



**MUNICIPAL SOLID WASTE MANAGEMENT IN THE
MANGAUNG METROPOLITAN MUNICIPALITY, FREE STATE
PROVINCE**

by

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DECLARATION OF INDEPENDENT WORK

I, Tshitso Ivan Mohatlane, student number _____, hereby declare that this thesis submitted to the Central University of Technology, Free State, is my independent work and has not been submitted before to any institution by myself or any other person for the attainment of any qualification.

.....

2 August 2025.....

STUDENT SIGNATURE

DATE

ABSTRACT

This study investigated the challenges that persistently plague municipal solid waste management (MSWM) in the Mangaung Metropolitan Municipality, Free State Province, South Africa. The study primarily focused on the inefficient and inconsistent collection of refuse, resulting in widespread illegal dumping and, therefore, the city of Bloemfontein being branded as the “City buried in waste”. The investigation aimed to identify key obstacles to proper waste management and to propose actionable solutions to improve waste management practices. Data were collected using structured questionnaires targeting 139 residents and 70 municipal employees across seven towns in the Mangaung area. These data were supplemented by completing observation checklists at various residential sampling points and landfill sites. The researcher ensured cultural sensitivity and inclusivity during the data collection processes.

The findings revealed significant inefficiencies in waste management practices, including inconsistent collection services, insufficient employee training, and limited recycling initiatives. The residents expressed their frustration with inadequate municipal services, while the observations highlighted poorly managed landfill sites and the prevalence of illegal dumping. Despite moderate awareness of recycling practices, significant knowledge gaps existed among residents and employees regarding the implementation of solid waste legislation. The data further revealed disparities in demographic and educational profiles, with younger residents dominating the sample, while the employees were of more mature ages but undertrained.

The study urges the Mangaung Municipality to adopt a comprehensive, sustainable waste management strategy. Key recommendations include investing in modern waste collection infrastructure, strengthening recycling programs, implementing waste-to-energy initiatives, and enhancing policy enforcement. Collaboration with the private sector and community engagement are also vital to foster a circular economy and to address systemic issues. Long-term planning and the integration of smart

waste management technologies will ensure that the municipality will meet the needs of its growing population while minimizing adverse environmental impacts.

LIST OF ACRONYMS

MSW	Municipal solid waste
MSWM	Municipal solid waste management
NEMWA	National Environment Management Waste Act No. 58 of 2009
RSA	Republic of South Africa, Constitution of the Republic of South Africa, Act 106 of 1996
MMM	Mangaung Metropolitan Municipality

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CHAPTER 1

BACKGROUND TO THE STUDY

Introduction

This chapter presents an overview of the study that was conducted on municipal solid waste management (MSWM) in the Mangaung Metropolitan Municipality,¹ Free State Province. The discourse highlights the complexities of, and challenges faced in waste management practices in urban environments, with specific focus on the unique issues experienced by the municipality under study. Shortcomings in the waste disposal infrastructure, lack of community awareness, and inefficiencies in waste collection systems are identified. The key research questions focused on how effective waste management strategies can be implemented to promote sustainable and environmentally friendly waste management solutions. Additionally, the research questions explored stakeholder engagement, policy implications, and technological interventions associated with appropriate waste management strategies. As the research aimed to propose practical and feasible waste management strategies in the municipality under study, the investigation was driven by predetermined objectives that included a comprehensive literature review, evaluation of current waste management practices, and formulation of relevant recommendations. As the study was delimited to a specific geographical area, its limitations included its relatively small geographical scope, while challenges were experienced in terms of data availability and time constraints.

1.1 Geographic scope of the study

As the geographical area in which this study was conducted was delimited to the Mangaung Municipality, the phenomenon under investigation first had to be explored from a broader perspective; hence, the literature review focused on waste management practices in four countries abroad to better understand how this issue is

¹Mangaung Metropolitan Municipality, Mangaung Municipality, Mangaung City, and the City of Mangaung are used interchangeably in this dissertation as these are terms that are commonly used to refer to this metropolitan city.

handled in other areas. These countries were the United States of America (USA), Germany, China, and Rwanda.

1.1.1 Municipal solid waste management in the United States (US)

Municipal solid waste in the US is a critical and evolving process that involves the collection, transportation, treatment, and disposal of waste generated by residential, commercial, and institutional sources. The management of solid waste is essential for maintaining public health, protecting the environment, and promoting sustainable practices. The discourse will explore the complexities, practices, challenges, and innovations in the MSWM domain in the US.

Currently, MSWM in the US consists of a range of practices that reduce waste generation, promote recycling and composting, and utilize advanced technologies for waste treatment (Khan, Anjum, Raza, Bazai and Ihtisham, 2022a). Waste collection services are typically provided by local governments or private contractors, with varying levels of services and infrastructure depending on the region.

Two key priorities in modern waste management are efforts to increase recycling rates and to divert waste from landfills. Many states and municipalities have implemented recycling programs that encourage residents to separate recyclable materials from their waste (Khan *et al.*, 2022a). These programs typically include kerbside recycling collection, drop-off centres, and educational initiatives to raise awareness about the importance of recycling. Composting is another important component of sustainable waste management in the US. Composting organic waste diverts valuable nutrients from landfills and produces a natural soil amendment that can benefit agriculture and landscaping (Farhidi, Madani and Crichton, 2022). Many communities have established composting programs for residents and businesses to reduce the amount of organic waste sent to landfills.

However, despite progress in waste management practices, several challenges persist in MSWM in the US. Inadequate infrastructure, limited funding, and disparities in waste management practices between urban and rural areas are significant obstacles that impede the achievement of sustainable waste management goals (Nanda and Berruti,

2021). Landfill capacity constraints and environmental concerns related to landfilling also present challenges for waste disposal.

Additionally, contamination of recyclable materials, lack of standardized recycling systems, and low market demand for certain recyclables hinder recycling efforts and result in valuable materials being disposed of as waste (Farhidi, Madani and Crichton, 2022). Addressing these challenges requires collaborative efforts between government agencies, private sector stakeholders, and the public to improve waste management infrastructure, increase recycling rates, and promote sustainable waste disposal practices.

1.1.2 Municipal solid waste management in Germany

Germany is globally acknowledged for its advanced and sustainable waste management practices that are rooted in stringent regulations, technological innovation, and community participation. Historically, the country faced waste management challenges like those of developing nations. However, with the implementation of the Waste Management Act (KrWG), Germany transitioned to a circular economy framework (Bilitewski, 2008; Gunarathne, Lee and Hitigala; Kaluarachchilage, 2021; Zorpas, 2020). This approach emphasizes waste prevention, reuse, recycling, and energy recovery while minimizing landfill reliance.

Germany's high recycling rates—estimated at 67% of municipal waste—are achieved through rigorous waste sorting and a sound recycling infrastructure (Fellner, Laner, Warrings, Schustereder and Lederer, 2018; Scharff, Breiner, Ueno, Underwood, Merritt, Welch and Litchford, 2021; Wagner, 2020). Citizens are encouraged to separate recyclables, organic waste, and residual materials; hence, waste is segregated into a multi-bin system. Moreover, public awareness campaigns and legal mandates promote compliance with these practices.

Non-recyclable waste is directed to waste-to-energy (WTE) facilities, which contributes to renewable energy generation while reducing landfill dependency (Kalmykova, Sadagopan and Rosado, 2018; Zorpas, 2020). Composting and anaerobic digestion

technologies process organic waste, producing biogas and nutrient-rich compost. As a result, less than 1% of Germany's municipal waste is sent to landfills.

Nevertheless, challenges remain, particularly in plastic recycling and hazardous waste management (Gunarathne *et al.*, 2019; Kalmykova *et al.*, 2018; Scharff *et al.*, 2021). Innovations in artificial intelligence (AI) and robotics for waste sorting are being explored to address these gaps. Public-private partnerships and collaborative research initiatives underline Germany's commitment to sustainability.

1.1.3 Municipal solid waste management in China

MSWM in China is a critical issue due to the country's rapid urbanization, population growth, and industrial development (Nanda and Berruti, 2021). The volumes of various waste types that are generated have been increasing significantly, posing environmental challenges and health risks. Historically, waste management practices in China relied heavily on landfilling, but with growing concerns about pollution and resource depletion, there has been a shift towards more sustainable approaches. Therefore, in recent years, China has made significant strides in improving waste management through policies, regulations, and investment in infrastructure, and the government has implemented initiatives to promote waste reduction, recycling, and energy recovery (Kumar and Agrawal, 2020). One of the key strategies has been the establishment of a circular economy model that aims to reduce waste generation and promote the reuse and recycling of materials.

Waste-to-energy facilities have been developed to convert solid waste into energy, and this has helped to reduce the volume of waste sent to landfills and to generate renewable energy. Recycling programs have also been expanded, and efforts have been made to improve waste sorting and expand processing facilities (Kumar and Agrawal, 2020). Many cities have introduced separate waste collection systems for different types of waste, with particular emphasis on recyclables and organic waste.

Despite these efforts, challenges persist in China's waste management sector. Issues such as illegal dumping, an inadequate waste collection infrastructure, and a lack of public awareness pose obstacles to effective waste management (Kumar, Singh, Mishra, Lo and Kumar, 2023). Limited financial resources and technical expertise in some regions also hinder progress in implementing sustainable waste management practices. Hence, innovations in waste management technologies, such as smart waste bins, data analytics for waste collection optimization, and waste sorting robots are being explored to improve efficiency and effectiveness (Kumar *et al.*, 2023). Public-private partnerships and community engagement initiatives are also encouraged to raise awareness and to promote sustainable waste management behaviours.

Looking ahead, the future of MSWM in China will likely involve continued efforts to enhance waste reduction, recycling rates, and waste-to-energy capabilities, and strengthening regulations, investing in infrastructure, and fostering innovation will be key in addressing the challenges facing China's waste management sector (Gao, Huang, Yue, Li, Ge, Lee and Zhou, 2023).

1.1.4 Municipal solid waste management in Rwanda

MSWM in Rwanda is key in this African country's sustainable development strategy as it aims to promote a clean environment, public health, and economic growth. Rwanda has gained international recognition for its innovative approaches to waste management and environmental sustainability, setting a precedent for other nations to follow, particularly those on the African continent (Mwenje and Kumar, 2024).

Rwanda has made remarkable progress in waste management, especially in the aftermath of the 1994 genocide when the country faced significant environmental challenges due to inadequate waste management infrastructure and practices (Ogutu, Akor, Mulindwa, Heshima and Nsengimana, 2023). In response to these challenges, the Rwandan government prioritized environmental sustainability and embarked on a journey to transform the waste management sector. Rwanda's current waste management strategy is characterized by a multi-faceted approach that includes waste reduction, recycling, composting, and energy recovery. The country has implemented

a nationwide ban on single-use plastic bags. It was one of the first countries in Africa to take such a bold step towards reducing plastic waste and promoting a cleaner environment (Mwenje and Kumar, 2024).

Community engagement plays a pivotal role in waste management in Rwanda, with citizen participation in waste collection, segregation, and recycling activities a key focus. The country has established a network of community-based waste collection centres and recovery facilities to sort, process, and recycle waste efficiently (Otukoya, 2024). Moreover, innovative solutions such as the use of modern waste management technologies, including waste-to-energy facilities and biogas plants, were introduced to maximize resource recovery and minimize the volume of waste sent to landfills (Mwenje and Kumar, 2024). These initiatives not only help manage waste effectively but also contribute to renewable energy production and sustainable development.

However, despite the significant progress Rwanda has made in waste management, it faces several challenges in maintaining sustainable practices. Limited financial resources, inadequate waste collection infrastructure in rural areas, and the need for continuous public awareness and education programs are key challenges that need to be addressed (Mwenje and Kumar, 2024). Additionally, rapid urbanization and population growth in Rwanda pose challenges in managing the increasing volume of waste that is generated. Proper waste segregation, efficient collection systems, and sustainable disposal practices in both urban and rural areas remain priorities for the government of this country.

1.1.5 Municipal solid waste management in Namibia

Namibia's waste management challenges stem from rapid urbanization, limited resources, and arid conditions, which complicate traditional landfill operations. Urban centres like Windhoek and Walvis Bay have adopted integrated waste management practices to address these issues (Ndhlovu, 2018; Nhapi, 2021; Simon, 2021). However, rural areas continue to struggle with inadequate waste collection infrastructure.

In Windhoek, waste management is facilitated through transfer stations, controlled landfills, and emerging recycling initiatives (Ndhlovu, 2018; Nhapi, 2021; Simon, 2021). While limited, recycling efforts that are supported by community-driven programs prioritize materials like plastics, metals, and paper. Composting of organic waste is also gaining traction. However, Namibia's primary waste disposal method remains controlled landfilling. Therefore, efforts to transition to engineered facilities are ongoing (Ndhlovu, 2018; Nhapi, 2021; Simon, 2021), while public-private partnerships have been instrumental in improving the waste collection and processing infrastructure. However, illegal dumping and public awareness gaps continue to impede progress.

Technological innovations, including the use of biogas production from organic waste and pilot projects in waste-to-energy conversion, have become a pathway toward sustainability (Ndhlovu, 2018; Nhapi, 2021; Simon, 2021). Future strategies will emphasize capacity building, community engagement, and government investment to enhance waste management.

1.1.6 Municipal solid waste management in South Africa

South Africa faces a diverse array of waste management challenges across its nine provinces, with these issues stemming from varying levels of urbanization and resource allocation. While the National Environmental Management: Waste Act (NEMWA) provides a cohesive framework, disparities persist in infrastructure and implementation (Godfrey, Muswema, Strydom, Mamafa and Mapako, 2017; Nahman and Godfrey, 2010; Scharff *et al.*, 2021).

1.1.6.1 Waste disposal methods and recycling

Landfilling is the predominant waste disposal method in South Africa as approximately 90% of waste is landfilled nationwide (Godfrey, Muswema, Strydom, Mamafa and Mapako, 2017; Nahman and Godfrey, 2010; Scharff *et al.*, 2021). Large metropolitan municipalities like Johannesburg in the Gauteng province and eThekweni in the

KwaZulu-Natal province utilize engineered landfills equipped with gas recovery systems. In Johannesburg, the Robinson Deep landfill utilises the advanced methane recovery technology (Godfrey *et al.*, 2017; Nahman and Godfrey, 2010; Scharff *et al.*, 2021).

Recycling efforts vary widely, with some urban centres achieving higher rates than others through formalized kerbside collection programs (Nahman and Godfrey, 2010; Oelofse and Godfrey, 2008; Scharff *et al.*, 2021). However, rural areas, that mostly rely on informal recycling sectors, lack comprehensive waste segregation and processing infrastructures.

1.1.6.2 Challenges and innovations

Municipalities like Mangaung in the Free State Province and Polokwane in the Limpopo Province face significant challenges, including illegal dumping and inefficient waste collection systems (Nahman and Godfrey, 2010; Oelofse and Godfrey, 2008; Scharff, 2021). However, innovations such as the establishment of waste-to-energy plants, composting facilities, and public-private partnerships are gradually addressing these gaps.

South Africa's waste management future hinges on improving resource efficiency, enhancing community awareness, and increasing investment in recycling technologies and engineered landfill sites (Godfrey *et al.*, 2017; Nahman and Godfrey, 2010; Oelofse and Godfrey, 2008).

Table 1.1 Summary of waste disposal initiatives by province

Province	Major Landfills	Disposal Methods	Recycling Efforts
Gauteng	Robinson Deep (Johannesburg)	Engineered landfills, WTE pilots	High; formal kerbside recycling programs
KwaZulu-Natal	Marianhill, Bissasar Road	Landfills with methane recovery	Moderate; public-private recycling partnerships

Western Cape	Vissershoek, Bellville South	Engineered landfills	High; focused on organic waste and plastics
Eastern Cape	Arlington (Port Elizabeth)	Open dumping, controlled landfills	Low; informal recycling sectors dominate
Free State	Bloemfontein Landfill	Limited engineered facilities	Emerging; plastic and organic waste targets
Limpopo	Polokwane Landfill	Controlled landfills	Low; small-scale community initiatives
Mpumalanga	Secunda Landfill	Open dumping, controlled landfills	Low; minimal formal recycling efforts
Northern Cape	Kimberley Landfill	Open dumping	Minimal; recycling is nascent
Northwest	Rustenburg Landfill	Controlled landfills	Low; informal recycling sector prevalent

(Table composed from two sources: Andrews (2014a) and StatsSA (2016).

1.2 Overview of legislative regulations governing waste management in South Africa

Various pieces of legislation govern South African waste management practices.

These include:

- The Constitution of the Republic of South Africa (Act 108 of 1996);
- National Environmental Management Act (Act No. 107 of 1998);
- National Environmental Management: Waste Act (Act 59 of 2008);
- National Waste Management Strategy (2011);
- National Water Act (Act 36 of 1998);
- Municipal Systems Act (Act 32 of 2000); and
- Environment Conservation Act (Act 73 of 1989).

1.2.1 The Constitution of the Republic of South Africa (Act 108 of 1996)

The Constitution provides the foundation for all environmental and waste management legislation in South Africa. Section 24 guarantees citizens' right to an environment that is not harmful to health or well-being and emphasizes the need for

sustainable development (De Villiers, Van As, and Botha (2020). It mandates the government to implement measures to protect the environment, including waste management practices that prevent pollution and promote sustainability.

1.2.2 National Environmental Management Act (Act 107 of 1998)

This Act, commonly referred to by its abbreviated acronym NEMA, serves as the overarching framework for environmental management in South Africa. Its primary aim is to integrate environmental considerations into all government policies (Kalembo and Odeku, 2023). It establishes principles for sustainable development, including waste management practices that minimize environmental harm. NEMA promotes public participation in environmental governance and ensures accountability in addressing environmental issues, including waste management.

1.2.3 National Environmental Management: Waste Act (Act 59 of 2008)

This Act provides a specific regulatory framework for waste management in South Africa.

It establishes the waste hierarchy and prioritizes waste reduction, reuse, recycling, and recovery over disposal (Claassens, Cilliers, Retief, Roos and Alberts, 2022). The Act also regulates waste treatment and disposal facilities, permits, and compliance with environmental standards. It aims to reduce the environmental impact of waste through proper handling and encourages the development of integrated waste management plans by municipalities.

1.2.4 National Waste Management Strategy (2011)

This strategy operationalizes the Waste Act by providing actionable steps to achieve sustainable waste management. It outlines goals such as promoting waste minimization, increasing recycling rates, and reducing the amount of waste sent to landfills (Kubanza, 2022; Kubanza and Simatele, 2020). The strategy also

emphasizes the importance of public awareness, industry participation, and the adoption of innovative technologies to manage waste sustainably.

1.2.5 National Water Act (Act 36 of 1998)

The National Water Act indirectly influences waste management by addressing water resource protection. It regulates activities that may result in water pollution, including waste disposal and landfill operations (Chisholm, Zamani, Negm, Said, Abdel Daiem, Dibaj and Akrami, 2021). The Act requires proper treatment and disposal of waste to prevent contamination of water resources and promotes the sustainable use of water in waste-related industries.

1.2.6 Municipal Systems Act (Act 32 of 2000)

This Act provides a framework for municipal governance and service delivery, including waste management, and it mandates municipalities to develop integrated development plans (IDPs) that include waste management strategies (Munzhedzi, 2021). Municipalities are obligated to ensure effective waste collection, introduce and manage recycling programs, and ensure proper disposal practices, particularly in urban areas.

