EVALUATION OF THE ENVIRONMENTAL HEALTH RISKS OF ABATTOIR WASTES ON RECEIVING WATER SOURCES

GEORGE ONUNGA OCHIENG'

A Thesis Submitted in Partial Fulfillment for The Requirements of the Award of Master of Science Degree in Environmental Science Of Masinde Muliro University Of Science and Technology.

July, 2023

DECLARATION

This thesis is my original work, prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other award(s)

Signature……. Date……

Ochieng Onunga George SEV/G/08/2015

CERTIFICATION

The undersigned certify that, we have read and hereby recommend for acceptance of, Masinde Muliro University of Science and Technology, a thesis entitled: *Evaluation of The Environmental Health Risks of Abattoir Wastes on Receiving Water Sources.*

Signature……... Date……

Dr. Millicent Florence Owuor Ndonga

Department of Biological Sciences,

Masinde Muliro University of Science and Technology

Signature……... Date……

Dr. Mario Kollenberg

Department of Biological Sciences,

Masinde Muliro University of Science and Technology

COPYRIGHT

DEDICATION

This work is dedicated with immense gratitude to my wife Beatrice Andeyo and parents the Late John Onunga and Asha Mirenga who have contributed to my success.

ACKNOWLEDGEMENT

I would like to thank almighty God for his guidance and love throughout my Studies and I would also like to express my gratitude to my supervisors Dr. Millicent Ndonga and Dr. Mario Kollenberg for their guidance, constructive criticism, and suggestions throughout this work. The Masinde Muliro University of Science and Technology staff in the Department of Biological Sciences for their timely input and constructive suggestions. I am grateful to the County Director of Veterinary Services Kakamega for allowing me access to slaughterhouses in Lurambi Sub County.

My sincere gratitude goes to my parents for their unfailing love and support that built me into what I am. Thanks to my sister, brothers, colleagues, and friends for their care, encouragement, and love. My heartfelt gratitude goes to my family and lovely wife Beatrice Andeyo for their love, patience, and encouragement. They have been my source of inspiration and motivation during this research.

Onunga O.G

ABSTRACT

Slaughterhouse effluent consists of several solid and liquid pollutants. Solid pollutants include condemned meat parts, aborted foetuses, trimmings, horns, undigested ingesta, bones, and hairs while the liquid consist of blood, dissolved solids, urine, gut contents, and wastewater. Various studies have shown that abattoir wastes have negative impacts on the environment and are of public health concerns. The main objective of this study was to evaluate the environmental health risks of abattoir wastes on the receiving freshwater sources, Specifically, the study (i) analyzed the microbiological and parasitological characteristics of wastes generated (ii) determined the physicochemical characteristics of wastes generated and their impact on the receiving water bodies and (iii) evaluated knowledge and practice of abattoir workers on waste management. Specific objectives one and two were determined using the Standard Methods of Wastewater Analysis as described by the American Public Health Association and use of Hydro Lab Quanta Water Quality Monitoring System while data on the third objective was collected based on a cross sectional survey using questionnaire. The study was carried out at five abattoirs - Shirere, Savona, Emusala, Ejinja corner and Bukura. The data was analyzed using inferential, descriptive and ANOVA statistics with SPSS version 20.0. Results revealed the presence of pathogenic microbes both in the abattoir effluent and water samples. The most notable of were, E. coli, P. aerugenosa, K. pneumoniae, E. faecalis, and S. dysenteriae. A number of fungi species were also present that included, A. flavus, S. cerevisiae, A. fumigatus, A. niger, F. oxysporum and Penicillium spp. Parasites that included, B. coli, T. hominis, A. duodenale, and A. lumbroicoides were also isolated. The mean bacterial concentrations of effluent were 8.17×106 MPN/100ml of TC, 3.94x104 cfu/ml of FC, 2.84x104 cfu/ml, of E. faecalis, 8.65x104 cfu/ml, of E. coli, and effluent BOD of 828.04mg/l. The mean bacterial values of borehole water 0-250m from abattoir TC ranged from 50 to 270 MPN/100ml, FC 12 to 44 cfu/ml, E faecalis 0 to 30 cfu/ml, E. coli 0 to 19 cfu/ml, Fungi was 5 to 1880 cfu/ml, and parasites 0 to 30 egg/oocysts/litre which shows that the water is contaminated. Results of Physico chemical characteristics of bore hole water at 0-250m from abattoir varied with those at 251-500m in mean values of SPC - 292.03± 0.50 µs/cm, P^H=10.018±0.49, TDS=173.46±3.23mg/l, TSS=0.7704±0.06mg/l, Turbidity-4.359±1.88NTUs, COD = 8.38 ± 0.76 mg/l, and the values were higher than the levels permitted by WHO for drinking water. The survey results clearly show that waste control measures were inadequately practiced despite waste management awareness among abattoir workers. Fifty-six percent of abattoir workers were in agreement that abattoir wastes were not properly disposed. River water and borehole water positively correlated with general health at r=0.208, r=0.2016, significant at $p<0.01$ respectively. There was also a significant negative correlation (r=-0.972, $p<0.01$) between bad odour and distance from the abattoir. The results clearly show that abattoir wastes result in pollution of the surrounding freshwater sources. These results are of great significance to the County government in the formulation of waste disposal policies. There is clearly a need for cleaner effluent treatment technologies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

ANOVA Analysis of Variance

APHA American Public Health Association.

BOD Biochemical Oxygen Demand

COD Chemical Oxygen Demand.

DO Dissolved oxygen

EC Electrical Conductivity

EMCA Environmental Management Coordination Act.

EPA Environmental Protection Agency.

FAO Food Agriculture Organization.

NEMA National Environment Management Authority.

SPSS Statistical Package for the Social Sciences

SWW Slaughter wastewater.

TC Total coliforms.

TDS Total Dissolved Salts.

TSS Total Suspended Solids.

TVC Total viable counts.

WHO World Health Organization.

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

Abattoirs, also known as slaughterhouses, generate waste that must be handled properly to protect the public and the environment (NEMA, 2014). In urban areas with high population density, large quantities of solid waste are produced, and improper disposal can have significant negative impacts on the environment (NEMA, 2014).

An abattoir is a specialized facility approved for hygienic ante mortem inspection, slaughtering, and carcass processing of animals to produce meat and meat products for human consumption (Alonge, 2005). Developed countries have regulated and closely monitored waste management systems that reduce risks to public health (Rushton, 2003; Ferronato *et al.,* 2019). However, in developing countries, particularly over the last 15-20 years, solid waste management has been prioritized while waste generated by livestock markets, abattoirs, and related facilities has been neglected (World Bank, 2009; Kaza *et al.,* 2018).

In developing countries like Kenya, most slaughterhouses are privately owned or operated by county governments. These abattoirs are characterized by poorly maintained buildings and operate beyond their original capacity (Cook *et al.,* 2017). If the waste from these facilities is not managed appropriately, it can lead to public health and environmental disasters (World Bank, 2009). This situation is exacerbated by the increasing annual per capita meat consumption due to population growth and rising

income levels. This has resulted in a higher number of animals slaughtered daily to meet market demand (FAO, 2010). The increased number of animals being slaughtered generates more waste that needs efficient handling to minimize the environmental contamination (Ilija, 2015). Abattoir waste can be solid, liquid, or gaseous in nature. It also contributes to climate change through acidification, eutrophication of water bodies, global warming and high consumption of water and energy. Liquid waste includes wastewater, blood, gut contents, urine, and dissolved solids. Gaseous waste consists of odours and emissions, while solid waste includes hooves, bones, paunch contents, condemned parts, hairs, and occasionally aborted foetuses (Fearon *et al.,* 2014).

In developing countries, slaughterhouses are stratified into three distinct groups based on the year of development and where products are to be marketed. The first strata are modern, technologically equipped abattoirs that process meat products for export and sale to high-end local meat markets. The second strata are large abattoirs in major towns owned by County governments that were poorly designed a long time ago and have obsolete equipment. They have poor waste management facilities, creating tremendous pollution problems. The last strata are slaughter slabs, which vary from small to medium in size and are owned privately or by the County government and are characterized by poor manufacturing practices and disposal of waste (FAO, 2008). In Kenya, under the Meat control act (Government of Kenya 2012), the Director of Veterinary Services is responsible for the categorization of all local slaughterhouses based on the criteria set out in the Second Schedule Category A slaughterhouses are large and have the capacity to process more than forty bovines/camels, fifty donkeys/horses, or twenty shoats. For pigs,

the number slaughtered depends on the size: fifteen units of porkers or thirty units of baconers or forty units of calves per day. Category B comprises medium slaughterhouses that can process between six to thirty-nine bovines/camels or nine to forty-nine donkeys/horses or sixteen to twenty-four shoats. For pigs, it will process one to seven small pigs two to fourteen porkers or four to twenty-nine bacon pigs or four to thirty-nine calves per day with good manufacturing practices. Category C are slaughter slabs that can process up to five units of bovine /camels, eight units of donkey/horse, fifteen units of shots, six units of small pigs, two units of porkers, one unit of baconers pigs, or three units of calves per day. Slaughterhouse wastes have been associated with air pollution, transferable antimicrobial resistance patterns, and several infectious pathogens in humans such as *Escherichia coli*, tuberculosis, and parasitic cysts (Meiramkulova e*t al.*, 2021: Savin *et al*., 2020) Developing countries tend to have poorly developed water supply infrastructure (WHO 2006). Given that slaughtering operations require large quantities of water, most abattoirs are located next to underground/surface water bodies (Bhunia *et al*., 2021; Asibor *et al.,* 2020).

The harmful risk of abattoir wastes on water, air and land will tend to occur when the wastewater is improperly channelled into water bodies and heaps of poorly disposed solid wastes are left unattended in open spaces. These act as non-point sources of pollution when precipitation occurs. The water bodies also act as the most convenient way to dispose of abattoir wastes because they lack waste treatment facilities and are not connected to sewer lines (Adelegan, 2002; Obidiegwu *et al.,* 2019: Abubakar, *et al.,* 2023). The pollution of water bodies leads to the proliferation of pathogenic microbes

that impact macroinvertebrates in rivers and ponds downstream of the abattoirs (Ibemenuga *et al*., 2017). It is also known that the air around most abattoirs tends to be offensive because of gases that result from the putrefaction of blood, condemned meat parts, rendering operations, and poor anaerobic treatment lagoons. (Enterprise Ireland, 2009). The physicochemical and microbiological characteristics of abattoir wastes and wastewater effluents vary daily and are influenced by the numbers and type of animals slaughtered (Weobong *et a*l.,2011).These wastes are organic with elevated levels of dissolved salts, suspended solids, grease, and fats which have been shown to cause changes in pH, Temperature, Chemical Oxygen Demand (COD), Turbidity, Total suspended solids (TSS), and Biochemical Oxygen demand (BOD) of surface water and underground water aquifers due leachates and runoffs (Omole *et al*.,, 2008: Isoken *et al*., 2018).

1.1 Statement of the problem

Abattoir waste disposal is problematic in less developed countries of Asia and Africa (Abubakar *et al.,* 2023). In countries like Ghana, Cameroon, Nigeria, Rwanda and Kenya, abattoir wastes have been reported to pollute air, water and soils posing serious public health risks (Nwanta *et al*., 2008; Koech *et al*., 2012; Regina *et al*., 2017). Increased industrialization, urbanization, and human and animal populations in developing countries have resulted in an increase in salmonellosis, tuberculosis, trichinosis, and cysticercosis, making abattoirs on the public health surveillance radar (Nwanta *et al.,* 2008). The livestock sector in Kakamega County has grown tremendously due to an increase in urbanization and population growth, guarantying the market for meat. This

has increased abattoir wastes. There are fifty-six registered slaughterhouses in Kakamega County ((Government of Kenya 2012, County Government of Kakamega 2018; County Government of Kakamega 2014). Fifty-four of these are class C while two are class B, and there is no export slaughterhouse class A. The establishment of abattoirs and the management of the resulting wastes in Kenya are currently under the control of the county governments following the enactment of the 2010 constitution. Similar to other African nations, this function has been neglected by County governments, resulting in mushrooming of poorly constructed slaughterhouses, deterioration of the already existing slaughterhouses, and an inadequate number of meat inspectors. This has resulted in improper meat inspection services and poor waste management that affect public health (Nwanta *et al*, 2008). Media in Kenya have reported NEMA closing various slaughter slabs in the country, for example fifteen Kiamaiko slaughter slabs in Nairobi for depositing wastes in the Nairobi River (Omulo, 2018).

Due to poor disposal practices, untreated abattoir wastes are channelled into open drainages and surrounding water bodies, while the leachates percolate enteric pathogens and nutrients into aquifers, contaminating boreholes near abattoirs that are used for drinking water. The abattoir grounds are covered with decomposing wastes such as uncovered condemned meat pits and soak pits, which attract rodents, flies, and domestic carnivores, which are known vectors of diseases (Regina *et al.,* 2017). This is despite the fact that good manufacturing practices that entail proper abattoir processing operations and management, including efficient ante mortem (inspection of live animal), slaughtering operations, post-mortem (carcass examination), and waste management, are

crucial in the surveillance of zoonoses in addition to ensuring suitable meat and meat by-products. This has raised concerns among public and private stakeholders in the meat industry. This study evaluated the environmental health risks of abattoir wastes in receiving water sources in Lurambi Sub County.

1.2 Justification of the Study

The waste generated by abattoirs in developing countries is a major concern due to its potential negative impacts on public health and the surrounding environment (Abubakar *et al*., 2023). These wastes can act as both point and non-point sources of pollution, with improper disposal resulting in their entry into water bodies. This leads to pollution and the proliferation of pathogenic microbes, which can have a detrimental impact on riverine macrofauna and downstream ponds (Ibemenuga *et al.*, 2017).

Gaseous wastes produced by abattoirs contribute to offensive odours and air pollution, further exacerbating the environmental issues associated with these facilities (Enterprise Ireland, 2009). Additionally, the improper management of abattoir waste can contribute to the development and spread of transferable antimicrobial resistance patterns and infectious pathogens in humans, including *Escherichia coli*, tuberculosis, and parasitic cysts (Meiramkulova *et al*., 2021; Savin *et al*., 2020).

The inadequate waste management facilities in most abattoirs in developing countries create significant pollution problems, resulting in negative environmental impacts, public health disasters, and the potential spread of infectious diseases (Nwanta *et al*., 2008;

Koech *et al.,* 2012; Regina *et al*., 2017). It is crucial to address these challenges and improve waste management practices to mitigate the adverse effects on both human health and environment.

1.3 Objectives

The main objective of this study was to evaluate the environmental human health risks of abattoir wastes on receiving water sources in Lurambi Sub-County

1.3.1 Specific Objectives

i. To determine the physicochemical characteristics of wastes generated and their impacts on water sources next to abattoirs.
ii. To analyse the parasitological and microbiological characteristics of wastes generated at abattoir facilities
iii. Evaluate the knowledge and practice of abattoir workers and environmental health implications on resident neighbouring abattoirs.

1.3.2 Research Questions

i. What are the physicochemical characteristics and impacts of wastes released into the water sources next to abattoirs in relation to the set limits?
ii. What are the parasitological and microbiological characteristics of wastes released into the environment and are they within the set limits?
iii. What is the knowledge and practices of abattoir workers on waste management and are abattoirs contributing factors to environmental health hazards?

1.4 Significance of the study

The significance of this study lies in its contribution to address pressing issues related to abattoir waste management in Kenya, specifically in the Lurambi Sub-County. The rapid urban growth and increasing human population in the country have resulted in a rise in per capita income and meat consumption. However, the implementation of existing laws and policies, such as the Environmental Management Coordination Act, has been inadequate, leading to public health and environmental risks (NEMA, 2014).

Abattoir waste streams have been linked to water, soil and air pollution, as well as antimicrobial resistance patterns and sources of pathogens to humans (Adelegan, 2002; Adeyemo, 2002; Abiade *et al*., 2006; Nwanta *et al.,* 2008; Omole *et al*., 2008). By conducting this study, it is expected to raise awareness among the County Department of Veterinary Services, County Department of Public Health, and NEMA regarding the need for proper management practices in abattoirs within Kakamega County. This can lead to policy considerations and the implementation of effective waste management strategies. Furthermore, the findings of the study can provide opportunities for the recycling and utilization of abattoir waste materials, and the adoption of cleaner production technologies. These practices can reduce environmental pollution and improve sustainability in the meat industry. Additionally, documenting the current status of abattoir waste management in Lurambi Sub-County will serve as a valuable resource for future research and decision-making processes in the region.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the literature on abattoir waste generation, its characteristics, and environmental risks, as well as the abattoir workers' knowledge and attitude toward waste management. In addition, it examines the microbiological, parasitological, and physicochemical effects of abattoir waste on receiving waters, as well as conformity with WHO guidelines (table 1).

Table 1: WHO Guideline of water quality and effluent

SNO	Parameters	Abattoir waste	Drinking water
1.	pH	6.5-8.5	6.5-8.5
2.	Electrical Conductance µS/cm^3	1200	Not available
3	Total Dissolved Solids mg/l	1200	1500
4.	Total Suspended Solids mg/l	30	NiL
5.	Turbidity NTU	< 5	< 1
6	COD, max mg/l	50	10
7	Temperature	+3^{o}C of the water	Not available
8	Total Viable Count at 37		100
9	BOD (5 days at 20°C) /l	30	< 5
10	Coliforms	30	Nil
11	E. Coli in 250ml	Nil	Nil
14	Streptococcus faecalis	Nil	Nil
15	Shigella in 250ml	Nil	Nil

2.2 Physicochemical characteristics of Abattoir wastes and their impacts on water sources

Waste water physicochemical qualities can vary greatly depending on its source and the specific actions that have contributed to its contamination. Colour, pH, temperature, turbidity, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TDS), and total suspended solids (TSS) are the key characteristics of abattoir wastewater that are normally examined. Nutrients such as nitrogen and phosphorus can also be found in high concentrations in wastewater, causing eutrophication in natural water bodies (Ullah *et al*., 2022).

Blood is an inevitable byproduct of meat processing procedures and accounts for some 4% of the live animal weight (Wismer-Pedersen, 1988). The oxygen requirement for oxidation of animal blood is generally high. BOD_5 in cattle blood is 156,500mg/l, while COD is 218,300mg/l. When blood is discharged into streams, it causes a decrease in dissolved oxygen (DO). Blood contains 2400 mg/l of nitrogen and 1500 mg/l of phosphorus, according to studies (Tritt *et al.,* 1992: EPA 2004).

Undigested materials in ruminant first stomach have a high amount of total suspended particles, a high BOD_5 of 50,200mg/l, an 88% moisture content, a COD of 177,300mg/ and organic content, a strong disagreeable odour, and are a breeding ground for pathogens (Wilson 1992). The solid components produce the most pollution burden, accounting for 40% and 73% of the BOD and COD, respectively. The discharge of rumen contents or paunch dung in aquatic environments can result in excessive oxygen demand and the

development of harmful microorganisms. Various researchers have analyzed abattoir wastewater. Studies by Ullah *et al.,* (2022) in Minna abattoir, yielded mean values of 5257.50 mg/l, 2630.00 mg/l, and 5830.00 mg/l for total suspended solids (TSS), Biochemical oxygen demand (BOD), and Chemical oxygen demand (COD), respectively. These values are higher than the WHO guidelines limits of 20 mg/I, 20 mg/l, and 1000 mg/l.

Omole *et al*., (2008) reported a chemical oxygen demand of 375000 mg/l for raw bovine blood in their study on the iimpact of abattoir effluents on river Illo, Ota, Nigeria. A study by Gauri (2007) on abattoirs in Québec, Canada, yielded Total Solids concentrations at 2333-8620 mg/l and Total Suspended Solids at 736-2099 mg/l. There is scant data on physical chemical characteristics of abattoir waste water in Kakamega County.

2.2 Microbial and Parasitological Characteristics of abattoir wastes

The microbiological and parasitological characteristics of abattoir wastes are of great interest because of their great pollution potential. The quality of slaughterhouse wastewater is determined by the cleaner production technologies utilized, which may include blood capture systems, grease and oil traps, blood retention during the bleeding process, amount of water used, and amount of meat processing activities (Masse *et al*., 2000).

Pathogenic bacteria such as *Escherichia coli, Salmonella* spp., *Campylobacte*r spp., and *Listeria monocytogenes* can be found in animal carcases and waste. In a study conducted by Ullah. *et al*., (2022) in Nigeria's Minna abattoir, numerous bacteria were isolated from

waste, including *Bacillus, Streptococcus, Escherichia, Klebsiella, Staphylococcus, Pseudomonas, Salmonella*, and *Penicillium* spp.These findings are consistent with of studies by Coker *et al.,* (2001) on Abattoir Wastewater Quality in Southwestern Nigeria, Svanstrom (2014) on Pathogens and Antibiotic-Resistant Bacteria in Abattoir Waste and Animals, Adegbola *et al.*, (2012) and Hassan *et al*., (2014), who isolated various bacteria from abattoir effluents.

A number of fungal species have been reported in abattoir wastes that include, *Aspergillus* spp *Penicillium* spp, *Candida* spp, *Cryptococcus* spp and *Trichosporon* spp. with *Candida lusitaniae, Cryptococcus neoformans, Candida tropicalis, Candida zeylanoides, Candida gulliernondii, Candida fermata*, and T*richosporon mucoides* (Ullah *et al.,* 2022; Rabah *et al.,* 2008).

Protozoa and helminths are intestinal parasites that infect both humans and animals. Prevalence and distribution of intestinal parasites in refuse, human, and animal wastes have been reported by various studies. Victoria *et al*., (2020) in a study on abattoir waste in Jos Metropolis Nigeria several intestinal parasites were isolated, including *Ascaris suum, Trichuris trichiura, Ancyclostoma duodenale*, *Strongyloides stercoralis, Taenia spp.,Enterobius vermicularis, Trichostrongylus, Diphyllobothrium latum, Schistosoma intercalatum, Fasciolopsis buski, Fasciola hepatica*, and *Metagonimus yokogawai. Oocysts of Entamoeba coli, Entamoeba histolytica, Giardia lamblia, Trichomonas hartmani, Balantidium coli,* and *Cryptosporidium* were also isolated. Similar to studies by Udoh *et al*., (2019).

2.4 Environmental and Public health effects of Abattoir Wastes.

The increased demand for meat as a result of urbanization has prompted the establishment of numerous slaughterhouses. Abattoir operations in low-income nations are technologically less developed, with poor waste handling and disposal systems, when compared to industrialized countries where waste creation, analysis, and treatment are prerequisites for building abattoirs (Coker *et al.,* 2001: Chukwu, 2008).

Poor abattoir waste disposal can have negative effects on the environment including, human health and. Some slaughterhouses in trading centres are littered with bones, hones, condemned meat parts, blood, urine, and wastewater, all of which can be recycled. Failure to manage this waste can lead to environmental hazards, public health problems, and ecological contamination.

Water quality is a major concern in the developing world, with drinking water sources increasingly threatened by contamination, with far-reaching implications for human health, economic and social development of communities and nations. Because, in most developing countries' water supply infrastructure is inadequate and has poor coverage, most abattoirs and adjacent communities depend on hand-dung wells and surface waters as sources of water. Aniobi *et al*., (2020).

Abattoir wastes pose an environmental threat due to high total suspended solids and foul odour. Poorly disposed effluent wastewater from abattoirs on surface water bodies has been found to raise the pH, temperature, BOD, COD, total solids (TS), and turbidity (Weobong *et al.,* 2011; Adewumi *et al.,* 2016). Because of their proximity to abattoir

waste disposal sites, leachates pollute aquifers and transfer enteric pathogens, parasites, and nutrients into waterways (Adegbola *et al.,* 2012; Hassan *et al*., 2014). There is also the possibility of pathogenic infectious organisms with antibiotic resistance patterns being transferred to humans (Coker *et al*., 2001: Svanstrom (2014)).

Indifferent dumping and unsanitary discharge of abattoir waste effluents have been reported to be some of the factors responsible for the alteration of abattoir air quality, producing substances such as sulphides, hydrocarbons (Mercaptans), amines, and organic acids (Ubuoh *et al.,* 2017). This type of pollution produces a disagreeable odour that has negative health consequences for communities adjacent to abattoirs more so, on those with pre-existing medical conditions. Magaji and Hassan (2017) found that gaseous pollutants around the abattoir plants can surpass the acceptable limits, making the air harmful. Other research studies have found that abattoir operations in developing countries pollute the environment, either directly or indirectly, which can lead to serious health problems (Olowoporoku, 2016; Adonu *et al*., 2017; Daramola and Olowoporoku, 2017; Ubuoh *et al.,* 2017).

