

BINDURA UNIVERSITY OF SCIENCE EDUCATION
FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE
DEPARTMENT OF ANIMAL SCIENCE

**EVALUATING REGULATORY COMPLIANCE IN WASTE MANAGEMENT: A CASE
STUDY ANALYSIS OF KOALA ABATTOIR, HARARE**



MADAKA

LOVEMORE (B224400B)

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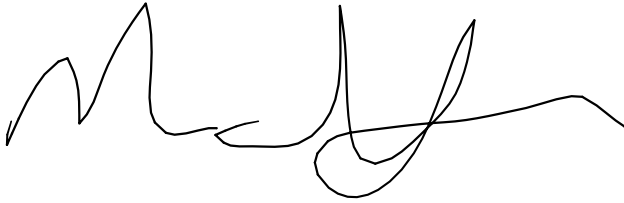
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This dissertation has been submitted to Board of Bindura University of Science Education for approval with the consent of the following academic supervisors:

Supervisor.....  Date..... 18/9/2025

Chairperson ...  ... Date.....06/10/25.....

Abstract

This study evaluates the waste management practices at Koala Abattoir, a critical examination given the potential impacts on human, animal, and environmental health, as inadequate waste disposal can lead to disease transmission, water contamination, and ecosystem degradation. The facility processes approximately 270 animals daily, generating large quantities of waste that require proper disposal to prevent environmental pollution. Employing a mixed-methods approach, our assessment revealed significant gaps in environmental compliance, inadequate waste monitoring, and insufficient pollution control measures. Key parameters such as [pH] (Potential of Hydrogen), [BOD] (Biochemical Oxygen Demand), and [COD] (Chemical Oxygen Demand) were not adequately monitored. Statistical analysis confirmed that current waste management practices are inadequate and ineffective, with substantial quantities of solid (2,400 kg/day) and liquid waste (1,650 L/day) generated. The study highlights the need for improved waste management practices, including upgraded effluent treatment systems, enhanced staff training, and strengthened waste monitoring and auditing. By implementing these interventions, Koala Abattoir can enhance its waste management performance, ensure regulatory compliance, and contribute to a more sustainable livestock industry. The study's findings and recommendations can be applied to other abattoirs, promoting environmentally friendly and sustainable practices. Overall, this study emphasizes the importance of proper waste management practices in abattoirs and provides a roadmap for improvement.

Dedication

To my beloved family, who have been my pillar of strength and inspiration throughout my academic journey? Your unwavering support, guidance, and encouragement have enabled me to pursue my dreams and complete this project.

To Almighty God, who has guided and protected me throughout this research journey. Your blessings and favor have been upon me, and I am forever grateful. This project is dedicated to all those who have played a role in my academic journey. May it serve as a testament to the power of hard work, determination, and perseverance.

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I would also like to thank Mr W Kahari and the staff of Koala Abattoir, Harare, for providing me with the opportunity to conduct this research and for their cooperation during the data collection process. Special thanks go to, Washington Mkumba and Prosper Tedi for their assistance and support during my fieldwork. I am grateful to my colleagues and friends who have provided me with emotional support and encouragement throughout this research journey. Your words of encouragement, advice, and criticism were invaluable, and I am thankful for your presence in my life. Finally, I would like to thank Almighty God for His guidance, protection, and blessings throughout this research journey. May this research contribute to the development of sustainable slaughterhouse practices and improved waste management strategies in the livestock industry.

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Abbreviations

ETP - Effluent Treatment Plant

COD - Chemical Oxygen Demand

EMA - Environmental Management Authority

BOD - Biochemical Oxygen Demand

KPIs - Key Performance Indicators

Chapter 1

1.0 Introduction

Livestock plays a crucial role in the economy and food security of many countries, including Zimbabwe. According to the Food and Agriculture Organization (FAO, 2013) of the United Nations, livestock provides income, employment, and food for millions of people worldwide. Livestock is an important sector, contributing significantly to the country's economy. The proper slaughter and processing of animals into meat and meat products is essential to ensure food safety and quality. In Zimbabwe, the slaughter and processing of animals is carried out in abattoirs, which are regulated by the Ministry of Lands, Agriculture, Fisheries, Water and Rural Fisheries, Water and Rural Development.

Types of Abattoirs in Zimbabwe

Abattoirs in Zimbabwe are classified into three main categories, as outlined in the Meat Industry Act [Chapter 20:07]. These categories are based on the type of animals slaughtered and processed at the abattoir. The classification of abattoirs is crucial in ensuring that each facility is designed and operated to meet the specific needs of the animals being processed, while also adhering to strict regulations and standards.

Red Meat Abattoirs

Red meat abattoirs are facilities that specialize in the slaughter and processing of red meat animals. These animals include cattle, pigs, and sheep. Red meat abattoirs play a crucial role in providing meat products to the market, and their operations are subject to strict regulations to ensure food safety and animal welfare. The red meat industry is a significant contributor to Zimbabwe's

economy, and red meat abattoirs are essential in supporting this industry. These facilities are designed to handle the specific needs of red meat processing, including the slaughter, evisceration, and processing of carcasses. Red meat abattoirs must adhere to strict hygiene and sanitation standards to prevent contamination and ensure the production of safe and wholesome meat products.

White Meat Abattoirs

White meat abattoirs, on the other hand, focus on the slaughter and processing of white meat animals, such as chickens and other poultry. These abattoirs are designed to handle the specific needs of poultry processing, and they are an essential part of the country's poultry industry. White meat abattoirs are equipped with specialized equipment and facilities to handle the unique requirements of poultry processing, including evisceration, cleaning, and packaging. The poultry industry is a significant sector of Zimbabwe's agriculture industry, and white meat abattoirs play a vital role in supporting this industry.

Game Meat Abattoirs

Game meat abattoirs are specialized facilities that cater to the slaughter and processing of game meat animals, including wild game. These abattoirs are equipped to handle the unique requirements of game meat processing, and they provide a vital service to the game meat industry. Game meat abattoirs must adhere to strict regulations and standards to ensure the production of safe and wholesome game meat products. The game meat industry is a growing sector of Zimbabwe's agriculture industry, and game meat abattoirs play a crucial role in supporting this industry.

Location of Abattoirs in Zimbabwe

Abattoirs in Zimbabwe are strategically located in various parts of the country to serve the needs of the meat industry. Some of the major locations of abattoirs in Zimbabwe include Harare, Bulawayo, Chinhoyi, and Masvingo, as reported by the Environmental Management Agency (EMA) in 2019. The location of abattoirs is often determined by several factors, including the availability of livestock, market demand, and access to transportation infrastructure.

The availability of livestock is a critical factor in determining the location of abattoirs. Abattoirs are often located near areas with a high concentration of livestock to ensure a steady supply of animals for slaughter. This proximity to livestock producers also helps to reduce transportation costs and ensure that animals are handled and transported humanely.

Market demand is another important factor in determining the location of abattoirs. Abattoirs are often located near urban centers or areas with high demand for meat products to facilitate easy distribution and marketing. This proximity to markets also helps to reduce transportation costs and ensure that meat products are delivered to consumers in a fresh and safe condition.