1.2.7 Environment Conservation Act (Act 73 of 1989)

Although repealed, this Act formed the groundwork for current waste management policies. It introduced regulations for waste disposal and landfill management and emphasized environmental protection. Elements of this Act have been incorporated into more recent legislations, such as the Waste Act and NEMA, to ensure continuity in addressing environmental concerns (Makanda, Nzama and Kanyerere, 2022).

Collectively, the laws and regulations referred to above create a comprehensive framework for waste management in South Africa. They emphasize sustainability,

public health, and environmental protection while addressing the challenges posed by urbanization and industrial growth.

1.3 Problem statement

The issue that this study explored and that towered above all other issues related to waste management was the poor and often inadequate collection rates of refuse in most parts of the Mangaung Municipality. Observations and public outcries have revealed that waste in the area is hardly ever collected, resulting in unsightly piles of waste which is one of the reasons why the city has been labelled as the “City buried in waste” (Setena, 2020). The media and other stakeholders have tried to get to the bottom of the waste collection problem in Mangaung, but they have not found any logical solutions as evidenced by the incessant piling up of waste in the area. This exposes a deficiency in research to conscientize the responsible authorities to act as far as waste collection in Mangaung is concerned. This research therefore sought answers for this persistent problem by evaluating the major drawbacks, obstacles, and challenges hindering the accomplishment of effective waste collection in all areas of the Mangaung Municipality.

1.4 Research aim and objectives

The aim and objectives of the study describe the waste management practices in the Mangaung Metropolitan Municipality and list the objectives.

1.4.1 Aim

This research aimed to explore strategies to enhance waste management practices in the Mangaung Metropolitan Municipality in the Free State Province to ensure sustainable and environmentally friendly solutions.

1.4.2 Objectives

To address the aim of the study, the objectives were to:

- Conduct a comprehensive assessment of current waste management practices and infrastructure in the Mangaung Metropolitan Municipality;
- Identify and analyse the key challenges, barriers, and shortcomings affecting efficient waste management in the study area;
- Investigate the role of stakeholder engagement, community participation, and existing policy frameworks that shape waste management practices in the study area; and
- Explore and recommend innovative technologies, best practices, and strategies that can be implemented to enhance waste management efficiency and sustainability and ensure the limited environmental impact of waste in the study area.

1.5 Research questions

This section includes the main research and supporting research questions.

1.5.1 Main research question

The key research question that gave impetus to the study was posed to elicit information that would facilitate the identification of the adverse factors that influence poor waste management in the study area:

- How can effective waste management practices be implemented to ensure sustainable and environmentally friendly solutions to waste management in the Mangaung Metropolitan Municipality, Free State Province?

1.5.2 Supporting research questions

- What current waste management practices and infrastructure are in place in the Mangaung Metropolitan Municipality?
- What are the key challenges and barriers that impede efficient waste management in the study area?
- How do stakeholder engagement, community participation, and policy frameworks impact waste management practices in the study area?
- What innovative technologies and best practices can be adopted to improve waste management efficiency and sustainability in the Mangaung Metropolitan Municipality?

1.6 Limitations and delimitations of the study

Limitations describe the data availability, time constraints, and the limitations caused by finance, while the delimitations of the study include geographic scope, stakeholder focus, technological scope and Covid-19 factors.

1.6.1 Limitations

Data availability: The limited availability of comprehensive data on waste management practices and outcomes in the Mangaung Metropolitan Municipality possibly restricted the depth of the study.

Time constraints: The time allocated for the research limited the scope of data collection, analysis, and thoroughness to some extent.

Resource limitations: Financial constraints and limited access to specialized tools, technologies, and other resources impacted the extent of the research to some extent.

1.6.2 Delimitations of the study

Geographic scope: The study focused on a particular geographical area in the Free State Province, namely the Mangaung Metropolitan Municipality (Bloemfontein).

Municipalities in other regions were excluded.

Stakeholder focus: The research primarily focused on stakeholder engagement, community participation, and policy frameworks that affected the municipality under study, thereby delimiting the study's scope to these areas of inquiry.

Technological scope: The examination of innovative technologies and best practices in waste management was limited to those that were relevant and applicable to the context of the Mangaung Metropolitan Municipality.

COVID-19: Protocol restrictions strained the data collection process and delayed the estimated time frame as respondents (residents of Mangaung Metropolitan Municipality and employees of the Solid Waste Department) could not readily be reached. The study had to be delimited to only one municipality in the larger district.

1.7 Structure of the dissertation

The dissertation is presented in six chapters as follows:

Chapter 1: Introduction

Chapter one provides an overview of the research topic, discusses the background to the study, and presents the problem statement. The main research question, the aim and objectives of the study, and the delimitations and limitations are also briefly discussed.

Chapter 2: Literature review

This chapter presents the findings based on an extensive literature review. Various related theories and the findings of earlier empirical studies related to MSWM,

sustainable practices, stakeholder engagement, policy frameworks, and innovative technologies in waste management are discussed.

Chapter 3: Methodology

The research methodology, study area, data collection methods, sampling techniques, research design, data analysis approaches, and the tools and models used in the study are discussed in chapter three.

Chapter 4: Data analysis and interpretation and discussion of results

Chapter 4 presents a discussion on the current status of waste management strategies to enhance waste management in the Mangaung Metropolitan Municipality. The data presented in this chapter will be submitted for publication in an accredited journal.

The content of the article includes the following information on the study area:

- A detailed analysis of current waste management practices, infrastructure, stakeholder engagement, policy landscape, and challenges.
- Recommendations associated with innovative waste management technologies, best practices, and strategies for improving efficiency, sustainability, and limited environmental impacts.

Chapter 5: Recommendations

Chapter 5 summarizes the key findings of the research, discusses implications for practice and policy, provides actionable recommendations for enhancing waste management practices. It also suggests avenues for future research in the field.

Chapter 6: Conclusions and recommendations

This research examined techniques for improving waste management practices to provide long-term and ecologically beneficial solutions. It concentrated on the Mangaung Metropolitan Municipality in the Free State Province.

1.8 Conclusion

This chapter provided a comprehensive introduction to the exploration of MSWM in the Mangaung Metropolitan Municipality. The study was first situated in a broader context with references to waste management strategies in national contexts abroad. Critical challenges such as inadequate waste collection infrastructure, poor community awareness, and policy inefficiencies were highlighted, while the necessity for sustainable and innovative waste management practices was prioritized. By drawing comparisons among the United States, Germany, China, Rwanda, and South Africa, the chapter underscored diverse approaches to waste management while showcasing best practices and the importance of stakeholder engagement, community participation, and technological innovations in the waste management sphere.

The problem statement, research aim, objectives, and questions established a sound foundation for the thorough investigation of the waste management practices in the study area. Moreover, the delimitations of the study were described while limitations such as data availability and resource constraints were acknowledged. Finally, the structure of the dissertation was outlined as this logical presentation ensures fluent progression of the background, findings, and arguments leading to the identified challenges and proposals for actionable solutions that the municipality under study, and even those with similar challenges, may adopt.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter focuses on earlier research related to this study. The Mangaung City has adopted a holistic approach to waste management as it combines legislative, environmental, social, technological, and financial aspects that are part and parcel of sustainable SWM practices. This municipality thus aims to reduce environmental degradation, ensure resource efficiency, and improve the communal quality of life.

2.1 History and background

SMW is a process that includes the collection, treatment, and disposal of solid waste to ensure environmental safety and hygiene (American Public Health Association, 2023). Waste management can be described as the multi-faceted approach taken by local authorities to create an aesthetically appealing environment that is also clean and safe (Jones and Wynn, 2024). The World Health Organization (2021) offers a similar definition, positing that SWM refers to the collection and treatment of waste that occurs in combination with the disposal of solid waste in a safe manner for the sustainability of the environment and to ensure public health. Palmer (2015) defines SWM as the use, collection, transportation, and disposal of solid waste together with recycling and composting. Nazir (2020) is of the view that SWM is a critical service to the public as it protects public health and the environment, creates and maintains an environment with pleasing aesthetics, and provides a safe and clean environment for people to live in. The latter author argues that, without a proper SWM regime, waste will pile up causing health and environmental problems. In essence, one may argue that SWM is a process that seeks to create and maintain a safe environment with pleasing aesthetics.

The history of waste management in Mangaung dates back to the early times of human settlement in the area (Eisenberg, 2014(b)). Over a period spanning hundreds of years, different measures have been employed to dispose of waste, including dumping it in open pits and burning it (Eisenberg, 2014(b); Khumalo, 2017). It has only been since the late 1800s that more modern waste management approaches have been used (Eisenberg, 2014; Khumalo, 2017). One of the first waste management facilities in Mangaung was a landfill site that was established in the early 20th century (Khumalo, 2017). As time progressed, the city's waste management system gradually changed to include numerous methods of waste collection and disposal, like burning and composting (Eisenberg, 2014; Khumalo, 2017).

Currently, the waste management system aims to reduce environmental waste impacts and improve collection efficiency (Eisenberg, Bartram and Wade, 2016). Andrews (2014b) states that Mangaung's current waste management system is based on a waste-reducing paradigm. This means that the intention is to reduce the amount of waste generated at the point of origin. This can be accomplished through various processes such as recycling, reusing, and composting (Andrews, 2014a). Mangaung City has also implemented numerous educational initiatives to create awareness of waste management and to cultivate responsible practices (Andrews, 2014b). In the dawn of the 1900s, waste management was mostly unregulated and very unsanitary as waste was dumped in open spaces or burnt most of the time (Andrews, 2014a; Görgens and Ramutsindela, 2016). This led to health and environmental problems, including the outbreak of diseases (Andrews, 2014a; Görgens and Ramutsindela, 2016).

In the 1980s and 1990s, the South African government started to introduce stricter regulations for waste management, including legislation on dangerous waste disposal and recycling (Andrews, 2014a). The Mangaung Council responded to these novel controls by developing adapted waste management services, and by the early 2000s the city had developed a comprehensive waste management system (Andrews,

2014a). The system now includes numerous landfills, recycling facilities, and composting sites, and these have helped to reduce the volumes of waste that are sent to landfills (Andrews, 2014a).

Govender, Munien, Pretorius and Foggin (2012) aver that, although the Mangaung waste management system has been growing since the 1950s, there are still areas that need great improvement. For instance, the city has a high number of illegal dumping sites, and it does not have an effective system for collecting and processing recyclable materials (Govender *et al.*, 2012). Moreover, Mangaung City has struggled to provide enough waste management services for people in informal settlements, as a significant percentage of its population resides in such settings (Mothibi, 2015). These settlements often do not have proper infrastructure; for example, the location of and poor access to waste collection points make it difficult for residents to dispose of their waste in an appropriate manner (Mothibi, 2015). Therefore, although Mangaung City has a long history of waste management that dates to the 1800s and its waste management system has developed from a rudimentary, small-scale system to a modern, large-scale system, its growth has faced challenges, particularly inadequate coverage as it barely services informal settlements (Govender *et al.*, 2012).

2.2 Legal and policy framework

A legal framework is a set of related laws, regulations, and policies that shape how a matter is approached and resolved. In terms of waste management, the legal framework involves all the laws, regulations, and policies that control how waste is generated, managed, and disposed of (Sethi, 2017). These laws may include rules for the storage, handling, and moving of waste, as well as a rules for recycling, composting, and other ways of waste treatment (Verhagen and Scott, 2019). Beder (1999) states that the legal framework governing toxic waste management has gradually changed over the years. This change in the legal framework acknowledges not only national laws, but also international agreements and conventions (Beder, 1999).

In the sphere of waste management, a policy framework is a portfolio of policies that guide how waste is managed in each administrative area (US EPA, 1990). Cooper (1987) is of the view that a policy framework is a set of guiding principles and objectives

that are designed to assist in building a strategy for waste management. This definition acknowledges the high value of policy frameworks that give strategic direction to waste management.

Numerous laws and directives govern SWM in the Free State Province. Some of these regulations and Acts include: the Free State Provincial Gazette No. 84 of 9 December 2011; the National Environmental Management Air Quality Act of 2004 (NEMAQA); the National Environmental Management: Waste Act of 2008 (NEMWA); the National Water Act of 1998 (NWA); the National Environmental Management Biodiversity Act of 2004 (NEMBA); and the National Environmental Integrated Coastal Management Act of 2008 (NEMICMA). Free State Provincial Gazette No. 84 of 9 December 2011 states that this piece of legislation aims to regulate all angles of waste management while providing norms and standards at national level to ensure effective and efficient management of waste. It also governs the enactment of norms and standards for the issuing of waste permits and licenses. Free State Provincial Gazette No. 84 of 9 December 2011 regulates waste management in the Free State Province to safeguard the environment and ensure that waste is disposed of in a safe and environmentally sensitive manner.

Free State Provincial Gazette No. 84 of 9 December 2011 and the National Environmental Management Waste Act of 2008 (NEMWA) can be highlighted as two major frameworks that govern MSWM in the Free State Province. Free State Provincial Gazette No. 84 of 9 December 2011 projects the broad framework of waste management in the province, whereas NEMWA provides for a more specific approach to different types of waste, including dangerous waste, organic waste, and general waste. NEMWA also initiated the South African Waste Information System (SAWIS,

South Africa, 2006) that collects and regulates data on waste production and management in the Republic of South Africa.

Le Roux and Visser (2016) are of the view that the Free State Provincial Gazette No. 84 of 9 December 2011 was enacted to address the low service delivery standards in waste management services throughout South Africa. This act speaks to a set of principles that should always inform the management of waste through the National Waste Management Strategy and the National Waste Management Framework (Le Roux and Visser, 2016).

It can thus be argued that the Free State Provincial Gazette No. 84 of 9, December December 2011 contains the guiding principles for waste management in the Free State Province while it drives the broad strategy of waste management. Free State Provincial Gazette No. 84 of 9 December determines that there should be an integrated waste management approach, meaning that waste management must be approached in an integrated and holistic manner that considers environmental, economic, and social factors to achieve waste management sustainability. This principle expresses the need for a multi-faceted approach to waste management which takes the economic, social, and environmental consequences of waste into consideration.

Sustainability is another principle outlined in the Free State Provincial Gazette No. 84 of 9 December 2011. Sustainability can be understood as the demand that waste management must respect the needs of today without compromising the ability of future generations to meet their own needs. This speaks to the high value of respecting the long-term effects of waste management and ensuring that current practices do not negatively affect future generations. Free State Provincial Gazette No. 84 of 9 December stipulates that waste management approaches must be prudent. The Free State Provincial Gazette No. 84 of 9 December 2011 dictates that reducing the amount of waste produced and reusing products or materials are more favourable than discarding them on landfills. This principle focuses on curbing the

amount of waste generated at source and avoiding accumulation which later becomes a challenge.

Multiple strategies are used to prevent the accumulation of waste, which includes measures such as product design and manufacturing processes that have a small waste footprint, and the use of packaging which takes concepts such as reusing and recycling into consideration. For instance, policy encourages the design of products that use less materials, can be sustainably recycled, and that provide incentives for consumers who buy products with less packaging to generate a smaller waste footprint.

Waste minimization is another principle that the Free State Provincial Gazette No. 84 of 9 December highlights. The Gazette defines this process as reducing the quantity of and/or the danger potential of waste and raising efficiency in the use of resources. This includes, for instance, reducing the quantity of packaging used for products as much as possible and encouraging the design of products that use resources economically and that are easily recyclable.

2.2.1 The Municipal Systems Act of 2000

The Municipal Systems Act (South Africa, 2000) is another piece of legislation that is used to regulate MSWM processes. Section 28 of this Act requires local authorities to develop and implement an integrated waste management plan in their areas of jurisdiction. Section 76 stipulates that municipalities should provide waste management services, while section 77 states that these waste management services should be provided in a prudent manner. Section 78 lists the steps that municipalities should follow to ensure that waste is managed in ways that are safe, hygienic, and economically sensitive (RSA, 2000).

These steps include: evaluating the waste management needs of communities; developing or drafting and implementing an integrated waste management plan; creating and implementing a system for the identification, classification, and disposal of hazardous waste; fostering a culture of reuse; reducing and recycling waste; sensitising the public to ensure responsible and prudent waste management practices; and providing safe, hygienic, and economically sensitive waste collection and disposal services (South Africa, 2000).

2.2.2 The National Environmental Management: Waste Act of 2008

This act applies to all waste management activities in municipalities and regulates the production, handling, treatment, storage, transportation, and disposal of both hazardous and MSW. The dangers posed by pollution and the need for environmental health are also addressed by this Act (South Africa, 2008). The main purposes of the Waste Act are to protect the environment and human health from the harmful effects of different kinds of waste and to promote waste reduction, reuse, and recycling. Gould (2009) states that the Waste Act is a significant improvement on earlier pieces of legislation as it advocates for a comprehensive and systematic waste management approach.

However, Gould (2009) notes that some challenges still need to be addressed to ensure that the act is effectively implemented. For instance, Gould (2009) refers to limited financial and human resources and states that implementing the Waste Act requires significant investments in infrastructure and capacity creation. The latter author also asserts that many municipalities in the Republic of South Africa do not have enough financial and human capital to effectively implement the Waste Act (Gould, 2009). Owusu-Sekyere (2014) also avers that this Act has numerous inadequacies that will negatively affect its effectiveness if they are not addressed. This Act focuses largely on 'end-of-pipe' solutions to waste management, like landfills and incineration, instead of more sustainable approaches like the reduction of waste, reusing, and recycling (Owusu-Sekyere, 2014). Moreover, Owusu-Sekyere (2014) argues that the Waste Act does not provide sufficient incentives for municipalities to

achieve good levels of waste minimization compared to disposal. The latter author indicates that, because of the stated shortcomings of the Waste Act of 2008, waste management in South Africa may not succeed because the legislative framework that should enable and guide proper waste management processes is flawed (Owusu-Sykyere, 2014).

The broad aim of waste management legislation is to underscore and regulate the responsibilities of different stakeholders, which are to reduce volumes of all generated waste, to ensure that there is an effective system for the collection and transportation of solid waste, and to monitor processes to ensure that solid waste is handled and separated according to well-defined categories. However, researchers who critically reviewed these laws have noted that there are no processes that stimulate municipal waste generation reduction; instead, they concentrate on end-of-pipe solutions that are not sustainable.

2.3 Current solid waste collection and transportation practices in the study area

Waste collection and transportation practices in the Mangaung Municipal area are, to a great degree, based on conventional collection and transportation practices. This is because waste is normally collected in bin containers and transported in trucks to central disposal dumping sites referred to as landfills (Van den Berg, 2018). Van den Berg (2018) states that this system is fraught with challenges, such as high transportation costs over long distances and the probability of accidents occurring during transportation. According to Van den Berg (2018), common waste collection and transportation practices include one or more of the following: waste collection by private contractors who are paid according to the mass of waste they carry; waste that is transported to dumping sites using a combination of trucks and trains; and harmful rudimental waste disposal practices that are used by members of the public, such as open waste dumping, open burning, and localised and unregulated/illegal landfilling (Van den Berg, 2018).

Moreover, the present system of waste management in the Mangaung area faces numerous problems, such as limited resources for proper waste management processes, lack of skilled labour, limited knowledge of resources among Council members, public ignorance about waste management initiatives, not enough facilities for recycling waste and composting, and non-existent long-term plans for the sustainable management of waste (Van den Berg, 2018).

2.3.1 Waste segregation and recycling initiatives in the Mangaung Municipality

Recycling and waste segregation efforts in the Mangaung Municipality are mainly aimed at improving waste management efforts and ensuring continued environmental sustainability (Smith, 2020). Smith (2020) also observes that municipalities in South Africa are implementing different programs aimed at introducing and maintaining environmental sustainability. These programs include community sensitisation campaigns and the development of recycling centres in municipalities' areas of jurisdiction.