According to the World Health Organization (WHO 2018), exposure to air pollution can cause major health impacts ranging from respiratory disorders to chronic diseases with a high mortality rate (Ghorani-Azam *et al.,* 2016) and Wang *et al.,* 2018). Studies by Adeyemo *et al.*, (2002 has revealed that paunch waste heaped up near the abattoir produce methane gas, which enhances the greenhouse effect.

Unregulated abattoirs adversely impact the environment and biodiversity with consequences such as the introduction of contaminants into the environment, disruption of ecosystem functions, pathogen transmission, eutrophication of water bodies, and the accumulation of recalcitrant chemicals in soil. (Elemile *et al*., (2019); Hosu *et al*., (2021); Olanrewaju *et al*., (2022); Bello, (2023); Igbinosa *et al,* (2018); Ebong *et al*.., (2020); Esemu *et al*., (2022); Ogun *et al*., (2023); Akpoka *et al*. (2022}; Sampson *et al*., (2022). This calls for a proper and efficient abattoir waste management system.

To date, there is insufficient data on how abattoir wastes impact receiving water systems and the health of the adjacent communities.

2.4 Knowledge, Attitude, and Practice of Abattoir Workers on waste management

Abattoirs generate large volumes of wastes on a regular basis, making waste management a critical issue. Improper garbage disposal can cause pollution, disease outbreaks, and health risks for workers and the general public (Tolera *et al*., 2022). Inadequate knowledge, a negative attitude, and poor practice among abattoir workers have been linked to poor waste management, substandard facilities, unsanitary environments, and poor hygienic practices in developing countries (Tolera *et al*., 2022; Olowoporoku, 2016). This calls for programs that enlighten abattoir personnel on the necessity of good waste management and must be provided the necessary tools and equipment (Tolera *et al*., 2022). To prevent contamination and encourage safe waste handling and disposal, effective waste management infrastructure, including as waste bins and disposal facilities, must be accessible to abattoir personnel.

Workers can benefit from training and education programs that educate them on the various forms of waste generated in abattoirs, their potential environmental and health implications, and how to properly sort and dispose of trash. Workers can also be taught how to recycle and compost in order to reduce waste and enhance sustainability (Tolera *et al*., 2022).

Management may promote correct waste management practices in addition to education and training by introducing reward systems and recognizing personnel who display good waste management practices.

To summarize, enhancing abattoir workers' knowledge and attitudes toward waste management necessitates a multifaceted approach that combines education, training, incentives, and adequate infrastructure. Abattoirs can reduce their environmental effect and promote sustainability by following these techniques, while also preserving the health and well-being of their employees and the general public.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This chapter provides an overview of the study materials and methodology. It offers a summary of the research design employed, the study's target population, sample size, sampling methodology, and data collection procedures (both quantitative and qualitative). Finally, the techniques for data analysis are also discussed.

3.2 Study Area

The study area Lurambi Sub County in Kakamega County is in the western region of Kenya (Figure 1). It is globally located at N 00°16.964, 34° 45.112'E. Lurambi has a total population of 188,212 people; 92,774 Male and 95,432 Female (KNBS 2019). Table 2 provides a fact sheet for Lurambi sub-county. It shows information on the administrative units (wards), their respective areas in square kilometers, the number of villages within each ward, and the number of community areas. The total area of Lurambi sub-county is 161.7 km^2, encompassing a total of 17 wards and 35 villages. Additionally, the table provides information on livestock farming in the sub-county. The livestock categories mentioned include exotic dairy cows (3,063), exotic beef cows (606), indigenous cows (9,084), shoats (3,527), pigs (1,084), indigenous chickens (14,460), and exotic chickens (1,363).

Table 2: Lurambi sub county fact sheet

Administrative units	**Wards**	**Area Km^2**	**Villages**	**Community areas**
	Shieywe	17.9	4	8
	Mahiakhalo	13.4	2	4
	Shirere	17.4	3	6
	Butsotso East	33	3	6
	Butsotso Central	48.8	3	6
	Butsotso South	31.2	2	5
Total		**161.7**	**17**	**35**
Livestock Farming	Exotic Dairy cows			3,063
	Exotic beef cows			606
	Indigenous cows			9,084
	Shoats			3527
	Pigs			1084
	Indigenous chicken			14,460
	Exotic chicken			1363

This study was carried out on 5 slaughterhouses in Lurambi sub county, Kakamega (Table 3). After getting a permit from National commission for sciences and innovation (APPENDIX 3). The slaughterhouses are located in different areas among residences with no regard to their suitability. This is against the existence of legislation that governs the location and operations of slaughterhouses both at the national and county level (Meat Control Act, 2012, Kakamega county abattoir Act, 2017).

Table 3: GPS coordinates of the sampling sites

Location	**Latitude**	**Longitude**
Shirere	0.25693(N	34.74696 E
Savona	0.27348(N	34.77682 E
Emusala	0.33185N	34.77982 E
Ejinja Corner	0.28041N	34.71228 E
Bukura	0.21993N	34.6183129E

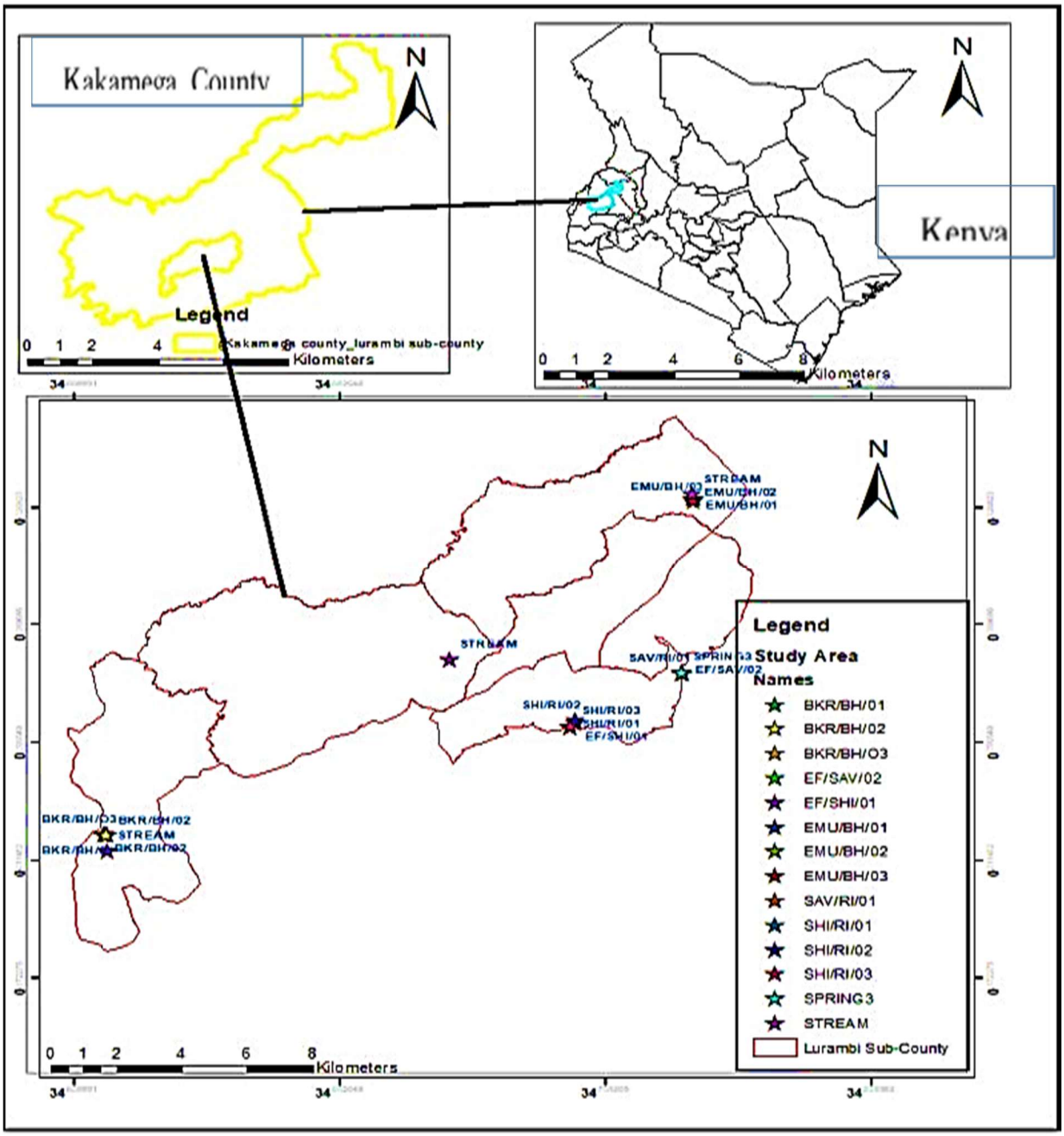

Figure 1: Map of study area

3.3 Research Design

To determine the physicochemical characteristics of waste generated and their impact on water sources adjacent to abattoirs, quantitative techniques described in APHA (2017)

were employed. Water samples from various sources next to abattoir and effluent waste were collected and analyzed in both the laboratory and on-site to determine relevant parameters. These results were then compared to the guidelines provided by the World Health Organization (WHO). Additionally, for the second objective of determining the parasitological and microbiological characteristics of waste generated at abattoir facilities, samples were analyzed in the laboratory using protocols described by Izuchukwu *et al*. (2016) and Cheesebrough (2009). The quantitative analysis provided valuable insights into the nature and extent of pollutants and contaminants present in water sources and effluent waste, as well as their potential risks to human health and the environment.

Lastly, the third objective aimed to ascertain the knowledge and practices of abattoir workers and the environmental health implications for nearby residents. A qualitative descriptive research survey design was chosen to assess the knowledge and practices of abattoir workers regarding waste disposal in the area and its potential adverse effects and probable health effect to residents. This survey method is particularly suitable for evaluating current practices and forming the basis for decision-making, as it involves describing, recording, analyzing, and reporting the existing conditions Check *et al*., (2012).

3.4 Data collection

The research was conducted between the 1st of December 2020 –February 2021 and the 7th of May and July 2021, with December and February relating to the dry period and

May and July corresponding to the wet period following the start of the rainy season in late April.

3.4.1 Data collection on Physico Chemical Properties of Water and Wastes

Water samples were collected using plastic bottles, which were first washed with non-ionic detergent and rinsed with deionized water. Prior to sample collection, the bottles were rinsed with water from the respective sampling locations and then filled with the appropriate samples. The sampling locations included hand-dug wells/boreholes within a distance of 0-250 meters from the abattoir, as well as control wells/boreholes situated 251-500 meters away.

River shikalamunga flows next to shirere abattoir where wastes water from abattoir flows into, samples were collected at the point where waste was being discharged into the river, as well as 50 meters upstream and 50 meters downstream from that point.

Wastewater samples were collected specifically between 6 a.m. and 10 a.m., during slaughtering and cleaning activities. To ensure proper preservation, the samples for laboratory examination were conserved in accordance with the American Public Health Association's Standard Methods of Wastewater Examination (APHA, 2017). All collected samples were labelled, stored at 4°C, and transported within 24 hours to the Microbiology laboratory at Masinde Muliro University of Science and Technology for analysis.

For the measurement of Chemical Oxygen Demand (COD), and Biochemical Oxygen Demand (BOD) samples were collected in triplicate using COD bottles covered with aluminium foil. This collection process was carried out for each sampling site during both the wet and dry seasons.

3.4.2 Data collection on Parasitological and Microbiological Characteristics of Wastes and Water Samples

Plastic bottles were used to collect waste and water samples, which were first washed with non-ionic detergents and rinsed with deionized water. The bottles were washed with water and waste water from the individual sampling locations before being filled with the appropriate samples. Hand-dug wells/boreholes within 0-250 meters of the abattoir, as well as control wells/boreholes 251-500 meters distant, were used for sampling. In the case of the Shikalamunga River next to shirere abattoir, samples were obtained at point of discharge, 50 meters upstream and 50 meters downstream of the location where waste was released into the river.

Specifically, wastewater samples were obtained between 6 a.m. and 10 a.m., during slaughtering and cleaning procedures. The samples for laboratory analysis were preserved in line with the American Public Health Association's Standard Methods of Wastewater Examination (APHA, 2017). All obtained samples were tagged, stored at 4°C, and transported to Masinde Muliro University of Science and Technology's Microbiology laboratory for processing within 24 hours.

3.4.3 Data collection on Assessment of Knowledge, Practice of Abattoir Workers and Environmental Health Implication on Residents Neighbouring Abattoirs

To collect data on specific objective three the questionnaire in appendix 1 was administered to abattoir workers and personnel in the industry. It is divided into two sections section, A for socio-demographic information while section B was on information on wastes produced, disposal methods, the number of cows slaughtered daily, infrastructural facilities about wastes management, and handling practices in the slaughterhouses. The questionnaire in appendix 2 was used on neighbourhood residents and included questions on socio-demographic information of respondents and potential human health complaints by surrounding residents to the slaughterhouse. Other instruments that were used were a reconnaissance survey and personal observation.

Abattoir workers were purposively selected for questionnaire administration as they understood the concept of the study. The neighbourhood residents within a 500m radius of the slaughterhouses were stratified into 0-250m radius and 251-500m and were selected with a probability that those chanced upon had relevant information.

3.5 Determination of Physicochemical Characteristics of Wastes Generated and the Impacts on Aquatic Environments

3.5.1 pH

The Hydro Lab Quanta Water Quality Monitoring System shown in Figure 2 was calibrated using buffer solutions of pH 4.0 and 7.0. The probe was rinsed with distilled

water and inserted into water or waste samples for 2 minutes and the readings recorded. The pH values of all samples were obtained *in situ.*

Figure 2: Quanta hydro lab water monitoring system

3.5.2 Temperature

The Hydro Lab Quanta Water Quality Monitoring System probe was dipped 10cm into the water and wastes sample. The figures obtained were then recorded. The temperature values of all samples were obtained *in situ.* It was done in triplicates per site.

3.5.3 Specific Conductance

The Hydro Lab Quanta Water Quality Monitoring System probe was dipped 10cm into water and waste samples. The figures obtained were then recorded. The specific conductance values of all samples were obtained *in situ*. It was done in triplicates per site.

3.5.4 Turbidity

The Hydro Lab Quanta Water Quality Monitoring System probe was dipped 10 cm into the sample of water and wastewater. The figures obtained were then recorded. The turbidity values of all samples were obtained as expressed as Nephelometric Turbidity units (NTUs).

3.5.5 Total Suspended Solids

TSS was determined by gravimetric methods. The filtration apparatus was set up following on the protocols. The filter was wetted with deionized water to set up it properly. Using a graduated cylinder sample was measured, recording the volume filtered in litres. The graduated cylinder was rinsed and filtered with 3 20 mL volumes of deionized water allowing complete drainage between washings. Continue suction for 3 minutes after filtration is complete Place the filters on the sheet into an oven set to 104 ± 1ºC and dry for a minimum of one hour. Once complete, remove filters from the oven and transfer them to a desiccator to cool to room temperature. Weigh one sample filter to the nearest 0.1mg. Repeat the cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained finally, record the Oven Dry Mass (in mg) .

TSS in mg/l was calculated using the following formulae;

$$\text{Total Suspended Solids, as mg/l} = \frac{A - D \times 1000}{S}$$

Where A = weight of filter+ residue in mg,

D = weight of filter, mg, and

S = mL of sample volume

3.5.6 Dissolved Oxygen (DO)

This is a measure of the amount of oxygen available in water to living aquatic organisms. The Hydro Lab Quanta Water Quality Monitoring System probe was dipped 10 cm into the water and wastewater samples and dissolved oxygen measured recorded. The dissolved oxygen was determined *in situ.*

3.5.7 Chemical Oxygen Demand (COD)

Using a pipette, a 10 ml of sample was measured into a round bottom reflux flask and 1ml of Mercury sulphate solution added. The mixture was swirled to mix well. Five (5) ml of potassium dichromate solution was added and mixed slowly then fifteen (15) ml silver sulphate-sulphuric acid solution added. After digestion ferroin indicator was added. This was then titrated with 0.025M ferrous ammonium sulphate solution. A blank of distilled water was also analyzed in the same procedure. (APHA 2005).

$$\text{COD} = \frac{8 \times 1000 \times DF \times M \times (SB - SV)}{\text{The volume of sample in ml}}$$

Where:

DF- Dilution factor if applicable

M – Molarity of Ammonium Ferrous Sulphate

SB - Volume in the titration of blank

SV – Volume in the titration of a sample.

3.5.8 Total Dissolved Solids (TDS)

To determine TDS of wastewater, a 100 ml of a well-mixed sample was placed in a gooch crucible of known weight. The weight of the crucible together with the water sample was

established and then placed in an oven set at 110ºC to dry. After drying, the crucible was placed in a desiccator to allow the contents to cool after which the weight of the crucible together with the dry contents was determined. The crucible was then returned to the oven and cooled repeatedly until a constant weight was achieved.

TDS in mg/l was calculated using the following formulae;

$$\text{Total Dissolved Solids, as mg/l} = \frac{\text{A - D x1000}}{\text{Sample volume, ml}}$$

Where A = weight of dried residue+ tared dish while

D = weight of dish

3.6 Determination of the Parasitological and Microbiological Characteristics of Wastes and Water Samples

3.6.1. Media preparation

The media for analysis were prepared following the protocols described by Izuchukwu *et al*., (2016) and Cheesebrough (2009). To prepare Nutrient Agar (NA), twenty-eight (28) grams of NA powder were measured with a clean spatula and suspended in one litre of distilled water. The mixture was then boiled to dissolve completely and sterilized by autoclaving at 121°C for 15 minutes. Afterward, the Rabbit blood (Rabbit or horse blood is used for growth of NAD-requiring organisms, such as *Haemophilus* species, but the hemolytic patterns may be inconsistent with those on sheep blood)50 ml for every 1000 ml of NA, at room temperature was added aseptically and mixed gently to avoid bubble formation. The mixture was then dispensed aseptically in 15 ml amounts into sterile petri dishes and allowed to solidify at room temperature.

To prepare Simmon's Citrate Agar (SCA), 4.6 grams of SCA powder were accurately weighed and suspended in 200ml of distilled water. The mixture was heated until it reached a boiling point, ensuring complete dissolution, and then transferred into 5ml bottles. Subsequently, the bottles were autoclaved at a temperature of 121°C for a duration of 10 minutes to achieve sterilization. Upon cooling, the agar solidified in a slanted position within the bottles. Simmon's Citrate Agar is utilized to assess an organism's capability to utilize citrate as a carbon source.

To prepare MacConkey agar, 49.53 grams of MacConkey agar powder were suspended in one litre of distilled water and allowed to boil to dissolve completely. The mixture was then sterilized by autoclaving at 121°C for 15 minutes and cooled to 45°C. MacConkey agar is used for the isolation of gram-negative enteric bacteria and the differentiation of lactose fermenting from lactose non- fermenting gram-negative bacteria.

Salmonella Shigella Agar was prepared by weighing 63 grams of the powder, suspending it into one litre of distilled water, and allowing it to boil to dissolve completely. The mixture was then sterilized by autoclaving at 121°C for 15 minutes. SS Agar (Salmonella Shigella Agar) is a differential selective media used for the isolation of Salmonella and some Shigella species from pathological specimens, and suspected foods.

Urease Agar was prepared by suspending 2.4 grams of urea base in 95ml of distilled water. The suspension was then sterilized by autoclaving at 121°C for 10 minutes. Then,

2 grams of urea was dissolved in 5ml of distilled water and boiled for about 30 minutes. The 2 solutions were allowed to cool in a water bath set at 45°C. Then, the urea was added to the urea base, and the mixture was dispensed into 5ml bottles, which were then kept in a slant position to solidify. The urease test identifies those organisms that are capable of hydrolyzing urea to produce ammonia and carbon dioxide. It is primarily used to distinguish urease-positive Protecae from other *Enterobacteriaceae.*

For MR/VP broth, 3 grams were suspended in 200ml of deionized water, swirled and mixed, hot plated for 15 minutes, then dispensed into tubes and sterilized by autoclaving for 15 minutes at 121°C.Methyl Red (MR) and Voges-Proskaeur (VP) tests are a part of IMViC reactions, which are used in the identification of certain fermentative bacteria (e.g., Enterobacteriaceae). These tests are performed together because organisms are generally positive for one of them. Rarely, some organisms are positive for both the tests. These tests are based on the facts that bacteria can ferment glucose into mixed acids or butylene glycol.

To prepare Triple Sugar Iron (TSI) Agar, 6.5 grams of TSI powder were suspended in 100ml deionized water, soaked for 10 minutes, swirled and mixed, and then boiled. The mixture was then dispensed into tubes and sterilized by autoclaving for 15 minutes at 121°C. The tubes were later placed in a slanting position to solidify, ensuring that the slant was over a butt at about 3cm deep. Triple sugar iron agar, or TSI, is a differential medium that tests a bacterial strain for several different properties at once. It tests for acid

and gas production from the fermentation of glucose and sucrose and/or lactose and for the production of hydrogen sulfide.

3.6.2 Isolation Identification of Bacterial Isolates

One millimetre (1ml) aliquot of the effluent sample was transferred into 9 ml diluents and serially diluted up to 10-5. Based on method by Mgbemena *et al.*, (2012) enumerations and culturing of bacteria was done in triplicates by pour plate technique in which. 0.5 ml aliquots of the serially diluted samples were inoculated in Nutrient Agar (NA), Mac Conkey Agar (MA), and Blood Agar (BA). The media plates were placed in an incubator set at 37 oC for 24 hours aerobically. Using the colony counter (Stuart/Sc6+) distinct colonies were counted and the number recorded as colony forming unit per millilitre (cfu/ml). This was repeated for all samples collected from various sites.

By repeatedly sub-culturing, pure colonies of bacteria were obtained for further characterization and identification using biochemical and microscopy tests (Cheesebrough, 2009). The bacteria were identified using Bergey‟s manual of determinative bacteriology. (Bergey *et al*., 1993).

3.6.3 Bacteria Biochemical Tests

3.6.3.1 Gram Staining

A thin smear was prepared in the staining process by putting a drop of sterile water on a glass slide, then using a hot sterilized wire loop to pick a significant colony and emulsifying it with the drop of sterile water on the glass slide to make a thin smear. It was then heat-fixed and then stained for 60 seconds with crystal violet, rinsed with water, then

treated with iodine for another 60 seconds. Rinsed with water again and treated for 5 seconds with alcohol. It was then cleaned with water and counter stained for 60 seconds with safranin. It was them washed with water and let to dry. The stained smears were examined microscopically using 100X oil immersion objective and 10X eye piece (Cheesebrough, 2009).

3.6.3.2 Urease Test

A portion of each test colony was streaked on urea agar slant and incubated for 24 hrs. at 37^{o}C.Urease positive organisms turned the medium red. *Salmonella* is urease negative (Cheesebrough, 2009).

3.6.3.3 Citrate Test

A colony of the test organisms was inoculated on the surface of simmon's citrate agar slant and incubated overnight at 37^{o}C for 24hrs.Blue colour indicates that the organism utilized citrate as a sole source of carbon (Cheesebrough, 2009).

3.6.3.4 Indole Test

Tryptone water was inoculated with a colony of the test organisms and incubated at 37^{o}C for 48hrs. 1ml of Kovac's reagent was added into the medium. The test determines the ability of the organism to convert tryptophan (amino acid) to indole. Indole production is indicated by a deep-red coloration at the top of the broth, production of a yellow ring indicates indole negative (Cheesebrough, 2009).

3.6.3.5 Methyl Red Test

This determines the ability of the test organism to ferment glucose and produce a pH of 4.5. Peptone water culture of suspected *Salmonella* organism was inoculated into glucose phosphate peptone water and incubated at 37^{o}C for 48hrs. Thereafter 5 drops of methyl red indicator were run down the side of the tube. A pink ring on the surface of the medium indicated a methyl red positive reaction (Cheesebrough, 2009).

