Determining the perceptions influencing solid waste management in Mahikeng, South Africa

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Dissertation submitted in fulfilment of the requirements for the degree of Master of Science in Environmental Sciences at the North-West University

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Graduation: October 2025

Declaration

I declare that the work presented in this dissertation "Determining the perceptions influencing solid waste management in Mahikeng, South Africa" is my own, except where explicitly acknowledged and referenced. This dissertation has not been submitted previously for any degree or qualification at any other institution.

I confirm that all sources used have been properly cited and referenced. I understand that any form of plagiarism or academic misconduct will be subject to disciplinary action.

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This thesis has been submitted with my approval as a university supervisors, and I hereby certify that the requirements for the degree of Master of Science in Environmental Sciences have been fulfilled.

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Dr S.C. NED

Dedication

I dedicate my work to my family and friends.

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Abbreviation and Acronyms

Chronic obstructive pulmonary disease (COPD)

Environmental Conservation Act (ECA)

Expanded public works programme (EPWP)

Extended Producer Responsibility (EPR)

Geographic Information System (GIS)

Global Positioning System (GPS)

Household Solid Waste (HSW)

Mahikeng Local Municipality (MLM)

Municipal solid waste management (MSWM)

Municipal household solid waste (MHSW)

Municipal solid waste (MSW)

National Environmental Management Act (NEMA)

National Environmental Management Waste Act (NEMWA)

North-West University (NWU)

Personal protective equipment (PPE)

Presidential employment stimulus (PES)

Reduce, reuse, and recycle (3Rs)

Solid waste management (SWM)

Sub-Saharan Africa (SSA)

Sustainable development goal (SDG)

Statistical package for social sciences (SPSS)

The Mahikeng City Council (MCC)

Theory of planned behaviour (TPB)

Tuberculosis (TB)

United Nations (UN)

Waste management hierarchy (WMH)

ACKNOWLEDGEMENTS

I would like to thank God for giving me the strength to complete this dissertation and express my deepest gratitude to my supervisor, Dr Sammy Bett and co-supervisor, Dr Samuel Nde, whose expertise, patience, and encouragement have been invaluable throughout this research.

I am especially grateful to Mr ND Makgala, my family and friends for their constant encouragement and understanding. Their support has been a great source of strength and motivation.

Finally, I would like to thank the community of Mmabatho and the Mahikeng Local Municipality and everyone who has contributed in various ways to the completion of this dissertation.

Abstract

This study investigated how perceptions of the Mmabatho residents influence household solid waste management in Mahikeng, South Africa. As urbanization and population expansion accelerate, proper waste management becomes more critical to public health and environmental sustainability.

Household solid waste illegal dumping is still a serious problem for the environment and public health, and it is frequently made worse by attitudes that affect how people dispose of their waste. This study investigated how the occurrence of unlawful dumping is influenced by people's views on waste management systems, environmental responsibility, and local governance. Despite current waste management regulations, households may turn to unlawful dumping due to several reasons, including poor waste infrastructure, a perception of inadequate enforcement, restricted access to suitable disposal facilities, and a lack of environmental knowledge. People frequently dispose of rubbish unlawfully due to public attitudes regarding waste, the expense or inconvenience of formal waste collection, and a general lack of trust in municipal waste management systems. This undermines attempts to keep urban surroundings clean and sustainable. Along with the influence of media, education, and community involvement in changing behaviours, the significance of cultural, socioeconomic, and psychological elements in forming these perspectives was examined. To decrease unlawful dumping, the study went on to highlight the significance of changing these beliefs through improved waste management infrastructure, public awareness initiatives, and legislation changes. Illegal dumping may be reduced, and communities can become more sustainable and climate-resilient by changing public attitudes and offering easily accessible and efficient trash disposal choices.

Using a mixed-methods approach, this study investigated the attitudes, beliefs, and actions of people, local governments, and waste management experts toward garbage disposal, recycling, and sanitation services. The questionnaire revealed a range of perceptions influenced by socioeconomic status, educational background, and awareness of environmental concerns. The findings showed that, while waste management is widely recognized as important, knowledge gaps, inadequate infrastructure, and limited community engagement, offer substantial problems. The study emphasizes the importance of focused educational efforts, improved waste management systems, and increased community involvement in improving the Mahikeng's waste management practices. These findings offer useful recommendations for policymakers

and practitioners seeking to promote sustainable waste management solutions in similar metropolitan settings.

Keywords: Perceptions, illegal dumping, household solid waste management, waste disposal behaviours, environmental responsibility, public health, waste infrastructure, community engagement.

Chapter 1
Introduction

1.1 Background to the study

Municipal household solid waste management (MSWM) is a global challenge, particularly in developing countries due to growing demographics, evolving lifestyles, rising living standards and increasing waste generation (Khan et al., 2022; Kumar and Agrawal, 2020; Han et al., 2018a). The situation is further compounded by rapidly increasing townships and urban areas, contributing enormously to municipal household solid generation. The United Nations (UN) projects that by the year 2050, over 70% of the world population will live in developing countries especially urban areas, signifying a direct proportional relationship between waste generation and population growth (O'Sullivan, 2023). Similarly, Wang et al. (2018) is of the view that the volume of household solid waste in developing countries will increase with future economic expansion and consumption capacity. This might likely lead to waste generation beyond the handling capacities of waste management authorities coupled with inadequate waste disposal technologies and procedures (Chowdhury and Afza, 2006).

MHSW sometimes referred to as trash or garbage emanated from households, is a type of waste that is generated by the public in various communities and is made up of common items that are discarded daily (kwun Omang et al., 2021). Similarly, Agwu (2012) defines MHSW management as the process of collecting, storing, treating, and disposing of solid wastes in a manner that is safe for humans, plants, animals, the ecosystem, and the environment in general. The inability of municipal authorities in fast-growing cities to manage household solid waste service efficiently is becoming increasingly common, posing significant environmental and human health risks (Tsheleza et al., 2019a). Also, the rising quality of life inevitably contributes to increased household solid waste generation, having unintended and negative impact in urban environment due to illegal wastes dumping (Han et al., 2018a). Most often, illegal solid waste is dumped in large piles on any unoccupied piece of land, around surrounding buildings, drainage systems, playing fields, roadside, and in open marketplaces in big cities and towns (Gogra et al., 2010).

Several studies have reported on the environmental and human health implication of illegal solid waste disposal (Hirpe and Yeom, 2021; Constantino et al., 2022; Barapatre and Rastogi, 2022) resulting to environmental contamination, landscape destruction, and having a

detrimental effect on people's health due to a lack of sanitation services and inadequate waste management facilities (Han et al., 2018b). According to Rasmeni and Madyira (2019), over 90% of MHSW is disposed in open dumps and landfills, which can cause significant ecological risks to the environment. Different health-related diseases have been attributed to illegal solid waste dump especially in and around residential areas. For instance, risks of cancer have been reported in people living near landfills, where landfill gas migrates through the soil (Narayana, 2009). The effects of leachate from a landfill can contaminate groundwater, surface streams, and soil, potentially hurting human health through inhalation, ingestion or dermal contact (Saha et al., 2021a). Furthermore, open dumpsites emit methane, from decomposing organic matter, which when released into the atmosphere, can influence climate change (Lendelvo et al., 2023). Additionally, open dumpsites emit odours that cause neighbouring residents to suffer from headaches, nausea, and respiratory difficulties (Chikowore, 2021).

Most environmental problems are mainly the result of human activities and actions (Gelan, 2021). This has prompted over the years for scholars to pay particular attention to environmentally friendly behaviours (Fadhullah et al., 2022c). In recent years, many scholars and scientists (Wilson, 2023; Grilli and Curtis, 2021; Chikowore, 2021) are increasingly emphasising the action of people’s unsustainable practices to environmental problems. This requires a change in people’s perception or habits towards more environmentally sustainable lifestyles, which are embedded in the theory of planned behaviour (TPB) (Kaplan et al., 2024). Behavioural change studies were developed with the objective of encouraging the wider audience to adopt environmentally conscious behaviours and take responsibilities for their actions (Grilli and Curtis, 2021). These pro-environmental behaviours refer to individuals' conscious activities towards the environment, including emotions, wants, and inclinations for optimal environmental outcomes (Kaplan et al., 2024). Pro-environmental behaviours encompass a wide spectrum of individual and communal actions, each of which is linked to individual and collective norms (Wu et al., 2024). This style of behaviour aims to reduce the harmful influence of human actions on the environment (Kaplan et al., 2024). Such actions encourage pro-environmental behaviours which communicate perception changes that are important in curbing illegal waste disposal in the environment, which this study sought to explore.

1.2 Problem statement

Improper management of municipal solid waste has been at the forefront of management strategies aimed at restoring pristine environment and to avoid environmental health hazards

(Wilson, 2023). South Africa, like the rest of the less developed countries is plagued with illegal MSWM. Most of the waste produced in South Africa (95 %) is sent to landfills, which in most cases, contribute to environmental pollution (Nyika et al., 2020). This is evident in the rising number of scientific scholars reporting the negative effect of illegal MSW occurring in most urban areas in South Africa (Tomita et al., 2020, Adeniran and Shakantu, 2022; Niyobuhungiro and Schenck, 2022; Owojori et al., 2022). Mahikeng as the capital city of the North West province, is plagued with illegal household solid waste dumping in the environment. The Mahikeng City Council (MCC) oversees the city's administration and provides municipal services such as waste collection, street lighting, water, electricity, sewerage, and storm water drainage to the city's residents. According to the Mahikeng local municipality environmental regulation, "the Mahikeng local municipality promotes a safe and healthy environment, incorporated in the National Environmental Management Act 107 of 1998 (NEMA)" (Mahikeng-local-municipality). Mmabatho being the capital city of Mahikeng is comprised of 13 units with approximately 12 000 houses having a total population of 354 504, according to STATS-SA (2022) and the town generates approximately 34.6% tons of MHSW daily emanating from household (Seabi, 2022; Hirpe and Yeom, 2021; Si et al., 2022). However, the overall MHSW treatment and disposal systems, are quite unsatisfactory, leading to the proliferation of illegal waste dumping sites in the city. The city of Mahikeng in the North West province of South Africa struggle to achieve sustainable solid waste management due to insufficient data about the increasing numbers of illegal dumping sites and negative public perceptions towards household solid waste (Vaverková et al., 2019; Mmereki, 2018b; Chireshe et al., 2023).

Research done so far on municipal household solid waste management in South Africa has focused on recycling of solid waste to minimise illegal dumping and to promote household participation on recycling behaviours (Dlamini et al., 2017a; Tsheleza et al., 2019b; Adeniran and Shakantu, 2022). As such research topics and funding have included proportion of household participation in recycling schemes including the characterisation of the recycling areas (Owojori et al., 2020). However, despite the well-established research into recycling in the country, less attention has been paid to pro-environmental behaviours towards minimising illegal waste disposal. Comparatively, less attention has been paid towards understanding the perception leading to illegal waste dumping and with few detailed research, which have addressed the underlying people's attitudes towards illegal waste dumping, centred on waste management in the North West province South Africa. This study therefore explored the focus

on understanding how societal perception influence the disposal and management of solid waste in Mahikeng, South Africa.

1.2.1 Research Questions

1) What are the different geographical locations of illegal solid waste dumping sites in Mahikeng?
2) What factors contribute to the prevalence of illegal solid waste dumping and collection in the different residential units?
3) What are the contributing factors influencing residents' perception toward dumping illegal solid waste in Mahikeng?
4) What's the most appropriate solid waste management strategy to be adopted in Mahikeng?

1.3 Aim of the study

The aim of this study was to determine the perceptions that influence household solid waste management in Mahikeng.

1.4 Objectives of the study

In line with the above-mentioned aim, the following objectives for the study were formulated:

1) To map out the different illegal solid waste dumping sites in Mahikeng.
2) To examine the frequency of household solid waste disposal and collection.
3) To examine contributing factors and attitude towards solid waste disposal at illegal dumping sites in Mahikeng.
4) To design an effective waste management strategy for Mahikeng.

1.5 Rationale of the study

The illegal dumping of solid wastes in the environment irrespective of their sources can negatively degrade ecosystems and the environment itself. There is a consensus that environmental solid waste pollution is of significant threat to air quality and human health globally, causing groundwater pollution, obnoxious odours and aesthetic deterioration due to its irreversibility in the environment, bioaccumulation in nature and their inhibitory effects on multiple physiological processes in vegetal organism (Han et al., 2018a; Lissah et al., 2021). It equally contributes to residence health-related problems such as typhoid fever, cholera, tuberculosis, respiratory ailments, and dengue (Macawile and Su, 2009). Similarly, the negative perception of uncontrolled and haphazard dumping of illegal solid wastes can have a

spill-over effect to future generations if the current situation is not well addressed. Thus, understanding community perception influencing illegal waste dumping can shed light onto community attitudes on waste disposal systems and environmental stewardship. Examining perceptions can assist uncover potential health concerns and provide measures for reducing the health risks connected with inappropriate garbage disposal withing residential areas.

Although several measures in waste control have been undertaken in the past to fix the problem, like expanded public works programme (EPWP) and presidential employment stimulus (PES) instituted by the local municipalities, however, the proliferation of illegal waste dumping sites continue to increase on daily basis (Mishi et al., 2022). At present, the public perception influencing solid waste in the province is highly negative thus understanding community attitudes can help establish more successful waste management policies and strategies that are suited to the population's individual requirements and preferences. Furthermore, understanding community views and preferences allows officials to execute projects that residents are more likely to embrace and approve. This study is important because it will assist in identifying cost-effective solutions that are consistent with community preferences and goals. Secondly, findings from this study will influence behavioural change to waste management wherein, fundamental assumptions and attitudes must typically be addressed. Research into these beliefs can help uncover impediments to behavioural change as well as opportunities for interventions that promote more sustainable waste management methods. Finally, engaging communities in waste management decision-making processes is critical for instilling a sense of ownership and accountability, and thus perception research can help stakeholders communicate and collaborate more effectively, resulting in more inclusive and participatory waste management practices.

1.6 Chapter Outline

The actual study project is organised into the following chapters,

Chapter 1: Introduction: This chapter introduces the project, the problem statement, aim, objectives and rationale/justification of the study.

Chapter 2: Literature Review: This chapter presents relevant literature linked to the presented objectives in Chapter One.

Chapter 3: Methodology: This one provides a detailed description of the methodology utilized in the work and provides justification for the selection of specific research methods and tools used.

Chapter 4: Results and Discussion: This chapter presents the research results and their discussion. The discussion is structured to address the objectives and answer the research questions.

Chapter 5: Conclusions and Recommendation: This chapter gives a conclusion of the whole work. The chapter also provides recommendations and proposals for future studies.

Chapter 2

Literature Review

2.1 Introduction

The literature review was set to explore the diverse perceptions influencing household solid waste management across different contexts, starting from a global perspective and narrowing down to the African and South African viewpoints. Initially, it examined the worldwide trends and insights, identifying common factors that shape public attitudes and behaviours towards waste management, such as environmental awareness, cultural values, and socioeconomic conditions. The review then shifted focus to the African continent, highlighting regional challenges and unique perceptions that affect waste management practices, including issues of infrastructure, policy, and community engagement. Finally, the South African perspective was explored in detail, considering local nuances, historical context, and current initiatives that influence public perceptions and participation in solid waste management. By examining these varying perspectives, the literature review aimed to provide a comprehensive understanding of the factors shaping household solid waste management practices at different scales, offering valuable insights for developing effective strategies tailored to specific contexts.

2.2 Definition of terms and concepts

Solid waste management is a critical aspect of environmental sustainability and public health, involving the systematic control of the generation, storage, collection, transfer, processing, and disposal of solid waste. Understanding the perceptions influencing solid waste management is essential for developing effective strategies and policies. This section defines key concepts and terms, such as public perception, risk perception, environmental awareness, social norms, behavioural intention, and community participation. These concepts shape how individuals and communities view and engage with solid waste management practices, influencing their behaviours and the overall success of waste management programs. By examining these perceptions, we can identify barriers and opportunities for improving waste management systems and promoting sustainable practices.

2.2.1 Concepts of perceptions influencing solid waste management

Perceptions emphasize the immediate comprehension of environmental information and describe how people feel about certain things in the external environment, this is known as the person's consciousness or perception of their surroundings, which is the psychological process by which the environment they live in on a daily basis leaves an overall impression on their

brains (Zhang et al., 2021). Hence, at the individual and communal levels, perception has a big impact on how solid waste is disposed of. People's attitudes, perceptions, and knowledge about waste management may affect how they dispose of solid waste and interact with their surroundings. For this reason, there are several ways perception might affect how solid waste is disposed of and they could be through:

Attitudes and beliefs: According to Constantino et al. (2022), people's attitudes toward waste disposal significantly influence their commitment to responsible waste management. Individuals who hold positive views about environmental conservation and cleanliness are more likely to dispose of waste properly, while those with negative perceptions are more inclined to litter or engage in illegal dumping.

Awareness and education: Education and awareness initiatives have the power to influence how waste disposal methods are perceived. People are more inclined to adopt responsible waste management practices when they are aware of the environmental effects of improper disposal (Si et al., 2022).

Social norms: People frequently imitate the actions of others around them. There are also more likely to follow the rules if their society places a high priority on cleanliness and proper garbage disposal. On the other hand, if littering or incorrect disposal practices are frequent, they might become acceptable and encourage more reckless behaviours (Constantino et al., 2022).

Convenience: People's disposal preferences may be influenced by their impression of convenience. If people believe that proper garbage disposal is time-consuming or inconvenient, they may choose less ethical alternatives that are simpler (Si et al., 2022).

Perceived impact: If individuals feel their activities have a good impact on the environment and the welfare of the community, they may be more likely to dispose of waste appropriately. On the other side, they might be more likely to engage in irresponsible disposal techniques if they believe their acts are minor (Li et al., 2023).

Cultural factors: Disposal practices can be influenced by cultural notions of hygiene, waste, and the environment. Some cultures put a lot of emphasis on keeping things neat and orderly, which might encourage proper waste management procedures (Adusei-Gyamfi et al., 2022).

Economic factors: Behaviours may be affected by perceptions of the expense of waste disposal. If people think recycling or proper disposal is expensive, they might be more likely to choose less expensive but potentially risky options (Ge et al., 2022).

Infrastructure and access: The perception of the availability of recycling facilities and disposal options can affect behaviour. People may turn to inappropriate disposal if they are unable to use suitable disposal techniques or are unaware of them (Adusei-Gyamfi et al., 2022).

Future consequences: People may be inspired to adopt responsible habits if they perceive the long-term effects of inappropriate disposal of waste, such as environmental deterioration and health concerns (Fadhullah et al., 2022c).

Incentives and penalties: Behaviour can be influenced by how people perceive getting rewarded for correct disposal and getting punished for it. While the notion of potential fines might discourage inappropriate disposal, incentive-based programs can promote effective disposal of waste (Ge et al., 2022).

Waste disposal: Is solid trash from a community that needs to be collected and transported to a facility for processing or disposal (Han et al., 2018a).

Waste management: Includes all the steps needed to manage trash, from its creation to its final disposal (Mmereki, 2018a).

2.3 Conceptual framework that underpinned this study

This study was underpinned by the theory of planned behaviour (TPB) conceptual framework. The basis of this review was to explore the various theories, which have been used to account and predict pro-environmental behaviours in general and the perceptions influencing solid waste management in particular. This is important in two-fold; provide an insight into researchers, who have focused on deeper understanding of the root cause of unusual behaviour to illegal waste disposal, waste removal and environmental conservation and deducing from existing theories and literature what could best explain behavioural factors that might influence pro-environmental behaviours to environmental conservation and sanity.

Icek Ajzen established TPB in 1985 as a psychological framework for predicting and understanding human behaviour (Ajzen, 2020). It asserts that an individual's conduct is driven by his/her goals, which are impacted by three major factors namely "attitude towards the behaviour" which refers to an individual's favourable or negative evaluation of completing a specific behaviour. It contains beliefs about the behaviour’s outcomes, as well as the subjective value assigned to those outcomes (Abadi and Kelboro, 2021). Subjective norms are impressions of social pressures or expectations that influence whether, or not a behaviour is performed (Ajzen, 2020). Subjective norms are a person's opinion on whether, or not how

significant others believe they should act in a certain way. Normative beliefs are the probability that how significant others would approve or disapprove of a behaviour, but subjective norms are impacted by an individual's normative beliefs and drive to comply. Three elements include personal attitude, perceived behavioural control, and purpose to engage in a behaviour that directly affect subjective standards (Ataei et al., 2022). Thus, these behaviours are central in understanding the perceptions of people influencing illegal waste dispersal in Mahikeng.

The TPB states that intentions to do a behaviour are the immediate predictor of conduct, and they are modified by attitudes towards the behaviour, subjective norms, and perceived behavioural control. Underlying beliefs and values influence these factors (Constantino et al., 2022). TPB has been widely used in many domains, including health psychology, consumer behaviour, environmental psychology, and social psychology (Ajzen, 2020; Abadi and Kelboro, 2021; Ataei et al., 2022). It offers a valuable framework for understanding and predicting behaviours, planning interventions to change behaviour, and assessing the efficacy of behaviour modification programs. One of the greater challenges for development around the world is management of solid waste (MSW) in general and household solid waste in particular. It is not only because MSW impacts on the environment or health, but poor implementation of MSW hinders the nation’s progress towards sustainable development goal (SDG) # 3, #6 and #11 of good health and wellbeing, clean water and sanitation, and sustainable cities, respectively, which is crucial for enhancing present practices, including assessing the viability of implementing proper source-sorting in households (Fadhullah et al., 2022b).

It is critical to examine the nature and frequency of household solid waste collection, as well as social factors influencing public behaviour. Waste classification, household waste assessments, recycling perceptions, and waste strategy investigation should all be examined from a local standpoint. Thus, it is crucial to study the composition and nature of wastes created holistically, visualize the geolocation of where wastes are placed, assess residents' impressions of the waste situation at the local level, and assess the efficacy of waste management measures (Oyedotun et al., 2021).