In some areas, residents are encouraged to segregate waste and to participate in recycling initiatives (Smith, 2020). Jones, Smith and Johnson (2019) argue that support for policies and infrastructural development to improve recycling levels will eventually reduce the negative environmental impact of waste in urban areas, and this is also true for Mangaung. There are numerous on-going waste segregation and recycling programmes in this area, and these initiatives include community education campaigns, the establishment of recycling centres, policy support, and a robust development of a waste management infrastructure (Smith, 2020). However, the fact that waste management is not yet at acceptable levels prompted this study.

2.3.2 Public participation and community involvement in waste management

According to Smith (2018), community involvement in waste management in the Mangaung Municipality is an essential part of the sustainable waste management regime, and there is some evidence that communities in the Mangaung area actively

participate in waste segregation and recycling programmes (Johnson and Jones, 2020). However, mass participation at grassroots level is of critical importance to enhance waste reduction rates and promote environmentally friendly behaviour by members of the Mangaung community. This means that all communities, and not only some, need to take ownership of these initiatives (Mphambukeli, 2015).

2.3.3 Technological innovations that encourage solid waste management programs

The adoption of technological innovations is important for successful waste management as they may significantly improve MSWM initiatives in a city like the one under study. For instance, automated waste collection methods have led to more efficient waste collection (Letawana, 2017). Also, the introduction of waste organising technologies at recycling points has improved the efficiency of waste segregation and recycling operations (Smith, 2020). By adopting such technological innovations, the Mangaung Municipality has shown its commitment to improving waste management practices and promoting environmental sustainability (Smith, 2020). However, most of the waste in this area still ends up at landfill sites or illegal dumpsites due to insufficient collection.

Automated waste collection systems that are in use the Mangaung Municipality include waste collection vehicles with automatic mechanical arms to lift and empty waste bins (Johnson, Lewis, Lischka and Breck, 2018). These vehicles collect waste from designated pickup points known to members of the public. Residents are provided with standardized waste receptacles (commonly black plastic bags) that ensure the efficient handling and management of waste that is collected from kerbsides or at certain points (Johnson *et al.*, 2018). Waste bins that are provided also eliminate reliance on manual handling of waste, enhances collection speed, and reduces the environmental effects of waste transportation in the urban area under study. Smith (2020) states that automated systems have also been employed at recycling centres to improve waste segregation and recycling operations. These practices emphasise this city's commitment to modernising waste management

practices and to ensure environmental sustainability (Smith, 2020). However, due to irregular and ineffective waste collection, lack of awareness, limited waste minimisation, poor recycling, and minimal waste separation at point of generation, poor waste management occurs across the metropolitan area under study.

2.3.4 Financial requirements for sustainable waste management

The financial sustainability of waste management in the Mangaung Metropolitan area requires a holistic approach. Revenue generation measures in the form of user fees and taxes for waste collection are important (Sitishe, Ntshangase, Klopper, Lubbe and Msosa, 2023). Operational engagements to reduce costs and sustain efficiency such as route optimisation are necessary (Hoorweg and Bhada-Tata, 2012). In this context, it has been argued that public-private partnerships (PPPs) can help distribute the financial responsibility and boost service delivery initiatives (Bel and Fageda, 2017). Moreover, recycling and resource recovery initiatives are vital for revenue generation and cost minimisation (Drechsel, Otoo, Rao and Hanjra, 2018). Community engagement, raising public awareness, encouraging community participation in waste management efforts, long-term planning, respecting the potential for population growth, and environmental management are all important in the quest to achieve sustainable environmental management efforts (Sbeih, 2023; Dube, 2017a). Therefore, the Mangaung City Council can improve financial sustainability for its waste management initiatives by building environmental resilience through community engagement.

2.3.5 Comparative summary of MSWM in Mangaung, Johannesburg, and Durban

As part of the literature review, the MSWM programs in Johannesburg and Durban were compared to those used in the Mangaung Metropolitan area. Based on this review, efforts to eliminate illegal dumping sites in residential and manufacturing neighbourhoods are discussed while various challenges, such as limited resources, are also explored and compared.

2.4.1 The solid waste management program of the City of Johannesburg

Black, Brown, Johnson and White (2022) state that SWM initiatives in the City of Johannesburg and the Mangaung Metro share both similarities and variations. For instance, both are committed to improving their waste collection efforts, eliminating illicit dumping sites in and around neighbourhoods, and increasing recycling rates. However, the City of Johannesburg has implemented programs that are more centralized in comparison to those in Mangaung, and the former has taken a leading role in waste

management by creating a centralised waste management system, while Mangaung's initiatives are more spread out and commonly involve communities that collaborate with businesses (Black *et al.*, 2022). However, the SMW systems of both cities face challenges that include insufficient resources, scanty funding, limited public awareness, and low community participation in waste management initiatives (Black *et al.*, 2022; Smith, 2018).

2.4.2 The Durban waste management program

SWM programs in Durban (eThekweni) are somewhat different from those in Mangaung. For instance, Durban takes a more decentralised approach to solid waste management while a strong focus is placed on community involvement and engagement (Dube, 2017). Also, Durban's programs are more focused on recycling in combination with waste generation reduction instead of mere collection and disposal (Dube, 2017).

However, these cities also share some similarities in terms of the challenges they face, such as limited resources, low public awareness, and limited community participation in waste management initiatives such as recycling and composting (Dube, 2017). Despite these challenges, each city takes measures to address its unique challenges (Dube, 2017). For example, Durban's program has been

successful in reducing the amount of waste through collaboration with local communities and partnering with various stakeholders (Dube, 2017).

2.5 Environmental impact assessment of municipal solid waste management practices

Dube (2017) states that an Environmental Impact Assessment (EIA) report on Mangaung's municipal waste management initiatives exposed various environmental glitches such as land degradation, air pollution, and water pollution. These problems highlight the need for sustainable waste management practices like recycling, composting, and energy recovery to minimise the environmental impact of poor and/or inappropriate waste management practices in the Mangaung area. Mangaung's solid waste management practices are, in most cases, non-compliant with the integrated waste management policies of South Africa. These policies, that prioritise waste reduction, wise use of resources, and environmentally sensitive technologies are often ignored or sidestepped by Mangaung waste workers and managers (Black *et al.*, 2022).

2.6 Conclusion

In a nutshell, waste management practices in Mangaung follow a multi-dimensional approach in which community participation, technological advancements, and legislative support are combined in efforts to create a sustainable waste management system. By attending to the challenges related to solid waste management, stakeholders in Mangaung should work collaboratively towards creating a clean and safe environment for present and future generations. This can be achieved by employing strategies aimed at reducing waste generation levels, establishing a solid waste transportation system, implementing proper disposal measures, recycling and reusing, enhancing public education and awareness, and ensuring environmental protection.

Just like the Durban and Johannesburg waste management regimes, the Mangaung regime is, to some degree, decentralised and community centred and faces the same challenges as its two sister cities. However, these challenges persist because of a lack of sufficient funds, ineffective and inefficiently skilled labour, and a limited knowledge base. Mangaung Municipality's SWM initiatives have been condemned by some researchers for not being compliant with the broad national policy framework that guides waste management; hence, the waste management practices in this city are, to a disturbing extent, not in harmony with environmental sustainability ideals or with national and international standards.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

This chapter unpacks the research design, study area, research approach, population and sampling, research instruments, research analysis, and the validity and reliability of the research findings. The researcher complied with all ethical requirements while investigating solid waste management practices in the Mangaung municipal area.

3.1 Aim and objectives

The study aimed to evaluate the level of municipal solid waste management service provision and environmental cleanliness while also assessing the knowledge of municipal solid waste management personnel. The study also explored the effectiveness of the waste management practices of residents as well as general recycling practices in the Mangaung Metropolitan Municipality in the Free State Province.

The objectives of the study were to:

- Evaluate the current waste-handling systems implemented by the municipality under study. This was achieved by administering copies of a questionnaire to employees and residents to determine their views on waste removal practices and schedules and the status of landfill sites within the municipality's jurisdiction.
- Evaluate the level of compliance of the landfill sites that were visited with current legislation. This was achieved by observations at these landfill sites to determine their daily operations and practices.
- Identify any environmental impacts caused by poor waste management practices. Pictures were taken to assess the cleanliness of the towns and to serve as evidence of related activities (e.g., burning of waste, stormwater

blockages, indiscriminate waste disposal around landfill sites, and the prevalence of illegal dumps).

- Evaluate the knowledge of municipal employees regarding waste management and waste legislation. Pertinent questions in the questionnaire addressed issues such as regular/irregular waste collection schedules, the burning of waste, and littering.
- Evaluate the knowledge of community members regarding waste management to determine their interest in segregating waste and recyclables. The questionnaire determined if the residents knew how and where to recycle waste and it elicited their views on the importance of recycling.
- Evaluate public awareness regarding waste management and waste legislation. Questions were posed to determine if the residents had been made aware of environmental cleanliness and the importance of recycling.

The findings of the study will be offered as recommendations to the Mangaung Municipality for consideration when updating or revising its Integrated Waste Management Plan (IWMP) and its Integrated Development Plan (IDP). It is also envisaged that the results may be used to educate residents on the importance of waste separation at source and the benefits of recycling. Moreover, the results will be disseminated to academics who work in the waste management field by means of publications, conferences, and presentations, while it is also envisaged that the findings will inform future research endeavours.

3.2 Ethical considerations

Legal and ethical issues form an important ingredient of a research project as they, to some degree, determine the acceptability of the research approach and its findings (Brady and O'Neill, 2016). The researcher requested ethical approval from the Health Sciences Research Ethics Committee of the University of the Free State (UFS), and approval was granted (UFS-HSD2019/1604/3006 approved 4 June 2020). The study

was also approved by the CUT Faculty Research and Innovation Centre (CUT FRIC) and funding was allocated for its execution as set out in the proposal.

3.2.1 Informed consent

“Informed consent is an ethical and legal requirement for research involving human participants” (Nijhaman *et al.*, 2013). It is a process whereby study participants² are informed about all aspects of the contents of the study that are important for them to decide and declare their willingness to participate in the study (Nijhaman *et al.*, 2013). Before the copies of the questionnaires (one for employees and one for residents) were administered, all the respondents were informed of the nature and scope of the research.

3.2.2 Confidentiality

Bos (2020) states that the principle of confidentiality involves the responsibility of the investigator to guarantee that the use of data obtained from or shared by human subjects respects the dignity and independence of the participants/respondents and does not violate their interests. All personal information and the identities of the respondents will remain protected.

3.2.3 Respect for participants

Upholding all participants’ right to confidentiality and privacy is a central tenet of every research work (Kang and Hwang, 2023). The researcher treated the research participants (respondents) with dignity and confidentiality and will protect their identities and privacy even after the completion of the study.

² The discourse will refer primarily to respondents because questionnaires were administered and completed.

3.3 Study area

This section describes the study area, locates it within the Free State province, and discusses Mangaung Metro Municipality and the demographics of the area.

3.3.1 The Free State Province

The study was conducted in the Mangaung Metropolitan Municipality in the Free State Province (Figure 3.1). This municipality (MMM) is situated in the heart of South Africa's central interior.



Figure 3. 1: Map showing the location of the study area
Source: Odun-Ayo, Chetty and Reddy, 2022

The Free State Province is bordered by the provinces of Gauteng, Northwest, Mpumalanga, KwaZulu-Natal, Eastern Cape, and Northern Cape, as well as the country of Lesotho to the east. The province is landlocked and primarily characterized by vast, flat plains and agricultural land.

3.3.2 Location of Mangaung Municipality

Figures 3.2 and 3.3, depicts the location of Mangaung Metropolitan Municipality (MMM) and the figure of spacial development.

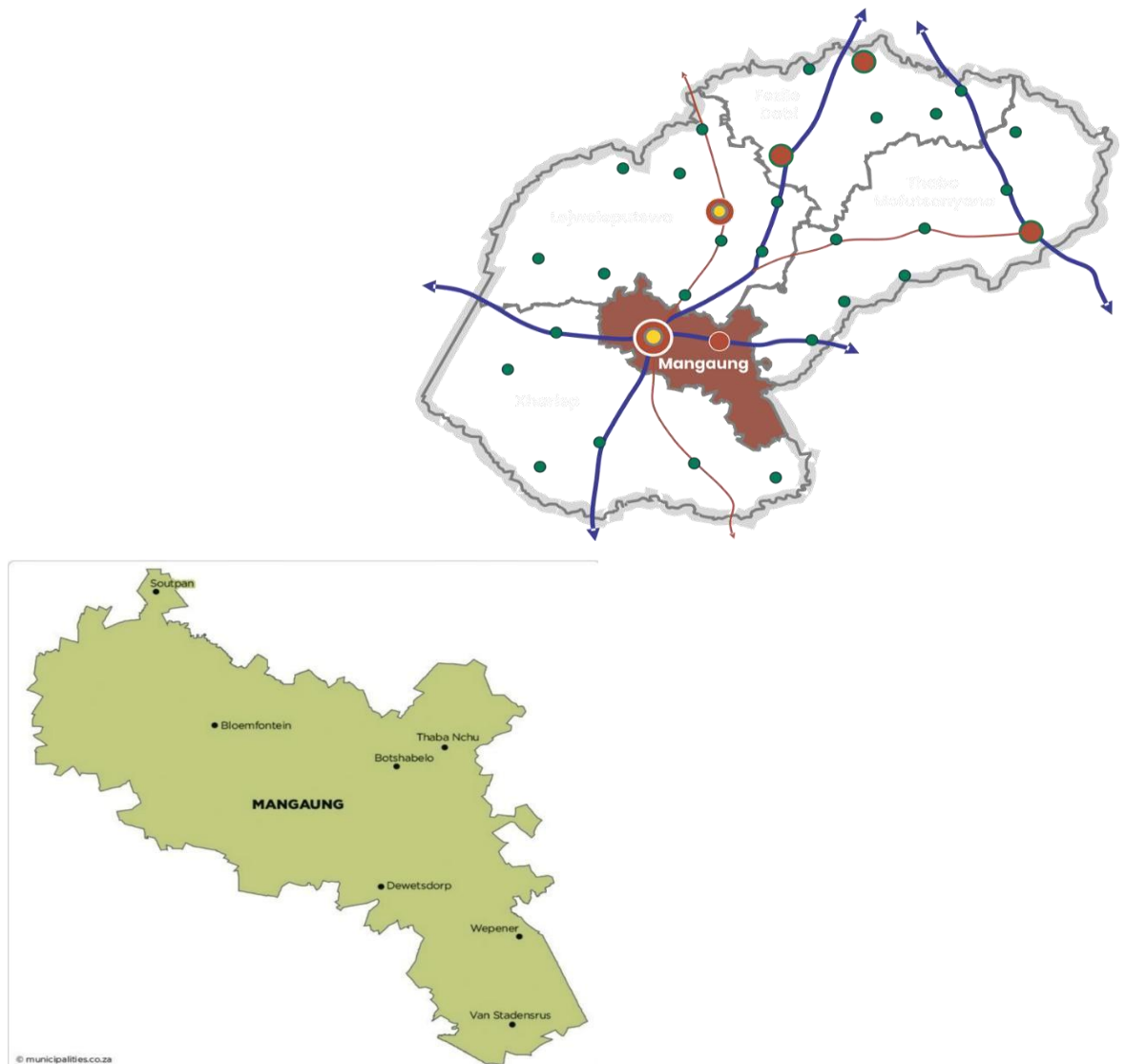


Figure 3.2 and 3.3: Map showing the location of Mangaung Metropolitan Municipality (MMM)

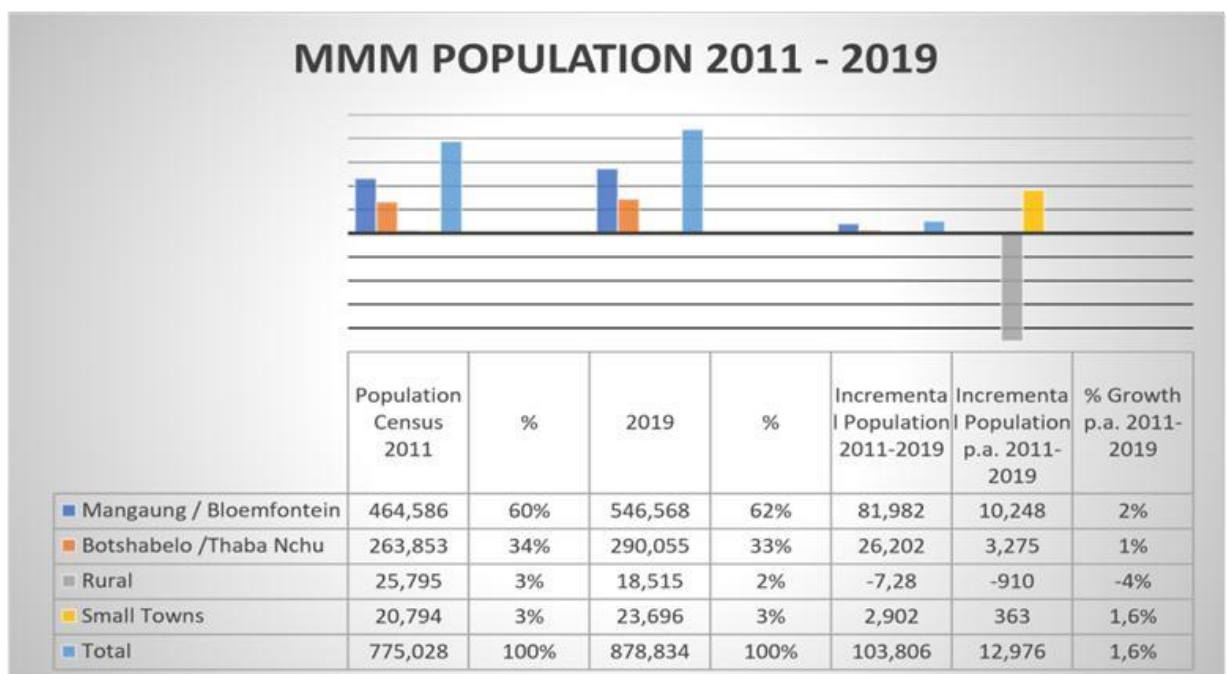
Source: Free State Provincial Spatial Development 2023/2024 and Municipalities of South Africa, 2020

Mangaung's boundaries are shared by the districts of Xhariep to the South, Lejweleputswa to the north, and Thabo Mofutsanyane to the east. To its southeast, Mangaung shares a border with Lesotho.

MMM is the only Metropolitan Municipality in the Free State. It services seven towns that were all included in the study, i.e., Bloemfontein, Botshabelo, Thaba Nchu, Soutpan, Dewetsdorp, Wepener, and Van Stadensrus.

3.3.3 Demographics

The municipality accommodates about 28% of the province's population. Figure 3.4 indicates that the population of Mangaung increased from 775 028 in 2011 to 878 834 in 2019. This was an increase of almost 103 806 (1.6%) people. Following the demarcation on 27 November 2020, with 101 councillors serving as representatives, the city was divided into 51 wards (Mangaung Spatial Development Framework, 2019). Bloemfontein is home to more than half of the population (63%), followed by Botshabelo (24%), Thaba Nchu (9%), Dewetsdorp and Wepener (1.5%), Soutpan (0.8%), and Van Stadensrus (0.2%) (Statistics South Africa, 2016). MMM has 265 560 households: 47% live in a house, 11.7% live in shacks or other informal housing, and 6.5% live in a backyard apartment (IDP, 2017-2022).



