ASSESSING PRODUCTION AND NUTRIENT COMPOSITION OF VERMICOMPOST OF BIODEGRADABLE DOMESTIC WASTE IN KASOKOSO SLUM IN KIRA MUNICIPALITY, WAKISO DISTRICT

BY

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DECLARATION

I **Atuhaire Mavis Gift** hereby declare that this research thesis is my original work and has not been presented for a degree or by any other institution of learning.

Signature Date

………………………………………… ………………………………

Atuhaire Mavis Gift

APPROVAL

This Thesis titled "Assessing Production and Nutrient Composition of Vermicompost of Biodegradable Domestic Waste in Kasokoso Slum in Kira Municipality, Wakiso District", has been compiled under our supervision and is ready for submission with approval.

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ABSTRACT

The study assessed the production of compost from organic domestic waste through vermicomposting. Vermicomposting is not well studied as a method of waste management in urban slums. This study uses Kasokoso slums as s case study to assess production and nutrient composition of biodegradable domestic waste through vermicomposting in slum amidst challenges of the densely populated urban slums. A total of 356 households were interviewed about waste handling methods used in the area and the challenges faced in waste handling using random sampling technique. An experiment aimed at investigating the effect of worms on soil nutrient levels over a period of four months was also carried out from November 2022 to February 2023. Five boxes containing organic waste and worms constituted the experimental sample, while the control sample comprised of five boxes of waste without worms. Samples from the experiment were collected on day one, and subsequently, monthly for the next three months. The results on waste handling practices in Kasokoso Village revealed that kitchen refuse (96.3%), plastic (31.3%), glass (22.5%), and animal waste (13.6%) were the main components of household waste. Disposal methods such as burning (32.4%), dumping in designated place (13.6%), waste pit (13.5%), open space (8.1%) and Burying (2.7%) were used by the community to manage domestically produced waste. Open dumping poses environmental and health risks. Whereas Informal waste management networks involving local individuals and collectors play a vital role, formal waste management services exist but face limitations due to cost and accessibility issues. Encouraging sustainable practices like recycling and composting is essential to tackle waste management challenges. The analysis of vermicompost quality showed an increase nutrient composition; of 5.8% nitrogen in the treatment as compared to 0.9% in the control, moisture content of 8.9% in the treatment compared to a 2.5% change in the control, and pH of 2.8% and 6.4% change in the treatment and control samples respectively. Although statistically insignificant, these nutrients were slightly higher in the experimental sample (P value of 0.161> 0.05). Challenges in waste disposal are accelerated by poor sanitation, leading to waste accumulation in public and residential areas. This results in health risks and diseases like cholera and bilharzia. The lack of a proper waste management system and limited resources make waste collection and transportation expensive and irregular. Improper waste disposal obstructs water channels, leading to damaged roads, causing stagnant water, increased flood risk, and environmental degradation. This research contributes valuable insights to the pool of knowledge regarding environmentally sustainable waste management techniques within densely populated slums of urban areas using vermicomposting. However, there is need to further research on vermicomposting using a different species of earth worms besides the red earth used in this study.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

The issue of organic waste globally is multifaceted, affecting environmental sustainability, public health, and economic efficiency. Organic waste, including food waste, farmyard debris, and other biodegradable materials, presents a significant problem due to its volume and management challenges. Improper disposal in landfills leads to anaerobic decomposition, releasing significant quantities of methane, which substantially contributes to greenhouse gas emissions; food waste alone accounts for 8% of global greenhouse gas emissions (FAO, 2013). The FAO estimates that one-third of all food produced for human consumption is lost or wasted globally, amounting to about 1.3 billion tons per year, translating to a significant loss of water, energy, and labor (FAO, 2011). The global economic cost of food waste is estimated at around $1 trillion annually, including direct economic losses to producers, retailers, and consumers, as well as indirect costs such as environmental degradation and public health impacts (FAO, 2014). Public health concerns arise from improperly managed organic waste, as decomposing organic matter can attract pests and pathogens, contributing to disease spread. Additionally, improper disposal of organic waste in water bodies can lead to water pollution, posing health risks to communities dependent on these water sources (WHO, 2015).

Many countries, especially in the developing world, face challenges in waste management due to inadequate infrastructure. This includes the absence of facilities for composting, anaerobic digestion, and other sustainable waste processing technologies. Inadequate waste management infrastructure exacerbates the environmental and health impacts of organic waste (World Bank, 2018). Strategies such as improving food supply chains, promoting composting and anaerobic digestion, and implementing educational campaigns to reduce food wastage at the consumer level are critical to mitigating the impacts of organic waste (UNEP, 2020; WRAP, 2020).

The worldwide environmental issue is being exacerbated by the growing amount of garbage produced by the rising population in low- and middle-income countries (Goorhuis, 2014). The consumption of numerous commodities and services has increased as a result of the world population's fast growth. As a result, there are now significantly more organic wastes (Hoornweg,Bhada-Tata, & Kennedy, 2013). Some of these wastes, which are gathered and disposed in publicplaces, are very infectious. They can also contribute to the environment's pollution problems. Thegeneration of solid waste is influenced by family size, education level, and income among other factors. Additionally, Alemayehu (2004) denotes that the majority of solid waste comes from residences and dwellings where people live.

Managing domestic garbage is particularly difficult, and this problem is exacerbated in underdeveloped metropolitan areas (slums) due to lack of accessibility, prohibitive costs where the service is expected to be paid for, and inadequate cleanliness. It is challenging to manage the various facets of waste management in slum regions where majority of the households do not employ proper solid waste disposal but instead use solid waste storage receptacles like sacs and yet the main type of waste collected are biodegradable materials (Ssemugabo at el., 2020) resulting into waste becoming nuisance in the area. In Kasokoso the different common waste handling methods include: open dumping, burning, scavenging & recycling, makeshift landfills, informal waste collection services, natural composting and only less than a third of waste generated ended up at a land fill.

A waste management agency's primary responsibility is to gather and transport waste to an appropriate disposal location, typically a landfill (Zhu *et al.,* 2008). However, besides being harmful to the environment, landfills also act as a source of contaminations that can affect underground water supplies and surface water bodies (Komakech *et al*., 2014). They are also known to emit greenhouse gases, which are known to contribute to global warming, are costly to manage and have long-term liabilities.

When organic wastes are applied to agricultural fields, they cause various problems, such as phytotoxicity (Marshall, and Farahbakhsh 2013), yet these wastes once recycled are turned into fertilizer or soil conditioner. They are turned into valuable organic resources.

Due to the growing awareness about the harmful effects of agricultural chemicals, the number of people who are interested in organic agriculture has increase ed (Sinha, and Chan, 2009).In order to treat organic wastes properly, composting as strategy is used to prevent their accumulation and degradation. Enhanced composting methods include; Aerated static pile composting, in vessel composting, anaerobic digesting, co-composting and vermicomposting (VC) among others (Ayilara *et al*., 2020). Such methods help transform the organic wastes into a safer and more stable material that can be used in agricultural applications (Dominguez and Edwards, 2010).

To advance the fulfilment of the Sustainable Development Goals, the government is aware of the need for inclusive and excellent development planning (SDGs). The third national development plan, which was introduced in 2020, is an effort by the government to hasten the accomplishment of these objectives. Through the use of integrated models and procedures, the government has identified key accelerators for the achievement of the goals. In addition, the government will enhance the policies and plans of local and sectoral governments to address the inclusiveness of the 2030 Agenda. Targets for reducing the consequences of climate change and managing water resources, land, terrestrial ecosystems, forests, and the environment sustainably are outlined in Agenda 2030 (SDG 12, 13, 14, and 15).

One of the most effective ways to deal with the environment's pollution problems is by using vermicomposting. In recent years, various studies have shown that this method can be used as an alternative to chemical fertilizers. Compared to compost, vermicompost is quick, more nutritious and has numerous beneficial microbes. It can also help improve the quality of soil and provide a boost to crop plants. There is however very limited information on vermicomposting in Uganda. This research therefore seeks to assess vermicomposting of waste as a potential eco-friendly way to manage biodegradable waste in poor urban/slums areas.

Vermicomposting is the process of using earthworms to convert organic waste into nutrient-rich compost. This natural and eco-friendly method reduces waste and produces high-quality compost, improving soil fertility and boosting plant growth (Byambas *et al.*, 2019). Slums around the world, including those in Uganda, face significant waste management challenges. Overcrowding, lack of infrastructure, and limited resources contribute to poor waste disposal practices, leading to environmental and health issues (Paulinho, 2023).

Vermicomposting can significantly reduce the amount of organic waste that ends up in open dumps and landfills, crucial in slums where waste management systems are overwhelmed (Julieanne, 2021). The compost produced is rich in nutrients, making it an excellent natural fertilizer, enhancing urban agriculture practices in slums and improving food security and income generation. Vermicomposting is a low-cost and sustainable waste management solution that can be implemented at the community level, empowering residents to manage their waste. Reducing waste decomposition minimizes methane production, a potent greenhouse gas, helping mitigate climate change impacts (Byambas *et al*., 2019).

Kasokoso, a slum located in Kampala, Uganda, exemplifies these challenges. Situated on the outskirts of Kampala, this slum has emerged due to rapid urbanization and population growth. The population is dense and diverse, with many residents living in makeshift homes. The community comprises individuals from different backgrounds, most of whom moved to the city seeking better opportunities. Residents engage in various informal economic activities such as small-scale trading, casual labor, and urban agriculture. Due to limited employment opportunities and financial constraints, waste management often takes a backseat, leading to indiscriminate disposal of waste (Paulinho, 2023).

The high population density in Kasokoso puts immense pressure on the limited waste management infrastructure, causing waste to accumulate rapidly. Basic amenities such as proper waste collection systems, sanitation facilities, and drainage systems are inadequate or non-existent, exacerbating the waste problem. Many residents live below the poverty line, making it difficult to afford proper waste disposal services, often prioritizing day-to-day survival over environmental sustainability (Julieanne, 2021).

Vermicomposting offers a practical and sustainable solution to the waste management challenges faced by slum dwellers in Kasokoso. By transforming organic waste into valuable compost, this innovation addresses the waste problem, enhances soil fertility, promotes urban agriculture, and contributes to environmental sustainability. With the right support and implementation, vermicomposting can become a powerful tool for improving the quality of life in slum communities.

Assessing the feasibility and impact of vermicomposting in slums is essential to develop effective waste management strategies that mitigate environmental degradation, enhance public health, and unlock economic opportunities. This holistic approach can significantly improve the quality of life in slum communities, promoting sustainability and resilience.

1.2 Problem Statement

The generation of huge amounts of solid waste is currently causing social and environmental issues globally (Usman, 2015) and the problem is more apparent in unplanned settlements (slums). These are congested, unplanned, and lack formal solid waste management infrastructures and yet approximately 5% of Uganda's urban population live in slums and other informal settlements. In Kampala metropolitan area, More than 60% of waste generated in slums is biodegradable of which less than 40% are disposed to landfills and the rest are dumped openly on land or in drainage channels. These are not eco-friendly or sustainable ways to manage biodegradable waste. Composting in general has also been explored as a management option of the biodegradable waste, with approaches including aerated static pile composting, in vessel composting, anaerobic digesting, co-composting and vermicomposting among others (Ayilara *et al*., 2020). Mukama *et al*. (2016) highlight the pressing issue of poor solid waste management in urban slums, emphasizing the need for community engagement in waste separation and composting initiatives. Their findings indicate that while a notable percentage of households express a willingness to participate in waste management improvements, actual composting practices remain low, with only 8% of households actively composting. Nsimbe *et al*. (2018) also show that knowledge and perceptions about composting are crucial determinants of participation.

However, less basic research has been done regarding the promotion and adoption of vermicomposting, yet it is highly rated as eco-friendly, efficient, produces high-quality compost, uses a small area and can be done at a household level and in landfills. This study uses Kasokoso slum area to assess (i) waste handling methods; (ii) challenges of organic domestic waste management & (iii) explores production & nutrient composition of vermicompost (use of vermins/earthworms).

1.3 General Objective

To assess the production and nutrient composition of vermicompost from biodegradable domestic waste in Kasokoso slum, Kira Division, Wakiso District.

1.3.1 Specific Objectives

i. To document the different waste handling practices used in Kasokoso slum area.

ii. To establish challenges faced in waste disposal and management in Kasokoso slum area.

iii. To determine the production and nutrient status of vermicompost of biodegradable domestic waste in Kasokoso slum.

1.4 Research Questions

i. What are the different waste handling practices used in Kasokoso slums?

ii. What challenges are faced regarding waste management in Kasokoso?

iii. What is the production and nutrient status of vermicompost of biodegradable domestic waste in Kasokoso slum?

1.5 Significance of the study

The solid waste problem is apparent in the different divisions of the city. It can be seen in the roads, in the residential areas, and in drainages. The failure to address the various issues related to solid waste management is expected to lead to environmental and social contaminations. In addition, the land tenure system makes it difficult for people living in informal settlements to properly manage their waste. The amount of rubbish produced by these localities has urban authorities overburdened (Water Aid 2011). This study explores an ecofriendly, efficient, cheap and small space requiring solution to the challenges of waste management in urban slums through vermicomposting. The findings from this study have the potential to influence policy at local and municipal levels by demonstrating the advantages of vermicomposting. This could lead to the development and implementation of supportive policies and programs that prioritize sustainable waste management practices.