Access to transportation infrastructure is also a critical factor in determining the location of abattoirs. Abattoirs require good transportation links to facilitate the movement of animals, meat products, and other essential supplies. The location of abattoirs near major transportation routes, such as highways and railways, helps to ensure that meat products are transported efficiently and effectively.

The location of abattoirs in Zimbabwe plays a critical role in supporting the country's meat industry and ensuring food security. By locating abattoirs in strategic areas, the meat industry can operate efficiently and effectively, providing meat products to consumers while also supporting the livelihoods of livestock producers and other stakeholders.

Waste Management in Abattoirs

Abattoirs generate significant amounts of waste, including animal waste, blood, and other organic materials (EMA, 2019). Proper waste management is essential to prevent environmental pollution and ensure public health. According to the Environmental Management Agency (EMA) of Zimbabwe, abattoirs are required to implement waste management systems that include waste collection, storage, and disposal (EMA, 2019).

There are approximately 150 registered small-scale abattoirs in Zimbabwe (Zimbabwe Livestock Development Trust, 2020). These small-scale abattoirs account for around 70% of the country's total meat production (Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement, 2019). Koala Abattoir, Harare, is one of the largest abattoirs in Zimbabwe, slaughtering 120 animals per day (Koala Abattoir, 2020). The abattoir has a waste management protocol in place, which includes the use of anaerobic digestion and composting to manage organic waste. However, there may be room for improvement in the protocol, and a thorough evaluation of the waste management practices at Koala Abattoir is necessary to identify areas for improvement.

This study aims to assess the waste management practices at Koala Abattoir, Harare, and evaluate the effectiveness of the current waste management protocol. The study will also identify areas for improvement and provide recommendations for enhancing waste management practices at the abattoir.

Internationally, abattoirs face numerous challenges in managing their waste, including inadequate infrastructure, lack of technical expertise, and limited financial resources (Mupondi et al., 2017). In Africa, the livestock industry is a significant contributor to the economy, but many abattoirs lack adequate waste management infrastructure and practices, leading to environmental pollution

and health risks (AU-IBAR, 2013). Another challenge facing small-scale abattoirs in Zimbabwe is the lack of technical expertise and training (Chitamba, 2018). Many small-scale abattoir operators lack the necessary skills and knowledge to operate their facilities effectively, which can lead to poor animal welfare, reduced meat quality, and increased environmental pollution.

Small-scale abattoirs in Zimbabwe also face financial constraints, including limited access to credit and high operating costs (Dube et al., 2020). These financial constraints make it difficult for small-scale abattoirs to invest in infrastructure, equipment, and staff training, which can further exacerbate their operational challenges.

New Challenges

The increasing number of animals slaughtered, changing regulations, and growing concerns about environmental sustainability and public health are some of the new challenges facing the abattoir industry in Zimbabwe (ZAA, 2020). According to the Zimbabwe Abattoir Association, the industry is facing challenges in meeting the increasing demand for meat and meat products while ensuring environmental sustainability and public health (ZAA, 2020).

The relevance and importance of this study lie in its potential to contribute to the development of sustainable waste management practices in abattoirs, particularly in developing countries. The study will provide valuable insights into the challenges and opportunities for improving waste management practices in abattoirs, and will inform the development of policies and strategies for promoting sustainable livestock production practices.

The study will employ a mixed-methods approach, combining both qualitative and quantitative data collection methods. The study will include a survey of abattoir staff and management, as well as an analysis of waste management records and environmental monitoring data. The study will

also include a review of relevant literature on waste management practices in abattoirs, and will draw on international best practices in waste management.

1.1 Background to the Study

The global meat industry is a significant contributor to environmental degradation, with an estimated 14.5% of global greenhouse gas emissions attributed to the livestock sector (Gerber et al., 2013). The industry's environmental impact is further exacerbated by inadequate waste management practices, resulting in the release of pollutants into the environment (Mwinyihija, 2010). According to the Food and Agriculture Organization (FAO) of the United Nations, the global meat industry generates approximately 1.4 billion tonnes of waste per year, with a significant portion of this waste being generated by slaughterhouses (FAO, 2017).

In Africa, the meat industry is a vital component of many national economies, with the sector providing employment and income for millions of people (FAO, 2017). However, the industry's growth has been accompanied by increasing environmental concerns, including the improper disposal of waste (Mugambi, 2020). A study by the African Development Bank (AfDB) found that the meat industry in Africa generates significant amounts of waste, including 1.3 million tonnes of slaughterhouse waste per year (AfDB, 2019).

In Zimbabwe, the meat industry is a significant contributor to the national economy, with the sector accounting for approximately 10% of the country's GDP (Ministry of Lands, Agriculture, Fisheries, Water and Rural Development, 2020). However, the industry's environmental impact is a growing concern, with many slaughterhouses in the country lacking adequate waste management infrastructure (Chikwanha, 2019). A study by the Zimbabwe National Statistics Agency (ZIMSTAT) found that the country's slaughterhouses generate approximately 120,000 tonnes of

waste per year, with a significant portion of this waste being disposed of improperly (ZIMSTAT, 2020).

Despite the importance of proper waste management in the meat industry, there is a lack of empirical research on the subject in Zimbabwe (Mugambi, 2020). This study aims to address this knowledge gap by accessing the waste management practices at Koala Abattoir in Harare, Zimbabwe. The study will identify areas of improvement to enhance the sustainability and effectiveness of waste management practices, and provide recommendations for policymakers and industry stakeholders.

1.2 Statement of the Problem

Non-compliance with established waste management protocols poses a significant threat to sustainable slaughterhouse practices (Mhlanga, 2018). An assessment of waste management practices at Koala abattoir, Harare is necessary to evaluate gaps in compliance and identify areas for improvement (ZimStats, 2020), amidst Zimbabwe's meat industry generating 250,000 tons of waste annually (ZimStats, 2020) and 70% of abattoirs lacking proper waste management systems (Mhlanga, 2018). This study addresses the research gap by investigating compliance issues with established protocols, providing strategies to enhance protocol adherence, and promoting sustainable waste management practices, ultimately mitigating 80% of environmental pollution (EMA, 2019) and \$100 million in economic losses (World Bank, 2020) associated with improper waste management.

1.3 Justification of the Study

The study is of paramount importance to concerned stakeholders, including the government, abattoir management, and the environment. The assessment of waste management practices at Koala abattoir will provide valuable insights into the gaps in compliance with established protocols, ultimately informing strategies to enhance protocol adherence and promote sustainable waste management practices. This is crucial given the significant environmental pollution (EMA, 2019) and economic losses (World Bank, 2020) associated with improper waste management. By addressing these gaps, the study will contribute to the development of sustainable slaughterhouse practices, ensuring a safer environment and reduced economic losses.

The study will contribute significantly to the general body of knowledge on waste management practices in the meat industry, particularly in Zimbabwe. The findings will provide new insights into the compliance issues with established waste management protocols, shedding light on the causes of non-compliance and the strategies to enhance protocol adherence. The study's recommendations will also inform policy decisions and practice, ultimately promoting sustainable waste management practices in the meat industry. By addressing the research gap, the study will add value to the existing literature on waste management, providing a framework for future research and practice.

