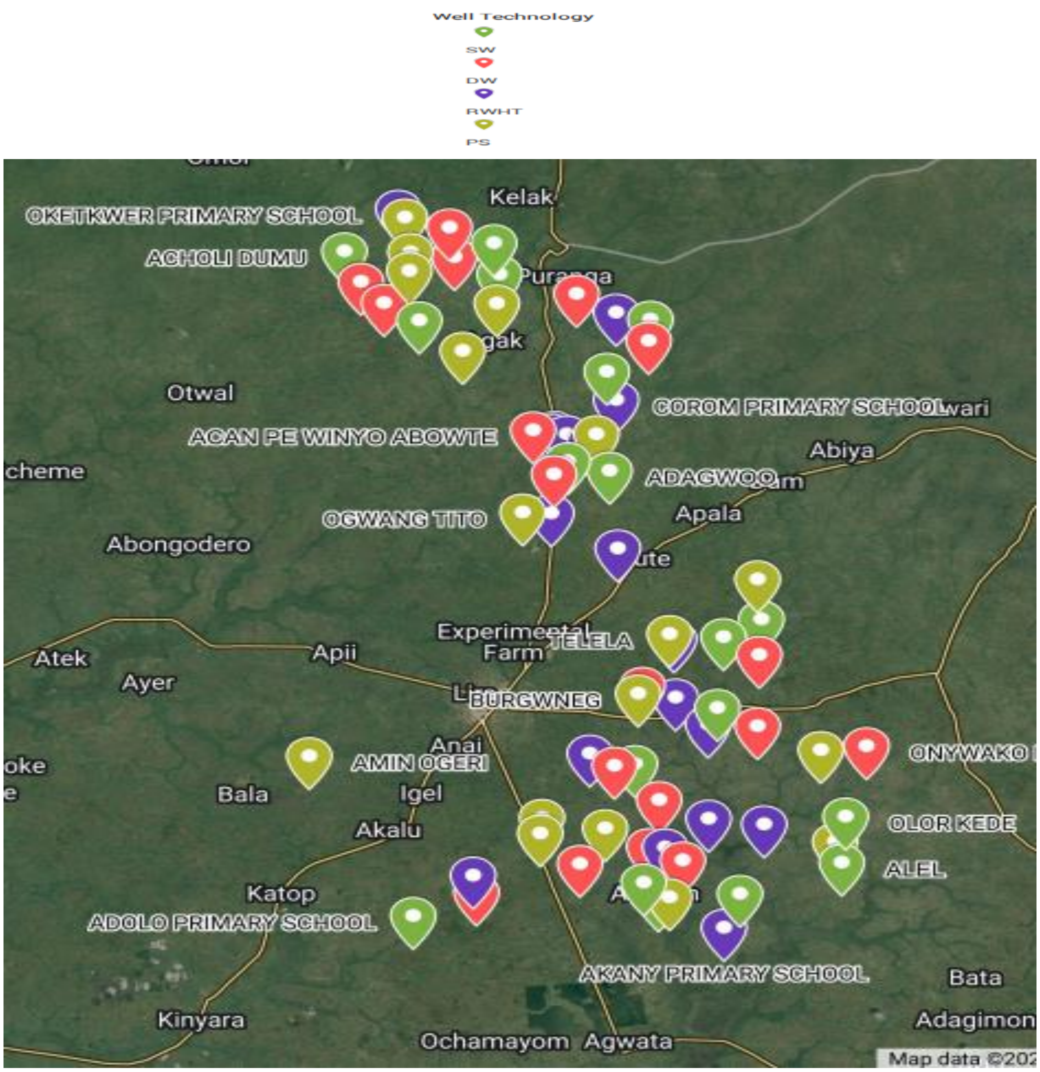
3.5 Study Variables and Indicators

The independent variable in the study is the technology of the Well, community and environmental factors, while dependent variable is the safety of the improved point water sources from bacteriological contamination. Where a water source is found to be bacterially contaminated it is assessed based on the water source technology of Deep Wells, Shallow Wells, Protected Spring, its location and environmental factors of sanitation, and Community factors of operation and maintenance.

3.6 Procedure of data collection

The list of improved point water sources in Lira District was obtained from the District Water Office, and then nine improved point water sources were selected from the eight sub-counties after confirmation that they were functional and in used by the communities, the assistant District Water Officer Lira took the sampling team to each water source identified. The staff of Ministry of Water and Environment water quality test laboratory, Lira was engaged in picking water samples from the 72 water sources identified and the quality test was conducted by MWE regional laboratory staff based in Lira, the result from the laboratory were compared with water source type, its operation and maintenance and its sanitation.

Location of water sources sampled in Lira District.



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3.7 Data Collection Instrument, equipment and Measurement

At each water source the spout of the water source was sterilized before picking the sample, the water sample was collected in a sterilize 100 milliliters transparent water polythene sheet then placed in a refrigerated water box and transported to the laboratory, picking the sample each day and transportation to the laboratory was done within six hours.

The water sample of 100ml from each water source was filtered through a sterilized membrane filter the filter was transferred to absorbent pad saturated with animal blood then incubated at 37°C for a period of 18 hours to allow bacterial colonies to developed on the surface of the filter and later the number of bacterial colony units counted using hand lens to show microbial growth which was tabulated in excel. The result was compared with WHO drinking water guidelines 2011 and Uganda National Bureau of standards (UNBS) DEAS 12:2018. The higher the number of bacterial colonies the more the water is contaminated. According to DEAS 12: 2018 there should be zero coliforms for 100ml of water sample tested. The water source location and its sanitation were observed during data collection, this provided information which was compared with the water quality test results.

3.8 Quality/error Control

All water samples were tested against the WHO/DEAS12:2018 standards of cfu/100ml non detectable. All the procedures for picking water samples like sterilizing spout, keeping the sample within the recommended temperature of below 65C during transportation was observed. The sample water sources were picked from all the sub-counties to represent the water sources in the entire District of Lira. The data was analyzed using STATA 15.

3.9 Data Processing and Analysis.

The data was analyzed using STATA 15 software. The information is presented using graphs and tables. Multivariate logistic regression analysis is used to determine relationship between improved point water sources safety and water source type, its location and operation and maintenance and assessed the risk of coliform contamination of improved point water sources using the P-Value of 0.05

3.10 Ethical Consideration

The approval was got from District Water Officer, Lira and the eight sub-counties before the study was conducted. A detailed description of how the study was to be conducted and the objectives of the study were shared with the District Water Officer. The study was first approved by Uganda Christian University Research Ethics Committee.