Furthermore, the success of vermicomposting in Kasokoso Slum serves as a replicable model for other urban slums facing similar waste management challenges. By showcasing its feasibility and effectiveness, this study can inspire and guide other communities to adopt vermicomposting and other sustainable waste management approaches, thereby fostering widespread adoption and contributing to long-term environmental sustainability and community well-being across urban areas.

1.6 Scope of the study

The scope of the study encompasses three main aspects; content studied, geographical coverage and timeframe.

1.7 Content Scope

The management of home waste in urban settings, specifically the utilization of vermicomposting, will be the main topic of this study. Documenting Kasokoso's various waste management techniques, the effectiveness of vermicomposting biodegradable wastes, and the vermicompost nutrient status as a replacement for chemical fertilizer are all important.

1.7.1 Geographical Scope

This study was carried out in Kasokoso in Kira Division. The choice of Kasokoso Village is informed by the fact that it is one of the most congested slums in Kira Municipality. It is evidenced, by the large population of over 2,400 residents in the area. Kira Municipality, the second-largest municipality in the country is in the Wakiso District of Uganda which makes part of Kampala metropolitan area bordered by Mukono and Kampala Districts. The challenge of waste management is acute in the slums Kasokoso, where infrastructure and services often struggle to keep pace with the rapid population growth. Studies indicate that in Kampala, over 28,000 tons of solid waste are generated monthly, yet only 40% is safely managed, leaving the majority of waste to be disposed of indiscriminately. This situation is exacerbated in the slums due to the high density of the population and limited access to waste management services. The growth of slums like Kasokoso is a direct result of the city's swelling population, driven by rural-urban migration and the search for better employment opportunities. This influx has led to increased waste generation, putting a strain on already overwhelmed waste management systems.

1.7.2 Time Scope

This study was conducted between the month of November 2022 and February 2023. The period was selected because it was sufficient time to carry out the experiments of vermicomposting.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The study area for this investigation is Kasokoso, located in Kira Division within the Wakiso District of Uganda. Kasokoso Village was specifically chosen due to its status as one of the most densely populated slums in Kira Municipality. The area suffers from significant congestion, leading to poor waste management and sanitation practices.

Kira Municipality, part of the Kampala metropolitan area, is notable for being the third most populous municipality in Uganda, highlighting the significant demographic pressures on infrastructure and services in the region. The 2014 Uganda Bureau of Statistics (UBOS) report underscores the high population density and the associated challenges faced by the community in Kasokoso.

The characteristics of diverse source materials are thought to be the most significant variable that can affect vermicomposting effectiveness. Since the earthworms use these materials as food, their growth and activities can be affected. Sim and Wu (2010) stated that the growth and operations of vermicompost might be impacted by the diverse properties of domestic waste. In addition to their composition, their pace of decomposition can have an impact on the post's nutrient content.

2.1 Physical composition of the waste

2.1.1 Solid Waste Management in slums area

Waste handling and management in urban slum areas has always been presented with challenges especially due to the fact that these areas are usually congested. For instance, in Kampala, flash floods in 2019 resulted in the deaths of eight individuals in low-lying slum communities on the outskirts of Kampala, with solid waste blockage in drainage channels being one of the contributing factors (Reliefweb, 2019). Indiscriminate waste management practices were prevalent among many households in slum communities. This issue is expected to worsen due to population growth and unplanned urbanization, leading to the development of more slums in sub- Saharan Africa.

The global generation of solid waste is increasing, with cities worldwide producing over 1.3 billion tonnes annually, projected to rise to 2.2 billion tonnes by 2025 (Hoornweg and Bhada, 2012). This increase is anticipated to be even higher in developing countries due to rapid urbanization. Uganda is currently experiencing rapid growth, with annual urbanization and population growth rates of 5.1% and 3.3% respectively (UBOS, 2018). However, the existing infrastructure for solid waste management cannot keep up with the growing urbanization and waste generation (Komakech *et al*., 2014). Approximately 2500 metric tons per day of solid waste is generated from Kampala metropolitan area. This waste consisted on average (by weight) of 92.1% organic material, 1.8% hard plastic, 0.1% , 1.3% papers, 3.0% soft plastic, 0.6% glass, 0.5% textile and leather at 0.6%, quite different from those reported for other Sub-Saharan African (SSA) cities like Abuja (Imam *et al*., 2008), Accra (Fobil *et al*., 2008,) and Gaborone (Bolaane and Ali, 2004 yet in Kampala, only 40% of the total waste generated in the city, approximately 28,000 tonnes per month, is collected and delivered to landfills. The remaining waste is indiscriminately disposed of, leading to environmental and public health issues, including blockage of drainage channels and subsequent flash floods. Poor solid waste management also contributes to pollution of water and soil, leading to the spread of diarrheal diseases.

Out of the 1,619,900 people residing in Kampala, approximately 53.6% (868,266) live in overcrowded and informal slum settlements, often located in low-lying areas and wetlands (United Nations, 2014). This has resulted in the development of more informal settlements due to overcrowding. While solid waste collection is an essential service, it has become a major challenge for slum residents, city authorities, and leaders. Solid waste management encompasses waste generation control, storage, collection, transfer and transport, processing, and disposal, based on best practices for public health, economics, and the environment (Omran, 2019). In Lubaga division, where Kasubi parish is situated, over 3,400 tonnes of solid waste are collected monthly. However, a significant portion of solid waste is dumped in unauthorized sites, including drainage channels. Additionally, there is a shortage of designated communal garbage collection points, exacerbated by landlords' unwillingness to allocate land for waste collection due to poor maintenance of waste collection sites.

According to Ssemugabo *et al*. (2020), only 41.3% of households in a slum community in Kampala practiced proper waste management. The majority of households (85.8%) owned solid waste storage receptacles, with sacs being the most common type (61.7%), aimed at minimizing nuisances (72.9%). Biodegradable materials constituted the main type of waste collected (56.7%).

However, a significant number of households (78.7%) did not segregate their waste. The primary method of transporting solid waste to collection points was pulling a collecting sac (54.4%). The study also found that waste collection was primarily carried out by the city authority (73.9%) and private companies (12.9%).

2.1.2 Solid Waste Management in slums area

Kampala Capital City Authority (KCCA) provides subsidized garbage collection services at the household level. However, slum dwellers often cannot afford this service and face challenges accessing waste collection vehicles. Disappointments from solid waste collection companies and a lack of awareness about the importance of solid waste management also contribute to the forfeit of this service by slum dwellers (Mukama, *et al*. 2016). Previous studies have not utilized observations to determine the level of waste collection and handling.

Kageenu (2023) in a study entitled “Challenges Facing Waste Management in Kampala City” highlights that the main challenges affecting Kampala in waste management include but are not limited to insufficient public infrastructure to manage the waste, lack of awareness among the people on waste management, insufficient private infrastructure to manage the waste, no incentive for the public to manage their waste better, lack of policy and regulations guiding the solid waste recycling space and cost paid for waste collection. He states that although Kiteezi landfill, the primary disposal site, reached its capacity in 2009, it still receives more waste every day. The landfill is overflowing even though it only receives 40–50% of the rubbish that is produced.

2.1.3 Role of earthworms in Vermicomposting

An ecosystem engineer known as an earthworm helps to increase the soil's capacity to retain water and to drain (Jones and Darrah, 1994). In addition to helping the soil, earthworms are essential for the growth and maintenance of ecosystems. They can also help alter the dynamics of the ecosystem by providing habitats for other organisms (Jouquet *et al*., 2006). Charles Darwin first introduced the concept of the study of earthworms in 1881. They are crucial to an ecosystem's ability to decompose organic materials, he said.

In the US, Earthworms were raised using a variety of materials during the 20th century. Among these were animal faeces. Oliver and Barrett highlighted that the castings of some epigeic earthworms could be helpful in increasing farmers' agricultural yield following the success of an intensive culture effort on these creatures (Edwards *et al*., 2012). The growing demand for these products led to the expansion of the vermiculture industry. These materials were used as animal feeds, fertilizers, and bait.

The issue has separated from studies on earthworms in general due to the growing number of studies on the use of epigeic earthworms in vermiculture. This is because the value of vermicomposting as an organic waste recovery process has been acknowledged. The cultivation of these creatures has advanced because of the rise in studies on the usage of compost earthworms. The ideal environments for these creatures' growth have been the subject of several of these researches.

Aside from animal wastes, other types of wastes such as sewage sludge and solid waste were also studied for their potential use in vermicomposting. Some of these include paper industry wastes, human excrement, and plant residues. In addition, various types of mixed wastes were also considered for their potential use (El-Haddad *et al*., 2014). The various studies on the use of vermicompost in various industries have confirmed its potential as a plant growth medium. However, there are still areas of research that need to be conducted. This review aims to provide a comprehensive analysis of the literature on the subject.

2.1.4 Vermicompost and the vermicomposting process

Vermicomposting is similar to composting in that epigeic worms are added to aid in the breakdown process. However, unlike regular compost, which is generally characterized by a variety of physical and biochemical properties, vermicompost has unique properties. This end product, which is referred to as vermicast, is a unique type of compost (Edwards *et al*., 2012).

Due to the unique properties of vermicompost, it is regarded as the main product of the commercial vermicompost industry. Most of the initial organic materials that are used for this process will eventually transform into an earthworm after being cast. The numerous activities of the worms in the process also help to degrade the organic components in addition to serving as an aerator, grinder, and sink. These include altering the number of harmful compounds as well as the original materials' biological and physical characteristics (Sinha *et al*., 2010).

Other mesophilic microorganisms, such as insects and invertebrates, are also known to contribute to the decomposition process in addition to earthworms. In addition, the complex food web that is used for the production of vermicompost allows various kinds of microorganisms to combine and recycle the organic matter. During the process, various biotic interactions can occur between the fauna and the microorganisms. These include competition, mutualism, and facilitation (Dominguez *et al*., 2009). These interactions are known to contribute to the formation of a type of organic matter known as vermicompost. It is difficult to predict the rate at which this organic material will be degraded due to the interactions between different microorganisms.

Due to the complexity of the process, it is difficult to study the interactions between different microorganisms in the food web of vermicompost. It is advised that the researchers concentrate on a few key nodes in the food chain to prevent this. The microorganisms that live in the various food groups are the most crucial nodes in the vermicompost food web. These include ciliates, bacteria, and fungi. These food web constituents aid in the breakdown of the organic food residues. Vermicompost breakdown is significantly influenced by interactions between microorganisms and earthworms, according to studies (Gomez-Brandon & Dominguez, 2014).

The activities of microorganisms can also help the decomposition process of earthworms by increasing the degradation rate of the initial materials. In addition, the presence of more microorganisms can stimulate the growth and development of the bacterial communities in the food web. Although the activities of microorganisms can help the decomposition process of the earthworms, competition may also occur between the organic materials produced by mineralization (Gomez-Brandon and Dominguez, 2014).

The activities of the earthworms can also affect the structure and development of microfauna and microflora communities. Although the relationship between the worms and microorganisms is known, it is not yet clear how they coordinate their activities. To pinpoint the precise methods by which the various microorganisms contribute to the vermicompost's decomposition process, more research is required.

2.2 Importance of Raw Materials

In addition to the physical characteristics of the ingredients utilized in vermicomposting, other factors such as the reproductive potential of the worms are also taken into account to determine their success.

According to a study by Manna and Vermaas (1997) reveals that a good feeding environment is crucial for vermicomposting to be successful. Aside from the physical properties of the raw materials used in vermicomposting, other factors such as the environment and the reproductive potential of the worms are also taken into account to determine their success. The abiotic factors and the biotic factors are two categories of variables that can influence the success of vermicomposting, according to Yadav and Garg (2011). The moisture level of the meal, pH, temperature, and light are examples of abiotic variables.

Numerous studies have been conducted on the various factors that affect the growth of earthworms. These studies have shown that various factors such as the environment and the stocking densities can help improve the conditions for the growth of the worms. However, these factors are also variable and can be affected by the different conditions of the process.

Although these factors are interrelated, they can also affect the success of a vermicomposting system. For instance, if the system has too much moisture content, it can cause poor aeration. Aside from the environment, other factors such as the composition and temperature of the raw materials can also affect the success of the process (Yadav & Garg, 2011). It is also significant to remember that both biotic and abiotic factors have an impact on the physical characteristics of theraw materials employed in the process.

This means that it is hard to determine the feasibility of a material without conducting proper testing. Aside from the physical properties of the raw materials used in the process, other factors such as the environment and the reproductive potential of the worms are also taken into accountto determine their success.

2.3 Quality of waste and its effect on earthworms

The quality of the raw materials used in a vermicomposting system is very important to the development and activity of the earthworms. High mortality might happen if the basic materials are inappropriate for the earthworms' growth and activity. For instance, earthworms *Eisenia foetida* were unable to survive in 100% of the plant sludge created by the food industry, according to research by Garg and Yadav from 2010. Ramamurthy *et al*. (2015) noted thatthe bedding materials used by the earthworms could not support their development and activity in various solid wastes, such as pig and cattle manure.

