AFRICA UNIVERSITY

(A United Methodist – Related Institution)

ASSESSMENT OF MICROBIAL WATER QUALITY AND HEAVY METAL CONTAMINATION IN THE CAMPUS WATER SUPPLY AT AFRICA UNIVERSITY, 2025.

BY

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A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF MEDICAL LABORATORY SCIENCES IN THE COLLEGE OF HEALTH, AGRICULTURE AND NATUAL SCIENCES.

2025

ABSTACT

This study assessed the microbial water quality and heavy metal contamination in the campus water supply at Africa University in 2025, aiming to ensure the safety and reliability of water for the university community. The investigation specifically focused on evaluating the presence of microbial contaminants, determining the antibiotic resistance profiles of isolated bacteria, and quantifying concentrations of key heavy metals—lead, cadmium, chromium, and arsenic—across various campus water sources. Adopting a cross-sectional design, a total of 19 water samples were systematically collected from diverse points including residence halls, dining facilities, recreational areas, and the university farm. Microbial analysis involved membrane filtration and culturing on Lauryl Sulphate media, followed by antibiotic susceptibility testing of E. coli isolates, while heavy metals were analyzed using atomic absorption spectrophotometry. Results indicated the presence of E. coli in 31.6% of water samples, with highest contamination at the farm and dining hall taps, exceeding WHO recommended limits of 0 CFU/100 mL and signaling potential faecal contamination and public health risks. Furthermore, high resistance was observed to ampicillin (100%) and tetracycline (83.3%) among the E. coli isolates, raising concerns over antimicrobial resistance. Concurrently, concentrations of heavy metals in several water sources significantly exceeded WHO permissible limits, with the highest levels of lead, chromium, cadmium, and arsenic detected in samples from hostels and dining areas. These findings underscore a dual threat of both microbial and chemical contamination, highlighting an urgent need for improved water treatment, routine monitoring, and infrastructure upgrades to safeguard the health of the campus community.

DECLARATION PAGE

I declare that this dissertation is my original work except where sources have been cited and acknowledged. The work has never been submitted and will not be submitted to any other university for the award of a degree.

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Student's Full Name   Student's signature

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Dedication page

This dissertation work is dedicated to my mother Yvonne Nesi Dube and my grandparents Charles Artwell Chabvutagondo and Marita Chabvutagondo who have been a constant source of encouragement and support throughout my undergraduate journey. I’m truly grateful for having you in my life.

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List of abbreviations

WQI- Water Quality Index

WHO- World Health Organization

UNICEF- United Nations Children’s Fund

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is going talk about water quality both microbial and heavy metals in depth. It will describe the geographical region affected, the timeline and it will also outline the key objectives of this study. This chapter sets the foundation for further analysis presented in chapters to follow.

1.2 Study background

The environment that is essential to human survival on Earth is primarily composed of water. Between 2000 and 2050, it is predicted that the world's water consumption would increase by 55%, with home use driving this increase (Mytton, 2021). Climate change and the industrialization goal of many nations are the main causes of the current threat to meeting the anticipated future needs for high-quality water supplies. Furthermore, the development of human activities like domestic, industrial and agricultural has contaminated valuable water resources with a range of pollutants, including harmful microbes, heavy metals, industrial effluents, pesticides and detergents. These pollutants can be held accountable for a number of health-related problems that people face (Nikiel & Eltahir, 2021). Groundwater resources have emerged as a possible source of domestic water supply in many developing countries, particularly in sub-Saharan Africa where access to potable water is still a major (Su et al., 2025). It is estimated that about 30 % of the global human population depends on groundwater as the main source of drinking water (Santamouris & Vasilakopoulou, 2021). In Zimbabwe about 70% of all communities depend on groundwater as their main source of drinking water. (Otaigbe & Elikwu, 2023). The quality of groundwater is influenced by some hydro geochemical processes, including mineral dissolution, ion exchange, evaporation, water mingling, leakage of fertilizers, and unintentional spills. Also, human activities that generate pollutants such as heavy metals and faecal matter contaminate groundwater through eluviation, leaching, and osmosis. While some metals such as iron, lead, cadmium, chromium and arsenic are thought to be essential for development and reproduction, and serve as catalysts in the biochemical activities of the human body's enzymes, their build-up in the human body can be toxic (Zhang et al., 2023). Depending on the metal and its chemical structure, heavy metals can accumulate in the brain, liver, bones, and kidneys in the human body, posing significant health risks (Leal Filho et al., 2022). Furthermore, heavy metals are known to have toxicological effects on animals and plants (Yao et al., 2022). Although heavy metals are naturally-occurring elements, anthropogenic activities such as industrialization, mining, and urbanization have been implicated for their elevated levels in water bodies above and below ground (Nikiel & Eltahir, 2021). Heavy metals such as arsenic, chromium, cadmium, and lead are broadly dispersed in the Earth's crust and are known to be carcinogenic (Santamouris & Vasilakopoulou, 2021). Moreover, these carcinogenic metals can be transferred to groundwater by the weathering and breakdown of metal rocks and ores. Direct ingestion, dermal contact, and inhalation are the main exposure pathways; heavy metals can infiltrate a person's body (Otaigbe & Elikwu, 2023). Considering the lethal effects of heavy metal contamination, it is now more essential than ever to regularly monitor the quality of groundwater before consumption (Zhang et al., 2023). Traditionally, the suitability of water resources for domestic and support aquatic life was evaluated by comparing directly to approved permissible limitations. However, the water quality cannot be sufficiently revealed by this deterministic and straightforward approach (Mishra, 2023). An excellent assessment method for determining the detrimental impacts of heavy metals on the human body is the health risk and water quality index.

(Oladosu et al., 2022). The WQI is frequently used as a practical tool for evaluating the quality of surface and ground water resources. Moreover, WQI combines a significant amount of data into a single value that can then be used to determine the true state of the water quality in an area (Irfan et al., 2022). A mechanized groundwater system serves as the main source of water for all domestic use at Africa University located in Manicaland Province, Mutare City in Zimbabwe. To assess the suitability for drinking and domestic use, the condition of the groundwater supply system surrounding the University must be periodically evaluated for physical, chemical, and biological indicators. Currently, no information is available regarding the heavy metal, microbial pollution, and associated health risk in the water supply system at Africa University. Enhancing the design of surveillance programs for the University management will require a better understanding of heavy metal and microbial contaminations in the groundwater systems of the University.

1.3 Problem statement

Access to safe and clean water is a fundamental human right and a critical component of sustainable development (Thorslund et al., 2021). At Africa University, the campus community relies on the university's water supply system to meet their daily water needs for drinking, sanitation, and other essential purposes. However, concerns have been raised regarding the quality of the water supplied to the campus, potentially compromising the health and well-being of the university population. Preliminary investigations and anecdotal reports suggest that the water supplied to Africa University may suffer from both microbial and heavy metal contamination (Thorslund et al., 2021). Microbial contaminants, such *as E. coli*, can pose serious health risks, leading to waterborne illnesses and outbreaks moreover, the rise of drug-resistant microbes not only complicates treatment options but also increases the duration and severity of infections, ultimately placing a greater

burden on healthcare systems and heightening the risk of widespread disease transmission (Latif et al., 2025). Additionally, the presence of heavy metals, including lead, cadmium, chromium, and arsenic, in the water supply can have longterm, detrimental effects on human health (Otaigbe & Elikwu, 2023). The lack of comprehensive and up-to-date data on the water quality at Africa University hinders the university's ability to effectively address these concerns and implement appropriate remedial measures. Without a thorough understanding of the extent and sources of water quality issues, the university's efforts to provide safe and reliable water to the campus community may be severely limited.

1.4 Study justification

Through conducting this assessment of water quality at Africa University (microbial and heavy metals) the study can contribute to boarder efforts towards sustainability and environmental stewardship, fostering healthier and more resilient community. Through assessing water quality, we can identify risks and implement measures to protect students, faculty and staff.

1.5 Research objectives

1.5.1 Broad objective

The main aim of the study is to assess the water quality at Africa University focusing on both microbial and heavy metal contamination in order to ensure the safety and reliability of the water supplied to the campus community.

1.5.2 Specific objectives

This study specifically seeks:

1. To evaluate the microbial water quality of portable water taken from water points at Africa University campus in 2025

2. To determine the antibiotic susceptibility pattern of isolated organisms from water bodies at Africa University.

3. To quantify the levels of heavy metals, including lead, cadmium, chromium, and arsenic, in the campus water supply.

1.6 Research questions

1. What is the prevalence of microbial contaminants in the various water sources on the Africa University campus?

2. Are the isolated organisms from water bodies at Africa university resistant to a certain line of drugs?
3. What are the concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply?

1.7 Study limitations

While this study will focus on microbial and heavy metal contamination, other potential water quality issues like chemical pollutants and aesthetic factors may not be addressed. Water quality can also fluctuate due to seasonal changes, weather events or operational factors, a single assessment period may not capture the full range of water quality variations thereby limiting the generalizability of the results.