3.11 Study Limitations

The researcher could have sampled more than 72 improved point water sources, but due to the high cost of water quality tests at the government-run water quality test centers, resources could not allow since all the costs were borne by the researcher.

The Improved point water sources data base of Lira District is not updated in areas of functionality and community use of the existing water sources, this affected sampling method used because some of the improved water sources were nonfunctional and abandoned by the communities without the notice of Lira District Water Office, yet there was limited time on the side of the researcher to verify the functionality and the use of the existing improved water sources.

CHAPTER FOUR: DATA ANALYSIS, PRESENTATION AND INTERPRETATION OF RESULTS

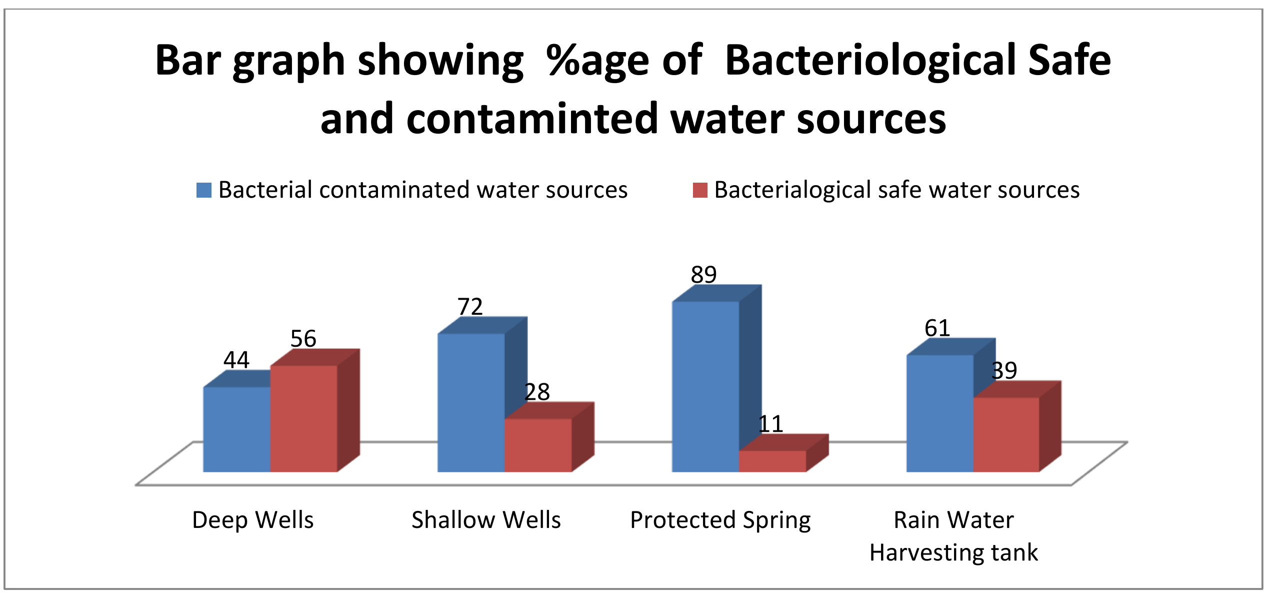
4.1The level of safety of different types of improved point water sources being used in Lira District

To evaluate the level of safety of different types of improved point water sources, I tested their Total Coliforms levels and also made an observation at each water source sampled. I obtained 72 samples from water sources in Lira district. The samples consisted of Deep boreholes 18(25%), protected springs 18(25%), rainwater harvesting 18(25%), and tanks 18(25%) table 1.

Table 1: Summary of test results per Water Source type.

No	Well Type	Water Sample Tested	Water Samples without total Coliforms detection	Water Samples with Total Coliforms detected	Percentage of Bacteriological contaminated water source	Percentage of Bacteriological safe water source
1	Deep Wells	18	10	8	44	56
2	Shallow Wells	18	5	13	72	28
3	Protected Spring	18	2	16	89	11
4	Rain Water Harvesting tank	18	7	11	61	39
	Totals	**72**	**24**	**48**	**67**	**33**

Bar graph 1: Percentage of bacteriological safe and unsafe water source



67% of the water samples were detected with Total Coliforms. The contamination was between 1 and more than 100 cfu/100ml of water tested.

The observation was made at each water source and recorded these includes the proximity of the water source to the pit latrine and swamp, the operation and maintenance which includes fencing of the water source, the condition of the casted apron, the clearance of the drainage line for the water source, the surface runoff diversion provision and the cleaning of the water source.

Table 2: Water quality level for the sources

Coliform colony recorded Type of water source	(A)(<1)	(B)(1-10)	(C)(11-50)	(D)(51-100)	>100	Total sample
Deep boreholes	10	1	4	3	0	18
Shallow Well	5	1	5	3	4	18
Protected Spring	2	2	3	5	6	18
Rainwater harvesting Tank	7	1	3	3	4	18

Multivariate Logistic Regression

Multivariate logistic regression analysis allowed the evaluation of the importance of each of independent variables in the model and test of overall fit of model data. This regression was conducted to know how much the independent variable explains the dependent variable.

The Logistic Regression Model for predicting "Bacteria Contamination" based on the independent variables "Water Source Type," "Location," and “Operation and maintenance" is expressed as follows:

Table 3: Logistic Regression

Variable	Coefficient	Std. Error	Odds Ratio
Intercept	-0.875***	0.234	0.416
Water Source Type	0.632***	0.178	1.881
Location	0.347**	0.159	1.415
Operation and maintenance	0.892***	0.241	2.440

a. *Dependent Variable: "Bacteria Contamination" (0 = No Contamination, 1 = Contamination)*
b. *P-value = 0.05*

The "Water Source Type" variable is statistically significant ($p < 0.05$). A one-unit increase in "Shallow Well or Protected spring" is associated with 1.881 times higher odds of the outcome occurring, holding other variables constant. This suggests that the type of water source significantly influences the likelihood of the outcome especially in the level of water contamination as provided in the appendix table 2-6) per Sub County with level and number of coliforms. According to the water quality test results the safety of the water source types were; 56% deep Wells, Shallow Wells 28%, protected spring 11%, Rainwater Harvesting tank 39%.