2.4 Solid waste management: The global perspective

Solid waste management is the process of gathering, handling, and disposal of solid waste that has been discarded because it is no longer needed or has served its purpose. This is due to the unsanitary circumstances brought on by improper municipal solid waste disposal, which can result in environmental contamination and epidemics of vector-borne diseases, which are

illnesses spread by rodents and insects. According to Tripathi et al. (2020), the handling of solid waste involves significant technical issues, which present several managements, economical, and social issues that must be addressed.

Globally, solid waste management is a significant environmental and public health challenge. To mitigate environmental pollution, protect public health, and promote sustainable development, proper solid waste management is essential (Batista et al., 2021). From a global perspective, solid waste management involves various critical factors, challenges, and strategies. As the world's population grows and urbanization, including industrialization increases, the production of solid waste also rises. This trend is particularly evident in developing countries, as noted by Khan et al. (2022). Solid waste comprises a wide range of materials, such as hazardous waste, construction and demolition debris, electronic waste (e-waste), household waste, and more (Venkatesh et al., 2022). So, each type of waste requires specific management approaches.

Improper solid waste management can lead to environmental degradation. Hence, hazardous waste, when not disposed of correctly, can contaminate soil and water, while landfills may release harmful chemicals and gases into the environment (Oyinlola and Kolade, 2023). Poor waste management practices can also attract disease-carrying rodents and flies, spread illnesses and posing significant health risks (Fadhullah et al., 2022c), as well as open burning and dumping of waste, which can produce toxic pollutants. However, many materials in the solid waste stream still have value and can be recovered. Recycling and resource recovery programs help reduce waste, conserve resources, and create job opportunities (Saha et al., 2021b). The success and implementation of these programs vary widely. A key strategy is to reduce waste at its source, which can be achieved through durable and recyclable product design, consumer education, and responsible consumption (Chikowore, 2021).

Some countries employ waste-to-energy technologies to convert solid waste into heat or power (Slorach et al., 2020). While these technologies can help generate clean energy and reduce landfill usage, they also raise health and environmental concerns. Effective solid waste management often requires adherence to local, national, and international regulations, including laws on waste disposal, recycling, and collection, as well as penalties for illegal dumping (Barapatre and Rastogi, 2022). Techniques for waste collection, recycling technology, and waste sorting innovations are continually evolving (Oyinlola and Kolade,

2023). These technological advancements can make waste management more sustainable and efficient.

Solid waste management poses a significant environmental challenge for city planners and government organizations worldwide. Rapid population growth, urbanization, and industrial expansion have exacerbated waste management problems in cities globally (Narayana, 2009; Hoornweg et al., 2015). According to Alam and Qiao (2020a), global solid waste generation was 10.4 billion tons in 2010 and is projected to reach 148 billion tons by 2025. While the composition of solid waste varies across countries, the issues it presents are universally challenging. These problems arise from mismanagement and inadequate waste collection and disposal systems. As Narayana (2009) notes, effective waste management requires a robust system for collection, transportation, and disposal, as well as an understanding of the types of waste and how they should be handled.

Successful waste management requires that there be a geared approach towards a participatory all-inclusive tactic of citizens, local governments, and private entrepreneurs. The factors influencing solid waste management remain a challenge because there are ineffective communication channels for disseminating environmental sanitation messages to communities and restricted access to information on safe and sanitary solid waste disposal procedures, as some communities have negative attitudes and beliefs about solid waste management (Lissah et al., 2021). Domestic waste dumped and scattered everywhere shows the lack of services and environmental awareness. It is encouraging to see local communities taking initiatives to deal with domestic waste problem on their own in a way that is also both beneficial to the environment and the residents. Thus, a study of this nature is necessary. If garbage was considered as a resource and managed appropriately, the rising volumes of garbage generated would not be a concern. Scavenging is a fantastic example of sustainable development that may be achieved in developing countries when it is encouraged, eradicating exploitation and injustice, where jobs are generated, poverty is reduced, industry's raw material costs are decreased (while boosting competitiveness), resources are preserved, and pollution is decreased.

Solid waste management is a multifaceted global issue involving economic, social, environmental, and health aspects. Addressing these challenges requires a comprehensive approach that includes recycling, waste reduction, responsible disposal, and the use of advanced technologies. Public engagement and international collaboration are crucial for

making progress towards more effective and sustainable waste management practices. From the above synthesis, solid waste management remains a significant global concern.

2.5 Solid waste management: Africa perspective

In Africa, urbanization and rapidly growing populations are leading to an increase in solid waste production, making effective waste management increasingly vital (Gelan, 2021). Proper solid waste handling is essential for protecting the environment, public health, and overall well-being. However, many African countries face significant challenges in managing solid waste. Due to urbanization, population growth, and changing consumer habits, cities in Africa are generating more waste from homes, businesses, and industries (Barapatre and Rastogi, 2022). Many African nations lack the infrastructure and resources needed for efficient waste collection and disposal (Oyinlola and Kolade, 2023). As a result, inadequate waste management systems are common, leading to frequent open burning and dumping, which negatively impact the environment and human health.

Informal waste pickers and collectors manage a significant portion of solid waste in many African cities. While they are crucial for recycling and reducing landfill waste, they often work in hazardous conditions without legal registration or protection (Gelan, 2021). Improper waste disposal negatively affects health and the environment, leading to environmental damage and health issues, such as the spread of infections. Unappealing landfills, polluted air, and contaminated water supplies can adversely affect community well-being (Saha et al., 2021b). Although many African countries have solid waste management regulations, enforcement and implementation are often inconsistent. For instance, the Environmental Policy of Ethiopia, adopted in 1997, aims to improve the health and quality of life while promoting sustainable development through sound environmental resource management. However, the current municipal solid waste management (MSWM) in Ethiopia mainly focuses on collection, transport, and disposal, with weak implementation of these functional elements (Hirpe and Yeom, 2021). Enhancing waste management requires stricter regulations and better enforcement.

Several African nations are adopting advanced waste management technologies, such as recycling programs and waste-to-energy plants, which can create jobs and reduce the environmental impact of waste (Saha et al., 2021b). Recycling activities, focusing on collecting and processing materials like plastics, paper, and metals, are gaining momentum in various African cities (Hirpe and Yeom, 2021). These initiatives not only decrease waste but also

provide employment opportunities and encourage community involvement. To improve solid waste management systems, some African countries receive support from foreign governments and international organizations (Debrah et al., 2022), which can offer financial aid, expertise, and technical assistance. Countries like China, India, and several in Africa, according to Lebbie et al. (2021) and Patil and Ramakrishna (2020), are particularly vulnerable as they are primary destinations for the developed world's electronic waste, often disposed of unsafely, such as through open burning or improper handling, which adversely affects air and water quality. Developing nations face challenges due to insufficient financial support, government action, and policies for establishing high-tech landfills (Saha et al., 2021b).

Efforts to improve solid waste management in Africa must consider the unique social, economic, and environmental challenges and opportunities on the continent. The waste management situation in Africa is deteriorating. Although Africa generates relatively little waste compared to wealthier nations, poor waste management practices are already negatively impacting human and environmental health. According to Godfrey et al. (2019), Africa is expected to undergo significant social and economic changes in the next century due to population growth, urbanization, and changing consumer spending patterns. Current data indicates that Africa produced 125 million tonnes MSW annually in 2012, with 81 million tonnes (65%) coming from sub-Saharan Africa. This amount is projected to rise to 244 million tonnes annually by 2025. However, with an average waste collection rate of only 55% (68 million tonnes), nearly half of all MSW generated in Africa remains in cities and towns, discarded on sidewalks, in open fields, stormwater drains, and waterways. The percentage of African cities that collect MSW varies greatly, ranging from over 20% to over 90% as is shown in Fig. 1 below.

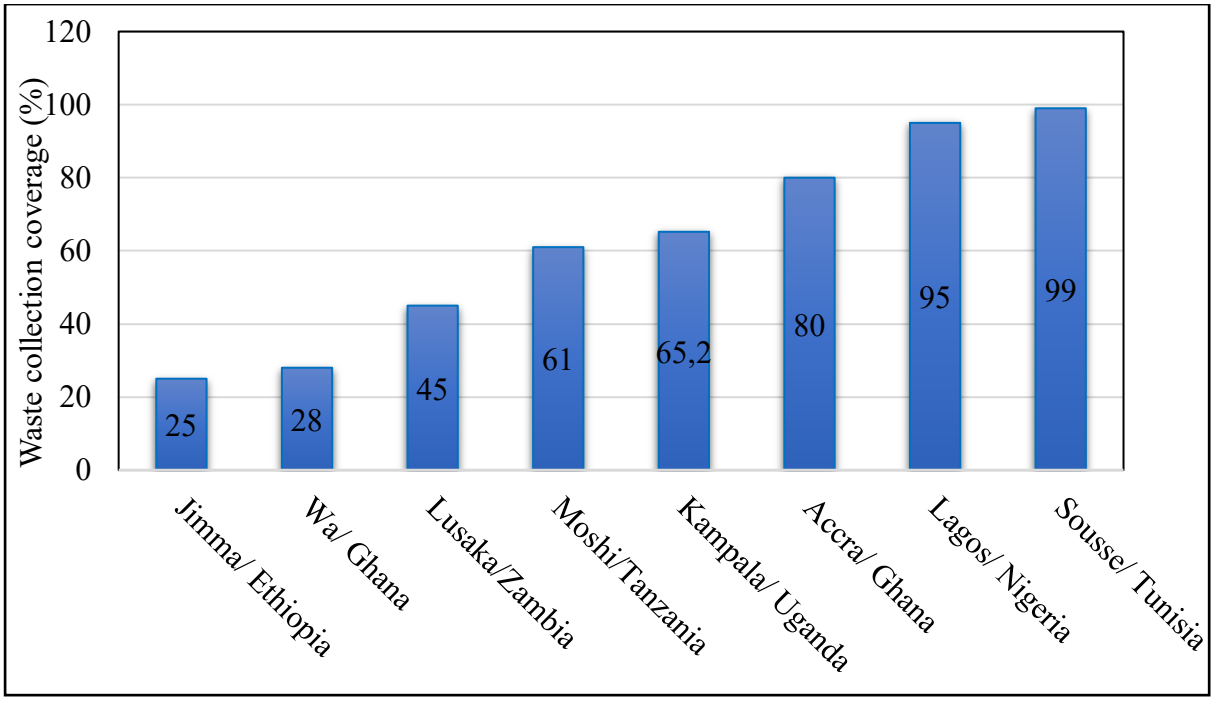


Fig. 1 - Coverage of MSW collections in African cities (Godfrey et al., 2019)

According to Gelan (2021), both household and industrial waste production are increasing in Africa due to a rise in consumption rates. Eastern and Western Africa, the fastest urbanizing sub-regions, are experiencing increased waste production alongside population growth and urbanization. As noted by Ndou and Rampedi (2022), Sub-Saharan African (SSA) generated MSW production of 174 million tons in 2016 and is expected to increase to 269 million tons by 2030. The most common practice for waste disposal in Africa is open dumping, which involves unplanned disposal of garbage without environmental protection measures. This method is detrimental to both the environment and society (Gelan, 2021).

2.6 Solid waste management: South Africa perspective

In South Africa, SWM is addressed holistically, with the government working to improve waste management practices, promote recycling, and reduce the environmental and health impacts of waste. Community involvement and public awareness are key components of these efforts. The evolving waste management landscape reflects the nation's commitment to environmental sustainability and addressing waste generation challenges. Like other parts of the world, SWM is a significant concern in South Africa. The country faces various opportunities and challenges in managing its solid waste, and efforts are underway to address these issues. Thus, an overview of South Africa's SWM approach needed to be addressed. South Africa's significant solid

waste generation is primarily driven by increasing urbanization, consumerism, and population growth (Tsheleza et al., 2019b). Waste is generated from residential, commercial, and industrial sources.

Many municipalities in South Africa still dispose of waste in landfills, but there is a growing emphasis on adopting more eco-friendly waste management practices, such as recycling and waste-to-energy technologies. By 2023, it was projected that all landfill airspace in Johannesburg will be exhausted (Dlamini et al., 2018). The rise of recycling programs in South Africa has been largely driven by public awareness campaigns and the recycling industry. Materials like metals, paper, glass, and plastics are collected and processed with a strong focus on recycling (Tsheleza et al., 2019b). The substantial informal waste sector, including waste pickers, plays a crucial role in waste collection and recycling, helping to reduce landfill waste despite often working under challenging conditions (Schenck et al., 2019). Efforts are ongoing to educate communities and raise public awareness about the importance of recycling and proper waste disposal. South Africa is working to integrate waste pickers into the formal waste management system, aiming to improve their working conditions and provide legal recognition for their contributions (Seabi, 2022).

The mismanagement of household solid waste is becoming a major environmental issue in South Africa due to the rapidly growing population. In fast-expanding cities, waste authorities often struggle to manage household solid waste service effectively, leading to significant environmental and health hazards (Tsheleza et al., 2019a). The high rates of population growth in recent years have exacerbated environmental problems, including increased solid waste production. This is partly due to rural-to-urban migration, industrialization, urbanization, and changes in manufacturing processes and living standards as stated by Dlamini et al. (2018). According to Gu et al. (2021), the global population is projected to reach 9.7 billion by 2050 and 10.9 billion by 2100, which will further impact solid waste production. Strategies to address solid waste issues include environmental education, training, and demonstration efforts to educate the public about the benefits of recycling and waste reduction. However, studies indicate that these initiatives are often ineffective when implemented (Dlamini et al., 2017a).

In many developing countries, including South Africa, open dumping is the predominant method of SWM due to its lower capital, operational, and maintenance costs compared to other disposal methods. However, this non-sanitary and non-engineered approach lacks proper

liners, gas collection, and leachate treatment, exposing the environment to various air, water, and soil pollution problems (Fadhullah et al., 2022c). South Africa has implemented policies to protect the environment, its population, and its biodiversity. Legislations such as the National Environmental Management Waste Act (NEMWA) and the Environmental Conservation Act (ECA) provide a framework for addressing waste issues, enabling municipalities and communities to manage waste effectively (Nyika et al., 2020). According to Fadhullah et al. (2022a), the public health impacts of ineffective household SWM can include physical, biological, non-communicable diseases, psychosocial, and ergonomic health risks.

Contaminated soil, air, and water can become breeding grounds for biological vectors such as flies, rodents, and insects (Han et al., 2018a). These vectors can cause various diseases including diarrhoea, dysentery, gastrointestinal issues, worm infections, food poisoning, dengue fever, cholera, leptospirosis, bacterial infections, skin, nose, and eye irritation, and respiratory problems. Therefore, plans have been put in place to curb such problems and thus, recent methods to manage solid waste include recycling, energy generation, and creating employment opportunities through waste management. Technologies such as composting, anaerobic degradation, incineration, pyrolysis, gasification, and recycling are well established, with residual waste disposed of in-modern sanitary landfills (Alam and Qiao, 2020a). However, South Africa lags 20-30 years behind Europe and other developed countries in waste management. The transition from landfilling to prevention, reuse, recycling, and recovery, is still a distant goal (Godfrey et al., 2017).

2.7 Household waste generation

The term "household waste generation" describes the waste or garbage that people and families produce in their homes. According to Fadhullah et al. (2022c), it is one of the main sources of MSW from residential areas, which includes food wastes, paper, plastic, rags, metal, and glasses. Thus, this waste can be produced in a few ways, such as:

MSW is typical household waste that comprises food scraps, packing materials, clothing, appliances, and other wasted materials. It is the most prevalent kind of waste in homes. MSW is generally disposed of in landfills or recycled or composted. Paint, batteries that are too old, cleaning supplies, and electronic waste (e-waste) are among the common household goods that fall under this category (Barapatre and Rastogi, 2022). It is important to properly dispose of these materials as they are hazardous waste through approved collection and recycling

programs as they may constitute a risk to the environment. Based on variables including lifestyle, consumption habits, recycling initiatives, and waste minimization efforts, the quantity of waste produced by households might differ dramatically between them and between regions. In order to lessen their environmental impact and cut down on the amount of waste that is dumped in landfills, different nations and municipalities have put in place waste management programs that involve the reduction, reuse, and recycling of domestic waste (Venkatesh et al., 2022).

Due to its effects on landfills, energy use, greenhouse gas emissions, and resource depletion, household waste creation is a significant environmental concern. To solve this issue, it is imperative to promote good waste management practices, decrease the usage of single-use items, and increase recycling and composting activities (Seabi, 2022). Waste is produced by human activities, and how these wastes are treated, processed, collected, and disposed of, can pose environmental and public health risks (Tsheleza et al., 2019a). Waste creation is a direct result of urbanisation and in many cities, rapid population development has outpaced municipal administrations' capability to deliver even basic services, resulting in health concerns and urban environment damage and the waste management hierarchy (WMH) views waste as a resource that should be reused, recycled or used for energy recovery and not merely a residue, which has to be discarded. The capability of city governments to offer appropriate and fair waste management services has been overburdened as the urban population has grown (Simatele et al., 2017).

MSW from developing countries typically contains a large fraction of organic material, which could provide nutrients to support agriculture and/or produce energy through biogas (after sorting out the waste, as waste can sometimes contain moisture), and achieving goal 7 of the SDG: affordable and clean energy (Hettiarachchi et al., 2018c). On the other hand, Lissah et al. (2021) stated that cities in low- and middle-income nations, like Ghana, only collect between 50 and 80% of the waste created, despite spending 30 to 50% of operational expenditures on SWM. Han et al. (2018a) also showed that the amount of urban population and its proportion, energy use, collection sites, waste disposals, typical family size, employment status, income, the number of rooms occupied by households, people's environmental concerns and willingness to separate the waste, tourism activity, and education, all have a significant impact on the generation of MSW and its composition.

Combating the health and environmental issues urbanized towns face, particularly in SSA, requires effective SWM. The generation of garbage in SSA is expected to be around 62 million tonnes annually and managing solid waste effectively and efficiently is one of the main issues local government bodies confront, particularly in urban areas (Lissah et al., 2021). The authors further indicated that in many cities in developing countries, growing urbanization and population expansion have led to a surge in the production of significant amounts of solid garbage, outpacing the capacity of local authorities to manage and dispose of solid trash in a sanitary manner.

2.8 Different types of household waste generation

The generation of waste in households can be divided into various categories according to the kind of waste and whether it can be recycled or disposed of. The precise categories of home waste can differ depending on the area and personal preferences; however, the following are some typical ones, biodegradable items such as food scraps, yard debris (such as leaves and grass clippings), and non-recyclable paper goods fall under the category of organic waste. By composting organic waste, nutrient-rich soil can be produced (Seabi, 2022). Materials that can be recycled include paper products (magazines, cardboard, newspapers), glass jars, plastic bottles, aluminium cans, and some kinds of plastic containers (Tsheleza et al., 2019b). Hazardous waste items such as paint, insecticides, cleaning supplies, batteries, and electronics are examples of hazardous household waste. Sincethey may be hazardous to the environment, these materials should not be disposed of with conventional trash. Hazardous waste has facilities for recycling or proper disposal (Hirpe and Yeom, 2021).

Electronic waste, or e-waste, is made up of outdated or malfunctioning electronics and appliances, including computers, televisions, refrigerators, and cell phones. Numerous parts of these products are recyclable, and valuable metals are frequently found in e-waste (Venkatesh et al., 2022). Metal waste other than aluminium cans, household appliances, cookware, and cutlery, can also be considered metal garbage. Metals are frequently recyclable (Hirpe and Yeom, 2021). Plastic waste, despite their recyclable nature, plastics constitute a substantial waste stream (Browning et al., 2021). Disposable utensils, bags, and packaging are examples of single-use plastic products that contribute to plastic pollution and take a long time to decompose in the environment (Si et al., 2022). Paper waste like cardboard, office paper, and junk mail fall into this category. Since many paper goods are recyclable, there is less needed to produce new paper. Demolition and building waste materials like wood, concrete, drywall,

and tiles, can be produced when renovating or building a home. For these materials, there are possibilities for recycling or proper disposal (Hunter et al., 2019).

To make sure that home waste is managed in an environmentally friendly manner, it is critical to be informed about local recycling initiatives and waste management policies. Sustainability also depends on waste reduction techniques like composting, recycling, and reusing (Seabi, 2022). Domestic waste is typically disposed of using the public collection service. However, some unfavourable environmental behaviours such as burning and the usage of illicit landfills have been reported (Buenrostro et al., 2014). Scavengers and refuse pickers primarily separate and sort plastics, glass, paper, bottles, beverage cans, and metals, which are later sold to recovery firms and scrap yards (Mmereki, 2018a) and due to the more varied nature of contemporary items, changing consumption patterns, wealth, changing lifestyles, rapid economic expansion, quick urbanization, and rapid population growth, it is a problem.

2.9 Household solid waste on illegal sites

Due to a lack of well-established waste management operations, waste generators resort to illegal and unsustainable practices such as indiscriminate dumping and open burning, which may result in the loss of vast amounts of solid waste that could be recycled as well as environmental contamination (Mmereki, 2018a). According to Bhuiyan (2010), there is a 'gap' between the generation and collection of solid waste daily, making city administration highly exposed to citizen complaints. The composition and character of municipal solid trash are always determined by the source of creation, with each city having its own unique mix of activities and waste characteristics, as most of the waste is generated in Mahikeng's residential districts (Chowdhury and Afza, 2006).

A serious problem for the environment and public health is the unlawful disposal of solid household waste. Unauthorized disposal of waste can result in a few issues, such as groundwater and soil contamination that can result from the illegal disposal of household solid waste, which also contaminates water supplies. Ecosystems and wildlife are at risk as toxic chemicals and other materials from the waste might seep into the environment (Mudemfu, 2023). Air pollution in some places it is standard practice to burn domestic waste on unlicensed property. This releases toxic pollutants into the air, causing poor air quality and maybe health problems for neighbouring individuals (Barapatre and Rastogi, 2022).