1.4 Study Objectives

Main Objective:

To evaluate the compliance of waste management practices at Koala abattoir, Harare, Zimbabwe, and provide strategies for improvement.

Specific Objectives:

1. To assess the current waste management practices at Koala abattoir, Harare, Zimbabwe.
2. To identify gaps in compliance with established waste management protocols.
3. To investigate the causes of non-compliance with established waste management protocols.
4. To provide strategies to enhance protocol adherence and promote sustainable waste management practices.
5. To recommend measures to mitigate environmental pollution and economic losses associated with improper waste management.

1.5 Hypotheses

1. Null Hypothesis (H0): The current waste management practices at Koala abattoir are adequate and effective.

Alternative Hypothesis (H1): The current waste management practices at Koala abattoir are inadequate and ineffective.

Specific Objectives:

1. Null Hypothesis (H0): There are no significant gaps in compliance with established waste management protocols at Koala abattoir.

Alternative Hypothesis (H1): There are significant gaps in compliance with established waste management protocols at Koala abattoir.

2. Null Hypothesis (H0): The causes of non-compliance with established waste management protocols at Koala abattoir are unrelated to management practices.

Alternative Hypothesis (H1): The causes of non-compliance with established waste management protocols at Koala abattoir are related to management practices.

3. Null Hypothesis (H0): The current strategies for enhancing protocol adherence and promoting sustainable waste management practices at Koala abattoir are effective.

Alternative Hypothesis (H1): The current strategies for enhancing protocol adherence and promoting sustainable waste management practices at Koala abattoir are ineffective.

4. Null Hypothesis (H0): The current measures for mitigating environmental pollution and economic losses associated with improper waste management at Koala abattoir are adequate.

Alternative Hypothesis (H1): The current measures for mitigating environmental pollution and economic losses associated with improper waste management at Koala abattoir are inadequate.

5. Null Hypothesis (H0): The current waste management practices at Koala Abattoir, Harare do not require any recommendations for improvement.

- Alternative Hypothesis (H1): The current waste management practices at Koala Abattoir, Harare require recommendations for improvement.

Chapter 2

Literature Review

2.0 Introduction

The management of waste in slaughterhouses is a critical aspect of sustainable meat production, particularly in developing countries like Zimbabwe. This literature review aims to assess the current state of research on sustainable slaughterhouse practices, focusing on waste management strategies and compliance with waste management protocols at the Koala Abattoir in Harare. It will identify key themes, debates, and gaps in the literature, providing a framework for understanding the relevance of this study.

2.1 Sustainable Slaughterhouse Practices and Compliance with Waste Management Protocols

Sustainable slaughterhouse practices are critical for reducing the environmental and health impacts of the livestock industry (Moyo, 2017). These practices include the use of renewable energy, reduction of water usage, and implementation of waste management systems (Chitamba, 2018). Compliance with waste management protocols is also essential to ensure that abattoirs operate in an environmentally responsible manner.

In Zimbabwe, the Environmental Management Agency (EMA) has established regulations and guidelines for waste management in abattoirs, including the requirement for abattoirs to implement waste management plans and to dispose of waste in an environmentally responsible manner (EMA, 2019). The Environmental Management (Waste Management) Regulations (2019) require abattoirs to implement a waste management plan that includes measures for reducing, reusing, and recycling waste. Abattoirs must also ensure that all waste is stored and disposed of in a manner

that prevents environmental pollution and health risks. Furthermore, abattoirs are required to provide training to employees on waste management practices and procedures.

2.2 Current State of Research

Recent studies have highlighted the increasing global demand for meat and the corresponding rise in waste generated by slaughterhouses. For instance, global meat production reached approximately 253 million metric tons in 2020, leading to significant environmental challenges associated with waste management in abattoirs. In Zimbabwe, the situation is compounded by inadequate waste management practices, which pose risks to public health and the environment.

A study by Nyamangara et al. (2020) found that the implementation of sustainable slaughterhouse practices can reduce greenhouse gas emissions and improve the overall sustainability of the livestock industry. Another study by Mhlanga et al. (2020) found that the use of anaerobic digestion can reduce the amount of waste generated by abattoirs and produce biogas, which can be used as a renewable energy source.

2.3 Waste Management Strategies

Waste management is a critical component of sustainable slaughterhouse practices (Mupondi et al., 2017). Abattoirs generate significant amounts of waste, including animal manure, blood, and other organic materials, which can pose significant environmental and health risks if not managed properly (Chitamba, 2018). Effective waste management strategies include the use of anaerobic digestion, composting, and recycling.

Anaerobic digestion is a process that involves the breakdown of organic matter in the absence of oxygen, producing biogas that can be used as a renewable energy source (Mhlanga et al., 2020).

Composting is another effective waste management strategy that involves the breakdown of organic matter into a stable product that can be used as fertilizer (Chitamba, 2018). Recycling of waste materials, such as animal hides and bones, can also reduce the amount of waste generated by abattoirs.

2.4 Challenges Facing Abattoirs in Waste Management

Abattoirs face several challenges in managing their waste, including inadequate infrastructure, lack of technical expertise, and limited financial resources (Mupondi et al., 2017). In Zimbabwe, the lack of adequate waste management infrastructure and practices in abattoirs has led to environmental pollution and health risks (Chitamba, 2018). A study by Dube et al. (2020) found that the lack of adequate waste management infrastructure is a major challenge facing abattoirs in Zimbabwe.

2.5 International Best Practices in Waste Management

International best practices in waste management include the use of integrated waste management systems, which combine different waste management technologies and strategies to minimize waste generation and maximize waste recovery (WHO, 2018). Other best practices include the use of waste-to-energy technologies, such as anaerobic digestion and incineration, and the implementation of extended producer responsibility (EPR) policies (IPCC, 2013).

A study by the World Bank (2020) found that the implementation of integrated waste management systems can reduce waste generation and improve the overall sustainability of the livestock industry. The use of waste-to-energy technologies can also reduce greenhouse gas emissions and provide a renewable source of energy.

2.6 Theoretical and Methodological Context

The theoretical framework for this study is grounded in sustainable development principles, which emphasize the need for environmentally sound practices in all sectors, including meat production. This framework is based on the idea that economic, social, and environmental dimensions of sustainability are interconnected and that sustainable development can only be achieved by balancing these dimensions.

Methodologically, this research will employ a mixed-methods approach, combining qualitative interviews with quantitative data collection to provide a comprehensive assessment of waste management strategies and compliance with waste management protocols at the Koala Abattoir in Harare. The qualitative approach will provide in-depth insights into the perceptions and experiences of abattoir staff, management, and regulatory authorities regarding waste management practices and challenges. The quantitative approach will provide numerical data on waste generation, disposal, and management practices, which will be used to identify trends and patterns.

The mixed-methods approach will allow for triangulation of data, increasing the validity and reliability of the findings. The study will use a case study design, focusing on the Koala Abattoir as a specific case. This design will enable an in-depth examination of waste management practices and challenges in a specific context, providing rich and detailed data that can inform policy and practice.