The "Location" variable is statistically significant ($p < 0.05$). A one-unit increase in "Location of the water source close to a pit latrine or swamp" is associated with 1.415 times higher odds of the outcome occurring, holding other variables constant. This indicates that the location in or close to a source of contamination also has a significant impact on the likelihood of the outcome of the level of water contamination.

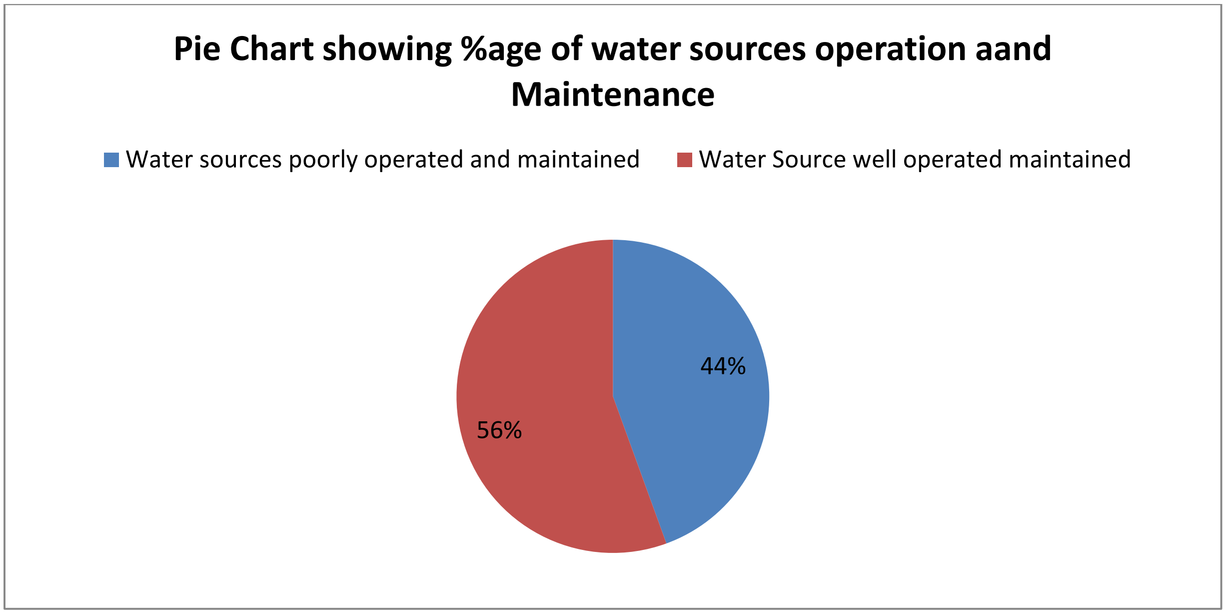
The "Operation and Maintenance" variable is statistically significant ($p < 0.05$). A one-unit increase in " Poor Operation and Maintenance" is associated with a substantial increase in odds (2.440 times higher), holding other variables constant. This suggests that the quality of operation and maintenance has a significant positive effect on the likelihood of the outcome.

The results conclude that all three predictor variables ("Water Source Type," "Location," and "Operation and Maintenance") are statistically significant at a significance level of 0.05. This means that they have a significant impact on the outcome, and their coefficients indicate the direction and strength of that impact. Specifically, "Operation and Maintenance" has the largest effect, followed by "Water Source Type" and "Location." These findings are based on the logistic regression analysis provided in the table 4.

Table 4: Summary of water source operation and maintenance and its location.

No	Well Type	Water Sample Tested	Water Samples without total Coliforms detection	Water Samples with total Coliforms detection	Water sources poorly operated and maintained	Water sources in a location risky to contamination	Water Source well operated maintained	Water Source in good location and environment
1	Deep Wells	18	10	8	5	5	13	13
2	Shallow Wells	18	5	13	12	12	6	6
3	Protected Spring	18	2	16	6	5	12	13
4	Rain Water Harvesting tank	18	7	11	9	18	9	18
	Totals	**72**	**24**	**48**	**32**	**40**	**40**	**50**
	Percentage		**33**	**67**	**44**	**56**	**56**	**69**

Pie Chart 1: Summary of percentage of water source operation and maintenance.



Out of the total 72 water sources sampled 56% were well operated in terms of fencing, surrounding kept clean, apron not cracked or water logged, drainage line kept clear, spout are kept clean and water storage tank cleaned or kept clean, 44% were not attended to yet are being used, protected springs were flooded, water logged at the apron of water sources which are cracked or worn-out, rain water storage tank not cleaned or with no provision for the first rainwater harvest to be cut off from accessing the water tank.

56% of the sampled water sources were located in upland and not near any pit latrine, while 44% were located in swamps or near pit latrine, or low laying area accessible by floods.

4.2 The risk factors associated with bacterial contamination of improved point water sources being used in Lira District.

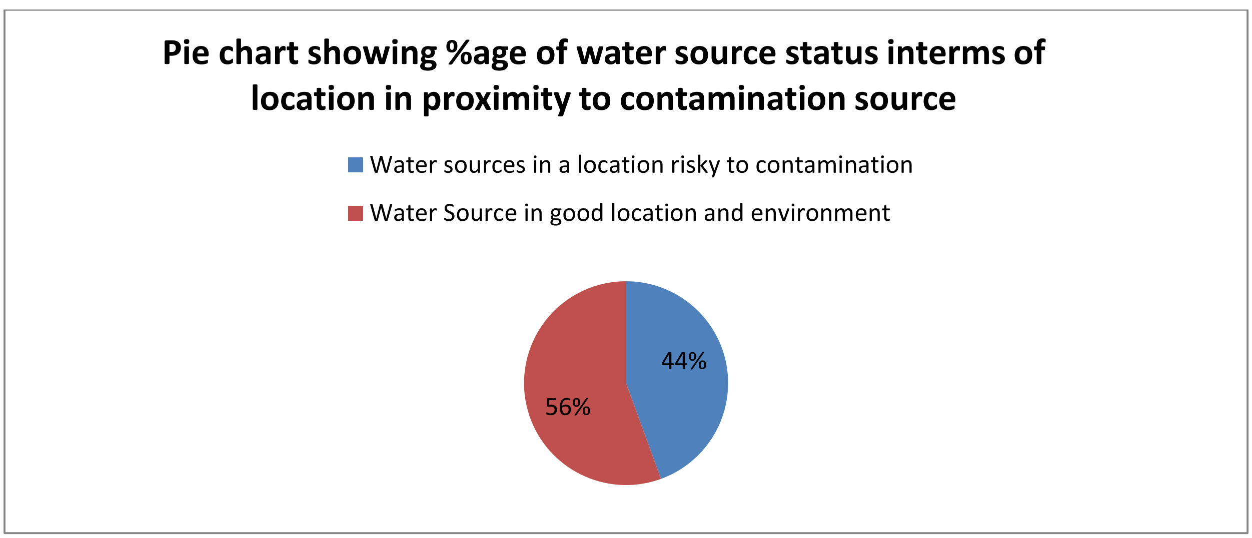
According to the multivariate analysis, the risk factor of water source type, water source location and operation and maintenance has an effect on the safety of the improved point water sources at the p-value of 0.005.