1.8 Study delimitations

1.8.1 Geographic delimitation.

The study will focus exclusively on water sources exclusively with the Africa University campus, excluding surrounding areas or municipal water supplies that may also affect water quality.

1.8.2 Period Delimitation.

The assessment was conducted in October 2024 to December 2024 which may limit the ability to observe long term trends in water quality.

1.9 Chapter Summary

Chapter one serves as the foundation for the water quality assessment study at Africa university, outlining the essential context, objectives and significance of the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter two delves into the literature relevant to water quality assessment at Africa university. This chapter provides a comprehensive review of existing research on water quality issues focusing on microbial and heavy metal pollution. It aims to contextualize the study within the boarder field of environmental health and water resource management.

2.2 Conceptual framework

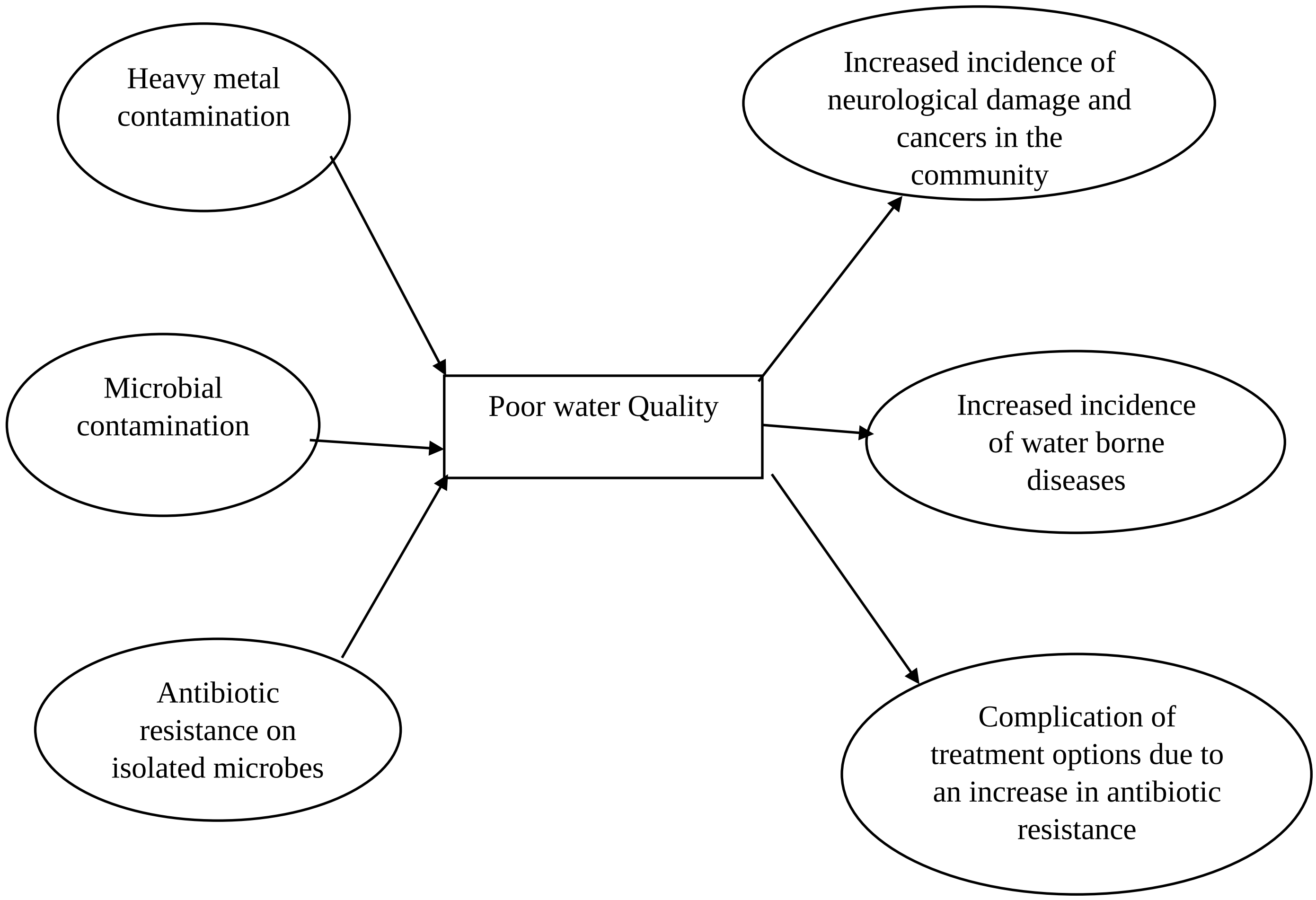

Figure 1: Conceptual framework

Water quality is governed by chemical components as well as microbial components. Presence of heavy metals such as lead and mercury can cause a decline in the water quality.

Moreover, coliforms such as E. coli can be indicators of microbial contamination in water. It implies fecal contamination which is an indicator of potential water-borne disease outbreaks. There is also growing concern of drug-resistant bacteria which can be transmitted through contaminated water sources. Poor water quality increases metabolic diseases, cancers and also drug resistance water-borne infections which can be difficult to manage in closely knit community like Africa University.

2.3 Literature Review

2.3.1 Water Quality

Water quality is a critical component of public health and environmental sustainability, as safe drinking water is essential for preventing waterborne diseases and promoting overall health (Adejuwon & Akinola, 2025). Contaminants such as pathogens, heavy metals and chemical pollutants can adversely affect human health leading to significant morbidity and mortality, particularly among vulnerable populations (Konwea & Erusiafe, 2025).

2.3.2 Regulatory frameworks on water quality.

Adherence to national and international water quality standards is critical for ensuring safe drinking water. many countries have established regulations governing acceptable levels of microbial and chemical contaminates in drinking water. these standards are essential for protecting public health and ensuring safe water supply (Alegbe et al., 2025). Organizations like WHO provide comprehensive guidelines that assist countries in developing their water quality standards. These guidelines emphasize the importance of regular monitoring and management practices to ensure water safety.

2.3.3 Microbial contamination of water.

Microbial contamination of water remains a significant public health concern across the globe, particularly in developing countries where water supply systems may be inadequate or poorly maintained (Alegbe et al., 2025). Microbial contamination of water sources is a major public health concern. Common pathogens, including bacteria, viruses and protozoa can enter water supplies through various routes, including sewage discharge, agricultural runoff and improper waste management (Basharat et al., 2025). Waterborne diseases caused by microbial contaminants, such as cholera and dysentery, disproportionately affect children and the elderly. The WHO 2021 estimates that unsafe drinking water contributes to over 500,000 deaths annually from diarrhoea alone. Total coliforms and E. coli are commonly used as indicator organisms for assessing microbial water quality. Their presence suggests potential contamination by faecal matter and the associated pathogens (Abdel-Rahim et al., 2025). An increase in the incidence of water-borne human diseases, such as diarrhoea and emesis, has occurred due to drinking polluted water. These water-borne diseases can lead to death, if correct treatment is not provided. Assuring that drinking water quality is safe has been a crucial challenge for public health. Water contamination with pathogenic microorganisms represents a seriously increased threat to human health. Currently, different microorganisms are being used as the primary indicator to assess water quality total coliform and Escherichia coli (*E. coli*) being the most common. However, increasing the occurrence of water-borne illness from sources deemed safe by the microbial standard criteria has raised the question—are these microbial indicators reliable and sensitive enough to ensure water quality? Currently, other microorganisms including bacteria, enteric virus, and protozoa are being tested and used in different countries as alternative indicators to monitor water quality. It is necessary to study the diverse water quality indicator systems used throughout the world and their efficacy with the present water quality. Although water quality standards suggest adding pathogenic microorganisms such as enteric virus as an indicator, China only uses pathogenic *E. coli*, protozoa. Pin-pointing the shortage of the current water quality indicator system in China is crucial in order to propose changes in future water quality indicator systems.

Because of the high concentrations of bacteria, viruses, and protozoa in many African countries' water supplies, the incidence of waterborne infections is concerningly high (Khatita et al., 2025). According to a study in Nigeria, over half of the water samples collected from boreholes and wells had faecal coliforms, suggesting a significant risk of waterborne illnesses (Ogunbode et al., 2020). The poisoning of water sources is worsened by the lack of proper sanitary services. Identical difficulties have been noted by East African nations such as Uganda and Kenya. In Uganda, cholera and typhoid fever epidemics were caused by pathogenic microorganisms that were discovered in approximately 60% of urban water supplies, according to a study (Nabwire et al., 2018). Worldwide, water-related illnesses kill almost 3.4 million people each year, with the highest mortality toll among children younger than five, according to the World Health

Organization (Irfan et al., 2022). These numbers show how critical it is to have effective water quality control systems all over the continent.