Source: Mangaung Spatial Development Framework 2019

Figure 3.4: The population of Mangaung Metropolitan Municipality

Source: Mangaung Metropolitan Municipality, Spacial Development Framework, 2019

Statistics show that 53 informal settlements house about 28 737 households in backyard shacks and other informal dwellings. Of these informal settlements, 13 are situated in Botshabelo, eight are in Thaba Nchu, and 27 are in and around Bloemfontein. It has been stated that 10 informal communities comprising 850 households must be relocated, while 24 informal settlements are in the process of being formalized with improved services (IDP, 2022). The Mangaung population is mostly African (83,3%), while 11% are White, 5% are Coloured, and other/s comprise 0,7% (StatsSA, 2016).

3.3.4 Refuse service

In Mangaung, 249 735 households receive formal waste removal services, which means that 60% of households are left without waste services. Ten percent of households rely on a communal dump, while 3% use a communal landfill. Local governments (towns) provide refuse removal to 82.4% of commercial companies and community members (IDP, 2017–2022).

3.3.5 Vacancies

In the 2018/2019 period, Engineering Services had the biggest number of open positions in the municipality under study (1 094), followed by social services (742) and waste and fleet management services (479). The supply and delivery of services are impacted by the significant number of open positions in the Engineering Services sector (Free State: Department of Cooperative Governance, 2019).

3.4 Research methodology

As stated earlier, the study was conducted in seven towns in the MMM, namely Bloemfontein, Botshabelo, Thaba Nchu, Soutpan, Dewetsdorp, Wepener and Van Stadensrus. The researcher utilized two questionnaires and two observation checklists.

Structured questions were posed in the two questionnaires that were respectively administered to the residents and Solid Waste Directorate employees in the towns under study. The questionnaires were available in both Sesotho and English to accommodate the language choice of the respondents. The checklists were completed by the researcher at each residential sampling point and landfill site.

3.4.1 Research design and data characteristics

“A research design is a blueprint that guides the research process by laying out how a study will move from the research purpose to the outcomes” (Abutabenjeh and Jaradat, 2018). It is a comprehensive planning process that is used to collect and examine data for the purpose of increasing understanding of a given phenomenon (Abutabenjeh and Jaradat, 2018). In essence, it is “the framework of research methods and techniques chosen by a researcher” (Zondi, 2024). The latter author also states that it is the design of choice that “...allows researchers to home in on research methods that are suitable for the subject matter and [that] set their studies up for success” (Zondi, 2024).

This study used an explorative design to investigate various aspects elicited from information on waste management in Mangaung. The opinions, perceptions, attitudes, and experiences of different waste management employees and refuse removal stakeholders in the study area (service renderers and service recipients) were explored. The study aimed to evaluate the status of solid waste management services, with reference to collection, landfill site management, general cleanliness, awareness campaigns, and best practices for managing waste from the point of generation to the final process. Other matters that were assessed were related to separation at source, awareness of the importance of recycling, and interest in recycling. A quantitative research design was chosen on the basis that numerical data and statistical analyses could be used to answer the research questions and test hypotheses.

Quantitative research begins with gathering numerical data using surveys, experiments, observations, or analysing existing data, and a quantitative study commonly intends to identify the gap between theoretical notions and practical applications (Gamage, Amila, 2025). Data were obtained by means of observations and questionnaires to gain a nuanced understanding of the phenomenon under study.

The questions that were posed in the respective questionnaires were compiled by the researcher after an extensive literature review. Both questionnaires contained close-ended questions, while two observation checklists were also completed by the researcher. The first observation checklist focused on residential areas and was used to assess the prevalence of awareness sessions in the various communities, street and environmental cleanliness, and the number of illegal dumps within a 100m radius of selected residential dwellings. The second observation checklist focused on landfill sites near the towns to assess their compliance with the minimum requirements for waste disposal at landfill sites. The sites were visited in person. The respondents included both residents from the various towns in the MMM and Solid Waste Management Directorate employees of the MMM.

3.4.2 Sampling population

The population from which a sample is drawn is the total number of individual elements that share the same characteristics that are of interest to the researcher (Noble and Smith, 2015). Jones, Peter and Wynn, (2019) concur, stating that it reflects the wider targeted elements of a study and is representative of a specific group or individual elements earmarked for investigation. The research objectives and research questions inform the selection of individuals for the sample and the sampling process (Brown and Davis, 2020). Identifying an appropriate research population and selecting a sample are important as these processes ensure that the results generated by a study are widely usable and generalizable for targeted research individuals or groups. The targeted population groups of this study were solid waste employees and residents of the Mangaung Metropolitan Municipality. The selection of

respondents from the population groups to serve as the sample will be discussed in a subsequent section.

3.4.3 Data collection and research instruments

A questionnaire is a tool used to collect information from respondents by asking them a range of questions with the purpose of eliciting specific data (Lindemann, 2023). Questionnaires produce high-quality outputs as they can be sent via electronic communication platforms or an online survey platform. This allows respondents from different geographic locations to participate while it saves time and resources, unlike conducting individual interviews (Lindemann, 2023). The researcher chose to use questionnaires because of the advantages this approach would have for this study over other research instruments. Also, the researcher had limited resources and little time to collect qualitative data on waste management practices in Mangaung; hence, the quantitative approach was adopted as the use of questionnaires and observation checklists was facilitated by this approach.

The questions were designed to gather specific data (opinions, views, experiences) on the topic under study. Administering questionnaires suited this study well because, according to Adams (2015), closed-ended questions could be posed that allowed the researcher to collect data that were quantitative in nature and that met the requirements of the research objectives and research questions (Taherdoost, 2021). Unlike other research methods such as interviews or group discussions, the questionnaires that were administered created a suitable structure for this research and were instrumental in maximizing the success of the study's outcomes (Taherdoost, 2021).

The two groups of respondents lived and worked in the seven towns that were demarcated for the study. Consent to conduct the study was obtained from the Mangaung City Manager and the Solid Waste Management Directorate who identified employees who could be engaged. Copies of the questionnaires were hand delivered

by the researcher to the respondents (i.e., MMM solid waste management employees and residents) in all seven the towns, and the observation checklists were completed at each residential waste sampling point and the landfill sites to assess the general cleanliness of these areas. Landfill checklists were completed at each of the landfills close to the towns to assess their adherence to the minimum requirements for landfilling operations. The checklists were compiled in English, while the questionnaires were available in Sesotho (the local lingua franca) and English.

A total of 209 participants were engaged from the seven towns in the Mangaung Metropolitan area (i.e., 30 respondents were targeted at each town). Of the 30 respondents from each town, 10 were employees of the solid waste management directorate. Of the 10 employees, three were at management level, three were at supervisory level, two were drivers, and two were general workers. Ten (10) were residents who resided close to landfills or dumpsites or who lived a short distance away from such sites, and 10 resided some distance from landfill or dump sites.

3.4.4 Selection of respondents

In a qualitative study, a comparatively small and purposively selected sample may be used to increase the depth of understanding (Miles and Huberman, 1994; Palinkas, Horwitz and Green, 2015). However, quantitative research commonly recruits larger samples, as was the case in the current study. Purposeful sampling ensured the recruitment of selected respondents who would be most likely to yield relevant and useful information, as proposed by Kelly and Dowd (2017, cited in Campbell, 2020). This method ensured the identification and selection of cases that would address the need for the efficient use of time and limited research resources.

A purposive sampling strategy deliberately avoids random approaches to sampling. Purposive sampling is meant to tap into the specific parts of the population that are supposed to be part of a study (Campbell, 2020). The reasons for using the purposive sampling strategy stemmed from the assumption that, given the aims and objectives

of this study, specific examples of people would hold different but important views about the waste management issues in Mangaung City (Mason, 2002; Robinson, 2014). This study used quota sampling, which is a sampling technique that specifies categories together with the minimum number of participants needed for each category (Mason, 2002). For this reason, the researcher focused on sampling municipal employees and residents living both near and far from dumping and landfill sites.

By applying the following selection criteria, the researcher chose respondents whose answers would guarantee the truthfulness of the study findings:

- Respondents between the ages of 18 and 75 years (both genders),
- Individuals living (including tenants renting) in the MMM,
- Individuals who could or could not read were assisted by the researcher,
- Individuals living close to an illegal dumpsite or landfill,
- Individuals who lived some distance from a dumpsite or landfill, and
- Municipal employees involved in waste management (managers, supervisors, drivers, and waste collectors).

Data collection plan for the study is illustrated in Figure 3.5

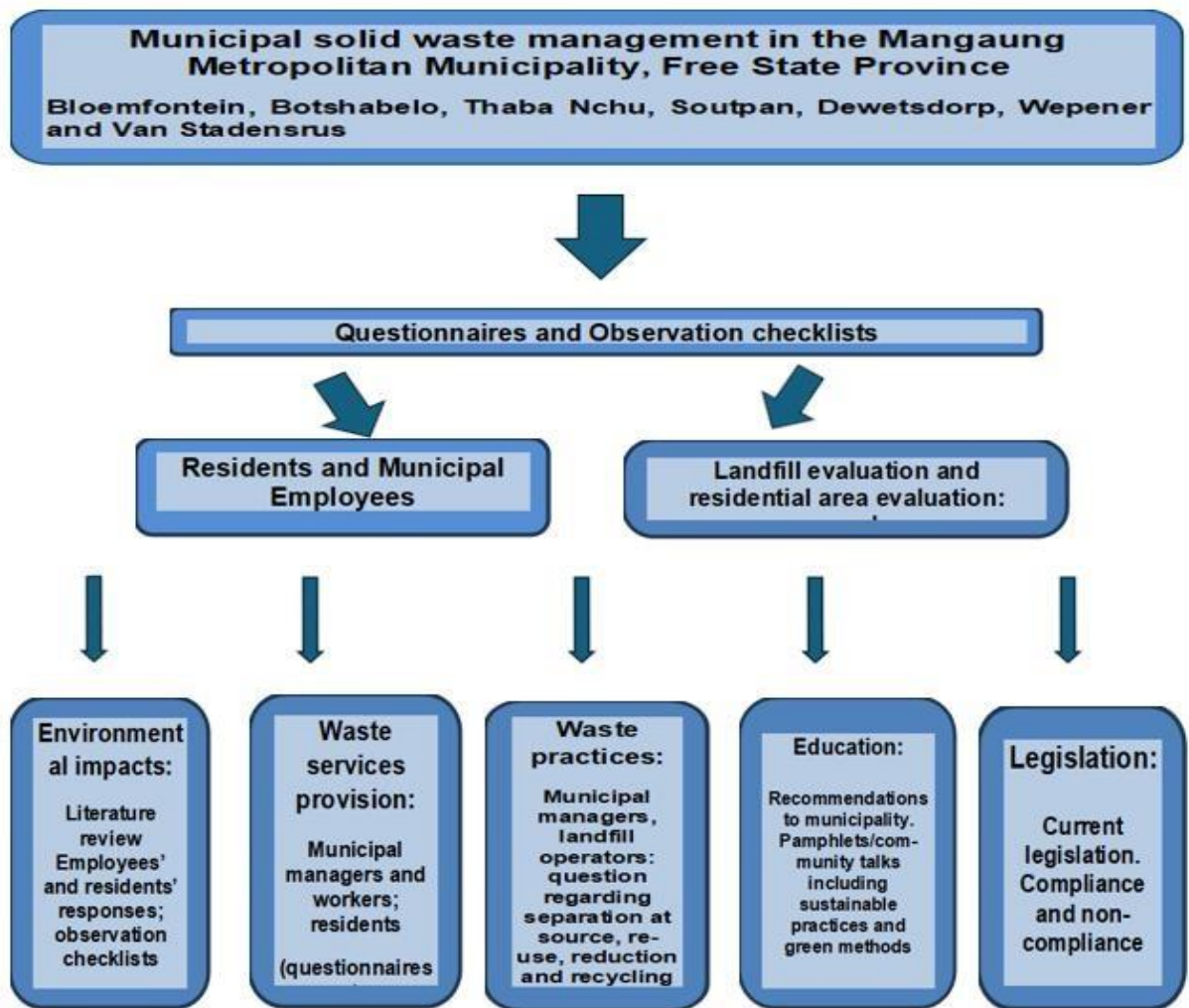


Figure 3.5: Data collection plan

3.4.5 Questionnaires and observation checklists

Both the municipal employee and resident questionnaires were drafted by the researcher, and so was the observation checklist. Photographs were taken at some residential sampling points and some landfill sites to provide a glimpse of current MMM waste management practices. Questionnaires and checklists were used to gather the primary data, and a variety of peer-reviewed sources, including government gazettes, the Internet, waste management reports, library databases, integrated waste management plans, and integrated development plans were used to collect the secondary data.

3.4.6 Validating the questionnaires

The validity of a research study is determined by the measure of how well it will represent true findings if individuals with similar characteristics who were not included in the study had been involved (Patino and Ferreira, 2018). A pilot study was therefore conducted in Bloemfontein involving four employees of the waste management division and four residents. These results were not used in the study. By engaging these respondents in the pilot study and considering their opinions and advice about the nature and accessibility of the questions posed, the researcher could identify questions that might cause discomfort to the respondents and amend them.

3.4.7 Structured questionnaire questions

Data were gathered by administering the questionnaires to municipal employees during working hours and to residents at their residences or when they were encountered in small groups. The observation checklists were completed when the landfill and dumpsites were visited in person by the researcher.

As the waste services issue is contentious in Mangaung, the residents who were approached were eager to participate in the study as they wanted to vent their frustration about poor waste service delivery. The researcher explained the study's objectives to residents on a one-on-one basis and a good response was received. The residents who were recruited willingly completed the questionnaire and assisted the researcher with information for the observation checklist at each residential sampling point.

The questionnaires were structured in such a way that the respondents had to choose their preferred options from the statements provided. Residents were randomly approached in each town and 20 were selected for the sample if they showed willingness to complete the questionnaire. Of these, 10 who resided near illegal

dumps or landfill sites and 10 who resided some distance from these sites were eventually selected. The observation checklist was completed at each sampling point by the researcher. A total of 139 resident questionnaires were handed out and completed by residents in the seven towns under study.

The researcher did not make any appointments with the employees but presented them with a letter requesting their participation as respondents in the study. This letter had been signed by the City Manager who had granted permission for the involvement of employees. The Solid Waste Directorate depot was visited in each of the seven towns at the beginning of a working shift. The signed letter was shown to managers and supervisors, and they were requested to allow willing employees to participate in the study. Ten (10) municipal employees were randomly selected at each depot, but care was taken to purposively recruit employees from management level, supervisory level, drivers, and general workers. In total, 70 employee questionnaires were administered in the seven towns.

3.4.8 Language and cultural considerations

The Mangaung Municipality accommodates residents of different religious backgrounds, races, ethnicity, and ages. Each cultural background was respected when the researcher approached the potential participants.

3.5 Questionnaire formulation and administration

The questionnaires (see Annexure 5: Residents' questionnaires; Annexure 6: Municipal employees' questionnaire) were used to collect data to address the objectives as listed in section 3.2, which were to:

- Conduct a comprehensive assessment of current waste management practices and infrastructure in the Mangaung Metropolitan Municipality;

- Identify and analyse the key challenges, barriers, and shortcomings affecting efficient waste management in the study area;
- Investigate the role of stakeholder engagement, community participation, and existing policy frameworks that shape waste management practices in the study area; and
- Explore and recommend innovative technologies, best practices, and strategies that can be implemented to enhance waste management efficiency and sustainability and ensure limited environmental impact of waste in the study area.

3.5.1 Breakdown of the residents' questionnaire

Section A: Demographic information: Questions 1 to 7;

Section B: Solid waste (reuse, reduction, and recycling): Questions 8 to 13;

Section C: Municipal solid waste services: Questions 14 to 21; and

Section D: Solid waste legislation.

3.5.2 Breakdown of the employees' questionnaire

Section A: Demographic information: Questions 1 to 8;

Section B: Solid waste (reuse, reduction, and recycling): Questions 9 to 12;

Section C: Municipal solid waste services: Questions 13 to 26; and

Section D: Solid waste legislation: Questions 27 to 30.

3.6 Checklists

Checklists were completed at each residential sampling point and landfill site to assess the environmental cleanliness of the respondents' surroundings and the landfill sites.

3.6.1 Residential area observation checklist

The checklist had eight questions that focused on nuisances and other environmental degradation factors, such as:

- Burning;
- Windblown litter;
- Bad odours;
- Infestation by rodents;
- Dust;
- Types of waste; and
- Accessibility for children.

3.6.2 Landfill observation checklist

This checklist focused on aspects such as:

- Signposting and road access (Questions 1 to 9);
- Access control, collection of disposal tariffs, and security (Questions 10 to 16);
- Landfill site resources and sanitary landfilling (Questions 17 to 20); and
- Nuisances and other environmental degradation factors (Questions 21 to 27).

3.7 Statistical analyses

Four different excel worksheets were used to electronically record the data from the two checklists and the two questionnaires. Mrs Viljoen, a biostatistician, performed the analyses utilizing the SAS Version 9.2 statistical software package. For categorical data, descriptive statistics were used to compute frequencies and percentages and for numerical data, these same statistics were used to calculate means, standard deviations, medians, and percentiles. These findings are presented in tables and graphs in the next chapter.

3.8 Conclusion

This chapter outlined the comprehensive methodological framework that was adopted to investigate solid waste management practices in the Mangaung municipal area. The discourse detailed the research design and described the study area. The study approach, population, sampling methods, and data collection instruments were also discussed. The chapter also highlighted measures taken to ensure the validity and reliability of the findings and affirmed the study's adherence to ethical considerations to provide a robust foundation for the study. The rigorous approach that was adopted ensured that the findings are reflective of the context, based on ethical research practices, and therefore credible.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION, AND DISCUSSION OF RESULTS

Introduction

This chapter presents the results of the quantitative data analysis process the study utilised to explore municipal solid waste management practices in the Mangaung Metropolitan Municipality, Free State Province. The data were collected using two observation checklists and two structured questionnaires that targeted residents and municipal employees respectively. The analysis process included descriptive aspects that elicited insights into aspects such as the demographic characteristics of the respondents, employees' waste management training status, the prevalence of awareness programs, solid waste management practices, residents' awareness and willingness to adopt reuse and recycling processes, the nature of the solid waste services provided by the municipality, and the impact and implementation efficacy of solid waste legislation on employees and residents.

4.1 Demographic profile of the respondents

The researcher administered the respective questionnaires to 70 municipal employees and 139 residents of Mangaung Metropolitan Municipality, Free State Province. Of the 39 resident respondents, 51,08% of the residents were males, while 58,57% of the employees were male. A lower percentage of employees (41,43%) were female, while 48,92% of the residents were female, as indicated in Figure 4.1.