The improved point water source of shallow Wells and protected springs are highly contaminated according to the test result at 72% and 89% respectively, they showed the lowest level of safety an indication that the choice of the water source type to be promoted should consider their vulnerability to contamination. Shallow Wells and protected springs are always located near the streams or swamps in valleys.

The location of these improved point water source has an impact on the safety of these water sources, according to the Multivariate analysis result a unit increase in location of these water sources near a pit latrine or the swamp result into 1.415 higher chances of contamination of the water source at the p-value of 0.005.

Operation and maintenance, poor operation and maintenance of these improved point water source like failure to re-cast worn out apron, replacing missing parts and routine cleaning of the water source, according to multivariate analysis result provides the highest chances of the contamination of these improved point water sources at an odd ratio of 2.440.

Pie chart 2: Summary of the location of the water sources in proximity to contamination source.



Some of the improved point water sources were poorly operated and maintained, deep Wells, Shallow Wells had cracked apron with dirty water logged on providing access into the underground stored water, some had no pump head side cover providing opportunity for any contaminant to access the water tank and the underground stored water. The cracked apron could have been cemented and missing side cover replaced to avoid contamination of the underground water.

Some of the Rain Water Harvesting tank had no provision for cleaning inside tank and no connection for diverting dirty first rain water. No attemp was being made by the users to clean these rainwater harvesting tank routinely.

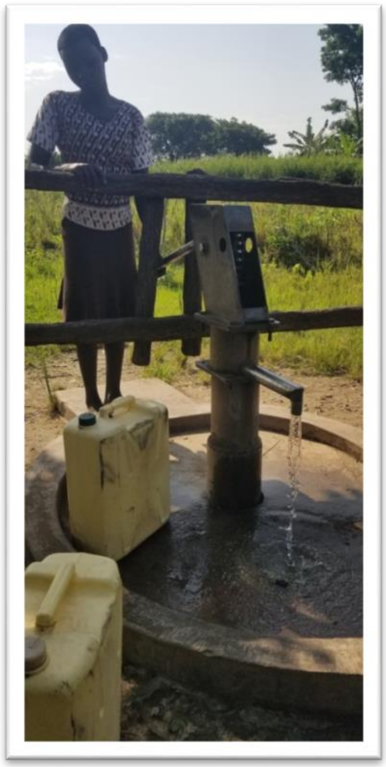




Photo1 ***Photo 2*** ***Photo 3***

Photos 1-Amidiki SW dirty water stagnant on the worn-out Apron. Photo 2-Amin Ogwang SW without pump head side cover

3-Alik Health Center III RWHT without provision for tank cleaning and connection to cut off dirty rain water from accessing the tank.

Some households near the Deep Wells, Shallow Wells, protected spring had constructed pit latrines less than 30 meters away these improved point water sources and some latrines were in the upper side of the water sources providing easy access to water fracture lines, there is a possibility of interference from these latrines with water fractures lines underground.

Acholi Dumu SW with Latrine on upper side. Adyere Central DW located less than 30meter away from pit latrine.

Some Communities are not cleaning the drainage path ways for protected spring, leaving them blocked causing back flow of dirty water to the storage tank, while spout of the protected spring was clogged with dirt's due to lack of routine cleaning and there was no diversion to protect the surface run off not even fencing to cut off access by animals which can break the protected water storage area.

Bung Amon Protected spring flooded with drainage line blocked and no diversion line for surface run off for water.

CHAPTER FIVE: DISCUSSION

5.1 The level of safety of different types of improved point water sources being used in Lira District

Ideally, drinking water is expected to be safe from any contamination and indicator organisms must not be detected in any 100 ml water sample (Allevi et al., 2013). Globally, groundwater sources are considered to be of better microbial quality than surface water; however, the results obtained from this study showed that groundwater sources are as polluted as surface water sources. (Amatobi & Agunwamba, 2022)Reported that untreated water sources were more heavily contaminated with both total coliforms than treated water sources.

Deep Wells registered few contaminated water sources at 44%, while protected spring reported many contaminated water sources at 89% followed by Shallow Wells at 72% and Rainwater harvesting tanks at 61%. Deep Wells had no water source with bacterial colony above 100 while Shallow Wells had 4, Protected spring 6, Rainwater harvesting tank 4. Deep Wells seems to be safer compared to other water source technology of Shallow Wells, protected spring and rainwater harvesting tank.

The presence of total coliforms in the water samples collected from the shallow well and protected water sources emphasized that bacterial contamination had occurred in the drinking water sources. Total Coliform found exclusively in the faeces of humans and other animals, and its presence in water indicates not only recent bacterial contamination of the water but also the possible presence of intestinal disease-causing bacteria, viruses, and protozoa.

5.2 The risk factors associated with bacterial contamination of improved point water sources being used in Lira District.

Shallow Wells and Protected spring are located near the stream or the valleys, this provide access of the contaminated surface run office to access the water storage area it also makes it difficult to control swamp flooded water with the spring and underground water especially during rainy season. A study in Ghana by (Gebrewahd et al., 2020b)revealed that overland wastes move into rivers during periods of heavy or extended precipitation and this subsequently leads to higher indicator bacteria numbers recorded during the rainy season compared with the dry season Rainfall is one of the most important causes of degradation of water source quality.

Deep Wells, Shallow Wells and protected spring are located within the communities with distance provided between the pit latrine and improved water sources are compromised to less than 30 meters due to land limitation, these provides the access of water fractures sharing between pit latrine and unground water. The findings that water locations with a standard distant from contamination source exhibit higher odds of safety than in congested areas corroborates numerous studies that have identified the challenges faced by rural communities in ensuring water safety (Batura, 2022). Factors such as population density, infrastructure development, and access to sanitation facilities contributes to improved water source safety. Some groundwater sources are constructed downhill and close to sanitation facilities as well as surface water. Consequently, runoff of human and domestic wastes and seepage of contaminants from the streams may pollute the water.