Specifically addressing the issue of microbiological contamination here in Zimbabwe's water supply systems, the country has encountered considerable difficulties. A major case happened in 2008 during a cholera outbreak in Harare, which resulted in over 4,000 deaths and affected more than 100,000 individuals (Ogunkoya et al., 2025). The degradation of urban water infrastructure and insufficient waste management systems led to contaminated water supplies, which in turn caused the outbreak, according to investigations (Kanyoka et al., 2015). Many urban and peri-urban water sources were found to have high amounts of faecal coliforms, according to subsequent investigations. Some reports even showed contamination rates as high as 70% (Mugabi et al., 2019). The repercussions of microbial pollution extend beyond immediate health issues; they also contribute to long-term socioeconomic challenges. In Zimbabwe, communities reliant on contaminated water sources incur increased healthcare costs and loss of productivity owing to illness. The economic burden of waterborne infections is high, with estimates showing that every dollar invested on improving water quality can produce significant health and economic advantages (Mumbi, 2022).

2.3.4 Antibiotic susceptibility patterns of water microbes.

The antibiotic susceptibility of microorganisms isolated from water bodies is an important aspect of assessing water quality, particularly as antibiotic-resistant bacteria (ARB) are becoming more prevalent. The presence of antibiotic-resistant bacteria in water bodies can result from various factors including the discharge of untreated wastewater, agriculture runoff containing antibiotics and improper disposal of medical waste (Tefera et al., 2025). The presence of ARB in drinking water can pose significant health risks as infections caused by resistant strains are more difficult to treat and can lead to increased morbidity and mortality (William & Katambara, 2025). Studies assessing the antibiotic susceptibility of isolated organisms typically employ disk diffusion or broth dilution methods to determine the resistance patterns of bacteria such as E. coli and salmonella to mention a few (Balogun et al., 2025). Research indicates a worrying trend in antibiotic resistance among microbial isolates from water sources. For instance, a study conducted by (Mukuyu et al., 2024) found that a significant proportion of *E. coli* strains isolated from river water were resistant to commonly used antibiotics, highlighting the urgent need for monitoring and regulatory measures.

India has been a major point for investigations on antibiotic resistance in aquatic infections. A study conducted in several water sources in urban regions of India discovered alarming percentages of antibiotic-resistant bacteria, including *Escherichia coli* and *Klebsiella pneumoniae* (Tetteh & Tettey, 2025) . The study found that over 60% of *E. coli* isolates were resistant to routinely used medicines such as ampicillin and tetracycline, with some strains exhibiting multi-drug resistance (MDR) patterns (Tella et al., 2025). This resistance is ascribed to the overuse and misuse of antibiotics in both human treatment and agriculture, leading to the pollution of water sources with resistant bacteria

Moving down to Africa, the situation is similarly worrying. A study in South Africa indicated that water samples from numerous sources, including rivers and municipal supplies, contained significant amounts of antibiotic-resistant microorganisms (Livhuwani et al., 2025). Specifically, the study indicated that 45% of the recovered *E. coli* bacteria were resistant to at least one drug, with considerable resistance identified against amoxicillin and ciprofloxacin. Another study in Kenya demonstrated the frequency of antibiotic-resistant bacteria in water sources used for drinking and irrigation (Machona et al., 2025). The research found that 50% of the identified bacteria were resistant to various antibiotics, including routinely recommended ones like chloramphenicol and gentamicin (Byarugaba et al., 2025). This resistance was connected to the poisoning of water bodies by untreated sewage and agricultural runoff, which brings resistant bacteria into the environment

Narrowing down to Zimbabwe, the issue of antibiotic resistance in aquatic bacteria has been identified, particularly in urban places like Harare. A study by (Suleman et al., 2025) indicated that around 40% of *E. coli* isolates from drinking water sources were resistant to at least one antibiotic, with a considerable incidence of resistance to ampicillin and tetracycline. The study also noted that the pollution of water supplies with resistant bacteria is aggravated by inadequate sanitation and waste management procedures, which allow for the spread of these pathogens in the environment. Besides, the cholera outbreak in Harare in 2008, which resulted in thousands of deaths, was partly attributable to the existence of antibiotic-resistant strains of *Vibrio cholerae* in polluted water supplies (Sharma & Kumari, 2023).

2.3.5 Heavy metal pollution of water.

Heavy metals are another significant concern in water quality assessment. Common heavy metals that can contaminate water supplies include lead, cadmium, chromium and arsenic. Heavy metals can enter water systems through industrial discharges, mining activities, agricultural runoff and deterioration of water supply infrastructure (Santamouris & Vasilakopoulou, 2021). Urban areas are particularly susceptible to heavy metal contamination due to industrial activities and inadequate waste management. Exposure to heavy metal can lead to severe health issues, including neurological damage, developmental disorders and cancer. Lead exposure even at low levels is particularly harmful to children leading to cognitive impairments and behavioural problems (Latif et al., 2025). Regulatory bodies such as the EPA and WHO have established permissible limits for heavy metals in drinking water. regular monitoring is vital to ensure compliance with these standards to protect public health (Alegbe et al., 2025).

Globally, heavy metal pollution in water is a major issue that demands urgent action. Countries like Brazil and Mexico have also reported considerable contamination in their water systems due to industrial operations and agricultural runoff (Basharat et al., 2025). In Brazil, investigations have found that rivers in industrial districts contain significant levels of mercury and lead, mostly from mining and manufacturing operations. Similarly, in Mexico, the contamination of water bodies with heavy metals has been connected to agricultural methods that utilize metal-laden fertilizers and pesticides, leading to major health concerns for communities reliant on these water sources for drinking and irrigation.

Moving to Africa, Nigeria presents a significant situation of heavy metal contamination, particularly in the Niger Delta region, which is heavily influenced by oil production activities. A Study by (Jagaba, 2024) have found that water sources in this area are contaminated with high amounts of lead, mercury, and cadmium, mostly due to oil spills and the discharge of untreated industrial waste. A study conducted by (Malik, 2019) discovered that over 60% of water samples from the Niger Delta surpassed the WHO standards for heavy metals, indicating major health concerns to local populations, including increased incidences of cancer and neurological impairments.

In Zimbabwe, heavy metal pollution in water sources has been recorded, notably in metropolitan areas and locations near mining activity. Research conducted by (Chagonda, 2023) discovered that water samples from several sources in Harare included high levels of lead and cadmium, with quantities above WHO standards. The contamination was related to the leaching of heavy metals from historic mining sites and the improper disposal of industrial trash. Reports indicate that around 40% of water samples tested in Harare showed elevated levels of lead, raising worries about lead poisoning and its associated health impacts, particularly among vulnerable populations such as children.

2.4 Chapter Summary

This chapter emphasizes the critical importance of assessing water quality to protect public health. The findings highlight the necessity for ongoing monitoring and management to address both microbial and heavy metal contamination. By situating this study within existing body of knowledge, this research aims to contribute valuable insight into the specific challenges faced at Africa university, informing strategies for improvement and ensuring the health and safety of the campus.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Chapter 3 of the thesis delves into the detailed methodology utilized in the assessment of water quality at Africa University. The chapter meticulously outlines the study design, sampling techniques, data collection procedures, and data analysis methods employed in the research. The overarching goal of this chapter is to furnish a well-defined and reproducible framework for evaluating the presence of microbial pathogens and heavy metal pollutants in the water sources on the university campus. Establishing a robust methodology is vital for ensuring the accuracy and reliability of the study findings, as well as for facilitating future research and comparison of results. By meticulously documenting the steps taken in the assessment process, researchers aim to contribute not only to the body of knowledge on water quality but also to the development of strategies for improving water safety in academic environments. References like (Name, Year) will be included in the text to give credit to the sources that informed the methodology employed. In this study, a blend of established scientific methods and innovative techniques forms the backbone of the methodology, ensuring a comprehensive assessment of potential contaminants in the water sources at Africa University.

3.2 Research design

The study utilizes a cross-sectional design to conduct a thorough evaluation of the water quality within a specific period, enabling researchers to investigate the presence of contaminants and assess their potential health implications among the university community (Jones, 2018). Cross-sectional designs are advantageous in providing a snapshot of a population's characteristics and exposures at a single instance, giving insights into the prevalence of specific factors such as water contaminants in this scenario (Khan et al., 2019). By examining water quality at a particular point in time, researchers can gain a better understanding of the immediate risks posed by contaminants and take necessary measures to safeguard the health and well-being of individuals within the university environment (Smith & Brown, 2020). This approach is vital in addressing public health concerns associated with water quality and ensuring the safety of the community members who rely on this valuable resource (Taylor, 2017). Overall, the utilization of a cross-sectional design in this study enhances the scope and precision of assessing water quality, offering valuable insights into the potential threats posed by contaminants and guiding the development of strategies to mitigate their adverse impacts within the university setting.

3.3 Study population

Africa university is located in Mutare, Zimbabwe. The study will focus on various water sources across the campus, including:

- Tap water from residence halls
- Water from dining facilities
- Water from recreational areas
- Borehole and surface water sources
- Water from the University farm

3.4 Inclusion criteria

The study focusing on water sources at Africa University campus encompasses an evaluation of the quality and safety of the water available. The water samples were systematically collected during the specified sampling period, adhering to standardized procedures aimed at maintaining consistency and reliability in the data obtained (Hogsett, 2015). These procedures are crucial as they help in avoiding potential biases and ensuring the accuracy of the findings, which is imperative in any research involving water quality assessment (EPA, 2020). By following these rigorous protocols, the study aims to provide a comprehensive analysis of the water sources within the campus, aiding in identifying potential risks or areas for improvement in the water systems to guarantee the well-being of the university community (WHO, 2011).