Throwing waste on the open land damages the quality of the soil and as a result, landfills are erected because the base of the landfill needs to be covered by the final cover in order to avoid

spillage of substances to the ground, which may contaminate the land. There is a growing trend of illegal waste dumping, with mini-dumping sites springing up all over Mahikeng, and such actions jeopardize the efforts of lobbying investors and tourism businesses as well as causing significant negative environmental consequences, a loss of economic benefits, and the depletion of valuable resources (Mmereki, 2018a). Some residents do not always take out their waste or forget when it is scheduled to be collected, opting instead to dump their refuse at the nearest illegal disposal site as pointed by Nkosi (2014). When illegal operations are carried out, the spill-over effect will be the destruction of habitat, caused by unauthorized disposal of waste materials that has the potential to strain natural habitats and ecosystems, resulting in wildlife displacement and the eradication of environmentally vital plants and microorganisms (Vaverková et al., 2019). Health risks associated with unauthorized disposal sites may serve as havens for vermin, including insects and rodents, which can harbour diseases (Fadhullah et al., 2022c). Those who reside nearby may also be at risk of health problems due to the harmful materials in the waste. Quality of life and aesthetic concerns caused on illegal waste sites frequently detract from the overall aesthetic appeal of a community. A lower quality of life for locals may result from this, as it may discourage tourist and economic growth (Vaverková et al., 2019).

2.10 Perceptions of solid waste disposal by households

According to Buenrostro et al. (2014), environmental perception is defined as the interaction between people and their surroundings. This connection impacts whether people have an attitude in favour of or against the environment. The majority of individuals hold negative views and impressions about the extent to which local governments provide various waste management services, for example, garden garbage from private residences is not collected by local government (Dlamini et al., 2017b). Poor waste management practices impede the development of integrated SWM in households, and correct decision- making in the direction of a more sustainable strategy requires knowledge about present practices and perceptions of household SWM (Fadhullah et al., 2022c).

Household perceptions of solid waste disposal can differ greatly depending on a variety of factors, such as social, cultural, and environmental concerns (Adusei-Gyamfi et al., 2022). Households may hold the following common beliefs and attitudes toward the disposing of solid waste:

Environmental awareness, recycling and waste reduction may be top priorities in some homes due to their great environmental consciousness. They could believe that reducing their environmental impact requires proper waste disposal (Hirpe and Yeom, 2021). Convenience and accessibility on how households view solid waste disposal is greatly influenced by the ease of use and accessibility of waste disposal services (Fadhullah et al., 2022c). Household perceptions are more likely to be favourable if waste collection services are easily accessible and user-friendly. Recycling families that see the advantages of recycling may be more inclined to separate recyclables from other rubbish (Chikowore, 2021). Recycling might be viewed by them as an ethical and sustainable method of managing waste. Concerns about pollution due to inappropriate garbage disposal, households in locations with inadequate waste management infrastructure may be concerned about odours, pollution, and the spread of diseases. This may cause people to have a bad opinion of the waste disposal system (Mmereki, 2018b).

Cultural practices on how households dispose of waste can be influenced by cultural norms and practices. Certain cultures place a strong emphasis on recycling and waste reduction, whereas others may have less ecologically friendly disposal methods (Adusei-Gyamfi et al., 2022). Socioeconomic variables perceptions can also be influenced by economic variables. Some households might rely on inexpensive disposal techniques because they lack the resources to participate in recycling or waste reduction initiatives (Li et al., 2023). Education and awareness on well-informed households are more likely to make them adopt appropriate waste management methods and to have more positive attitudes of the environmental and awareness of the health effects of incorrect waste disposal (Si et al., 2022). Household attitudes can be positively influenced by communities that actively participate in garbage reduction and clean-up activities. The perception of group accountability for waste management has the potential to exert an impact (Barapatre and Rastogi, 2022). Perceptions may be affected by the existence of efficient waste management rules and enforcement. Households are more likely to comply with proper disposal methods and have positive attitudes of waste management when governments enforce them and penalize violators (Ge et al., 2022) and when households encounter problems like pests, pollution, or unpleasant odours on account of poor waste management, they may view waste disposal as a health and safety risk.

2.11 Waste avoidance, recycling, storage and waste collection

A vital component of both public health and environmental sustainability is waste management. It usually consists of a few essential elements, such as collecting, recycling, storage, and waste prevention. Waste avoidance, sometimes referred to as source reduction or waste minimization,

is the practice of minimizing waste production at its source. This can be accomplished in several ways, including implementing more environmentally friendly production techniques, using less packaging, and improving product design (Si et al., 2022; Hunter et al., 2019). Businesses and consumers can both contribute to waste avoidance by choosing products and services that generate less waste and by being aware of what they consume.

Recycling is the process of gathering, processing, and reusing things that would normally be thrown away as garbage. Materials including paper, glass, plastic, metal, and organic waste are frequently recycled (Seabi, 2022). Recycling helps lessen the negative effects of trash disposal on the environment, conserves natural resources, and uses less energy. Numerous local governments and areas offer recycling services to their citizens, such as curb-side collection or recycling drop-off locations. Before waste products are moved for eventual disposal or recycling, they must first be temporarily stored. It is essential to store garbage properly to avoid contaminating the environment, spreading illness, and creating unsightly waste piles (Tripathi et al., 2020). Garbage containers, dumpsters, and sealed bids for hazardous items, are common ways to store waste.

The process of collecting waste from different sources and moving it to a recycling facility, disposal facility, or other suitable location is known as waste collection. Municipalities usually offer regular schedules for collecting waste from businesses and residents (Barapatre and Rastogi, 2022). To keep towns clean and healthy, effective garbage collection systems are necessary. Waste treatment and disposal, which entails the appropriate handling and ultimate disposal of waste products, is another aspect of waste management in addition to the first four. Treatment and disposal techniques can differ and may involve burning, landfilling, composting, or other specialized processes, depending on the type of waste e.g., hazardous, non-hazardous (Venkatesh et al., 2022).

Good waste management techniques are crucial for resource conservation, environmental protection, and reducing the harmful effects of waste on human health. Regulations and programs have been put in place by numerous towns and governments to promote recycling, waste reduction, and appropriate disposal of garbage. Promoting sustainable waste management procedures involves a lot of community involvement and public education. Communities lack relevant knowledge on how waste recycling can be practiced at the household level, as well as waste sorting facilities or buy-back centres located near their homes. According to Dlamini et al. (2017b) inevitably, communities fail to adopt waste recycling and

all of the associated mechanisms (i.e., waste separation, recovery, sorting, and reuse) that go with it and as long as this status quo exists and communities are unaware of waste separation facilities, the mixing of household solid wastes will continue for the foreseeable future, and recyclable waste will be directed to landfill sites for final disposal, undermining long-term environmental sustainability.

2.12 Transportation and transfer of waste

The efficient, safe, and ecologically responsible transportation and transfer of waste products from the place of generation to the final disposal or treatment locations is a crucial component of waste management. Waste transportation and transfer involve several important factors, where waste collection has many different places, where waste is produced, including homes, companies, industries, and building sites. To enable appropriate treatment and disposal, waste must be gathered and separated at the source (Han et al., 2018a). Collection containers are needed for different waste categories, including hazardous items, organic trash, recyclables, and general rubbish. Appropriate containers facilitate effective transit and collection (Tsheleza et al., 2019b). Collection vehicles for waste – waste is collected by means of a variety of collection vehicles, including hazardous waste transport vehicles, garbage trucks, and recycling trucks. To manage various waste kinds, these cars are fitted with specific features (Amaral et al., 2022).

Waste transfer stations are intermediate locations, where waste is combined and moved from transport trucks that are smaller in size to larger ones. This procedure cuts down on the number of journeys to disposal sites, which lowers the impact on the environment and transportation expenses (Han et al., 2018a). Waste sorting for employees at transfer stations, is where and when they shift rubbish to take out hazardous materials, recyclables, and other things that require special care. This guarantees that hazardous waste is disposed of properly and helps divert important resources from landfills (Venkatesh et al., 2022). Transportation modes depending on the type of garbage being transported and the location of the disposal facility, many modes of transportation such as trucks, trains, barges, and ships, can be used for trash transportation. A few factors, including cost, trash volume, and distance, affect the mode of transportation that is chosen (Amaral et al., 2022). Packaging and labelling are needed to comply with regulations, hazardous waste needs to be packaged and labelled appropriately. This guarantees the environment's safety, public safety, and worker safety while in transit (Si et al., 2022).

Regulatory compliance on federal, state, and local laws must be followed when transferring and transporting waste. In order to reduce the negative effects on the environment and safeguard public health, regulatory compliance guarantees that trash is handled properly and responsibly (Barapatre and Rastogi, 2022). Tracking, maintaining accurate documentation and monitoring the flow of garbage are crucial for keeping an eye on waste amounts and disposal sites. Authorities, waste management firms, and other stakeholders, can guarantee accountability and compliance with the aid of this documentation (Rasmeni and Madyira, 2019). Environmental considerations are critical to lessen trash transportation's negative environmental effects. The environmental impact of trash transportation can be lessened by adopting strategies including route optimization, using fuel-efficient cars, and reducing emissions (Amaral et al., 2022).

Safety measures when moving and transferring garbage, safety procedures for both the public and employees, are essential to avoiding mishaps, spills, and exposure to dangerous substances (Seabi, 2022). A waste management process's overall success depends on efficient trash transportation and transfer, which guarantees that waste is handled securely, effectively, and environmentally responsible while also following to pertinent rules and fostering sustainability (Amaral et al., 2022). Separate collection is recognized as a responsible approach to dispose of domestic solid trash, which is one of the difficulties brought on by the increasing household solid waste that is causing environmental contamination and land occupation as a result of rapid mass migration into cities and economic expansion. Separate collection practices are uncommon, and there is little data on the dynamics of urban households' intentions for separate collection of household solid garbage (Lissah et al., 2021). As a result, the municipality should foster a system that is friendly to the environment, offer practical facilities, provide thorough cases, develop environmental moral obligations, and suggest suitable promotional and incentive programs for various recycling modes (Wang et al., 2018).

2.13 Environmental municipal bylaws in South Africa

Since local governments in South Africa can create and enforce their own regulations to address environmental issues, municipal environmental bylaws may vary across different municipalities. These regulations are typically designed to promote community well-being, sustainability, and environmental protection. Municipalities may introduce bylaws that limit the use of certain fuels, regulate equipment that emits pollutants, and control emissions from open burning and industrial sites to improve air quality management.

Many South African municipalities have rules regarding waste collection, disposal, recycling, and reduction. Some communities also support initiatives to reduce single-use plastics and promote composting (Rasmeni and Madyira, 2019). Additionally, certain local governments implement regulations to protect native plants and wildlife, restrict the removal of vegetation, and encourage the preservation of natural areas to safeguard biodiversity (Semenya and Mokgoebo, 2020, Constant and Taylor, 2020). Bylaws related to zoning and land use may protect environmentally sensitive areas, regulate development, and promote eco-friendly building practices (Seabi, 2022).

The bill of rights of the South African constitution (1996) states that citizens have a right to a healthy and safe environment that will not be harmful to their quality of life or ability to work, as well as a right to the protection of the environment (Masilo et al., 2021). The constitution further states that this will help for both current and future generations through governmental and other actions that will stop pollution and ecological degradation and ensure the sustainable use of natural resources while fostering ethical economic and social development. For the garbage firms to adhere to the accepted practices in SWM, the local government authorities must enforce sanitation and SWM bylaws. At the community level, it is necessary for the local government authorities to enforce sanitation and waste management standards in homes for the sanitary disposal of garbage (Lissah et al., 2021).

2.14 Environmental health issues on solid waste management

Humanity continues to invent and manufacture cutting-edge products to meet its most basic requirements, however, in certain regions of the world, the consequent production and use of resources results in significant challenges with solid waste generation and management (Si et al., 2022). Landfilling, composting, incineration, and pyrolysis are some of the waste disposal methods used in developed countries, however, the pollution caused by indiscriminate trash disposal has major consequences for public health and safety (Mudemfu, 2023).

Concerns about environmental health are important aspects of SWM. It entails several procedures and actions that may influence community and environmental health directly or indirectly. The following are some significant SWM related environmental health issues like recycling health on chemical exposure when processing, sorting, and disposing of waste products, workers may encounter dangerous chemicals and substances. Chemical poisoning, skin disorders, and respiratory disorders are just a few of the immediate or long-term health difficulties that can arise from this contact (Oyinlola and Kolade, 2023). Biological hazards

such as bacteria, viruses, and other diseases can be found in solid waste. There is a chance that workers will get gastrointestinal illnesses, tetanus, or hepatitis (Han et al., 2018a).

The handling and disposal of garbage can produce dust and other airborne particles that could harm employees' respiratory systems and cause diseases including asthma and chronic obstructive pulmonary disease (COPD) (Chikowore, 2021). Wearing insufficient personal protective equipment (PPE), workers may be more susceptible to illnesses and injuries if they are not wearing the appropriate PPE, such as gloves, masks, and safety gear (Si et al., 2022). The nature of SWM labour, which frequently entails long hours, disagreeable smells, and monotonous duties, can lead to worker burnout and psychological stress (Ge et al., 2022). Inadequate waste management techniques can produce habitats for rats and mosquitoes, two vectors that spread disease to people (Han et al., 2018a). It is critical to put in place appropriate waste management procedures, such as waste segregation, recycling, safe disposal techniques, and giving employees the necessary training and protective gear, in order to address these occupational and environmental health concerns (Seabi, 2022). To guarantee the appropriate handling of solid waste and lessen its effects on the environment and labourers, rules and regulations should also be upheld.

The municipality's solid waste issue contributes to the development of several public health issues like typhoid fever, cholera, dysentery, TB (tuberculosis), parasitism, malaria, respiratory illnesses, and dengue by fostering an unclean and poorly sanitary environment (Macawile and Su, 2009). Household waste dumped in an open landfill degrades the aesthetics, has an adverse effect on the ecosystem, and poses a public health risk. Waste disposal in public areas results in a loss of local aesthetics, which is related to concerns about the environment and public health. The trash that is thrown into the environment around it significantly contaminates it and poses risks (Chikowore, 2021). Non-communicable illnesses are a different group of health impacts that may be intimately linked to household SWM. Preterm births, congenital diseases, Down's syndrome, and other birth defects fall into this category of health repercussions that are also worth addressing. In addition to physical and biological repercussions, poor waste management in the home can have psychosocial effects, including unpleasant odors, ugly garbage, and issues with thinking, cognition, and stress (Ge et al., 2022).

According to Fadhullah et al. (2022b), ergonomics is the final category of related health effects that is worth mentioning specifically for the working community of household waste management and the risk of ergonomic issues is related to body posture, repetitive movement

and excessive force movement. The most important phase in waste management is handling and waste separation at the source because much of the solid waste produced in Malaysia is organic waste with a high moisture content (Yusliza et al., 2020).

2.15 Challenges and methods used to address the solid waste problem

Challenges include rapid urbanization as cities expand, so does the volume of waste they produce (Tsheleza et al., 2019b). According to Sharma et al. (2020), many cities lack the necessary infrastructure to efficiently manage this rising waste volume. Poor infrastructure for garbage collection, transportation, and disposal, can result in improper waste disposal, such as open dumping and burning, which adds to pollution and health risks (Venkatesh et al., 2022). As civilizations become more consumer-oriented, the types of waste generated change. This can include an increase in single-use plastics and electronic waste, which can be difficult to control. In many less developed nations, an informal sector handles a large amount of waste collection and recycling. While they play a role in trash management, they frequently lack sufficient training and equipment, resulting in sub-optimal waste treatment (Barapatre and Rastogi, 2022).

Lack of financial management and logistics, insufficient municipal infrastructures, imbalanced planning decisions, disrespect for fundamental aesthetics, and industrial and commercial growth, as well as perceptions and sociocultural habits, are the key reasons of inappropriate SWM (Hunter et al., 2019). Littering and illegal dumping can be exacerbated by a lack of public awareness and information about the necessity of waste management and correct disposal techniques. Implementing successful waste management systems necessitates financial resources, well-trained employees, and cutting-edge technology. Many municipalities and regions face these constraints on resources in these areas (Mudemfu, 2023).

Methods to solve the problem include reduce, reuse, and recycle. The "3Rs" method promotes reducing unnecessary consumption, reusing products, and recycling materials to extend their life cycle in order to reduce waste generation (Neves and Marques, 2022). Proper waste segregation at the source aids in the recycling and treatment processes. Organic waste separation from non-organic trash can improve composting and minimize landfill load (Venkatesh et al., 2022). Improved landfill construction and management procedures, such as adequate liner and leachate collection systems, can help landfills have a lower environmental effect (Neves and Marques, 2022). Organic waste can be composted to produce nutrient-rich soil amendments (Tsheleza et al., 2019a), reducing the amount of garbage that must be disposed

of in landfills and recycling various items, such as paper, plastics, glass, and metals, reduces the demand for raw materials and waste in landfills (Dlamini et al., 2017a).

While technologies such as incineration and anaerobic digestion are contentious due to environmental concerns, they can assist reduce waste volume and provide energy (Tsui and Wong, 2019). Public awareness campaigns that educate the public about the importance of responsible waste management and provide guidelines for proper disposal can reduce littering and encourage better waste practices, as waste management awareness is critical to addressing waste management challenges in many cities. Priority should be given to environmental education that promotes waste separation, reuse, recycling, and waste reduction (Tsheleza et al., 2019a). Persistence of the problem include several factors such as lack of political will, can be attributed for the problem's recurrence. Adequate waste management frequently necessitates ongoing political commitment, funding, and policy enforcement (Browning et al., 2021). These elements might be absent in some circumstances. Lack of infrastructure is a problem since creating and maintaining waste management infrastructure takes a large expenditure that may not be feasible in all areas. Changing attitudes and behaviours toward garbage disposal and consumption patterns is difficult (Neves and Marques, 2022) and takes time due to behavioural and cultural variables. If they do not gain anything from a clean environment, some people are not interested in it. Economic aspects must be considered because they might affect the choice of methods for waste management and some waste management techniques may be more expensive to adopt than others (Barapatre and Rastogi, 2022).

A comprehensive and multifaceted strategy incorporating government action, resident involvement, technical breakthroughs, and international cooperation is needed to address the solid waste problem. Achieving sustainable waste management methods is a difficult task that calls for constant effort.

2.16 Conclusion

The sustainable use of the environment and public health both depend on SWM. In summary, several important issues about SWM can be raised. Impact on the environment due to improper SWM and disposal can have a major negative impact on the environment, resulting in greenhouse gas emissions, habitat destruction, and pollution of the land and water. To reduce these effects, waste management must be done effectively. Health and safety of communities may be at danger for disease outbreaks and other health issues because of inadequate SWM. To safeguard the public's health, hazardous waste must be disposed of and contained properly.

A key element of sustainable waste management is the "3Rs" approach (reduce, reuse, recycle). By cutting down on waste production, reusing items, and recycling materials, the amount of waste sent to landfills or incinerators can be significantly reduced. Incineration and landfills are common methods for disposing of solid waste, but they require proper design, maintenance, and regulation to minimize negative impacts like air pollution and groundwater contamination.

In some regions, waste-to-energy technologies have been introduced to generate electricity from solid waste, which can be a sustainable option if emissions and environmental effects are well controlled. Embracing a circular economy, which focuses on resource efficiency and reducing waste, is another long-term solution for sustainable waste management. This involves designing products that are durable, repairable, and recyclable (Oyinlola and Kolade, 2023). Laws and regulations play a crucial role in shaping SWM practices, and effective enforcement is necessary to promote recycling and responsible waste disposal. Community involvement for SWM programs to be successful, increasing public awareness and encouraging community involvement, are essential. More sustainable behaviours can result from teaching people the value of the 3Rs and how to dispose of waste responsibly. New technological developments in waste management technologies, like equipment for recycling and sorting garbage, can increase processing efficiency and lessen environmental effect.

Managing solid waste is an issue that affects the entire world. To safeguard both human health and the planet's ecosystems, it is imperative that waste management issues be addressed globally as the world's population grows. Households' progress toward integrated SWM is hampered by poor trash disposal practices. For appropriate decision making in the transition to a more sustainable strategy, knowledge of present practices and perceptions of household SWM is required (Fadhullah et al., 2022a). To have a clean environment, the municipality can appoint individuals within the community to collect the waste and every six months rotate them so it will favour every household. Communities lack knowledge about the negative health implications of burning waste, which should be covered in environmental awareness initiatives and the city to have a waste database, where they will be able to track where people throw waste and act accordingly (Chikowore, 2021). Having different days for collection and different days for recycling can assist in managing MSW.

In conclusion, resource conservation, public health, and environmental preservation all depend on efficient SWM. It necessitates a multidimensional strategy that incorporates personal accountability, governmental control, technology advancement, and a dedication to

sustainability. Important first steps toward a more sustainable future include the adoption of the 3Rs to reduce waste output and the transition to a circular economy (Oyinlola and Kolade, 2023). Recycling and reuse waste materials should never be burned or dumped in landfills; instead, they should be repurposed or reused. To assist recycling and reuse programs, proper sorting and transportation are crucial. The existence of improperly managed waste sites may lower local property values and quality. MSW management laws are often weak, and historically, local municipalities have been responsible for managing MSW, which generates limited revenue. Most municipalities struggle to collect taxes or fees for waste management services.

The lack of a financially sustainable service model, combined with insufficient political and legislative commitment to address the need for effective waste treatment, pose a significant challenge (Hettiarachchi et al., 2018a). Effective waste management strategies must consider these challenges and address them through policy implementation, infrastructure improvements, targeted educational programs, and awareness campaigns. Aligning public attitudes with responsible waste disposal practices can help communities move towards cleaner, more sustainable environments.

Chapter 3

Research Methodology

3.1 Introduction

In this chapter, research philosophy, validity and reliability and ethical consideration methods are explained, and their choice is justified as they were conducted when the study took place. Furthermore, details of the specified research design, target population, sampling strategies, methods and procedures for data collection as well as the analysis delineation are described.

3.2 Philosophical positionality

The present study is an attempt to problematize the attitudes, practices and utility in solid waste management. The work mixes quantitative techniques (to estimate patterns in the frequency of disposal and spatial patterns of trash), and qualitative analysis (to investigate individual and community attitudes and explanatory variables) in an acknowledgement that questions of waste and treatment are inextricably linked with the questions of what are encouraging human behaviour in regard to the environment. The goal of the study is to contribute to the development of sustainable waste management practices in consistent with a pragmatic standpoint that promises findings that can be applied on real life. Pragmatism, according to Creswell and Plano Clark's (2018) focuses on the research problem and uses all the methods at its disposal to understand it thoroughly.