Diarrheal-related diseases are among the top five reported causes of outpatient visit in Lira District. High incidence of diarrhea is associated with the drinking of contaminated water, and people who are at particularly high risk include the very young and the very old, as well as immune compromised individuals, such as those suffering from HIV/AIDS (Bain et al., 2014b).

Diarrhea is a major killer among the poor, especially in developing countries, and each year an estimated number of 2.2 million people, most of whom are under 5 years of age, die from diarrhea-related diseases(Asefa et al., 2021)

All improved point water sources require routine operation and maintenance like sealing or re-casting worn-out apron, replacing worn out parts, ensuring that the source is fenced and surface run off diversion provision is kept opened especially for protected spring. This study showed (observation) that safety of Improved point water cannot be guaranteed since it depends on its operation and maintenance. Some of the protected spring had no diversion for dirty surface run off from accessing the spring water storage tank, they are feeding directly into the protected storage tank for the springs. Most drainage line of the protected spring are not lined with concrete hence soft soil keeps on pilling and blocking the drainage line causing flooded dirty water to access the protected spring water storage tank while apron of shallow and deep wells are always worn out and they are not being replaced by the communities.

The significant positive impact of effective Operation and Maintenance practices on water source safety is consistent with extensive literature emphasizing the critical role of maintenance in sustaining safe water sources (Okurut, 2018). Neglecting regular maintenance can lead to the deterioration of water source infrastructure, potentially resulting in contamination. These findings pointed out the importance of robust maintenance strategies to ensure the long-term safety of water sources.

The water source type, the results from the logistics regression indicated that there was positive association between Water Source Type and water source safety. Various studies have highlighted that certain water source types, such as deep Wells, are less susceptible to contamination and are, therefore, safer sources of drinking water (Wright et al., 2019). The elevated odds of safety associated with the Water Source Type are in line with these established trends. Promoting the use of these safer source types could play a significant role in enhancing overall water safety. In this study deep Wells was safer compared to Shallow Wells, protected spring and rain water harvesting tank because they depend on the water filtered through the bed rock and they are deeper in depth making it hard to be compromise by the surface run off contaminated water and they are located upland compared to shallow Wells and protected spring which are located down the valley and can easily be flooded during rainy season.

The detection of bacterial contamination of water sources in the study area could be attributed to the fact that the groundwater (Wells) have similar features: they lack proper physical barriers like concrete sanitary seals, concrete plinths, well compacted concrete aprons, sealed Well linings, which could prevent overland runoff containing human, animals and domestic wastes from contaminating the water sources and the poor workmanship and poor quality materials which has made these infrastructures to wore out fast providing access of contaminated water to the protected water sources.

The (Kelly et al., 2021b)reported that groundwater is less vulnerable to contamination due to the barrier effect, and that once the protective barrier is breached direct contamination may occur. (Njuguna et al., 2016b)noted that due to the relatively slow movement of water through the ground, once polluted, a groundwater body could remain so for decades, or even centuries.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

The study reveals significant challenges of bacterial contamination of drinking water sources in Lira District, Uganda. Protected spring and shallow Wells were highly contaminated at 72% and 89% respectively. It pointed out the need to improve the protection of the shallow Well, protected spring and rainwater harvesting tank during construction or more deep wells should be constructed instead of rainwater harvesting tanks, protected spring and shallow Wells.

The improved point water sources water quality can easily be compromised by its locations in terms of proximity to the contamination source and their operation and maintenance by the beneficiaries. Implementations of different types of improved point water sources should consider future contamination source proximity and community plan and capacity for repair and replacement of worn-out parts.

Lastly, despite being considered as improved, improved point water sources still harbor contaminants that pose risks to human health, 67% sampled in this study was found to be contaminated, there is need for routine disinfection of these improved point water source and treatment of drinking water at the household.

6.2 Recommendations

Based on the study results there is need to build the capacity of the beneficiary communities on operation and maintenance of these improved point water sources so that they are able to repair worn out parts especially apron which always wear out providing access of contaminated surface water to underground water and ensure standard distance of pit latrine to the water source is maintained at 30 meters before, during and after the establishment of the water source.

There should be routine water quality testing for the existing improved water sources either by the lower local government offices, private water actors or District water authorities in order to provide water source list for decommissioning or disinfection where contamination is identified. The cost of water quality test should also be subsidized by the government to encourage NGOs and other water actors to test quality of all improved water sources they are providing routinely.

Water treatment at the household level should be promoted by all water actors to minimized drinking of contaminated water by communities and communities should be be trianed on how to treat their drinking water locally.

Future research could be conducted in the safety of improved water sources by testing all water sources in the district including pipe water schemes since this study tested only a few improved water sources out of the total water sources existing in Lira District. Further research could also be done on community perceptions on operation and maintenance of improved point water sources.

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APENDICIES

Appendix 1.**Test results from deep borehole water sources in Lira District per sub-county**

Community	Source[1]	six (hours) Coliform(non-*E.coli*)
Awiodyek	1	0
	2	0
Amach	1	0
	2	15
Agali	1	0
	2	0
Itek	1	0
	2	0
Barr	1	0
	2	0
Ogur	1	82
	2	TNTC
Agweng	1	0
	2	29
Aromo	1	88
	1	0
	2	2
	3	20
	4	0

[1]Source (*e.g.*, 1, 2,3&4) references the first, second, or third site tested in the community identified.
TNTC = TNTC = Too Numerous To Count

Appendix 2.**Testresults from Shallow Well water sources in Lira District per sub-county**

Community	Source[1]	six (hours) Coliform(non-*E.coli*)
Amach	1	72
	2	83
	3	96
Awiodyek	1	132
Agali	1	0
	2	0
Itek	1	0
	2	21
Barr	1	240
	2	4
Ogur	1	16
	2	28
Agweng	1	TNTC
	2	0
Aromo	1	156
	1	25
	2	0
	3	36
	4	72

[1]Source (*e.g.*, 1, 2,3&4) references the first, second, or third site tested in the community identified.
TNTC = Too Numerous To Count

Appendix 3.**Testresults from Protected Spring sources in Lira District per sub-county**