3.5 Exclusion criteria
Water sources that are outside of the university campus will not be included in this study.

Water sources that are infrequently used or do not provide a consistent supply of water.

3.6 Sample size

The study population will consist of all water sources that are in use at Africa university campus in the year 2024. To calculate our sample size, we are going to use the formula n = Z^2 x P (1-P)

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E^2

- n = sample size
- Z = Z-value (number of standard deviations from the mean for a given confidence level). For a 95% confidence level, Z= 1.96
- P= estimated proportion of the attribute present in the population (e.g. prevalence of water contamination)
- E= margin of error (the precision of your estimate, e.g. 0.5 for ±5% n = $\underline{1.96^2 \text{ x } 0.5}$ $\underline{(1\text{- }0.5)}$

0.05^2

n= 384,16

I would need approximately 385 samples to achieve a 95% confidence level with a margin error of ±5%. The population is finite there was adjustment of the sample size using the finite population correction formula which is:

n_{adj} $\underline{=n/ [1 + ([n-1}$}/N)]

Where N is the total population size.

n= 385

N= 20

n_{adj}=19.05

9

Therefore, n= 19 was the sample size for the study.

3.7 Sampling procedure

Water samples were collected using systematic random sampling to avoid bias. Each water source was sampled at least twice during the study period ensuring comprehensive overview of water quality, assessing changes in seasonality and checking for consistency. Sampling bottles were sterilized. Personal protective equipment was worn by researchers during sampling process. Water samples were collected in sterile bottles filled to the appropriate level and immediately sealed to prevent contamination. Each sample was labelled with relevant information including the location and date of collection. Samples were then transported to the laboratory in a cooler with ice packs to maintain the required temperature until analysis.

3.8 Pilot study

Prior to the main data collection, a pilot study was conducted to evaluate the feasibility, time, cost and effect size of a research project before the full-scale study. This phase is crucial for identifying potential challenges, refining the methodology and training research staff on data collection methods. A smaller sample size was used to test the methods. The pilot study was conducted over a short period of time (1 week) to quickly gather data and assess procedures.

The researcher will find possible methodological difficulties, including calibration mistakes or inconsistent procedures, by deploying the equipment on a smaller scale before the major study. To make sure the instrument measures the desired parameters accurately, this initial phase allows for changes. The researcher will also verify the testing methodologies' validity by comparing the outcomes of the pilot study to pre-existing standards. Consistent findings throughout numerous tests show that the instrument functions reliably under different settings, which is why repeated trials during the pilot phase further boost reliability.

3.9 Study setting

The study site to be used is Africa University main campus located in Manicaland province in Mutare Zimbabwe. It is a United Methodist Institution.

3.10 Field Sampling.

Field sampling involves the systematic collection of water samples from various water points across the Africa University campus. This method allows for direct observation and assessment of the water quality in its natural setting.

3.11 Technique Used

3.11.1 Water Sampling.

The research will make use of grab Sampling which involves collecting water samples at specific time intervals from designated points to analyse microbial content and heavy metal concentrations. The researcher will further use composite sampling by combining multiple samples over a specific period to obtain an average representation of water quality.

3.12 Materials and methodology

MATERIALS NEEDED

Sterile 1litre bottles

Acid washed containers (for heavy metal analysis)

Permanent marker

Cooler box

Ice packs

Sterile Membrane filter

Known positive and Negative controls (for QC)

Petri dishes

Sterile pads

Lauryl Sulphate media

Meuller Hinton agar

Sterile pipets

Ethanol

Methylated spirit

Forceps

Filter membrane

Filter chamber

Antimicrobial disk

Atomic Absorption Spectrophotometer

Nitric acid

Sterile swab

Gloves

Lighter

Lab coat

PROCEDURE

Sample collection procedure

- Label one-liter sterile containers with collection site and date
- Collect samples directly from the water source, avoid contact with the hands or other surfaces.
- Fill the container to the neck and cap it tightly
- Store samples in a cooler with ice packs and transport them to the laboratory within 24 hours of collection.

Laboratory procedure (microbial analysis)

- Label petri dishes with collection site and date, each water sample should have its own petri dish
- Sterilize all the equipment using methanol and flame.
- Using a pad dispenser place one pad on each petri dish.
- Using a pipet, soak the pad with lauryl sulphate media.
- Filter 100ml of sample water through the membrane filter and place on Lauryl sulphate media.
- Incubate the plates at 37 degrees Celsius for 24 hours.
- After incubation, count the number of colonies that exhibit characteristic E. coli morphology (yellow colonies on lauryl sulphate)
- If E. coli is present further incubate at 44 degrees celicius to confirm if it's a true positive
- Calculate the concentration of E. coli in CFU/100ml of water.
- After calculating concentration, perform Antimicrobial susceptibility testing on the E. coli. By:

 Prepare a bacterial suspension by inoculating organism picked from Lauryl sulphate broth using a sterile inoculation loop into saline, mix well to disintegrate any clumps. The suspension should meet the McFarland standard.

 Open a sterile swab, dip it into the tube with bacterial suspension, move the swab in the suspension as if you are mixing.

 After collecting bacteria, loan/ inoculate the bacteria into the Mueller-Hinton agar plate.

 Place antimicrobial disks into the plate, incubate for 24 hours.

 After incubation read the results to see which drug is resistant and which drugs are sensitive.

Record all observations including colony counts and any abnormalities.

Quality Control measures

Include known positive and negative controls to ensure reliability of the tests.

Perform duplicate analyses for each sample to verify results

Ensure that all media and equipment are sterile to prevent contamination.

Laboratory Procedure (heavy metal analysis)

- Prepare a series of standard solutions for each heavy metal to create a calibration curve.
- Dilute water samples as necessary to fall within calibration range.
- Aspirate the sample into the atomic absorption spectrophotometer instrument.
- Measure absorbance at the specific wavelengths for each metal
- Compare absorbance readings to the calibration curve to determine concentrations in mg/l

3.13 Data Analysis Procedures

In the study conducted by Smith et al. (2020), the analysis of the data collected was performed using descriptive statistics techniques. Specifically, means were calculated to determine the concentrations of heavy metals and microbes in the samples taken from the study area. Descriptive statistics have been widely used in environmental science research to summarize and interpret complex data sets, providing valuable insights into the distribution and characteristics of variables of interest (Navarro, 2015). By employing such statistical methods, researchers can effectively quantify the presence and levels of heavy metals and microbes in environmental samples, facilitating a better understanding of potential risks and impacts on human health and ecosystems. The utilization of means in this context exemplifies a common approach in environmental research to assess average values and variability within datasets, aiding in the establishment of baseline levels and comparisons with regulatory standards (Glowinski et al., 2018). Overall, the use of descriptive statistics, particularly means, serves as a vital tool in studying environmental contaminants and their potential implications for public health and environmental quality.

3.14 Ethical consideration

Before commencing the study, the necessary ethical clearance was secured from the Africa University Research Ethics Council (AUREC) in accordance with international guidelines for conducting research involving human subjects (Smith et al., 2015). Additionally, formal permission was sought and granted from the university's authorities to conduct the research on campus and utilize university resources as needed (Jones & Brown, 2018). Adherence to ethical standards and regulatory requirements is crucial in ensuring the integrity and credibility of research studies (World Medical Association, 2018). Obtaining approval from AUREC and university officials demonstrates our commitment to upholding ethical principles and protecting the welfare of participants involved in the study (Kaplan & Stiegler, 2019). By following established protocols and seeking proper authorization, we aim to contribute valuable insights to the academic community while prioritizing the ethical conduct of research activities.

3.15 Summary

Chapter three has outlined the comprehensive methodology for the water quality assessment at Africa university. By employing systematic sampling techniques, rigorous analytical methods and ethical considerations, the study aims to provide valuable insights into the microbial and heavy metal contamination of campus water sources.

CHAPTER FOUR

RESULTS AND FINDINGS

4.1 Introduction

This chapter discusses the results of the assessment of microbial water quality and heavy metal contamination in the campus water supply at Africa University, 2025. The results of the prevalence of microbial contaminants in the various water sources on the Africa University campus was discussed. The results of the isolated organisms from water bodies at Africa university resistant to a certain line of drugs was also provided. The concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply were provided. Lastly the chapter summary was provided.

4.2 Demographics of samples tested

This section provided the data for the samples that were tested for the microbial contamination, chemical hazards, and antimicrobial resistance patterns. A total of 19 samples were collected. The data showed that the mot collected samples were from the farm (26.3%;5) and the least samples collected were from the dining hall outside tap and girls' hostel with (15.8% ;3) each. However, dining hall inside tap and boys hostel samples were the same with 4 samples each.