3.6.3.6 Voges Proskaeur Test

This test was used to detect which of the isolates were able to produce a neutral red end point acetyl methyl carbinol (acetoin) from glucose fermentation or its reductive product butylene glycerol. The test is usually used to differentiate between Gram negative organisms especially members of the *Enterobacteriaceae*. The colony is inoculated into a test tube containing buffered glucose peptone water then incubated at 37^{o}C for 24 hours. Into the incubated medium, add 0.6% w/v solution of A 5g of - naphlho100ml absolute ethyl alcohol) and 0.2ml of solution B (100ml distilled water 40g potassium hydroxide.) Shake the mixture and leave to stand. A red colour is a positive result while a yellow colour indicates a negative reaction. (Cheesebrough, 2009).

3.6.3.7 Catalase Test

The test was performed by dropping a loopful of the isolate mix with the hydrogen peroxide on the slide. The production of gas bubbles (0_2) from the mixture which will occur almost immediately is a positive reaction. (Cheesebrough, 2009).

3.6.3.8 Reaction on Triple Sugar Iron Agar

This test determines the ability of the test organism to produce hydrogen sulfide, gas and ferment glucose. A colony of the test organism was stabbed and the slant surface streaked and incubated overnight at 370C for 24hrs. Hydrogen sulphide production gas production and sugars fermentation indicated TSI positive (Cheesebrough, 2009).

3.6.4 Biochemical Oxygen Demand (BOD)

This was done by measuring the difference in DO concentration over (5days) in water samples at a defined temperature of 20° C after neutralization and removal of chlorine in the sample. The BOD is computed from the difference between initial and final DO. (APHA, 2005)

$$BOD\ (mg/l) = D1 - D2$$

Where:

D1 = Initial Dissolved Oxygen on the first day

D2 = Final Dissolved Oxygen on the Fifth day after storing water samples in a dark place.

3.6.5 Fungal Analysis

One millilitre (1ml) of each of the diluted samples was transferred into sterile triplicate Petri-dishes. Cooled Potato Dextrose Agar (PDA) in molten state was dispensed aseptically into the petri dish and swirled to evenly distribute the samples. The plates were allowed to be set undisturbed at 25^0C for 5 days and examined for fungal growth. Distinct colonies on each plate were counted and expressed as cfu/ml (colony forming units /millilitre). (Cheesebrough, 2009).

3.6.5.1 Fungal Isolation and Identification

Using a sterile inoculating needle different distinct representative colonies were transferred to a sterile solidified PDA (Spread technique) and thereafter placed in incubator at 25°C for 3 days. The developed colonies were counted and identified was based on macroscopic observations of morphology of colony, colour, texture, shape, appearance, microscopic characteristics of septation in mycelium, presence of specific reproductive structures, shape, and structure of conidia (Cheesebrough, 2009).

3.6.6 Parasitological Analysis

A sample of 1 litre of raw effluent and 10 litres of treated effluent was collected and allowed to sediment for 1-2 hrs. The sediment was then centrifuged and suspended in an aceto-acetic buffer, followed by extraction using ethyl acetate. The sample was centrifuged again, and the debris, including helminth eggs, settled at the bottom while the buffer formed the top layer. The volume of the pellet containing the eggs was recorded, and then the rest of the supernatant was poured off. The pellet containing the eggs was then resuspended in zinc sulfate solution, and an aliquot was transferred to a McMaster slide for examination under a microscope. The eggs were counted, and the average of 3 slides was recorded. (Rachel *et al*., 1996).

The parasites were quantified using the below equation:

$$N = \frac{AX}{PV}$$

Where:

N = number of eggs per litre of sample

A = number of eggs counted in the McMaster slide or the mean of counts from 2 or 3 slides

X = volume of the final product (ml)

P = volume of the McMaster slide (0.3 ml)

V = original sample volume (litres)

3.7 Assessment of Knowledge, Practice of Abattoir Workers and Environmental Health Implication on Residents Neighbouring Abattoirs

3.7.1 Sample Size and Sampling Technique

For specific objective 3 a cross-sectional survey was done with the target population being all people working in abattoirs and neighbourhood within 500m radius from the abattoirs. The neighbourhood was stratified into 0-250m and 251-500m.

The single proportion formula (Fischer 1935) was used to determine sample size Jung (2014)

$$N = \frac{Z^2pq}{d^2}$$

The sample size was estimated based on the single proportion formula: where N is the required sample size, Z is the reliability coefficient at 95% confidence interval (1.96), p is the population proportion, q is equal to 1-p, and d is the acceptable error (0.05) Wesson (2006).

There is scant literature on previous work on Knowledge, Attitude and Practices of abattoir workers on waste management and its impacts on neighbourhoods in Lurambi

sub county kakamega. Hence, a pilot study was conducted to compute an estimate of the value of *p* that was later applied to calculate the sample size. (Wesson, 2006). The sub county used in the pilot study was Matungu with 3 abattoirs and 158 residents and 20 Abattoir workers. The value for *p* used in this study was 96%, which was obtained from the overall practice score during the pilot study. The calculated sample size was 384 with a 10% non-response rate included the total sample size was 423. Table 4 shows that 382 respondents in the neighbourhood of the 5 abattoirs were randomly contacted and the actual number interviewed.

Table 4: Number of Neighbourhood Respondents and those chosen for the Questionnaire as per Fischer (1935).

Abattoir	**Number**	**Selected for questionnaire**
Bukura abattoir	57	4
Ejinja corner abattoir	49	8
Emusala abattoir	130	10
Savona abattoir	47	9
Shirere abattoir	99	10
Total	**382**	**41**

3.7.2 Research instrument and measurement

A structured questionnaire was developed for the pilot study and later validated and used in the main study. Validity refers to how well evidence and theory support the interpretation of test scores obtained from using tests. In this case, the validity of the instrument refers to how well it measures what it is supposed to measure. The research instrument will be validated in terms of content and face validity. The content-related technique assesses the extent to which the questions reflect the specific areas covered. Reliability, on the other hand, refers to the ability of a research instrument to consistently

measure the characteristics of interest over time. It is a measure of how consistent the results or data are when the instrument is used repeatedly.

To establish the validity of the instrument, it was given to three experts in social sciences and environmental health from Masinde Muliro University. Their corrections and suggestions were used to modify the instrument. The reliability of the instrument was determined using the test-retest technique. This involved administering the same test twice to the same group of respondents who were specifically identified for this purpose. To assess the reliability of the instrument, 30 copies of the instrument were given to 30 respondents in Matungu sub-county, Kakamega County, who were not part of the population used for the study. The reliability of the instrument was calculated using the Pearson product correlation coefficient, and it was found to be 0.96.

The questionnaire in Appendix I was administered to all abattoir workers and personnel in the industry. It is divided into two sections: Section A collects sociodemographic information, while Section B focuses on information related to waste production, disposal methods, and the number of cattle slaughtered daily, infrastructural facilities for waste management, and handling practices in the slaughterhouses. The questionnaire in Appendix II was used for residents living in the vicinity of the abattoir, and it includes questions about their sociodemographic information and potential health complaints associated with the slaughterhouse.

3.8 Data Analysis

The data obtained in specific objective one and 2 were analyzed using inferential and descriptive statistics. The descriptive statistics used were bar charts and pie charts to display variation of results while inferential statistics employed t -test and ANOVA at 95% confidence level for the test of significant differences between the means of water quality parameters. In specific objective 3 descriptive statistics such as frequency (%) for categorical data and mean and standard deviation (SD) for numerical data was used primarily to summarize and describe the data to make them more graspable. $\chi 2$ test was also used to find the relationship between the sociodemographic characteristics with knowledge and practice scores. Finally, the correlation was used to check the relationship between knowledge and practice as well as attitude and practice and health impacts of wastes on neighbourhoods. This was done using SPSS version 20.0 and Microsoft Excel version 2007.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the findings and data analysis related to three specific objectives. Firstly, it focuses on the physicochemical characteristics of abattoir wastes and their effects on water sources. Secondly, it examines the presence of parasites and microbiological organisms in the abattoir wastes and receiving water sources. Lastly, it assesses the knowledge and practices of abattoir workers regarding waste management and the potential environmental health implications for residents living near abattoir facilities.

4.1 Physicochemical Characteristics of Wastes and Water Sources

4.1.1 Abattoir Effluent

Table 5 shows that the temperature of the abattoir effluent ranged between 22 and 25 degrees Celsius in both the wet and dry seasons. This was within the World Health Organization (WHO) standard limit of less than 30 degrees Celsius. (Table 1)

The pH of the effluent was between 9 and 13 in both seasons. This was above the WHO recommended limit of 6.0 to 9.0, indicating that the effluent was alkaline. The higher pH values of 13 were observed during the wet season, but the t-test showed that they were not significantly different from the dry season.

The dissolved oxygen (DO) levels of the effluent varied between 2 and 3 milligrams per litre (mg/l) in both seasons. This was below the WHO permissible limit of 5 mg/l. The

total dissolved solids (TDS) of the effluent were between 409 and 473 mg/l in both seasons. This was also within the WHO permissible limit of 1000 mg/l.

The chemical oxygen demand (COD) levels of the effluent varied between 4922 and 5830 mg/l in both seasons. This was above the WHO permissible limit of 1000 mg/l. The total suspended solids (TSS) levels of the effluent were between 220 and 277 mg/l in both seasons, which were above the WHO permissible limit of 20 mg/l.

The turbidity levels of the effluent were between 1330 and 1448 NTU in both seasons. This was above the WHO permissible limit of 50 NTU. An independent sample t-test showed that there was a significant difference in temperature (t_8=-4.122, p< 0.003), TSS (t_8=3.654, p<0.006), and turbidity (t_8=3.248, p<0.012) between the 2 seasons (p<0.05). The abattoirs sampled showed a wide range of BOD levels in the effluent, ranging from $3.10x10^3$ to 104 mg/l. These levels exceeded the WHO permissible limit of 30 mg/l. The BOD value was found to be higher during the dry season compared to the wet season, An independent sample t-test showed that there was no significant difference in BOD values (t_8=- 1.48, p > 0.886 between the 2 seasons (p<0.05).

Furthermore, the COD levels in the abattoir effluent varied from 5830 mg/l to 4902 mg/l. These levels were also higher than the WHO permissible limit of less than 1000 mg/l, which is recommended for the release of effluent into the environment.

Table 5: The Mean Physico-Chemical Parameters of Effluent from Abattoir Sites in Lurambi Kakamega County

Abattoir	Season	Temp ^{0}C	E.C (µs/Cm)	DO Mg/l	PH	TDS Mg/l	TSS Mg/l	Turbidity NTU	BOD Mg/l	COD Mg/l
Bukura	Wet	22	520	2.5	13	473	277	1448	2.63 X10^3	5830
	Dry	23	322	2	9	423	267	1401	3.10 X10^3	5203
Ejinja	Wet	23	330	3	10	409	257	1388	2.63 X10^3	5540
	Dry	25	401	2	11	423	220	1357	2.83 X10^3	4902
Shirere	Wet	23	406	2	9	416	268	1402	104	4908
	Dry	24	429	2	10	423	231	1349	110	4922
Savona	Wet	23	409	2	9	418	267	1406	105	4918
	Dry	24	503	2	10	424	230	1330	111	4991
Emusala	Wet	23	411	2	9	418	269	1401	105	4922
	Dry	24	441	2	10	424	233	1356	112	4950
WHO		< 30°C	< 5000	> 5	6.0-9.0	< 1000	20	< 50	30	< 1000

4.1.2. Fresh Water Sources

The physiochemical results of fresh water are shown in Table 6 below. The temperature of the water samples was higher in the dry season than in the wet season. In the wet season, the temperature ranged from 20.63°C to 23.77°C, while in the dry season the temperature ranged from 23.40°C to 24.49°C. These temperatures were within the WHO set limits value of 25°C. Results of ANOVA revealed a significant difference between temperature and the seasons ($F = 44$, $p < 0.012$). ANOVA results also revealed a significant difference in temperature between the 3 points of River Shikalamunga ($F = 27$, $p < 0.007$) at a confidence level of $p < 0.05$) and the seasons.

The pH of the water was higher in the wet season than in the dry season. In boreholes 0-250m, the pH of the water ranged from 7.23 to 11.43, while in boreholes 251-500m, the pH ranged from 7.23 to 7.60. In River Shikalamunga, the pH of the water ranged from 7.91 to 8.56. The WHO set guidelines for drinking water is 6.5-8.5. ANOVA test showed a significant difference in pH between borehole 0-250m and 251-500m ($F=21.473$, $p < 0.001$).

The specific conductivity of the water was generally higher in the dry season than in the wet season. In the wet season, the specific conductivity of the water ranged from 165.33 to 319 µs/cm, while in the dry season, it ranged from 178 to 379.67 µs/cm. The specific conductivity of the water was also generally higher in the boreholes closer to the abattoirs. In the borehole 0-250m, the specific conductivity ranged from 251.93 to 321.67 µs/cm, and in the borehole 251-500m, it ranged from 165.33 to 182.50 µs/cm.

In River Shikalamunga 50m upstream, the specific conductivity ranged from 269.67 to 307.67 µs/cm, and at the point of discharge, it ranged from 319 to 379.67 µs/cm. In the spring water, the specific conductivity ranged from 292.33 to 298.67 µs/cm. ANOVA test showed a significant difference in specific conductivity between borehole 0-250m and 251-500m ($F=138.704$, $p = 0.001$). ($p < 0.05$).

The dissolved oxygen (DO) levels were generally lower in the wet season compared to the dry season. In the wet season, DO levels ranged from 1.81 to 6.60 mg/l, while in the dry season, they ranged from 1.42 to 5.35 mg/l. Furthermore, DO levels were lower in

boreholes closer to the abattoirs. In the 0-250m borehole, DO levels ranged from 1.42 to 5.45 mg/l, while in the 251-500m borehole, they ranged from 3.86 to 6.60 mg/l. Upstream of River Shikalamunga, DO levels ranged from 5.02 to 6.02 mg/l, at the point of discharge they ranged from 4.61 to 5.63 mg/l, and 50m downstream they ranged from 4.31 to 5.39 mg/l. ANOVA analysis revealed a significant difference between temperature and the seasons ($F=5.668$, $p=0.027$). There was also a significant difference in DO between the 3 points of River Shikalamunga ($F = 12.162$, $p = 0.025$) at a confidence level of $p < 0.05$ and the seasons.

The total dissolved solids (TDS) levels were higher in the wet season compared to the dry season. In the wet season, TDS levels ranged from 107.67 to 263.83 mg/L, while in the dry season, they ranged from 107.67 to 293.67 mg/L. TDS levels were also higher in boreholes closer to the abattoirs. In the 0-250m borehole, TDS levels ranged from 161.33 to 185 mg/l, while in the 251-500m borehole, they ranged from 123.67 to 160.67 mg/l. Upstream of River Shikalamunga, TDS levels ranged from 107.67 to 131.67 mg/l, at the point of discharge they ranged from 263.83 to 293.67 mg/l, and 50m downstream they ranged from 113.33 to 286 mg/l. In the spring water, TDS levels ranged from 115 to 133 mg/l. ANOVA tests showed a significant difference in TDS between the 0-250m and 251-500m boreholes ($F=22.151$, $p= 0.001$).at $p <0.05$).

The total suspended solids (TSS) levels were generally higher in the wet season compared to the dry season. In the wet season, TSS levels ranged from 0.64 to 108.43 mg/l, while in the dry season, they ranged from 0.53 to 108.43 mg/l. TSS levels were also higher in

boreholes closer to the abattoirs. In the 0-250m borehole, TSS levels ranged from 0.61 to 0.97 mg/l, while in the 251-500m borehole, they ranged from 0.53 to 0.68 mg/l. There was a significant difference in TSS between the 0-250m and 251-500m boreholes ($F=5.332$, $p = 0.040$) at $p<0.05$.

In river water samples the TSS levels upstream during dry season was 80.97 mg /I and wet season 63.67 mg /l, and at the point of discharge during dry season was 83.67mg/l and wet season 108.43 mg/l, while 50m downstream during wet season the value was 86.33mg/l and dry season 101 mg/l However, there was no significant difference between the 3 points in terms of TSS.

The turbidity levels in borehole water were found to be higher during the wet season compared to the dry season. In the wet season, the turbidity levels ranged from 2.03 to 36.07 NTU, while during the dry season, they ranged from 1.21 to 28.03 NTU. Regarding Shikalamunga River, upstream, the turbidity level was 27.03 NTU during the dry season and 20.82 NTU during the wet season. At the point of discharge, the turbidity level was 36.07 NTU during the dry season and 25.67 NTU during the wet season. 50 meters downstream, the turbidity level was 30.28 NTU during the dry season and 28.30 NTU during the wet season. However, there was no significant difference between the 3 points in terms of turbidity.

In Bukura abattoir, the BOD levels in the borehole ranged from 12 mg/l to 13 mg/l during both the wet and dry seasons for the 0-250m located boreholes. For the 251-500m range,

the BOD values were 5.05 mg/l and 6.05 mg/l during the wet and dry seasons, respectively. In Ejinja, the BOD levels for the borehole within the 0-250m range were 12.41 mg/l during the wet season and 13.08 mg/l during the dry season. In river Shikalamunga, the BOD values varied during the wet and dry seasons at different points: 10.52 mg/l, 28 mg/l, and 11.3 mg/l were recorded at 50m upstream, at the point of discharge, and 50m below the point of discharge, respectively, during the wet season. In the dry season, the values were 12.1 mg/l, 33 mg/l, and 11.83 mg/l at the same locations. In Emusala, the BOD levels in the borehole within the 0-250m range were 12.3 mg/l during the wet season and 13.33 mg/l during the dry season. For the 251-500m range, the BOD levels were 5.06 mg/l and 7.03 mg/l during the dry season. These findings indicate that the BOD levels were higher during the dry season compared to the wet season. Notably, the boreholes located 251-500m from the abattoirs remained within the recommended WHO limits of less than 5 mg/l.An independent sample t-test indicated that there was no significant difference in BOD levels between the wet and dry seasons (t_{18}=0.431, p=0.672). Furthermore, the ANOVA results revealed no significant differences in BOD levels between the different abattoirs (F = 1.603, p = 0.225) at ($p<0.05$).

The chemical oxygen demand (COD) levels were higher in the dry season compared to the wet season. In the wet season, COD levels ranged from 5.44 to 121.30 mg/l, while in the dry season, they ranged from 5.44 to 143 mg/l. Similar to other parameters, COD levels were higher in boreholes closer to the abattoirs. In the 0-250m borehole, COD levels ranged from 6.83 to 8.82 mg/l, while in the 251-500m borehole, they ranged from

5.44 to 6.53 mg/l.During the wet season at Shikalamunga River, the samples collected 50 meters upstream showed a COD level of 128 mg/l, whereas during the dry season, it was 107.67 mg/l. At the point of discharge, the COD level was 140.67 mg/l during the wet season and 121.30 mg/l during the dry season. Similarly, 50 meters downstream, the COD level was 143 mg/l during the wet season and 119 mg/l during the dry season. ANOVA tests showed a significant difference in COD between the 0 - 250m and 251-500m boreholes ($F=7.963$, $p<0.015$). Additionally, there was a significant difference in COD between the 3 points of River Shikalamunga ($F=11.346$, $p<0.028$) at a confidence level of $p < 0.05$. However, there was no significant difference in COD between the seasons.

Table 6: Physiochemical characteristics of water sources next to the abattoirs in Lurambi Kakamega County

Abattoir	Season	Sample	Temp ^{0}C	E.C µs/cm	DO mg/L	PH	TDS mg/L	TSS mg/L	Turbidity NTU	BOD mg/l	COD mg/L
Bukura	Wet	Borehole 0-250m	22.43	251.93	5.31	9.51	161.33	.78	17.50	12	8.82
		Borehole 251-500m	22.95	165.33	6.60	7.23	144.00	.64	2.66	13	6.53
	Dry	Borehole 0-250m	24.30	293.67	3.22	7.60	185.00	.65	2.52	5.05	8.33
		Borehole 251-500m	24.47	182.50	5.35	7.60	154.33	.53	1.82	6.05	6.01
Ejinja	Wet	Borehole 0-250m	23.77	278.00	5.45	11.43	166.00	.92	2.75	12.41	6.91
		Borehole 251-500m	23.21	167.97	5.85	7.28	149.00	.68	2.03	13	5.58
	Dry	Borehole 0-250m	24.47	321.67	4.12	8.46	184.00	.61	1.99	13.08	7.97
		Borehole 251-500m	24.49	178.67	3.86	7.55	160.67	.54	1.21	12	6.05
Shirere	Dry	50m upstream	20.63	269.67	6.02	7.91	107.67	80.97	27.03	10.52	107.67
		Point of discharge	22.30	319.00	5.63	8.45	263.83	108.43	36.07	12.1	121.30
		50m downstream	21.60	292.00	5.39	8.33	113.33	101.00	30.28	28	119.00
	Wet	50m upstream	24.45	307.67	5.02	8.03	131.67	63.67	20.82	33	128.00
		Point of discharge	24.48	379.67	4.61	8.91	293.67	83.67	25.67	11.3	140.67
		50m downstream	24.44	376.67	4.31	8.56	286.00	86.33	28.30	11.83	143.00
Savona	Dry	Borehole 0-250m	23.23	283.67	5.41	11.00	167.00	.97	2.81	12.72	6.94
		Borehole 251-500m	23.21	166.00	5.38	7.30	146.33	.66	2.08	13.35	114.50
	Wet	Borehole 0-250m	24.44	321.00	3.95	10.08	179.00	.58	1.82	12.23	13.35
Emusala	Dry	Borehole 0-250m	22.93	281.00	1.81	10.90	167.00	.96	2.88	12.23	6.83
		Borehole 251-500m	23.21	166.00	5.38	7.30	146.33	.66	2.08	13.33	5.44
	Wet	Borehole 0-250m	24.42	305.33	1.42	11.17	178.33	.70	2.60	5.06	7.91
		Borehole 251-500m	24.49	178.33	5.10	7.53	123.67	.54	1.41	7.03	6.12
WHO			25	< 500	5	6.5-8.5	<500	20	<5	5	500

4.2. The Parasitological and Microbiological Characteristics of Wastes Generated and water sources.

4.2.1. Abattoir effluent

In all abattoirs, the effluent had objectionable colour and odour resulting from the mixing of blood and paunch contents. Results of the wet and dry season the mean bacterial counts are shown in table 7. An independent sample t-test revealed no significant difference in mean bacterial counts in the effluents between wet and dry seasons total coliform (t_{10} = -0.634 p= 0.541), faecal coliforms (t_{10} = -0,884 p = 0.397), *Streptococcus faecalis* (t_{10}=0.879 p = 0.401), fungal counts (t_{10} = 0.996 p = 0,368) at $p < .05$.

Table 7: Mean values of Bacteria, Fungal counts and BOD in effluent of abattoir sites in Lurambi Kakamega County

Slaughter House	**Season**	**Total Coliform (cfu/ml)**	**Faecal Coliform(cfu/ml)**	***Streptococcus faecalis*(cfu/ml)**	***Escherichia Co*li(cfu/ml)**	**Fungal counts**
Bukura	Wet	$8.17x10^5$	$4.37\ X10^4$	$1.97\ X10^4$	$2.03\ X10^3$	$6.803\ X10^3$
	Dry	$1.01\ X10^6$	$6.53\ X10^4$	$3.78\ X10^4$	$3.07\ X10^3$	$7.81\ X10^3$.
Ejinja	Wet	$4.73.\ X10^6$	$3.82\ X10^4$	$3.41\ X10^4$	$5.79\ X10^5$	$4.93\ X10^5$
	Dry	$5.78\ X10^6$	$4.62.\ X10^4$	$4.13\ X10^4$	$6.52\ X10^5$	$5.81\ X10^5$
Shirere	Wet	3.37 X106	$3.20\ X10^4$	$2.90\ X10^4$	$6.13\ X10^3$	$5.71\ X10^5$
	Dry	$4.33\ X10^6$	$3.97\ X10^4$	$2.90\ X10^4$	$6.90\ X10^3$	$6.46\ X10^5$
Savona	Wet	$7.30\ X10^5$	$3.60\ X10^4$	$1.63\ X10^4$	$1.87\ X10^3$	$2.15\ X10^4$.
	Dry	$8.59.\ X10^5$	$4.77.\ X10^4$	$2.78\ X10^4$	$2.88\ X10^3$	$6.52\ X10^3$
Emusala	Wet	$3.46\ X10^6$	$3.25\ X10^4$	$3.03\ X10^4$	$6.10x10^3$	$5.25\ X10^5$
	Dry	$4.80\ X10^6$	$4.58\ X10^4$	$4.16.\ X10^4$	$7.78\ X10^3$	$7.13\ X10^5$
Total	Wet	$2.62X10^6$	$3.65.40\ X10^4$	$2.59\ X10^4$	$1.19.\ X10^5$	$3.23\ X10^5$
	Dry	$3.36\ X10^6$	$4.89\ X10^4$	$3.55\ X10^4$	$1.34\ X10^5$	$3.91\ X10^5$

Table 8 shows differences in parasitic counts during the wet and dry seasons. An independent sample t-test revealed a significant difference in mean parasitic counts between wet and dry seasons for *B. coli* (t_8= -2.309, p = 0.05) and *A. duodenale* (t_8 = -3.347, p = 0.010). ANOVA tests showed that there was no significant difference in parasitic counts *B. coli* (F=5.433 p=0.374), *A. duodenale* (F=0.576 p=0.693), A. *lumbroicoides* (F=4.122 p=0.076) within the abattoirs at $p < .05$.