Community	**Source**[1]	six (hours) **Coliform(non-*E.coli*)**
Awiodyek	1	64
	2	86
Amach	1	68
	2	80
Agali	1	0
	2	136
Itek	1	0
	2	12
Barr	1	TNTC
	2	326
Ogur	1	8
	2	389
Agweng	1	62
	2	18
Aromo	1	58
	1	136
	2	2
	3	TNTC
	4	64

[1]Source (*e.g.*, 1, 2,3&4) references the first, second, or third site tested in the community identified.
TNTC = Too Numerous To Count

Appendix 4 .**Testresults from Rainwater harvesting Tank sources in Lira District per sub-county**

Community	**Source**[1]	six (hours) **Coliform(non-*E.coli*)**
Awiodyek	1	28
Amach	1	124
	2	0
Aromo	1	13
Agali	1	0
	2	360
	3	322
Itek	1	TNTC
Barr	1	0
	2	96
Ogur	1	0
	2	58
	3	0
	4	89
	5	0
	6	26
	7	0
Agweng	1	8

[1]Source (*e.g.*, 1, 2,3&4) references the first, second, or third site tested in the community identified.
TNTC = Too Numerous To Count

Appendix 5: Work plan

Schedules for proposal development, approval, data collection, analysis and presentation of final research report.

NO	DETAILS	YEAR: 2023	YEAR:2023	2024
		May-June	July-Dec	Jan-April
1	Research proposal development			
2	Research proposal presentation			
3	Research proposal approval			
4	Seeking approval from DWO and local leaders			
5	Water sample collection/data collection			
6	Water quality laboratory analysis			
7	Data analysis			
8	Research report writing			
9	Final research report presentation			

Appendix 6: Budget

Activity budget for the proposal development, presentation, approval, data collection, analysis and final research presentation and approval.

NO	DETAILS	UNITS	QUANTITY	RATE	AMOUNT
1	Research proposal development and presentation				
1.1	Travel	Trips	1	100,000	100,000
1.2	Accommodation	Nights	2	100,000	200,000
1.3	Meals	Days	2	60,000	120,000
1.4	Stationeries	Pcs	5	20,000	100,000
	Sub-Total				**520,000**
2	Water sample collection and Analysis				
2.1	Water sample collection	Sites	72	10,000	720,000
2.2	Transportation	Trips	72	15,000	1,080,000
2.3	Water sample analysis	Samples	72	10,000	1,440,000
2.4	**Sub-Total**				**3,240,000**

3	Final research report writing and presentation				
3.1	Stationeries	Pcs	5	30,000	150,000
3.2	Travel	Trips	2	100,000	200,000
3.3	Accommodation	Nights	2	100,000	200,000
3.4	Meals	Days	2	60,000	120,000
	Sub-Total				**670,000**
	Grand Total				**4,430,000**

Appendix Seven: Water quality test results certificate.

APPENDIX 7: Testing of the samples in the lab

Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
LIRA REGIONAL WATER QUALITY LABORATORY

MINISTRY OF WATER & ENVIRONMENT LIRA REGIONAL WATER QUALITY LABORATORY ★ 28 AUG 2023 ★ QUALITY CONTROL

Certificate of Analysis

Client Name : Edwin Okabo
Client Address : P. O. Box 146 Lira
Sample type and condition : Potable Water
Sampled by : Client
Analysis Completion date : 26th August 2023

TEST RESULTS

Sampling date	Reception Date	Lab No.	Source Type	Sample Source Name	Village	Parish	Sub-county	District	Total Coliforms
19/07/2023	19/07/2023	UN23/1321	Protected Spring	Swayili	Alit	Adola	Awiodyek	Lira	64
19/07/2023	19/07/2023	UN23/1322	Protected Spring	Agweng	Olil B	Abwocolil	Awiodyek	Lira	86
19/07/2023	19/07/2023	UN23/1323	Rainwater Harvesting Tank	Alik H C III	Alik	Amokoge	Awiodyek	Lira	28
19/07/2023	19/07/2023	UN23/1324	Deep Borehole	Kulu Amery	Abyemwonyi	Amokoge	Awiodyek	Lira	10
19/07/2023	19/07/2023	UN23/1325	Deep Borehole	Ewop B	Ewop B	Abwocolil	Awiodyek	Lira	0
19/07/2023	19/07/2023	UN23/1326	Shallow Well	Aweo	Aweo	Alworo	Amach	Lira	72
19/07/2023	19/07/2023	UN23/1327	Protected Spring	Anekolali	Bungamon	Alworo	Amach	Lira	68
19/07/2023	19/07/2023	UN23/1328	Shallow Well	Amin Odur	Alworo Central	Alworo	Amach	Lira	83
19/07/2023	19/07/2023	UN23/1329	Shallow Well	Amin Ogwang	Adyel	Onyakede	Amach	Lira	96
19/07/2023	19/07/2023	UN23/1330	Deep Borehole	Ayach	Ayach	Ayach	Amach	Lira	0
19/07/2023	19/07/2023	UN23/1331	Rainwater Harvesting Tank	Amach H C IV	Akaidebe A	Ayach	Amach	Lira	124

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Sampling date	Reception Date	Lab No.	Source Type	Sample Source Name	Village	Parish	Sub-county	District	Total Coliforms
19/07/2023	19/07/2023	UN23/1332	Deep Borehole	Amach p / S	Otweotai	Banya	Amach	Lira	15
19/07/2023	19/07/2023	UN23/1333	Protected Spring	Apadi	Olaipii	Banya	Amach	Lira	80
19/07/2023	19/07/2023	UN23/1334	Shallow Well	Adolo P / S	Odyekcamosaor	Adola	Awiodyek	Lira	132
20/07/2023	20/07/2023	UN23/1335	Protected Spring	Alik Pot	Alik Pot	Adyaka	Agali	Lira	0
20/07/2023	20/07/2023	UN23/1336	Deep Borehole	Abwong A	Abwong A	Adyaka	Agali	Lira	0
20/07/2023	20/07/2023	UN23/1337	Deep Borehole	Odipa Wigweng	Odipa Wigweng	Alyet	Agali	Lira	0
20/07/2023	20/07/2023	UN23/1338	Shallow Well	Olor Kede	Olor Kede	Abongorwot	Agali	Lira	0
20/07/2023	20/07/2023	UN23/1339	Shallow Well	Alel	Alel	Ocamonyang	Agali	Lira	0
20/07/2023	20/07/2023	UN23/1340	Protected Spring	Acan pii B	Acan pii B	Ocamonyang	Agali	Lira	136
20/07/2023	20/07/2023	UN23/1341	Shallow Well	Awei Wot	Omwelonero	Olilo	Itek	Lira	0
20/07/2023	20/07/2023	UN23/1342	Protected Spring	Burgweng	Omeny	Ajia	Itek	Lira	0
20/07/2023	20/07/2023	UN23/1343	Deep Borehole	Agulutwoo	Agulutwoo	Alebere	Itek	Lira	0