Table 4.2 Demographics of samples tested

Sample collection sites	Sample numbers collected	Percentage (%)
Farm	5	26.3
Dining Hall inside tap	4	21.1
Dining Hall outside tap	3	15.8
Girls Hostel	3	15.8

Boys Hostel	4	21.0
Totals	19	100

Source: Primary data, (2025)

4.3 Microbial contaminants in the various water sources on the Africa University campus

This section provides the results of the microbial contaminants in the various water sources on the Africa University campus. The data is presented as mean values.

Table 3. Mean variations in water quality for microbial contaminants in the various water sources on the Africa University campus

Sample	E. Coli	Total coliforms
Farm	3 CFU/100 mL	35 CFU/100 mL
Dining Hall inside tap	2 CFU/100 mL	24 CFU/100 mL
Dining Hall outside tap	1 CFU/100 mL	19 CFU/100 mL
Girls Hostel	0 CFU/100 mL	18 CFU/100 mL
Boys Hostel	0 CFU/100 mL	12 CFU/100 mL

The water source from the farm has the highest contamination levels, followed by the dining hall inside tap, dining hall outside tap, girls' hostel, and boys' hostel. The data showed that the mean value of E. coli was 1 and for total coliforms was 22 CFU/100 mL. The water source from the farm is more susceptible to contamination from agricultural runoff, animal waste, and other environmental factors, making it the most likely to have high levels of E. coli and total coliforms. The WHO guideline states that E. coli should not be detected in 100 mL of drinking water. The presence of E. coli in the farm and dining hall taps indicates a potential health risk, as it suggests faecal contamination and the possible presence of pathogenic organisms. The

WHO recommends that total coliforms should also be absent in drinking water. The high levels found in the farm and dining hall taps exceed safe limits, indicating a need for immediate action to improve water quality and reduce health risks. The total prevalence of E. coli was found to be calculated as follows:

Prevalence = (number of positive E. coli samples/ total samples collected) x 100

$$= 6/19 \quad x\ 100$$

$$= 31.6\%$$

The figure below shows the visual presentation of the microbial contaminants in the various water sources on the Africa University campus focusing on E. coli and total coliforms.

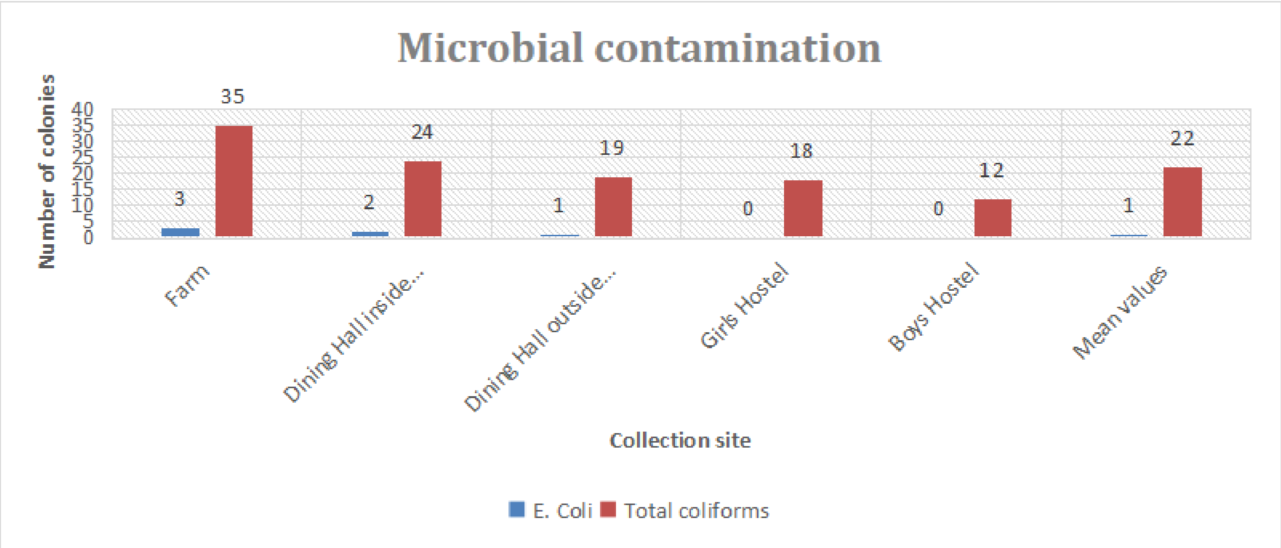

Figure 4.3 Results of the microbial contaminants in the various water sources on the Africa University campus

4.4 The concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply

This section provides the concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply.

Table 4.4. The mean variations of concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply

Heavy metal	Collection sample sites (mean values)					WHO VALUES
	Farm	Dining Hall inside tap	Dining Hall outside tap	Girls Hostel	Boys Hostel	
Cadmium	0.045 µg/L	1.103 µg/L	0.372 µg/L	0.552 µg/L	0.870 µg/L	0.003 µg/L
Lead	0.022 µg/L	1.013 µg/L	0.260 µg/L	0.925 µg/L	1.230 µg/L	0.01 µg/L
Chromium	0.030 µg/L	0.645 µg/L	0.190 µg/L	1.045 µg/L	1.225 µg/L	0.05 µg/L
Arsenic	0.019 µg/L	0.580 µg/L	0.099 µg/L	1.140 µg/L	0.666 µg/L	0.01 µg/L

Source: Primary data, (2025)

The highest concentration of lead and chromium was found in the water samples collected from the boys' hostel with mean values of 1.230 and 1.225 respectively The WHO guideline for chromium in drinking water is 0.05 µg/L. The levels in the dining hall and hostels exceed the WHO guideline, indicating potential health risks, including skin irritation and respiratory issues, as well as long-term effects on the liver and kidneys.

The highest concentration of arsenic was found in the water samples collected from the girls' hostel with a mean value of 1.140. The WHO guideline for arsenic in drinking water is 0.01 µg/L. The levels in the dining hall and both hostels significantly exceed the WHO guideline, posing serious health risks, including cancer and skin lesions, as well as developmental effects in children.

The highest concentration of cadmium was found in the water samples collected from the dining hall inside tap with mean value of 1.103. The WHO guideline for cadmium in drinking water is 0.003 µg/L. The levels in the dining hall inside tap and both hostels exceed the WHO guideline, indicating potential health risks associated with long-term exposure to cadmium, which can lead to kidney damage and other health issues. The concentrations of these contaminants in the water samples collected from the dining hall outside tap were comparatively lower. The farm had the lowest concentration of all four contaminants ranging from mean of 0.019 to 0.045. Below shows the visual presentation of the mean variations of the heavy metal concentrations.

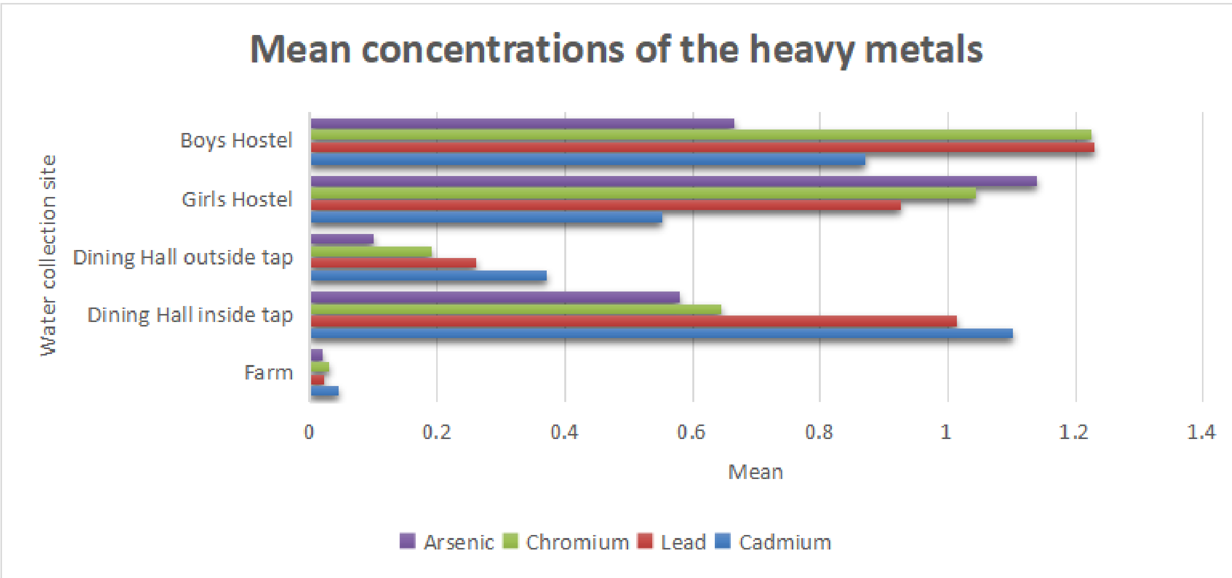

Figure 4.4. The mean variations of concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply

4.5 The results of the isolated organisms from water bodies at Africa university resistant to a certain line of drugs.

This section provided the results of the isolated organisms from water bodies at Africa university resistant to a certain line of drugs. The table below shows the results. The antibiotic drugs that were used were; Ciprofloxacin, Gentamicin, Chloramphenicol, Ampicillin and Tetracycline. The drugs were tested 6 times where *E. coli* was isolated.