Table 8: Mean values of parasitic counts in effluent of abattoirs sites in Lurambi Kakamega County

Abattoir	**Season**	***B. coli***	***T. hominis***	***S. enterocalis***	***A. duodenale***	***A. lumbroicoides***
Bukura	Wet	13.0	50.0	12.0	10.0	25.0
	Dry	16.00	54.0	14.0	12.0	26.0
Ejinja Corner	Wet	15.00	62.0	10.0	10.0	30.0
	Dry	17.00	58.0	12.0	12.0	33.0
Shirere	Wet	17.00	40.0	16.0	11.0	20.0
	Dry	23.00	46.0	19.0	14.0	24.0
Savona	Wet	16.00	45.0	16.0	11.0	20.0
	Dry	19.00	52.0	20.0	16.0	24.0
Emusala	Wet	16.00	50.0	12.0	10.0	20.0
	Dry	18.00	55.0	14.0	12.0	26.0
Total	Wet	15.40	49.4	13.2	10.4	23.0
	Dry	18.60	53.0	15.8	13.2	26.6

Figure 3; Shirere lagoon during dry season

Figure 4: Emusala lagoon during dry season

Figure 5; Shirere lagoon overflowing during wet season

Figure 6: Broken down effluent pipe in River isiukhu

Figure 7; Savona abattoir lagoon next to River isiukhu

Figure 8: Savona waste overflowing during wet season

4.2.2. Fresh Water sources

Table 9 shows information on the mean values of bacterial and fungal counts in water sources from different sample sites during the wet and dry seasons. In Bukura abattoir, the borehole at 0-250m had a higher total coliform count during the dry season at 7.20 x 10^2 cfu/ml, while fungal counts were higher during the wet season at 1.88 x 10^3 cfu/mL. In Ejinja, these counts were slightly higher during the dry season than in the wet season. Additionally, the fungal counts were higher during the wet season, ranging from 18.33 cfu/ml to 14 cfu/ml.

In Emusala abattoir, for borehole 251-500m, the values during the wet season were as follows: total coliform count - 1.23 x 10^2 cfu/ml, faecal coliform - 14 cfu/ml, *Streptococcus faecalis* - 19 cfu/ml, *Escherichia coli* - 0 cfu/ml, and fungal count - 18 cfu/ml. In comparison, during the dry season, the counts were 1.77 x 102 cfu/ml, 18 cfu/ml, 11 cfu/ml, 0 cfu/ml, and 8 cfu/ml, respectively.

The results of the independent sample t-tests showed no significant difference in total coliform count (t_{10} = -0.634, p = 0.534), faecal coliform (t_{10} = -0.884, p = 0.397), *Streptococcus faecalis* (t_{10} = -1.150, p = 0.277), *Escherichia coli* (t_{10} = 0.878, p = 0.401), and fungal counts (t_{10} = 0.996, p = 0.343) between the wet and dry seasons. Additionally, the ANOVA results indicated no significant differences in total coliform count (F = 0.395, p = 0.760), faecal coliform (F = 0.437, p = 0.773), *Streptococcus faecalis* (F = 0.705, p = 0.553), *Escherichia coli* (F = 0.360, p = 0.784), and fungal counts (F = 0.586, p = 0.641) among the different abattoirs at a significance level of $p < 0.05$. However, the ANOVA

results did reveal significant differences in total coliform counts (F = 58.586, $p = 0.001$), faecal coliforms (F = 22.660, $p = 0.001$), *Streptococcus faecalis* (F = 7.006, $p = 0.024$), *Escherichia coli* (F = 36.497, $p = 0.001$), and boreholes located at 0-250m and those at 251-500m.

In Shirere River Shikalamunga, the total coliform count, faecal coliform, *Streptococcus faecalis, Escherichia coli,* and fungal counts were higher at the point of discharge during both seasons compared to upstream and downstream sites. Total coliform count and *Escherichia coli* downstream were quite high at 7.10×10^5 cfu/ml and 4.58×10^3 cfu/ml, respectively. Fungal counts downstream were highest at 2.80×10^4 cfu/ml. The ANOVA test revealed significant differences in total coliform count (F = 49.341, $p = 0.05$) and *Escherichia coli* (F = 30.149, $p = 0.010$) between the two seasons at a significance level of $p < 0.05$.

Table 9: Mean values of bacteria and fungi of water sources during wet and dry seasons

Slaughter House	Sample Site	Season	Total Coliform cfu/ml	Faecal Coliform cfu/ml	*S. faecalis* cfu/ml	*E. coli* cfu/ml	Fungal counts
Bukura	Borehole 0-250m	Wet	6.07×10^2	37	28	11	1.88×10^3
		Dry	7.20×10^2	44	30	19	20
	Borehole 251-500m	Wet	1.03×10^2	13	10	0	8.33
		Dry	1.30×10^2	15	13	0	7.33
Ejinja	Borehole 0-250m	Wet	4.27×10^2	26	13	8	18.33
		Dry	4.91×10^2	31	22	12	14
Shirere	50m Above Upstream	Wet	2.77×10^3	3.97×10^2	2.43×10^2	1.20×10^2	140.33
		Dry	3.80×10^3	5.06×10^2	3.60×10^2	19	21
	At Point of Discharge	Wet	5.40×10^5	1.17×10^4	1.13×10^4	2.87×10^3	$6.23. \times 10^5$
		Dry	6.82×10^5	2.50×10^4	2.17×10^4	3.63×10^3	3.90×10^3
	50m Below Point of Discharge	Wet	6×10^5	1.87×10^4	1.63×10^4	3.50×10^3	6.43×10^5
		Dry	7.10×10^5	2.88×10^4	2.58×10^4	4.58×10^3	2.80×10^4
Emusala	Borehole 0-250m	Wet	4.37×10^2	24	12	8	18.33
		Dry	5.42×10^2	29	19	12	4.67
	Borehole 251-500m	Wet	1.23×10^2	14	9	0	18.33
		Dry	1.77×10^2	18	11	0	8

The table 10 shows the mean number of parasite eggs or oocytes found in different water sources during wet and dry seasons. Eggs/oocytes that ranged from 30 to 18 per millilitre of *Ascaris lumbroicoides* were identified in the borehole samples taken from 0-250 meters distance from the abattoir. No parasite eggs or oocytes were found in borehole samples taken from 251-500 meters in Bukura, Ejinja, and Emusala abattoirs during both wet and dry seasons.

The highest level of parasite eggs or oocytes was found at the discharge point of the River Shikalamunga water sample at the Shirere slaughterhouse during the wet season (50 eggs/oocytes per millilitre of *B. coli)*. The least number of eggs/oocytes were 13 eggs/oocytes per millilitre for *B. coli, S. enterocolalis,* and *A. duodenale*, upstream. During the dry season, the largest number of parasite eggs or oocytes detected was 43 per millilitre of *A. lumbroicoides* at the downstream.

According to WHO standards for water intended for human consumption, total coliforms, *Escherichia coli*, fungi, helminths, and free-living nematodes should be absent.

Table 10: Mean values of parasites in fresh water sources next to abattoirs

	Sample type	**Season**	***B. coli***	***T. hominis***	***S. enterocalis***	***A. duodenale***	***A lumbroicoides***
Bukura	bore hole 0-250m	Wet	0	0	0	0	28
		Dry	0	0	0	0	20
	borehole 251-500m	Wet	0	0	0	0	0
		Dry	0	0	0	0	0
Ejinja	bore hole 0-250m	Wet	0	0	0	0	25
		Dry	0	0	0	0	20
	borehole 251-500m	Wet	0	0	0	0	0
		Dry	0	0	0	0	0
Shirere	50m above upstream	Wet	14	15	13	15	30
		Dry	17	18	15	19	34
	discharge point	Wet	16	18	15	18	50
		Dry	19	23	18	21	33
	50m downstream	Wet	24	33	25	29	38
		Dry	28	36	28	34	43
		Dry	18	9	7	6	24
Emusala	bore hole 0-250m	Wet	0	0	0	0	23
		Dry	0	0	0	0	18
	borehole 251-500m	Wet	0	0	0	0	0
		Dry	0	0	0	0	0

4.2.3. Characterization and Identification of Bacteria, Fungi and Parasites

4.2.3.1. Bacteria

The identification of bacteria was done using morphological descriptions and biochemical tests as shown in appendices 4&5. These characteristics were then compared with information in Manual for the Identification of Medical Bacteria (Barrow *et al.,* 1993). The bacteria isolated and identified were *Escherichia coli, Pseudomonas*

aerugenosa Klebsiella pneumoniae Streptococcus faecalis, Shigella dysenteriae (Appendices 6).

4.2.3.2. Fungi

The Fungi isolated were differentiated on the basis of their morphological, macroscopic and microscopic characteristics (Appendix 8: Cheeseborough 2009). The abundance of the 6 isolates identified are shown in Table 11. *Aspergillus fumigatus accounted for* 25.9%, *Saccharomyces cerevisiae 19*%. *Aspergillus niger,* 16%, *Fusarium oxysporum*, 14%, Penicillium *spp*, 14 %, *Aspergillus flavus*-12.07%.

Table 11: Frequency of Occurrence of Fungi

Name of isolates	**Number of colonies of isolates**	**Frequency of occurrence %**
Aspegillus flavus	7	12.0
Aspergillus niger	9	15.5
Aspergillus fumigatus	15	25.9
Fusarium oxysporum	8	13.8
Saccharymyoces cerevisae	11	19
Penicillium species	8	13.8
	58	100

4.1.3.3. Parasites

Parasites found in the study included trophozoite of flagellates such as *Balantidium coli* and *Trichomonas hominis*, as well as larvae of *Strongyloides stercoralis* and *Ancylostoma duodenale*. The identification of these parasites was conducted using microscopy and the centrifugation method, (Table 12).

Table 12: Parasites identified in abattoir and water samples:

Parasite	Size (µm)	Shape	Structure	Colour	Motility	Staining characteristics
B. coli	50-200	Oval	Cilia	Pink	Motile	Lugol's iodine
T. hominis	10-20	Pear-shaped	Flagella	Pink	Motile	Methylene blue
S. stercoralis	200-300	Pointed tail	Spindle-shaped	White	Motile	Hematoxylin and eosin
A. duodenale	500-1000	Hook shape mouth	Spindle-shaped	White	Non-motile	Hematoxylin and eosin

4.3. Knowledge, Practice of abattoir workers and environmental health implications

4.3.1. Socio Demographic Characteristic of Abattoir Workers.

4.3.1.1. Location of Abattoir workers

Figure 9 shows the distribution of abattoir workers respondents in the 5 abattoirs. In total, 47 respondents were interviewed.

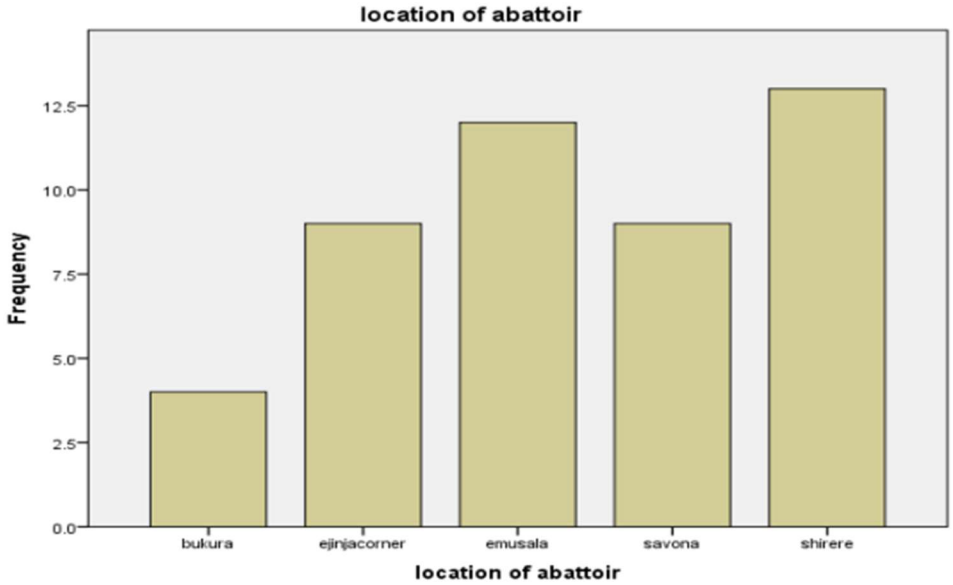

Figure 9: Location distributions of abattoir respondents.

4.3.1.2. Gender Distribution of Abattoir workers

Figure 10 shows gender distribution of the 47 abattoir respondents. Majority of respondents were males.

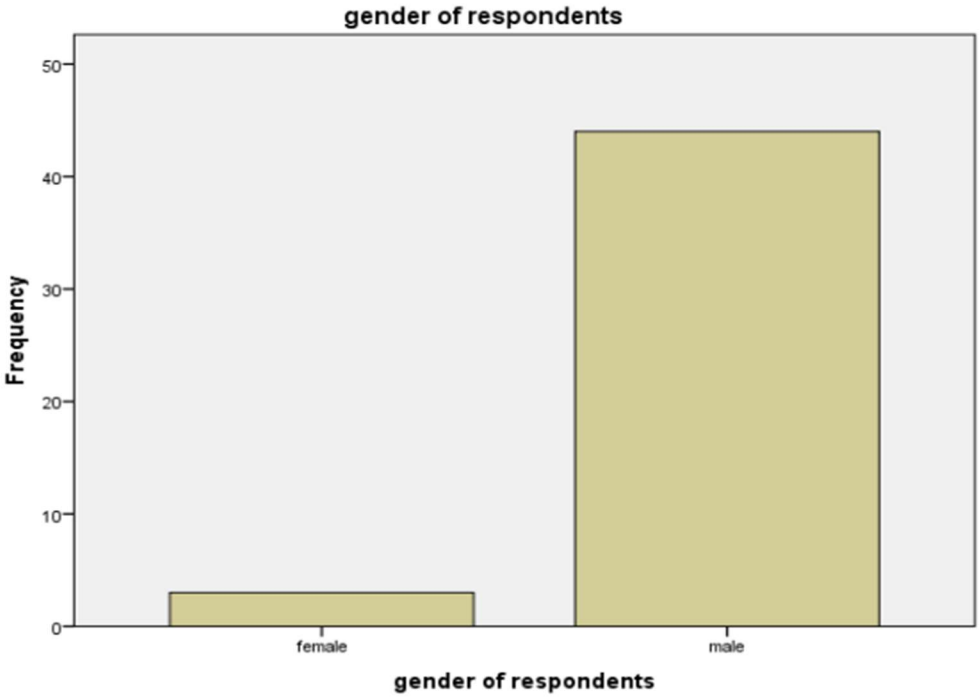

Figure 10: Gender of abattoir workers.

4.3.1.3. Age distribution of Abattoir workers

Figure 11 shows the Age distribution of the 47 abattoir workers respondents. The age group 19-40 yrs. had the higher percentage of abattoir workers.

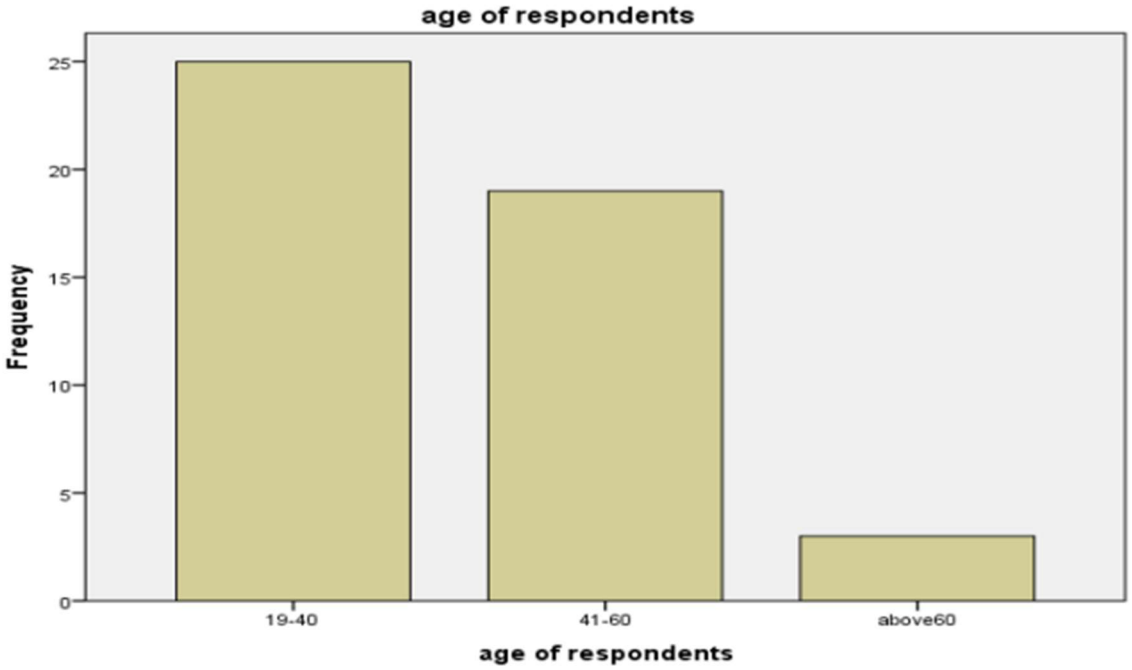

Figure 11: Age distribution of abattoir respondents

4.3.1.4. Marital status of Abattoir workers

Figure 12 shows the marital status of 47 abattoir workers respondents contacted. Majority of abattoir workers were married.

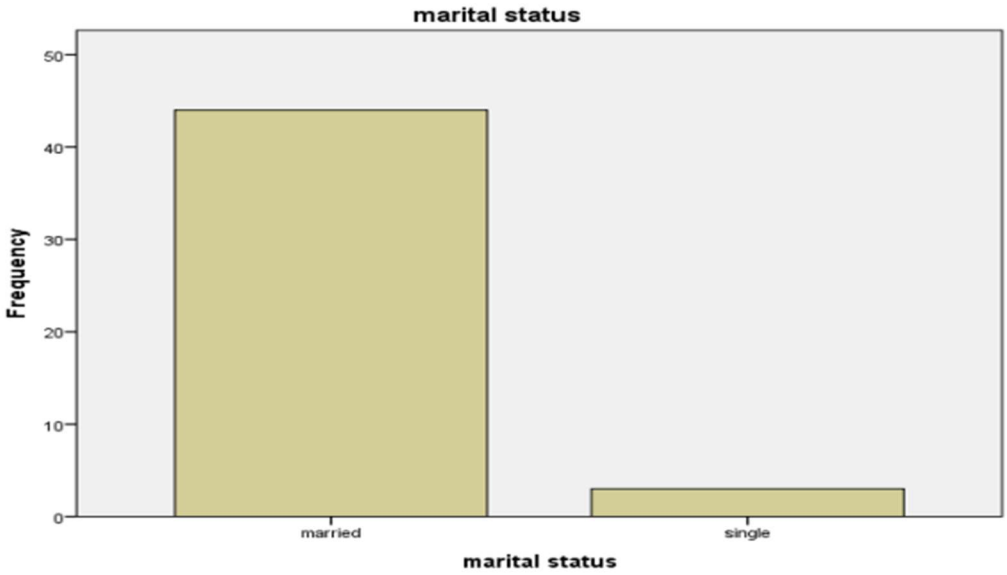

Figure 12: Marital status of abattoir workers

4.3.1.5. Occupation of Abattoir workers

Figure 13 shows the occupation of 47abattoir workers respondents contacted. Majority of abattoir workers were flayers.

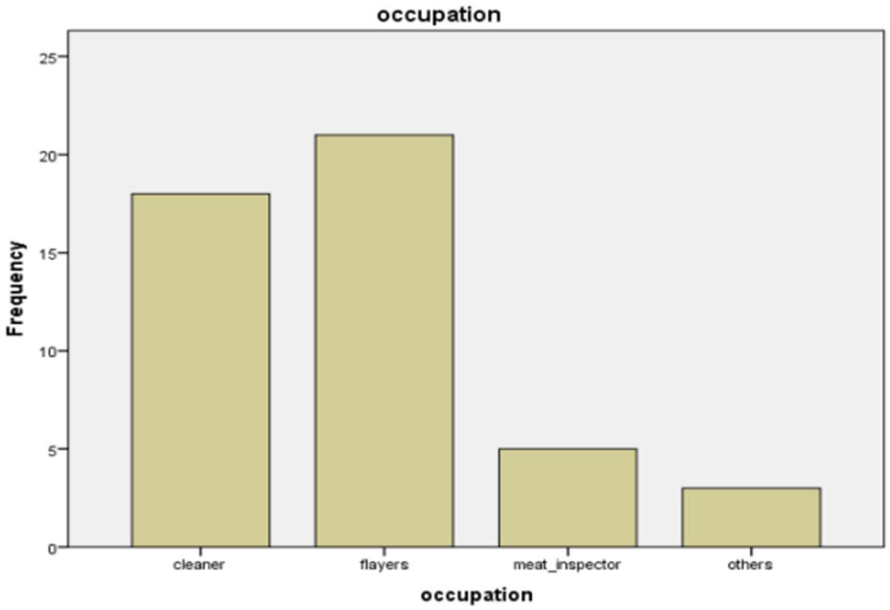

Figure 13: Occupations of abattoir workers

4.3.2. Socio Demographic Characteristic of neighbourhood residents.

4.3.2.1 Level of education of neighbourhood respondents.

Figure 14 shows the level of education of neighbourhood respondents. Of the total respondents contacted, 11.3% had no formal education, 19.9% had a primary education, 48.8% had a secondary education, and 19.9% had a tertiary education. This shows that the majority of neighbourhood respondents had a secondary education.

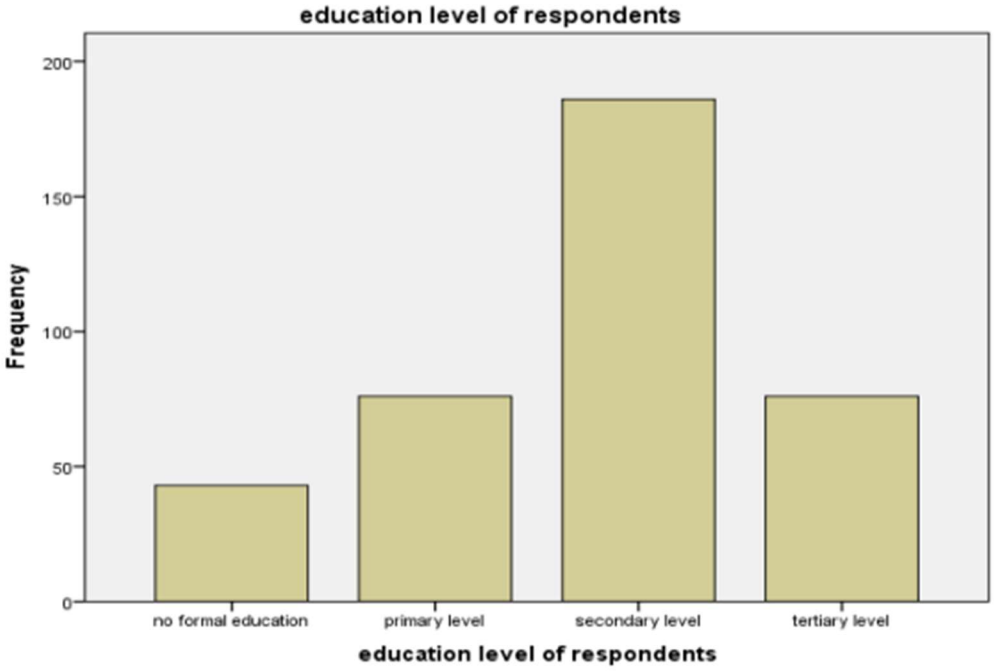

Figure 14: Education level of neighbourhood respondents.