3.3 Research design

This study adopted the mixed research method. Within a single study, a mixed methods research design integrates both quantitative and qualitative research methodologies. It provides a more thorough grasp of research issues and seeks to use the advantages of both forms of data. Both closed ended (quantitative) and open-ended (qualitative) questions are commonly included in questionnaire designs used as data collecting tools (Mohajan, 2020). A questionnaire used in a mixed method study design is an effective way to collect rich, thorough data that considers both human experiences and numerical trends (Rahman, 2020). According to Park et al. (2020), a research design is a study strategy that is a roadmap or master plan detailing the strategies and techniques for collecting and analysing data required for conducting research as used to meet specific research goals or theories, which shows an overall plan for how study questions can be addressed.

3.3.1 Description of the research site

The study was conducted in the North West province, South Africa (Fig. 2A). Ngaka Modiri Molema district municipality is one of the four districts of the North West province of South Africa namely Bojanala platinum district, Dr Kenneth Kaunda district and Dr Ruth Segomotsi Mompati district (Fig. 2B). Its capital is Mahikeng, which is also the capital of the province. The main economic activity in Mahikeng is agriculture alongside scattered secondary manufacturing industries and retails shops. Ngaka Modiri Molema is an umbrella of the Mahikeng local municipality, Ramotshere Moiloa, Ditsobotla, Ratlou, Tswaing of which the Mahikeng local municipality in 2022 had total population of 354,504 according to STATS-SA (2022) and the town's weekly refuse disposal service dropped from 59,8% in 2011 to 34,6% in 2022.

3.4 Population and sampling

3.4.1 Population of the study

Rahman et al. (2022) defines the study population as all objects or groups of people that the scholar becomes interested in studying in his or her research. O'Sullivan (2023) notes that population is the entire set of relevant units of analysis from which a research information is needed for analysis. Thus, the population of this study comprised of local residences within the Mahikeng Local Municipality (MLM), 13 units and the managing officials in the waste management department at MLM in North West province.

3.4.2 Sampling

Two sampling strategies were adopted in this study. Firstly, a stratify simple random sampling technique based on the municipal boundary demarcation of the different residential units (Fig. 2C) was adopted to choose the participants to be included in the survey. A total of 12 000 households according to the data obtained from the MLM of all the household from the 13 units that was included in the survey. The Raosoft® calculator, was subsequently used to determine the required sampling size as reported in other studies (Gul et al., 2022; Kharaba et al., 2024; Khawagi et al., 2023; Sargidy et al., 2022). The total population size from the 12 000 households of the 13 units was 373 households that participated in the survey with a 95% confidence level and margin of error of 5% ($P > 0.5$). Rahman et al. (2022) describes a study sample as a sub-set of measurements taken from a population of concern to the researcher to explain the specific population. In qualitative research, a sample is a small number because respondents are chosen to reach a given proportion and in quantitative research, sample refers

to quantify and generalize the results obtained from a representative sample of the total population chosen (Mohajan, 2020). Sample size relies more on what the researcher wants to know; the aim of the investigation; the number of people that will be part of the research; and what will be done with the information obtained (Rahman et al., 2022). The inclusion criteria for the study population were based on only adults' residents, house owner while the exclusion criteria were infants and children (Browning and Lee, 2017). Mohajan (2020) remarks that the unit of analysis for a study should focus on participants, who have knowledge and experience as they can better contribute to a greater understanding of the phenomenon being studied.

Secondly, a purposive sampling technique was adopted to choose participants from the MLM managing officials. The participants were purposefully selected based on the predisposed information relevant to this study (Obilor, 2023; Zickar and Keith, 2023). Thus, only the managers in waste management unit were chosen for the questionnaires administration. In total, five managers were selected for the questionnaires administration.

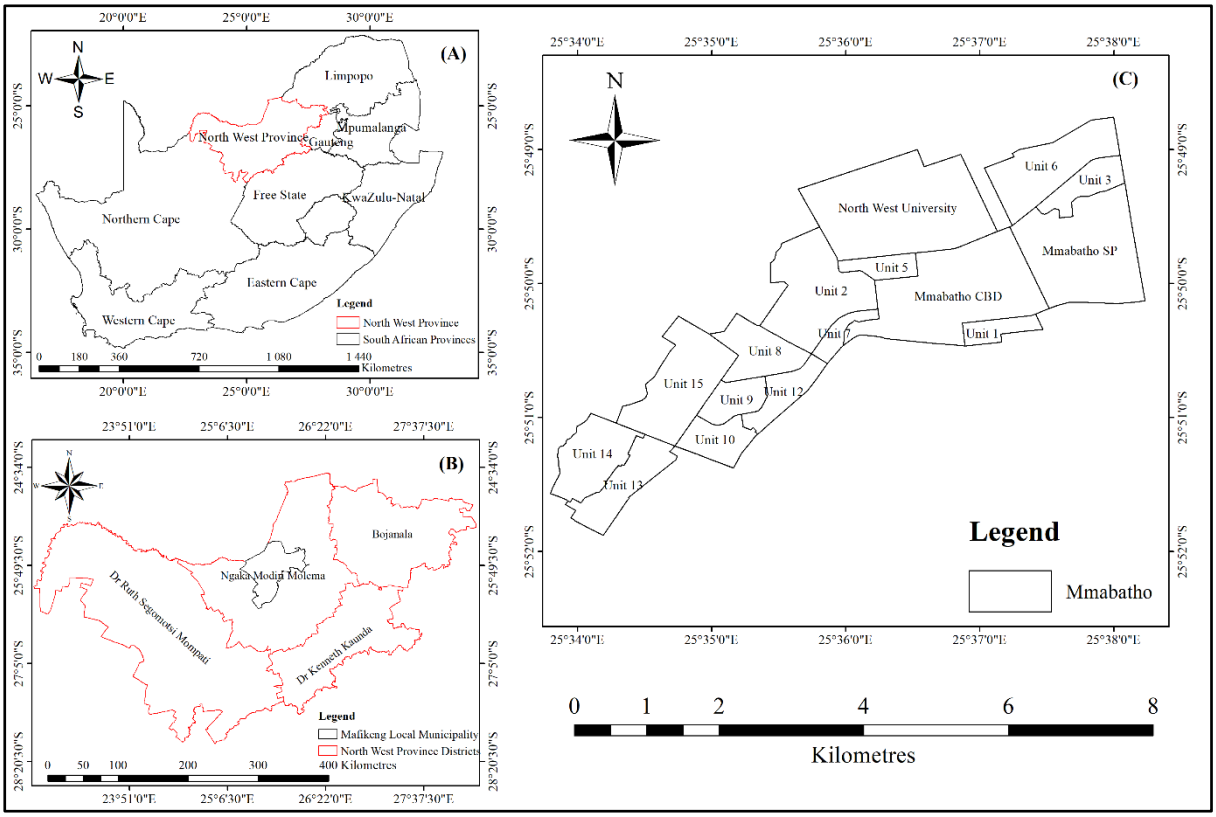


Fig. 2 - Map of the study area.

3.5 Pre-field visit

The field visit was important to ascertain the nature of the illegal household solid waste dumps, the frequency of solid wastes removal by the local municipality, the distance of the solid waste to residential households and reoccurrence of new illegal waste dumps sites. Also, it afforded an opportunity for the researcher to map out the different illegal waste dump using a handheld GPS (Global Positioning System) (Garmin). Field visits are crucial because they provide first-hand experience and insight into a particular subject or area. They allow for observation, interaction and visual appraisal and gathering of data, enhancing understand and enabling better decision making as depicted in Fig. 3 (Bergquist et al., 2023; Guo et al., 2023; Kong et al., 2023; Organization, 2023).

3.6 Data collection

Questionnaires were the main instrument used for data collection in this study. According to Taherdoost (2021), the benefit of using a questionnaire during data collection is that it gives the respondents ample time to answer the questions. The questionnaires used in this study consisted of semi-structured questions administered in order to probe the respondents' perception to household solid waste management (HSWM) (See appendix A). The questionnaire was divided into three sections: (1) household and demographic characteristics; (2) domestic waste disposal procedures; and (3) attitudes and perceptions concerning HSWM techniques. Data was collected primarily through a questionnaire sent to the participants.

The questionnaires were designed to gather general information of the respondents' biographic data, reasons for illegal household solid waste disposal, means of household waste disposal, strategies adopted to curb the proliferation of illegal household solid waste disposal and methods put in place by managing authorities from the municipality on HSWM. The questionnaires were self-administered to the respondents with a respond rate of 100%.

3.7 Data analysis and interpretation

The data obtained from the survey were coded and analysed using statistical package for social sciences (SPSS) version 24, to generate descriptive statistics, table and graphs. The multiple regression analysis was used to determine variables relationship. The dependent variable used for the multiple regression analysis were rating the current SWM by the municipality and the independent variables were the rest of the items on the questionnaires. The person correlation matrix was used to test for any significant relationship between age and income ($P > 0.5$). These variables were linked in order to determine the perception and attitude of the respondents in the study area.



Fig. 3 - Pre-field visit photographs. Picture A represents illegal dumpsite in Unit 15, Celosia close opposite Living Faith Primary, while picture B shows illegal dumpsite in Unit 13, Sepodisi Close (Both pictures date 25 April 2024).

3.8 Reliability of the research instruments

In order to ascertain the reliability of the questionnaires, the Cronbach's alpha was used to test all the items in the questionnaires to ascertain the validity of the generated and presented results. The analysis of the Cronbach's alpha test was $p = 0.84$, indicating that the items on the questionnaires were reliable and thus suited for the empirical investigation.

3.9 Ethical consideration

Prior to initiating the study, ethical clearance was obtained from the North-West University (NWU) Research Committee. The committee granted approval with the issuance of an ethical clearance certificate, reference number NWU-01237-22-A9 (see Appendix B).

3.9.1 Informed consents

All participants were assured of confidentiality and anonymity with regard to any information provided, and they were further assured and told that the questionnaire would only be used for this study reason. For the protection of the participants, all private information related to participants was not going to be named, would be kept secret by the researcher due to sensitivity of the subject under investigation. All the participants were free to not respond if they felt unhappy. The responses and results were treated with utmost confidentiality and no participants' names were mentioned.

3.10 Methodological reflections: Successes, challenges and adaptations

1) One of the methodological challenges we encountered involved the administration of questionnaires, as some participants were hesitant to take part. Due to strict ethical guidelines, these issues were carefully addressed. The researcher had to contact individuals personally to explain that participation was voluntary, and in some cases, meetings were scheduled at their convenience, which sometimes conflicted with the research timeline.
2) Secondly, some individuals were hesitant to complete the questionnaires because they believed it was a government attempt to monitor and potentially arrest them. However, after thoroughly explaining that their information would remain anonymous and would not be shared with the government in any way, they gained confidence and were willing to provide their information.
3) Thirdly, the staff at the municipality experienced scheduling conflicts because the research timeframe did not align with their work hours. To accommodate them and collect the necessary information, which ultimately led to the thesis being postponed and the timeline was adjusted. Consequently, the project needed to be extended due to these adjustments and time constraints.
4) Another challenge encountered during field visits was collecting data on individuals disposing of illegal waste, as most of these activities occur in the evening and early morning hours. This made it difficult to observe the people involved in waste disposal directly. As a result, the only time to confirm that waste had been dumped was during

morning visits, after the activity had taken place overnight. Since the disposal happens spontaneously at night, the research could not be conducted during those hours.

3.11 Conclusion

In this chapter, a careful selection of appropriate research methods and details, collection procedures, have been used to clearly explain the situation in Mahikeng. The study addressed why the analysis utilized qualitative and quantitative data collection techniques while the type of research was exploratory and brief. The collection of data used was in questionnaires format, which intended to produce a complete, cohesive and unbiased report on the findings about the perception influencing SWM in Mahikeng, South Africa.

Chapter 4

Data Analysis and Discussion

4.1 Introduction

This chapter presents and discusses the results of the empirical research on the perceptions influencing solid waste management (SWM). The results obtained are presented in the form of descriptive statistics such as tables, graphs, frequencies and percentages of responses reflected in the questionnaire. Similarly, correlation analysis was equally performed to further understand relationships amongst the variables. For the ease of data presentation and discussion, this chapter is divided into section A, which presents and discuss the results of the reliability test of the measuring instruments (questionnaires), section B that presents the demographic characteristics of the respondents, and section C that focuses on frequency of household solid waste disposal and collection, and explores contributing factors and perceptions towards solid waste disposal at illegal dumping sites.

4.2 Cronbach alpha test measuring instrument

4.2.1 Section A: Reliability tests of the measuring instrument

The reliability test was conducted using the Cronbach's alpha test. This test gauges how reliable a number of a questionnaire's items are. There are 0 to 1 dependability coefficients. A Cronbach's alpha of 0.8 or above is generally regarded as extremely dependable, and a number closer to 1 denotes increased reliability (Izah et al., 2023; Kennedy, 2022). Every one of the fifty-two items on the questionnaires that were given to the respondents in the research region was tested.

Table 1 - Statistics on reliability test.

Process quantity		
Cases	**N**	**%**
Valid	478	100.0
Excluded [a]	0	0
Total	478	100.0

Source: Authors'

Result obtained from Table 1 show that all survey information was included in the reliability analysis process and that none was excluded. This is consistent with the statement made by Hair and Alamer (2022) that in order to obtain an accurate reliability test, all available data

must be included in the analytical process so that it is possible to use the available data to corroborate each other.

Table 2 - Reliability test.

Cronbach's alpha	Number of items
.854	52

Source: Authors'

According to Table 2, the factor analysis of this question produced two components. The following items were included in the initial component, whose dependability was assessed. With a Cronbach alpha of 0.854, the reliability factor was outstanding. There were 54 items that were tested, and all question's item-total statistics were noted. Considering that the reliability test was effective and legitimate, the value of the Cronbach alpha if each item was deleted was not indicated. This result correlates well with that of Nawi et al. (2020), who states that a reliability test of 0.6 to 1 is an indication of high consistency and strong association for all variables.

4.2.2 Section B: Demographic characteristics of the respondents

The results of the demographic data of the respondents are presented in Fig. 4. The results indicates that the majority of the respondents belonged to the active working age group between 35-44 years with a total of 25% followed by those between 45-54 years, representing 21%. Respondents between the ages of 25-34 years represented 21% and 18-24 years represented 15%, while those between the age group of 55-64 years was 14% and 65 years and older represented 5%. The findings from this survey indicates that the opinions gathered strongly represented those within the working age group. According to Tian et al. (2023), the demographic profile of the studied population is important as it provides important attributes in understanding the population behavioural perception. This perception, also known as perceived behaviour, reflects the extent to which an individual feels and how he or she can actually carry out the behaviour, which is based on beliefs about factors that may facilitate or impede performance of the behaviour (control beliefs) (Ajzen, 1991; Ajzen, 2020). For instance, Abebe et al. (2021) attributed changes in behaviour to age disparity, which might have an influence on their behavioural attitude towards household SWM.

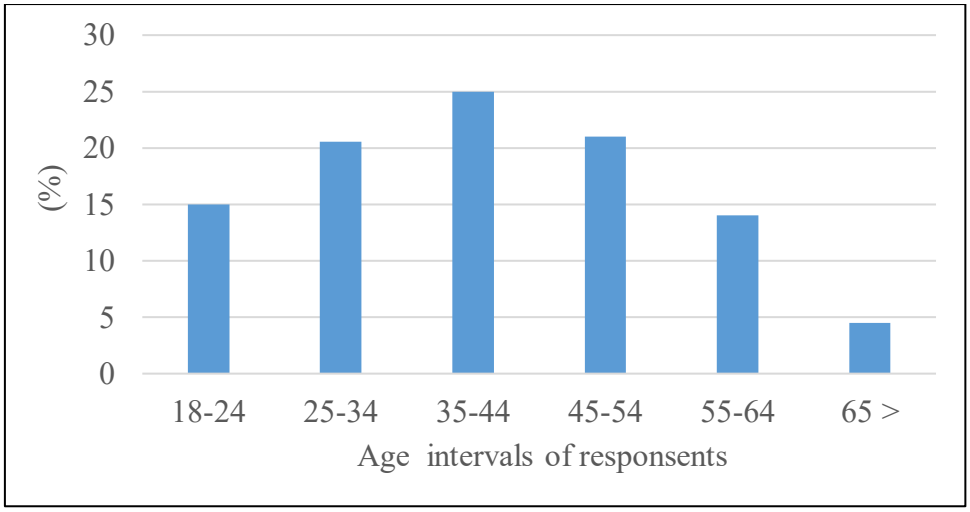


Fig. 4 - Age intervals of the population in the studied area.

The results of the responders' educational profile are presented in Fig. 5. The analysis of the results indicates that majority of the respondents were holders of matric certificate making a total of 26%, followed by diploma with 25%, degree with 23% and honours 16%. Master's holders represented 8% while those with a PhD accounted for 2%. The results of these findings further show that most of the people living in the sampled residential units were literate with holders of high school certificate. Thus, there was a general awareness from the educational perspective to environmental issues. Studies have shown that peoples with a certain education profile tend to respond differently and are more susceptible to respond and to be mostly engaged in pro-environmental behaviours (Hopwood et al., 2020; Hickman et al., 2021; Garrett and Bond, 2021). Also, people's educational profile, according to Ataei et al. (2022), are significantly influenced by their socio-cognitive level, resulting from social pressures, which might have an influence in engaging in pro-environmental behaviours. It could be concluded that the proliferation of illegal dumping sites within the residential units is not influenced by people's educational background.

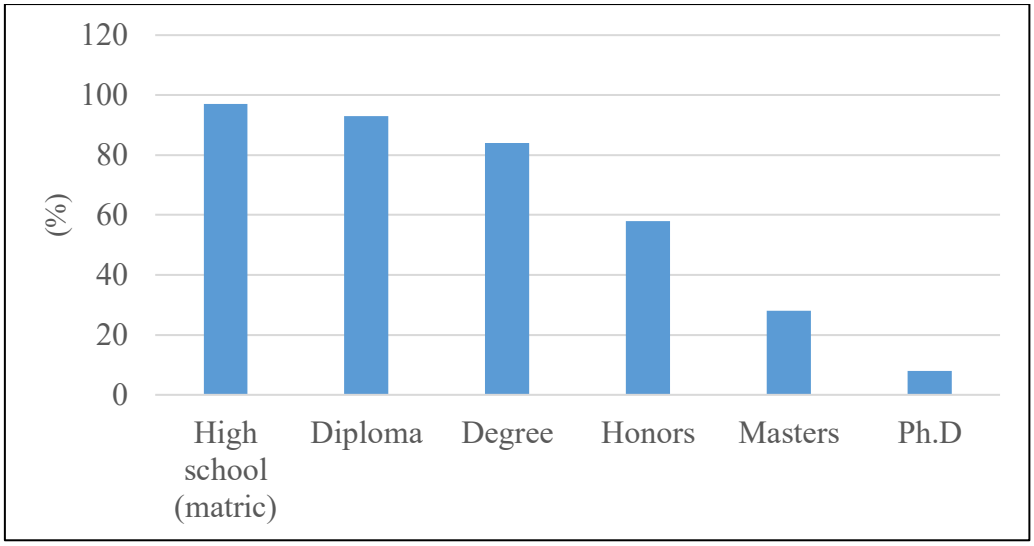


Fig. 5 - Educational profile of the respondents.

The professional occupation profile of the respondents is presented in Fig. 6. The results indicate that the number of unemployed respondents represented the highest with a total of 26% while 25% of the sampled respondents held professional/managerial positions. 18% of the respondents did not specify their occupation, however, 14% held sales/administrative positions. Holders of educator/teacher positions made up 9% of the respondents and skilled in trade represented 5%. Those in service/retail were represented by the lowest percentage of 3%.

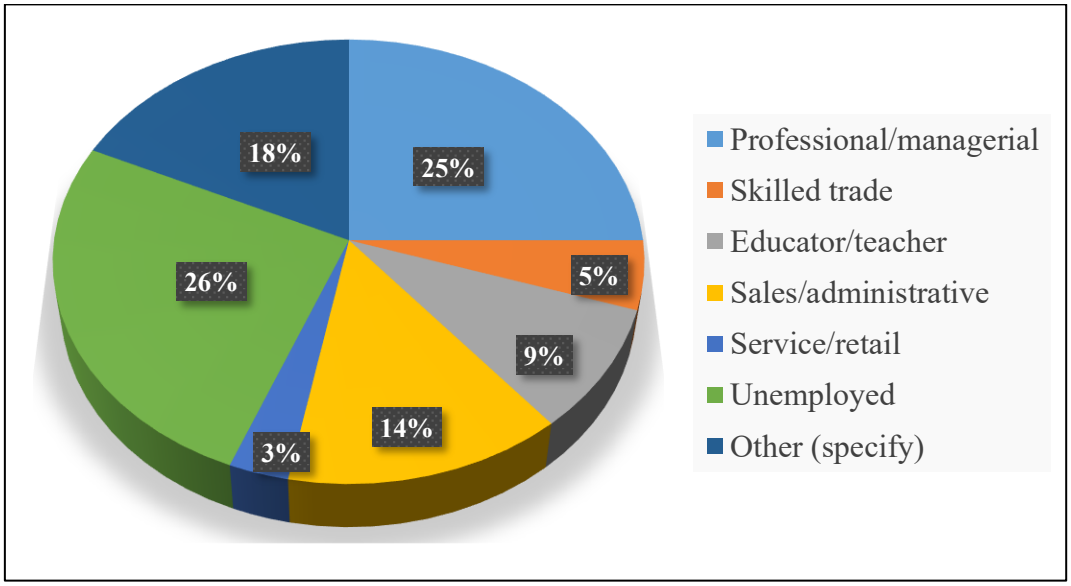


Fig. 6 - Occupational profile.