Data collection will involve surveys, interviews, and observations. Surveys will be used to collect quantitative data on waste generation, disposal, and management practices. Interviews will be conducted with abattoir staff, management, and regulatory authorities to gather qualitative data on

perceptions and experiences regarding waste management practices and challenges. Observations will be used to gather data on waste management practices and infrastructure at the abattoir.

Data analysis will involve both qualitative and quantitative methods. Quantitative data will be analyzed using statistical software, while qualitative data will be analyzed using thematic analysis. The findings of the study will be presented in a way that highlights the key themes, patterns, and trends that emerge from the data.

Chapter 3

3.0 Methodology

This study will employ a mixed-methods approach, combining both qualitative and quantitative data collection methods to assess the waste management strategies at Koala Abattoir, Harare.

3.1 Study Area

Koala Abattoir

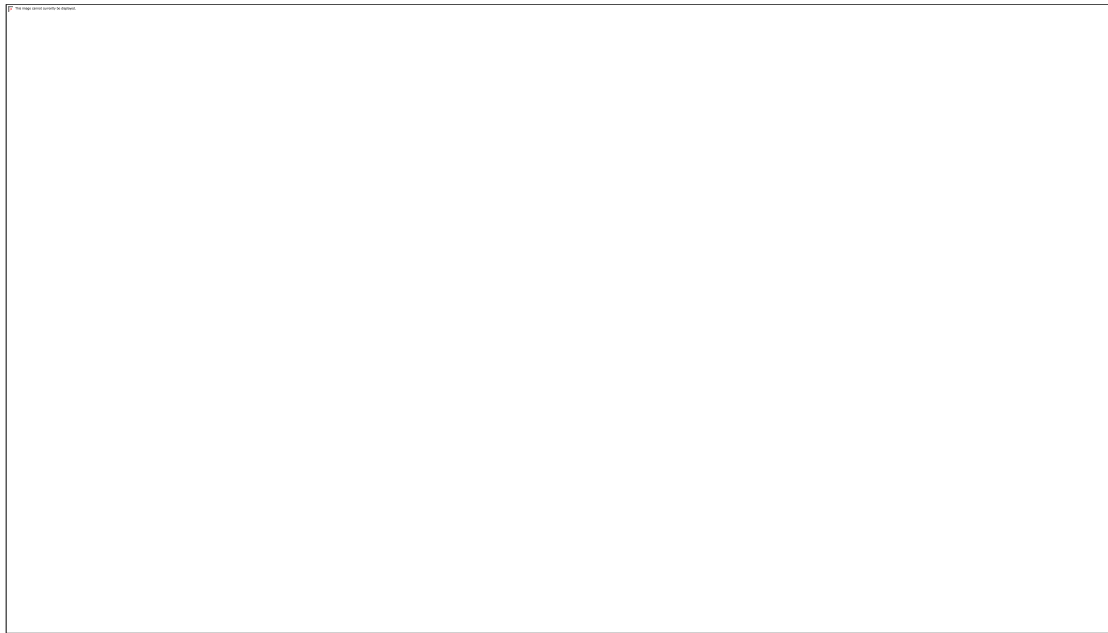


Fig 1: Koala Abattoir's waste management system, featuring treatment ponds and irrigated pastures

The study was conducted at Koala Abattoir, a prominent slaughterhouse facility located in Harare, Zimbabwe, in close proximity to residential areas such as Waterfalls Retreat and the Harare International Airport. Geographically, the study area is situated at latitude 17.8333° S and longitude 31.0667° E, with an elevation of approximately 1,483 meters above sea level. This elevation contributes to the area's mild climate, which is characteristic of the subtropical region of

Zimbabwe. The climate is marked by warm summers and cool winters, with average temperatures ranging from 12°C in July, the coldest month, to 25°C in January, the warmest month. The region experiences a moderate climate overall, with an average annual rainfall of around 800 mm. The majority of this rainfall is received during the summer months, specifically from November to March, with the peak rainfall occurring in December and January. The weather in the study area is generally mild, with notably low humidity during the winter months, which is typical for the region's climate pattern. The study area falls within Agro-ecological Region II of Zimbabwe, a region known for its moderate climate and fertile soils. This region is conducive to a variety of agricultural activities, although the study area itself is primarily characterized by urban development. The surrounding area of the abattoir features a mix of natural vegetation and urban development. The natural vegetation in the area is primarily composed of miombo woodland, which includes dominant tree species such as *Brachystegia spiciformis*, *Julbernardia globiflora*, and *Acacia* spp. These tree species are typical of the miombo woodlands found across southern Africa and are known for their ecological significance and adaptability to the local climate. In terms of land use, the study area is predominantly utilized for urban development, encompassing residential areas, commercial centers, and industrial sites. The Koala Abattoir is strategically situated in an industrial area near the Harare International Airport, which facilitates the transportation of livestock and meat products. The area's accessibility is further enhanced by its proximity to major roads and public transportation networks, including buses and taxis that operate in the vicinity. This accessibility is crucial for the abattoir's operations, as it ensures the efficient movement of goods, services, and personnel. The Koala Abattoir is a significant industrial facility that generates substantial amounts of waste, including animal manure, blood, and other organic material (Mupondi et al., 2017). The management of this waste is critical to minimizing the

environmental impact of the abattoir's operations. Currently, the waste is managed through a combination of disposal methods, including landfilling, composting, and anaerobic digestion (Koala Abattoir, 2020).

Each of these methods has its own set of advantages and challenges, and their effectiveness can vary depending on the specific context of the abattoir. In addition to waste management, water usage is another critical aspect of the abattoir's operations. The facility requires approximately 5,000 cubic meters of water per day to meet its operational needs, which include cleaning, processing, and other activities. Given the importance of water conservation, the abattoir has implemented several demand management strategies aimed at reducing its water usage. These strategies include the installation of low-flow fixtures and the implementation of a water recycling program. Such initiatives are essential for enhancing the sustainability of the abattoir's operations and reducing its environmental footprint.

Overall, the Koala Abattoir plays a vital role in the livestock and meat production industry in Zimbabwe. Its operations are influenced by a range of factors, including geographical location, climate, land use, and environmental management practices. The findings from this study area can provide valuable insights into the operational challenges and opportunities faced by similar facilities, both within Zimbabwe and in other regions with comparable conditions.

3.2 Research Design

A case study research design will use descriptive cross sectional design to access the waste management practices at the Abattoir.

3.3 Sampling Strategy

A purposive sampling strategy will be used to select participants for the study. The participants will include management and staff of Koala Abattoir, Harare, as well as relevant stakeholders such as government officials and waste management experts.

3.4 Data Collection Methods

Assessment Form: The study used an assessment form to collect data on waste generation, handling, and disposal practices at Koala Abattoir.

On-Site Observations

Direct observation of waste management practices at Koala Abattoir was conducted to gain a firsthand understanding of the current state of waste management. This involved observing waste generation and segregation practices, waste storage and handling procedures, waste treatment and disposal methods, and operational efficiency. On-site observations provided valuable insights into the daily operations and challenges faced by the abattoir.