High mortality can also occur due to the presence of toxic substances in the raw materials. Most often, inadequate conditions and the presence of dangerously high levels of chemicals were to blame for the deaths (Suthar and Singh, 2008). In 2010, Yadav and colleagues noted that the presence of toxic substances in the raw materials, such as salt, ammonia, and additives, affected the development and activity of the earthworms.

Sinha *et al*. (2010) noted that the presence of toxic substances in the raw materials, such as salt, could affect the development and activity of the earthworms. In 2003, Gunadi and Edwards notedthat the high electrical conductivity and moisture content of the feed materials could cause the death of the *Eisenia foetida*. Kaushik and Garg (2003) noted that the presence of toxic substances in the raw materials used forthe production of vermicompost could affect the reproductive and growth rates of the earthworms. Studies have demonstrated that the presence of hazardous compounds can still significantly affect the development and activity of the earthworms, even while their adverse effects can be mitigated by combining with other elements. Noor and Adi (2009), revealed that the presence of coffee grounds and cow dung in a combination resulted in the highest number of new earthworms.

Studies have shown that the presence of hazardous substances can still significantly affect the growth and activity of the earthworms, even while the detrimental effects of toxic substances can be mitigated by combining with other elements. A number of studies have shown that it can be feasible to mix various wastes in varying proportions. According to a study conducted by Fernandez-Gomez *et al*. (2010) showed that the presence of harmful chemicals in the raw materials used toproduce tomatoes increased the worms' rates of reproduction and growth. On the other hand, when the hazardous ingredients were combined with cow dung, a decrease in cocoon creation was seen.

Studies have revealed that the nutrients and raw materials used to create vermicompost have a significant impact on the growth and activity of earthworms. Suthar *et al*. (2006) also found a correlation between the initial nitrogen content of the materials utilized for theworms' creation and the *Perionyx sansibaricus* species' rates of reproduction and growth. Additionally, they discovered that the carbon/nitrogen ratio had no discernible impact on the growth and reproduction of the organisms.

However, a different study conducted in 2008 revealed that the initial nitrogen content of the materials used for the production of the worms did not affect the development and reproductionof the organisms (Sangwan *et al.*, 2008). It was noted that the negative effect of the nitrogen ratio on the reproductive rate was clear and the optimal meal for the growth and reproduction of the worms was a combination of horse manure and sugar mill filter cake.

The study also revealed that the average net weight gain of the worms during the treatment periodwas 900mg. However, the production rate of the cocoons was significantly higher than that of the50: 50 mixtures. Despite this, the mixture's C:N ratio fell inside the optimal range. According to the study's findings, the physical makeup and chemical make-up of the raw materials have an impact on how the worms grow and function. It also implied that the overall amount of nutrients in the diet might not be as significant as the presence of both nitrogen and carbon in the raw materials. There has been a lack of studies on the various nutrients and structure of the raw materials used for the production of the worms. This could lead to new research findings that could benefit the development and reproduction of the organisms. The quantity of the feed, in addition to the quality of the raw materials, is crucial for the growth and reproduction of the worms. In a study, the researchers found that the decreased biomass and cocoon production rate were due to a shortage of feed.

In an extreme situation, the lack of a food source can lead to the death of the entire population of the worms. Edwards and Gunadi (2003) reported that *Eisenia foetida*, the most prevalent type of worm, could not survive for 60 weeks without a new food source. The researchers noted that the increase in the production of cocoons following the addition of new food materials significantly increased the number of worms. The study revealed that the use of adequate amounts of feed is also important for the development and reproduction of the earthworms. It suggested that introducing new feeding materials could help stimulate the growth and reproduction of theorganisms.

2.4 Vermicomposting Efficiency

Aside from affecting the activities of the earthworms, the characteristics of raw materials also play a role in their decomposition rate. Different materials have varying degradation rates. For instance, while carbohydrates and proteins can be easily broken down, cellulose requires a longer time to decompose (Warman and Anglopez, 2010). The faster worms and microbes can break down a material, the faster its breakdown rate can be reached.

Nedgwa *et al.* (2000) noted that the maximum rate of degradation can be achieved by microorganisms when the C: N ratio is around 25. However, this efficiency can be greatly improved by adding amendments. Edwards *et al*. (2012) noted that various enzymes and nutrients can help improve the efficiency of the vermicomposting process. Singh *et al*. (2013) noted that the addition of certain microorganisms to distillation waste can improve the efficiency of the process by up to 15%. These include the strains of *Trichoderma harzianum*, *Azotobacter monteilii*, and *Bacillus megaterium*. The researchers also noted that these additions significantly increased the degradation rates of various materials, such as hemicelluloses and lignin. The faster the decomposition rate, the higher the yield. It's also believed that the nutrients were going to the beneficial microorganisms instead of the earthworms, as they require time to multiply.

Nedgwa *et al.* (2000) noted that the beneficial microorganisms can serve as the food source for the worms. Due to the actions of the microorganisms, the composition of the raw materials changes as the vermicomposting process progresses. The proper growth conditions and the optimal rate of vermicomposting are some of the factors that can affect the success of the industry. When it comes to creating a sustainable waste management system, Edwards and Gunadi (2003) stated that keeping an earthworm culture consistent is crucial.

Most studies that looked at how feeding affected the growth of vermicomposting systems were conducted in enclosed systems. These systems allow the researchers to monitor the development of the organisms inside the environment (Sahariah *et al*., 2015). The quality of the materials utilized in the process can also be impacted by the rate at which various earthworm species eat. Although it's known that enclosed systems have a significant effect on the development of the organisms, it's not yet clear how they can also affect the growth rate of the worms.

2.5 Vermicompost Quality

The initial materials used to make vermicompost can also affect its properties. For instance, Warman and Anglopez (2010) noted that the darker and finer vermicompost was produced from paper waste compared to the lighter and finer materials from kitchen waste and cattle manure. After 90 days, they were able to confirm that the initial materials were still traceable in the cast earthworms.

According to Edwards *et al*. (2012), the quality of vermicompost is linked to various parameters such a s its composition, physical properties, and chemical composition. These include the composition of its solid and liquid components, its plant nutrient content, and its bacterial and fungi communities. Depending on the raw material used, the quality of the finished product can vary. For instance, in 2014, El-Haddad and colleagues noted that the bulk density of the raw materials used for making vermicompost was lower than that of the treated materials.

In addition, when rice straw was treated with organic compounds, such as potassium and phosphorus, the N content of vermicompost improved by 2.4%. This compared to the control group, which had a pure rice straw. Pramanik *et al.* (2007) noted that the use of lime can increase the nutrient content of vermicompost. The reason for this was that the nutrients came from different organic wastes, including grass, cow manure, and municipal solid waste.

The findings of the tests showed that the quality of the finished vermicompost can be impactedby the inclusion of various modifications to the raw materials used in its production. Studies also indicated that the quality of vermicompost produced from different wastes can vary due to the presence of different microorganisms (Fernandez-Gomez *et al*., 2011)

Despite the positive effects of certain microorganisms on the quality of vermicompost, it is still not clear if the diversity of the microorganisms in the cast earthworms' gut microbiota is beneficial for the development of the product. In addition, during the process of vermicomposting, the animals can accumulate various metals in their intestines. Monroy *et al*. (2009) revealed that the reduction in the number of human pathogens in pig slurry after it was processed using the cast earthworms' gut microbiota had been beneficial.

Tittarelli *et al.* (2007) noted that the presence of harmful microorganisms in vermicompost could pose a threat to human health. The quality of the product should be maintained at the same level as that of thermophilic compost. Due to the varying characteristics of vermicompost, it is difficult to determine its agronomic value or quality (Edwards *et al*. 2012). This is why it is important that the quality criteria are established for the production of vermicompost are also taken into account when the process of composting and vermicomposting are combined.

Although vermicompost is typically derived from organic wastes, it can also be mixed with thermophlic composts to produce a product that's called vermicompost. Edwards *et al.* (2012) proposed three methods that can help determine if the process of vermicompost is sustainable. These include monitoring the temperature of the raw materials and the aerobicproperties of the process. They also calculated the densities of living earthworms in the finished product.

Although there are no specific criteria for the quality of vermicompost, the characteristics that arebeneficial for its intended use are often the ones that are most important. This makes it difficult tocontrol the quality of the finished product. One of the most practical methods to determine the quality of vermicompost is to analyse the population densities of different earthworm species. Aside from the quality of the raw materials, other factors such as the nutrients required by plants are also taken into account to determine the appropriate application of vermicompost (Edwards *et al*., 2012).

2.6 Vermicompost application and use

Numerous researches on the commercial potential of vermicompost have been done because of its high nutrient content. These studies were conducted to evaluate their nutrient value as a substrate or soil amendment. The majority of studies discovered that plant growth parameters can be affected by the amount of vermicompost given to different crops, including maize. These consist of pepper, potato, and lettuce. Vermicompost's nutrients, according to several studies,may help plants function better (Arancon *et al*., 2006; Singh *et al*., 2010).

Unfortunately, depending on the species, maturity, and amount of the product employed, vermicompost can also have an impact on a plant's growth factors. For instance, in a study on petunias, it was discovered that the plant's poor seed germination rate occurred when it wasgrown in commercial potting soil that contained 80%, 90%, and 100% cattle dung

(Arancon *et al*., 2008).

Atiyeh *et al.* (2001) noted that the growth parameters of tomatoes were affected by the amount of pig manure used as a vermicompost as the plants were less tall and had lower weight. They also noted that the amount of vermicompost that was used as a replacement for the old MM360 increased the plant's vegetative growth with a negated effect of 5%. This reduced the amount of vermicompost used by 30-40% as an effective way to increase the plant's vegetative growth. However, the 5% application of vermicompost led to a significant increase in the plant's seedling growth.

Carlile and Wilson (1988) found that applying 10%, 8%, or 6% of vermicompost to a medium formed of duck faeces resulted in the best development of various crops, including lettuce, tomatoes, and peppers. Scott also observed that the ideal vermicomposting rate varied from 20% to 50% depending on the source, such as cattle dung and duck waste. The results of this study imply that the effects of vermicompost on plants can be significantly influenced by various factors, including the species and the medium employed.

Although the studies analyzed the effects of various factors on the plant's growth, they were not able to directly compare the results of the previous studies with the results of the new ones. Dueto the limited number of studies on the subject, it is not yet clear if the various factors that affect the plant's growth can affect the effectiveness of the application of the product.

The surface treatment of vermicompost with the use of straw mulch can improve the growth of grapevines. The researchers also observed that exposure to sunlight and air may cause the product's benefits to fade (Magdoff & Weil, 2004). It is also likely that the product's application technique has different results on plant growth and development than conventional compost or chemical fertilizers.

CHAPTER THREE

METHODS AND MATERIALS

3.1 Study Area

The study area for this investigation was Kasokoso, located in Kira Division within the Wakiso District of Uganda. Kasokoso Village was specifically chosen due to its status as one of the most densely populated slums in Kira Municipality. The area suffers from significant congestion, leading to poor waste management and sanitation practices.

Kira Municipality, part of the Kampala metropolitan area, is notable for being the third most populous municipality in Uganda, highlighting the significant demographic pressures on infrastructure and services in the region. The 2014 Uganda Bureau of Statistics (UBOS) report underscores the high population density and the associated challenges faced by the community in Kasokoso.

Due to congestion in the area, Slums are characterized by poor waste management and sanitation practices. Kira Municipality is the third most populous municipality in the country, located in Wakiso District of Uganda, part of Kampala metropolitan area (UBOS, 2014).


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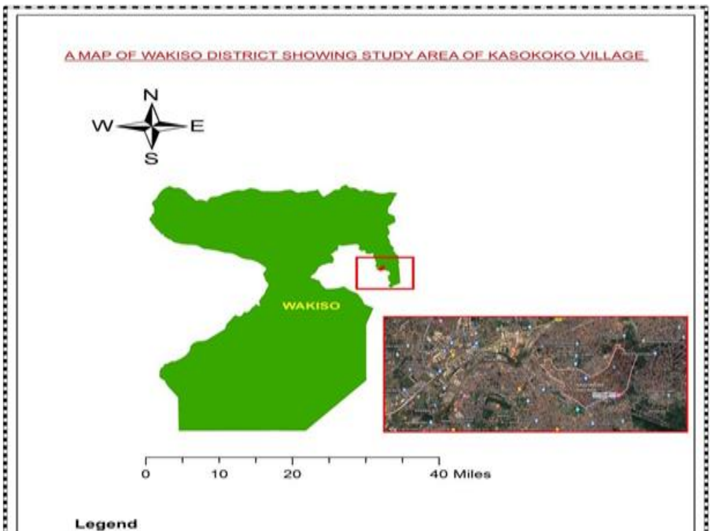
A MAP OF WAKISO DISTRICT SHOWING STUDY AREA OF KASOKOKO VILLAGE
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KASOKOSO VILLAGE
WAKISO DISTRICT

Figure 3.1: Maps of Uganda, Wakiso and Kasokoso which is the study area

Kasokoso, a densely populated slum on the outskirts of Kampala, Uganda, experiences significant waste disposal challenges due to its geographical, demographic, and socio-economic conditions. The area is characterized by makeshift housing and limited infrastructure, leading to inadequate waste management systems. Overcrowding exacerbates the waste problem, as the high population density places immense pressure on the few existing facilities. The residents, often engaged in informal economic activities such as small-scale trading and urban agriculture, face economic hardships that restrict their ability to invest in proper waste disposal methods. This socio-economic context, combined with the lack of basic amenities and financial constraints, influences waste management practices and presents both challenges and opportunities for implementing vermicomposting, which could offer a sustainable and cost-effective solution to the waste issues in Kasokoso

3.2 Research design and sample size

The study used both qualitative and quantitative approaches under a cross-sectional design. This research however largely adopted an experimental research design as this deemed suitable in scientific study that required testing of different variables

3.3 Documentation of different waste handling practices and challenges in waste management in Kasokoso (Objective i and ii).