The results of monthly income range of the respondents are presented in Fig. 7. The results reveal that the respondents who earned less than R 5,000 were 32%, followed by those with income ranges of above R 20,000, representing 34%. Those whose income range was between R 15,000 to R 19,999 made up 14% and those between R 10,000-R 14,999 made up 11% of the respondents. Those whose income range was between R 5,000-R 9,999 represented 9% of the respondents. Household solid waste generation has been linked to income and lifestyle of individuals. Possible effects of higher income earners frequently consume more products and services, which increases trash production for both individuals and households (Zambrano-Monserrate et al., 2021). They might use more packaging, buy more goods, and throw things away more frequently. This may lead to increased waste production quantities (Han et al., 2018a). Communities and people with lower incomes might have less access to goods and services, which could lead to a decrease in waste production. However, because they have fewer alternatives and resources, they could also have trouble managing the trash they do produce (Zambrano-Monserrate et al., 2021). In general, income can affect how much waste is produced as well as how well communities are able to manage that waste (Browning et al., 2021).

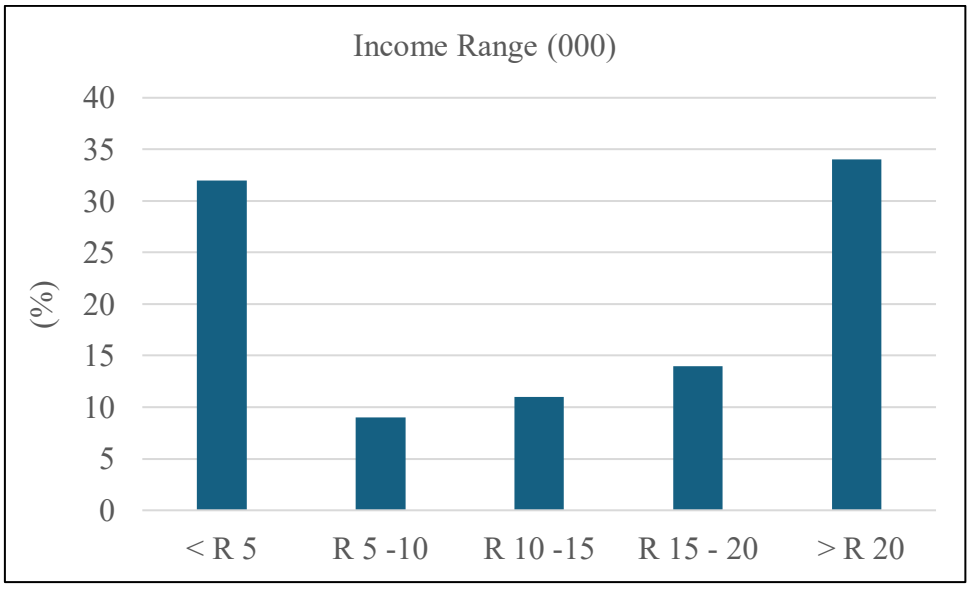


Fig. 7 - Income range of the respondents.

The survey results on individual household sizes revealed that 32 households reported to having only one resident, while 48 households indicated two residents. Additionally, 95 households were occupied by three individuals, and the maximum number of residents per household, as depicted in Fig. 8, was four. This trend may suggest a potential increase in waste generation as

household size grows. Similar findings by Syafrudin et al. (2023) indicate that larger households tend to generate more solid waste. However, Fadhullah et al. (2022c) present a differing perspective, suggesting that waste generation is not directly linked to the number of people per household. Albeit the results as observed from the field visit might suggest a likelihood of increase in household solid waste due to the increased number of individuals per household.

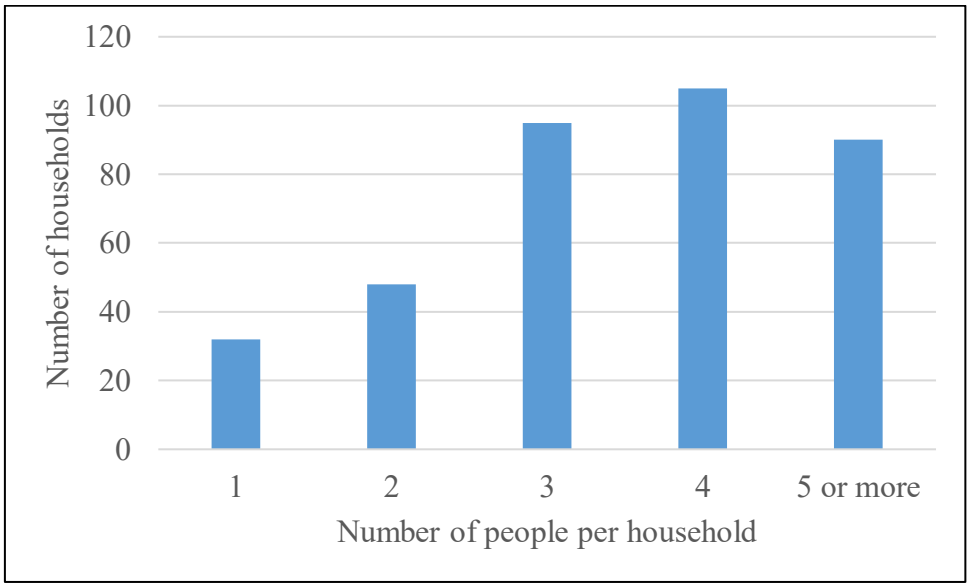


Fig. 8 - Number of people per household.

4.2.3 Demographic characteristics of municipal personnel in the unit of waste management

The analysis of the respondents' profile in the department of waste management is presented in Table 3. From the survey, the department of waste management had a total of five managers that were further broken down into three units namely, the unit of litter picking headed by 2 managers, unit of refuse removal headed by 2 managers, and the unit of illegal litter picking headed by 1 manager (Table 3). A general overview of the respondent characteristic in terms of age and gender revealed that from the five managerial posts, four were males and only one female. Similarly, the respondents age group revealed that four of the five managers age group fell between 45-54 while one was between 35-44. Similarly, Table 3 shows that 80% of the respondents were males while 20% were females. A breakdown of the respondents according to their respective units indicated that 40% of the respondents were in the unit of litter picking, while another 40% were in the unit of refuse removal and 20% were in the unit of removal of

illegal dumps as shown in Table 3. This finding was also an indication that the opinions gathered did not represent a balanced view of both males and females among the managers.

A study by Singhirunnusorn et al. (2012) demonstrated that gender disparity plays a crucial role in environmental managerial behaviours likewise, Hablemitoğlu and Özmete (2010) found that environmental conservation consciousness is more prevalent among women than men. This component is also influenced by past experiences, general women hygiene compared to men, and memories of hard times in waste management at household levels. Also, situational, cultural, and social constraints can encourage a particular gender to take certain responsibility at household level, in their communities or resources conservation in the workplace (De Clercq and Brieger, 2022). In other words, these results in this study agree with findings on gender differences in environmental evaluation and responsibility reported by Gholamrezai et al. (2021).

Table 3 - Sub-section unit involved in the waste sector.

Age group	Gender	Frequency	%	Unit of Waste management	No of managers
35-44	Male	4	80	Litter picking	2
45-54	Female	1	20	Refuse removal	2
	Total	5	100	Removal of illegal dumps	1

4.3 Section C: Spatial distribution of illegal MHSW in the study area

Solid waste generation and management reflects the current environmental and social status in each country. However, the rise of illegal dumping waste sites reflects the inability of municipal authority to proper manage household solid wastes. This is often due to the sporadic rise of illegal dump sites, which hinders the municipal ability to properly collect and dispose household solid wastes. Thus, it was important in this current study to map out the different illegal household waste dumping sites in MLM. The study entailed field visit to identify and numerically count from each of the residential units, mapping out sporadic illegal dumping sites. The results revealed that a total of 37 illegal dump sites were identified in all the residential units as shown in Fig. 9. Based on the municipal demarcation as shown in Fig. 9, Unit 10 had the highest illegal dumping sites with a total of 6, while Units 9 and 13 had a total of 4 illegal dumping sites each. Units 3, 5, 6, and 14 had 3 illegal dumping sites each while Units 1, 2, 7 and 12 had a total of 2 illegal dumping sites each. Similarly, Units 8 and15 recorded the least number of illegal dumping sites of 1 each. A closer analysis of the results from the mapping of illegal dumping sites suggests that the summation of all the illegal

dumping sites could double the number of the residential units thus confirming the rampant proliferation of illegal household solid waste illegal dumping sites in the study area and the need for a prompt intervention by the authority.

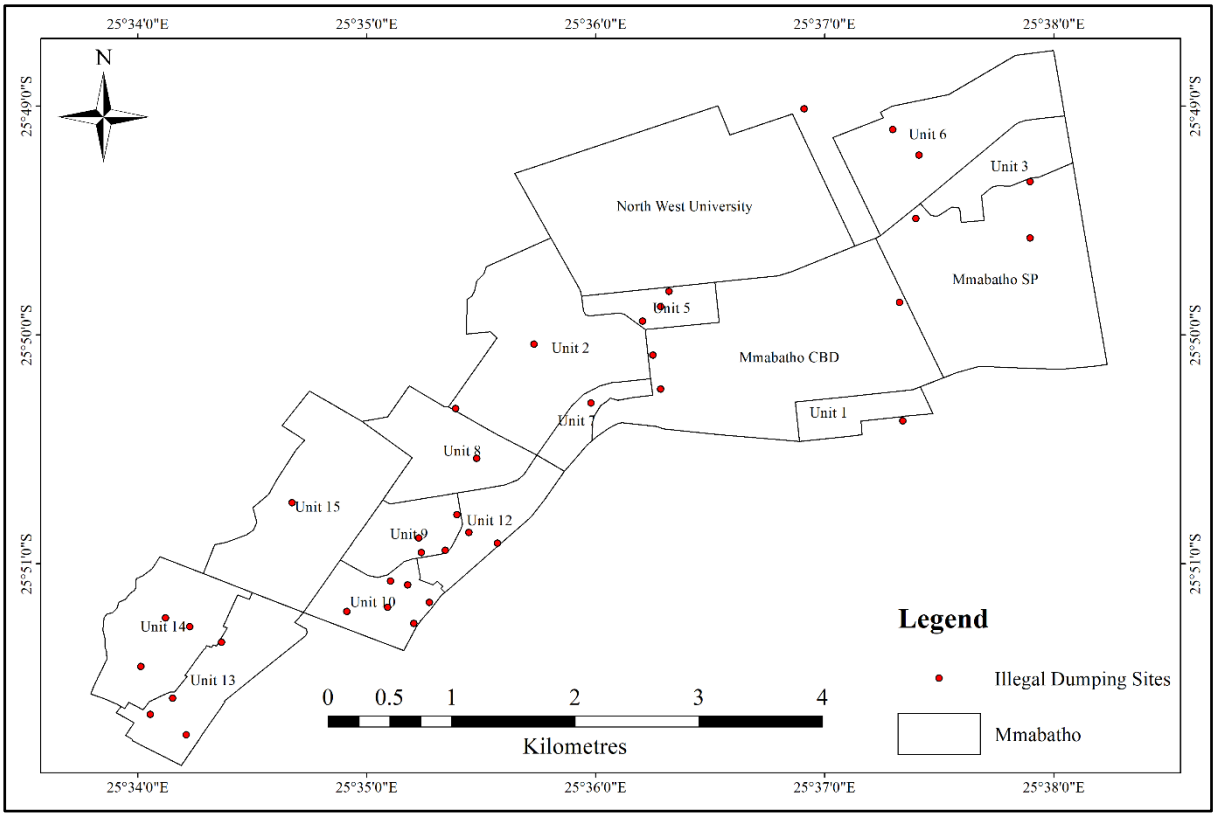


Fig. 9 - Illegal MHSW in the study area.

The proliferation of illegal dumpsites suggest that household solid wastes are indiscriminately dumped by inhabitants in any open and unoccupied space available. Alam and Qiao (2020a), reported high amount of household solid waste dump in into nearby open floodplains in the town of Dhaka in Bangladesh. Other authors have reported that human induce factors are of high significance in relation to environmental degradation and household wastes generation (Hirpe and Yeom, 2021; Constantino et al., 2022; Browning et al., 2021), which in most case, can be attributed to the respondents' attitude and behaviour (Seabi, 2022). In Iran, Gholamrezai et al. (2021) sought to investigate the role of social norms, personal norms, and perceived behavioural control on pro-environmental behaviour. The authors found out that personal norms, social norms, and perceived behavioural control had a significant effect on the pro-environmental behaviours. For instance, personal norms and people belief intrinsically play a role in responsible action towards performing pro-environmental behaviours through sustainable behaviour (Yusliza et al., 2020). Most people perceived that the municipality was

the sole standard authorised entity for household solid waste collection and was responsible for the rise in illegal dumping sites in the residential units. This assertion is supported by following respondent's remarks.

Comment 1"Municipality must take full responsibility for waste collection and disposal as we are paying rates and taxes"

Attempts to promote voluntary action will require an understanding of existing behaviour along with an understanding of how behavioural change can be influenced (Yazdanpanah et al., 2014). Thus, the failure of the municipality as the sole entity for household waste collection in the residential units might have been the cause of the proliferation of illegal dumping sites. According to the theory of planned behaviour, residents may resort to unlawful dumping when the municipality is the only one responsible for waste collection and fails to meet its expectations. These behaviours can be lessened by addressing these variables through enhanced community involvement, better service quality, and more support for appropriate waste management (Boakye et al., 2024). However, the daily generated MHSW is commonly disposed of by crude dumping in some areas, the theory of planned behaviour enables us to comprehend how societal norms, personal attitudes, and perceived control over conduct all affect the careless disposal of MHSW. To analyse attitudes about MHSW, one can get insight into the ways in which social pressures, attitudes, and perceived control, affect people's waste management activities (Boakye et al., 2024). Communities and legislators can endeavour to lessen the frequency of unlawful dumping and encourage improved waste management techniques by addressing these variables (Syafrudin et al., 2023).

4.4 Municipal household solid waste management in the area

Several factors were considered during this survey to probe the respondents' view on MHSW management in the study area. This involved respondents' perceptions to MHSW management, rating the current household SWM in the study area, reasons for improper MHSW management in the different residential units, and challenges faced during the process of removing illegal refuse from the different illegal dumping sites. The results presented as revealed in Fig. 10 indicate that a greater proportion of the respondents (41%) considered household SWM by the municipality to be slightly satisfactory, followed by 35% of the respondent that considered it to be unsatisfactory, while 20% considered it to be satisfactory, and 2% and 2% of the respondents considered it to be very satisfactory and extremely satisfactory respectively. Going by this assertion, one may deduce that household solid waste is not properly managed by the

municipality and is an issue, but the results further support the earlier result of the increasing numbers of illegal dumping sites as seen in Fig. 9.

Many communities throughout the world are dealing with serious problems like improperly managed home solid waste and the growth of illicit dumping sites. To lessen the negative consequences of illegal dumping, a multifaceted strategy including enhanced governance, public education, regulatory enforcement, and technology advancements is required (Vaverková et al., 2019). Furthermore, supporting sustainable waste management techniques, fostering community involvement, and incorporating informal trash management networks can all be very important in resolving this problem (Syafrudin et al., 2023).

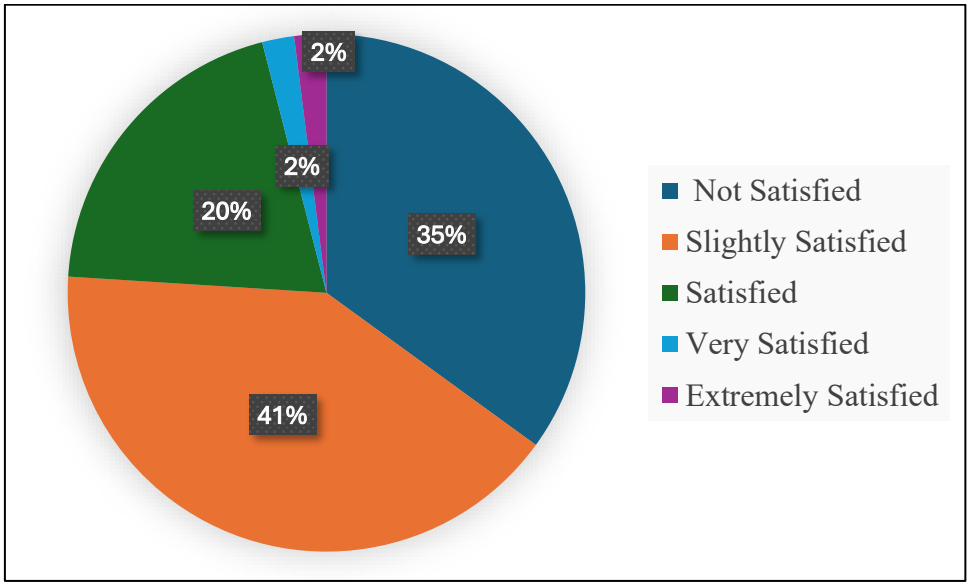


Fig. 10 - Respondents' opinion on household solid waste management by the municipality.

Regarding the rating of municipal service in terms of MSW management in the study area, the results are given in in Fig. 11. The respondents' survey indicated that 48% of the respondents considered MHSW management in the study area to be generally poor, while 27% considered it to be fair, 11% considered it to be good and 2% considered it to be excellent. On the other hand, 12% of the respondents held a neutral position. From these findings, it could be inferred that MHSW management by the municipality is a problem, further corroborating the earlier assertion about the rise of illegal dumping sites and why the general perception about MSW in the study area by the respondents was unsatisfactory.

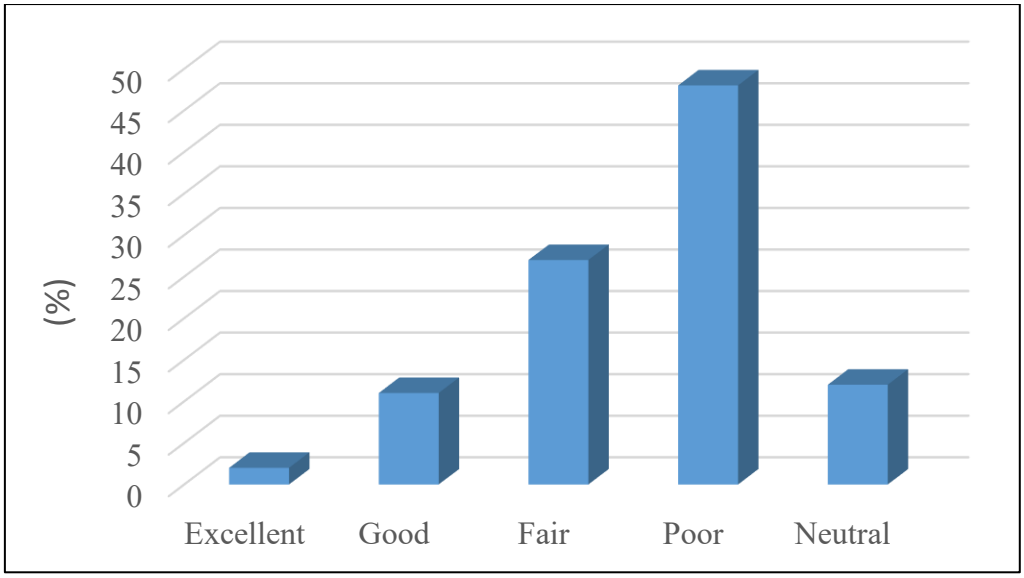


Fig. 11 - General MHSW management in the study area.

In addition, in terms of the reasons for improper household SWM in the study area, Fig. 12 shows that 32% perceived illegal and haphazard MHSW disposal by residents as the cause of poor waste management in the study area, 30% considered lack of awareness by residents as the main reason for poor household SWM, while 24% of the respondents were of the opinion that inadequate recycling infrastructure was the main reason for poor household SWM and 8% considered inadequate staff workers in the waste management department as the reason for poor household solid management. Only 6% of the respondents considered cost associated with operation as the reason for poor household SWM in the area. MHSW's improper management can have serious negative effects on the environment, human health, and economy (Tsheleza et al., 2019b). Recognizing these causes aids in efficiently resolving the issues. Municipalities can endeavour to create a more sustainable and healthier environment by addressing the underlying causes and consequences of inappropriate waste management (Pinho and Gomes, 2023).

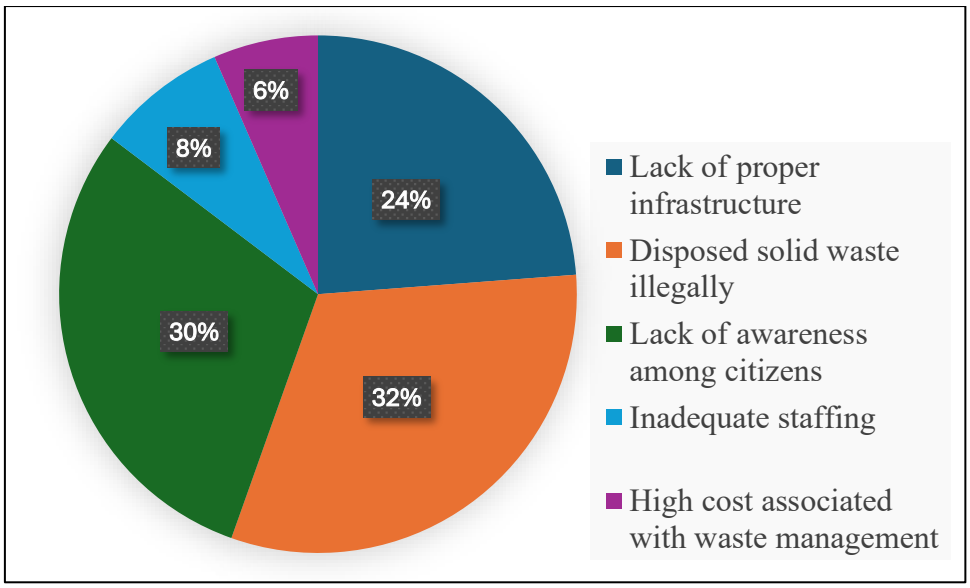


Fig. 12 -Reasons for improper household solid waste management in the study area.