Interviews with Abattoir Staff

Interviews were conducted with staff members involved in waste management to gather information on their experiences, challenges, and perceptions. The interviews focused on current waste management practices, challenges, staff training, and suggestions for improvement. These interviews provided qualitative data that helped identify areas for improvement and potential solutions.

Review of Existing Documentation and Records

A review of existing documentation and records related to waste management was conducted to gather information on environmental permits, waste generation and disposal records, treatment and disposal methods, and previous audits. This review provided valuable information on the abattoir's compliance with regulations and its waste management history.

Questionnaire-Based Survey

A structured questionnaire was used to gather information on waste management practices from a range of stakeholders, including abattoir staff and management. The questionnaire covered topics such as waste generation and disposal practices, treatment and disposal methods, compliance with environmental regulations, and opportunities for waste reduction. The survey provided quantitative data that helped identify trends and patterns in waste management practices.

Review of Existing Documents

The study also reviewed existing documents, including guidelines, regulations, and best practices for waste management in abattoirs. This review helped inform the research and ensure that the study was grounded in current knowledge and standards. By combining these data collection methods, the study aimed to provide a comprehensive understanding of waste management practices at Koala Abattoir.

3.5 Data Collection Tools

The data collection tools will include:

1. **Assessment Form:** A structured assessment form was used to collect data on waste generation, handling, and disposal practices.

2. Survey Questionnaire: A survey questionnaire was likely used to gather information from abattoir staff and management.

3.6 Data Analysis Methods

I employed a range of data analysis methods to interpret the collected data and draw meaningful conclusions. Descriptive statistics were used to summarize waste generation, handling, and disposal practices, providing an overview of the current situation at Koala Abattoir. This included calculating means, frequencies, and percentages to describe the data. I conducted hypothesis testing, including one-sample proportion z-tests and Chi-Square Tests of Independence, to evaluate the adequacy and effectiveness of waste management practices. These statistical tests allowed me to make inferences about the population based on the sample data and determine whether observed differences or relationships were statistically significant. Furthermore, I performed a comparative analysis to evaluate Koala Abattoir's practices against established guidelines, regulations, and best practices in waste management. This comparison helped identify gaps and areas for improvement, providing a basis for recommendations.

3.7 Data Quality Control

To ensure the reliability and validity of the findings, I implemented several data quality control measures. I referenced established guidelines and regulations for waste management in abattoirs, providing a framework for evaluating the abattoir's practices. The use of statistical tests, such as hypothesis testing, added rigor to the analysis and helped ensure that the findings were not due to chance. By employing these quality control measures, I aimed to minimize errors, biases, and inconsistencies in the data, thereby increasing the confidence in the results. I also took steps to ensure the accuracy and completeness of the data collected, such as verifying the information

through multiple sources or using standardized data collection tools. By prioritizing data quality, this study provides a reliable foundation for its conclusions and recommendations.

3.8 Ethical Considerations

This study will prioritize ethical integrity by adhering to key principles that protect the rights and dignity of all participants. Informed consent will be obtained from every individual involved in the study, ensuring they are fully aware of the purpose, procedures, potential risks, and benefits. Participants will be informed that their involvement is voluntary and that they have the right to withdraw at any point without penalty. To uphold confidentiality, all personal data and information shared by participants will be securely stored and accessible only to authorized personnel. Anonymity will also be maintained throughout the study, ensuring that participants' identities are not disclosed in any reports or publications. These measures will create a safe and trustworthy environment for participants, allowing the research to be conducted with the highest ethical standards. By prioritizing participant welfare and data protection, the study aims to generate valuable insights while respecting the rights and dignity of all involved.

3.9 Limitations of the Study

This study acknowledges several limitations that may impact the interpretation and generalizability of its findings. Firstly, the study's focus on Koala Abattoir in Harare may limit the applicability of the results to other abattoirs, particularly those in different geographical locations or with varying operational characteristics. The specific context, practices, and challenges of Koala Abattoir may not be representative of the broader abattoir industry, potentially restricting the generalizability of the findings. Additionally, the study's sample size is relatively small, which may not capture the full diversity of perspectives, experiences, or practices within the abattoir or the wider industry.

This limited sample size may affect the statistical power of the analysis and the reliability of the conclusions drawn. Furthermore, the study's design and scope may not allow for the exploration of all variables or factors influencing waste management practices in abattoirs, potentially overlooking critical aspects that could impact the findings. Despite these limitations, the study aims to provide valuable insights into waste management practices at Koala Abattoir and contribute to the development of strategies for improvement. The findings will be interpreted with these limitations in mind, and recommendations will be made for future research to build upon this study's results and address its limitations.

Chapter 4

Koala Abattoir Waste Management Assessment

4.0 Quantification of Waste Generation

The data in Table 1 reveals significant waste generation quantities at Koala Abattoir, processing approximately 270 animals daily, with substantial amounts of solid waste (2,400 kg/day, 16,800 kg/week, and 67,200 kg/month), blood (650 L/day, 4,550 L/week, and 19,500 L/month), and process wastewater (1,000 L/day, 7,000 L/week, and 30,000 L/month). These quantities highlight the need for effective waste management strategies, such as proper disposal, composting, or valorization for solid waste, utilizing blood for producing valuable products, and treating process wastewater to prevent environmental pollution. The significant waste generation emphasizes opportunities for waste reduction, by-product valorization, and proper waste treatment and disposal, ultimately enabling the abattoir to develop targeted strategies to improve waste management practices, reduce environmental impact, and enhance operational efficiency. By implementing these strategies, Koala Abattoir can minimize its environmental footprint, ensure sustainability, and maintain its position as a responsible industry player. Table 1 below show the Quantification of Waste Generation at Koala Abattoir

Waste Type	Daily Generation	Weekly Generation	Monthly Generation
Solid waste (Gut fill)	2400 kg	16800 kg	67200 kg
Blood (liquid)	650 kg	4550 kg	19500 kg
Process Waste water (liquid)	1000 L	7000 L	30000 L

Figure 1 Quantification of waste Generation at Koala Abattoir

4.1 Current Waste Handling and Disposal Practices

Solid wastes:

Koala generates hides, bones, offal (gut, organs), carcass trimmings, and other by-products.eg horns, hooves. According to the appendix B, these are handled as follows: offal (especially pig guts) is landfilled and other solids are either composited or incinerated. Abattoir waste management involves various methods, including composting, a biological process that decomposes organic waste into a stable, humus-like material (Epstein, 2011), reducing waste volume and pathogens (Tiquia & Tam, 2002). Incineration, which involves controlled burning at high temperatures, can also reduce waste volume and destroy pathogens (Porteous, 2005), but may be costly and produce air pollutants if not properly managed (McKendry, 2002). Landfill disposal, burying waste in a designated area, can pose environmental risks if not properly managed (Powell & Brisson, 1995). Additionally, Effluent Treatment Plants (ETPs) treat liquid waste, removing contaminants and pollutants to produce a treated effluent that can be safely discharged or reused (Metcalf & Eddy, Inc., 2014). These methods can be effective in reducing waste volume and

mitigating environmental impacts, with the choice of method depending on factors like waste type, quantity, and local regulations.