A survey was conducted on households using structured and semi-structured questioners to 392 respondents obtain relevant information. According local authority (LC1), Kasokoso is residence to 20,000 people. Sample size determination was guide by Yamane’s formular for the known population below;

$$\Pi = \frac{N}{1 + Ne^2}$$

Where;

- n is sample size N is population
- e margin of error (0.05)

n=20,000/1+20,000* (0.05*0.05) n=392

Therefore, the survey consisted of 392 respondents for objective i & ii (documentation of waste handling practices and challenges faced in waste management in Kasokoso slums.

Data was then analyzed using SPSS version 25 and presented using graphs, tables and pie charts.

3.4 Experimental design to determine Nutrient Composition over a period of time (Objective iii)

3.4.1 Vermicomposting Experiment

The experiment was carried out in Kasokoso, where the materials were sourced. This was to cutoff the cost of transporting the raw materials and also as a form of transferring the knowledge the knowledge of vermicomposting to the people of Kasokoso. The experiment's goals were to determine the impact of earthworms on decomposition of biodegradable domestic waste in terms of time taken and quality of the humus produced.

During the initial phase of the process, waste collected from a sample of 60 households was kept under a shade and left for at least a week to set before the experiment. The experiment was conducted in wooden boxes (60x60x60cm) in a conducive environment under a semi – closed building in Kasokoso. The experiment lasted for three months between the month of November and February 2023.

Figure 3.2: Boxes used in experiment; Waste being weighed; Source: Fi

3.4.2 Preparation of waste materials for experimentation

Domestic waste was obtained from households of residents of Kasokoso and these included fresh shredded, hot rotten and old shredded domestic organic waste and then sorted to maintain only biodegradable waste.

Figure 3.3: Domestic waste after sorting, Source: Field 2022

3.4.3 Source of earthworms

The earthworms were obtained from a Vermiculture farm in Entebbe Animal Care Centre ltd.The red wigglers (*Eisenia fetida*) earthworm species was used. This is the most common type of earthworm used in vermicomposting due to the fact that it is tolerant to a wide range of environmental conditions as well as its high metabolism (Yadav and Garg, 2011).

The experiment aimed to investigate the effect of earth worms on soil nutrient levels over a period of four months between the month of November 2022 and February 2023.

Figure 3.4: Red-earth (red wigglers (Eisenia fetida)) worms used in the experiment

3.5 Vermicomposting Experiment; Data collection and sampling

The study focused on various house hold organic waste within the Kasokoso slum to ensure diverse and representative sampling.

Selection of Organic Waste: Domestic organic waste was used based on its suitability for vermicomposting and this research, ensuring a variety of materials to provide a balanced diet for the worms.

Preparation of Bedding: The bedding for the worms was prepared using a mix of shredded newspaper, cardboard, and aged compost to create a hospitable environment for the earthworms.

Selection of Worms: Appropriate worm species, the red earthworm (*Eisenia fetida*), were selected for their efficiency in breaking down organic matter and producing high-quality compost.

Setting up the vermicompost bin: Semi-closed structure feasible for the experiment was identified in Kasokoso where the experiment was carried out, with ten wooden beds (labelled 1-10) and 100kgs of organic biodegradable waste in each box. One Kg of red earthworms (*Eisenia fetida)* (same levels of maturity and genotype) were introduced to each wooden box labelled number one (1) to number five (5). Wooden boxes labelled 6-10 are left as control. : The setup was monitored regularly until the waste turned into humus.

The control experiment did not have earthworms added and was left to undergo natural compositing

Adding water to the bin: Distilled water was added to the bins every three days to maintain 50-75% moisture content in the setup.

Maintaining the vermicompost bin: The bins were maintained by regularly monitoring moisture levels, temperature, and pH, and adding water or dry bedding as needed to maintain balance.

Harvesting Vermicompost: Vermicompost was harvested after three (3) months, once the organic waste had been fully broken down by the worms into nutrient-rich compost and the vermis carefully disposed off.

Utilizing Vermicompost: The harvested vermicompost was utilized to enhance soil fertility in urban agriculture projects within Kasokoso, promoting sustainable farming practices.

Testing Nutrient Composition: Samples were collected every 30 days to monitor the vermicomposting process. Various analytical tools were used to analyze samples collected from different levels of the bins: the top level and the middle-bottom level. Five randomly selected grab samples, each weighing about 300 grams, were obtained from each level and kept in a cooling box. Soil parameters, including pH, moisture, total nitrogen, total phosphorus, total potassium, and total organic carbon, were recorded for analysis 24 hours after collection. The worms were also monitored by observation throughout the experiment.

3.6 Determine nutrient status for vermicompost

Tests on parameters including pH, moisture, total nitrogen, total phosphorus, total potassium, and total organic carbon parameters were conducted to determine the quality of vermicompost.

The moisture content of waste materials and vermicompost was calculated using the Suthar formula.

$$Moisture\ content = \frac{wet\ weight - Dry\ weight}{Wet\ weight} \times 100$$

Afterward, a sample of vermicompost and garbage was baked for 24 hours at 60°C to assess its dry weight.

For the determination of Nitrogen (N), Potassium (K), and phosphorus (P) concentrations in the biodegradable waste, samples collected from the experiment were mineralized through pressurized digestion with mineral acid, and then the N, K, and P elements in each of the predigested samples of each of the ten samples were determined by the AOAC method for N and the ICP-OES method for K and P.

Figure 3.5: Testing for Nutrient composition

3.7 Determination of pH and electrical conductivity

When measuring the pH of wastes and vermicompost, 5g of ground samples and 25ml of deionized (DI) water were used. Before analysis and pH measurement, samples were agitated for five minutes and centrifuged for fifteen minutes at a speed of 1500 rpm (Blakemore *et al*., 1987). Following pH analysis, electrical conductivity was measured with a radiometer using the same samples. Total soluble salts were determined by measuring the samples' electrical conductivity and applying the equation (Blakemore *et al*., 1987). Then additional analyses using the same measurements for total nitrogen, total phosphorus, total potassium, and total organic carbon usinga thermal decomposition approach. Four samples were picked from each experiment in total at one month interval (top, middle and bottom).

3.8 Statistical data analysis

A descriptive analysis was performed for the background information of the people in the area where the study was conducted. In the pursuit of realizing objectives 1 and 2, the statistical analysis was undertaken using IBM SPSS Ver 25, to perform T-Tests for qualitative analysis. On the other hand, for the accomplishment of objective 3,data collection was executed using Excel version2016, followed by the processing of this data through the utilization of the GraphPad 9 tool to perform descriptive statistics. The assessment of soil nutrients such as pH, organic carbon (OC), moisture content (MC), and potassium (K) was performed utilizing the T-tests in SPSS software at a significance level of 0.05.

3.9 Ethical consideration

The researcher obtained informed consent from all participants before involving them in the study. The study's purpose, and objectives were clearly explained, and participants were allowed to ask questions for clarification.

The researcher was keen to the negativity of plagiarism to any scholarly work and intends to keep the similarity levels very low. This was done through thorough review of related literature and paraphrasing to generate own insights from the literature. All reviewed literature was acknowledged and cross-referenced basing on American Psychological Association (APA), guidelines, in-text and in the referencing list. The work was tested for similarity using turntin and paraphrased to fit the institution similarity standards before submission.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the study findings, including an in-depth analysis and interpretation of the obtained results. The findings presented here are the culmination of extensive research and data collection to address the research questions and objectives outlined in the study. The analysis of the findings involves systematically examining the collected data, employing various statistical methods.

4.1 Response Rate

The study targeted 392 respondents and out of these, 90.8% of the targeted sample participated in the study by completing a survey. A high response rate like this is generally considered a positive sign for the study's relevance eliminating the risks of nonresponse bias, which occurs when individuals who choose not to participate in a study differ in some meaningful way from those who do participate. This response rate (90.8%) presents confidence in the patterns, characteristics and trends observed in the broader population.

4.2 Demographical Data

It was found that the average household size among the sample of 5 households was 20 people for the largest household, while the smallest household had only 1 person (Table 4.1). This indicates a wide range of household sizes in the studied population. The mode of 4 suggests the commonality of the household size in the population (Table 4.1). In terms of age, the average age of household heads was 36 years, indicating that the majority of household heads were in their thirties. The oldest household head observed in the sample was aged 69 years, while the youngest was only 20 years old. This suggests a wide range of ages among household heads, with some being relatively young and others approaching or exceeding retirement age. The higher the education the better the informed decision-making about waste management.

Table 4.1: The number of Household and age of household head

	Number of peoplein the household	Age of householdHead
Mean	4.94	36.2
Std. Error of Mean	0.162	0.538
Median	4	35
Mode	4[a]	45
Std. Deviation	2.988	9.57

a. Multiple modes exist. The smallest value is shown (Source; Statistically generated from the data)

4.3 Sex, education of the household head and Ownership of the house

4.3.1 Sex of Household Head

Most households (73%) were headed by males and 23% by females (Table 4.2). This suggests a gender imbalance in terms of who is responsible for managing households within the population being studied.

Table 4.2: Sex of household head

		Frequency	Percent
Sex of Household Head	Male	260	73.0
	Female	96	27.0
	Total	**356**	**100.0**

(Source; Statistically generated from the data)

4.3.2 Level of Education

The largest proportion of respondents (24.4%), did not have an ordinary level of education, 22.1% had never completed primary school leaving education, while16.3% had completed P7, 12.8% of respondents had completed Ordinary Level secondary education, and 8.1% had completed Advanced Level secondary education. This suggests that a relatively small proportion of the population had achieved higher levels of secondary education. It was also revealed that 4.7% of respondents held a certificate, while 3.5% had obtained a university degree. Only 2.3% of respondents never completed Advanced level secondary education, while an equal proportion (2.3%) of the respondents had obtained a diploma (Table 4.3).

Table 4.3: Level of education of the study population

	Status of completion	Frequency	Percent
Level of Education	Never completed O'level	84	24.4
	Never completed P7	76	22.1
	Completed P7	56	16.3
	O'Level	44	12.8
	Completed A'Level	28	8.1
	Certificate	16	4.7
	Degree	12	3.5
	Don't know	12	3.5
	Never completed A'level	8	2.3
	Diploma	8	2.3

(Source; Statistically generated from the data)

4.3.3 Household Income Level

Kasoskoso had a diverse range of income levels among the population. The largest proportion of households, 45%, earned between 100,000 and 299,000 shillings, 27.5% of households reported earning between 300,000 and 499,000 shillings, 10% of households reported earning between 500,000 and 699,000 shillings, 2.5% of households earned less than 100,000 shillings, 2.5% earned between 700,000 and 899,000 shillings and 2.5% of households earned above 900,000 shillings, suggesting a relatively small group of households with a relatively high-income level (Table 4.4).

Table 4.4: Income of the study population

	Amount earned	Frequency	Percent
Monthly Income	100,000-299,000	144	45.0
	300,000-499,000	88	27.5
	500,000-699,000	32	10.0
	Don't know	20	6.3
	Not willing to mention	12	3.8
	Less than 100,000	8	2.5
	700,000-899,000	8	2.5
	900,000+	8	2.5

(Source; Statistically generated from the data)

4.3.4 House Ownership Status

The largest proportion of respondents (62.8%) in Kasokoso live in rented houses, 34.8% own houses and 1.2% do not own house but live freely (they include individuals who do not have a permanent residence or who are staying with family or friends for an extended period of time).

Table 4.5: House ownership status in Kasokoso

	Status	Frequency	Percent
House Ownership Status	Rent	216	62.8
	Own	124	34.8
	Do not own but live freely	4	1.2

4.4 Waste Handling Practices in Kasokoso

4.4.1 Type of waste generated by households

In the Kasokoso slum, various types of waste are generated due to the dense population and limited infrastructure. These wastes can be broadly categorized into several types. Organic waste is prevalent, including kitchen waste such as fruit and vegetable peels, food scraps, and eggshells, as well as yard waste like grass clippings, leaves, and small branches. Plastic waste is another major category, comprising packaging materials such as plastic bags, bottles, and wrappers, along with containers like jugs, tubs, and plastic utensils. Paper waste is also common, with household paper items such as newspapers, magazines, cardboard, and paper packaging, as well as miscellaneous paper products like receipts, notebooks, and paper bags.