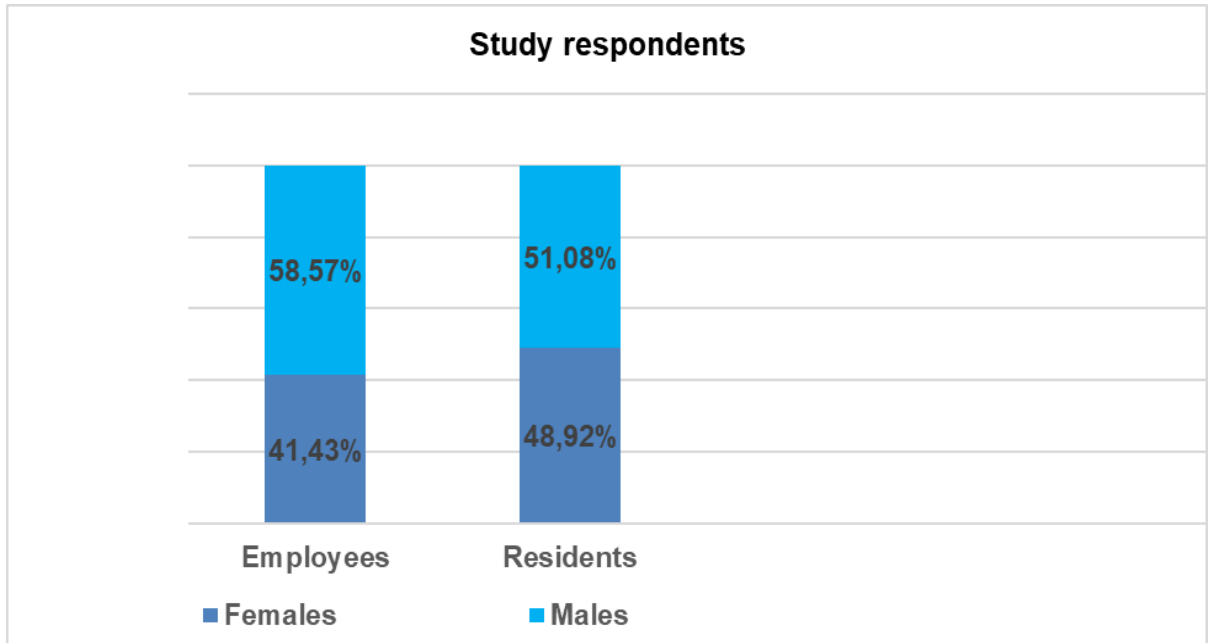


Figure 4. 1: Study respondents in percentages

The demographic characteristics of the respondents that were of interest in this study included the age, gender, ethnicity, and educational background of both the employees and the residents. Furthermore, the study looked at the employees' years of experience, job titles, and areas of residence, while residents' demographic details focused on the number of years they had resided in Mangaung, whether they resided there permanently or not, and the number of people living in their households (see Table 4.1).

The gender distribution was dominated by males at a total of 112 (41 employees and 71 residents) while a total of 97 females (29 employees and 68 residents) participated in the study. The employee distribution reflected that more males than females were employed by the Mangaung Municipality at the time of the study, resulting in a gender imbalance. In terms of age, the majority (34%) of the employees was between 46 and 55 years old, followed by those who were 36 to 45 years old (26%) and 26 to 35 years old (16%). Only 14% of the employees was 56 years and older, while only 10% represented the 18 to 25-year-old category.

Conversely, the dominating age category in the resident group was 26 to 35 years (28%), followed by those who were 36 to 45 years old (26%) and those who were 18 to 25 years old (21%). Only 14% fell in the 56 year and older age category, while 12% represented the 46 to 55 years old category. In terms of ethnicity, most respondents (98%) were Black Africans, while one respondent was Asian and one was Coloured.

Table 4. 1 Demographic characteristics of the respondents

Characteristics	Demographics	Employees* n (%)	Residents ** n (%)
Gender	Male	41 (59)	71 (51)
	Female	29 (41)	68 (49)
Age	18 – 25 years	7 (10)	29 (21)
	26 – 35 years	11 (16)	39 (28)
	36 – 45 years	18 (26)	36 (26)
	46 – 55 years	24 (34)	16 (12)
	56 years +	10 (14)	19 (14)
Ethnicity	Africans	70 (100)	137 (98)
	Asians	0 (0)	1 (1)
	Coloured	0 (0)	1 (1)
	White	0 (0)	0 (0)
Education	No education	3 (4)	15 (11)
	Primary School	8 (11)	23 (17)
	Secondary School	28 (40)	49 (35)
	Matriculation	21 (30)	39 (28)
	Cert	10 (14)	13 (9)
	Post Matriculation		

Employees* (n = 139)

Respondents** (n = 70)

Most residents and employees had attained a secondary school education level, with fewer attaining lower and higher levels.

4.1.1 Employees designated positions

Figure 4.1 illustrates the distribution of the employees according to their job titles. The majority (39, or 55.7%) of the waste management employees who took part in this study represented the general workers category, whereas non-specified departments were represented by 19 (27.1%) employees. Of the employees, six (8.6%) were inspectors, four (5.7%) were managers, and two (2.9%) were truck drivers.

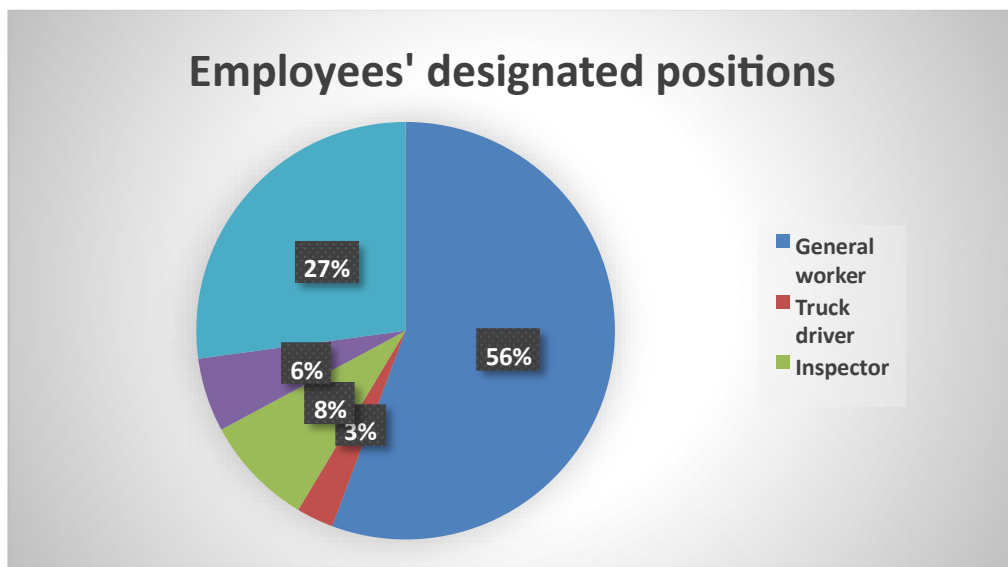


Figure 4. 2: Employees designated positions (n = 70)

4.1.2 Employees' work experience and the periods residents resided in Mangaung

Figure 4.2 presents the data on the employees' work experience and the number of years the residents had lived in Mangaung at the time of the study. According to the data, 36 (51.4%) of the employees had more than 10 years' work experience, indicating a high level of experience and a potentially stable workforce. However, 34 (48.6%) of the employees had less than 10 years' experience, indicating a mixture of both medium- and long-term employment. On the other hand, 106 (76.3%) residents had lived in Mangaung for more than 10 years. This suggests a stable and long-term resident population. Only a small portion of the residents (33, 23.7%) had lived in the

area for fewer than 10 years, thus affirming a stable population. Figure 4.2 indicates that the high percentage of employees with waste management employment of 10 years related to the high percentage of residents who had lived in Mangaung for 10 years or more. Therefore, these respondents' insights were deemed beneficial to the study as they were able to provide accurate and reliable information about waste management in the Mangaung municipal area.

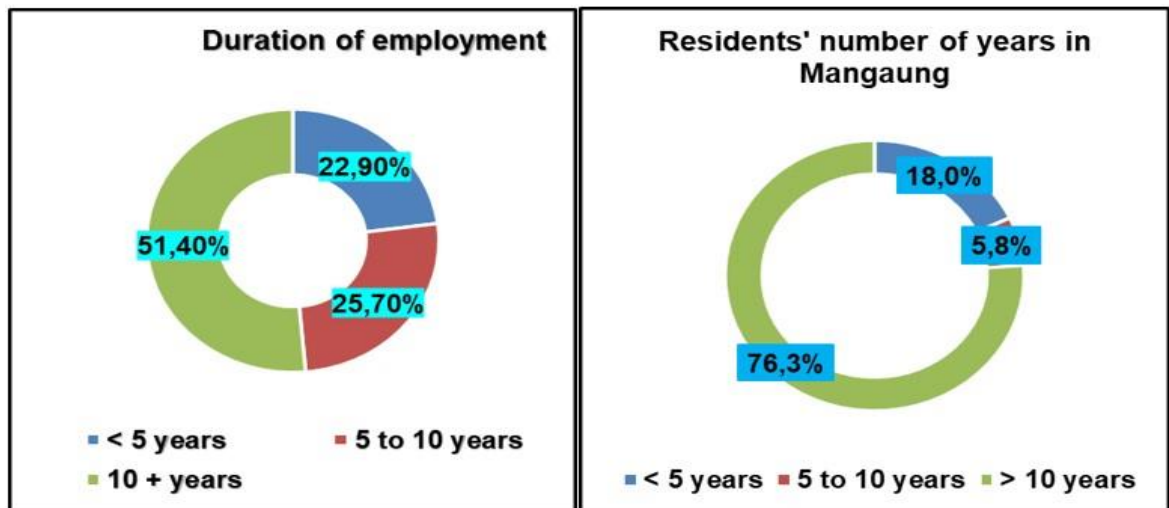


Figure 4. 3: Employees' work experience and residents' period of stay in Mangaung

The literature revealed that, in other municipalities and metros across South Africa, municipal workers' experience levels varied significantly depending on size, structure, and regional challenges. For instance, Banda, Nkosi and Mthembu (2017) found that in Cape Town, which is an urban metro, 65% of employees had more than 10 years' experience, which is like the finding in Mangaung. This suggests that larger metros tend to retain more experienced employees, which is possibly due to the complexity of urban management and the need for seasoned staff to handle the diverse range of services, including waste management, public health, and infrastructure maintenance. Municipalities with long-standing employees often experience fewer disruptions in service delivery and can manage their resources well Dlamini (2019). On the other hand, Dlamini (2019) avers that smaller municipalities with fewer financial resources, such as those in the Eastern Cape, often have a younger workforce with employees having less than 10 years' work experience. This is attributed to the lower retention rates in such municipalities due to limited career

advancement opportunities and the scarcity of training programs. This finding contrasts with that of a more experienced workforce in Mangaung, highlighting how local economic factors influence employee retention and the overall work experience in municipal services. This difference in work experience levels may impact the quality-of-service delivery, including waste management practices that require institutional knowledge and continuity in operations.

Moreover, a South African Local Government Association (SALGA) report (2021) notes that municipalities that have invested in capacity-building and long-term workforce retention strategies tend to have more experienced staff. Cities such as Johannesburg and Pretoria, which employ large numbers of municipal workers in various departments, reported that around 55% of employees had over 10 years' experience. This trend emphasizes the benefits of stable workforce management, especially in critical service areas like waste management where experienced employees can improve operational efficiency and ensure that municipal policies are implemented effectively. In comparison to these municipalities, the high percentage of long-term employees in waste management in Mangaung Municipality can be seen as an asset that will ensure sustainability and effectiveness in service delivery.

4.1.3 Employees' areas of residence

Figure 4.4 illustrates the areas of residence of the municipality employees. This signifies that most employees lived close to their workplace, which could be due to convenience, reduced commuting costs, or local residency requirements.

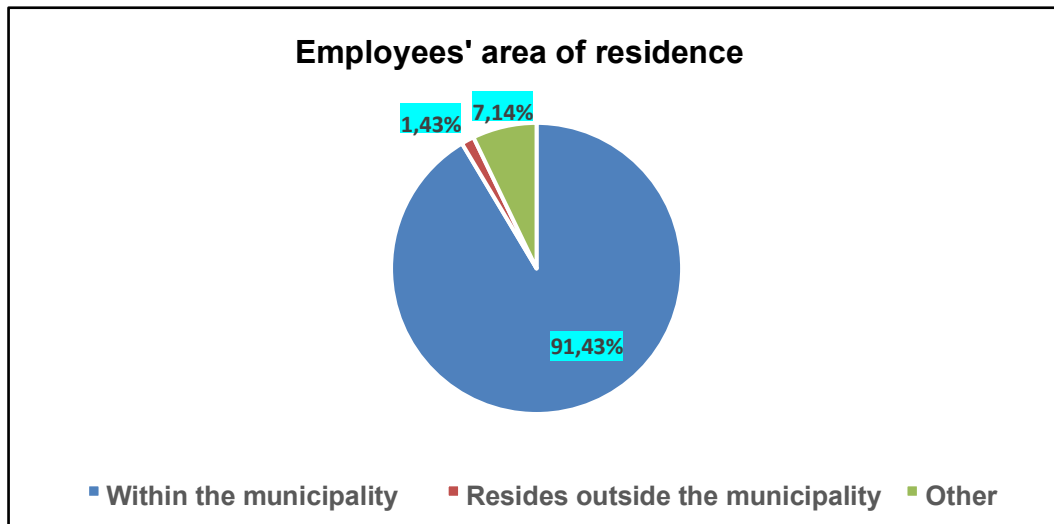


Figure 4. 4: Employees' areas of residence

Only one (1.43%) of the employees resided outside the municipality. This could have been due to personal preference or other factors that were not explored. Only five (7.14%) of the employees did not indicate whether they lived within or outside the municipality's area. They could have lived in another municipality or there might have been specific residential arrangements that were not explored.

4.1.4 Number of people in households

Many of the residents (64, or 91.4%) resided in the urban residential areas in the municipality.

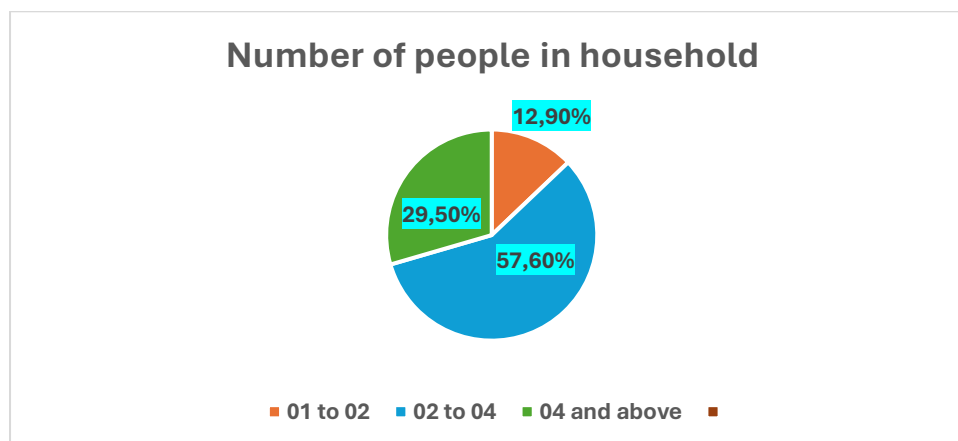


Figure 4.5: Number of people in household

Figure 4.5 illustrates that the study was dominated by small households (40, 57.6%) consisting of two to four people, followed by households with four or more people (21, 29.5%). Only nine (12.9%) of the residents had one to two people in the household. This implies that the larger proportion of households with more than four people per household was likely to generate more waste than the households with a smaller number of occupants. If this pattern persists, it will call for more frequent waste collection by the municipality as well as robust reuse and recycling initiatives targeting these larger households.

4.2 Solid waste reuse and recycling

Employees' training history and awareness of waste management, as well as the need for improved educational initiatives, are discussed in this section. The discourse also evaluates awareness of buy-back centres among employees and residents and emphasizes the necessity for enhanced communication and engagement. Additionally, the researcher assessed the attitudes towards and knowledge of the respondents regarding recycling considering the prevalence of, and threat posed by plastic waste and the importance of recycling programs to reduce such waste.

4.2.1 Employees' exposure to training

Figure 4.6 depicts that only 21 (30%) of the employees had received training on waste management, 48 (68.6%) had never received any training, and one (1.4%) could not remember whether he had received training or not.

The lack of exposure to training by this sizable number of employees highlights a critical gap in the effective management and handling of waste.



Figure 4. 6: Employees' exposure to training

There is a need to involve employees at all levels in waste management training programs to ensure that they understand the importance of waste segregation and safe handling and recycling practices (Davids and Smit, 2018). Andrews (2014b) argues that training and awareness programs are crucial for efficient waste management practices as educational initiatives build awareness and cultivate responsible waste handling and management.

Davids and Smit (2018) also argue that training municipal workers in waste management is essential for the effective implementation of waste reduction strategies. They refer to a case study that was conducted in the City of Durban, where a training program significantly improved targeted employees' understanding of waste segregation and recycling practices. The program, which included both theoretical learning and practical demonstrations, resulted in a noticeable reduction in contamination levels in recyclable materials and better compliance with waste management regulations. Similarly, a study by Dlamini (2019) that was conducted in rural municipalities in the Free State found that municipal workers who participated in regular training programs were more likely to adopt responsible waste practices, such as proper waste segregation and safe handling of hazardous materials, than their untrained co-workers. The lack of such training in Mangaung, as indicated by the

68.6% of employees who had not received any training, underscores the critical need for educational initiatives to improve both employee and public engagement in responsible waste management practices.

4.2.2 Awareness of the significance of buy-back centres

Figure 4.7 depicts that 41 (58.6%) of the employees and 74 (53.2%) of the residents were aware of the existence of buy-back centres. This slim majority indicates a fair but improvable awareness among employees and residents of the role and significance of waste buy-back centres. This also suggests that most employees' knowledge about such centres might have been due to internal communication and direct involvement with related activities.

4.2.3 Awareness of the significance of buy-back centres

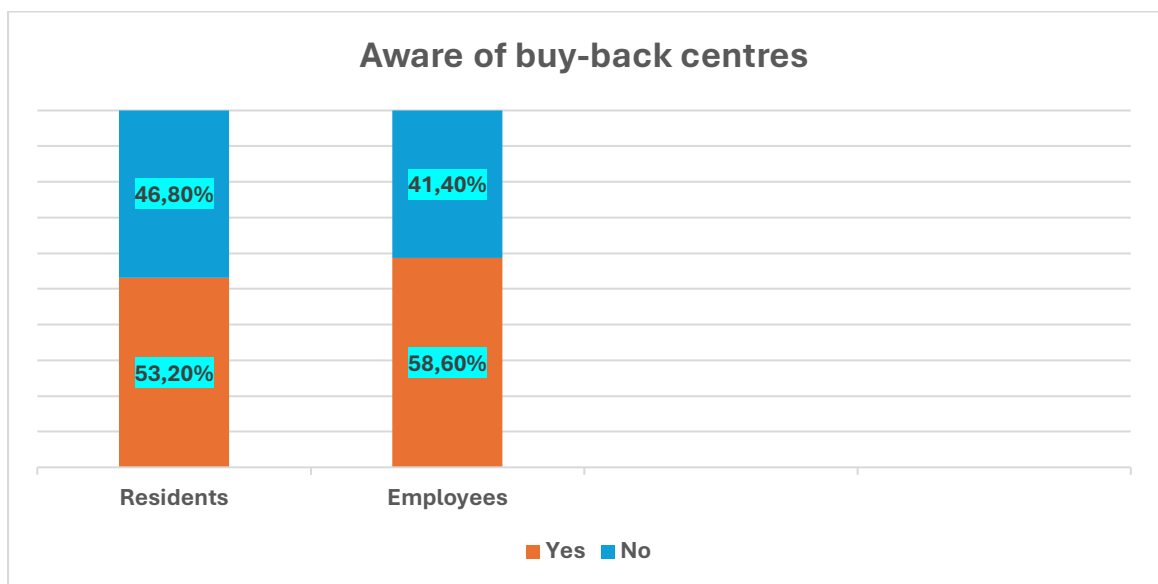


Figure 4. 7: Awareness of buy-back centres

On the other hand, 28 (40%) of the employees were not aware of buy-back centres while one (1.4%) was unsure what a buy-back centre is (Fig 4.7). These findings show that some employees were uninformed about waste reuse and its commercial value, and it may be argued that a vital communication gap exists in this regard. As for the residents, 65 (46.8%), or almost half of the residents were unaware of the existence of

buy-back centres. This lack of awareness points to the need for enhanced awareness and education programs. Overall, awareness among employees was slightly higher than among the residents, which could have been due to the connection of the former group with the municipality.