4.3.2.2. Distance from abattoir of neighbourhood respondents

Figure 15 shows the distance of neighbourhood respondents from the abattoir. Of the respondents contacted, 53.5% lived 0-250 meters from the abattoir, and 46.5% lived more than 250 meters from the abattoir. This shows that the majority of neighbourhood respondents lived within 250 meters of the abattoir.

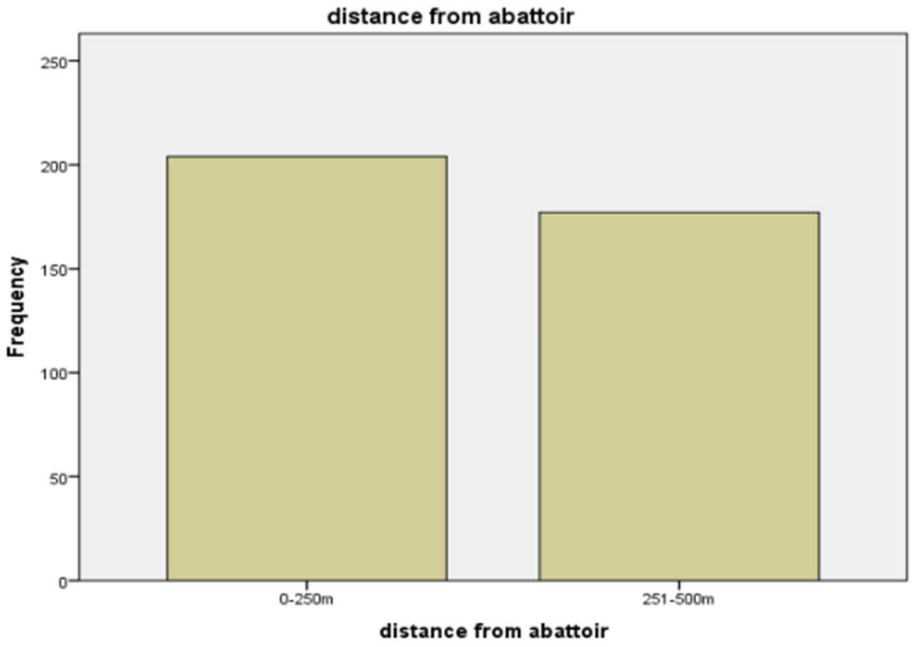

Figure 15: Distance from abattoir of neighbourhood respondents

4.3.2.3. Number of years of living next to abattoirs of neighbourhood respondents

Figure 16 shows the length of time neighbourhood respondents have been living next to an abattoir. Of the respondents contacted, 6% have been living next to an abattoir for 0-5 years, 13.4% have been living next to an abattoir for 6-10 years, 17.3% have been living next to an abattoir for 11-15 years, and 63.3% have been living next to an abattoir for over 15 years. This shows that the majority of neighbourhood respondents have been living next to an abattoir for over 15 years.

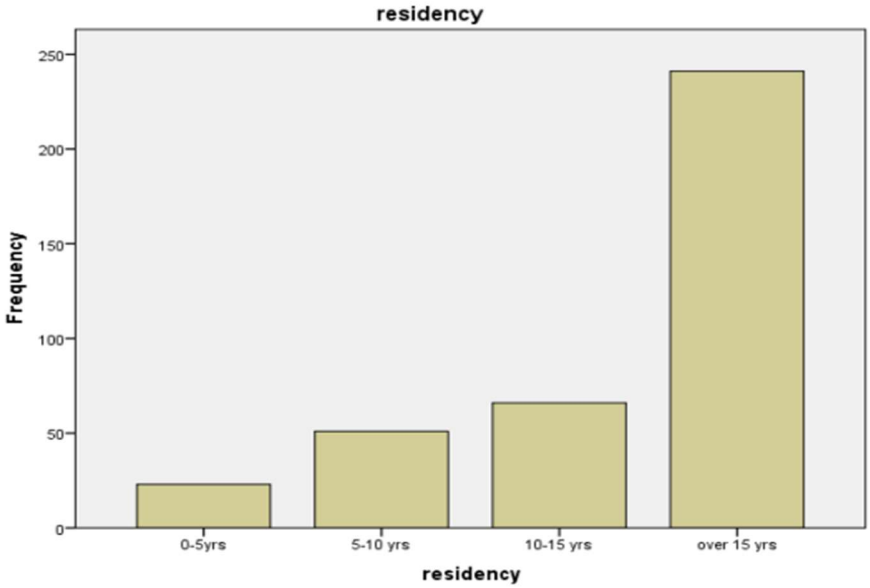

Figure 16: Showing number of years of living next to abattoirs of neighbourhood respondents

4.3.3. Knowledge, Practice of Abattoir Workers and Environmental Health Risks

4.3.3.1. Types and Quantity of Waste Produced

Table 13 shows the number of animals slaughtered monthly in the abattoirs. The data reveals that, on average, a total of 480 cows and 60 shoats (Sheep and goats) are slaughtered across the 5 abattoirs. The Shirere abattoir, had the highest number of slaughters, followed by the Savona abattoir.

Table 13: Animals Slaughtered Per Month

Abattoir	**Number and type of animals**		
	Cows	**Shoats**	**Total**
Bukura	12	12	24
Ejinja corner	60	40	100
Shirere	168	120	288
Savona	120	168	288
Emusala	12O	120	240
TOTAL	**480**	**460**	

The average slaughter figures in Table 13 were used to calculate the number of wastes generated. This was based on Aniebo *et al.,* (2009) methodology of calculating waste streams from slaughter houses. Table 14 shows the quantity of individual wastes produced in the abattoirs. In all the abattoirs meat is not processed but moved as whole carcass to retail butcheries thus bones are not disposed at the abattoir sites.

Table 14: Quantity of wastes produced by abattoirs in Lurambi Sub County

Abattoir Name	**Type of animal**	**Waste blood (Kg)**	**Paunch/intestinal contents (Kg)**	**Tissue wastes (Kg)**	**Bones wastes (Kg)**
Bukura	Cows	151.2	96	76.8	141.6
	Shoats	8.64	15	9.6	24.72
Ejinja corner	Cows	756	480	384	708
	Shoats	28.8	50	32	82.4
Shirere	Cows	2116.8	1344	1075.2	1982.4
	Shoats	86.4	150	96	247.2
Savona	Cows	1512	960	768	1416
	Shoats	120.96	210	134.4	346.08
Emusala	Cows	1512	960	768	1416
	Shoats	69.12	120	76.8	197.76
TOTAL		**5613.48**	**4385**	**3420.8**	**6562.16**

The abattoir workers were asked what the commonly produced wastes in the Abattoirs were. Their frequency of responses on a Likert scale of Very low -1, low -2. Middle-3, High -4 Very high-5 (Table 15). Results show that bone waste was produced in low amounts at a mean of 2.24. The other waste streams are produced in high amount with mean above 3.

Table 15: Amount of Perceived Commonly Produced Wastes

Category	% Frequency of number of wastes						
	Very low	Low	Middle	High	Very high	Mean	Std. Dev.
Bones	14.6	43.9	9.8	17.1	14.6	2.73	1.32
Blood	4.9	41.5	0	14.6	13.9	3.41	1.48
Paunch manure	12.2	17.1	19.5	14.6	36.6	3.46	1.45
Hooves and hones	12.2	36.6	9.8	17.1	24.4	3.05	1.43
Condemned parts	7.3	22	24.4	17.1	29.3	3.39	1.32
Abattoir wastewater	4.9	19.5	9.8	22	43.9	3.80	1.33
Animal faeces generated	9.8	19.5	19.5	9.8	41.5	3.54	1.45

4.3.2.2. Methods of Waste Disposal

The abattoir workers were unanimous that the common waste disposal used in the abattoirs were dump pits at 82.9% (Figure 17) with incineration and land fill not practiced at all in the abattoirs.

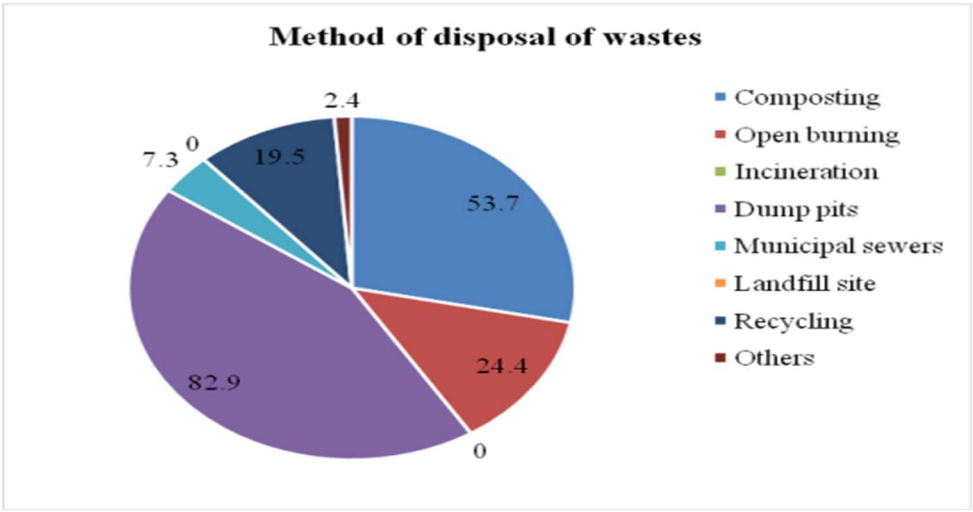

Figure 37: Responses on methods of waste disposal

4.3.2.3. Knowledge and Practice on Waste Management

Figure 18 shows that the majority of the respondents (73.2%) indicated that there were no awareness programs on waste management in the abattoir prior to their employment. This suggests a lack of prior knowledge or exposure to waste management practices among the participants.

Figure 19 reveals that 63.4% of the abattoir workers had not received any training in waste management before their employment. This indicates that a significant proportion of the workers had not been formally trained in waste management practices, which could potentially lead to improper waste handling and disposal methods.

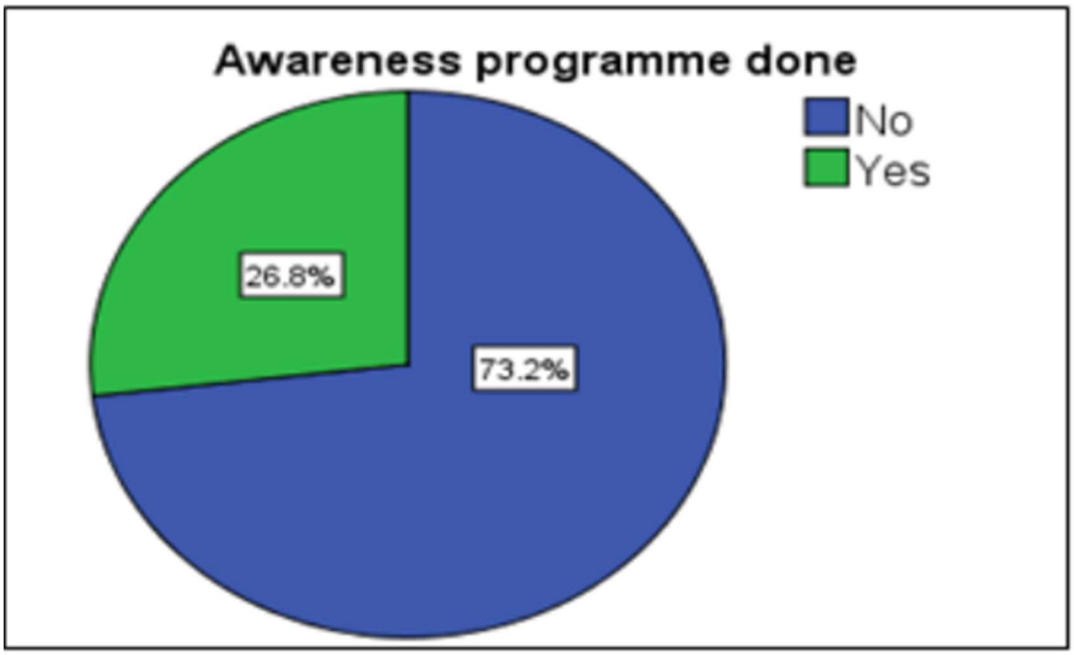

Figure 48: Responses on awareness programs on waste management

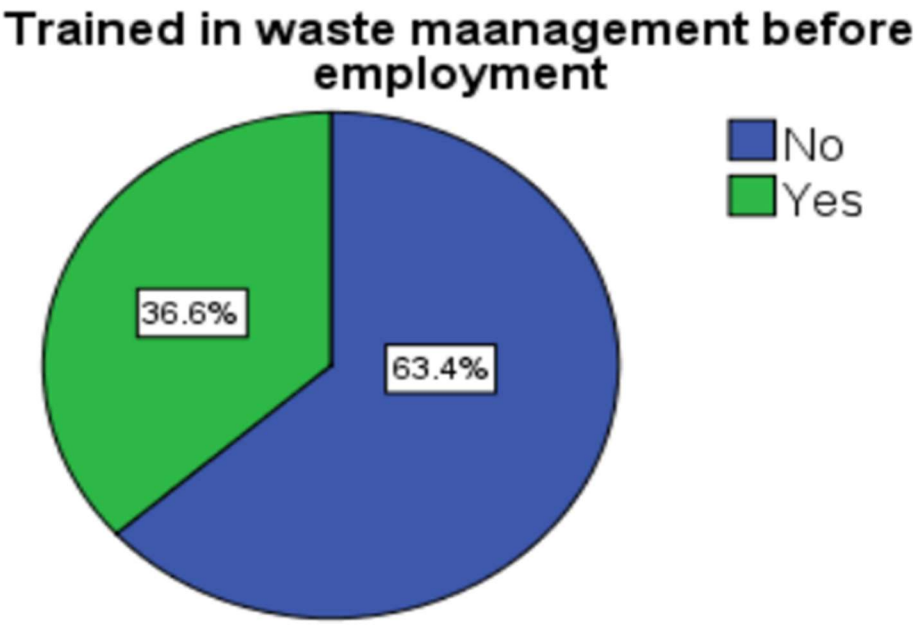

Figure 19: Responses on trained in waste management before employment

On knowledge and practice on waste management in the abattoirs the responses on a Likert scale of strongly disagree -1; Disagree -2; Neutral -3; Agree -4; Strongly Agree -5) are shown in Table 16. Twenty-two (22) percent strongly disagreed that they attended awareness program offered by the county government. The minimum and maximum rating means to the statements were 2.29 and 4.41 respectively, and a general mean was 3.35. It therefore implied that abattoir workers had knowledge in waste management and practice.

Table 16: Abattoir Workers Knowledge and Practice on Waste Management

	% Frequency of respondents						
Description	**1**	**2**	**3**	**4**	**5**	**Mean**	**Std. Dev**
I attend awareness programmes conducted by the local authority	22.0	14.6	14.6	9.8	13.9	2.29	1.632
I am knowledgeable in waste minimization and segregation principles	4.9	17.1	24.4	7.3	46.3	3.73	1.342
I understand problems caused by poor waste management	7.3	7.3	26.8	9.8	48.8	3.85	1.315
I should be trained in environmental issues before employment	7.3	0.0	29.3	7.3	56.1	4.05	1.244
I am knowledgeable about environmental issues related to waste	9.8	2.4	26.8	4.9	56.1	3.95	1.359
I should be aware of personal protective equipment for handling waste	2.4	2.4	19.5	0.0	75.6	4.41	1.140

Responses on waste control practices in the abattoirs the abattoir workers are shown in table 17. The minimum and maximum rating means to the statements were 1.37 and 2.37 respectively, and a general rating mean was 1.87, implying that waste control is inadequately practiced.

Table 17: Waste control practices in the abattoirs

	% Frequency of respondents						
Description	**1**	**2**	**3**	**4**	**5**	**Mean**	**Std. Dev**
Control of waste at the abattoir is done regularly	26.8	31.7	22.0	12.2	7.3	1.37	1.260
Waste Separation is ensured to help in waste management	17.1	41.5	24.4	7.3	9.8	2.34	1.051
Abattoir carries out Waste collection and storage	17.1	46.3	19.5	7.3	9.8	1.44	1.246
Professional transportation of waste from disposal sites is done	22.0	39.0	22.0	4.9	12.2	1.85	1.442
Type and nature of waste determines waste disposal method	19.5	36.6	29.3	12.2	2.4	2.37	1.240

Table 18 on waste practices technologies done in the abattoirs. It is clear that abattoir workers were in agreement that compositing is adequately done at mean of 1.80 and agree that incineration at mean of 3.29 should be encouraged and is a responsibility of the abattoir owner. The minimum and maximum rating means to the statements were 1.8 and 4.12 respectively, and a general rating mean was 2.9, implies that waste practices are inadequate.

Table 18: Waste practices

	% Frequency of respondents						
Description	**1**	**2**	**3**	**4**	**5**	**Mean**	**Std.Dev**
Composting of waste is done in the abattoir	27.5	17.5	5.0	0.0	50.0	1.80	0.720
Abattoirs encourages Open burning of waste	58.5	14.6	7.3	2.4	17.1	2.05	1.532
Abattoir management should practice Incineration	26.8	7.3	22.0	41.5	2.4	3.29	1.736
Dumpsites are well placed in the abattoir grounds	58.5	17.1	7.3	2.4	14.6	3.73	1.628
Recycling before waste disposal should be practiced	2.4	4.9	29.3	4.9	58.5	4.12	1.144

On the question on satisfaction on waste disposal done in the abattoirs. 56.1% of abattoir workers were in agreement that waste disposal is inadequately done with observation showing most of the dump pits remained abandoned and not covered and paunch contents left in the open with no manure sheds. 58.5% of abattoir workers agreed with the statement that waste is not disposed according to schedule.

Table 19 shows results of responses on waste management. Abattoir workers were in agreement that there was no proper control done during disposal of wastes. The minimum and maximum rating means to the statements were 1.68 and 2.27 respectively with a general mean was 2.195 implying that proper waste management is not practiced in the abattoirs.

Table 19: Waste management

	% Frequency of respondents						
Description	**1**	**2**	**3**	**4**	**5**	**Mean**	**Std.Dev**
Disposal of abattoir wastes are not disposed to rivers, vacant lots	85.4	4.9	9.8	0.0	0.0	1.66	.855
Government methods of disposal of wastes are followed	73.2	9.8	14.6	2.4	0.0	2.39	1.070
Waste is disposed of in the designated collection area	75.6	9.8	9.8	4.9	0.0	2.46	1.027
Disposal of infectious waste is done properly	61.0	4.9	24.4	9.8	0.0	2.27	1.001

On environmental health perception and problems due to inadequate waste disposal, Abattoir workers responded that the following health problems may be caused by inadequate waste disposal: Typhoid (63.4%) Dysentery (51.2%) Parasitic infection (19.5%) Brucellosis (12.2%) Tuberculosis (9.8%) These health problems are shown in Figure 20.

Environmental problems due to inadequate waste disposal are shown in Table 20. 82.9 % of abattoir workers responded that it caused pollution, 46.3 % believed that it results in disease transmission while 14.6 % said no cause on environment

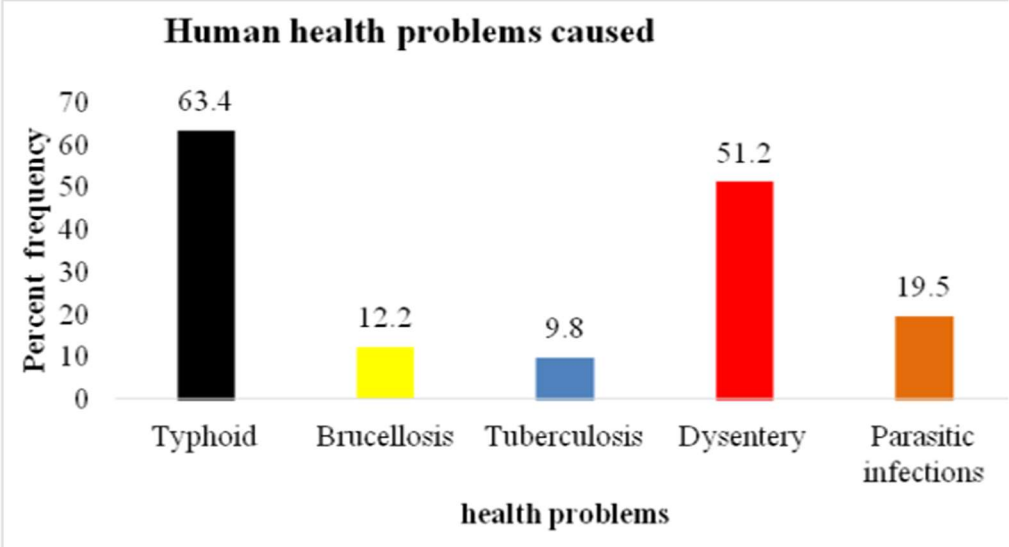

Figure 50; Responses on probable health problems due to inadequate waste disposal

Table 20: Environmental Problems due to Inadequate Waste Disposal

Environmental problems	Frequency	Percent
Pollution	34	82.9
Disease transmission	19	46.3
None	6	14.6

Figure 21: Disposal of paunch contents next to river

Figure 22: Waste lagoon in the open

Figure 23: Plastic bins used as collection point of abattoir wastes

4.3.4: Environmental Health Implications of Wastes Generated

4.3.4.1. Water sources and probable impact on health

To understand the environmental health implications of abattoir wastes, neighbourhood residents were asked about their source of water and if it affected their health. Figure 24

shows that 40.1% of the respondents used stream/river water, 39% used house connection, 35.6% used borehole/hand dug wells, and 3.4% used other sources of water. And that 63.9% of respondents said that the water they used affected their health (Figure 25). There was a positive correlation between respondents using river water and claims on probable cause of disease ($r = 0.208$, $p < 0.01$).

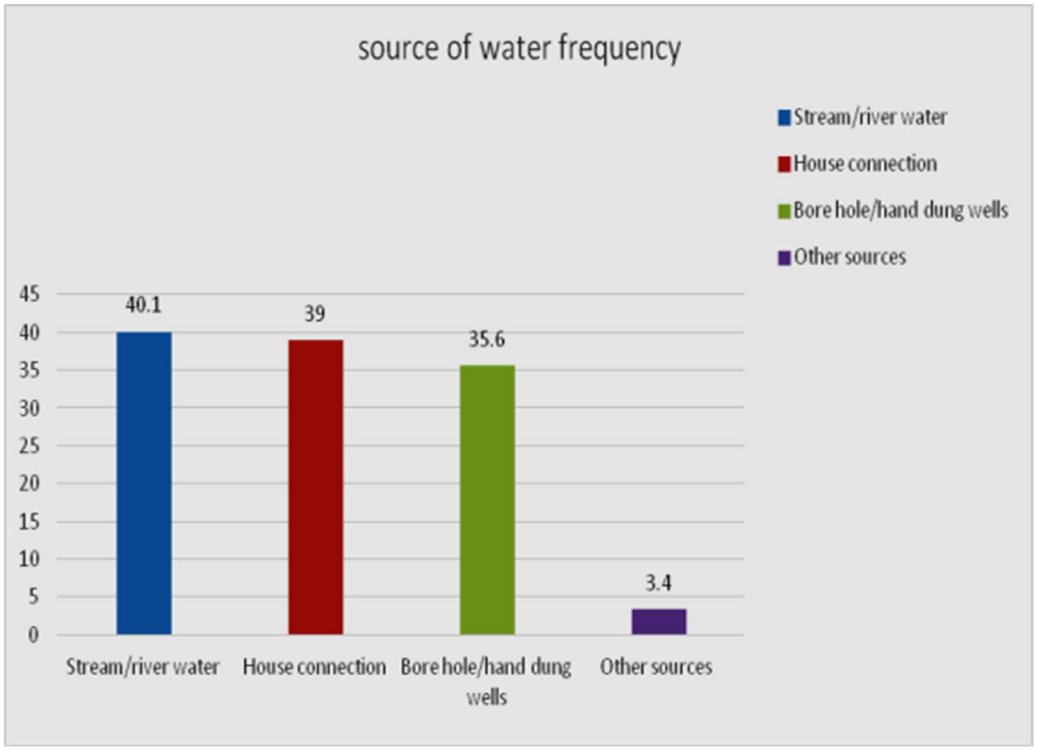

Figure 24: Source of Water for Domestic Use

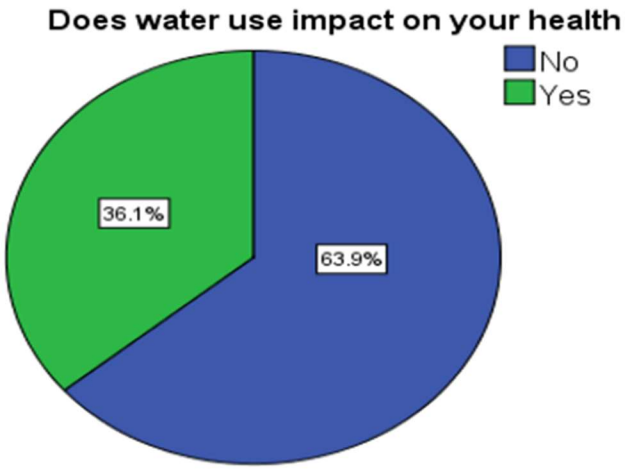

Figure 25: Neighbourhood Response on Impact of Water on Health

4.3.4.2. Odour Problem and Concern about abattoir location

When asked if the Odour from the abattoir was a problem (Table 26). Sixty-three (63) percent of the respondents who lived within 250 meters of the abattoir agreed that odour was a problem, while 60.4% of residents who lived between 251 and 500 meters of the abattoir said that the Odour was not a problem. Correlation test showed a statistically significant linear relationship r = -0.972 $p < .001$.