Metal waste in Kasokoso includes beverage cans, food cans, small metal parts, wires, and various household items. Glass waste primarily consists of beverage bottles, jars, and broken glass fragments from household items. Textile waste includes worn-out clothes, fabric scraps, towels, and bed linens. Electronic waste, or e-waste, is generated from small electronics like mobile phones, chargers, and batteries, as well as broken appliances and old gadgets.

Hazardous waste is another critical category, encompassing chemical products such as cleaning agents, pesticides, and paints, as well as medical waste like used syringes and expired medications. Construction and demolition waste, including debris such as bricks, concrete, and wood, along with remnants like tiles and insulation materials, also contribute to the waste stream.

Lastly, miscellaneous waste includes various household items like broken toys and discarded personal items, as well as sanitary waste such as diapers and sanitary pads. The accumulation of these diverse types of waste, exacerbated by inadequate waste management systems, poses significant environmental and health risks to the Kasokoso community.

The data collected on household waste generation revealed that a significant proportion of households in Kasokoso were generating different types of waste as shown in Figure 4.1. Specifically, it was found that the majority of households, 96.3%, generated kitchen refuse, which includes food waste, vegetable and fruit peels, and other organic matter that is generated during cooking and food preparation. In addition to kitchen refuse, 31.3% of households reported producing plastic waste. This may include packaging materials, bags, and other plastic items that are commonly used in the household. The data also showed that 22.5% of households generated glass waste, which may include glass bottles or containers used for food and beverages. Furthermore, a smaller proportion of households, 13.8%, reported producing animal waste, which may include pet waste or waste generated from livestock, such as cows, goats, or chickens.

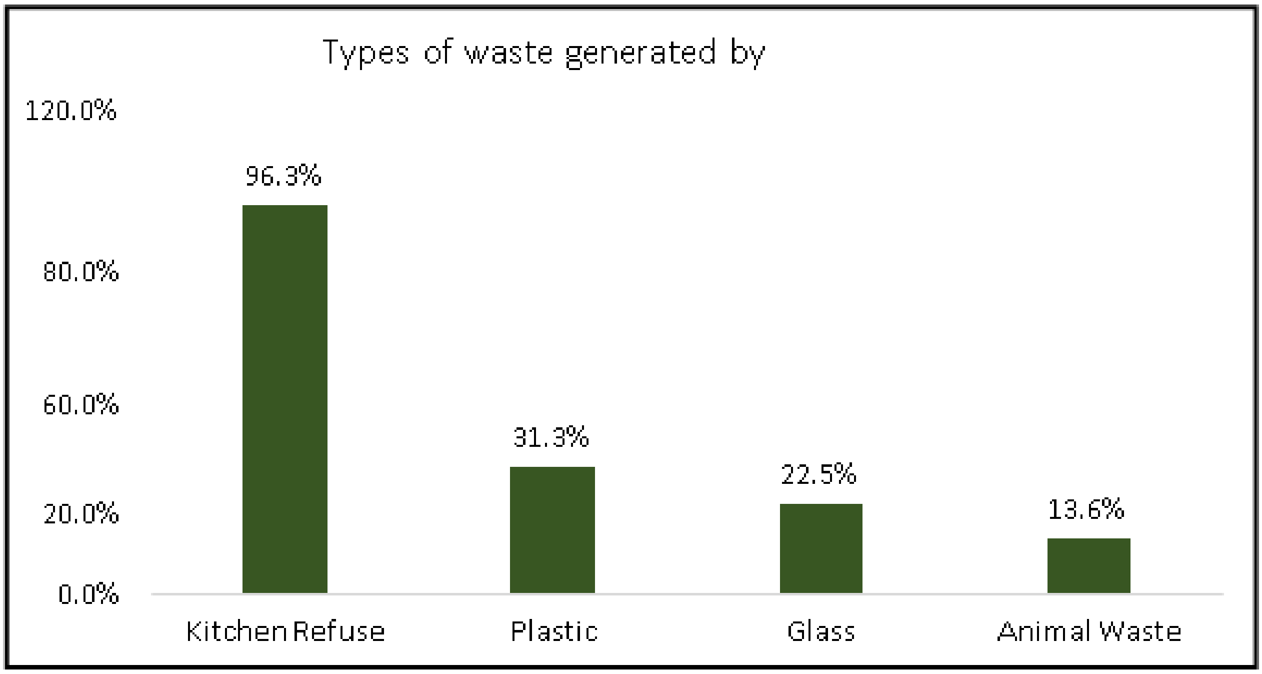

Figure 4.1: Type of waste generated by households in Kasokoso

4.4.2 Sorting waste before disposal

It was found that a significant proportion (68.2%) of the population did not sort waste before disposing off. This suggests that there is a lack of awareness or knowledge regarding proper waste management practices, or that households may not have access to the necessary tools or infrastructure to effectively sort and dispose of their waste. However, the data also showed that a considerable proportion of households, 31.8%, reported that they did sort their waste before disposal. This indicates that some households are actively engaged in proper waste management practices and may be taking steps to reduce their environmental impact.

4.4.3 Methods of Waste Disposal Applied

The study revealed that the common method of waste disposal in Kasokoso is burning with 32.4% of the households practicing it. This was followed by dumping waste in a designated area, with 16.2% of households, dumping in waste pit, 13.5%, open spaces dumping, 8.1% and burying 2.7%. However, 27% of households employed other methods of waste disposal, which could include recycling, composting, or using waste collection services (Table 4.6).

Table 4.6: Methods of waste disposal

	Frequency	Valid Percent
Burning	96	32.4
Designated dumping area	48	16.2
Waste Pit	40	13.5
Open Space	24	8.1
Burying	8	2.7
Total	296	100.0

4.4.4 Waste Disposal Frequency

The majority of households (41.8%) dispose of their waste daily, 30% dispose weekly, 21.5% twice a week and 7.6% of the households have no clear trend of waste disposal (Table 4.7).

Table 4.7: Domestic Waste Disposal Frequency

	Frequency	**Valid Percent**
Daily	132	41.8
Twice a week	68	21.5
Weekly	92	29.1
No clear trend	24	7.6
Total	316	100.0

4.4.5 Household Members Responsible for Waste Disposal

In Kasokoso, 72.5% of the respondent are adult females responsible for waste handling, 24.6% adult males, 21.7% young females and 20% young males (Figure 4.2).

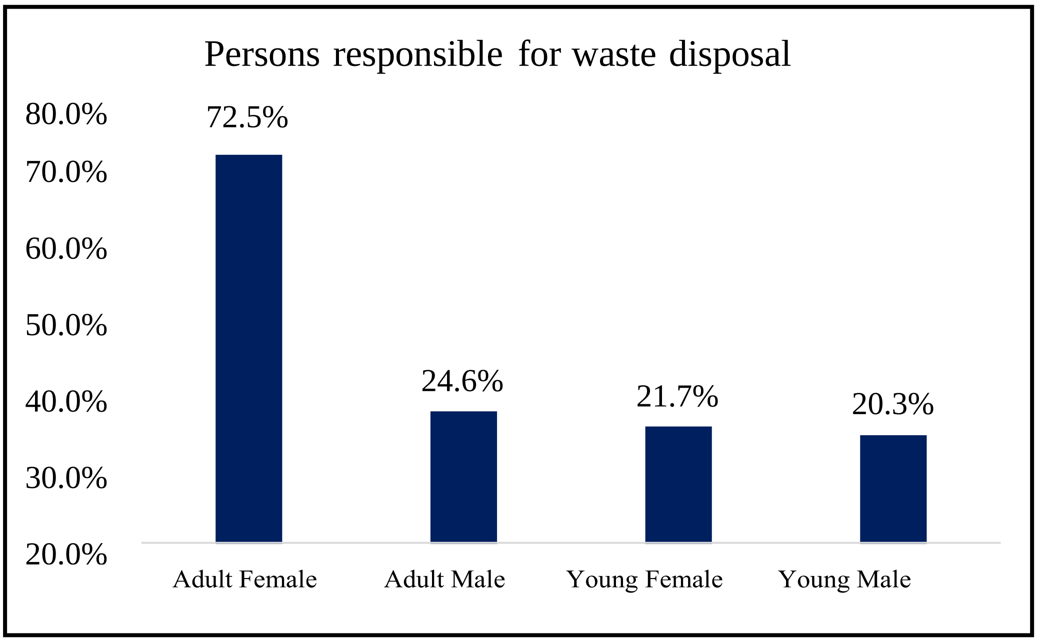

Figure 4.2: Showing person responsible for waste disposal

4.4.6 Use of external service providers in waste management

The majority of households, accounting for 62.8%, were not using the services of external waste management providers and 37.2%, reported using the services of external providers for waste management. This suggests that these households were managing their own waste, perhaps using local resources. However, 97.1% of the households outsourced waste management. This suggests that informal waste management networks are common in these communities, with local collectors providing a vital service in waste collection and disposal. Only a very small percentage of households, around 2.9%, reported using firms that collect waste. This suggests that formal waste management services are less commonly used among households, perhaps because they are not affordable or accessible to all. The data highlights the importance of informal waste management networks in many communities, with local individuals and collectors providing a vital service in waste collection and disposal.

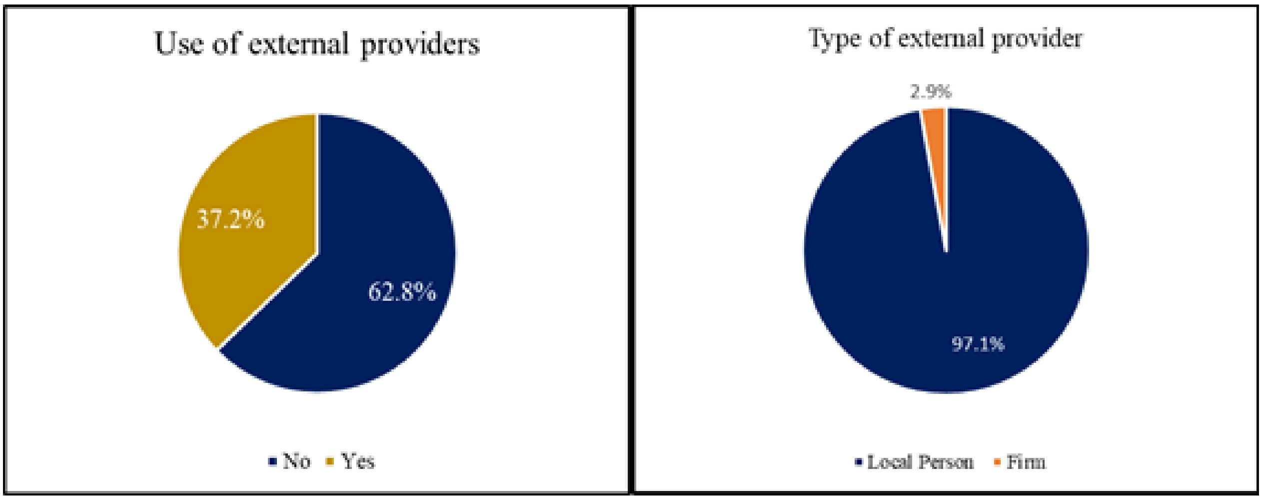

Figure 4.3: Showing use of external service providers in waste handling

4.4.7 Relationship between number of people in household and amount spent on waste disposal

There is a direct and positive relationship between the number of people living in a householdand the amount of money spent on waste disposal. This is indicated by a Pearson correlation coefficient of 0.261, which is statistically significant at a level of 0.001. The correlation coefficient of 0.261 indicates a moderate positive relationship between the two variables. In other words, as the number of people in a household increase, the amount of money spent on waste disposal also tends to increase.

Table 4 8: Showing relationship between number of people in household and amount of waste generated

		No. of people in HH	Money spent on waste disposal
Number of people in Household	Pearson Correlation	1	.261**
	Sig. (2-tailed)		.001
	N	340	156
Money spent on waste disposal	Pearson Correlation	.261**	1
	Sig. (2-tailed)	.001	
	N	156	164

***. Correlation is significant at the 0.01 level (2-tailed).*

a. 40 cells (66.7%) have an expected count of less than 5. The minimum expected count is .11.

The Pearson chi-square value of 152.175 indicates the overall strength of association between the level of education and waste handling. A higher chi-square value suggests a stronger association. In this case, the chi-square value is relatively high, indicating a potentially significant association between the level of education and waste handling.

The linear-by-linear association value of 12.102 refers to a specific type of association test withinthe Pearson chi-square framework. This test assesses whether there is a linear trend between the two variables. In other words, it examines if there is a systematic increase or decrease in the proportion of waste handling across different levels of education. The value of 12.102 indicates the strength of this linear association. A higher value suggests a stronger linear trend.

The "asymptotic significance" of 0.001 indicates the p-value associated with the test. This p-value is a measure of the probability of observing the given association between the variables, assuming there is no true association in the population. In this case, the p-value is very low (0.001), indicating strong evidence of association. Therefore, the association between education level and waste handling is considered statistically significant.