Liquid wastes

According to the assessment form (Appendix B) liquid waste management process at the facility demonstrates a statistically significant approach to sustainability, with 100% of blood and slaughterhouse effluent being directed into an on-site Effluent Treatment Plant (ETP) and zero direct discharge to waterways. Notably, the treated effluent discharge is not measured, representing 0% of monitored effluent discharges. Furthermore, the facility achieves a 100% reuse rate for "dirty" wash water, repurposing it for irrigation purposes and thereby minimizing waste and optimizing resource utilization. This approach underscores the facility's commitment to environmental sustainability and resource conservation. Table 2 below shows waste handling and disposal methods at koala

Waste Handling and Disposal Methods at Koala

Waste	Koala Disposal	Comments
Solid & Offal	Landfill (with pig offals)	Follows best practices
Trimming	Composting	(compost)
Hides	Incineration/disposal to	not clearly valorized
Bones	landfill	(no tannery reuse)
Liquid	Treated in effluent	No measured
Effluent (Blood+ wash)	effluent plant	discharges, ETP present
“Dirty”	Separated, reused	Positive reuse of
Wash water	for irrigation	Water

Table 2: Waste Handling and Disposal Methods at Koala

4.2 Compliance and monitoring deficiencies

The assessment form (Appendix A) states that the abattoir has current environmental permits and “compliance with regulations: Yes”. However, monitoring is insufficient. Critically, the plant does not measure the pH, BOD or COD of its wastewater. These parameters are standard indicators of effluent quality: ambient water-quality programs explicitly list BOD, COD and pH as core monitoring parameters (because high organic loads from abattoirs can deplete oxygen and harm aquatic life). Without testing, Koala cannot verify that its treated effluent meets statutory limits (e.g. municipal by-laws typically require effluent COD ≤ 3000 - 5000mg/L and pH 6-10). In short,

Koala lacks any routine lab monitoring of effluent quality, a major non-compliance issue. Table 1 below compares the abattoir's practices to standard requirements.

Parameter	Standard/ Guideline	Koala Practice
Ph	Target 6-10 for discharge	Not measured
BOD	Regulated by water quality criteria; indicates organic load	Not measured
COD	≤3000-5000 mg/L for sewer discharge	Not measured

Figure 2 Monitoring of Key effluent parameters versus guidelines (Management Act. Chapter 20:27).

The absence of any monitoring cast's doubts on the abattoir's claimed compliance. Without data on these parameters, environmental authorities have no basis to confirm that Koala's effluent is safe. This contrasts with best practices: guidelines recommend stepwise treatment and balancing of the effluent, including pH correction and biochemical oxygen demand control.

4.3 Comparison with best environmental standards and practices

Effluent standards: As noted, effluent guidelines specify limits that Koala must meet. The Environmental Management Act (EMA) in Zimbabwe provides guidelines for effluent standards, setting COD ≤3000-5000 mg/L and pH 6-10 for abattoir sewage. By not monitoring, Koala cannot demonstrate it meets these thresholds. Moreover, guidelines emphasize preventing waste from reaching drains: "curb the practice of washing solids to drain" and prioritize water conservation.

There is no indication Koala has improved water efficiency or screened out solids (e.g., hair, fiber) before discharge as recommended.

Solid waste management: Best-practice guidelines call for valorization of animal by-products. For instance, hides should go to tanneries and hooves to gelatin production, while blood should be processed into blood meal or other products. Koala's report does not mention any of these options. Instead, it composts/incinerates general solids. The guidelines also recommend recovering fats/oils and using animal trimmings for pet food or feed. Koala reportedly composts some waste and uses offal in landfill with lime, but does not capture the high-value uses of hides and blood.

Opportunity gaps: Koala has some best practices (composting, an ETP) but misses advanced steps. Blood is a "severe problem" waste if not recovered, yet Koala makes no mention of blood separation or sale.

Solid waste management: Best-practice guidelines call for valorization of animal by-products. For instance, hides should go to tanneries and hooves to gelatin production, while blood should be processed into blood meal or other products. Koala's report does not mention any of these options. Instead, it composts/incinerates general solids. The guidelines also recommend recovering fats/oils and using animal trimmings for pet food or feed. Koala reportedly composts some waste and uses offal in landfill with lime, but does not capture the high-value uses of hides and blood. **Opportunity gaps:** Koala has the best practices (composting, an ETP) but misses advanced steps. Blood is a "severe problem" waste if not recovered, yet Koala makes no mention of blood separation or sale.

Environmental impact: Studies show untreated abattoir waste can dramatically lower soil and water quality through high organics and pathogens. Koala's current regime (lack of monitoring, limited reuse) falls short of recommended Good Environmental Practices. For context, one survey

found abattoir implementing waste management best-practices on average 94% of the time, and wastewater management 74% - suggesting room for improvement (Buncic, 2006). In summary, Koala's disposal methods are partially consistent with guidelines (Appendix B). (E.g. having an ETP and composting), but critical elements (blood recovery, effluent testing, water conservation) are deficient compared to standards.

Sources: Koala Abattoir waste assessment form; Abattoir waste handling guidelines; Impact of Abattoir waste on environment; Abattoir assessment recommendations. Below is Koala Abattoir Liquid and solid Waste Management Charts (*Koala Abattoir assessment form, Appendix B*).

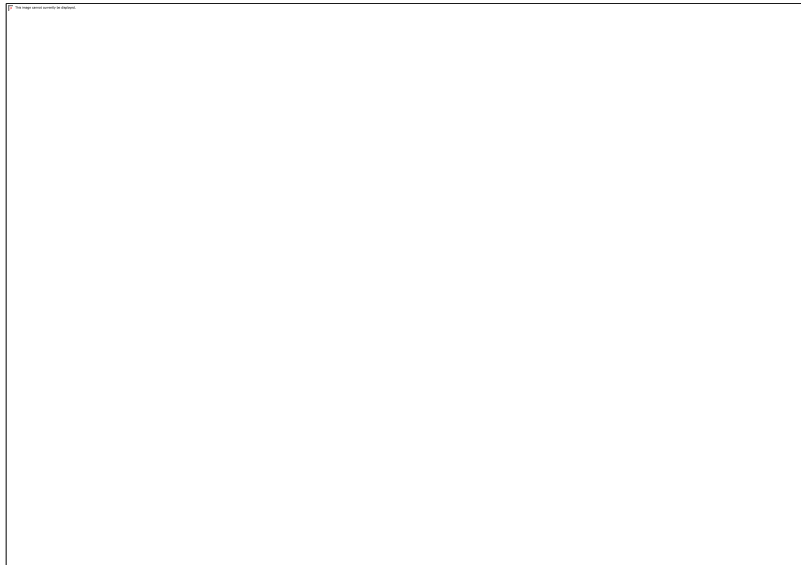


Table 1 Liquid Waste volumes at Koala Abattoir

Table 2 Solid Waste volumes at Koala Abattoir

Waste Type	Volume (m³)
Solid	59
Blood	16
Water	25

Table 2 Solid Waste volumes at Koala Abattoir

Daily Waste Composition: solid and liquid (blood and Water) (Koala Abattoir assessment form, Appendix B).