Similarly, it was imperative to find out from the respondents' perspective of the cleaning operations carried out by the MLM of the different illegal dumping sites and the frequency of the cleaning operations are as shown in Fig. 13. The results indicated that 40% of the respondents declared that the illegal dump sites were not cleaned regularly, while 22% indicated that the illegal dump sites were cleaned regularly while 38% of the respondents maintained a neutral position. Also, it was important to find out from the respondents the frequency of the cleaning operation of the refuse removal. The results obtained from the survey indicated that a whooping majority of the respondents (62%) were unsure of the cleaning frequency of the refuse removal from illegal dumping sites, while 22% of the respondents declared that illegal dumping site were never cleaned, followed by 7%, who declared that the illegal dumping sites were cleaned once in every month and another 7% of the respondents declared that the illegal dumping sites were cleaned once a week while a small percentage (2%) declared that the illegal dumping sites were cleaned once every fortnight (Fig. 14).

The frequency of removal of household solid waste dumped into open spaces also known as illegal dumping sites requires prompt response from the MLM to safeguard the environment and public health safety. However, depending on how often the field is maintained, cleaned, and preserved, if not properly manage, may rather lead to environmental degradation. Resolving these issues through careful planning and community involvement can improve the efficiency and long-term viability of clean-up operations. Sustainable and efficient field

management requires striking a balance between the frequency of maintenance, the distribution of resources, and the demands of the community (Si et al., 2022).

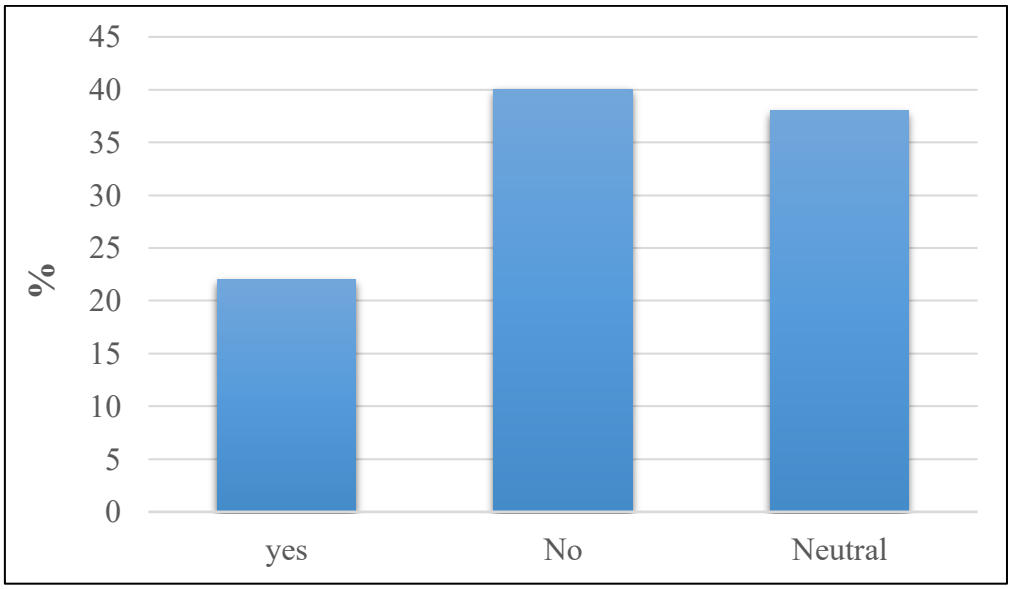


Fig. 13 - Awareness of MSW removal from the illegal dumping sites.

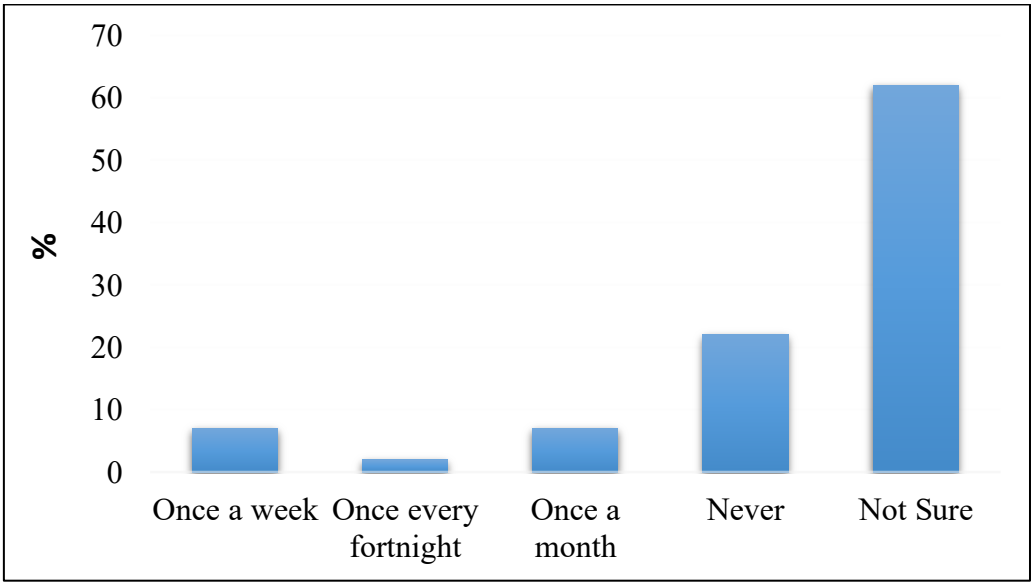


Fig. 14 - Frequency of refuse removal from illegal dumping sites.

4.5 Respondent's perceptions regarding household solid waste management in the study area

In terms of household SWM by the municipality, information obtained from the municipality webpage (https://www.mahikeng.gov.za/refuse-collection/) regarding the collection of household solid wastes is clearly stated. However, the continuous dumping of household solid

waste into open field suggests the lack of proper coordinated actions by the municipality to manage household solid waste as mentioned in section 2.15 in the literature review. Thus, there is a likelihood that some residence might dump their household solid waste in illegal dump sites. This is because the MLM is the sole authorised entity in charge of waste collection and disposal from the different residential units. It was therefore imperative to find out from the respondent if the frequency of waste collection should be increased as indicated by the comment below.

Comment "*How often do you think waste should be collected from your house?*".

The results as presented in Fig. 15 revealed that 1% and another 1% again of the respondents suggested that household solid wastes should be collected daily and once a month respectively, followed by 48% of the respondents, who suggested twice a week and the majority (50%) of the respondents suggested once a week. Sources of environmental pollution and degradation emanate from household solid waste, which are being disposal in a haphazard manner and should be collected frequently to avoid propagation. This assertion is supported by Syafrudin et al. (2023), who opined that waste collection schedule should be done frequently to avoid illegal dumping. Other scholars have identified household solid waste as the major source of environmental degradation and pollution. For instance, Alam and Qiao (2020b) stated that household solid waste contributes to over 90% of the entire MHSW streams and approximately 80% to 92% which is organic solid waste.

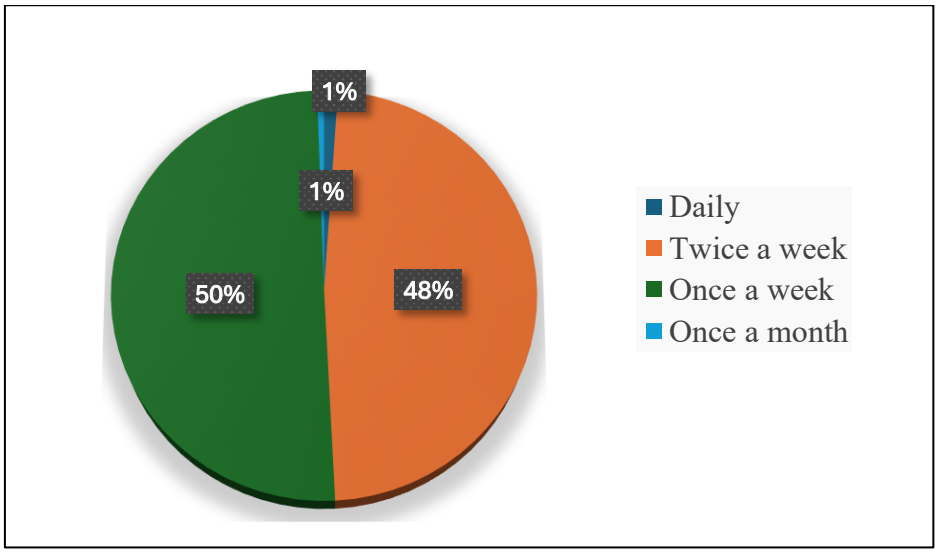


Fig. 15 - Frequency of waste collection from residential area.

Considering that the municipality was the only entity in charge of household waste collection, it was necessary to find out from the respondent the different means by which waste was collected from the residential units as revealed in section 2.12 and in Fig. 16. The results indicated that 53% of the respondents opined that their household solid waste was collected by the municipal truck, 33% of the respondents indicated that their household solid wastes was collected in dust bins before being disposed by the locally hired labours, 6% of the respondents indicated that they used their own personal cars for household waste disposal and 4% of the respondents hired cars for disposing their household solid waste. Judging from the responses, only 53% of all household solid waste was collected and disposed in an appropriate manner while the remaining 47% of the household solid waste was being disposed illegally. Also, a small percentage of the respondents (4%) used other methods like wheelbarrow, plastic, walk and drop, boxes of used products, hired skip at personal cost to dispose their household solid waste.

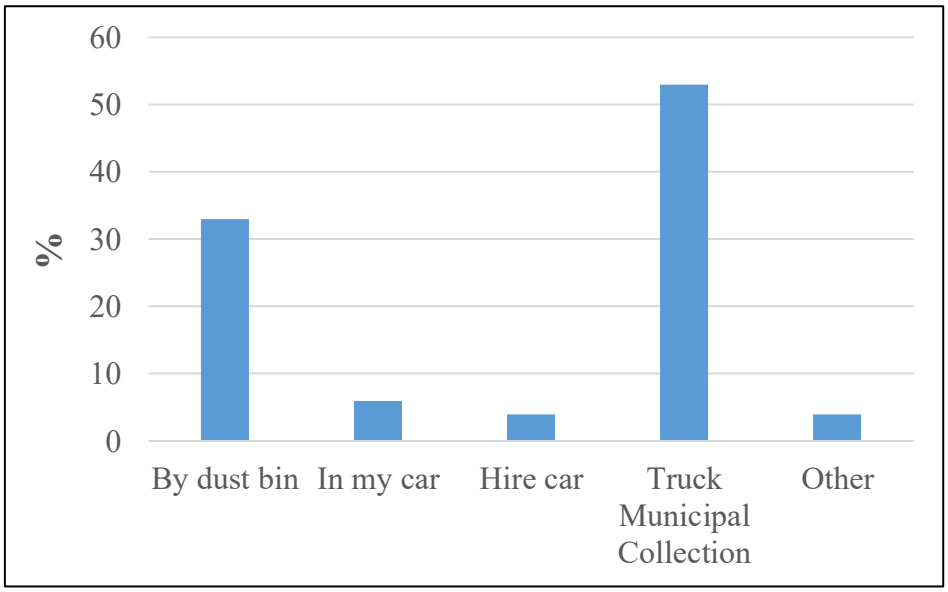


Fig. 16 Method of waste collection from households.

Regarding storing of household solid waste prior to municipal collection and personal disposal, different types of waste storing items were identified during the field visit such as large refuse bags, standardised municipal dust bins, supermarkets plastic shopping bags and other, which might include and not limited to boxes. The reason was twofold; firstly, to match the type of refuse found in the illegal dump site to the type of item indicated by the respondents and secondly, to ascertain the source of the refuse emanating from residential household. The following question item was asked.

Comment: "*What item do you use to store and dispose waste from your household?*".

The result reveal that 52% of the respondents used standardised municipal dust bins, 24% used large refuse bags, and 24% used supermarket plastics shopping bags (Fig. 17). Most of the refuse found in the illegal dumping sites were stored in large refuse bags and supermarkets plastic shopping bags and municipal refuse bins as shown in Fig. 19D. which constituted a serious environmental risk through illegal dumping. Different studies have shown that non-degradable plastic bags have a negative effect to the environment as well as on micro-organisms (Sharma et al., 2023; Molenveld et al., 2020; Khare and Khare, 2023). These non-degradable plastic bags have the life span of 450 years according to Kabir et al. (2021), which means they can stay for long time in the environment without being degraded.

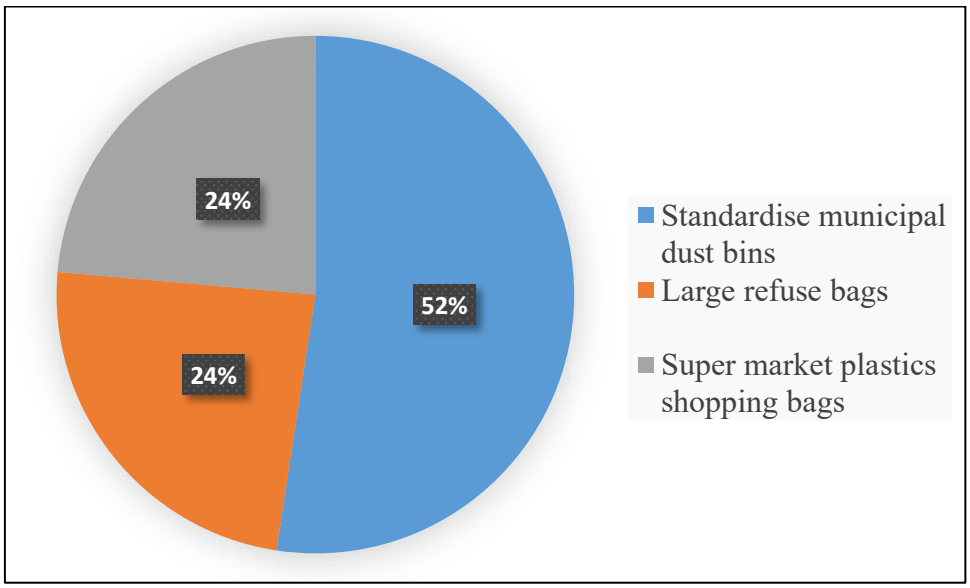


Fig. 17 - Items used to store waste before disposal.

Considering that the municipal standardised refuse bins were the most used to store household waste, it was therefore, important to find out from the respondents the reason for improper household solid waste disposal in illegal sites as shown in Fig. 18. The results indicated that the majority of the respondents (28%) were of the opinion that lack of proper bins/collection points in the area was the reason for the improper household solid waste disposal to illegal dumping sites. In addition, 24% of the respondents suggested the lack of proper access to waste disposal locations as the major cause of illegal waste dump, while 20% of the respondents were of the opinion that low turnout of municipal collections might have been the cause of illegal

household solid waste disposal. Only 17% of the respondents indicated that insufficient access to authorized waste collection bins and 13% of the respondents declared that not penalizing inappropriate behaviours in most cases were the causes of the improper disposal of household solid waste.

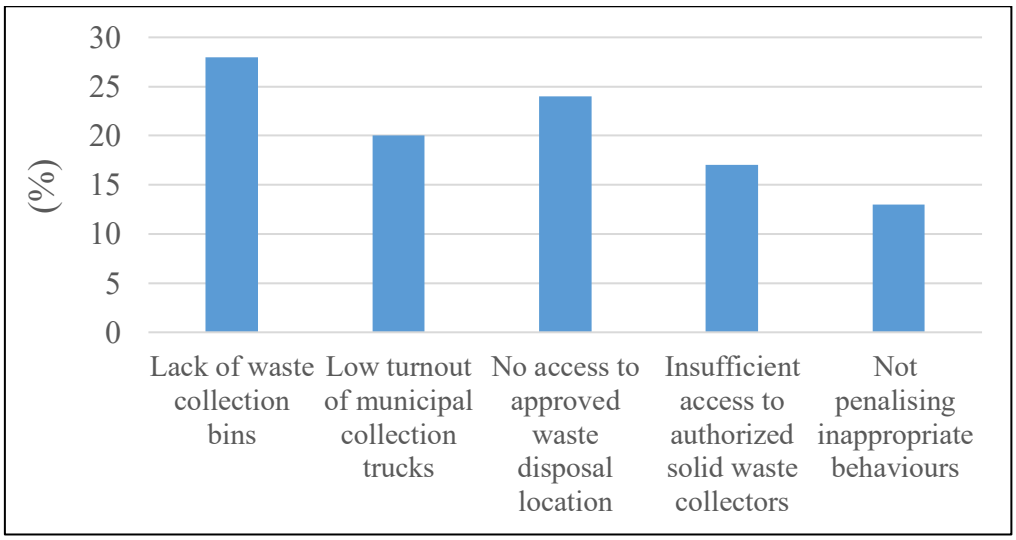


Fig. 18 - Reasons for improper disposal.

The results of the household solid wastes dumping location is presented in Fig. 19. The following waste disposal locations were identified; landfill, municipal collection, open field/space within residential areas. The result revealed that 66% of the respondents used municipal collection services to dispose their waste while 25% used open fields and 9% used landfills (Fig. 20).

From the respondents' responses, a fraction of the respondents (25%), who dumped their household solid wastes in the open fields was significant enough to cause the proliferation of illegal waste dumps within the residential units. Although the percentages of those, who dumped their household solid wastes in open fields were relatively small compared to municipal collection, continuous dumping of household solid waste in open fields could become hotpot areas and might eventually increase in size over time. It is widely accepted that negative behaviours towards the environment might be perceived as a norm over time. Ajzen (2020) opined that negative habits over time can become a norm and easily accepted by the society. Attempts to promote voluntary action will require an understanding of existing behaviour, and an understanding of how behavioural change can be influenced (Abadi and

Kelboro, 2021). Thus, when people see other engaged in certain behaviours, involuntarily, they will replicate the same behaviour.



Fig. 19 - A photograph of illegal waste dumping site in the study area: Date of photograph June 2023.

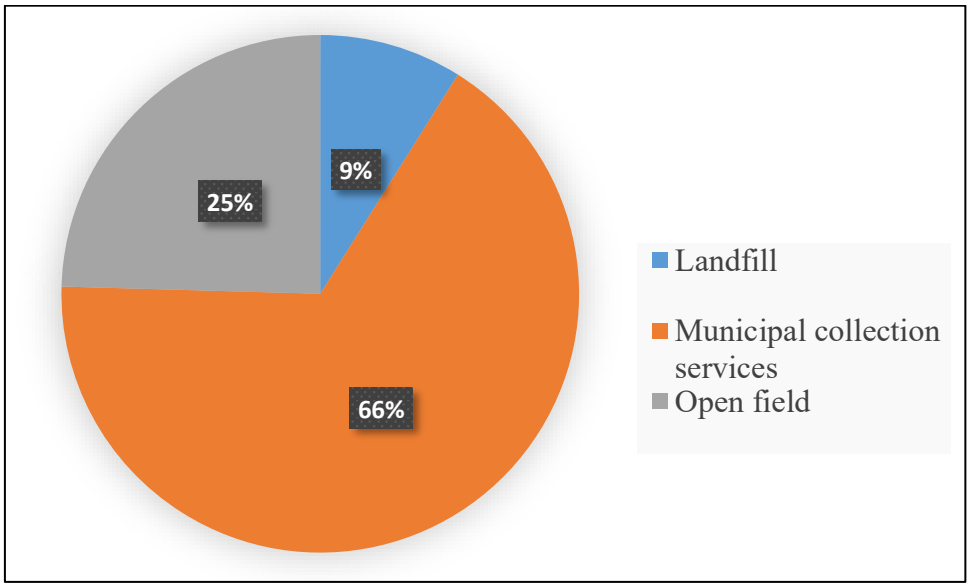


Fig. 20 - Household solid wastes disposal locations.

It was also important to determine the respondents' perspectives regarding the proximity of illegal dumping sites to residential areas. The findings clearly indicated that 79% of the respondents declared that the illegal dumping sites were located near their households, while 21% indicated that those sites were not in close proximity to their residences (Fig. 21).

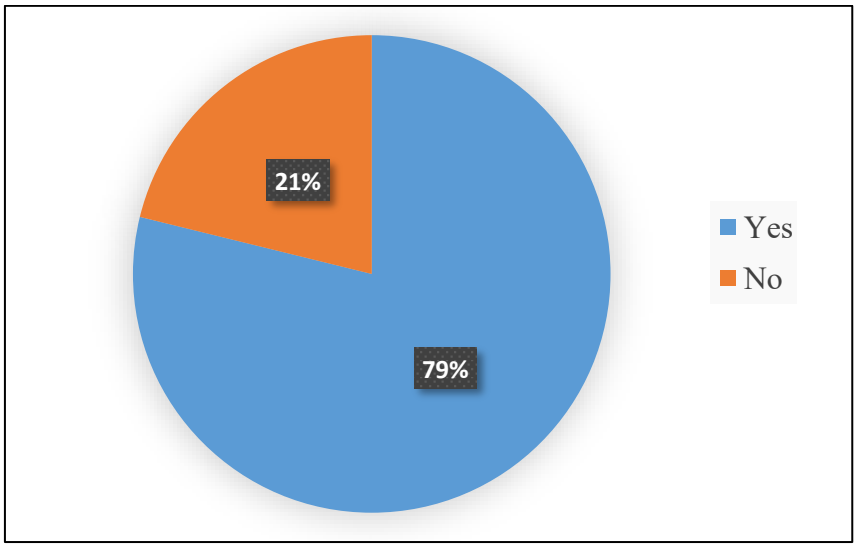


Fig. 21 - Proximity of illegal waste dumping sites to residential areas.

Similarly, a follow-up question included the distance of the illegal dumping site to the household. This was important to determine if dumping of household solid waste in open fields could cause degradation and human health risks associated with the illegal dumping sites close by to the human residences as is indicated in Fig. 22. For instance, different types of illnesses have been attributed to human exposure to untreated household solid wastes such as respiratory diseases (Chireshe et al., 2023), diarrhoea, bacterial infections (Perkumienė et al., 2023). The results showed that 60% of the respondents' households were less than 1 km radius to the illegal dumping sites and 40% of the respondents' households were located at above 1 km radius to the illegal dumping sites. This assertion was further confirmed during the filed visit as indicated in Fig. 3.