4.2.4 Attitudes towards and knowledge of recycling

Attitudes towards and knowledge of recycling play a crucial role in the effectiveness of waste management programs. A positive attitude towards recycling, combined with adequate knowledge of its benefits and proper techniques, can significantly improve participation and compliance. However, a lack of awareness or understanding can hinder recycling efforts and lead to inefficiencies and increased waste. Therefore, assessing employees' attitudes towards and knowledge of recycling was essential, as the findings may inform the development of effective training and awareness initiatives. Table 4.2 indicates that 109 (78.4%) of the residents knew what recycling is while only 30 (1.6%) did not know what it is.

Table 4. 2 Attitudes towards and knowledge of recycling

Items	Response	Employees (n = 70)	%	Residents (n = 139)	%
What is recycling?	Yes			109	78.4
	No			30	21.6
Do you know anyone collecting recyclables or waste?	Yes	56	80	103	74.1
	No	14	20	36	25.9
Is there a need for recycling?	Yes	69	98.6	127	91.4
	No	1	1.4	11	7.9

The study results coincided with the 69 employees (98.6%) and 127 residents (91.4%) who said "Yes" when asked if there was a need for recycling.

This consensus provides a foundation for the development of recycling programs because, with such a positive attitude towards recycling, initiating such programmes

will have a good starting point. This notion is supported by Andrews (2014a), who underscores the importance of reducing waste generation through recycling and reusing. When asked if they knew anyone who collected recyclables, 56 (80%) of the employees said “Yes” while 14 (20%) said “No”, and 103 (74.1%) of the residents said “Yes” while 36 (25.9%) said “No”. It is important to know who waste collectors are as this knowledge fosters a sense of accountability and trust in the waste management system. Although many respondents were familiar with the presence and operations of waste collector entities, there is a need to ensure that the existing gap for the few who did not know of such collectors could be informed through communication and improved interaction between the community and waste managers of the municipality.

In line with the findings of Andrews (2014b), other studies have highlighted the significance of public awareness and knowledge in promoting recycling behaviours. Chamberlain and Smith-Hall (2017) note that, in municipalities where residents and employees are well-informed about recycling, participation rates are high and waste diversion rates have improved. Their study emphasizes that a strong understanding of the recycling process, combined with the identification of waste collectors, fosters a sense of responsibility and trust among community members. Furthermore, Petersen (2021) argues that residents who know their waste collectors are more likely to engage in responsible disposal practices as they feel more connected to the waste management system. Similarly, Mugambi (2017) argues that community education and clear communication about municipal waste services can bridge the information gap for those unaware of their waste management responsibilities, thereby improving collaboration and the effectiveness of recycling initiatives. These findings suggest that an informed and engaged community plays a vital role in the success of waste management and recycling programs.

4.2.5 Most generated types of waste

As was highlighted in Figure 4.8, the most generated types of waste were plastic (63.5%), followed by paper (17.6%), glass (11.5%), metal (3.4%), cardboard (2%), and other types (2%).

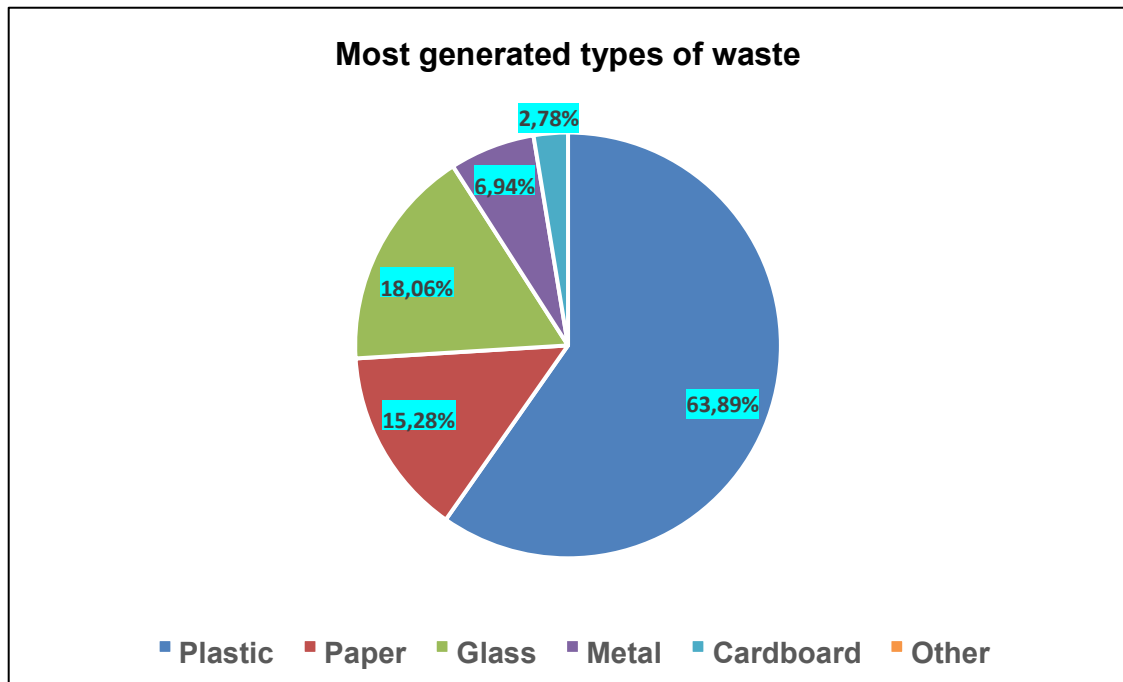


Figure 4. 8: Most types of waste being generated

The increase in paper and cardboard waste has been linked to the growing consumption of packaging materials that have become more prevalent in e-commerce and retail industries. Furthermore, Liu, Liu, Wei, Zhao, Li, Weng, Xin Guo, Yanzhang Wang and Yanfei Lin (2022) state that metal and glass, while still present in the waste stream, represent a small percentage of total waste as they account for about 5% each in many cities globally. This aligns with the findings in Mangaung, where metal waste represented 3.4% and glass 11.5% of the waste stream. The data (Figure 4.8) underscore the need for improved recycling initiatives for both plastics and other materials as well as public awareness campaigns to address these waste streams effectively.

Recent global studies on waste generation have revealed similar trends in the composition of waste, with plastic being the dominant waste stream. According to Mugambi (2017), plastic waste accounts for a significant portion of the global waste stream, with recent reports indicating that it contributes up to 60% of the total waste generated in urban environments. Figure 4.8 also depicts that plastic waste in the

Mangaung municipality was the most generated waste at 63.89% of the total waste volume. Mugambi (2017) emphasizes that plastic pollution is a critical environmental issue as it not only constitutes a large share of waste, but also takes centuries to decompose, posing serious environmental hazards. This highlights the importance of reducing plastic consumption (Andrews, 2014a) and improving waste management practices, especially in urban areas where waste generation is typically higher than in rural areas.

Geyer, Gavigan, Jackson, Saccomanno, Suh and Gleason (2022), who conducted a study on global waste composition, state that paper and cardboard are some of the major components of urban waste although their share is generally lower than that of plastic. Their research found that paper and cardboard typically make up around 17.20% of waste in high-income countries, which is similar to the 17.6% observed in Mangaung (Geyer *et al.*, 2022).

4.3 Solid waste services

This section addresses the frequency and challenges of waste collection by the Mangaung Municipality, and the discourse highlights various inconsistencies and the prevalence of reliance on informal waste management methods. The findings underscore the need for improved communication of waste collection schedules, enhanced segregation and recycling practices, and compliance with landfill site standards to minimize environmental impacts, as proposed by Adeyinka and Taiwo (2024).

4.3.1 Frequency of waste collection in the municipality

Figure 4.9 depicts the varied time intervals at which the municipality collected waste from the sampled households. A significant proportion of the employees (52, 74.29%) stated that the municipality collected waste once a week, while six (8.57%) reported that collection occurred twice a week, and three (4.29%) thought it was monthly. Only

seven (10.00%) said that the municipality never collected waste, while two (2.85%) were uncertain. These results suggest some inconsistency regarding waste collection in the municipality. Eisenberg (2014a) highlights the importance of consistent and efficient waste collection as a mechanism that reduces adverse environmental impacts.

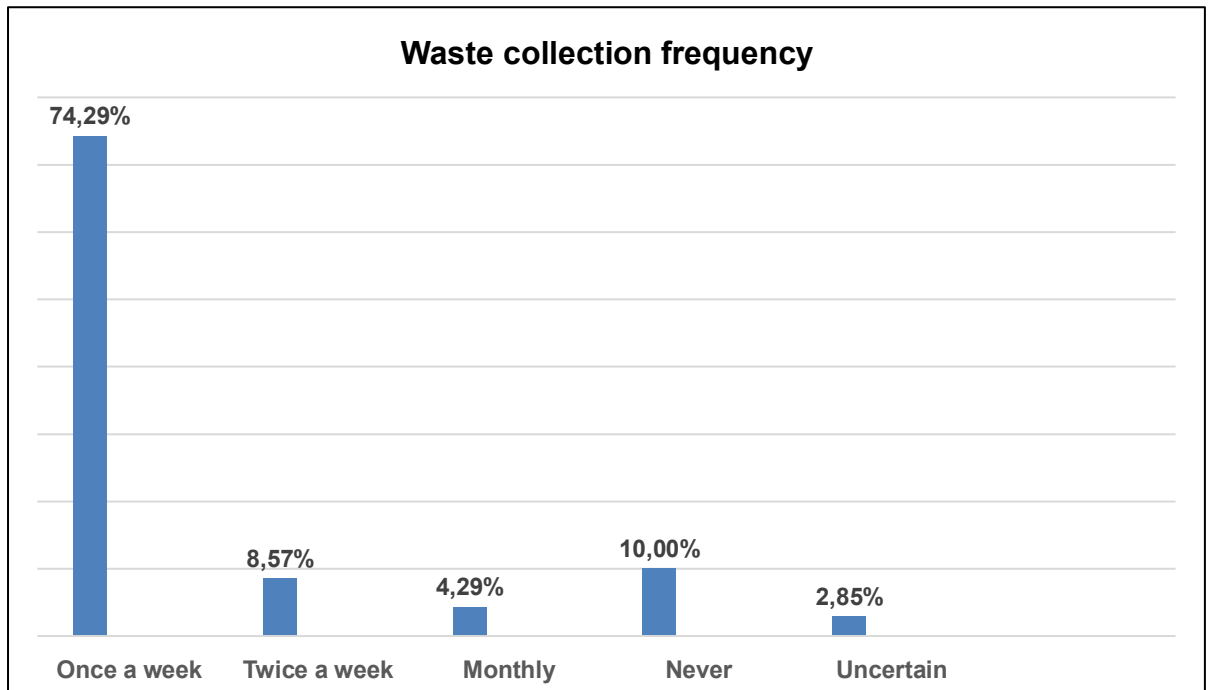


Figure 4. 9: Frequency of waste collection in the municipality

Inconsistent waste collection practices have been observed in other municipalities as well, which is a phenomenon that can negatively impact waste management efficiency and increase environmental pollution. Pereira, Dos Santos and Cruz (2018) argue that in several South African municipalities waste collection frequencies vary significantly, with some areas receiving collections twice a week while others being serviced only once a week or even monthly. This inconsistency often results in overflowing bins and improper disposal practices, leading to increased waste in public spaces and the environment. Similarly, Kakooza, Ngobese and Mpofu (2017) highlight that, in large urban centres like Johannesburg, inconsistent waste collection schedules have been identified as a major challenge that contributes to poor waste segregation and

increased reliance on informal waste pickers. These findings align with Eisenberg's (2014b) assertion of the importance of regular and reliable waste collection schedules, which are essential in promoting better waste management practices and reducing the environmental footprint of waste. Implementing standardized and more frequent collection services, as recommended by several studies, could improve efficiency and foster a more sustainable approach to waste management.

4.3.2 Resource shortages and non-collection of waste

The employees were requested to provide details of the waste collection service they received. In cases of omission or limited waste collection, the residents were asked to state what they did with their waste when it was not collected. The results (Figure 4.9) revealed that 38 (53.5%) of the employees stated that informal methods were used to collect waste. Less than half of the respondents (31, 43.7%) stated that waste collection was done by waste pickers. One (1.4%) of the employees stated that contractors collected waste while another (1.4%) said that there was no collection service. These data show that the municipality relies excessively on waste pickers and other informal waste disposal methods, which highlights the significant role of the informal sector in waste management. A large portion of the residents (87, 62.4%) stated that they burnt their waste in instances of non-collection, while 34 (24.8%) dumped their waste in open spaces, 12 (8.5%) left their waste on the sidewalk until collection, and 4.3% returned their waste to the receptacle. These findings align with Eisenberg's (2014b) view that, over a period spanning hundreds of years, different ways have been employed to dispose of waste, including dumping it in open pits and burning it.

The reliance on informal waste management methods is not unique to Mangaung but has been observed in various regions globally. Oelofse, Nahman, Baig, Salemdeeb, Nizami and Reynolds (2020) aver that in many South African municipalities informal waste pickers play a crucial role in waste collection, particularly in areas with insufficient municipal services. The latter study showed that informal waste pickers

contributed significantly to waste recovery, as these workers often sorted recyclable materials before waste reached official waste management facilities.

However, the heavy reliance on informal methods can lead to challenges such as inadequate waste segregation, pollution, and health risks. Furthermore, Mekonnen, dos Muchangos, Ito and Tokai (2022) reported that, in some urban areas of Kenya, residents resorted to burning or dumping their waste in open spaces when waste collection was irregular and that these practices significantly impacted environmental quality. In the latter study, it was found that 35% of urban residents reported engaging in open dumping or burning due to inadequate waste collection services. This highlights the need for municipalities to improve waste collection infrastructure to reduce the adverse environmental and health impacts associated with informal waste disposal methods.

4.3.3 Waste collection information and schedule

Figure 4.10 shows that a significant number of respondents were informed about the waste collection schedule at their places of residence, 69.06%. However, Figure 4.11 shows that 66.9% of the respondents indicated that they never get informed when no collection will take place, while 15.8% stated that the information was sometimes shared, and 17.27% noted that the information was always shared.

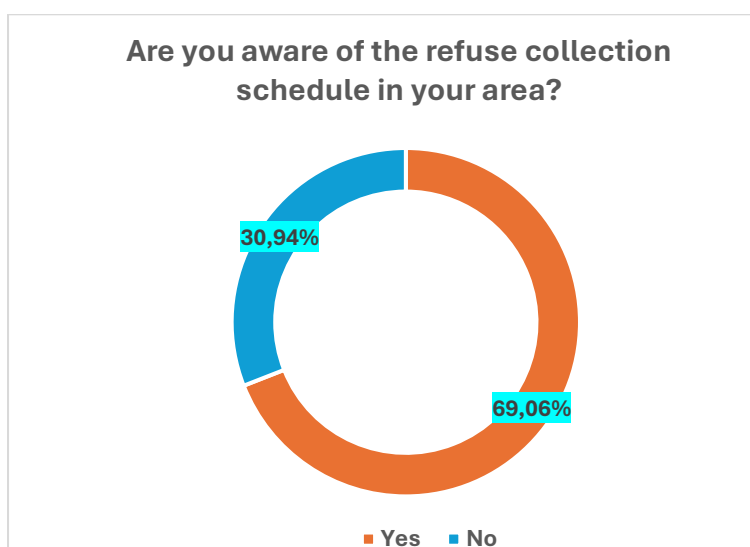


Figure 4.10: Residents' awareness of the existence of a waste collection schedule

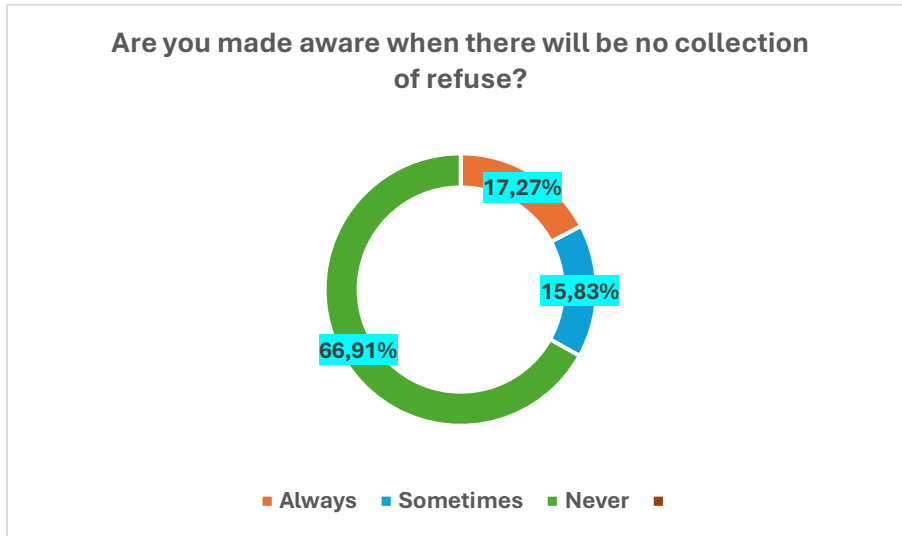


Figure 4.11: Residents' awareness if no waste collection will occur?

Many residents 88 (63%) resorted to burning their waste if not collected (Figure 4.12), while 38 (54.29%) indicated that there's no collection when there is a resource shortage (Figure 4.13). Therefore, as corroborated by Johnson and Brown (2018), there is a need for effective communication and awareness of waste collection schedules as this is critical for efficient waste management.