Responses on location of abattoir and quality of effluent are shown in Table 21. 81.6% who lived within 250 meters of the abattoir were against the location of the abattoir in their neighbourhood, while 65.1% who lived between 251 and 500 meters of the abattoir had no problem with the location of the abattoir. The majority of the respondents were unaware of the quality of effluent released from abattoirs to the environment. **(**Table 22).

Table 21: Distance from abattoir and Odour problem in Lurambi Sub County

Location Of Abattoir	Distance from Abattoir	Is Abattoir Odour A Problem		Total
		No	Yes	
Bukura	0-250m	69.6%	84.0%	77.1%
	251-500m	30.4%	16.0%	22.9%
Ejinja Corner	0-250m	82.4%	58.3%	68.3%
	251-500m	17.6%	41.7%	31.7%
Emusala	0-250m	44.1%	58.6%	52.7%
	251-500m	55.9%	41.4%	47.3%
Savona	0-250m	42.9%	72.5%	68.1%
	251-500m	57.1%	27.5%	31.9%
Shirere	0-250m	4.2%	54.9%	30.3%
	251-500m	95.8%	45.1%	69.7%
Total	0-250m	39.6%	63.0%	53.5%
	251-500m	60.4%	37.0%	46.5%

Table 22: Concern on abattoir location and quality of effluent released by abattoirs

Parameter	Distance from abattoir			Total
		No	Yes	
Do you have any concern about the abattoir being in your neighbourhood	0-250m	34.9%	81.6%	53.5%
	251-500m	65.1%	18.4%	46.5%
	251-500m	43.6%	53.8%	46.5%
Do you have an idea of the quality of the effluent discharged from the abattoir	0-250m	53.5%	54.0%	53.5%
	251-500m	46.5%	46.0%	46.5%

4.3.4.3. Health Problems Experienced by Residents and Probable Causes of the Diseases

The abattoir adjacent respondents when asked about health problems they have experienced (Figure 26). The chi square results show there is significant association between distance from abattoir and health problems in respect to diarrhoea ($\chi 2_{(5)}$=24.218, ρ<0.001), intestinal worms (($\chi 2_{(5)}$=35.422, ρ<0.001) Skin irritation (($\chi 2_{(5)}$=24.149, ρ =0.001) respiratory problems (($\chi 2_{(5)}$=32.791, ρ<0.001) experienced no problem (($\chi 2_{(5)}$=21.260, ρ<0.001) other problems (($\chi 2_{(5)}$=6.014, ρ<0.001). On the kind of assistance, residents seek when sick 20.9 % did self-medication, 49.2 % went to the dispensary and 29.8 % did not take any action.

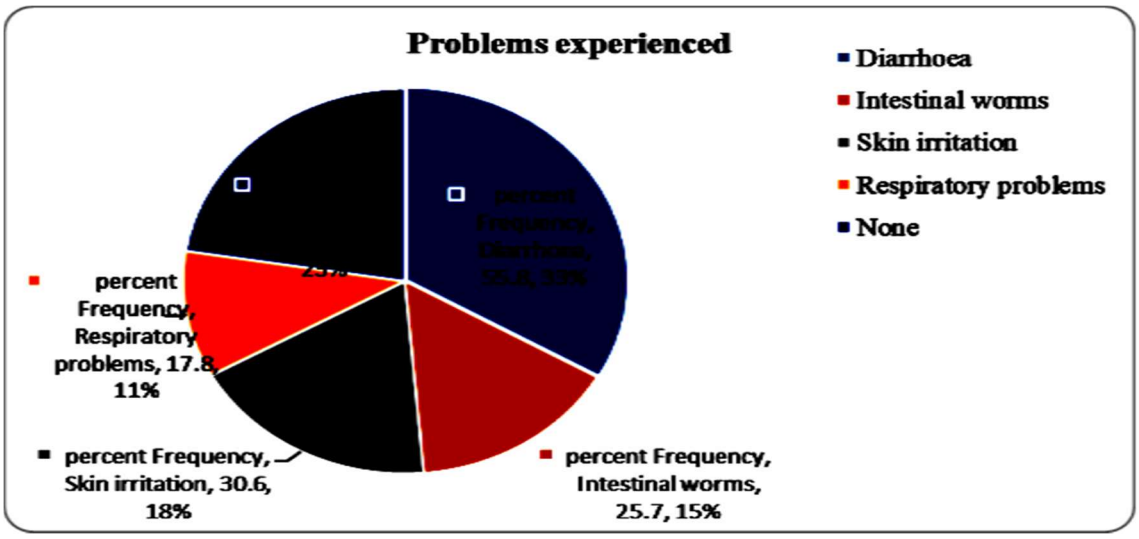

Figure 26: Health Problems Experienced by neighbourhood Respondents

When asked about the potential causes of the diseases they complained about (Figure 27), 70.4% of the residents were unable to link the diseases, they experienced to either poor hygiene or low water quality.

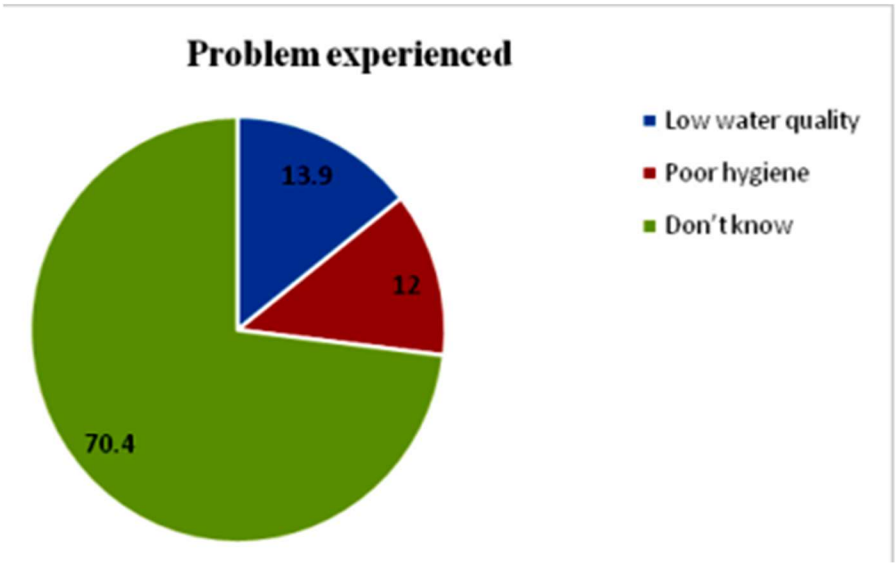

Figure 27: Response on Probable Cause of Problem Experienced

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter discusses the findings of a study that evaluated the environmental and human health risks of abattoir wastes on receiving water sources. The study addressed three specific objectives: The physicochemical characteristics of abattoir wastes and their impact on water sources. Secondly the presence of parasites and microbiological organisms in abattoir wastes and receiving water sources. And lastly the knowledge and practices of abattoir workers regarding waste management and the potential implications for nearby residents.

By discussing the results obtained from these objectives, the chapter provides a comprehensive analysis of the risks associated with abattoir wastes and offers insights for developing effective mitigation strategies and sustainable waste management practices.

5.2. Physicochemical Characteristics of Wastes and Water Sources

The temperature of the abattoir effluent samples collected ranged from 22°C to 25°C, which falls within the acceptable limits set by the World Health Organization (WHO) for water sources. The temperature range observed was considered normal for Kakamega County, which has a tropical climate. Statistical analysis did not show a significant difference between temperature and season. These findings align with a previous study by Chinakwe *et al*., (2022) and highlight the importance of temperature in wastewater as it affects the behaviour of organisms and the solubility of gases and salts in water.

The pH values of the untreated wastewater samples ranged from 9.30 to 13.13, exceeding the acceptable range specified by the WHO for wastewater discharge. The alkaline nature of abattoir wastewater, due to its high concentration of proteinaceous compounds, contributed to these pH values. Similar pH values were reported in studies conducted by Muhirwa *et al*., (2011) in Rwanda and Egesi *et al.,* (2019) in Nigeria, which also focused on abattoir wastewater.

The conductivity levels of the abattoir wastewater samples ranged from 520 µS/cm to 322 µS/cm, indicating the presence of various ions such as iron, nitrate, and sulfate. These levels exceeded the recommended limit set by the WHO. These findings differ from previous studies on slaughterhouse wastewater, which reported varying conductivity values depending on location and wastewater characteristics. For instance, Koech *et al*., (2012) found conductivity values of 2140 µS/cm, Hassan *et al*., (2014) reported values of 284.3 µS/cm, and Jimoh *et al*., (2022) reported a range of 80.94 to 139.93 µS/cm for abattoir wastewater.

The dissolved oxygen (DO) levels in the slaughter waste samples ranged from 2 to 3 mg/l, which is below the recommended value set by the WHO. Low DO levels in abattoir wastewater were consistently observed in studies conducted by Asibor *et al.,* (2020) in Nigeria and Koech *et a*l., (2012) in Kenya. These findings indicate a concern for suboptimal DO levels that could potentially harm the aquatic ecosystem, as DO serves as an indicator of organic matter pollution and impacts the biological life in water bodies.

The total dissolved solids (TDS) levels of the abattoir effluent ranged from 409 to 473 mg/l, falling within the acceptable limit set by the WHO. These findings differ from a

study by Chinakwe *et al*., (2022) in Nigeria, which reported higher TDS values. However, they align with the findings of Asibor *et al*., (2020) in their study on abattoir wastewater. TDS levels provide insights into the composition and quality of the effluent, aiding in the evaluation of treatment processes and compliance with regulatory standards.

The chemical oxygen demand (COD) levels of the effluent ranged from 4922 to 5830 mg/l, exceeding the permissible limit set by the WHO. High COD values were consistently observed in studies conducted by Adesina *et al*., (2018) in Nigeria and Hailu *et al*., (2015) in Ethiopia. The elevated COD values in the study could be attributed to the absence or inadequate implementation of waste separation practices in the abattoirs.

The total suspended solids (TSS) levels of the effluent ranged from 220 to 277 mg/l, exceeding the WHO permissible limit. Similarly, the turbidity levels of the effluent ranged from 1330 to 1448 NTU, surpassing the WHO permissible limit. These high TSS and turbidity levels were attributed to the presence of solid particles such as animal feces, urine, blood, trimmings, grease, hair, hides, and hooves. These findings were consistent with previous studies conducted by Chinakwe *et al*., (2022), Ocheje *et al*., (2021), Ajanaku *et al*., (2018), Adesina *et al*., (2018), and Koech *et al.,* (2012).

Given the potential negative impacts on water quality and ecosystems, it is crucial to monitor and manage the discharge of abattoir wastewater to prevent environmental harm, as highlighted in studies by Asibor *et al*., (2020) and Ibemenuga *et al*., (2017). Fresh water sources located near abattoirs investigated in this study revealed several important insights. Firstly, the temperature of the water samples remained within the acceptable

limits set by the World Health Organization (WHO), with slightly higher temperatures observed during the dry season. Similar results were reported in a study conducted by Adejumobi *et al.,* (2019) in Nigeria. However, other studies by Garba *et al.,* (2020) in Sokoto, Nigeria, and Duressa *et al.*, (2019) in Ethiopia reported higher temperatures, surpassing the WHO limit. Statistical analysis confirmed a significant difference between temperature and seasons, consistent with the findings of a study by Makwe *et al*., (2013) in Ethiopia.

The pH levels of the water samples were on average, higher during the wet season compared to the dry season. The borehole samples taken closer to the abattoirs and the river exhibited alkaline pH values that exceeded the WHO guidelines for drinking water. This aligns with studies conducted by Jimoh *et al.,* (2022) and Wizor *et al.*., (2019) in Nigeria. However, it differs from studies by Adejumobi *et al*., (2019) and Ajanaku *et al*., (2018) that reported pH values within the WHO guidelines for adjacent wells near abattoirs. Significant differences in pH were found among the different distances of the borehole samples. The quality of groundwater in the vicinity of an abattoir was negatively impacted by the seepage of abattoir effluent, as reported by Sangodoyin (1992).

The specific conductivity of the water samples varied between the dry and wet seasons, with higher values observed during the dry season. The specific conductivity was generally higher in boreholes closer to the abattoirs compared to those located further away. However, all samples remained within the permissible limits set by the WHO, indicating relatively low concentrations of dissolved salts in the water. It is worth noting that prolonged consumption of water with specific conductivity values above permissible

limits can have harmful effects on human health, as highlighted by Yogendra (2008). Similar findings were reported in studies conducted by Jimoh *et al.,* (2022) and Elemile *et al*., (2019) in different regions of Nigeria.

Dissolved oxygen (DO) levels were lower during the wet season compared to the dry season, and boreholes closer to the abattoirs exhibited lower DO levels. These findings align with studies by Hassan *et al.,* (2014) and Elemile *et al*., (2019) that demonstrated reduced DO levels with proximity to abattoirs. The WHO recommended DO level of 5.0 mg/l was not consistently met. The discharge of untreated abattoir effluents into water bodies can lead to deteriorated water quality, including increased DO levels, as shown in previous studies. Organic matter and biodegradable wastes in abattoir wastewater can deplete DO in the discharged effluent (Igbinosa *et al.,* 2020). Implementing proper waste management practices in abattoirs is crucial for safeguarding public health and environmental safety (Esemu *et al*., 2022).

Total suspended solids (TSS) levels were generally higher during the wet season compared to the dry season, and boreholes closer to the abattoirs exhibited higher TSS levels. Significant differences in TSS were observed between boreholes located at different distances from the abattoirs. The turbidity levels followed a similar pattern, with higher levels during the wet season and elevated levels closer to the abattoirs. However, no significant differences in turbidity were found between the sampled points. The presence of solid particles, such as animal faeces and trimmings, contributed to these higher TSS and turbidity levels. These findings were consistent with studies conducted

by Chinakwe *et al.,* (2022), Ocheje *et al*., (2021), Ajanaku *et al*., (2018), Adesina *et al*., (2018), and Koech *et al*., (2012).

The study also investigated the chemical oxygen demand (COD) levels in the water samples. COD levels were generally higher during the dry season, and boreholes closer to the abattoirs exhibited higher COD levels. However, these levels were still within the WHO's recommended limit. Similar findings were reported in studies conducted by Amoo *et al.,* (2023), Ogbonna *et al*., (2014), and Elemile *et al.,* (2019) in Nigeria. Variations in COD levels were observed at different points along the River Shikalamunga, with higher levels at the point of discharge compared to upstream and downstream locations. These findings highlight the impact of abattoir effluent on water quality and the need for proper waste management practices.

Overall, the study emphasized that the discharge of abattoir effluent significantly affects the water quality of nearby rivers. This aligns with the findings of Ogbeibu *et al.*, (2022), Ogeleka *et al*., (2021), Businge *et al*., (2021), Asibor *et al*., (2020), Wizor *et al*., (2019), Bobor *et al*., (2019), and Jega *et al*., (2019). Proper waste management practices in abattoirs are crucial for protecting public health and ensuring environmental safety (Esemu *et al.,* 2022).

5.3. Parasitological and Microbiological Characteristics of Wastes Generated and water sources

The findings of the study showed that the effluent from all abattoirs had an objectionable colour and odour due to the mixing of blood and paunch contents. This is consistent with

the findings of Ayoade *et al.,* (2016) on abattoirs in Lagos Ogun State of Nigeria. The mean bacteriological, fungal counts and BOD levels during the wet season and dry season exceeded the recommended limit for the discharge of effluents into water bodies and land. The BOD and Fungal counts values were higher than the recommended limit of WHO guidelines of 20mg/L and 1×10^2 cfu/ml respectively. The high count of these organisms in these effluents may be due to their high content of whole blood which served as a rich protein medium for microbial growth. Zhao *et al.,* (2022). The bacteria isolated and identified were *Escherichia coli, Pseudomonas aerugenosa, Klebsiella pneumoniae, Streptococcus faecalis and Shigella dysenteriae* are indicators of presence of pathogenic and opportunistic microorganisms. Similar findings have been reported by Nafarnda *et al*., (2012); Neboh *et al*., (2013); Adebowale *et al*., (2016); Ayoade *et al.,* (2016); Akpan *et al*., (2020); Abdullah *et al.,* (2020) and Joseph *et al*., (2021), who also identified bacterial pathogens in effluent samples from various abattoirs. These findings are in disagreement with those of El-Gamal and EL-Bahi, (2016) who reported 0% *E coli* and other bacteria from abattoir environmental samples investigated in Egypt.

The results of fungal isolates showed that most of the isolates were dermatophytes together with common spoilage organisms found in the beef industry Rabah *et al.,* (2008), The identified fungi were *Aspergillus flavus* (12.07%), *Aspergillus fumigatus* (25.86%), *Aspergillus niger* (15.52%), *Fusarium oxysporum (1*3.79%), *Penicillium* spp. (13.79%), and *Saccharomyces cerevisiae* (18.97%).This is consistent with the findings of Adesemoye *et al.,* (2006);Dauda *et al.,* (2016); Makinde *et al.,* (2018) and Ebah *et al.,*(2022) on the microbiological quality of abattoir wastewater in Minna Niger State, Lagos, Sokoto and Akure in Nigeria respectively. These studies also found that

*Aspergillus, Penicillium, Muco*r, *Saccharomyces* and *Fusarium* were the most common fungi found in abattoir wastewater.

The study found that the discharge of abattoir effluent into the river significantly impacted the water quality. The total coliform count, *Escherichia coli*, and BOD levels were all significantly higher at the point of discharge than at upstream and downstream sites. This is consistent with the findings of previous studies, by Adebowale *et al.,* (2016) and Bobor *et al.,* (2019) are below WHO recommended limits of 5mg/L in their respective study areas.

Additionally, a range of parasite eggs or oocytes were found in the river water samples analyzed, with the highest level found at the discharge point. These findings suggest that the discharge of abattoir effluent is a major source of microbial and organic pollution in the study area, and that this pollution is having a negative impact on the water quality and public health. No parasite eggs or oocytes were found in any of the borehole samples taken from 251-500 meters distance in Bukura, Ejinja, and Emusala abattoirs during both wet and dry seasons. However, eggs/oocytes of *Ascaris lumbroicoides* were identified in the borehole samples taken from 0-250 meters distance from abattoir. The parasites isolated from various samples were *Balantidium coli*, *Trichomonas hominis, Strongyle enterocalis, hookworm, and Ascaris lumbroicoides* from abattoir effluents, spring water, and borehole water. This could be due to the discharge of wastewater from the abattoirs. Faecal coliform and *Streptococcus faecalis* and BOD were higher in the borehole at 0-250m during the dry season, while fungal counts were higher during the wet season. The

higher levels of total coliform and fungal counts in the boreholes at 0-250m suggest that there is a source of contamination in the vicinity of the abattoirs.

The higher levels of total coliform, fungal counts and BOD in the boreholes at 0-250m suggest that there is a high level of organic matter in the water and that the water in this area is not safe for human consumption. This could be due to the presence of livestock waste, or to the discharge of wastewater from the abattoirs. The results of the study are consistent with the results of other studies that have investigated the impact of abattoir effluent on water quality. For example, a study conducted in Nigeria found that the discharge of abattoir effluent into a river resulted in a significant increase in the levels of total coliforms, *Escherichia coli,* and BOD Adeyeba *et al.,* (2002). It also similar to studies done by Coker *et al.,* (2001); Kareem *et al.,* (2015); Udoh SJ *et al.,*2019), and Elemile *et al.,* (2019): These findings suggest that the discharge of abattoir effluent is a major source of water pollution, and that this pollution can have a negative impact on the environment and public health.

When compared to WHO guidelines for drinking water, the results of the study show that the water quality in the study area is significantly below acceptable standards. The WHO guidelines state that the BOD limit should be less than 5.0 mg/L, and that total coliforms, *Escherichia coli,* fungi, helminths, and free-living nematodes should be absent. The results of the study show that the BOD levels in the water samples were significantly higher than the WHO guideline, and that total coliforms, *Escherichia coli*, fungi, helminths, and free-living nematodes were present in the water samples. This suggests that the water in the study area is not safe for human consumption.

5.4. Knowledge, practice of abattoir workers and environmental health implications on residents neighbouring abattoirs

The socio-demographic findings indicate that the majority of abattoir workers were males, and their ages ranged from 19 to 40 years. Among the abattoir workers, flayers comprised 51.2% of the workforce, while meat inspectors accounted for only 3%. It was observed that there were few meat inspectors, and some of them worked in more than two abattoirs. This pattern of greater male youth involvement in abattoir activities aligns with previous studies conducted by Nathaniel *et al.,* (2021); Daramola *et al.,* (2017), and Cook *et al.,* (2017).in abattoirs in various states in Nigeria.

The socio-demographic characteristics of the residents revealed that the majority of them resided within a distance of 0-250 meters from the abattoir. They were primarily in the age range of 21-40 years and had completed secondary education. This age group is crucial as they can make informed decisions regarding environmental concerns and understand the potential harmful effects of abattoir waste. Interestingly, 63.7% of the residents had been living near the abattoirs for over 15 years. This finding is in agreement with previous studies by Kamara (2009) and Kinyua *et al.,* (2016), which demonstrated that socio-demographic factors influence individuals' perceptions regarding waste management issues.

Based on the survey conducted among abattoir workers, dump pits are the most commonly used method of waste disposal, while incineration and landfill practices are absent. This finding is in disagreement with studies by Nathaniel *et al.,* (2021); Adeolu

et al., (2019); Fadare *et al.,* (2010) and Adebowale, (2019) who found that open dumping is the major waste disposal method at the abattoirs in Nigeria.

Overall, 73.2% of the studied participants had good knowledge of abattoir waste management, higher than 51.5% reported earlier in Nigeria by Adesokan *et al.,* (2014) and similar to 76% found by Tolera *et al.,* (2022) in Ethiopia. It is evident that there is insufficient knowledge and awareness among abattoir workers on waste disposal and its impact on public and environmental health as also reported by Nwankwo, (2023); Gebeyehu *et al.,* (2022, Tolera *et al.,* (2022) in Nigeria and Ethiopia respectively.

Results clearly reveal that waste control practices, in abattoirs are inadequately practiced. Workers expressed disagreement regarding the adequacy of composting, while agreeing that incineration should be encouraged and made the responsibility of abattoir owners. Overall, the survey findings highlight the inadequacy of waste disposal practices in abattoirs. Observations made during the survey revealed that many dump pits remained abandoned and uncovered, and paunch contents were left exposed without proper manure sheds.