Table 4.9: Relationship between level of education and waste handing

Chi-Square Tests			
	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	152.175[a]	45	.000
Likelihood Ratio	176.920	45	.000
Linear-by-Linear Association	12.102	1	.001
N of Valid Cases	292		

4.4.8 Community Level of satisfaction with waste management

The level of waste management in Kasokoso was tested and it was found that about 37.5% of the respondents were both satisfied and dissatisfied with the way wastes are managed in their community. However, 5.0% were very satisfied and 20.0% were very dissatisfied with waste management (Table 4.10)

Table 4.10: Level of community satisfaction with waste management

	Frequency	Valid Percent
Very Satisfied	16	5.0
Satisfied	120	37.5
Dissatisfied	120	37.5
Very Dissatisfied	64	20.0
Total	320	100.0

4.5 Challenges faced by the community in waste disposal and management

Poor sanitation of the surroundings: One of the major challenges in waste disposal and management in Kasokoso Village is the poor sanitation of the surrounding areas. Improper waste disposal practices, such as open dumping and littering, contribute to the accumulation of waste in public spaces, streets, and residential areas. This not only creates an unpleasant and unhygienic environment but also poses serious health risks to the residents.

Disease spread like cholera, bilharzia, and other related infections: Inadequate waste disposal and management in Kasokoso Village increase the risk of disease spread. Improperly disposed waste attracts pests, such as rodents, flies, and mosquitoes, which can transmit diseases like cholera, bilharzia, and other infections. Contaminated water sources and poor sanitation facilities further exacerbate the problem, making the residents vulnerable to waterborne diseases.

High costs of waste collection: Waste collection in Kasokoso Village is a costly endeavour to the average resident. The lack of a proper waste management system and infrastructure, coupled with limited financial resources, makes waste collection and transportation a challenging and expensive task. As a result, waste is most often not be collected regularly, leading to accumulation and further worsening of thewaste management situation.

Flooding due to disposal in water channels: Improper disposal of waste in water channels is another significant challenge faced in Kasokoso Village. When waste is thrown into water channels, it can block the flow of water, leading to stagnant water and increased risk of flooding during heavy rains. The clogged channels not only disrupt the natural drainage system but also contribute to the spread of waterborne diseases and environmental degradation.

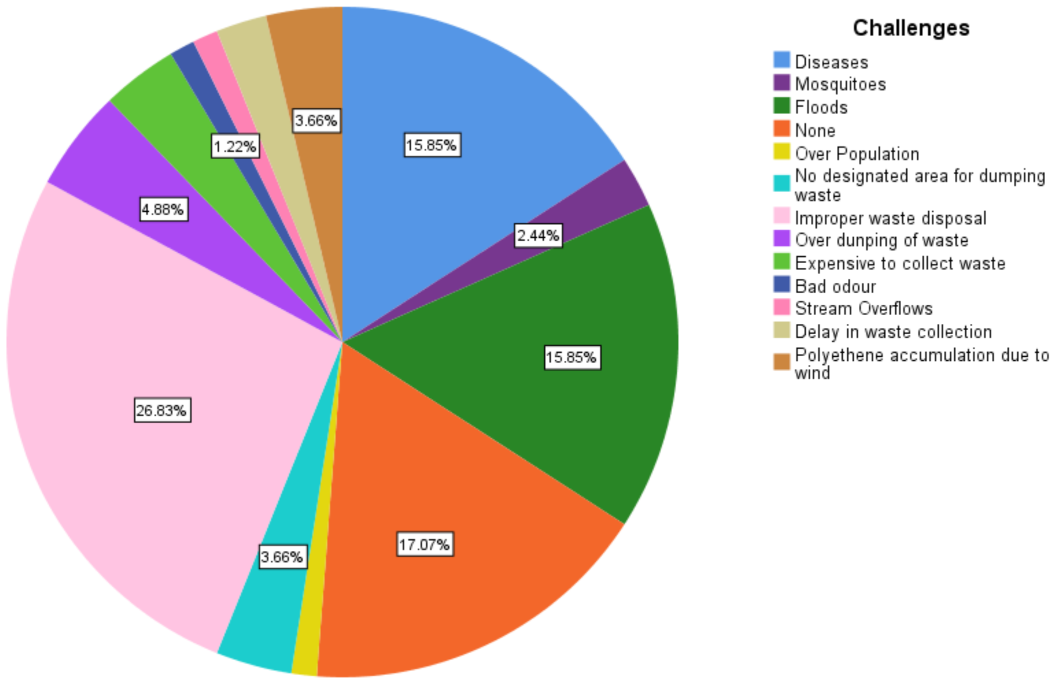

Figure 4.4: Challenges in waste disposal in Kasokoso

4.6 Efficiency and Quality of vermicompost for the nutrient status over a period of time

The samples picked from the experiment and control were then analyzed in the laboratory to assess changes in soil nutrient content.

Potassium (K)

Findings from table 4.12 the paired sample test p-value associated with Potassium was 0.360. This value indicates the probability of observing the obtained difference between the means or a more extreme difference, assuming that the null hypothesis (no difference between the means in the treatment and control) is true. In this case, the p-value is 0.360, which is greater than the assumed significance level of 0.05. Therefore, the difference between the means is not statistically significant. Based on the t-value of 1.033 which does not reach statistical significance (p = 0.360), suggesting that there was insufficient evidence to reject the null hypothesis. This means that the observed difference between the means of potassium in treatment and control sample was likely due to chance, rather than a true difference between the paired samples.

pH

Findings from the paired sample test p-value associated with pH was 0.663. This value indicates the probability of observing the obtained difference between the means or a more extremedifference, assuming that the null hypothesis (no difference between the mean in the control and experiment) is true. In this case, the p-value is 0.663, which is greater than 0.05. Therefore, the difference between the means is not statistically significant.

Based on the t-value of -0.470 much as it does not reach statistical significance (p = 0.663), it suggests that there was insufficient evidence to reject the null hypothesis. This means that the observed difference between the means in pH in the control and treatment sample was different between the paired samples. Additionally, since the t-value is negative, it indicates that the mean of the “control” was smaller than the mean in the treatment (Vermicompost), although this difference is not statistically significant.

Phosphorus (P)

The t-value of phosphorus was 1.062. This value measures the magnitude of the difference between the means of the paired samples relative to the variability within the sample.

The p-value associated with the test statistic is 0.348. This value indicates the probability of observing the obtained difference between the means or a more extreme difference, assuming thatthe null hypothesis (no difference between the mean in the experiment and control) was true. In this case, the p-value is 0.348, which is greater than 0.05. Therefore, the difference between the "P" means in the treatment and the control sample was not statistically significant.

Based on the provided information, the t-value of 1.062 does not reach statistical significance (p = 0.348), suggesting that there was insufficient evidence to reject the null hypothesis. This means that the observed difference between the means of phosphorus (in treatment and control sample) was likely due to chance, rather than a true difference between the paired samples.

Moisture Content (MC)

The p-value associated with MC was 0.202. This value indicates the probability of observing the obtained difference between the means or a more extreme difference, assuming that the null hypothesis (no difference between the means experiments and control) was true. In this case, the p-value is 0.202, which was greater than 0.05. Therefore, the difference between the means was not statistically significant.

Based on the provided information, the t-value of -1.526 does not reach statistical significance (p=0.202), suggesting that there was insufficient evidence to reject the null hypothesis. This means that the observed difference between the MC in the experiment and the control was the difference between the paired samples. Additionally, since the t-value was negative, it indicates that the mean of the control was smaller than the mean of the treatment, although this difference is not statistically significant, there is observed higher MC in the experiment than in the control. Thus, MC was higher in the treatment sample as compared to the control.

Organic Matter (OM)

The p-value associated with OM was 0.823. This value indicates the probability of observing the obtained difference between the means or a more extreme difference, assuming that the null hypothesis (no difference between the means) was true. In this case, the p-value was 0.823, whichwas greater than 0.05. Therefore, the difference between the means was not statistically significant.

Based on the provided information, the t-value of -0.239 does not reach statistical significance (p = 0.823), suggesting that there was insufficient evidence to reject the null hypothesis. This means that there was an observed difference between the means in the treatment and control samples. Additionally, since the t-value is negative, it indicates that the mean of the control was smaller than the mean of the treatment, suggesting a higher OM content in the treatment.

Organic Carbon (OC)

The p-value associated with OC was 0.821. This value indicates the probability of observing the obtained difference between the means or a more extreme difference, assuming that the null hypothesis (no difference between the two means in the experiment and control) was true. In this case, the p-value is 0.821, which was greater than 0.05. Indicates that the difference between the means is not statistically significant.

Based on the t-value of -0.241 does not reach statistical significance (p = 0.821), suggesting that there was insufficient evidence to reject the null hypothesis. This means that the observed difference between the means in the experiment and the control was likely due to chance, rather than a true difference between the paired samples. Additionally, since the t-value was negative, it indicates that the mean in the control sample was higher in the treatment sample.

Nitrogen (N)

The p-value associated with the test statistic above is 0.161. This value indicates the probability of observing the obtained difference between the means or a more extreme difference, assuming that the null hypothesis (no difference between the means in the experiment and control samples) is true. In this case, the p-value was 0.161, which is greater than 0.05. Therefore, the difference between the means is not statistically significant.

Based on results of the t-value of -1.715 which does not reach statistical significance ($p = 0.161$), suggesting that there was insufficient evidence to reject the null hypothesis. This means that the observed difference between the means in the experiment and the control sample was also likely due to chance, rather than a true difference between the paired samples. Additionally, since the t- value is negative, it indicates that the mean of Nitrogen the control sample variable is higher in treatment than in control sample.

While the change was relatively lower, comparison to the treatment sample, it holds the potential to influence the physical properties and stability of the substance. In contrast, the control sample exhibited only a marginal shift of 0.9% in nitrogen levels. This subtle modification indicates a relatively consistent nitrogen content within the control sample when contrasted with the treatment sample.

Table 4.11: Mean averages of the nutrient composition of the results from the lab tests

Sampling Time	Sample	pH	O.M (%)	N (%)	P (%)	K (%)	MC (%)	O.C (%)
Period 1	Control	10.05±0.3	26.46±6.21	0.70±0.17	0.75±0.06	2.80±0.2	50.45±1.34	76.75±3.60
	Treatment	9.96±0.25	24.53±4.1	0.62±0.02	0.74±0.05	2.48±0	54.45±7.29	71.14±2.42
Period 2	Control	10.20±0.17	20.91±6.89	0.87±0.01	1.99±0.31	0.99±0.3	73.11±5.19	60.65±3.99
	Treatment	9.95±0.27	18.85±6.77	0.78±0.08	2.19±0.57	0.81±0.2	70.70±6.02	54.66±3.92
Period 3	Control	10.16±0.19	18.57±3.01	0.53±0.02	2.02±0.07	2.24±0.8	66.37±2.66	32.32±1.74
	Treatment	10.44±0.16	19.26±2.96	0.59±0.06	1.95±0.07	3.56±0.7	62.80±2.09	55.86±1.71
Period 4	Control	10.36±0.36	15.87±4.81	1.08±0.13	2.37±0.39	4.80±0.6	60.72±6.09	46.04±2.79
	Treatment	10.33±0.22	17.75±3.96	0.99±0.15	2.76±0.33	5.08±1	57.36±4.98	51.48±2.31

Table 4.12: Composition in a paired Sample Test

Paired Samples Test

Experiment – Control	Paired Differences		T	Sig. (2-tailed)
	Mean	Std. Dev		
Potassium (K)	.222	.481	1.033	.360
pH	.034	.161	-.470	.663
phosphorus (P)	.128	.270	1.062	.348
moisture content (MC)	-1.555	1.0195	-1.526	.202
Organic Matter	-.254	2.381	-.239	.823
Organic Carbon (OC)	-.149	1.382	-.241	.821
Nitrogen (N	-.0477	.062	-1.715	.161

4.6.1 Efficiency in the decomposition

A remarkable transformation in the decomposition over the course of three months was observed and noted. There was a noticeable surge in the population of earthworms, a testament to the thriving ecosystem within the treatment area. Observation unveiled a striking disparity in the composition of waste between the treatment group (Figure 4.4 Right) and the control sample (Figure 4.4 Left). In the treatment area, the organic waste exhibited a remarkable breakdown into finely granulated particles, a stark contrast to the control samples where substantial portions of waste remained intact after the same period.

As the three-month mark approached, the control samples still retained visible traces of unprocessed organic matter. In contrast, the treatment area displayed a thorough decomposition of organic materials, highlighting the efficacy of the earthworms in accelerating the breakdown of these substances. This compelling evidence underscores the significance of the earthworm in treatment in fostering the efficient decomposition of organic waste.

Figure 4.5 : Decomposed soil Source: Field 2023

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.0 Introduction

This chapter highlights a comprehensive exploration and analysis of the outcomes derived from the study. It aims to present a thorough examination of the data collected, drawing meaningful conclusions and implications of the study.

The response rate to initiatives in terms of waste management in Kasokoso slum is influenced by various demographic factors. The education level of the household head, for instance, often correlates with greater awareness and participation in waste management programs (Bhawal *et al*., 2016). Typically, households with higher educational attainment are more likely to understand the importance of such initiatives and thus participate more actively. Conversely, lower levels of education result in a lack of understanding or awareness, leading to lower response rates (Debrah *et al.,* 2021)

Sex and gender dynamics also play a crucial role. In many communities, women are often the primary managers of household waste, yet their input may be undervalued in the planning and implementation of waste management strategies. Ensuring that women's perspectives are included leads to more effective and inclusive waste management solutions (McAllister, 2015).