Table 4.4 the antimicrobial resistance patterns of E. coli isolated (n=6 times each)

Antibiotic used	Frequency of antimicrobial resistance of E. coli
Ciprofloxacin	1
Gentamicin	2
Chloramphenicol	3
Ampicillin	6
Tetracycline	5

Source: Primary data, (2025).

The study showed that the overall mean resistance was 3. Meaning those antibiotics that had resistances of below 3 are critical for treatment of *E. coli* infections. However, the results showed that ciprofloxacin and gentamicin are the least resisted antibiotics with ciprofloxacin being the least resisted antibiotic with 16.7% that is 1 out of 6 times it was used. Ampicillin and tetracycline are the most resisted antibiotics with resistances of 100% and 83.3% respectively. However, chloramphenicol has the resistance which is equal to the mean therefore using it can have a 50% chance of failure or success on treatment of E. coli infections. The figure 4.4 is provided below to show the antimicrobial resistance pattern.

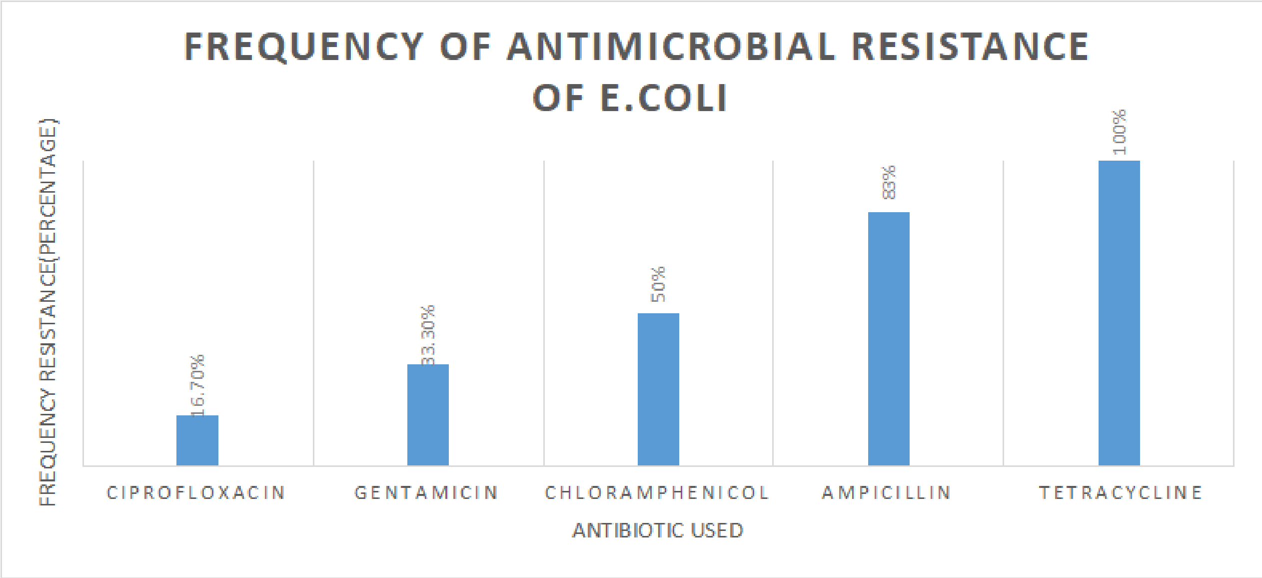

Figure 4.4. The antimicrobial resistance patterns of E. coli isolated

4.5 Chapter summary

This chapter discusses the results of the assessment of microbial water quality and heavy metal contamination in the campus water supply at Africa University, 2025. The results of the prevalence of microbial contaminants in the various water sources on the Africa University campus was discussed. The results of the isolated organisms from water bodies at Africa university resistant to a certain line of drugs was also provided. The concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply were provided.

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

This chapter provided the discussion of the the assessment of microbial water quality and heavy metal contamination in the campus water supply at Africa University, 2025. The summary of the major findings, conclusions and recommendations were provided in this chapter.

5.2 Findings

5.2.1 Microbial contaminants in the various water sources on the Africa University campus

The water source from the farm has the highest contamination levels, followed by the dining hall inside tap, dining hall outside tap, girls' hostel, and boys' hostel. The data showed that the mean value of E. coli was 1 and for total coliforms was 22 CFU/100 mL. The water source from the farm is more susceptible to contamination from agricultural runoff, animal waste, and other environmental factors, making it the most likely to have high levels of E. coli and total coliforms. The WHO guideline states that E. coli should not be detected in 100 mL of drinking water. The presence of E. coli in the farm and dining hall taps indicates a potential health risk, as it suggests faecal contamination and the possible presence of pathogenic organisms. The WHO recommends that total coliforms should also be absent in drinking water. The high levels found in the farm and dining hall taps exceed safe limits, indicating a need for immediate action to improve water quality and reduce health risks

5.2.2 The concentrations of heavy metals including lead, cadmium, chromium and arsenic in the campus water supply

The highest concentration of lead and chromium was found in the water samples collected from the boys' hostel with mean values of 1.230 and 1.225 respectively The WHO guideline for chromium in drinking water is 0.05 µg/L. The levels in the dining hall and hostels exceed the WHO guideline, indicating potential health risks, including skin irritation and respiratory issues, as well as long-term effects on the liver and kidneys.

The highest concentration of arsenic was found in the water samples collected from the girls' hostel with a mean value of 1.140. The WHO guideline for arsenic in drinking water is 0.01 µg/L. The levels in the dining hall and both hostels significantly exceed the WHO guideline, posing serious health risks, including cancer and skin lesions, as well as developmental effects in children. The highest concentration of cadmium was found in the water samples collected from the dining hall inside tap with mean value of 1.103. The WHO guideline for cadmium in drinking water is 0.003 µg/L. The levels in the dining hall inside tap and both hostels exceed the WHO guideline, indicating potential health risks associated with long-term exposure to cadmium, which can lead to kidney damage and other health issues. The concentrations of these contaminants in the water samples collected from the dining hall outside tap were comparatively lower. The farm had the lowest concentration of all four contaminants ranging from mean of 0.019 to 0.045.

5.2.3 The isolated organisms from water bodies at Africa university resistant to a certain line of drugs.

Ciprofloxacin and gentamicin are among the least resisted antibiotics by E. coli due to their mechanisms of action and the relative lower prevalence of resistance mechanisms against these drugs in E. coli strains. Ciprofloxacin belongs to the fluoroquinolone class of antibiotics and acts by inhibiting bacterial DNA replication and transcription, while gentamicin is an aminoglycoside antibiotic that interferes with protein synthesis in bacteria (Thorslund et al., 2021).

E. coli strains exhibit relatively lower rates of resistance to ciprofloxacin and gentamicin compared to other antibiotics, likely due to the less frequent occurrence of specific resistance mechanisms, such as target site mutations or drug inactivation enzymes, against these drugs among E. coli isolates (Suleman et al., 2025). The use of ciprofloxacin and gentamicin as second-line or reserve antibiotics in the treatment of severe E. coli infections may contribute to the lower levels of resistance observed, as these drugs are often reserved for cases where resistance to first-line antibiotics is more common. This restricted use of ciprofloxacin and gentamicin may help slow the development of resistance in E. coli populations (Tella et al., 2025).

Ampicillin and tetracycline are often reported as the most resisted antibiotics by E. coli due to several factors. One reason for the high resistance levels to these antibiotics is the widespread and historical use of these drugs in both human medicine and agriculture. The overuse and misuse of ampicillin and tetracycline have exerted selective pressure on E. coli populations, leading to the development and spread of resistant strains (Zhang et al., 2023). Resistance to ampicillin often occurs due to the production of beta-lactamase enzymes that can inactivate the antibiotic, rendering it ineffective. Similarly, resistance to tetracycline can result from efflux pumps that actively remove the drug from bacterial cells or ribosomal protection proteins that prevent tetracycline from binding to its target site (Thorslund et al., 2021).

The presence of resistance genes on mobile genetic elements, such as plasmids, allows for the rapid dissemination of resistance mechanisms among different bacterial strains, including E. coli. This horizontal transfer of resistance genes contributes to the widespread resistance to ampicillin and tetracycline observed in E. coli isolates (Abdel-Rahim et al., 2025**.** .The high resistance levels of E. coli to ampicillin and tetracycline are attributed to the historical use of these antibiotics, the presence of specific resistance mechanisms, and the ability of resistance genes to transfer horizontally among bacterial populations.

5.3 Conclusion

This study reveals critical public health concerns in the Africa University water supply. While microbial contamination levels may seem moderate, the detection of *E. coli* and total coliforms above WHO-recommended limits confirms faecal contamination and the potential for waterborne disease transmission.