The study reveals that abattoir wastes have environmental health implications and impact on neighbourhood residents. A majority of respondents opined the water had a detrimental effect on their health, suggesting a potential association between water source and health outcomes. Positive correlations were found between river and borehole water, suggesting potential health issues among residents. Studies by Megan *et al.,* (2013) have shown that improperly disposed of wastes and wastewater had a negative impact on

health. Results of this study revealed that there was a positive correlation between the use of river water There was a positive correlation between respondents using river water and claims on probable cause of disease ($r = 0.208$, $p < 0.01$). Studies by Bello *et al.,* 2009, Weobong *et al., (*2011), Adeolu, *et al., (*2019), Daramola *et al.,* 2017 have shown that poor abattoir waste management makes communities living close to abattoir suffer from negative effects of pollution and disease transmission. In addition, they have shown that there is an association between characteristics such as education, household size, and place of residence, and residents' environmental management practices.

The study demonstrates a clear relationship between the proximity to the abattoir and various health problems. Although poor hygiene and water quality are not identified as the sole causes, further investigation is needed to uncover other potential factors contributing to the residents' health issues. The findings also highlight the diverse approaches residents take in seeking medical assistance when they fall ill.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1. Conclusion

The study revealed that abattoirs generate a significant amount of waste that includes various substances such as wastewater, animal blood, urine, carcass, bones, hoofs, animal faeces, hides and skin, and intestinal contents. These wastes have a detrimental impact on the water sources near abattoir disposal sites, as evidenced by the presence of harmful bacteria, fungi, and parasites associated with waterborne diseases found in all five study abattoirs.

Analysis of abattoir wastes showed deviations from recommended standards for disposal of abattoir wastes to the environment in terms of, pH, conductivity, dissolved oxygen, chemical oxygen demand, total suspended solids, BOD and total dissolved solids. These pollutants pose a serious public health hazard and contribute to the poor quality of water sources especially for boreholes 0-250m from abattoirs.

Pathogenic parasites and microorganisms were present which included, harmful bacteria, fungi, and parasites associated with waterborne diseases in the abattoir wastes and receiving water sources. This poses a significant risk to human health, emphasizing the importance of proper waste management to prevent the spread of these pathogens and protect public health.

There are gaps in the understanding and implementation of appropriate health measures among the abattoir workers. This lack of knowledge and inadequate waste management

practices contribute to water source pollution and potential health implications for nearby residents.

There is urgent need for effective waste management strategies in abattoirs to mitigate the environmental and human health risks associated with abattoir wastes on water sources; and raising awareness among abattoir workers and stakeholders about responsible waste management which is crucial for a clean environment and the health of abattoir-adjacent communities.

6.2 Recommendations

i. The abattoirs should be upgraded with modern abattoir infrastructures and facilities for hygienic slaughtering, handling, storage, and selling of meat to consumers to forestall infestation that may affect human health

ii. The county government should prioritize the construction of adequate waste disposal facilities for both solid and liquid waste, while also increasing the number of meat inspectors. It is crucial to implement primary and secondary treatment measures for all types of waste before their discharge. Encouraging the adoption of modern waste management practices, such as reduction, re-use, and recycling, will help utilize waste by-products like bones, horns, skin, hides, and blood in other sectors of the economy.

iii. Sensitization of stakeholders through environmental education on the implications of poor waste management of abattoir for both workers and residents. Abattoirs enveloped by urban growth should be relocated. (least)

iv. Proper assessments and documentation of categories of wastes. This would help in the development of appropriate technology to take care of wastes including abattoir wastewater treatment and recycling for irrigation, compost, and biogas production.

v. Enforcement of environmental regulations guiding abattoirs and offenders be punished

vi. Further research on health problems experienced by abattoir-adjacent communities is urgently required.

REFERENCES

Ghorani-Azam, A., B. Riahi- Zanjani, M. Balali-Mood (2016). Effects of Air Pollution on Human Health and Practical Measures for Prevention in Iran J. Res. Med. Sci., 21 (2016), P. 65

Rabah, A.B., J.J. Ijah, S.B. Manga, M.L. Ibrahim. (2008). Assessment of Physico-Chemical and Microbiological Qualities of Abattoir Wastewater in Sokoto, Nigeria. Nigerian Journal of Basic and Applied Sciences Vol. 16 No. 2 December 2008

Abdullah Manir, Mehraj Gul, Safiullah Khan Achakzai, Safia Gul, Allah Nawaz Khan Mehmoona Safeer, Safiullah Khan, Uzma Ayaz, Hamid Shah, Muhammad Junaid Alam, Habibullah, Matiullah, Asif Ali, Sana Ashiq, Kanwal Ashiq, Unsa Tabassim, Nadia Hameed (2020). Isolation of Bacteria and Fungi from Effluent from Gusau Modern Abattoir Bulletin of Environment, Pharmacology and Life Sciences, Vol 9. January 2020: 45-54 ©2020 Academy for Environment and Life Sciences, India

Abiade -Paul C.U., Kene I.C, Chah K.F. (2006). Occurrence and Antibiogram of Salmonellae in the Effluent from Nsukka Municipal Abattoir. Nigerian Veterinary Journal, 1: 48-54.

Abubakar, A. S., & Bello, N. I. (2023). Effects Of Locating Abattoir to the Neighbouring Communities in Kano State, Nigeria. International Journal of Geography and Geography Education (Igge), 48, 187-201

Adebowale O.O. (2019). Waste Management and Practices in a Slaughterhouse in Abeokuta Nigeria. Case Study, Implications and Alternative Methods. Sokoto journal of Veterinary Medicine, 17(3):52-55.

Adebowale, O.O., Jayeola, A., Adeyemo, O.K. & Kperegbeyi, E. (2016). Potential Bacterial Zoonotic Pathogens Isolated from a Major Abattoir and It's Receiving Surface Water in Abeokuta, Nigeria', *Alexandria Journal of Veterinary Science* 50(1), 94–98. Https://Doi.Org/10.5455/Ajvs.222912

Adegbola, A. A., Adewoye, Abosede, O. (2012). On Investigating Pollution of Groundwater from Atenda Abattoir Wastes, Ogbomoso, Nigeria. *International Journal of Engineering and Technology. ISSN 2029-3444.2(9).*

Adejumobi, M., Alonge, T. (2019). Evaluation of Abattoir Effluent on Ground Water quality. Laujoces, Issue1(3).

Https://Doi.Org/10.36108/Laujoces/9102/20(0250).

Adelegan, J.A. (2002). Environmental Policy and Slaughterhouse Waste in Nigeria, 28th W.E.D.C. Conference Report, Calcutta, India.

Adeolu A.T., Opasola A.O., Salami O.O., Iyanda A.Y., Omenta R.C. (2019). Sanitary Status and Compliance with the Standard Slaughter Practices in Karu Abattoir Abuja Municipal Area Council of the Fct, Nigeria. International Journal of Current Innovations in Advanced Research, 2(2):1-14.

Adesemoye A. O., Opere B. O., Makinde S. C. O. (2006). Microbial Content of Abattoir Wastewater and Its Contaminated Soil in Lagos, Nigeria African Journal of Biotechnology Vol. 5 (20), Pp. 1963-1968.

Adesina, A., Ogunyebi, A., Fingesi, T., Oludoye, O. (2018). Assessment of Kara Abattoir Effluent on the Water Quality of Ogun River, Nigeria. Journal of Applied Sciences and Environmental Management, 9(22), 1461

Adesokan, H.K. Sulaimon, M.A. (2014). Slaughterhouse Waste Management: Empirical Evidences from Nigeria and Implications on Achieving Millennium Development Goals. Afrrev Stech: An International Journal of Science and Technology Bahir Dar, Ethiopia Vol. 3 (1): 110-127.

Adewumi, J. R., Babatola, J. O., E. O. Adejuwon. (2016). Assessment of Abattoir Wastes Management Strategy in Akure South West Nigeria Vol.2 (1):186 – 194

Adeyeba O.A., Akinbo J.A. (2002). Pathogenic Intestinal Parasites and Bacterial Agents in Solid Wastes East African Medical Journal Vol. 79 (11).

Adeyemo, O.K., I.O., Ayodeji, C.O., Aiki-Raji. (2002). The Water Quality and Sanitary Conditions Major Abattoir (Bodija) In Ibadan. A. J. Biomed. Res., 5: 51-55.

Adonu, R.E. Dzokoto, L. Salifu S.I. (2017). Sanitary and Hygiene Conditions of Slaughterhouses and Its Effect on the Health of Residents: A Case Study of Amasaman Slaughterhouse in the Ga West Municipality, Ghana Food Sci. Qual. Manag., 65 (2017).

Ajanaku A. O., Olusola O.O., Oyelami B. A., P. (2018). Effect Of Abattoir Activities on The Ground Waters Around Bodija and Akinyele Abattoirs in Oyo State. *International Journal of Environment Agriculture and Biotechnology (*ISSN: 2456-1878).3(3), 1002-1010.10.22161/Ijeab/3.3.37

Akpan, S.N., Odeniyi, O.A., Adebowale, O.O., Alarape, S.A. & Adeyemo, O.K. (2020). Antibiotic Resistance Profile of Gram-Negative Bacteria Isolated from Lafenwa Abattoir Effluent and Its Receiving Water (Ogun River) In Abeokuta, Ogun State, Nigeria', *Onderstepoort Journal of Veterinary Research* 87(1), A1854.

Akpoka, O. A., Solanke, E., Akinyeye, A. J., Mekomah, H. (2022). Bacteria Diversity of Two Abattoir Effluents in Ikpoba Hill and Oluku, Benin City, Nigeria and Their Potential Public Health Implications. Microbes and InfectiousDiseases,0(0),0-Https://Doi.Org/10.21608/Mid.2022.114174.1226

Alonge, D.O. (2005). Meat and Milk Hygiene in the Tropics. Farmose Press, Ibadan, Nigeria. Pp: 77-86.

American Public Health Association. (2017). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.

Amoo, A. O., Adeleye, N. A. O., Madu, N. I. E., Asaju, N. C. I., Amoo, N. N. B., Abdullahi, N. A. A., Alabi, N. I. A. (2023). Impact of Slaughterhouse Effluents on Groundwater Quality: Evidence-Based Assessment in Tudun-Wada and Kawo Residential Suburbs, Kaduna, Nigeria. Jeicc, 1(2), 41-50.

Aniobi C.C., Ezeh E., Okeke O., Akagha C.I and Alieze A.B. (2020). Environmental Impact of Abattoir Effluents Discharge on the Quality of Well Water in Abakpa, Enugu State-Nigeria. International Journal of Innovation and Applied Studies. Vol. 29 (3): Pp. 821-830.

Asibor, G., Edjere, O., Azubuike, C. (2020). Status of Discharged Abattoir Effluent and Its Effects on the Physico-Chemical Characteristics of Orogodo River, Delta State, Nigeria. Https://Doi.Org/10.2495/Wp200051

Ayoade, F., Olayioye, E. (2016). Microbiological Assessment of Housekeeping Practices and Environmental Impact of Selected Abattoirs in Lagos and Ogun States of Nigeria. J. App. Bioscience., 1(99), 9363. Https://Doi.Org/10.4314/Jab.V99i1.2

Barrow, G.I., Feltham R.K.A. (1993). Cowan and Steel Manual for the Identification of Medical Bacteria. New York: Cambridge University Press.

Bello Y.O., Oyedemi D.T.A. (2009). The Impact of Abattoir Activities and Management in Residential Neighbourhoods: A Case Study of Ogbomosho, Nigeria. Journal of Social Science, 19(2):121-127

Bello, N. I. (2023). Effects of Locating Abattoir to the Neighbouring Communities in Kano State, Nigeria. International Journal of Geography and Geography Education, 48, 187-201. Https://Doi.Org/10.32003/Igge.1161854

Bergey, D. H., & Holt, J. G. (1993). Bergey's Manual of Determinative Bacteriology (9th Ed.). Baltimore: Williams & Wilkins.

Bhunia Shantanu, Ankita Bhowmik, Rambilash Mallick, Anupam Debsarcar, Joydeep Mukherjee. (2021). Application of Recycled Slaughterhouse Wastes as an Organic Fertilizer for Successive Cultivations of Bell Pepper and Amaranth.

Bobor, L., Umeh, C. (2019). Physicochemical and Microbiological Water Quality Assessment of Aba Waterside River, Aba, Nigeria. Nig. J. Env. Sci. & Tech., 1(3), 142-148. Https://Doi.Org/10.36263/Nijest.2019.01.0124

Businge, F., Kagoya, S., Omara, T., Angiro, C. (2021). Pollution of Mpanga River by Kabundaire Abattoir Effluents, Fort Portal Tourism City, Uganda. Ajfar, 34-43. Https://Doi.Org/10.9734/Ajfar/2021/V11i130195

Check, J., Schutt, R. K. (2012). Survey Research. In J. Check & R. K. Schutt (Eds.), Research Methods in Education (Pp. 159–185). Thousand Oaks, Ca: Sage Publications.

Cheesebrough Monica (2009). District Laboratory Practice In Tropical Countries Part 1, Second, Cambridge University Press, New York, NY, USA.

Chinakwe, E. C., Nwogwugwu, N., Ihejirika, C. E., Ngumah, J., Mike-Anosike, E. E., Ajugwo, G. C., Iwuji, J. C. (2022). Physico-Chemical and Microbiological Qualities of Abattoir Wastewater in Egbu, Imo State, Nigeria. Mrji, 31-36. Https://Doi.Org/10.9734/Mrji/2022/V32i430383

Chukwu, Ogbonnaya. (2008) Analysis of Groundwater Pollution from Abattoir Waste in Minna, Nigeria. Research Journal of Diary Science, 2, 74-77.

Coker, A.O., Olugasa, B.O., Adeyemi A.O. (2001). Abattoir Wastewater Quality in Southwestern Nigeria People and Systems for Water Sanitation and Health 27th WEDC Conference Lusaka Zambia.

Cook, E.A.J., De Glanville, W.A., Thomas, L.F. (2017). Working Conditions and Public Health Risks in Slaughterhouses in Western Kenya. *BMC Public Health* 17, 14 (2017). Https://Doi.Org/10.1186/S12889-016-3923-Y

County Government of Kakamega (2014). Kakamega Abattoir Act (2014).

County Government of Kakamega (2018). Directorate of Veterinary Services Annual Report of Department of Veterinary Services. Kakamega County.

Daramola O.P., Olowoporoku O.A (2017). Living With a Fatal Choice: Effects of Slaughterhouse Activities on Residents' Health in Osogbo, Nigeria. International Journal of Environmental Problems, 3 (1):26-35.

Daramola, O.P. Olawuni, P. O, Soumah M. (2017). Environmental Implications of Abattoir Waste Generation and Management in Developing Countries: The Case of Lagos State Abattoir in Agege, Nigeria Greener Journal of Social Sciences Vol. 7 (2), Pp. 007-014.

Dauda. D.R., Duro. D U., J. J. Ijah (2016). Physicochemical and Microbiological Qualities of the Abattoir Wastewater in Part of Minna Niger State Advances in Life Science and Technology Vol.51.

Duressa G, Assefa F., Jida M (2019). Assessment of Bacteriological and Physicochemical Quality of Drinking Water from Source to Household Tap Connection in Nekemte, Oromia, Ethiopia. Journal of Environmental and Public. Health

Ebah, N. E. E., Odo, N. J. I., Adah, N. J. A. (2022). Screening and Identification of Some Selected Fungi Species from Abattoir Waste Water. Int. J. Scholarly Res. Multidiscipline. Studies, 1(1): 009-015. Https://Doi.Org/10.56781/Ijsrms.2022.1.1.0025

Ebong, G. A., Ettesam, E. S., Dan, E. (2020). Impact of Abattoir Wastes on Trace Metal Accumulation, Speciation, and Human Health–Related Problems in Soils within Southern Nigeria. Air, Soil and Water Research, (13), 117862211989843. Https://Doi.Org/10.1177/1178622119898430

Egesi Constance, Victor E., Anthony C. Ekeleme, Charles E. Obiukwu (2019). Compliance Monitoring of Microbiological and Physicochemical Parameters of Abattoirs' Effluents Discharged into Water Bodies In Owerri, Nigeria Microbiology Research Journal International 28(6): 1-16, 2019.

Elemile, O. O., Raphael, D. O., Omole, D. O., Oloruntoba, E. O., Ajayi, E. O., Ohwavborua, N. A. (2019). Assessment of the Impact of Abattoir Effluent on the Quality of Groundwater in a Residential Area of Omu-Aran, Nigeria. Environ Sci Eur, 1(31). Https://Doi.Org/10.1186/S12302-019-0201-5

El-Gamal, A. M. And El-Bahi, E. F. (2016). Molecular Characterization of Rectal Carriage of *E. coli* O157: H7and *Salmonella* Spp. In Feedlot Animals and Its Effects on Carcasses Contamination. Anterior Jugular Venous Systems, 48 (1):42-49

Enterprise Ireland. (2009). Sustainable Practices In Irish Beef Processing. National Development Plan, Government of Ireland.

Esemu, S. N., Aka, T. K., Kfusi, A. J., Ndip, R. N., Ndip, L. M. (2022). Multidrug-Resistant Bacteria and Enterobacteriaceae Count in Abattoir Wastes And its Receiving Waters In Limbe Municipality, Cameroon: Public Health Implications. Biomed Research International, (2022), 1-11. Https://Doi.Org/10.1155/2022/9977371

Fadare S.O., Afon A.O. (2010) Waste Handling Practices at Abattoirs: Experience from Ile-Ife, Nigeria. The Lagos Journal of Environmental Studies, 7(2): 51-57

Fearon, J., Mensah, S. B., Boateng, V. (2014). Abattoir Operations, Waste Generation, and Management in the Tamale Metropolis: A Case Study of the Tamale Slaughterhouse.

Ferronato N, Torretta V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *International Journal of Environmental Research and Public Health*. 2019; 16(6):1060. Https://Doi.Org/10.3390/Ijerph16061060

Food and Agricultural Organization. (2008). Abattoir Development, Options, and Designs for Hygienic Basic and Medium-Sized Abattoirs.

Food and Agricultural Organization. (2010). Food and Agriculture Organization of the United Nations (The State of Food and Agriculture 2009: Livestock in the Balance, 176pp, 2010).

Garba, B., Salihu, M., Saidu, B., Rambo, U. (2020). Health Hazards of Abattoir Effluents Discharged from The Sokoto Central Abattoir, Nigeria. Sokoto J. Vet. Sc., 1(18), 47-52. Https://Doi.Org/10.4314/Sokjvs.V18i1.7

Gauri, S. Mittal (2007). Characterization of the Effluent Wastewater from Abattoirs for Land Application Food Reviews International vol. 20, No. 3, Pp. 229–256, 2004

Gebeyehu, D., Tsegaye, H. (2022). Food Safety Knowledge and Practice of Abattoir and Butcher Shop Workers: A Health Risk Management Perspective. One Health Outlook, 1(4). Https://Doi.Org/10.1186/S42522-022-00070-1

Government of Kenya. (2012). Meat Control Act, Vol. 356. National Council for Law Reporting Meat Control Act.

Hailu, Abrha, Ayenew, Tenalem. (2015). Characterization Of Abattoir Wastewater And Evaluation Of The Effectiveness Of The Wastewater Treatment Systems In Luna And Kera Abattoirs In Central Ethiopia. International Journal of Scientific and Engineering Research. 6. 1026-1040.

Hassan I. A., Campbell C., Ademola T. G. (2014). Effect of Abattoir Effluent on Surrounding Underground Water Quality: A Case Study of Governor Road Abattoir at Ikotun, Lagos State. International Journal of Advances in Pharmacy, Biology, and Chemistry: Vol. 3(4): 2277 – 4688.

Hosu, M. C., Vasaikar, S. D., Okuthe, G. E., Apalata, T. (2021). Molecular Detection of Antibiotic-Resistant Genes in Pseudomonas Aeruginosa from Nonclinical Environment: Public Health Implications in Mthatha, Eastern Cape Province, South Africa. International Journal of Microbiology, (2021), 1-9. Https://Doi.Org/10.1016/J.Scienta.2021.109927.

Ibemenuga K., Nduba B., Eyo J. (2017). The Influence of Abattoir Wastes on Macroinvertebrate Distribution in River Idemili, Obosi, South-Eastern Nigeria. Notulae Scientia Biologicae. 480-486.

Igbinosa, I. H., Raje, O. C. (2020). Characterization Of Lt; I ≫ Enterococcus ≪ /I & Gt; Species Isolated from Abattoir Environment in Benin City, Nigeria Ife Journal of Science, 3(21), 81. Https://Doi.Org/10.4314/Ijs.V21i3.8

Igbinosa,I.H.Uwidia,I.E.(2018).Effect of Abattoir Effluents on the Physicochemical Properties of a Receiving Watershed in an Urban Community.Ife,Journal of Science, (20), 219. Https://Doi.Org/10.4314/Ijs.V20i2.2

Ilija D. (2015). Environmental Impact of the Meat Industry – Current Status and Future Perspectives. Elsevier Limited Procedia Food Science 5 61 – 64.

Isoken H. Igbinosa, Ita E. Uwidia (2018). Effect of Abattoir Effluents on the Physicochemical Properties of a Receiving Watershed in an Urban Community Ife Journal of Science Vol. 20, No. 2 (2018)

Izuchukwu, I. F., Ozim, S. J., Ama, H., Uduji, H., Nworu, D. C., Agu, G. C., Uduji, O. G., Edward, A. Nnatuanya, I. (2016). Determination of the Microbiological and Physicochemical Quality of Borehole Water in Orji Amawire in Owerrii North Local Government Area Imo State. International Journal of Advance Research in Biological Sciences, 3: 64-70

Jega, B., Adebisi, O., Manga, S. (2019). Antibiotic Susceptibility Of Bacteria Isolated From Abattoir Effluent-Impacted Tagangu River, Aliero, Kebbi State, andNorth-WesternNigeria.Sajrm,1-8 Https://Doi.Org/10.9734/Sajrm/2018/V2i430072

Jimoh, T. Y., Olayeri, A. A., Falebita, T. E., Reis, G. A., Olufowobi, B. I., Saba, A. O., Akinbode, B. P., Olorunfemi, O. T., & Nwabuisi, P. N. (2022). Environmental Impacts of Agbara Abattoir Waste on the Ecosystem of Ologe Lagoon, Nigeria. *Journal of Advances in Biology & Biotechnology*, *25*(5), 11–17. Https://Doi.Org/10.9734/Jabb/2022/V25i530281

Joseph M.O., Ibrahim B., Zaky S.K., S. Abdulkadir., I.K. Auta (2021). Bacterial Assessment of Effluents from Selected Abattoirs into Adjoining Water Bodies in Kaduna Metropolis Science World Journal Vol. 16(No 1) 2021

Jung, Sin-Ho. (2014). Stratified Fisher's Exact Test and Its Sample Size Calculation. Biometrical Journal. Biometrische Zeitschrift. 56. 129-40. 10.1002/Bimj.201300048.

Kamara, A. J. (2009). Household Participation in Domestic Waste Disposal and Recycling In the Tshwane Metropolitan Area: An Environmental Education Perspective. University Of South Africa

Kareem H.N., Amir H. M., Mehdi M., Hossein K., Iraj M., Mostafa R. (2015). Detection of Parasitic Particles in Domestic and Urban Wastewaters and Assessment of Removal Efficiency of Treatment Plants in Tehran, Iran

Kaza Silpa, Yao, Lisa C., Bhada-Tata, Perinaz. Van Woerden, Frank. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Urban Development; © Washington, Dc: World Bank. Http://Hdl.Handle.Net/10986/30317 License: Cc By 3.0 Igo."

Kenya National Bureau of Statistics. (2019). 2019 Kenya Population and Housing Census: Volume I: Population by County and Sub-County.

Kinyua, L., Ogwayo, O., Muthoni, A. (2016). Social-Cultural Factors Associated with Household Solid Waste Management in A Kenyan Informal Settlement. Environmental Science, Toxicology and Food Technology, 10(10).63-68.