Ownership of the house is another critical factor. Tenants may feel less responsibility or ability to make long-term investments in waste management compared to homeowners who have a vested interest in maintaining property values (Palmer *et al*., 2015). Similarly, the household income level significantly impacts the ability to participate in waste management. Higher-income households have more resources to invest in solutions like recycling systems or waste removal services, while lower-income households may prioritize immediate needs over waste management (Zohoori and Ghani, 2017; Manga *et al*., 2019). House ownership status ties into the long-term engagement with waste management practices. Homeowners are more inclined to engage in sustainable practices that contribute to the overall well-being of the community, while renters may have a more transient relationship with their living spaces, potentially leading to less engagement with long-term waste management practices.

5.1 Waste handling practices used in Kasokoso slum area

The majority (93.6%) of the waste produced in Kasokoso was biodegradable, such as leftover meals. The biodegradable wastes were dumped in open areas, which can lead to nauces such bad odors and the development of vermin and insect vectors that threaten the environment and the health of slum people (Guerrero *et al*., 2013; Satterthwaite, 2016). In Uganda, the majority of the municipal garbage collected by local authorities is made up of biodegradable wastes (Mukama *et al*., 2016; Nyakaana, 1997). Because so many wastes are biodegradable, there is a chance to recover trash through separation and composting, as well as an option to lessen waste quantities and the strain on garbage collection and disposal services (Ravichandran & Venkatesan, 2021). Similar to trends reported by the United Nations (2014), which observed that most of the waste in Kampala was indiscriminately disposed leading toenvironmental and public health issues, including blockage of drainage channels and subsequent flash floods.

Despite the fact that most respondents recycled plastics on a regular basis, most of them ended up burning them in open pits and disposing of them at open dumping sites. Reusing plastics to carry and cover food is most likely to expose slum dwellers to more phthalates, which have been shown to have negative effects on fertility via affecting the reproductive system (Latini *et al*., 2006). Burning plastics can also expose locals to carcinogenic chlorinated organic chemicals like dioxins (Velis & Cook, 2021) which is why it should be prohibited. Burning is the common waste disposal method in Kasokoso practiced by most people. This is because it is cheaper and easy to manage as compared to other methods, of households indicating its use. However, burning waste can have detrimental effects on the environment and human health because it releases toxins and pollutants.

These poor solid waste management methods contribute to the pollution of water and soil, leading to the spread of diarrheal diseases. Similar findings were reported by Ssemugabo *et al*., (2020) in their study, they noted that only 41.3% of households residing in a slum community in Kampala actively engaged in proper waste management practices. This statistic underscores the challenges and deficiencies in waste management and hygiene issues within such settings. The study conducted by Ssemugabo and colleagues shed light on the pressing need for improved waste management strategies and infrastructure in slum communities, emphasizing the importance of addressing this issue to promote public health and environmental sustainability.

The results thus point to the need for an integrated approach to waste management that addresses waste generation, disposal methods, infrastructure, behaviour change, and the roles of both formal and informal waste management networks. By implementing a combination of policies and interventions, the aim is to promote sustainable waste management practices, reduce environmental impacts, and improve public health in the affected area.

5.2 Challenges faced in waste disposal

Results revealed that the major challenges in waste disposal and management in Kasokoso Village included: Poor sanitation of the surroundings. The village suffers from inadequate sanitation practices, such as open dumping and littering. This leads to the accumulation of waste in public spaces, streets, and residential areas, creating an unhygienic environment and posing health risks to the residents. Poor waste disposal attracts pests like rodents, flies, and mosquitoes, which can transmit diseases such as cholera, bilharzia, and their infections. It was observed by Zohoori & Ghani, (2017) that economically disadvantaged developing nations are grappling with the 'dual challenge' of the interconnected impact of lifestyle diseases and infectious illnesses because of inadequate waste management structures. The lack of clean water sources and proper sanitation facilities further increases the vulnerability of residents to waterborne diseases. Ike *et al*. (2018) discovered that dealing with organic waste presented additional challenges in disposal. These challenges encompassed the absence of a proper waste management database, inadequate financial resources, failure to adhere to legal regulations, and a lack of awareness concerning the healthhazards associated with poor sanitation practices.

Similar findings were reported by the UN (2014) indicating 53.6% of 1,619,900 people residing in Kampala live in overcrowded and informal slum settlements, often located in low-lying areas and wetlands practicing poor waste management practices and were prone to waterborne diseases (United Nations, 2014).

The absence of a proper waste management system and limited financial resources make waste collection and transportation costly (Aryampa, *et al*, 2019). As a result, waste may not be collected regularly, leading to further accumulation and deterioration of the waste management situation: Flooding due to disposal in water channels Waste disposal in water channels causes blockage, leading to stagnant water and an increased risk of flooding during heavy rains. According to Mensah (2024), Flash floods due to blockage of water channels by waste resulted in the deaths of eight individuals in low-lying slum communities on the outskirts of Kampala. This disruption in the natural drainage system contributes to the spreadof waterborne diseases and causes environmental degradation.

The challenges associated with waste disposal have garnered significant attention in recent scholarly discourse, particularly as urbanization and population growth exacerbate existing issues within waste management systems. The studies reveal a complex interplay of factors influencing effective solid waste management (SWM), with a particular emphasis on the sociocultural dynamics and infrastructural limitations that characterize various regions.

Suardi *et al*. (2018) highlight the intricate relationships between community behavior and waste management practices. They argue that effective waste management is contingent upon public involvement and communication, which can facilitate a better understanding of community concerns regarding SWM facilities. It contends that while organized waste management has evolved significantly since its inception, contemporary challenges such as pollution from improperly disposed wastes and the scarcity of dumping sites necessitate a more integrated approach to waste management. This integration includes not only prevention and collection strategies but also the need for individuals to actively participate in waste separation efforts.

This is in line with Ferronato & Torretta (2019) who state the global implications of solid waste mismanagement, particularly in developing countries. They assert that uncontrolled waste disposal leads to severe environmental consequences, including heavy metal pollution and health risks associated with waste picking in open dump sites. Their analysis underscores the urgency of adopting holistic approaches to address these issues, emphasizing the need for context-appropriate solutions that align with global waste management goals. Despite the potential for innovative strategies such as waste-to-energy programs and the integration of informal waste pickers.

In the context of Liberia, (David *et al*., 2020) provide a critical examination of the country's municipal solid waste management systems, revealing a landscape fraught with challenges. The lack of knowledge, inadequate resources, and institutional failures as key contributors to the increasing trend of indiscriminate waste dumping. They note that the legacy of civil conflict has severely impacted infrastructure, leading to deteriorating facilities and ineffective waste management practices.

5.3 Efficiency in the decomposition

Figure 3.3a corresponds to the control group, while Figure 3.3b represents the treatment group. A notable discrepancy in waste composition became evident upon close observation between these two groups. Within the treatment area, there was a remarkable transformation as the organic waste underwent a profound breakdown into finely granulated particles. This starkly contrasted with the control samples, where substantial portions of waste remained unaltered even after the same duration of observation. Remarkably, as the three-month milestone approached, the control samples still bore visible traces of unprocessed organic matter. In sharp contrast, the treatment area displayed a thorough decomposition of organic materials. This compelling evidence serves as a testament to the efficacy of the experimental process in accelerating the breakdown of these substances. Moreover, it underscores the critical role played by earthworms in promoting efficient organic waste decomposition, as also noted by Sinha *et al*. (2010).

The contributions of earthworms within this context are noteworthy. They act as invaluable biotic agents, serving as aerators, grinders, and sinks in the decomposition process. They actively participate in altering the composition of harmful compounds and modifying the biological and physical characteristics of the original materials. Such interactions, as identified by Aira *et al.* (2008), encompass a spectrum of both positive and negative biotic relationships, including competition,mutualism, and facilitation, all of which contribute to the formation of a valuable organic material known as vermicompost. Predicting the degradation rate of this organic matter can be challenging due to the intricate interplay between various microorganisms, as also highlighted by Warman and Anglopez (2010). The efficiency of waste breakdown is directly related to the collaborative efforts of earthworms and microorganisms. As posited by Edwards *et al*., (2011), the quality of vermicompost is intricately tied to diverse parameters, encompassing its composition, physical attributes, and chemical makeup. This includes the relative proportions of solid and liquid components, the nutrient content essential for plant growth, and the intricate communities of bacteria and fungi. It is important to note that the quality of the final product can vary significantly depending on the raw materials employed in the process. The integrated efforts of earthworms and microorganisms in organic waste decomposition notonly yield observable benefits but also contribute to the production of high-quality vermicompost.

5.4 Efficiency of vermicomposting of biodegradable waste and quality of vermicompost produced

Results of the study revealed that there were higher nutrients in the treatment sample (vermicompost) as compared to the control sample as shown in Table 4.11. Similar observations were made by Iqbal *et al.,* (2024) observed that vermicompost is a mulch-related organic matter and tends to increase the utmost minerals and soil nutrients, especially pH, nitrogen, and organic carbon.

El-Haddad *et al*. (2014), noted that, potassium, phosphorus, and the Nitrogen content of vermicompost improved by only 2.4%. Pramanik *et al*. (2007), also noted that the use of lime can increase the nutrient content of vermicompost, different materials have varying degradation rates. For instance, while carbohydrates and proteins can be easily broken down, cellulose requires a longer time to decompose (Warman and Anglopez, 2010). Gomez-Brandon and Dominguez, (2014), also observed that although the activities of microorganisms can aid the decomposition process, competition may also occur between the organic materials producedby mineralization. The reason for this was that the nutrients came from different organic wastes, including grass,cow manure, and municipal solid waste. In the study of Fernandez-Gomez *et al*. (2011), the findings of the tests showed that the quality of the finished vermicompost can be impacted by the inclusion of various modifications to the raw materials used in its production. The study also indicated that the quality of vermicompost produced from different wastes can vary due to the presence of different microorganisms. Despite the positive effects of certain microorganisms like earthworms on the quality of vermicompost, it is still not clear if the diversity of the microorganisms in the cast earthworms' gut microbiota is beneficial for the development of the product. In addition, during the process of vermicomposting, the animals can accumulate various metals in their intestines. A study by Monroy *et al*., (2009) revealed that the reduction in the number of human pathogens in pig slurry after it was processed usingthe cast earthworms' gut microbiota had been beneficial. It is thus clear that although earthworms increase the quality of soil nutrients through vermicomposting, their effectiveness is still statistically insignificant. Therefore, it is evident that earthworms can enhance soil nutrient quality but it’s not clear on the influence of earthworms on the effectiveness during vermicomposting.

The efficiency of vermicomposting as a method for managing biodegradable waste and the quality of the vermicompost produced has garnered significant attention in recent years, reflecting its potential as an environmentally friendly alternative to traditional composting methods. A study by Pathma & Sakthivel (2012), highlights the unique characteristics of vermicomposting, defining it as a non-thermophilic biological oxidation process that transforms organic materials into a high-quality peat-like material known as vermicompost. Their findings emphasize the role of earthworms in enhancing microbial activity and biodegradation potential, noting that vermicomposting can accelerate the decomposition process by 2 to 5 times compared to conventional composting methods. The authors further differentiate the microbial communities present in vermicomposts from those in traditional composts, suggesting that the distinct microbial processes associated with vermicomposting contribute to the production of more homogenous materials.

Building on this foundation, Noor Zalina, (2017) research explores the potential of vermicomposting to transform urban biodegradable wastes into pathogen-free biofertilizers. This study underscores the versatility of vermicomposting, demonstrating its effectiveness in processing various waste materials, including kitchen waste. This study also illustrates the dual benefit of vermicomposting: not only does it mitigate the risks associated with biohazardous waste, but it also yields a nutrient-rich product that can enhance agricultural productivity. Further expanding the discourse, the 2018 study by Cai *et al*. (2018) compares the chemical and microbiological changes occurring during aerobic composting and vermicomposting of green waste. Their findings reinforce the notion that vermicomposting is a rapid, energy-efficient, and cost-effective method for waste disposal, particularly for urban green waste. The study highlights the critical role of fungi in breaking down lignocellulosic materials, while also noting the complex interplay between earthworms and microbial communities. The authors suggest that, despite a reduction in microbial numbers, the diversity of microbial communities increases as materials pass through the earthworm intestinal tract, indicating a dynamic transformation process that merits further investigation (Cai *et al*., 2018).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Waste Handling Practices

Results show that household waste generation is primarily focused on kitchen refuse, with varying levels of plastic, glass, and animal waste. The disposal methods commonly employed include burning, dumping, waste pits, and open dumping, which pose environmental and health risks. However, there is a notable presence of informal waste management networks, with local individuals and collectors playing a crucial role. While formal waste management services exist, their utilization is limited by cost or accessibility constraints.

6.1.2 Challenges Faced in Waste Disposal

The lack of a proper waste management system and limited financial resources make waste collection and transportation expensive and challenging, resulting in irregular waste collection and exacerbating the waste management situation.