20/07/2023	20/07/2023	UN23/1344	Shallow Well	Aguru	Aguru	Alebere	Itek	Lira	**21**
20/07/2023	20/07/2023	UN23/1345	Protected Spring	Apadi	Apadi	Onywako	Itek	Lira	**12**
20/07/2023	20/07/2023	UN23/1346	Deep Borehole	Onywako H C II	Onywako H C II	Onywako	Itek	Lira	**0**
20/07/2023	20/07/2023	UN23/1347	Deep Borehole	Ololango A	Ololango A	Ayira	Barr	Lira	**0**
20/07/2023	20/07/2023	UN23/1348	Shallow Well	Amin Lemo	Akwo	Abunga	Barr	Lira	**240**
20/07/2023	20/07/2023	UN23/1349	Protected Spring	Otunu B	Otunu B	Ober	Barr	Lira	**TNTC**

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Sampling date	Reception Date	Lab No.	Source Type	Sample Source Name	Village	Parish	Sub-county	District	Total Coliforms
20/07/2023	20/07/2023	UN23/1350	Deep Borehole	Green Land High sch.	Teyao	Ober	Barr	Lira	0
21/07/2023	21/07/2023	UN23/1351	Protected Spring	Amin- Agoro	Acede	Abunga	Barr	Lira	326
21/07/2023	21/07/2023	UN23/1352	Shallow Well	Amadi	Agulukure	Ayamo	Barr	Lira	4
21/07/2023	21/07/2023	UN23/1353	Protected Spring	Ogwang Tito	Acan Akwo	Aler	Ogur	Lira	8
21/07/2023	21/07/2023	UN23/1354	Deep Borehole	Nginynginya	Nginynginya	Apoka	Ogur	Lira	82
21/07/2023	21/07/2023	UN23/1355	Shallow Well	Amidiki	Amidiki	Apoka	Ogur	Lira	16
21/07/2023	21/07/2023	UN23/1356	Shallow Well	Kulu Obong	Adagwoo	Akaro	Ogur	Lira	28
21/07/2023	21/07/2023	UN23/1357	Protected Spring	Olimi	Adeknino	Adwoa	Ogur	Lira	389
21/07/2023	21/07/2023	UN23/1358	Deep Borehole	Acan pe winyo abwote	Acan pe winyo abwote	Okwaloamara	Ogur	Lira	TNTC
21/07/2023	21/07/2023	UN23/1359	Deep Borehole	Orit P /S	Awiealem	Orit	Ogur	Lira	0
21/07/2023	21/07/2023	UN23/1360	Shallow Well	Barkwogo B	Barkwogo B	Abala	Agweng	Lira	TNTC
21/07/2023	21/07/2023	UN23/1361	Deep Borehole	Onywal Oyere	Onywal Oyere	Baroganda	Agweng	Lira	29
21/07/2023	21/07/2023	UN23/1362	Protected Spring	Amon Koc	Onywal Oyere	Te- Oburu	Agweng	Lira	62
21/07/2023	21/07/2023	UN23/1363	Protected Spring	Kulu Awill	Okanoidero	Te-Adwong	Agweng	Lira	18
21/07/2023	21/07/2023	UN23/1364	Shallow Well	Owiny Acimi	Ayegero	Orit	Agweng	Lira	0
22/07/2023	22/07/2023	UN23/1365	Shallow Well	Walela	Walela	Walela	Aromo	Lira	156
22/07/2023	22/07/2023	UN23/1366	Protected Spring	Acere	Kulu Obia	Okio	Aromo	Lira	58
22/07/2023	22/07/2023	UN23/1367	Deep Borehole	Aloc A	Aloc A	Odoro	Aromo	Lira	88

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Sampling date	Reception Date	Lab No.	Source Type	Sample Source Name	Village	Parish	Sub-county	District	Total Coliforms
22/07/2023	22/07/2023	UN23/1368	Deep Borehole	Te-gweng	Te-gweng	Apua	Aromo	Lira	**0**
22/07/2023	22/07/2023	UN23/1369	Shallow Well	Akaidebe	Akaidebe	Odoca	Aromo	Lira	**25**
22/07/2023	22/07/2023	UN23/1370	Shallow Well	Acholidumu	Acholidumu	Barpii	Aromo	Lira	**0**
22/07/2023	22/07/2023	UN23/1371	Protected Spring	Lwala	Lwala	Barpii	Aromo	Lira	**136**
22/07/2023	22/07/2023	UN23/1372	Protected Spring	Telela	Telela	Barpii	Aromo	Lira	**2**
22/07/2023	22/07/2023	UN23/1373	Deep Borehole	Adyere Central	Adyere Central	Acut Kumu	Aromo	Lira	**2**
22/07/2023	22/07/2023	UN23/1374	Shallow Well	Apuce B	Apuce B	Apuce	Aromo	Lira	**36**
22/07/2023	22/07/2023	UN23/1375	Protected Spring	Kulu Oyugi	Awinya	Apuce	Aromo	Lira	**TNTC**
22/07/2023	22/07/2023	UN23/1376	Deep Borehole	Abako	Abako	Acut Kumu	Aromo	Lira	**20**
11/8/2023	11/8/2023	UN23/1377	Rainwater Harvesting Tank	Oketkwer P/S	Ogot	Otara	Aromo	Lira	**13**
25/8/2023	25/8/2023	UN23/1529	Rainwater Harvesting Tank	Akany P/S	Akany	Onyakede	Amach	Lira	**0**
25/8/2023	25/8/2023	UN23/1530	Rainwater Harvesting Tank	Alik Pot P/S	Alik Pot	Adyaka	Agali	Lira	**0**
25/8/2023	25/8/2023	UN23/1531	Rainwater Harvesting Tank	Agali S/County HQTRS	Abeli	Okile	Agali	Lira	**360**
25/8/2023	25/8/2023	UN23/1532	Rainwater Harvesting Tank	Agali SS	Abongorot	Abongorwot	Agali	Lira	**322**
25/8/2023	25/8/2023	UN23/1533	Rainwater Harvesting Tank	Abolet P/S	Abolet	Alebere	Itek	Lira	**TNTC**
25/8/2023	25/8/2023	UN23/1534	Rainwater Harvesting Tank	Akalocero	Ololee	Ober	Barr	Lira	**0**
25/8/2023	25/8/2023	UN23/1535	Rainwater Harvesting Tank	Opem ECD	Otono	Ober	Barr	Lira	**96**