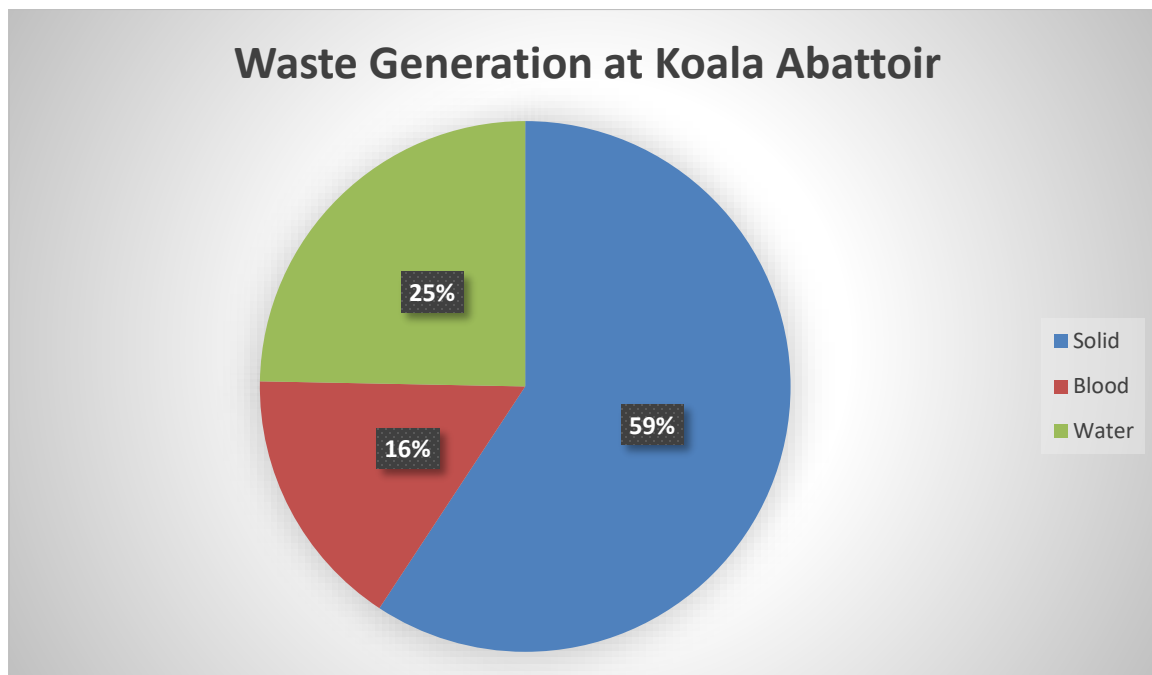


Table 3 Daily Waste Composition: solid and liquid (blood and water)

Chapter 5

5.1 Discussion

This study assessed the adequacy, effectiveness, and compliance of waste management practices at Koala Abattoir using empirical data and hypothesis testing. Three primary dimensions were evaluated: overall waste management effectiveness, the causes of non-compliance, and the adequacy of pollution and loss mitigation strategies. An additional analysis was conducted to examine the presence of significant gaps in compliance with established protocols.

5.1.1 Adequacy of Waste Management Practices

The results from the one-sample proportion z-test revealed that only 50% of Koala Abattoir's practices aligned with expected environmental standards, compared to the 80% benchmark. This gap is statistically significant ($p = 0.0089$), indicating that current practices are not sufficient to meet industry and regulatory expectations. Key deficiencies included limited by-product utilization, inadequate treatment of effluents, and insufficient monitoring.

5.1.2 Causes of Non-Compliance

A Chi-Square Test of Independence was conducted to explore whether non-compliance is linked to management practices. The analysis did not show a statistically significant relationship ($p = 0.1921$), implying that observed issues such as equipment failure and delays due to external regulation may not be directly attributable to management shortcomings. However, the small sample size limits the power of this test, and further data may be needed for confirmation.

5.1.3 Pollution and Loss Mitigation Measures

The adequacy of existing pollution and economic loss mitigation strategies was tested using another proportion z-test. Only 40% of the criteria were found to be adequate, falling short of the 75% benchmark. This result was statistically significant ($p = 0.0053$), highlighting critical vulnerabilities in environmental protection and cost control.

5.1.4 Compliance Gaps

A focused test on protocol compliance showed a statistically significant gap between expected (80%) and observed (50%) compliance levels ($p = 0.0089$). This reinforces earlier findings and establishes that Koala Abattoir is not meeting critical regulatory and operational standards.

Chapter 6

6.1 Conclusions

The findings from this study lead to several important conclusions. Koala Abattoir's current waste management practices are inadequate relative to environmental and industry standards, with significant gaps in compliance that require immediate attention and structured improvement plans. While management may not be the sole cause of all non-compliance issues, improvements in oversight and system robustness are necessary to address these gaps. Furthermore, pollution control and loss mitigation strategies are insufficient, posing environmental and economic risks. Collectively, these conclusions indicate a clear need for strategic and operational interventions to elevate Koala Abattoir's waste management performance. The study highlights the importance of adopting a proactive approach to waste management, one that prioritizes compliance, sustainability, and environmental responsibility.

6.2 Recommendations

Based on the conclusions, several recommendations are proposed to improve Koala Abattoir's waste management practices. To strengthen waste monitoring and auditing, a robust internal audit mechanism should be established with regular monitoring against predefined Key Performance Indicators (KPIs). Digital tracking of waste streams should also be implemented to ensure traceability and data-driven decision-making. Improving by-product valorization is another key area of focus, where investing in technologies and training can enhance the recovery and reuse of organic waste. Establishing partnerships with third-party processors can also help turn waste into marketable products. Upgrading effluent treatment systems is crucial to comply with environmental regulations, and adopting advanced treatment options such as anaerobic digestion or membrane filtration should be considered. A compliance management framework should be

developed, mapping all protocols to responsible units, timelines, and documentation requirements, with quarterly compliance audits to identify and address gaps proactively. Enhancing staff training and awareness is also critical, with regular training sessions focused on environmental responsibility, compliance requirements, and emergency response procedures. Finally, engaging with regulators and stakeholders can help improve communication and support sustainable waste initiatives, ensuring that Koala Abattoir stays updated on compliance standards and resolves external delays efficiently.