The results of the different possible health risks and environmental problems associated with illegal dumping sites as revealed in Fig. 23 indicated that that 25% of the respondents considered air pollution as a problem, 24% considered insect infections as the main problems, 23% considered land contamination as the main problem emanating from the illegal dumping sites while 17% considered harmful chemicals while 9% considered water pollution and 2%

attributed it to others such as lower house values in the market and hotspot for criminals to hide as the main problems. The same view was expressed and revealed as captured from the respondents.

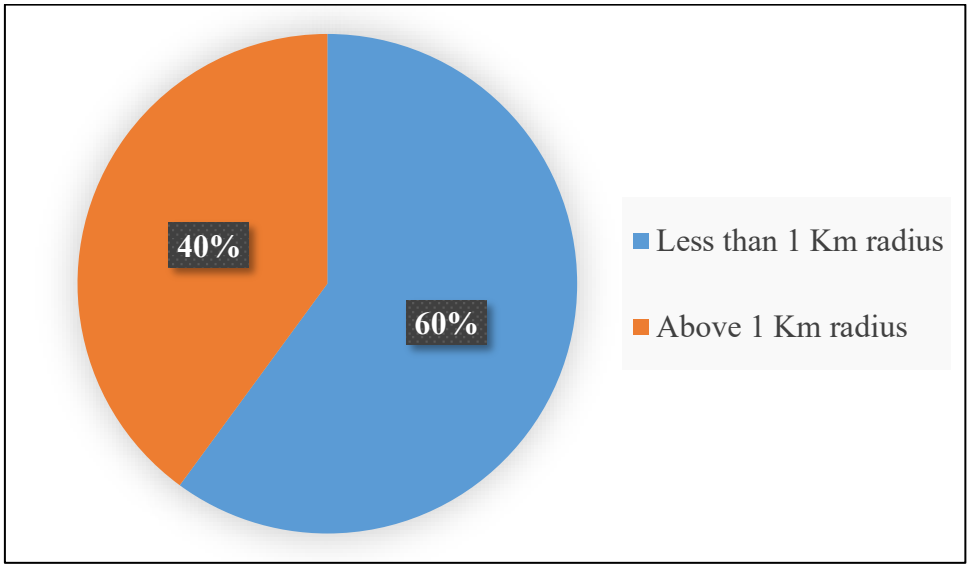


Fig. 22 - Distance of dumping sites close to residential units.

comments 1 "*The community should be told that an open piece of land is not for them to throw waste there*"

comment 2; "*They should be taught how to be tidy, and they should not allow people from far away to come pollute their areas as well*."

To guarantee a healthier living environment, addressing these issues frequently entails a combination of community action, legislative changes, and environmental regulations. For these solutions to be successful, cooperation between local governments, corporations, community organizations, and residents is frequently necessary (Si et al., 2022). Pinho and Gomes (2023) asserted that providing information is a frequently applied technique to raise awareness, it changes attitudes and enhances environmental conservation behaviour. Likewise, Si et al. (2022) presented the view that proper household waste education promotes awareness and has effects on general environmental concerns as well as on pro-environmental conservation behaviour. Thus, the more people know about waste issues and environmental conservation, the more likely it is that their attitude towards environmental management will be positive.

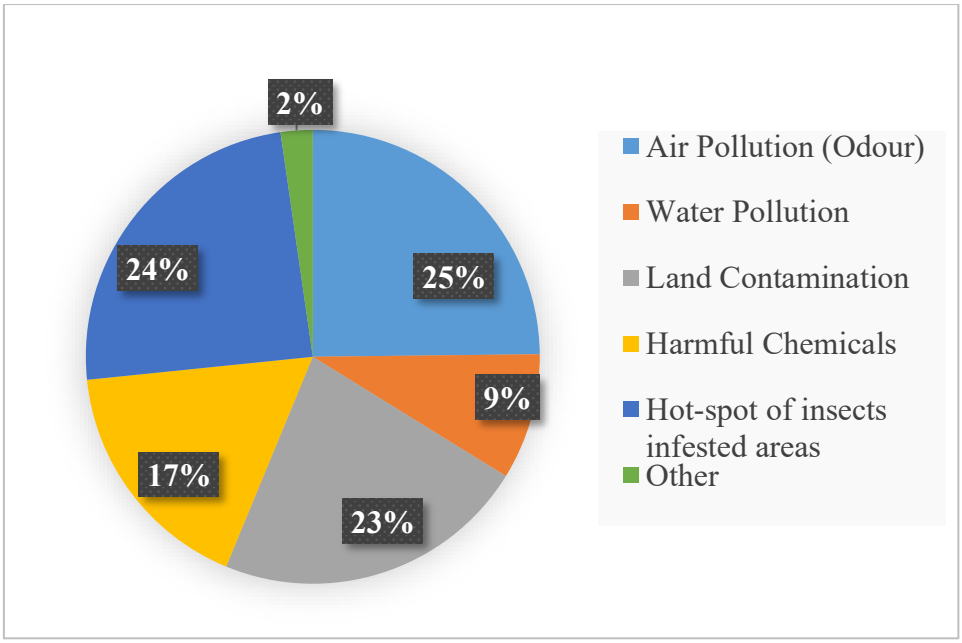


Fig. 23 - Environmental problems.

4.5.1 Strategies to effective MHSW in the study area

Municipality can be key players in the efficient management of MHSW by expanding the range of materials that are acceptable for recycling, guaranteeing convenient curb side pickups, and making investments in cutting-edge, sorting equipment at recycling facilities to boost productivity. Municipalities may greatly lessen the spread of MHSW, increase sustainability, and raise the standard of living for citizens by putting these strategies into practice (Hirpe and Yeom, 2021). The strategies include keeping an eye on and assessing waste practices by monitoring advancements to find opportunities for improvement, monitor waste production and recycling activities and regularly modifying waste management practices as well as considering evolving situations and their efficacy (Li et al., 2023). Residents can greatly improve the environmental health of their town, reduce MHSW, and encourage sustainability by doing these actions.

Fig. 24's results reveal that 39% of the respondents considered improving on existing waste methods, 30% considered door to door collection on daily basis to be the most effect way to solve the problem of illegal waste disposal while 19% considered an integrated waste management scheme through compost usage and 12% considered burning as an effective waste management strategy to be adopted. This is detailed in some typical comments by the respondents as follows.

Comment 1, "*with an ever-increasing population, relevant officials must utilize information collected by Census to improve their planning strategies for waste removal*".

Comment 2, "*They should charge the owner of the stands*".

Comment 3, "*Recycle materials and organize for government and industry to develop community recycling programs*".

Comment 4, "*Recycling the waste as some could be used at our farms*".

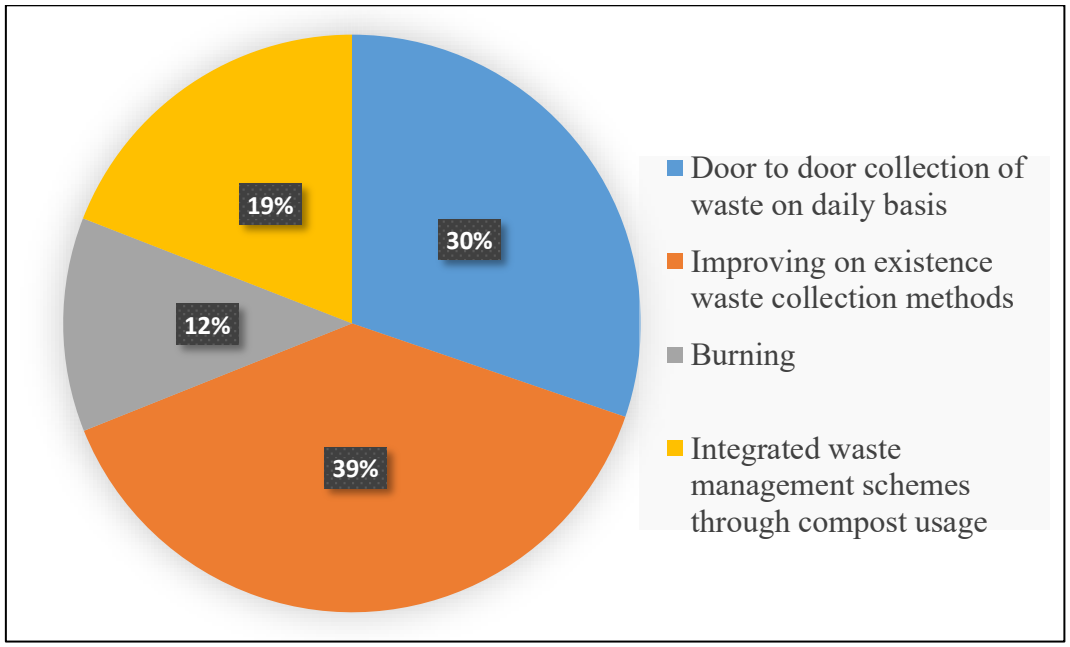


Fig. 24 - Strategies to effect MHSW management in the study area by the municipality.

Similarly, other measures that could be used for MHSW management proposed to be adopted according to the respondents' perspectives within the different residential units include waste separation for compost manufacturing, sensitisation campaigns among residence, encouraging private waste management collectors and encouraging recycling for cash among residential people. The results, as revealed in Fig. 25 showed that 41% of the respondents suggested recycling for cash as an effective measure to manage waste while 17% agreed with waste separation as it would add to recycling. Similarly, 28% agreed with sensitisation campaigns and 14% believed setting up private waste collectors as an appropriate measure in improving SWM. Different authors have reported that various methods provide an effective waste management strategy (Fang et al., 2023; Kurniawan et al., 2023; Mandpe et al., 2023). A study

by Niyommaneerat et al. (2023) investigated the value of recycling and concluded that it had a positive effect on the environment, the economy, and society. Also, the same authors further asserted that apart from promoting economic expansion and employment creation, recycling aids in resource conservation, pollution reduction, and energy savings. However, in order to fully realize these advantages, efficient procedures and processes are required, as is public involvement. This is detailed in typical comments by the respondents.

Comment 1, "*Educating the community about the importance of not littering and the effects that it has on the environment*".

Comment 2, "*By teaching people to stop throwing things on the street*".

Comment 3, "*An integrated plan whereby waste is segregated according to its colours and waste management education*".

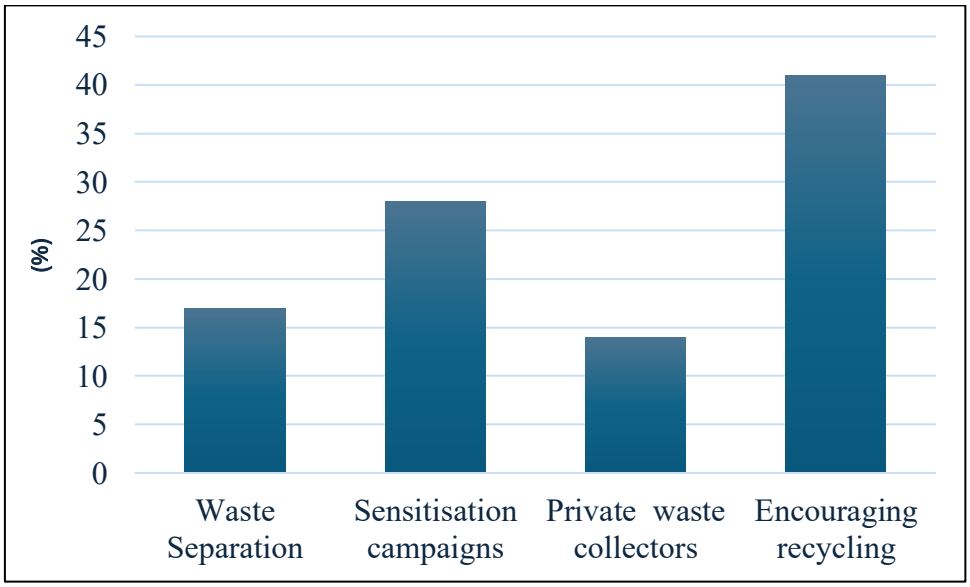


Fig. 25 - Measures to improve solid waste within the different residential units.

Also pro-environmental measure that could be used for MHSW management in the different units as revealed in Fig. 26 indicated that most of the respondents (37%) expressed their concern that creating local waste management committee in each residential unit will help curb waste proliferation while 29% of the respondents suggested converting household waste to biofuel, while 17% considered reducing single use plastic as a pro-environmental behaviour

and 17% believed in adopting new technology in waste sorting from a household level as is highlighted below by the respondents comments;

Comment 1, "*The community members should invest more in consuming or purchasing green products that are biodegradable -Re-use shopper bags to avoid once-off use of plastics to also save costs on waste management*."

Comment 2, "*Stricter regulations on illegal dumping*"

Comment 3, "*Better waste disposable sites i.e. designated area for construction rubble and other waste that would not fit it waste cans*".

When people portray favourable attitude and tendencies of engaging in pro-environmental behaviours as is according to Lede et al. (2019), they tend to generate a favourable cognitive framework by which they perceive and internalise the necessity to adopt environmental behaviours effectively and efficiently (Grilli and Curtis, 2021). In other words, as revealed in this findings, behavioural intentions have the potential to predict the behaviour of individuals, that is, if residents intend to adopt pro-environmental conservation measures in their environment, they are more likely to even perform conservation behaviours outside the said environment.

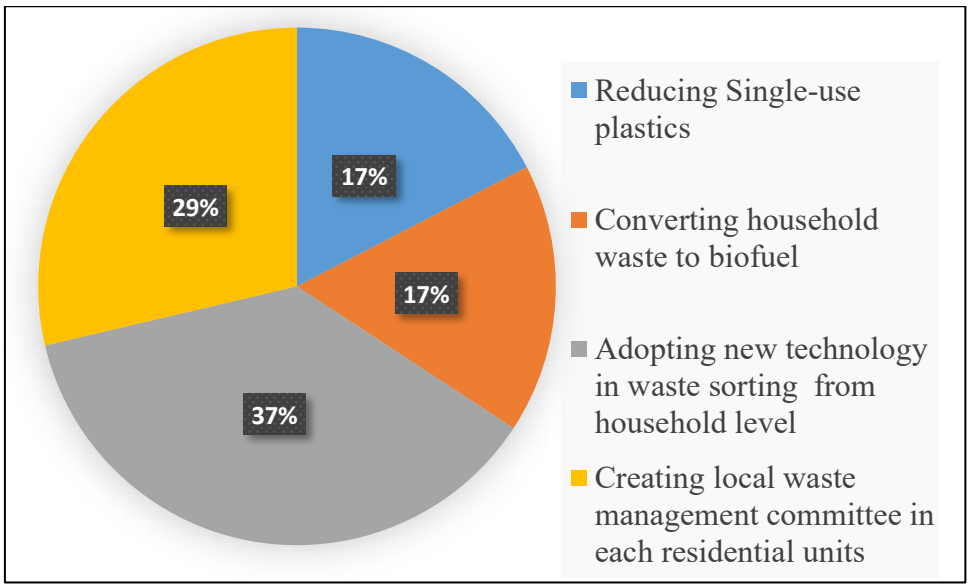


Fig. 26 - Pro-environmental measures to reduce proliferation of illegal solid.

4.6 Residents attitude towards MHSW

To determine the factors influencing MSW management in Mahikeng, South Africa, the age-income association was examined using Pearson correlation. According to Rakhra et al. (2022),

MSW have an impact on people's attitude towards effective waste management systems because they either have years of experience implementing new strategies in solving waste related problems or might have the financial means to do so. These factors may also be used to affect how successful individuals perceive and manage household solid waste. The chi-squared results for the different age groups and questions related to income are shown in Table 4 where any p-value of > 0.05 is considered not statistically significant.

Table 4 - Pearson correlation between age and income.

Variable		Q5 - What is your age?	Q11 - What is your income range?
Q5 - What is your age?		1	.558**
	Sig. (2-tailed)		<.001
	N	478	478
Q11 - What is your income range?		.558**	1
	Sig. (2-tailed)	<.001	
	N	478	478

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

Similarly, a greater majority of the respondents (> 50 %) shared their views on how to improve household solid waste in the different residential units by the municipality.

Table 5 presents the results of the factors associated with SWM in the study area. The findings showed a substantial correlation between the independent variables and revitalization-related parameters ($P < 0.05$, $F = 30.777$). Furthermore, a significant connection between the dependent and independent variables is indicated by the R value of 0.862. A helpful foundation for comprehending the variables influencing SWM procedures is offered by the Theory of Planned Behaviour (Ajzen, 2020). Governments and companies can create more successful interventions to promote responsible waste management practices by focusing on attitudes, subjective norms, and a perceived behavioural control. Strategies based on the TPB that can result in more sustainable and responsible waste disposal practices include making recycling facilities easily available, encouraging positive community norms surrounding waste management, and informing the public on the environmental advantages of appropriate trash handling (Boakye et al., 2024).

4.7 Effective waste management strategy

Governments and communities can take the following actions to address the problem of residential solid waste on unapproved sites. To solve these issues and enhance environmentally

friendly waste management techniques, a comprehensive strategy combining technology advancements, community involvement, and governmental legislation is required. Enforcing regulations is necessary as it is the responsibility of local authorities to uphold waste disposal laws and penalize unlawful dumping (Barapatre and Rastogi, 2022). Localities can spread knowledge about appropriate trash disposal practices and the repercussions of unlawful dumping.

Facilities for the convenient and accessible disposal of waste, recycling centres and landfills are examples that can help lower the motivation for illicit dumping (Han et al., 2018a). Surveillance and monitoring by putting in place these measures, authorities may identify and penalize criminals and prevent illegal dumping. Clean-up efforts that can lessen the harm to the environment, frequent clean-up events to clear trash from unapproved locations and follow ups on the workers and making sure to keep the open fields clean. It is imperative that people properly dispose of their household garbage by adhering to local ordinances and utilizing approved disposal techniques (Barapatre and Rastogi, 2022). The environment's sustainability as well as the health of communities depend on effective waste management.

To avoid contaminating the environment, encourage the reuse, repair, and purchase of products with little packaging as ways to reduce waste at the source (Si et al., 2022). Put measures in place to cut back on disposables and single- use items. Provide extensive recycling initiatives that include recycling facilities and curb-side pickups for commodities such as cardboard, paper, glass, plastics, and metals (Li et al., 2023). Inform the public about the recyclables that are accepted in the community (Si et al., 2022). Encourage the composting of organic waste, such as leftover food and yard waste, to create beneficial composts for improving soil and to lessen the quantity of organic matter that ends up in landfills (Seabi, 2022). To avoid contaminating the environment, develop appropriate plans for the disposal and recycling of hazardous products, such as chemicals, electronics, and batteries (Oyinlola and Kolade, 2023). Encourage businesses and homes to sort their garbage into distinct categories (such as organic, non-recyclable, and recyclables) in order to facilitate a more effective waste management.

Create a dependable and effective garbage collection and transportation system to stop littering and make sure that waste is delivered to the right places (Amaral et al., 2022). Examine possibilities for incineration or waste-to-energy plants to produce heat or power from non-recyclable garbage while abiding by tight emission regulations (Dlamini et al., 2018). Launch public awareness programs to inform the public about appropriate waste disposal techniques,

the value of recycling, and the need to reduce waste, create parks and gardens from the open fields. To guarantee adherence by individuals, companies and municipalities must establish and implement laws, rules, and regulations pertaining to waste management (Barapatre and Rastogi, 2022). Enable manufacturers to be held accountable for the product's end-of-life management by implementing EPR (extended producer responsibility) programs that promote environmentally friendly and recyclable product design (Orhorhoro and Oghoghorie, 2019).

Table 5 – Current household solid waste management.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.265	.159		1.669	.096
	Q19 - Current MGT	-.478	.056	-.359	-8.597	<.001
	Q10 - Household size	.108	.030	.114	3.567	<.001
	Q3A1 - Environmental problems	.267	.091	.087	2.946	.003
	Q14 - Appropriate Waste Measure	.101	.040	.083	2.563	.011
	Q17A1 - Challenge to Effective Mgt.	.026	.093	.008	.274	.784
	Q20 - Waste disposal location	-.117	.206	-.021	-.567	.571
	Q25 - Proximity to open area	.235	.109	.098	2.163	.031
	Q21A1 - Proximity land field area	.633	.234	.204	2.709	.007
	Q23A1- Dustbin mode of collection	.167	.133	.052	1.256	.210
	Q23-Transportation mode	.282	.198	.046	1.426	.155
	Q25 - Field maintenance period	.087	.044	.117	1.990	.047
	Q26A1 - Disposal Method	-.136	.133	-.044	-1.026	.305
	R	.862[a]				
	R^2	.743				
	F	30.777				
	P	.01[b]				

*Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed)*

a. Dependent Variable: Q2 - How do you rate the current solid waste management by the municipality in your neighbourhood?

Monitoring and analysing data on waste production, collection, and disposal are crucial for identifying areas for improvement and evaluating progress towards waste reduction and diversion goals. Sustainable procurement encourages public and private organizations to purchase products with minimal packaging, made from recycled materials, or designed for easier disassembly and recycling (Si et al., 2022). Investing in research and the development of innovative waste management solutions, such as advanced recycling methods or waste-to-resource technologies, is essential (Dlamini et al., 2018). Collaboration with businesses, non-governmental organizations, and other local stakeholders can help build support and share resources for effective waste management.

Each sustainable waste management project must have a "functioning business model" to be successful. The business plan must take into account the regional environment and emphasize its "strengths" (Hettiarachchi et al., 2018a). By implementing suitable user fees, subsidies, and cost-recovery techniques, make sure the waste management system is financially viable. An

effective waste management plan should be flexible enough to accommodate local circumstances, laws, and resource constraints (Barapatre and Rastogi, 2022). It should strive to decrease the amount of garbage produced, boost the rates of recycling and composting, and lessen the negative effects of waste disposal on the environment and society (Seabi, 2022). Furthermore, the public's involvement and education are essential components of any successful waste management program.