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Sampling date	Reception Date	Lab No.	Source Type	Sample Source Name	Village	Parish	Sub-county	District	Total Coliforms
26/8/2023	26/8/2023	UN23/1536	Rainwater Harvesting Tank	Akor P/s	Akor	Akor	Ogur	Lira	**0**
26/8/2023	26/8/2023	UN23/1537	Rainwater Harvesting Tank	Perac	Perac	Aler	Ogur	Lira	**58**
26/8/2023	26/8/2023	UN23/1538	Rainwater Harvesting Tank	Odongo Fred	Aduu	Aler	Ogur	Lira	**0**
26/8/2023	26/8/2023	UN23/1539	Rainwater Harvesting Tank	Ogwal Alfred	Ongokoremo	Ogur	Ogur	Lira	**89**
26/8/2023	26/8/2023	UN23/1540	Rainwater Harvesting Tank	Imat Mira	Ogur Corner	Ogur	Ogur	Lira	**0**
26/8/2023	26/8/2023	UN23/1541	Rainwater Harvesting Tank	Ogur HCIV	Ogur Corner	Ogur	Ogur	Lira	**26**
26/8/2023	26/8/2023	UN23/1542	Rainwater Harvesting Tank	Coorom P/S	Baradanga	Adwoa	Ogur	Lira	**0**
26/8/2023	26/8/2023	UN23/1543	Rainwater Harvesting Tank	Abala HCIII	Bardago	Abala	Agweng	Lira	**8**

Potable water standard (DEAS12:2018) for Total coliforms is "**NOT DETECTABLE**"

Note:

1. *NR= Not Required; ND = Not Done; TNTC = Too Numerous To Count; N/I=Not Indicated*
2. *This certificate shall not be reproduced without approval of the Laboratory.*
3. **Test result from sub-contracted Laboratory.*
4. *Analysis site is Lira Regional Water Quality Laboratory*

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WATER QUALITY LABORATORY
28 AUG 2023

Disclaimer

- These results relate to the sample as received.
- Details of the sample with respect to source and representativeness is the responsibility of the client.
- This certificate of analysis does not substitute certification of a business or product by the relevant authority

QUALITY CONTROL

Issued by:
Laboratory Manager

LIRA REGIONAL WATER QUALITY LABORATORY
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Appendix 8: Water source data collection checklist

WATER SOURCE DATA COLLECTION CHECK LIST.

LIRA DISTRICT.

SEPTEMBER,2023.

NO	LOCAL NAME	VILLAGE	PARISH	SUB-COUNTY	WATER SOURCE TECHNOLOGY	LOCATION	CONTAMINATION SOURCE PROXIMINTY	OPERATION AND MAINTENANCE	LATITUDE	LONGITUDE	ALTITUDE	TOTAL COLIFORM COLONY (IES)

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SCHOOL OF RESEARCH & POSTGRADUATE STUDIES

DISSERTATION CORRECTION COMPLIANCE REPORT BY THE CANDIDATE (POST VIVA FORM)

Date: …23rd /MAY/2024………………………………………………………………………….

Name of Candidate: ………OKABO EDWIN……………………………………………….. **Reg.No:** RJ20M21/055

Title of Dissertation ……RISK OF BACTERIAL CONTAMINATION OF IMPROVED POINT WATER SOURCES IN LIRA DISTRICT

………..

SN	COMMENTS BY EXTERNAL EXAMINER	ACTION TAKEN	INDICATOR
1	Delete the sentence primary source 2023 at the foot of every table	Deleted	Removed
2	Just check again and be sure that the cultures were kept at 44^{o}C	Re-checked	Confimed

3	The candidate cannot conclusively say that the contaminated water was responsible for the diarrheal diseases in Lira City but it is safe to say the probably the rampant diarrheal dieases seen in Lira are a result of the contaminated watrer since the candidate did not interview or observe the users.	Adjusted	Improved
4	In the study procedure the candidate should tell the readers how the water sources were reached. Yes information about the location of water sources was obtained from the district headquarters but still needed someone to guide the research team to the exact spot were the water source was.	Included	Assitant District Water officer field guidance was included in the narration
5			

SN	COMMENTS BY INTERNAL EXAMINER	ACTION TAKEN	INDICATOR
1	The abstract is fair- organized following IMRAD and with word count less than 300 words	IMRAD was adopted	Abstruct now arrange according to IMRAD
2	The objectives 1 &2 are fair BUT objective 3, it is not clear how it could be measured. In other-words, it is not SMART.	Objective three was deleted	Only two objectives now being reported on
3	Language or grammer This is good- in general but can improved more	It was improved	Correction made
4	The analysis is fair BUT the data was inadequate for quantitative analysis	Explanation was provided for the reason as to why few water samples were tested	Explanation provided
5	Reccommendations.These need to be re-done after dealing with the inadequacy of data. For now, they address the findings in the study	It was re-done in line with the findings	Reccommendation improved

SN	COMMENTS BY VIVA VOCE PANNEL	ACTION TAKEN	INDICATOR
1	Did you have to add the 3rd objective, why can't you only do objective 1&2. Objective one covers objective 3	Objective three deleted	Objective three not included in the report
2	What instruments or tool did you use to collect this data? Please add the check list in your book as the tool used in the data collection	Check list form attached	Check proivded

3	Please change the order of IV and DV in your conceptual framework	Changed	Independent Varriables now on the left
4	The objective has more than one objective; there is observation and testing of the water. Observation would be one and testing the other	Seperation made between the two methods of testing and observation	Explanation provided
5	Your findings are not showing what the risk factors are and after the testing. The way you presented the findings is like qualitative, and yet there is a quantitative data like the odds rations	Findings improved showing clearly risk factors	Presented in both test result analysed and obeservation made seperately

OKABO EDWIN		**Dr. ROBINSON ISAAC OGWANG**	
Candidate's Name	Signature	Supervisor's Name	Signature