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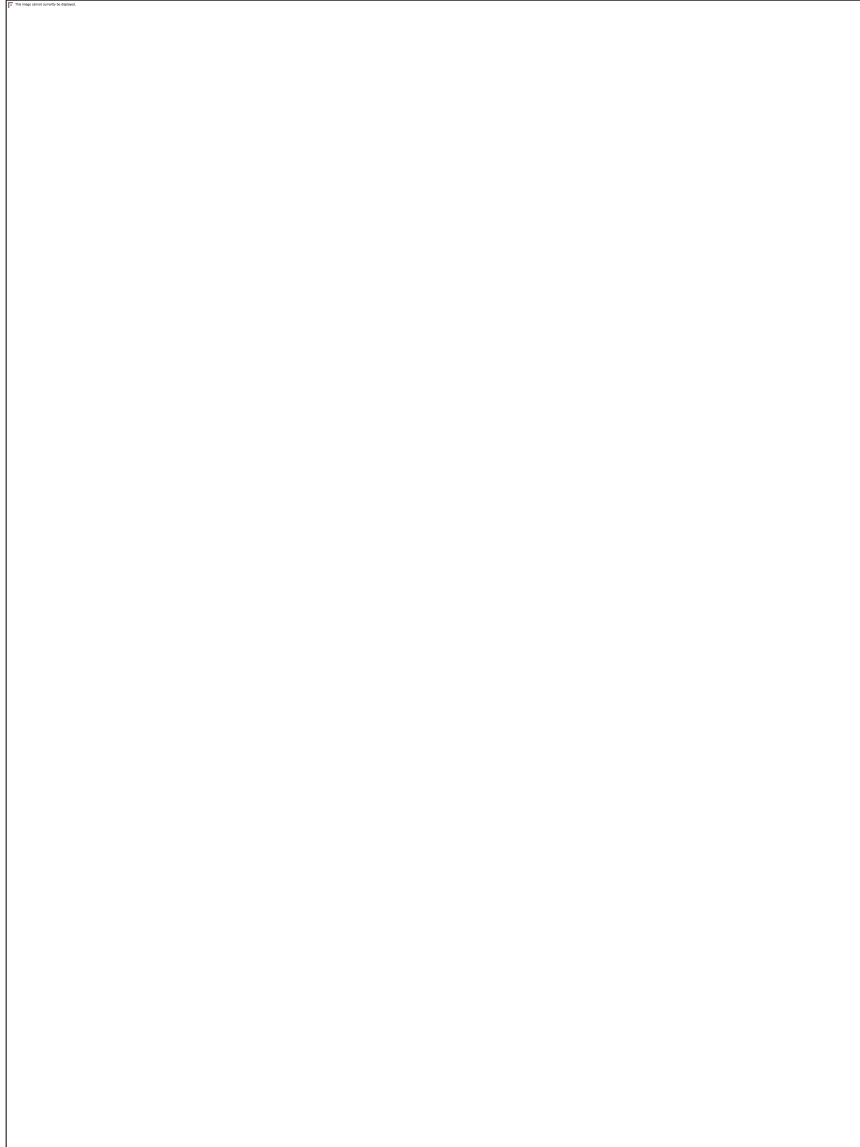
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Appendices

Appendix A: Assessment form



Appendix B: Raw data

The Koala Abattoir, located in Harare, slaughters approximately 120 cattle and 150 pigs per day. The abattoir generates various types of solid waste, including hides, bones, offal, carcass trimmings, horns, and hooves. The disposal methods used include landfilling, incineration, and composting, with offals from pigs being particularly sent to landfills. The abattoir practices waste

segregation and separation, reusing dirty water for lawn watering after separating it from solid waste. The daily solid waste generation is approximately 2400kgs (gut fill), translating to 16800 kgs weekly and 67200 kgs monthly. In terms of liquid waste, the abattoir generates around 650 liters of blood and 1000 liters of wastewater per day, treating the effluent through an on-site treatment plant and avoiding discharge into waterways. However, wastewater quality parameters like pH, BOD, and COD are not monitored. The abattoir has implemented waste reduction initiatives, including by-product utilization and composting, but does not currently engage in recycling practices. The facility complies with environmental regulations and holds necessary permits from the Environmental Management Authority (EMA) and Veterinary Department, including HACCP certification. Employees are trained on environmental regulations and compliance, and environmental audits are conducted annually by external auditors. Recommendations for improvement include exploring value-added products from cattle blood, partnering with medical institutions, investing in blood collection infrastructure, developing a marketing strategy, and ensuring regulatory compliance.

Section 1: General Information

1. Abattoir name and location: koala Abattoir
2. Number of cattle slaughtered per day/week/month: 120 per day and 150 pigs per day
3. Types of animals slaughtered: Cattle and pigs

Section 2: Solid Waste Management

1. Types of solid waste generated:

- Hides: Yes

- Bones: Yes
- Offal (organs and entrails): Yes
- Carcass trimmings: Yes
- Other (specify): horns, hooves

2. Disposal methods:

- Landfilling: Yes, especially with offals of pigs.
- Incineration: Yes
- Composting: Yes
- Other (specify):

3. Waste segregation and separation practices:

- Yes

If yes, describe: the dirty water is separated with solid waste and then reused for watering the lawn

4. Average daily/weekly/monthly quantity of solid waste generated:

- Daily: approximately 2400kgs (gut fill)
- Weekly: approximately 16800 kgs (gut fill)
- Monthly: approximately 67200 kgs.

Section 3: Liquid Waste Management

1. Types of liquid waste generated:

- Blood: Yes (approx. 650 liters per day)
- Wastewater: Yes (approx. 1000 liters per day)
- Other (specify):

2. Treatment and disposal methods:

- Effluent treatment plants: Yes
- Discharge into waterways: No
- Other (specify):

4. Wastewater quality parameters monitored:

- pH: No
- BOD (Biochemical Oxygen Demand): No
- COD (Chemical Oxygen Demand): No
- Other (specify):

Section 4: Waste Reduction and Recycling

1. Waste reduction initiatives:

- Yes

If yes, describe: by - product utilization,

Composting

2. Recycling practices:

- No

If yes, describe: _____

3. Percentage of waste recycled or reused: _____

Section 5: Regulatory Compliance

1. Compliance with environmental regulations and standards: Yes

2. Certifications or accreditations:

- ISO 14001: No
- HACCP (Hazard Analysis and Critical Control Points): Yes
- Other (specify): they are given appraisal authority from veterinary department annually

3. Frequency of environmental audits and inspections: inspections are done daily

- How often are environmental audits conducted? Annually by EMA.

Who conducts the audits (e.g., internal staff, external auditors)? External Veterinary Department, EMA

4. Regulatory permits and licenses:

- List the permits and licenses held by the abattoir (e.g., water discharge permit, air quality permit): __EMA permits, Veterinary permits,

- Are the permits and licenses up to date? Yes

5. Compliance with waste management regulations:

- Are hazardous wastes handled and disposed of in accordance with regulations? Yes

- Are non-hazardous wastes handled and disposed of in accordance with regulations? Yes

6. Training and awareness:

- Are employees trained on environmental regulations and compliance? Yes

- Are employees aware of their roles and responsibilities in maintaining compliance? Yes

Recommendations

1. Explore value-added products: Consider utilizing cattle blood to produce value-added products like blood sausage, blood pudding, or blood meal for fertilizers or animal feed.

2. Partner with medical institutions: Collaborate with medical institutions or pharmaceutical companies to explore opportunities for serum production, antibody production, or medical research.

3. Invest in blood collection and processing infrastructure: Ensure proper collection, storage, and processing of cattle blood to maintain its quality and safety.

4. Develop a marketing strategy: Create a marketing plan to promote the abattoir's products and services to potential customers.

5. Ensure regulatory compliance: Verify that all products and processes comply with relevant regulations and standards.