Through the recovery of valuable recyclables, the waste sector can provide significant opportunities for improving livelihoods, creating jobs, and developing businesses (Godfrey et al., 2017). Therefore, it is crucial to understand local environmental perceptions before implementing solid waste management strategies (Buenrostro et al., 2014). Environmental, social, technical, technically skilled human resources, financial and technological resources, resource recycling, environmental pollution awareness programs, and public participation, are all part of the effective waste management practices. In order to curb illegal dumping (Fig. 27) the environmental laws must be adhered to and enforced.

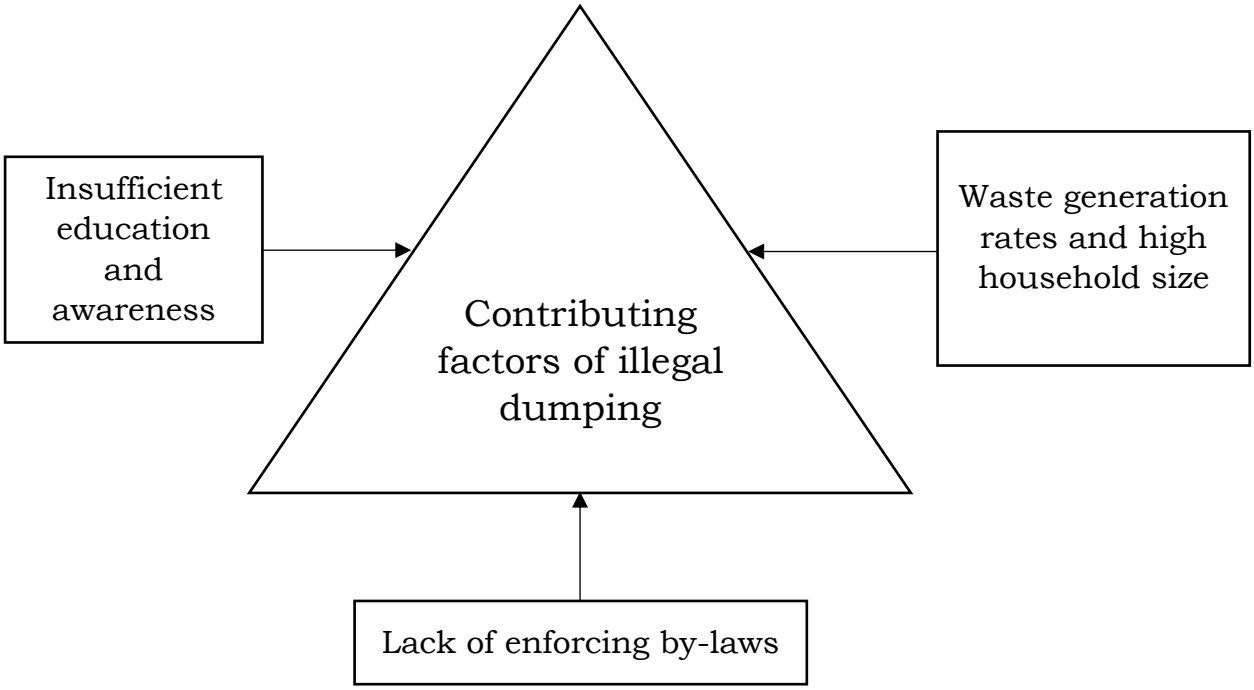


Fig. 27 - The factors that influence illegal dumping in residential areas.

Waste management issues arise as a result of human conduct, changing one's behaviour is the key to finding solutions (Chikowore, 2021). When launching new waste management initiatives, it is important to consider the existence of the informal sector and its current

contribution to the local economy because the abrupt removal of their services can undoubtedly have a detrimental effect on local economies (Hirpe and Yeom, 2021). On the other hand, if carefully planned to be included in any new waste management systems, the informal sector delivers a cost-effective labour force (Hettiarachchi et al., 2018b).

A comprehensive waste management system, including all phases from garbage collection and transport through waste treatment and disposal, is necessary for the sustainable development of suburban areas (Amaral et al., 2025882). The amount of garbage and its characteristics are intimately correlated with these stages. Based on faulty predictions of waste generation and characteristics, it is challenging to optimize the design of the necessary infrastructure and facilities, or even management techniques (Han et al., 2018a). Indeed, managing solid waste is a major global concern with wide-ranging effects on the environment, society, and the economy. Solid waste must be handled and disposed of properly to prevent pollution, habitat loss, problems with public health, and resource depletion (Lendelvo et al., 2023).

Understanding these perceptions is key to developing strategies that resonate with a wide range of stakeholders, including policymakers, industry leaders, local communities, and individuals. By analysing factors influencing these perceptions, ranging from cultural norms and economic factors to environmental awareness and technological progress, this study sought to provide actionable insights for fostering inclusive, efficient, and environmentally responsible waste management systems. Chapter 4 offered a multidimensional analysis of the complexities surrounding perceptions in waste management, providing a comprehensive framework for stakeholders to effectively navigate and leverage these perceptions. By bridging the gap between perception and practice, the chapter aimed to guide the development of sustainable waste management solutions that were both technically sound and socially and culturally aligned with the diverse needs and expectations of communities.

Chapter 5

Summary, Findings and Recommendations

5.1 Introduction

Having determined the perceptions influencing household solid waste management (HSWM)in Mahikeng, South Africa. In this chapter, the research was concluded by examining three distinct subjects. First, a recap of all the work completed from Chapter One through to Chapter Four. Second, this chapter provides a conclusion to the study based on the objectives mentioned in Chapter One and the data acquired in the previous chapter. Finally, recommendations are provided.

5.2 Findings of the study

According to Objective 1, which was to map out the different illegal solid waste dumping sites in Mahikeng, the following are the findings: 37 illegal dump sites were identified in all of the 13 residential units based on municipal demarcation, Unit 10 had the highest number of dump sites and total of 6 illegal dumping sites, while Units 9 and 13 had a total of 4 dumping sites and 4 illegal dumping sites apiece, while Units 3, 5, 6, and 14 had 3 illegal dump sites each while Units 1, 2, 7 and 12 had a total of 2 illegal dumping sites each. Similarly, Units 8 and 15 recorded the least number of illegal dumping site of 1 each. The continuous increase of illegal dumping sites especially close to residential units causes flies, odour especially during the heatwaves.

Objective 2, which was to examine the frequency of household solid waste disposal and collection. The following were the findings: only 53% of all household solid waste was collected and disposed in an appropriate manner while the remaining 47% of household solid waste was being disposed illegally. Also, a small percentage of the respondents (4%) used other methods like wheelbarrow. The increase in the proliferation of illegal waste increased as it was seen during the field visits.

Objective 3, which was to examine contributing factors and attitude towards solid waste disposal at illegal dumping sites in Mahikeng. The findings were as follows, there were various critical factors, challenges, such as the growth of the population and urbanization as the production of solid waste also rose, lack of adequate waste management funding, and policy enforcement. Lack of infrastructure was a major problem since creating and maintaining waste management infrastructure takes a large expenditure that may not be feasible in all areas.

Objective 4 was linked to chapter 4 which was to design an effective waste management strategy for Mahikeng,

5.3 Recommendations

The researcher thus proposed the following recommendations considering the study's findings: To decrease the amount of waste generated in households, it was advised that the promotion of the reduction, reuse, and recycling of waste methods be strengthened. This would lessen the quantity of waste, particularly non-biodegradable waste, that is dumped in open spaces. Waste recycling operations should be started by local communities. These initiatives must be long-term to generate revenue and benefit the municipality as well as the community. Another thing is to prevent gardeners from emptying the trash cans in the open fields while tending to the gardens, the municipality should collect rubbish at least twice a week. With the aim of improving the current waste management practices and safeguard our environment, the government and its partners should offer outreach programs in addition to the EPWP, awareness campaigns, and capacity-building within communities.

5.4 Conclusion

This research focused on Mahikeng as the study area, with the objective of understanding the perceptions that influence HSWM. To achieve this, the study involved mapping various illegal solid waste dumping sites, analysing the frequency of household waste disposal and collection, examining contributing factors and attitudes towards illegal dumping, and formulating an effective waste management strategy for Mahikeng. The rise in illegal dumping could be attributed to unpredictable demographic changes and consumer spending patterns. Additionally, the theory of planned behaviour was discussed and explained, while the methods of data collection and analysis were outlined. The research delved into the perceptions that shape SWM practices. These perceptions, as a lens through which individuals and communities engage with waste management, are crucial in determining the effectiveness and sustainability of waste management efforts. This study examined how perceptions impact decision-making, policy development, and community involvement in waste management.

Based on the findings presented, it is evident that there is a negative relationship between the public, the environment, and the municipality. However, this issue can be effectively addressed with the implementation of appropriate controlled variables. Furthermore, it is essential for community councillors to ensure the enforcement of local bylaws, as these regulations are designed to benefit and support the community. The implications of the study findings and what they mean for improved solid waste management in Mahikeng is a more robust and

sustainable SWM system, decreased hazards to the environment and public health and increased public involvement and confidence in waste management.

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Appendices

Appendix A

Hello: You are invited to participate in our survey Perception influencing solid waste management in Mahikeng. The purpose of this survey is to probe the perception influencing the solid waste management in Mahikeng, particularly in the residential units. Determining the contributing factors of illegal waste dumping is pre-requisite in proposing a sustainable solution to curb the problem of illegal waste proliferation in the different residential units in Mmabatho. Participants · Participation is open to all members in the Mahikeng municipality involved in the waste department. The representatives or managerial members in the waste departments. Confidentiality and protection of identity Participation is voluntary, and you are free to withdraw your participation at any time. Participants identities will remain anonymous and all the information you provide will remain confidential. The participants and researchers can collectively decide what to be used for research purposes. The data will be kept safe on a password-protected document. If you have questions at any time about the survey or the procedures, you may contact Ms Charity Molefe at 0736710962 or by email at Charity.Molefe@nwu.ac.za Dissemination of findings Study results will be widely disseminated and will used to inform current municipality authorities regarding the perception influencing solid waste and holistic solutions to waste management. A report of the summary of the main findings will acknowledge all participant's contributions, because participants are considered as co-researchers. Please start with the survey now by clicking on the Continue button below.

1. SECTION A (Demographic data) What is your age?
    1. 18-24
    2. 25-34
    3. 35-44
    4. 45-54
    5. 55-64
    6. 65 or older

2. What is your gender?
    1. Male
    2. Female

3. SECTION B (Waste management) Which sub-section unit are you involved in the waste sector
    1. A. Unit of litter picking
    2. B. Unit of refuse removal
    3. C. Unit of removal of illegal dumps

4. SECTION 1 (LITTER PICKING) Number of personnel in the unit of litter picking
    1. 0-5
    2. 6-10
    3. 11-15
    4. 16-20
    5. 20>

5. In your opinion, do you think the number of personnel assigned for each daily task is enough, if not propose the number?

6. What do you think are the challenges in litter picking?
    1. Lack of personnel
    2. Lack of funds to pay the personnel
    3. Slow recruitment of personnel
    4. Lack of plastic bags
    5. Lack of litter picker sticks

7. How often in a week is waste/ litter picked?
   1. Everyday
   2. Once a week
   3. Twice a week
   4. Three times a week

8. Do you think improving the existing method of litter picking can solve the problem of waste proliferation in the environment?
   1. Yes
   2. No

9. In your opinion, why do people litter in the residential areas?
   1. No refuse collection bin
   2. Lack of environmental education
   3. Unknown schedule for waste collection by municipality
   4. No legal action by authorities by the municipality

10. How satisfied are you with the following:

	Very dissatisfied	Not satisfied	Neutral	Satisfied	Very satisfied
daily tasks allocated to your unit	❑	❑	❑	❑	❑
resources allocated to your unit to carry out its daily tasks	❑	❑	❑	❑	❑

11. In your opinion, why do you think the municipality does not collect garden waste?

12. In your opinion, do you think more effort can be done by the municipality to keep residential areas clean?

SECTION 1 COMPLETE, PRESS NEXT

13. SECTION 2 (REFUSE REMOVAL) Number of personnel in the unit of refuse removal
   1. 0-5
   2. 6-10
   3. 11-15
   4. 16-20
   5. 20>

14. In your opinion, do you think the number of personnel assigned for each daily task is enough, if not propose the number?

15. In your opinion what are the challenges in the unit of refuse removal?
    1. Lack of personnel
    2. Lack of funds to pay the personnel
    3. Slow recruitment of personnel
    4. Lack of fuel
    5. Lack of vehicle
    6. Faulty vehicle

16. How often in a week is waste collected in the different units?
    1. Once a week
    2. Once every two weeks
    3. Once a month

17. In your opinion, do you think the municipality respect the collection schedule for refuse removal?
    1. Yes
    2. No

18. Do you have a remedial method for refuse not collected? Please specify.

19. Does the municipality sub-contract refuse collection to private company?
    1. Yes
    2. No

20. How satisfied are you with the following

	Very dissatisfied	Not satisfied	Neutral	Satisfied	Very satisfied
Cleanness of residential areas	❑	❑	❑	❑	❑
Management of refuse removal	❑	❑	❑	❑	❑
Resources allocated for refuse removal	❑	❑	❑	❑	❑
Personnel's perception towards refuse removal	❑	❑	❑	❑	❑

21. In your opinion, why do you think the municipality does not collect garden waste?

22. In your opinion, do you think improving existing method of refuse collection by the municipality is important to keep residential areas clean?

SECTION 2 COMPLETE, PRESS NEXT

23. SECTION 3 (ILLEGAL DUMPING) Number of personnel in the unit of illegal dumping
    1. 0-5
    2. 6-10
    3. 11-15
    4. 16-20
    5. 20>

24. In your opinion, do you think the number of personnel assigned for each daily task is enough, if not propose the number?

25. In your opinion what are the challenges in the unit of illegal dumping?
    1. The lack of civic environmental education
    2. Lack of punitive measures by the authority
    3. Lack sensitization of the people dumping the waste
    4. Lack of community engagement to curb illegal waste dumping

26. In your opinion, what are the measures put in place by the municipality to deal with illegal dumping?

27. Is there a sign that warns people against illegal dumping at all illegal dumping fields?
    1. Yes
    2. No

28. In your opinion, does the municipality enforce environmental by-laws that prohibit illegal waste dumping proliferation in the environment?
    1. Yes
    2. No

29. How satisfied are you with the following:

	Very dissatisfied	Not satisfied	Neutral	Satisfied	Very satisfied
Measures put in place to curb illegal dumping	❑	❑	❑	❑	❑
Resources allocated in dealing with illegal waste dumping	❑	❑	❑	❑	❑
Municipality commitment in dealing with illegal waste	❑	❑	❑	❑	❑
Municipality & community joined effort in illegal waste management	❑	❑	❑	❑	❑

30. In your opinion, do you think more can be done by the municipality to curb the problem of illegal waste dumping?

SECTION 3 COMPLETE, PRESS NEXT

Hello: You are invited to participate in our survey Perception influencing solid waste management in Mahikeng. Solid waste management is the process of collecting and treating any type of garbage, trash, refuse or discarded material. The objective of this questionnaire is to determine how best can we keep our residential areas clean. In this survey, approximately 400 people will be asked to complete a survey that asks questions about waste disposal location, availability of storage bins, disposal techniques. It will take approximately 5 minutes to complete the questionnaire. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. It is very important for us to learn your opinions. Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact Ms Molefe at 0835766418 or by email at the email address specified below. Thank you very much for your time and support. Please start with the survey now by clicking on the Continue button below.

1. Which of the following unit do you reside at?
    1. Unit 1
    2. Unit 2
    3. Unit 3
    4. Unit 5
    5. Unit 6
    6. Unit 7
    7. Unit 8
    8. Unit 9
    9. Unit 10
    10. Unit 12
    11. Unit 13
    12. Unit 14
    13. Unit 15

2. What is your age?
    1. 18-24
    2. 25-34
    3. 35-44
    4. 45-54
    5. 55-64
    6. 65 or older

3. What is your highest level of education completed?
    1. Less than high school
    2. High school (matric)
    3. Diploma
    4. Degree
    5. Honors
    6. Masters
    7. Ph.D.

4. What is your occupation?
    1. Professional/managerial
    2. Skilled trade
    3. Educator/teacher
    4. Sales/administrative
    5. Service/retail
    6. Unemployed
    7. Other (specify)

5. What is your income range?
   1. Less than R 5,000
   2. R 5,000-R 9,999
   3. R 10,000-R 14,999
   4. R 15,000-R 19,999
   5. R 20,000 or more

6. How many people are currently living in your household?
   1. 1
   2. 2
   3. 3
   4. 4
   5. 5 or more

7. How do you rate the current solid waste management by the municipality in your neighbourhood?
   1. Excellent
   2. Good
   3. Fair
   4. Poor
   5. Neutral

8. What do you think are the main reason(s) for improper disposal of solid waste in your neighbourhood?
   1. Lack of proper bins/collection points in the area
   2. Lack of proper segregation of waste at the source
   3. Lack of proper access to waste disposal locations
   4. Insufficient access to authorized solid waste collectors
   5. Not penalizing inappropriate behaviours

9. How often do you think Waste should be collected from your house?
   1. Daily
   2. Twice a week
   3. Once a week
   4. Once a month

10. What type of environmental problem you concerned with due to illegal solid waste disposal in your neighbourhood?
   1. Air Pollution (Odour)
   2. Water Pollution
   3. Land Contamination
   4. Harmful Chemicals
   5. Hot-spot of insects infested areas
   6. Other _____

11. What do you think is the most appropriate measure in improving solid waste management in your neighbourhood?
   1. Door to door collection of waste on daily basis
   2. Improving on existence waste collection methods
   3. Burning
   4. Integrated waste management schemes through compost usage

12. Please share your opinion on what could be done to improve solid waste management in your neighbourhood.

13. Which of the following measures should Priority be given in order to improve Solid waste management in your neighbourhood?

1. Waste Separation
2. Sensitization campaigns
3. Private waste collectors
4. Encouraging recycling

14. Which of the following strategies do you think may help in reducing proliferation of illegal solid waste dumping in your neighbourhood?

1. Reducing Single-use plastics
2. Converting household waste to biofuel
3. Adopting new technology in waste sorting from household level
4. Creating local waste management committee in each residential unit

15. What do you think are the reasons for improper municipal solid waste management in your neighbourhood?

1. Lack of proper infrastructure
2. Disposed solid waste illegally
3. Lack of awareness among citizens
4. Inadequate staffing
5. High cost associated with waste management

16. Share the initiatives you think should be taken to help the local community tackle solid waste management better?

17. Waste disposal location used by your household

1. Landfill
2. Municipal collection services
3. Open field

18. On a scale of 1-5, how satisfied are you with the present solid waste management by the municipality in your neighbourhood?

1. 1 - Not Satisfied
2. 2 - Slightly Satisfied
3. 3 - Satisfied
4. 4 - Very Satisfied
5. 5 - Extremely Satisfied

19. Is there an open field close to your residential area?

1. Yes
2. No

20. Indicate the nearest location of the landfill/open field used by your household

1. Less than 1 Km radius
2. Above 1 Km radius

21. Is there a skip/bin in the open field where you dump your waste
    1. Yes
    2. No

22. How is waste collected from your household?
    1. By dust bin
    2. In my car
    3. Hire car
    4. Animal cart
    5. Municipal truck collection
    6. Other _____

23. In your opinion, is the open field close to your resident maintained?
    1. yes
    2. No
    3. Neutral

24. How often is the open field maintained
    1. Once a week
    2. Once every fortnight
    3. Once a month
    4. Never
    5. Not Sure

25. What item do you use to store and dispose waste from your household?
    1. Standardized municipal dust bin
    2. Large municipal refuse bags
    3. Supermarket plastics/ shopping bags
    4. Other _____

Appendix B

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ETHICS APPROVAL LETTER OF STUDY

Based on approval by the **Faculty of Natural and Agricultural Sciences Ethics Committee (FNAS-REC)**, the Faculty of Natural and Agricultural Sciences Ethics Committee hereby **approves** your study as indicated below. This implies that the North-West University Senate Committee for Research Ethics (NWU-SCRE) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Determining the perception influencing Solid Waste Management in Mahikeng, South Africa
Study Leader/Supervisor: Dr S Bett
Student: CK Molefe

Ethics number: **N W U - 0 1 2 3 7 - 2 2 - A 9**
Institution Study Number Year Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application type: Single **Risk Category: Minimal**

Commencement date: 01/02/2022
Expiry date: 31/01/2025

Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt and review of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

Special in process conditions of the research for approval (if applicable):

- The following documentation are archived by FNASREC and should be complete and kept up to date:
  - Research proposal
  - Signed approval from the scientific committee indicating the proposed risk category
- All researchers involved in the study should submit signed NWU code of conduct statements annually.
- All researchers of low risk studies should submit proof of relevant ethics training every two years.
- All researchers that take part in activities that pose a safety and security threat to the researchers or the environment should submit a risk assessment form annually.
- All research involving human interaction should follow best ethical practise and keep documents as proof. This includes informed consent, questionnaires, incorporation of risk-benefit, and responsible data management.
- Any research at governmental or private institutions, permission must still be obtained from relevant authorities and provided to the FNASREC. Ethics approval is required BEFORE approval can be obtained from these authorities.

Appendix C

SCHOOL OF BIOLOGICAL SCIENCES

Tel: +27 18 389 2289 **Fax:** 018 389 2134

Cell: +27 72 626 8446 **E-mail:** Oziniel.Ruzvidzo@nwu.ac.za

Date: 25th November 2024

To Whom It May Concern,

REF: Language Editing and Proof-reading of Dissertations/Theses

Dear Sir or Madam,

This serves to confirm that I have proof-read and edited the **MSc Dissertation** of **CK Molefe** (Student number: **24821047**; orcid.org/**0000-0001-6929-3970**) entitled: **Determining the perceptions influencing solid waste management in Mahikeng, South Africa**. The candidate then later corrected all the identified language and technical errors to the satisfaction of the supervisor. Thus, the document presented here is of sufficient and acceptable academic standards.

Editor



Prof. O Ruzvidzo

Supervisor

Dr SK Bett

Appendix D



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