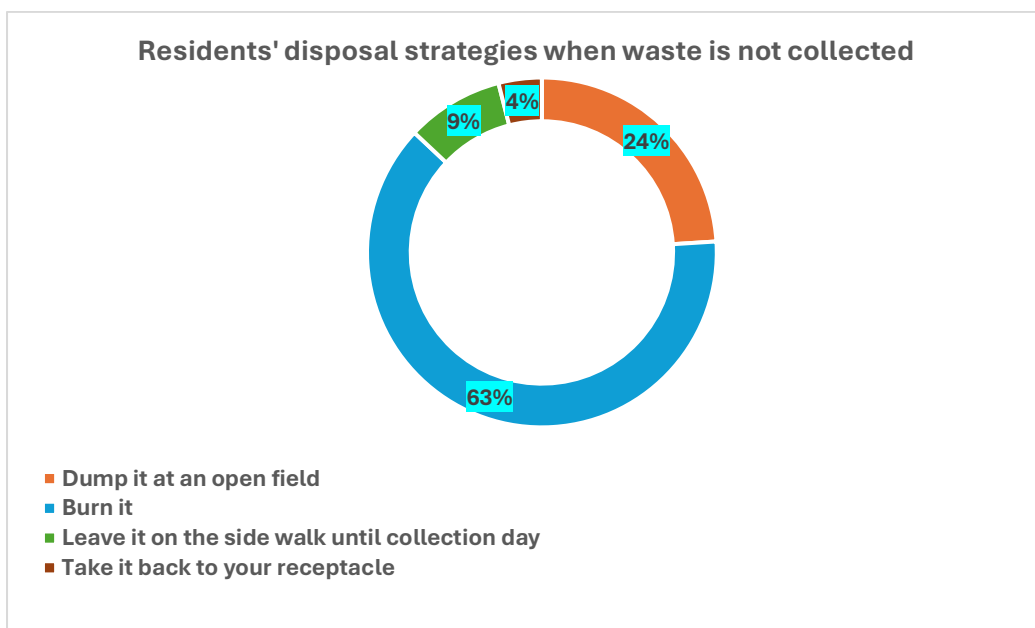


Figure 4.12: Residents' disposal strategies when waste is not collected

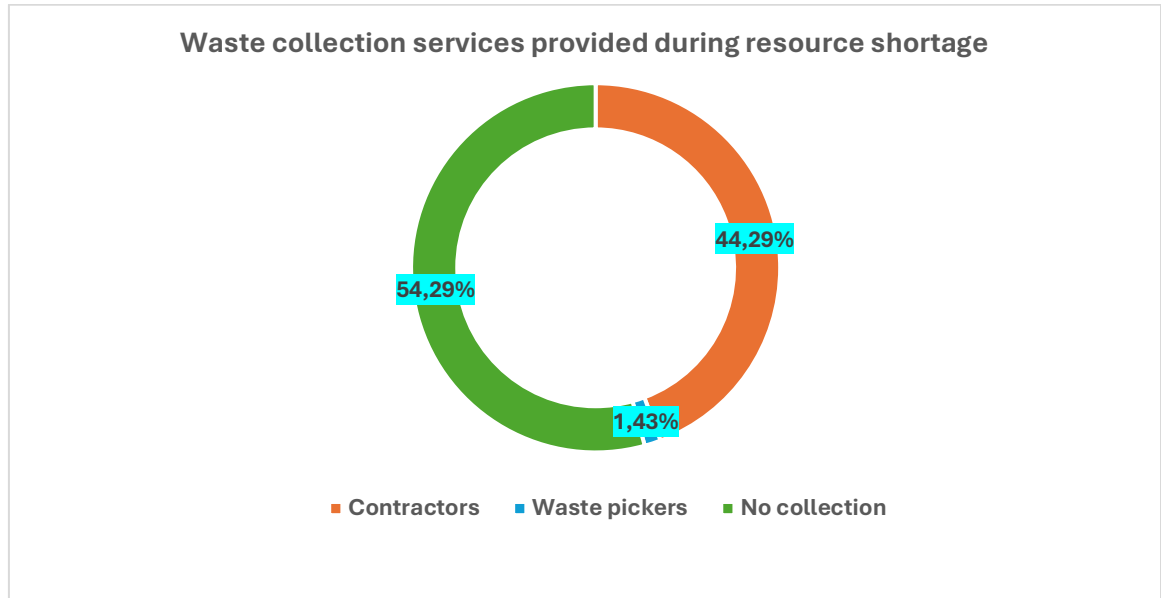


Figure 4.13: Waste collection services during resource shortages

The issue of inadequate communication regarding waste collection schedules has been observed in municipalities globally, and it has been argued that this omission often leads to confusion and inefficiency in waste management. According to Scheinberg, Wilson and Rodic (2015), residents in Accra in Ghana were frequently unaware of the local waste collection schedules, and this contributed to improper waste disposal such as illegal dumping and burning of waste.

Their study highlights the importance of clear communication strategies, including public announcements, community meetings, and digital platforms to ensure that residents are well-informed. Similarly, Parker, Thomas and Louw (2019), whose study on waste management was conducted in Johannesburg, South Africa, noted that, despite regular collection services, 42% of the respondents was not familiar with the exact collection schedule due to inconsistent information dissemination by the municipality. This lack of communication led to disruptions in the waste collection process and undermined efforts to maintain a clean and sustainable urban environment.

In contrast, Nguyen, Tan and Lim (2020) refer to the success of waste management systems in cities with robust communication frameworks, such as Singapore, where residents are consistently informed through multiple channels about waste collection schedules. Their study avers that clear communication, supported by mobile apps and regular community engagement programs, will significantly improve participation in scheduled waste collection. They argue that consistency in communication ensures that waste is appropriately sorted and disposed of, thus contributing to higher recycling rates and lower contamination levels. Conversely, the lack of effective communication in Mangaung, as identified by the survey results, highlights a critical gap in the municipality's waste management strategy and emphasizes the need to adopt more proactive and transparent information-sharing methods to improve service delivery and encourage responsible waste disposal practices.

4.3.4 Segregation, recycling, reuse, waste reduction, and awareness campaigns

Figure 4.14 indicates that a total of 47 (33.8%) respondents answered “Yes” to the question whether they segregated recyclables from any other waste, 79 (56.83%) stated that they re-used unwanted waste, and 93 (66.91%) were not aware of any awareness campaigns regarding waste management in Mangaung.

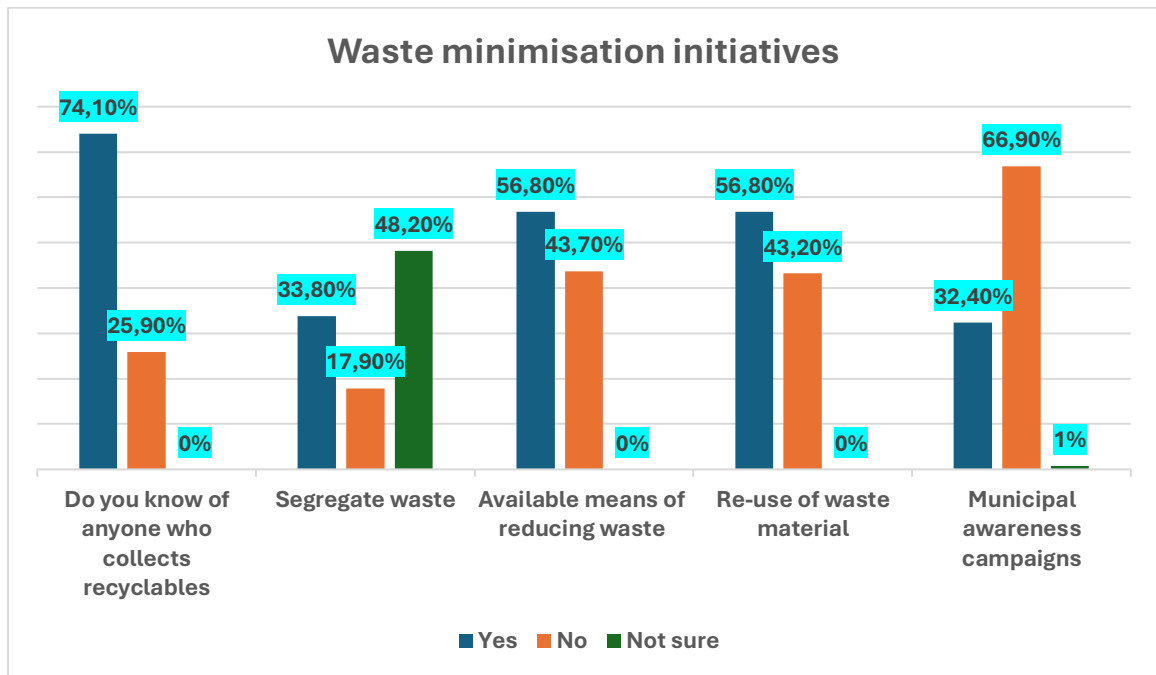


Figure 4.14: Segregation, recycling, reuse, waste reduction, and awareness campaigns

Figure 4.14 depicts that a total of 79 (56.8%) residents answered “Yes” to the questions whether they segregated recyclables from all other waste, whether they reused unwanted waste, and whether they had the means to reduce the quantity of waste generated, while 60 (43.2%) admitted that they did not engage in any such practices. This suggests insufficient knowledge among residents in the study area on how waste management and separation of waste should be done according to waste types. If waste is properly treated at source, it eases the recovery of resources for recycling and reuse. In line with this finding, Andrews (2014) emphasizes that segregation is a key step in effective waste management as it promotes recycling and reduces landfill waste. Therefore, based on this data, there is a need for increased efforts to encourage more residents to segregate waste.

On the question that sought to discover if the community members were aware of solid waste legislation, 93 (66.9%) of the residents replied “Yes” and 46 (33.1%) replied “No”. This reflects a low awareness of the waste legal framework among the residents and could have been the result of insufficient campaigns or lack of communication between

the municipality and its residents. Johnson and Brown (2018) state that effective municipal campaigns are pivotal in fostering public awareness and engagement in waste management practices.

In other municipalities, effective awareness campaigns have been proven to significantly improve public engagement in waste management practices. Muthusamy, Singh and Smith (2020) found that in Cape Town, South Africa, a comprehensive public awareness campaign that focused on waste segregation and recycling resulted in a 35% increase in residents' participation in recycling programs over two years. Similarly, Goh, Lee and Tan (2019) reported that in Singapore the government successfully used targeted educational initiatives, including community workshops and social media outreach programmes, to raise awareness about waste management legislation. As a result, it was found that 75% of residents segregated waste at source, reflecting the effectiveness of these campaigns in promoting environmentally responsible behaviours. The findings of the studies referred to above highlight the importance of well-designed and accessible awareness campaigns to improve waste segregation practices and enhance public understanding of waste management regulations, something that is currently lacking in Mangaung based on the survey results.

4.3.5 Dumpsite location and distance from collection points

Based on the results (Figure 4.15), 61 (87.14%) of the employees identified landfills as waste disposal sites, while six (8.57%) respondents did not know, two (2.86%) mentioned open spaces, and one (1.43%) identified the dumpsite in their area as “other”.

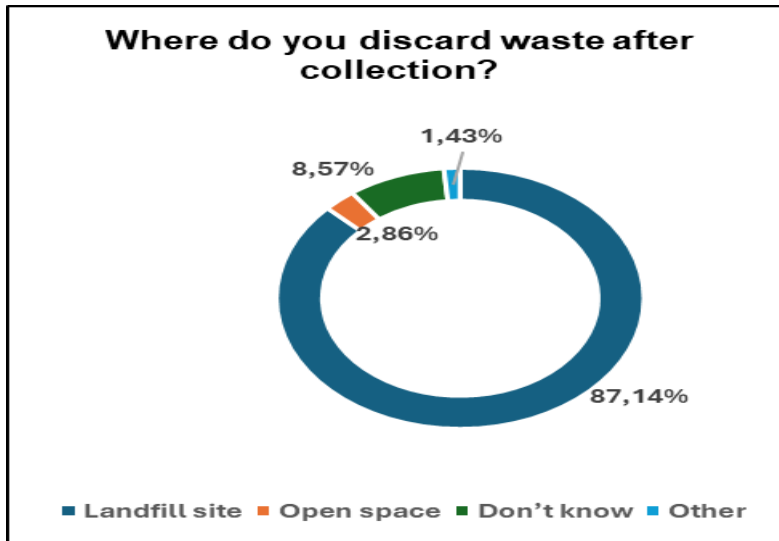


Figure 4.15: Where refuse is discarded after collection

Furthermore, see figure 4.16, most employees (60%) stated that the landfill site was less than 10 km from the collection area, (34.29%) said it was between 10 and 25 km, while two (2.86%) of the respondents indicated that it was between 25 and 40 km from their residential areas. Only three (4.3%) reported that it was more than 40 km from the collection point. If collection areas are in close proximity to landfill sites, it is beneficial in terms of reducing transport costs and creating fewer technical problems, while it also minimizes the environmental impact of waste management (Johnson, Lewis, Lischka and Breck, 2018). However, landfill and waste dumping sites are also associated with adverse impacts such as polluted air, odours, and rodents; hence, most people prefer to live as far away from such facilities as possible.

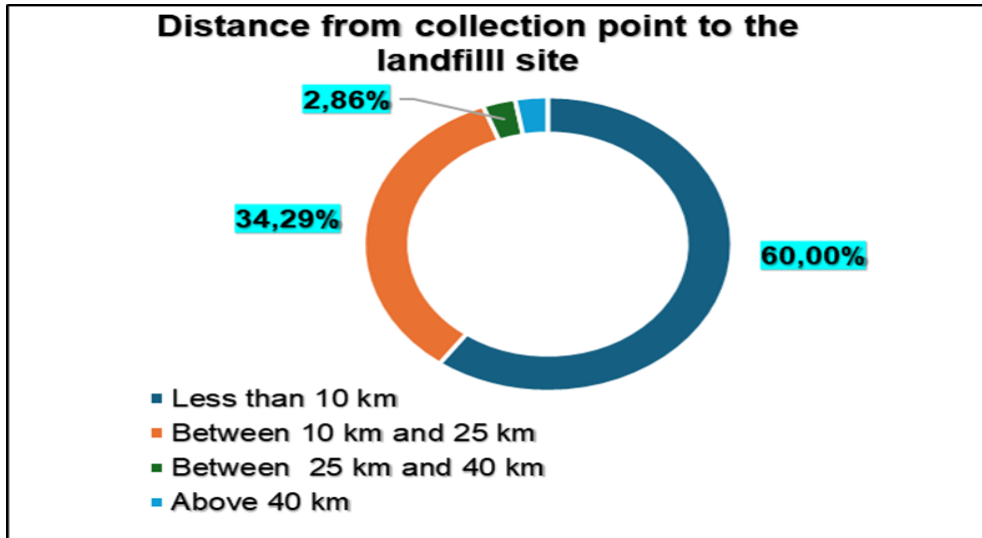


Figure 4.16: Dumpsite location and distance from the collection area

In some earlier studies that explored landfill proximity and waste management, similar findings regarding the importance of distance between collection areas and landfill sites have been reported. Mkhize, Zuma and Nkosi (2017) conducted their study on waste management practices in Durban and found that 65% of their respondents lived within 10km from their collection areas. However, they also noted that longer distances, particularly those greater than 40 km, increased transport costs and adverse environmental impacts due to higher fuel consumption and gas emissions.

The findings of Mkhize, Zuma and Nkosi (2017) is similar to the findings in Mangaung, where 60% of the employees indicated that the landfill site was less than 10 km from the collection area. Interestingly, Mbande, Tlou and Nkosi (2021), whose study was conducted in Johannesburg, found that landfill sites were often located a considerable distance from residential areas, with over 40% of their respondents indicating distances greater than 25 km. However, distance posed significant challenges in terms of logistics and waste management efficiency, which contrasted with the relatively shorter distances between collection points and landfill sites in Mangaung. The findings cited above emphasize the impact of distance as a factor that can minimize costs and reduce environmental impacts, and this in turn highlights the need for municipalities to

carefully consider the effects of the location of current and future landfills on residential areas.

Wanjiru and Karanja (2018) state that in smaller municipalities in Kenya waste management systems often face challenges due to the physical distance from collection points to landfill sites as well as a limited to poor transport infrastructure. They found that about 55% of waste collection points was more than 25 km from a landfill, which made timely disposal difficult and often resulted in waste accumulation in urban areas. In contrast, Mangaung's proximity to landfill sites seems advantageous in terms of ease of transportation, although further improvements in waste collection and transportation efficiency should be considered for the benefit of the municipality's overall waste management strategy.

4.3.6 Waste collection and disposal operations

The results that are reflected in Figure 4.17 highlight the observation of some solid waste services and operations, including waste collection schedules, monitoring of operations at landfill sites, and disturbances that occur during waste collection in the study area. The results show that only 42 (60%) of the employees agreed that landfill sites were monitored after waste was dumped, while 28 (40%) disagreed with this statement.

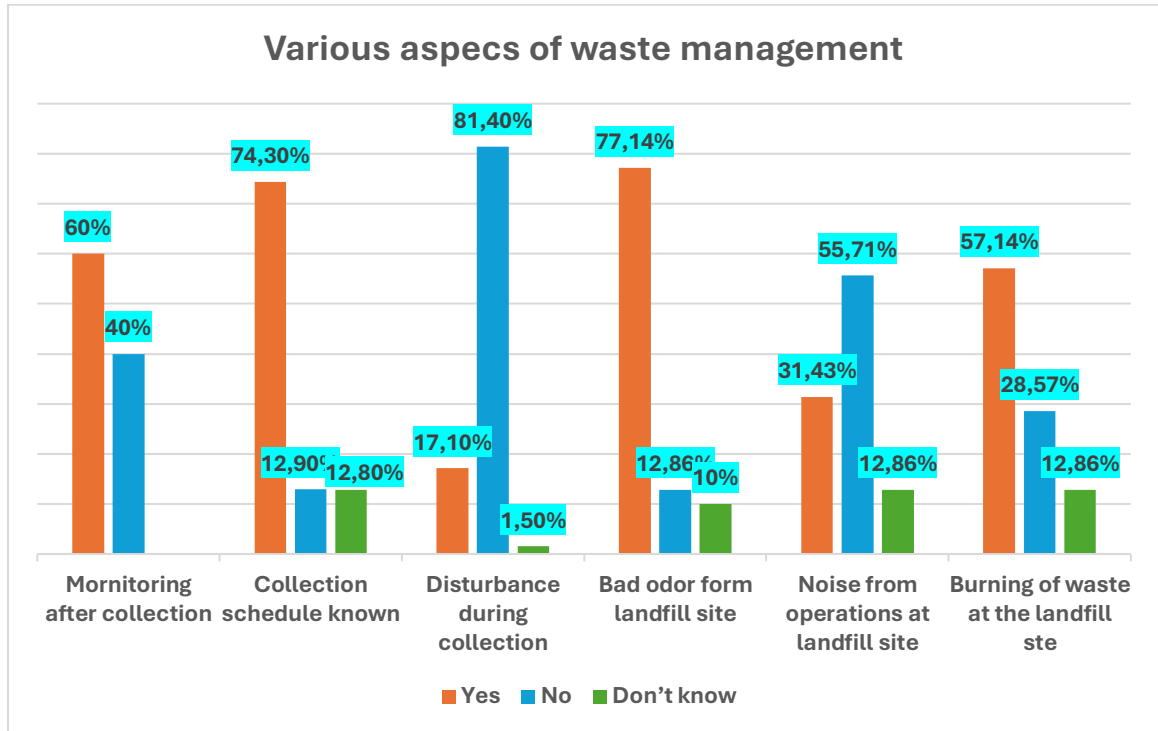


Figure 4. 17: Operations in waste collection and disposal

4.3.7 Compliance with landfill site regulations

The data in Figure 4.18 were mostly obtained from the observation checklists that had been completed in at each landfill and dumpsite during the researcher's visits, and the data illustrate the compliance rates at these sites in the Mangaung area. These requirements had been developed to alleviate the effect of landfilling refuse on the environment and to minimize any other hazards. They are regarded as the *minimum* requirements for waste disposal at landfill sites. However, the Mangaung Municipality scored low in terms of each requirement.