The presence of antimicrobial-resistant *E. coli*, especially with high resistance to ampicillin and tetracycline, highlights a growing environmental AMR threat likely linked to agricultural and wastewater practices.

Additionally, several water sources—particularly in the hostels and dining areas—show heavy metal concentrations (lead, cadmium, chromium, arsenic) that exceed WHO limits, posing long-term health risks such as organ damage and carcinogenic effects.

Collectively, these findings underscore the urgent need for improved water treatment systems, routine monitoring, and stricter controls on antibiotic use to protect the health of the university community.

5.4 Recommendations

1. Based on the high chemical contamination, Africa University should establish a comprehensive water quality monitoring program, focusing on heavy metal testing in highrisk areas such as the hostels. The university should also invest in modern water treatment

technologies, including filtration and reverse osmosis, to reduce contaminant levels and meet WHO drinking water standards.

2. Based on the high resistance in faecal contaminants, the university and associated stakeholders should reduce the non-essential use of antibiotics in agriculture to limit environmental antimicrobial resistance, particularly among waterborne organisms.

3. Timely repair of damaged water infrastructure and the restriction of agricultural activities near water sources are essential to minimize microbial contamination risks.

5.5 Discussion of findings

The findings from the water quality analysis demonstrate that the farm water source exhibited the highest contamination levels, particularly in E. coli and total coliforms, likely due to susceptibility to agricultural runoff and animal waste. This poses a significant health risk as per WHO guidelines. Furthermore, the presence of concerning levels of lead, chromium, arsenic, and cadmium in the water samples from the hostels and dining hall exceeds safe limits, indicating potential health hazards such as skin irritation, respiratory issues, and organ damage. On the other hand, the study showed that E. coli strains have lower resistance to antibiotics like ciprofloxacin and gentamicin, which are crucial in treating severe infections. Proper intervention strategies are crucial to address the water quality issues and potential health risks identified in this study.

5.6 Areas of further research

There should be an analysis of the environmental impact and health impact on water quality at Africa University

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Appendix 1: Timeframe

Month	Week	Activity
January	1	Finalize study design and methodology. Obtain ethical approval from the university's ethics committee.
	2	Recruit and train research staff on sampling and analysis procedures
	3	Conduct a pilot study to test sampling techniques and data collection methods. Analyse preliminary data to refine methodologies.

	4	Review pilot study results and make necessary adjustments to the study design.
February	1	Conduct water sampling from designated sources across the campus.
	2	Collect health related data through survey.
	3	Continue water sampling and complete data collection.
	4	Ensure all samples are properly labelled and transported to the laboratory for analysis.
March	1	Perform microbial and heavy metal analysis on collected water samples.
	2	Document and maintain records of laboratory results.
	3	Analyse data using statistical software to assess water quality and health outcomes. Prepare preliminary findings and interpretations.
	4	Compile and finalize the report, including recommendations based on the findings. Prepare for dissemination of results e.g. presentations or publications.

Appendix 2: Budget

Category	Cost (USD)
Materials and supplies	100
Laboratory analysis	200
Transportation costs	100
Unforeseen expenses	100
Total	**$500**

Appendix 3: Letter requesting for permission.

To : The Registrar Africa University

I hope this letter finds you well. My name is Lindiwe Harriet Dube, I am writing to request permission to conduct a study at Africa university main campus as part of my research on water quality assessment. The study aims to assess the quality of drinking water at Africa university main campus in the year 2025.

Given the mining and farming activities that happen around the university there is need to assess the quality of water for both microbial and heavy metal contamination to avoid usage of unsafe water by the university campus family. I believe that conducting this study will help maintain acceptable water quality at Africa university. I assure you that the research will adhere to all ethical guide lines and will prioritize confidentiality and the well-being of all participants involved. I would be grateful for the opportunity to discuss this study further and address any questions or concerns you may have.

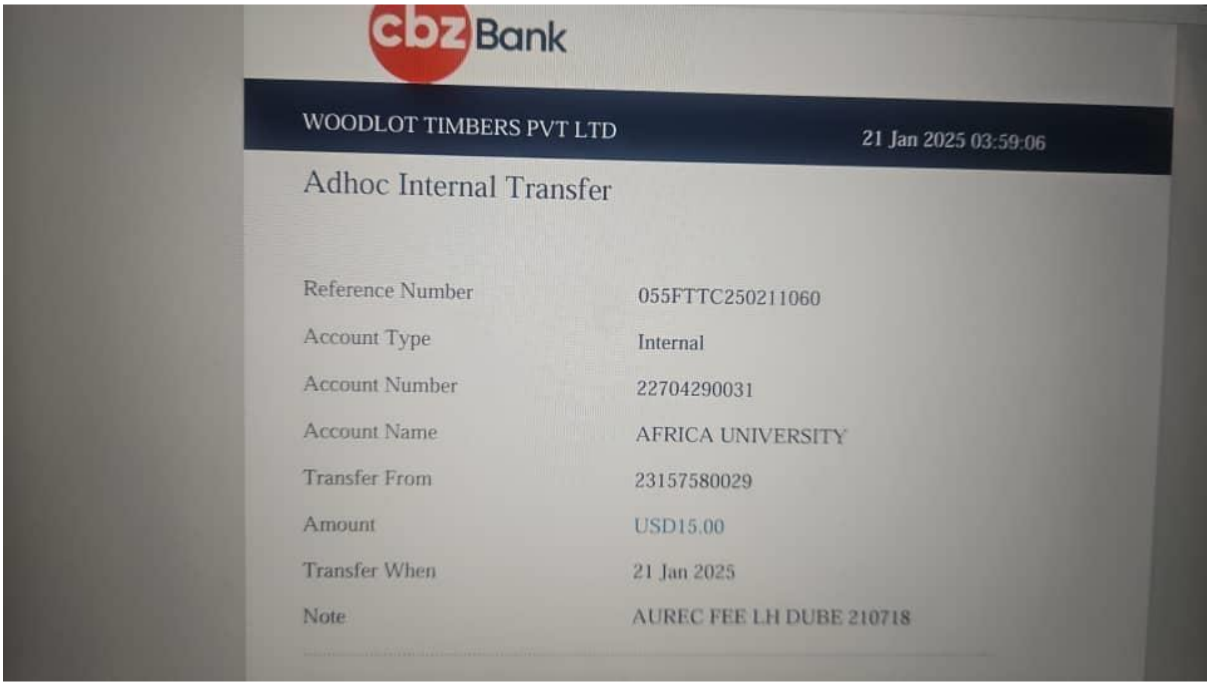
Thank you for considering my request. I look forward to your positive response.

Sincerely

Lindiwe Harriet Dube

[Africa university Student]

Appendix 4: AUREC fee proof of payment.



cbz Bank

WOODLOT TIMBERS PVT LTD 21 Jan 2025 03:59:06

Adhoc Internal Transfer

Reference Number	055FTTC250211060
Account Type	Internal
Account Number	22704290031
Account Name	AFRICA UNIVERSITY
Transfer From	23157580029
Amount	USD15.00
Transfer When	21 Jan 2025
Note	AUREC FEE LH DUBE 210718

Appendix 5 : Letter from Supervisor

AFRICA UNIVERSITY
(A United Methodist-Related Institution)

"Investing in Africa's Future"

DEPARTMENT OF BIOMEDICAL AND LABORATORY SCIENCES
COLLEGE OF HEALTH, AGRICULTURE AND NATURAL RESOURCES

17 January 2025

The Director
Africa University Research Ethics Comminette

Dear Sir/ Madam

RE: APPLICATION FOR SUBMISSION OF PROJECT PROPOSAL FOR LINDIWE DUBE

This letter serves to confirm that I am supervising the above-mentioned student in her final year dissertation. She has satisfied the requirements of the college in developing her research proposal and it is ready for ethical review.

Your facilitation for the review of the proposal is greatly appreciated.

Thank you

Mr Z Chiwodza
Research Supervisor
zchiwodza@africau.edu

P.O. BOX 1320, MUTARE, ZIMBABWE. TEL (263-220) 60075/60026/61611/61618. FAX (263-20) 61785. E-MAIL: registrar@africau.edu

08 April, 2025

REGISTRAR'S OFFICE

A UNITED METHODIST- RELATED INSTITUTION

Lindiwe Harriet Dube
C/O Africa University
Box 1320
MUTARE

E-mail: dubel@africau.edu

Dear Lindiwe

RE: PERMISSION TO CONDUCT RESEARCH AT AFRICA UNIVERSITY: ASSESSMENT OF MICROBIAL WATER QUALITY AND HEAVY METAL CONTAMINATION IN THE CAMPUS WATER SUPPLY AT AFRICA UNIVERSITY, 2025.

We acknowledge receipt of your email dated 18 February, 2025 regarding the above.

We have pleasure to inform you that your application to carry out the above titled research at Africa University has been approved in line with the Africa University Research Ethics Committee (AUREC) terms and conditions.

Please liaise with relevant offices to access secondary data for your research.