Koech, H.K., Ogendi, G., Kipkemboi, J. (2012). Status of Treated Slaughter-House Effluent and Its Effects on the Physico-Chemical Characteristics of Surface Water in Kavuthi Stream, Dagoretti-Kenya: Research Journal Of Environmental And Earth Sciences 4(8): 789-796

Lesley Rushton. (2003). Health Hazards and Waste Management. British Medical Bulletin, Volume 68(1)183–197, Https://Doi.Org/10.1093/Bmb/Ldg034

Magaji J.Y., Hassan S.M. (2017). An Assessment of Air Quality In And Around Gwagwalada Abattoir, Gwagwalada, Abuja, Fct J. Environ. Earth Sci., 5 (2017), Pp. 87-92

Makinde, O. Olusola., O., J. Arotupin, D., C. Adetuyi, F. (2018). Filamentous Fungal Quality of a Bovine Abattoir and Associated Water Sources in Akure, Southwestern, Nigeria. *South Asian Journal of Research in Microbiology*, *1*(1), 1–8. Https://Doi.Org/10.9734/Sajrm/2018/V1i1734

Makwe, E. U., Chup, C. (2013). Seasonal Variation in Physico-Chemical Properties of Groundwater around Karu Abattoir. Ethiop. J. Env Stud &Amp; Manag, 5(6). Https://Doi.Org/10.4314/Ejesm.V6i5.6.

Masse, D.1., Masse, L. (2000). Characterization of Waste Water from Hop Slaughterhouses Eastern Canada and Evaluation of Their Implant Wastewater Treatment System Agriculture and Agric Food Canada East, Lennoxnille Quba

Megan, E. G., Stefan, S. (2013). Microbiological Quality of the Msunduzi River (Kwazulu- Natal South Africa) Suitable for Domestic, Recreational and Agricultural Purposes. Environmental Sciences and Pollution Research, 20: 6551-6562.

Meiramkulova, K., Devrishov, D., Zhumagulov, M., Arystanova, S., Karagoishin, Z., Marzanova, S., Kydyrbekova, A.; Mkilima, T.; Li, J. (2020). Performance Of an Integrated Membrane Process with Electrochemical Pre-Treatment on Poultry Slaughterhouse Wastewater Purification. Membranes 2020, 10, 256.

Mgbemena, I. C., Okechukwu, I. J., Onyemekera, N. N., Nnokwe, J. C. (2012). Physicochemical and Microbial Characterization of Somberiro River in

Ahoada East Local Government Area, Rivers State, Nigeria. International Journal of Biosciences, 2: 36-44.

Muhirwa D., Nhapi I., Wali U.G., Banadda N., Kashaigili J. J., Kimwaga R. (2010). Characterization of Wastewater from an Abattoir in Rwanda and the Impact on Downstream Water Quality International Journal of Ecology & Development Vol. 16,

Nafarnda, W. D. Ajayi, I. E. J. C. Shawulu, M. S. Kawe, G. K. Omeiza, N. A. Sani, O. Z. Tenuche, D. D. Dantong, S. Z. Tags, (2012). Bacteriological Quality of Abattoir Effluents Discharged into Water Bodies In Abuja, Nigeria", *International Scholarly Research Notices*, Vol. 2012.

Nathaniel O. O., Ifeoluwa T. A., Olanrewaju T. D., Adewunmi I. B., Bashir O. O., Chikodi D. A. (2021). Operators' Perceptions of Abattoir Waste Management: Evidence from a Semi-Urban Nigerian City Eqa - International Journal of Environmental Quality Vol. 43 (2021): 16-29

Neboh, H.A.1, Ilusanya, O.A., Ezekoye C.C. And Orji, F.A (2013). Assessment of Ijebu-Igbo Abattoir Effluent and Its Impact on the Ecology of the Receiving Soil and River IOSR Journal of Environmental Science, Toxicology and Food Technology ISSN: 2319-2399. Volume 7(5) Pp 61-67

NEMA (2014). The National Solid Waste Management Strategy. Nairobi, Kenya: National Environment Management Authority

Nwankwo, I., Nwanta, J., Onunkwo, J. (2023). Abattoirs as Meat Safety and Disease Surveillance Points in Nigeria: The Case of Ikpa Slaughterhouse, Nsukka, Nigeria. Sokoto J. Vet. Sc., 1(21), 47-50. Https://Doi.Org/10.4314/Sokjvs.V21i1.6

Nwanta, J.A., Onunkwo J.I., Ezenduka, V.E., Phil-Eze, P.O., Egege, S.C. (2008). Abattoir Operations and Waste Management in Nigeria. A Review of the Challenges and Prospects Journal of Environmental Science and Technology, *1*(2), 56 - 54.

Obidiegwu, C., Chineke, H., Ubajaka, C., Adogu, P. (2019). Public Health Challenges in Somachi Main Abattoir Owerri, Nigeria: A Review and Field Activity Report. European Journal of Medical and Health Sciences

Ocheje, J. M., Basira, I., Abdulkadir, S., Suzy, Z., Kato, A. I. (2021). Physical Attributes in Three Abattoirs Wastewater in Kaduna Metropolis. Ijbbmb, 2(6), 56. Https://Doi.Org/10.11648/J.Ijbbmb.20210602.15

Ogbeibu, A., Erhirhi, A. (2022). Assessment Of the Impact of Abattoir Effluent on The Physico-Chemical And Microbiological Characteristics Of The Effurun River, Effurun And Eburu Canal, Warri In Delta State, Nigeria. Tfb, 1(30), 45-59. Https://Doi.Org/10.4314/Tfb.V30i1.4

Ogbonna, D.N., Ideriah, T.J.K. (2014). Effect of Abattoir Waste Water on Physico-Chemical Characteristics of Soil and Sediment in Southern Nigeria. Journal of Scientific Research & Reports3 (12): 1612-1632.

Ogeleka, D., Emegha, M., Okieimen, F. (2021). Eco toxicological Risk Assessment of Surface Water Receiving Abattoir Effluent. Sjc, 1(9), 14. Https://Doi.Org/10.11648/J.Sjc.20210901.13

Ogun, M. L., Anagun, O. S., Awote, O. K., Oluwole, S. O., Kappo, S. C., Alonge, F. O. (2023). Abattoirs: The Hidden Sources of Plants' Heavy Metals and Other Pollutants in Lagos, Nigeria. Heavy Metals - Recent Advances [Working Title]. Https://Doi.Org/10.5772/Intechopen.110339

Olanrewaju, S., Garba, F., Babayemi, Y. (2022). Locational Characteristics and Impact of Attenda Abattoir, Ogbomoso, Nigeria. Gazi University Journal of Science. Https://Doi.Org/10.35378/Gujs.964138

Olowoporoku A. (2016). Assessing Environmental Sanitation Practices in Slaughterhouses in Osogbo, Nigeria: Taking the Good with the Bad J. Environ. Sci., 1 (2016), Pp. 44-54

Omole, D.O., Longe, E.O. (2008). An Assessment of the Impact of Abattoir Effluents on River Illo, Ota, Nigeria, Journal of Environmental Science and Technology, 1 (2), Pp. 56-54.

Omulo Collins (2018 April 24). Nema Closes Kimaiko Slaughterhouses. Daily Nation.Https://Www.Nation.Co.Ke/News/Nemacloses-Kimaiko Slaughterhouses

Rabah A.B., Ijah U.J.J., Manga S.B., Ibrahim M.L. (2008): Assessment of Physico-Chemical and Microbiological Qualities of Abattoir Wastewater in Sokoto, Nigeria. Nigerian Journal of Basic and Applied Sciences Vol. 16 (2)

Rachel. M. Ayres, Duncan, Mara. (1996). Analysis of Wastewater for Use in Agriculture. Laboratory Manual of Parasitological and Bacteriological Techniques, Who, Geneva, Switzerland, 1996.

Regina E. Adonu, Lucia D., Sherifatu I. S. (2017). Sanitary and Hygiene Conditions of Slaughterhouses and Its Effect on the Health of Residents. Food Science and Quality Management) Vol.65, 2017.

Sampson, T., Deele, R. D. (2022). Impact of Abattoir Activities on the Physicochemical and Bacteriological Properties of Soil Samples from Choba Slaughter, Rivers State,Nigeria.Asrj,12-23. Https://Doi.Org/10.9734/Asrj/2022/V6i4114

Sangodoyin, A.Y., (1992). Ground Water and Surface Water Pollution By Open Refuse Dump In Ibadan, Nigeria. Journal of Discovery and Innovations, 3(3): 24 – 31.

Savin, M.; Bierbaum, G.; Hammerl, J.A.; Heinemann, C.; Parcina, M.; Sib Ekreyenschmidt, J. (2021) Antibiotic-Resistant Bacteria and Antimicrobial Residues in Wastewater and Process Water from German Pig Slaughterhouses And Their Receiving Municipal Wastewater Treatment Plants. Sci. Total Environ. 2020, 727, 138788.Scientia Horticulturae, Volume 280, 2021, 109927, ISSN 0304-4238,

Svanstrom Peter. (2014). Pathogens and Antibiotic-Resistant Bacteria in Abattoir Waste and Animals. Swedish University of Agricultural Sciences, Department of Biomedical Sciences and Veterinary Public Health

Tolera, S., Alemu, F., Mengistu, D. (2022). Knowledge, Attitude, and Practice of Abattoir Workers toward Abattoirs Waste Management in Eastern Ethiopia. Environ. HealthInsights, (16),117863022210754. Https://Doi.Org/10.1177/11786302221075450

Tritt, W.P. Schuchardt, F. (1992). Materials Flow and Possibilities of Treating Liquid and Solids Wastes from Slaughterhouse in Germany. Bioresource Technology 41:235- 245.

Ubuoh, E.A. Uchendu, U.I. Kanu C. (2017). Characterization of Atmospheric Gaseous Components in Abattoir Operation Site in Ogbo-Hill, Abia State, Nigeria J. Environ. Anal. Toxicol. 7 (2017), Pp. 1-4

Udoh S.J, Olaniran O, Adedire B.A, Hassan-Olajokun R.E, Olaniran O.O, Oyetokeo O, (2019). Investigation On the Pattern of Intestinal Parasites Present In Refuse Dumps And Abattoir Wastes In Ile-Ife. Nigeria. Biol Med (Aligarh). 11:460.

Ullah.J.J. Ijah, I.O. Musa, F. Amao, A.M. Maude, M.O. Victor-Ekwebelem (2022). Wastewater Quality and Unhygienic Practices in Minna Abattoir, North Central Nigeria Science World Journal Vol. 17(No 2) 2022.

Victoria Daminabo, James Damen (2020). Prevalence of Intestinal Parasites from Abattoir Effluents in Jos Metropolis, Nigeria International Journal of Photochemistry, and Photobiology 2020; 4(1):1-10 Http://Www.Sciencepublishinggroup.Com/J/IjppDoi:10.11648/J.Ijpp.20200401.11

Wang, L., C. Liu, X. Meng, Y. Niu, Z. Lin, Y. Liu, J. Liu, J. Qi, J. You, L.A. Tse (2018). Associations between Short-Term Exposures to Ambient Sulphur Dioxide and Increased Cause-Specific Mortality in 272 Chinese Cities

Weobong C. A.A., Enyonam Y. A. (2011). Operational Impacts of the Tamale Abattoir on the Environment Journal of Public Health and Epidemiology Vol. 3(9), Pp. 386-393.

WHO (2006) Guidelines for the Safe Use of Wastewater, Excreta and Greater, Vol. 3. World Health Organization Press, Geneva, Switzerland

WHO (2018) Air Quality and Health

Wilson, D. (1992). Methods of Disposal of Paunch Contents with Emphasis on Composting. In: Pearson A.M., Dutson T.R. (Eds) Inedible Meat By-Products. Advances In Meat Research Series, Vol 8. Springer, Dordrecht

Wismer-Pedersen, J. (1988). Use of Hemoglobin in Foods. Meat Science Vol.24 Pg. 31-45.

Wizor, C., Nwankwoala, H. (2019). Effects of Municipal Abattoir Waste on Water Quality of Woji River in Trans-Amadi Industrial Area of Port Harcourt, Nigeria: Implication for Sustainable Urban Environmental Management. International Journal of Geography and Geology, 2(8), 44-57. Https://Doi.Org/10.18488/Journal.10.2019.82.44.57

World Bank. (2009). Global Study of Livestock Markets, Slaughterhouses, and Related Waste Management Systems.

Yogendra K, Puttaiah Et. (2008). Determination of Water Quality Index and Suitability of an Urban Water Body in Shimoga Town, Karnataka. In: Proceedings on the 12th World Lake Conference, Jaipur, India. Pp 342–346

Zhao, S., Lin, H., Li, S., Liu, C., Junhong, M., Guan, W. & Liu, B. (2022). Modeling of Chilled/Super cooled Pork Storage Quality Based on the Entropy Weight Method. Animals, 11(12), 1415. Https://Doi.Org/10.3390/Ani12111415

APPENDICES

Appendix 1: Questionnaire for Abattoir Workers

SECTION A: Respondents Socio Demographic Characteristics

1. Location: Shirere ( ) Savona ( ) Bukura ( ) Emusala ( ) ejinja corner ( )
2. Sex: male ( ) female ( )
3. Age in years: 10-18 ( ) 19-40 ( ) 41-60 ( ) 60 above ( )
4. Marital status: Single ( ) widow ( ) Divorced ( ) Married ( )
5. Occupation: Flayers ( ) meat inspector ( ) cleaner ( ) others ( )
6. Level of education: Non () Primary ( ) Secondary ( ) Tertiary ( )

SECTION B: **Quantity of Waste Produced and Methods for Disposal**

7. What is the number of animals slaughtered per day?

(a) Cow…… (b) Shoats……..... (c) Others……..

8. On a scale of 1 to 5 representing (**1**= Very Low; **2**= Low; **3**= Neutral; **4**= High; **5**= Very High) which types of waste do you produce mostly in the abattoir?

Categories of Waste	**1**	**2**	**3**	**4**	**5**
Bones					
Blood					
Paunch manure					
Hooves and hones					
Condemned parts					
Abattoir wastewater					
Animal faeces					

Please specify if others……..

Waste Disposal Methods

9. Which methods do you use to dispose wastes? tick appropriate

Composting ( ) Incineration ( ) Dump pits ( ) Recycling ( )
Municipal sewer ( ) Open burning ( ) Landfill site ( ) don't know ( )
Please specify if others ……

SECTION C: Waste Management Knowledge and Practice

10. Does your abattoir conduct any awareness programs on waste management?

Yes ( ) No ( )

11. Are workers trained in waste management before being employed? Yes ( ) No ( )

If yes, which areas were you trained on

……

12. How can the management enhance knowledge and awareness in waste management?

……

13. List the probable human health problems caused by improper waste disposal?

……...

14. List the probable environmental problems caused by improper waste disposal?

…… ……..

15. Which of the following statements is agreeable? On a scale of 1 to 5

Knowledge description	**1**	**2**	**3**	**4**	**5**
I attended awareness programs done by the county government					
I have knowledge in waste minimization and segregation principles					
I understand problems caused by poor waste management					
I should be trained in environmental issues before employment					
I have knowledge about environmental issues caused by waste					
I am aware of personal protective equipment for handling waste					

(**1**= Strongly Disagree; **2**= Disagree; **3**= Neutral; **4**= Agree; **5**= Strongly Agree)

Waste Practices and Waste Management

16. Are the following statements agreeable? On a scale of 1 to 5;

Statement	**1**	**2**	**3**	**4**	**5**
There is regular control of wastes at the abattoir.					
Waste Separation is practiced					
Abattoir practices waste collection and storage					
There is Professional transportation of abattoir waste from disposal sites					
Type and nature of waste determines waste disposal method					

(**1**= Strongly Disagree; **2**= Disagree; **3**= Neutral; **4**= Agree; **5**= Strongly Agree)

17. Are the following statements agreeable? On a scale of 1 to 5; on a scale of 1 to 5;

Statement	1	2	3	4	5

Composting waste is properly done in the abattoir					
Abattoirs encourages Open burning of waste					
Abattoir management should practice Incineration					
Dumpsites are well placed in the abattoir grounds					
Recycling before waste disposal should be practiced					

(**1**= Strongly Disagree; **2**= Disagree; **3**= Neutral; **4**= Agree; **5**= Strongly Agree)

Waste management

18. Are you satisfied with the waste management system you use? Yes () No ()

19. Is the waste disposed of according to schedule? Yes () No ()

20. To what extent do you agree with each of the following statements? Rate your response on a scale of 1 to 5

Statement	1	2	3	4	5
Disposal of abattoir wastes are not disposed to rivers, vacant lots.					
Government methods of disposal of wastes are followed					
Waste is disposed of in the designated collection area					
Disposal of infectious waste is done properly					

(1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly Agree)

APPENDIX 2

Questionnaire for Impacts of the Abattoir on Local Population

A. Socio demographic characteristics

1. Location: Shirere ( ) Savona ( ) Bukura ( ) Emusala ( ) ejinja corner ( )
2. Sex Male ( ) Female ( )
3. Age: Below 20 () 21- 40 ( ) 41- 50 ( ) Above 50 ( )
4. Education Level: Primary () Secondary ( ) Tertiary ( )
5. For how long have you been living here?
   0- 5years () 5-10 () 10-15 () Over15 years ()

B. Environmental health implications of wastes generated

6. What is your main source of water for domestic use? Public kiosk ( ) Bore hole( ) House connection ( ) stream / river ( ) Others ( )
7. Do you think water you use has adverse impacts on your health? No ( ) Do not know ( ) es ( ) If yes, which ones? ……
8. Is the abattoir odour a problem yes ( ) No ( )
9. Has any member of your household experienced any of the health problems listed below between the last two weeks, and year?
   Diarrhea ( ) Skin irritation ( ) respiratory infections () Intestinal worms ( ) other specify ( ) none ( )
10. If any of the diseases above is complained about, what do you think could be the reason? Low water quality ( ) Poor hygiene ( )
    Do not know ( )
11. What action do you take when affected by one of these diseases above? Go to the dispensary/ hospital ( ) Buy medication ( ) None ( )
12. Do you have any concern about the abattoir being in your neighbourhood? Yes () No ( )

13. Do you have an idea of the quality of the effluent discharged from the abattoir? Yes ( ) Not at all ( )

APPENDIX 3

NACOSTI Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 228327

Date of Issue: 09/March/2021

RESEARCH LICENSE

This is to Certify that Mr.. GEORGE onunga Ochieng of Masinde Muliro University of Science and Technology, has been licensed to conduct research in Kakamega on the topic: EVALUATION OF THE ENVIRONMENTAL HEALTH RISKS OF SLAUGHTER WASTES ON THE BUILT SURROUNDINGS IN LURAMBI SUB-COUNTY, KAKAMEGA TOWN, KENYA for the period ending : 09/March/2022.

License No: NACOSTI/P/21/8943

228327

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

APPENDIX 4

Morphological Identification of Bacteria Isolates in Abattoirs in Lurambi Kakamega County

Sample type	Morphological characteristics
Effluent	Small circular Colonies, white, raised. smooth edges
	Small circular colonies, white, smooth edges
	large milky flat colonies, rough edges
	circular, white/cream, entire edges, smooth
Lagoon	small circular white colonies raised smooth edges
	small circular white colonies smooth edges
	large milky flat colonies, rough edges
	circular, white/cream, entire edges, smooth
Borehole water	small circular white colonies raised smooth edges
	Small circular colonies, white, raised. rough edges
	large milky flat colonies, rough edges
	circular, white/cream, entire edges, smooth
River water	small circular white colonies raised rough edges
	small circular white colonies raised smooth edges
	circular, white/cream, entire edges, smooth
	large milky flat colonies, rough edges
Spring	small circular white colonies raised smooth edges
	circular, white/cream, entire edges, smooth
	large milky flat colonies, rough edges

APPENDIX 5

Biochemical Characteristics of Bacteria Isolated in Abattoirs Lurambi Kakamega County

Gram's reaction	Catalase	Citrate t	Indole	urease	MR	V/P	Glucose	lactose	Sucrose	Motility	H2S	Gas	Micro organism
- rods	+	-	+	-	+	-	+	+	-	+	-	+	*Escherichia coli*
- rods	+	+	-	-	+	-	+	+	+	+	-	-	*Psedomonas aerugenosa*
- rods	+	+	+	-	+	-	+	+	+	-	-	+	*Klebsiella pneumoniae*
+ ve cocci	-	-	-	-	-	+	+	+	+	-	-	-	*Enterococcus faecalis*
- rods	+	+	+	-	+	-	+	-	-	-	-	+	*Shigella dysenteriae*

APPENDIX 6

Bacteria Identified at Bukura, Ejinja and Emusala Abattoirs in Lurambi Kakamega County.

Abattoir	Sample type	Code	Micro organism
BUKURA	**Effluent**	BBEW-1	*Escherichia coli*
		BBEW-2	*Pseudomonas aerugenosa*
		BBEW-3	*Klebsiella pneumoniae*
		BBEW-4	*Enterococcus faecalis*
	Borehole 0-250m	BB1W-1	*Enterococcus faecalis*
		BB1W-2	*Escherichia coli*
		BB1W-3	*Shigella dysenteriae*
	Borehole251-500m	BB2W-1	*Klebsiella pneumoniae*
		BB2W-2	*Enterococcus faecalis*
EJINJA	**Effluent**	EJEW-1	*Pseudomonas aerugenosa*
		EJEW-2	*Escherichia coli*
		EJEW-3	*Klebsiella pneumoniae*
		EJEW-4	*Enterococcus faecalis*
	Borehole 0-250m	EJB1W-1	*Escherichia coli*
		EJB1W-2	*Shigella dysenteriae*
		EJB1W-3	*Klebsiella pneumoniae*
		EJB1W-4	*Enterococcus faecalis*
	Borehole 251-500m	EJB2W-1	*Enterococcus faecalis*
		EJB2W-2	*Klebsiella pneumoniae*
EMUSALA	**Effluent**	EMEW-1	*Pseudomonas aerugenosa*
		EMEW-2	*Klebsiella pneumoniae*
		EMEW-3	*Escherichia coli*
		EMEW-4	*Enterococcus faecalis*
	Borehole 0-250m	EMB1W-1	*Shigella dysenteriae*
		EMB1W-2	*Enterococcus faecalis*

		EMB1W-3	*Escherichia coli*
	Borehole 250-500m	EMB2W-1	*Enterococcus faecalis*

APPENDIX 7

Bacteria Identified at Shirere and Savona Abattoir Sites in Lurambi Kakamega County

Abattoir	Sample type	Code	Micro organism
SHIRERE	**Effluent**	SHEW-1	*Pseudomonas aerugenosa*
		SHEW-2	*Klebsiella pneumoniae*
		SHEW-3	*Enterococcus faecalis*
		SHEW-4	*Escherichia coli*
	50m above Upstream	SHWU-1	*Enterococcus faecalis*
		SHWU-2	*Klebsiella pneumoniae*
		SHWU-3	*Shigella dysenteriae*
		SHWU-4	*Escherichia coli*
	Point of discharge	SHOW-1	*Shigella dysenteriae*
		SHOW-2	*Escherichia coli*
		SHOW-3	*Klebsiella pneumoniae*
		SHOW-4	*Enterococcus faecalis*
	River 50m below point of discharge	SHWE-1	*Shigella dysenteriae*
		SHWE-2	*Klebsiella pneumoniae*
		SHWE-3	*Escherichia coli*
		SHWE-4	*Enterococcus faecalis*
SAVONA	**Effluent**	SAEW-1	*Escherichia coli*
		SAEW-2	*Pseudomonas aerugenosa*
		SAEW-3	*Klebsiella pneumoniae*
		SAEW-4	*Enterococcus faecalis*
	Borehole(0-250m)	SAB1W-1	*Klebsiella pneumoniae*

		SAB1W-2	*Escherichia coli*
		SAB1W-3	*Shigella dysenteriae*
		SAB1W-4	*Enterococcus faecalis*
		SASW-3	*Enterococcus faecalis*

APPENDIX 8

Morphological Identification of Fungi

MACROSCOPY	MICROSCOPY	IDENTIFICATION
olive green and granular on surface, white edges, granular surface, green colour on reverse	thick-walled conidiophores, roughened hyaline, long, aseptate and erect with vesicle conidial chains are short	*Aspergillus flavus*
widely spread colonies, black, smooth white edges, spongy surface, brown on reverse side	conidiophores are long erect, smooth walled, hyaline with globes conidial heads	*Aspergillus niger*
colony widely spread, dark green, smooth white edges, spongy surface, brown on reverse	Conidiophores long, narrow at base smooth walled hyaline	*Aspergillus fumigatus*
Pale pink in colour, fluffy white growth, dark violet on reverse side	macroconidia canoe shaped, single celled, oval shape	*Fusarium oxysporum*
White cream, smooth, ellipsoidal in shape	Oval yeasts budding presence	*Saccharymyoces cerevisae*
White cream yellow colour, reverse colour white to cream yellow	conidiophores, simple branched terminated by clusters of flasks shaped philades	*Penicillium species*