6.1.3 Quality of vermicompost for the nutrient status

The statistical analysis conducted indicates that there was no significant difference in soil nutrient levels between the treatment sample and the control sample. However, there was a trend of increasing levels of nitrogen (N), organic carbon (OC), organic matter (OM), moisture content (MC), and pH. Notably, these nutrients were observed to be higher in the treatment sample with earthworms compared to the control sample without earthworms indicating a visible disease, causing environmental degradation.

6.2 Recommendation for the Community

The recommendations aim to promote sustainable waste management practices, improve environmental and public health conditions, and address the observed limitations and challenges.

Implement Sustainable Waste Management Practices; The Municipality should encourage and promote environmentally friendly waste handling methods like recycling. This is to reduce the amount of waste that ends up in landfills or open dumping sites and establish a community-based composting program to process organic waste, such as kitchen refuse and animal waste, into nutrient-rich vermicompost that can be used to enrich agricultural soils and reduce the need for chemical fertilizers. This leads to smart gardens nurtured to produce organic vegetables for consumption.

Enhance Informal Waste Management Networks; Recognize the importance of local individuals and collectors who are involved in informal waste management and engage them as valuable stakeholders in the formal waste management system. Provide training andsupport to these informal waste collectors to improve their waste sorting and recyclingpractices, ensuring a more efficient and sustainable waste management process.

Strengthen Formal Waste Management Services; Invest in expanding formal waste management services in Kasokoso Village to cover more areas and increase accessibility for residents. Explore options for cost-effective waste collection and transportation methods, such as using eco-friendly vehicles or collaborating with nearby communities to share waste management resources.

Public Awareness and Education; Conduct educational campaigns and workshops to raise awareness among residents about the importance of proper waste disposal, recycling, and composting. Highlight the environmental and health risks associated with improper waste management and the benefits of adopting sustainable waste practices.

Community Participation and Governance; involve the community in decision-making processes related to waste management and seek their input on potential solutions and improvements. Collaborate with local authorities and stakeholders to develop and enforce waste management regulations and policies that align with sustainable practices.

6.3 Recommendation for future research

Assessment of the Environmental and Health Impacts of Waste Disposal Methods. Conduct a detailed environmental and health impact assessment of the different waste disposal methods used in Kasokoso Village, including burning, dumping, waste pits, and open dumping. Compare the risks associated with each method and propose safer and more sustainable alternatives.

Evaluation of Sustainable Waste Management Interventions. Implement and assess the effectiveness of various sustainable waste management interventions in the village, such as recycling programs, composting initiatives, and waste separation at the source. Measure their impact on waste reduction, soil quality, and public health.

Long-Term Monitoring of Vermicomposting Effects on Soil Health. Conduct long-termstudies to monitor the effects of vermicompost application on soil nutrient levels and overall soil health. Assess the sustainability and benefits of vermicomposting as an organic alternative to chemical fertilizers for agricultural practices.

Comparative Studies with Other Similar Communities. Conduct comparative studies with other communities facing similar waste management challenges to identify best practices, transferable solutions, and potential policy recommendations.

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Appendices

Appendix I : Tables

Table showing Lab Results for the treatment sample

V1	(K)	pH	P	MC	OM	OC	N
Box1 12th Nov 2022	2.501	9.86	0.7144	57.46	29.05000	16.848	0.64000
Box2 12th Nov 2022	2.542	9.59	0.7384	46.62	22.59000	13.104	0.60000
Box3 12th Nov 2022	2.460	10.25	0.6941	46.60	29.05000	16.848	0.63000
Box4 12th Nov 2022	2.419	9.95	0.8196	60.30	20.98000	12.168	0.61000
Box5 12th Nov 2022	2.460	10.13	0.7162	61.28	20.98000	12.168	0.63000
Box1 12th Dec 2022	0.558	10.10	1.7792	69.17	24.76354	14.360	0.81300
Box2 12th Dec 2022	0.651	10.10	1.9424	61.90	26.13929	15.160	0.88700
Box3 12th Dec 2022	1.023	9.97	1.9392	76.95	19.26053	11.170	0.77800
Box4 12th Dec 2022	0.775	10.11	2.0992	69.77	13.06964	7.580	0.70200
Box5 12th Dec 2022	1.054	9.49	3.1808	75.72	11.00602	6.380	0.71400
Box1 12th Jan 2023	3.224	10.43	2.0208	59.70	23.39000	13.570	0.55800
Box2 12th Jan 2023	2.604	10.31	1.9328	62.70	18.57000	10.770	0.54500
Box3 12th Jan 2023	4.092	10.68	1.9088	65.30	19.95000	11.570	0.60000
Box4 12th Jan 2023	4.216	10.29	2.0336	64.00	15.13000	8.780	0.69500
Box5 12th Jan 2023	3.658	10.51	1.8768	62.30	19.26000	11.170	0.54400
Box1 12th Feb 2023	4.182	10.05	2.7390	63.30	11.95000	6.930	0.95598
Box2 12th Feb 2023	5.202	10.51	3.1970	61.37	20.48000	11.880	1.21260
Box3 12th Feb 2023	6.324	10.54	2.3780	54.86	22.19000	12.870	0.90710

Box4 12th Feb 2023	5.763	10.13	2.9790	56.28	17.92000	10.395	1.05750
Box5 12th Feb 2023	3.927	10.40	2.5150	51.00	16.21000	9.405	0.82062

Table showing lab result for the control sample

V1	K	Ph	P	MC	OM	OC	N
Box6 12th Nov 2022	3.034	9.80	0.8270	50.25	18.560000	10.764	0.76000
Box7 12th Nov 2022	2.583	9.75	0.7310	52.33	20.980000	12.168	0.61000
Box8 12th Nov 2022	3.034	10.20	0.7809	49.23	31.470000	18.252	0.97000
Box9 12th Nov 2022	2.829	10.03	0.6941	49.21	29.850000	17.316	0.53000
Box10 12th Nov 2022	2.542	10.48	0.6959	51.22	31.470000	18.252	0.64000
Box6 12th Dec 2022	1.426	9.99	2.5088	68.65	26.827160	15.560	0.86900
Box7 12th Dec 2022	0.620	10.09	1.8944	66.65	24.763540	14.360	0.85500
Box8 12th Dec 2022	1.240	10.20	1.8672	75.88	19.260530	11.170	0.87300
Box9 12th Dec 2022	0.713	10.42	2.0112	75.58	9.630264	5.590	0.86300
Box10 12th Dec 2022	0.961	10.32	1.6832	78.79	24.075660	13.970	0.88400
Box6 12th Jan 2023	2.635	10.28	2.0992	66.80	19.950000	11.570	0.50800
Box7 12th Jan 2023	2.821	10.25	1.9600	70.40	15.130000	8.780	0.52200
Box8 12th Jan 2023	1.271	9.94	1.9872	61.90	20.640000	11.970	0.55200
Box9 12th Jan 2023	2.635	10.28	2.0992	66.80	19.950000	11.570	0.50800
Box10 12th Jan 2023	2.821	10.25	1.9600	70.40	15.130000	8.780	0.52200
Box6 12th Feb 2023	4.080	10.32	2.5210	69.67	21.330000	12.375	1.00110
Box7 12th Feb 2023	5.661	10.58	2.8160	63.69	20.480000	11.880	1.07066

Box8 12th Feb 2023	4.692	10.49	2.3360	59.22	13.650000	7.920	0.98512
Box9 12th Feb 2023	4.896	9.76	2.4080	54.26	10.240000	5.940	1.31130
Box10 12th Feb 2023	4.692	10.65	1.7540	56.77	13.650000	7.920	1.02084

APPENDIX II: QUESTIONNAIRE

Good morning/afternoon. My name is Atuhaire Marvis**,** a student at Kyambogo University. I am conducting academic research on Assessing production of Vermicompost of Biodegradable Domestic Waste in Kasokoso. This research will help expand knowledge on domestic waste management.

If you would like to participate in this study, I will ask you some questions regarding waste handling & disposal. This survey will take about 10-15 minutes. By participating in this study, you will make a contribution on having the waste management methods documented. Your name will not appear anywhere. The information you provide will be confidential and will only be used for this study.

Thank you for your time and cooperation. I appreciate your assistance in supporting this effort to complete this research study.

Do you agree to participate in the survey? YES NO CONTACT: ……………………….
Household Name: ……………………………..

Section A: Identification Particulars			
A1. District:	**A2: Parish:**	A3. Village:	
A4. HH Head's		A5: Phone contact:	
A10. Respondent's		A11. Respondent's	
A12. Sex of	1. Male 2.	A13. Respondent's	
A.14 Relationship to HH Head	1. Head 2. Spouse	5. Parent to the head/spouse 6. Sister to HH Head	
A17.Starting Time **(***24 Hr*		A18. Date	
SECTION B- SOCIAL ECONOMIC DATA			
What is the sex of the HH head?	Male	1	
	Female	2	

What is the age of the HH head?	In complete Years	
What is the marital status of HH head?	Married /cohabiting	1
	Divorced/separated	2
	Widow /widower	3
	Single	4
What is the religion of the HH head?	Catholic	1
	Anglican	2
	Muslim	3
	Pentecostal	4
	Seventh day Adventist	5
	Others (specify)	6
Can the HH Head read or write in any language?	Yes	1
	No	2
How many people usually live in this household?	…………………………………………………	
What is the highest level of education attained by the HH head?	Never went to school	1
	Never completed P.7	2
	Completed P.7	3
	Completed O' level	4
	Never completed O' Level	5
	Completed A' level	6
	Never completed A' level	7
	Certificate	8

	Diploma	9
	Degree	10
	Don’t know	11
What is the HH head’s Employment status?	Employer	1
	Self employed	2
	Government employee	3
	Privately employed	4
	Unpaid family worker	5
	Does not have a job	6
	Full time student	7
	Too old to work	8
	Other (specify):	9

What are the sources and monthly incomes for your household?	Sources, B8.1	Code	Income, B8.2	Code
	Farming	1	Less than Shs 100,000	1
	Government or private sector monthly salary	2	Shs 100,000-299,000	2
	Enterprise or business	3	Shs 300,000-499,000	3
	Mining	4	Shs 500,000-699,000	4
	Service job	5	Shs 700,000-899,000	5
	Par-time work	6	Shs 900,000 and above	6
	Fishing	7	Does not know	7

			income	
	Others (specify): ………………….	8	Not willing to mention income	8

Add observation questionsE.g.

What is the household structure type**?(***observe, do not ask***)**	Temporally		1
	Semi-permanent		2
	Permanent		3
Does your household own or rent this dwelling/building?	Own		1
	Don't own but live for free		2
	Rent		3
How much do you pay per month for rent?		UGX/month	
How many rooms does your household occupy? (*exclude kitchen*)		Rooms	
What is the type of house floor? *(observe, do not ask)*	Mud floor		1
	Cemented floor		2
	Tiled floor		3
	Other (specify)		4
What is the type of house roofing *(observe, do not ask)*	Grass thatched		1
	Iron sheets		2
	Tiles		3
	Other		4

	(specify):	
Does the household have a toilet (you can ask or observe)	1. Own toilet 2. shared toilet	

1. Gender; Male (1) Female(2)

2.Marital Status; Married (1) Single (2) Divorced (3) Separated(4) Widow(5) 3.Household size;………………………….

4.Age;……………………….

5.Religion: Christianity (1) Islam (2) Traditional (3) Others--------------------

6.Education Level; No Formal Education (1) Primary(2) Secondary(3) Vocational (4) Post-Secondary(5)

7. What do you do for a living?

8. Level of Income;

1. Below 100,000 2. 200001 – 5000003. 500001 – 800000 4. 800001 – 1000001 5.Above 1000001

PART 2: Waste handling Questions

1. What kind of Waste do you generate?

Kitchen Refuse(1) Plastics(2) Glass(3) Animal Waste(4) Others--------------------

2. Do you sort out the solid waste generated in this household before you dispose it off?Yes (1) No (2)

3. How long does the waste generated stay before disposal? Daily (1) Twice a week (2) Weekly(3) No clear trend (4)4 How do you dispose off your waste?

1. Burying

2. Burning
3. Taking to designated dumping area within the settlement
4. Throwing away in open spaces
5. Waste pit
6. Others (specify)

5.Who disposes off the waste in the household?

Adult Male(1) Adult Female(2) Young Male(3) Young Female(4) Have you participated in any initiatives of recycling or reusing waste?

Do you use services of any solid waste collection providers?6 If yes, to QN above, who collects your waste?

1. Private firm
2. Local waste picker
3. Division waste picking department
4. Others (specify)

Do you pay for the services of waste collection? 1. Yes 2. No

7. If Yes, how much do you spend on waste collection averagely in a month?

…………………………………………………………..

Do you have an idea where the waste collector (if private) dumps the waste or disposes it?

8. How satisfied are you regarding waste management in this community? Very Satisfied(1) Satisfied(2) Dissatisfied(3) Very Dissatisfies(4)

Have there been community efforts to clean up or collectively handle waste in your locality? 9.What Challenges are faced regarding waste disposal/management?

What could be the solutions to the challenges mentioned aboveNotes and observation:

End time: **(***24 Hr Format***)**		Date