We wish you success in your studies.

Yours faithfully,

DR. P. L. MANGEZVO REGISTRAR

cc AUREC

APPENDIX 6: Study site Approval

APPENDIX 7: Letter from AUREC

"Investing in Africa's future"

AFRICA UNIVERSITY RESEARCH ETHICS COMMITTEE (AUREC)

P.O. Box 1320 Mutare, Zimbabwe, Off Nyanga Road, Old Mutare-Tel (+263-20) 60075/60026/61611 Fax: (+263 20) 61785 Website: www.africau.edu

Ref: AU 3617/25

18 February, 2025

LINDIWE HARRIET DUBE
C/O Africa University

Box 1320

MUTARE

RE: ***ASSESSMENT OF MICROBIAL WATER QUALITY AND HEAVY METAL CONTAMINATION IN THE CAMPUS WATER SUPPLY AT AFRICA UNIVERSITY, 2025.***

Thank you for the above-titled proposal you submitted to the Africa University Research Ethics Committee for review. Please be advised that AUREC has reviewed and approved your application to conduct the above research.

The approval is based on the following.
a) Research proposal

- **APPROVAL NUMBER** AUREC 3617/25
  This number should be used on all correspondences, consent forms, and appropriate document

- **AUREC MEETING DATE** NA
- **APPROVAL DATE** February 18, 2025
- **EXPIRATION DATE** February 18, 2026
- **TYPE OF MEETING**: Expedited
  After the expiration date, this research may only continue upon renewal. A progress report on a standard AUREC form should be submitted a month before the expiration date for renewal purposes.
- **SERIOUS ADVERSE EVENTS** All serious problems concerning subject safety must be reported to AUREC within 3 working days on the standard AUREC form.
- **MODIFICATIONS** Prior AUREC approval is required before implementing any changes in the proposal (including changes in the consent documents)
- **TERMINATION OF STUDY** Upon termination of the study a report has to be submitted to AUREC.

AFRICA UNIVERSITY
RESEARCH ETHICS COMMITTEE (AUREC)

APPROVED
P.O. BOX 1320, MUTARE, ZIMBABWE

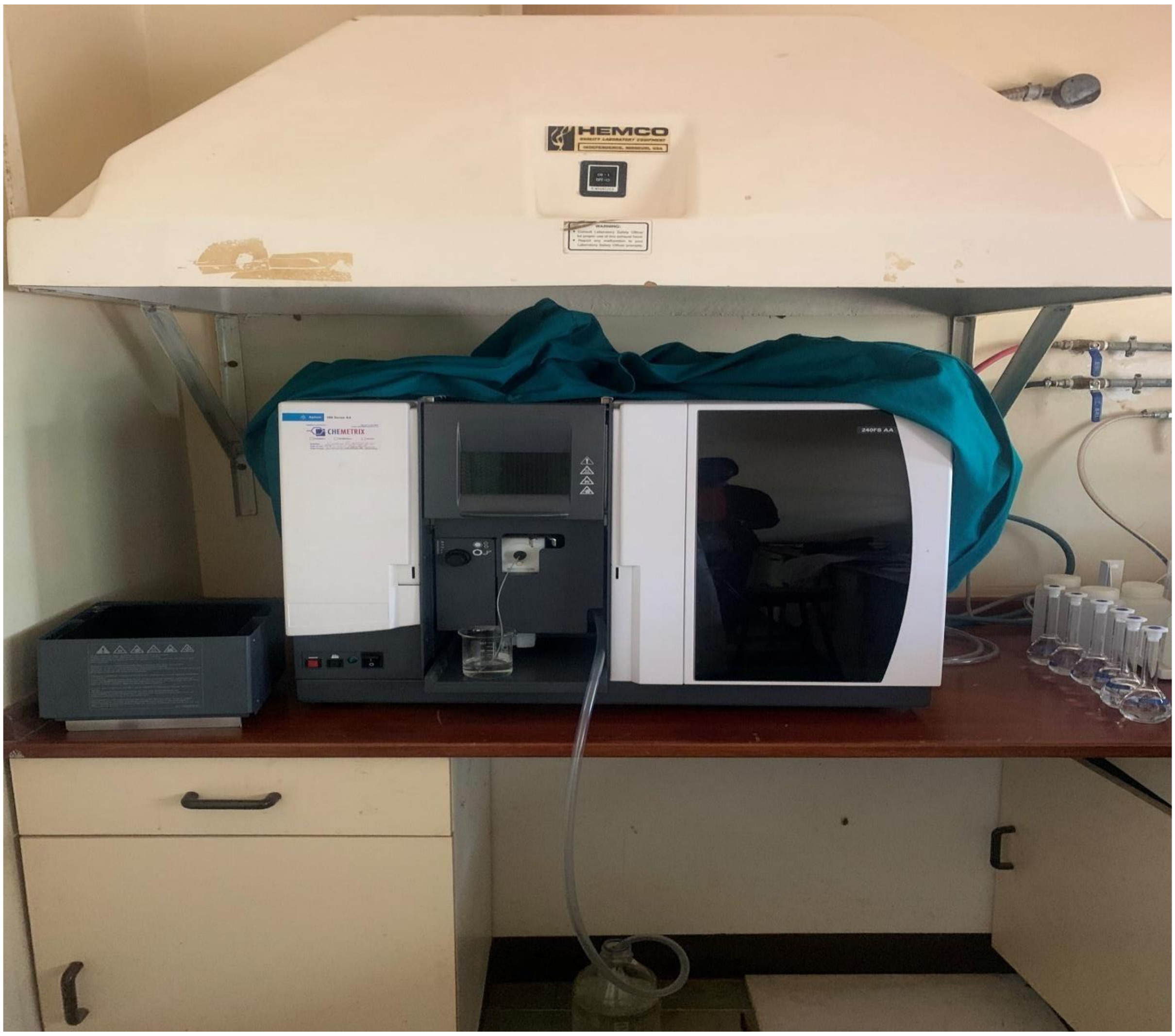
Yours Faithfully

Chinzou

MARY CHINZOU FOR CHAIRPERSON
AFRICA UNIVERSITY RESEARCH ETHICS COMMITTEE

APPENDIX 8: MATERIALS USED MICROBIAL TESTING

Atomic Absorption Spectrophotometer



Water testing kit

Water ready for filtering

Materials needed

Sterile 1litre bottles

Acid washed containers (for heavy metal analysis)

Permanent marker

Cooler box

Ice packs

Sterile Membrane filter

Known positive and Negative controls (for QC)

Petri dishes

Sterile pads

Lauryl Sulphate media

Sterile pipets

Ethanol

Methylated spirit

Forceps

Filter membrane

Filter chamber

Antimicrobial disk

Atomic Absorption Spectrophotometer

Nitric acid

Sterile swab

Gloves

Lighter

Lab coat

PROCEDURE Sample collection procedure

- Label one-liter sterile containers with collection site and date
- Collect samples directly from the water source, avoid contact with the hands or other surfaces.
- Fill the container to the neck and cap it tightly
- Store samples in a cooler with ice packs and transport them to the laboratory within 24 hours of collection.

Laboratory procedure (microbial analysis)

- Label petri dishes with collection site and date, each water sample should have its own petri dish
- Sterilize all the equipment using methanol and flame.
- Using a pad dispenser place one pad on each petri dish.
- Using a pipet, soak the pad with lauryl sulphate media.
- Filter 100ml of sample water through the membrane filter and place on Lauryl sulphate media.
- Incubate the plates at 37 degrees Celsius for 24 hours.
- After incubation, count the number of colonies that exhibit characteristic E. coli morphology (yellow colonies on lauryl sulphate)
- If E. coli is present further incubate at 44 degrees celicius to confirm if it's a true positive
- Calculate the concentration of E. coli in CFU/100ml of water.
- After calculating concentration, perform Antimicrobial susceptibility testing on the E. coli. By:
    - Prepare a bacterial suspension by inoculating organism picked from MacConkey agar using a sterile inoculation loop into saline, mix well to disintegrate any clumps. The suspension should meet the McFarland standard.
    - Open a sterile swab, dip it into the tube with bacterial suspension, move the swab in the suspension as if you are mixing.

- After collecting bacteria, loan/ inoculate the bacteria into the Mueller-Hinton agar plate.
- Place antimicrobial disks into the plate, incubate for 24 hours.
- After incubation read the results to see which drug is resistant and which drugs are sensitive.

Record all observations including colony counts and any abnormalities.

Quality Control measures

Include known positive and negative controls to ensure reliability of the tests.

Perform duplicate analyses for each sample to verify results

Ensure that all media and equipment are sterile to prevent contamination. **Laboratory**

Procedure (heavy metal analysis)

- Prepare a series of standard solutions for each heavy metal to create a calibration curve.
- Dilute water samples as necessary to fall within calibration range.
- Aspirate the sample into the atomic absorption spectrophotometer instrument.
- Measure absorbance at the specific wavelengths for each metal
- Compare absorbance readings to the calibration curve to determine concentrations in mg/l