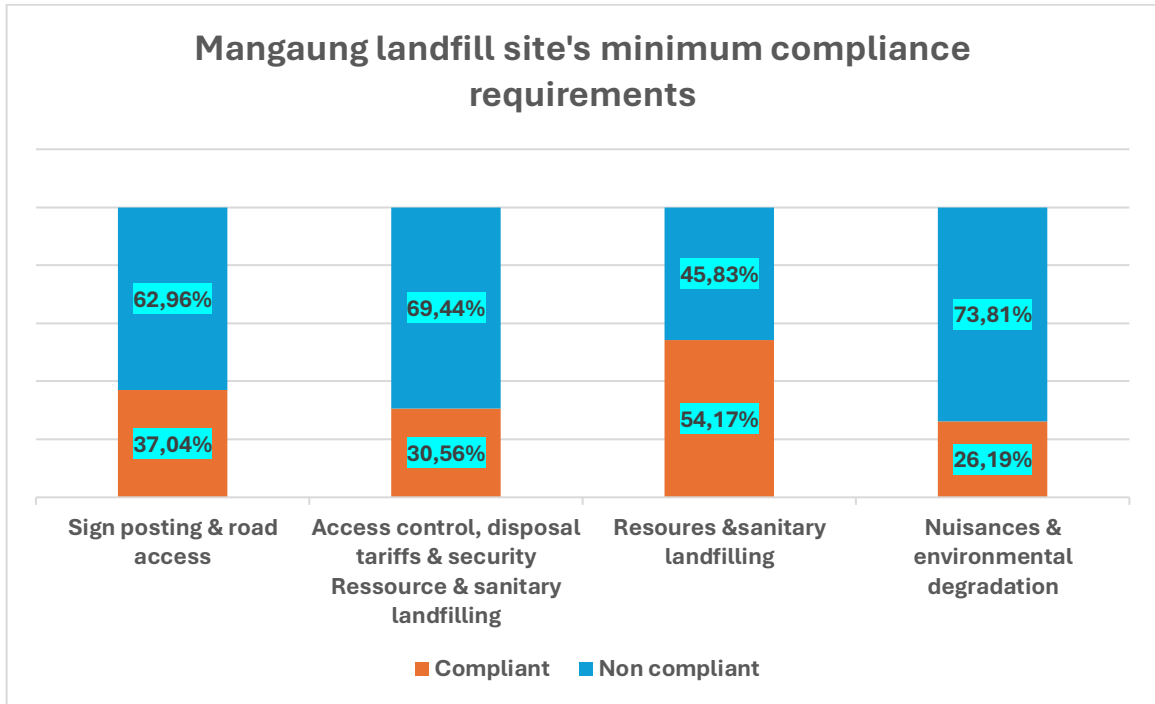


Figure 4.18: Minimum requirements for landfill site compliance

Together, signposting and road access achieved a 37.04% rating; access control, disposal tariffs, and security achieved 30.56%; availability of resources and sanitary landfilling achieved 54.17%, while controlling nuisance factors and preventing environmental degradation factors achieved only a 26.19% compliant rate.

Adequate signage must be placed at each landfill site to direct drivers and limit speed. A clearly readable notice board must be erected at the entrance of each site, indicating name of the site, the municipality's address, and emergency phone numbers of responsible persons and permit holders. The wording of these signs must be written in at least three official languages. The signage should also include the operating hours and clearly state the landfill class and what kinds of waste are acceptable. Tariffs should be stated on the notice board and must be determined by mass and estimated volumes obtained by utilising a weighbridge.

Sufficient security and access control to safeguard any on-site machinery and facility must be in place and visible. It is a minimum requirement that illegal access to a landfill site must be restricted, and waste reclamation and squatting should be prevented to protect public health and safety (South Africa, Department of Environmental Affairs, 2013). Moreover, adequate resources such as machinery and appropriately qualified personnel are essential to ensure continuous waste disposal operations in an environmentally friendly manner. This means that appropriate, functional, and sufficient resources must be available to fulfil the operational requirements at each landfill site.

4.4 Implementation of and adherence to solid waste legislation

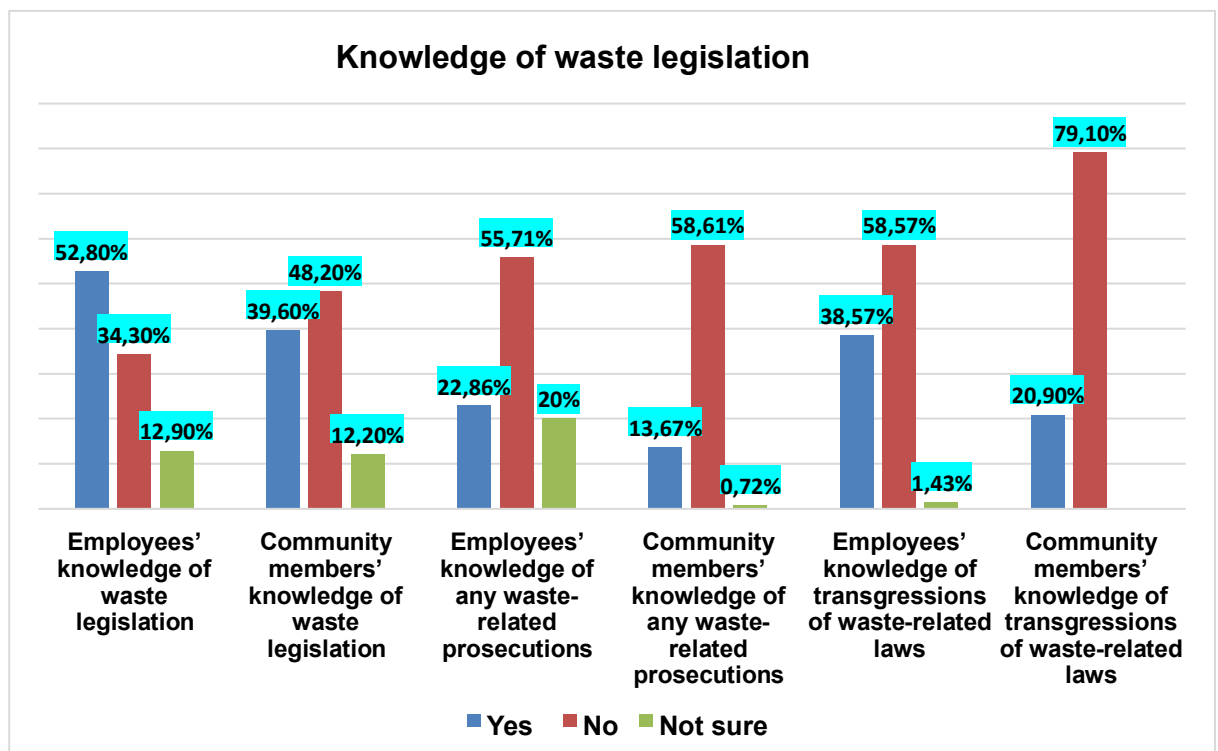


Figure 4.19: Implementation of and adherence to solid waste legislation

Figure 4.19 summarizes the results that emerged when a question was posed to determine the respondents' knowledge of solid waste legislation. It was found that 37 (52.8%) of the employees were aware of existing solid waste legislation, 24 (34.3%) were not aware, and nine (12.9%) were not sure about such legislation. Most of the residents (67, 48.2%) were not aware of any MSW legislation, while 55 (39.6%) were aware of such legislation and 17 (12.2%) were unsure. The results revealed a mixed degree of knowledge of solid waste legislation among the employees as well as the

residents, indicating that while some were aware of this crucial legislation, a significant number was not. This gap in awareness can lead to non-compliance and improper waste disposal practices. However, Andrews (2014b) highlights that the Mangaung Municipality introduced awareness programs on waste management that emphasized the importance of robust legislative frameworks in the 1980s and 1990s. However, this was a long time ago, and such initiatives should be resuscitated.

Most employees (41, 58.57%) and residents (53, 79.10%) did not know of any transgressions of waste laws, while 14 (20.9%) residents and 27 (38.57%) employees were aware of such illegal activities. The predominant lack of awareness of the law suggests a need for more stringent enforcement and communication about the consequences of non-compliance. Moreover, the fact that a few residents were aware of prosecutions and that a few had received notices for transgressions suggests that the enforcement system needs to be more visible and more effective.

4.5 Conclusion

This chapter discussed the analyses of the quantitative data on municipal solid waste management in the Mangaung Municipality. The male gender dominated gender among the municipal employees. Also, the municipal employees' sample was dominated by a mature and experienced age group, whereas the dominant age group of the residents was younger. Most of the respondents were Africans, whereas the levels of education of the respondents varied. However, most had attained a secondary school and/or matric education. This chapter also suggested that the waste generation rate within the study area might be lower than that of other areas as the sample was dominated by small households.

This chapter revealed that municipal employees lacked sufficient waste management training which calls for robust training programs in this area. Furthermore, the respondents' awareness of buy-back centres was moderate, which means that it should be enhanced so that the importance of recycling is disseminated on a larger

scale. The chapter also indicated that most employees and residents were aware of recycling and understood the need for the recycling of waste. The landfill sites were identified as dumpsites, and it was noted that the proximity of landfill and dumpsites to waste collection points was favourable, although some adverse points were also raised. Moreover, the respondents indicated that waste collection frequencies were erratic, leading to illegal dumping and burning of waste by residents. This chapter further exposed mixed and conflicting knowledge of solid waste legislation, with a significant gap in awareness. This gap calls for training, education, and communication with residents and employees regarding waste collection and management services to ensure full compliance with basic regulations.

CHAPTER 5

GENERAL DISCUSSION

Introduction

This chapter presents the researcher's critical reflections on the challenges, opportunities, and strategies to enhance solid waste management in the Mangaung Municipality. Based on the findings, the discourse explores inefficiencies in waste management practices, especially in terms of collection, stakeholder involvement, and technological integration. To put these findings in context, comparisons are drawn with countries such as Rwanda, China, and the United States. The purpose is to recommend strategies that will address the gaps in Mangaung's waste management system by following global best practices. The key points that are discussed are:

- Current practices and the challenges that impact solid waste management;
- Stakeholder engagement and community participation in waste management;
- Policy and a legal framework for waste disposal and management;
- Technological innovations in waste management; and
- Sustainability and the environmental impact of waste management.

5.1 Current practices and the challenges that impact solid waste management

Solid waste management is a process that includes the collection, treatment, and disposal of solid waste in ways that are safe for the environment and hygienic for humans (American Public Health Association, 2023). Solid waste management in the study area was characterized by traditional and out-of-date collection methods, inefficient allocation of resources, and a lack of infrastructure. It may be argued that all these factors contribute to the city's waste management challenges. It was established that the municipal waste collection schedule was inconsistent and infrequent. This aligned with Eisenberg's (2014b) and Khumalo's (2017) view that consistent and efficient waste collection is a mechanism that reduces environmental impacts. Other issues that emerged were instances of no collection of refuse by the municipality due to shortages of resources and no or limited communication with the community, which encouraged illegal dumping and created unsanitary living conditions, thus raising

environmental concerns. It was evident that waste was burnt, dumped in open spaces, left on sidewalks until collection, or returned to their receptacles. These informal waste disposal methods are criticized by Eisenberg (2014a) and Khumalo (2017), who postulate that such methods are harmful to human life and the environment. The high rates of burning and illegal dumping of waste underscore the need for more reliable waste collection services and better public education in the study area. Moreover, the over-reliance on traditional methods exacerbates the problem, as these approaches are unable to cope with rising waste generation rates due to population growth and urban expansion (Ailyn, 2025).

Mangaung Metropolitan municipality has a high number of illegal dumping sites, and it does not have an effective system for collecting and processing recyclable materials (Mofokeng, du Plessis and du Plessis, 2022). Furthermore, the municipality has struggled to provide enough waste management services to its informal settlements, which are home to a significant percentage of its population (Grangxabe, Maphanga, Madonsela, Gqomfa, Phungela, Malakane and Angwenyi, 2023). These settlements often do not have enough facilities or the proper infrastructure such as waste collection points, which means that residents cannot properly dispose of their waste (Mothibi, 2015).

The proximity of collection areas to landfill sites is deemed beneficial as this reduces transport costs and technical challenges while minimizing the environmental impact of waste management (Mofokeng, du Plessis and du Plessis, 2022). However, odours, the burning of waste, and the prevalence of rodents negatively affect those residing near landfill sites (Roy, Subham and Bose, Arghadeep and Basak, Debanjan and Chowdhury, Indrajit, 2022). The study also identified that some people lived some distance between waste generation points and landfills, which resulted in infrequent waste collection services in outlying areas and contributed to illegal dumping and waste burning. In comparison, China has addressed similar challenges by decentralizing waste management services and investing in waste-to-energy plants to reduce its reliance on distant landfills (Peckl, 2022). In the case of Mangaung, there is a need to

implement a decentralized waste collection system to reduce transportation costs and improve service efficiency.

5.2 Stakeholder engagement and community participation in Waste Management

The Johannesburg Metro plays a leading role in waste management as it has created a centralised waste management system, while Mangaung's initiatives are more scattered and largely involve communities and businesses (Kubanza, Matsika and Magha, 2022). Successful waste management requires the active participation of all stakeholders, namely residents, businesses, and municipal authorities. Unfortunately, there seems to be limited community engagement in Mangaung's waste management efforts. The findings suggest that many residents are unaware of proper waste disposal practices, while public education campaigns have been sporadic and ineffective.

Community participation is particularly crucial in encouraging recycling and waste segregation. For instance, Kigali in Rwanda has demonstrated the importance of grassroots involvement in waste management. Rwanda's focus on community-driven waste management programs, coupled with strict enforcement of waste regulations, has led to significant improvement in cleanliness and waste diversion (Mwenje and Kumar, 2024). The success of Rwanda's approach suggests that Mangaung could benefit from adopting similar strategies, such as engaging residents through awareness campaigns, encouraging participation in local recycling programs, and incentivizing responsible waste disposal.

Furthermore, stakeholder engagement should extend beyond residents to include businesses, non-governmental organizations (NGOs), and the private sector. Public private partnerships have been a driving force behind waste management success stories worldwide. For instance, in Japan collaboration between government agencies and private companies has created a highly efficient recycling system. Businesses are held accountable for the waste they generate, and they are required to adopt ecofriendly practices such as packaging reduction and waste reuse. Mangaung could

benefit from similar partnerships if local businesses are incentivized to reduce their waste footprint, recycle more, and contribute to the city's broader waste management goals.

However, recycling efforts in the Mangaung Municipality remain low, with limited infrastructure to support waste segregation. Trushna, Krishnan, Soni, Singh, Kalyanasundaram, Annerstedt, Pathak, Purohit, Lundbog, Sabde, Atkins, Sahoo, Roustá, and Diwan (2024) emphasize that segregation is a key step in effective waste management as it promotes recycling and reduces landfill waste. Community involvement in recycling in the study area is minimal, and this presents a missed opportunity for the municipality to divert waste from landfills. The failure to invest in robust recycling infrastructure contributes to the continued pressure on landfills, and this has led to environmental degradation. In contrast, developed economies like the United States have made substantial progress in increasing recycling rates through public-private partnerships, educational campaigns, and offering incentives to encourage waste separation at the source. This notion is supported by Johnson and Brown (2018), who posit that effective municipal campaigns are pivotal in fostering public awareness and engagement in waste management practices.

5.3 The legal framework that governs waste disposal and management

Scott (2019) avers that a legal framework entails the laws and regulations that control how waste is collected, treated, and disposed of. In other words, a well-structured legal framework is essential for effective waste management. There are numerous laws that govern and control SWM in the Free State Province. Some of these are the Free State Provincial Gazette No. 84 of 9 December 2011, the National Environmental Management: Air Quality Act of 2004 (NEMAQA), the Waste Information and Pricing Regulation Act of 2014 (NEMWIPR), the National Environmental Management Waste Act of 2008 (NEMWA), and the National Water Act of 1998 (NWA). A Free State Provincial Gazette No. 84 of 9 December 2011 states that the aim of this piece of legislation is to regulate all aspects of waste management and to provide for norms

and standards at the national level to ensure effective and efficient management of waste by enacting norms and standards expressed in the issuing of waste permits and licenses. The key aim of this provincial Gazette, which regulates waste management in the Free State Province, is to safeguard the environment and ensure that waste is disposed of in a safe and environmentally sensitive way. Unfortunately, Mangaung's policies are not fully aligned with national waste management strategies like the Integrated Waste Management Plan (IWMP), and this weakens the effective implementation of relevant policies and regulations. The absence of a strong enforcement mechanism makes it difficult to promote practices like recycling, waste separation, and composting at municipal level. The current study exposed a high level of awareness of solid waste legislation by the respondents of the Mangaung municipality, but they lacked knowledge of the transgressions as stated in solid waste legislation as well as prosecutions for transgressions of the law. Andrews (2014b) highlights that the Mangaung Municipality introduced awareness programs on waste management that included emphasis on the importance of robust legislative frameworks, but these were introduced in the 1980s and 1990s and have not been activated recently.

The National Environmental Management Waste Act (NEMWA) of 2008 provides a robust legislative framework for waste management in South Africa. However, its potential remains underutilized in Mangaung. It was observed that the study area's dumping sites did not have adequate signage to direct drivers and indicate the speed limit. At the sites' entrances, there were no notice boards that indicated the name of the site, addresses, and emergency phone numbers of responsible persons and permit holders, as required. The signage that did exist did not include the operating hours or clearly stated the landfill class and what kinds of waste would be acceptable, and tariffs were not stated on the notice boards (South Africa, DEA, 2013). Thus, Mangaung municipality needs to enforce waste management legislation more rigorously to address issues related to illegal dumping and poor waste separation at source. Stricter penalties for non-compliance with waste regulations, combined with incentives for good waste management practices, could significantly improve the city's waste management outcomes.

Global examples have shown that strong policy enforcement is a critical component of successful waste management. In China, stringent regulations on waste generation and recycling have contributed to the country's success in managing its waste challenges. The government's policy-driven approach, supported by public-private partnerships, has enabled China to implement large-scale recycling and waste-to-energy initiatives (Kumar *et al.*, 2023). This policy framework could serve as a model for Mangaung to adopt more stringent measures to ensure compliance and encourage innovation in waste management practices. Additionally, policies that promote a circular economy could benefit Mangaung as implementing them will reduce waste generation and encourage the reuse of materials. The circular economy model, as implemented by member countries of the European Union, focuses on reducing waste by keeping resources in use for as long as possible (Degefu and Asefa, 2024). This approach does not only minimize waste but also generates economic opportunities through the recycling and remanufacturing sectors.

5.4 Technological Innovations in Waste Management

Technological innovations have transformed waste management globally and have improved efficiency, reduced costs, and minimized environmental impacts. However, the adoption of such technologies in Mangaung has been limited. The municipality continues to rely on manual waste collection methods, but these are inefficient and prone to operational challenges (Smith, 2020). In the study area, waste is normally collected in bin containers and transported to central disposal dumping sites like landfills. According to Van Rooyen and Venter (2021), waste collection is usually done by private contractors who are paid for the mass of waste they carry, and this waste is transported to dumping sites using a combination of trucks and trains. This is contrary to the more efficient use of automated waste collection vehicles that are equipped with mechanical arms, such as those that have been successfully deployed in cities like Johannesburg and Durban, where they have significantly improved the speed and efficiency of waste collection. Mangaung has yet to fully embrace these innovations, which could enhance its waste management operations.

Smart waste management technologies, such as sensor-equipped bins and data-driven waste tracking systems, are increasingly being used in cities like Singapore and New York (Nanda and Berruti, 2021). These technologies allow waste collection services to optimize routes, reduce fuel consumption, and minimize labour costs by only servicing bins that are full. Should Mangaung procure these technologies, it could help the municipality to address its resource constraints by making waste collection more targeted and efficient.

In addition to improving collection processes, technological innovations can also enhance recycling efforts. In Rwanda, for example, biogas plants convert organic waste into energy, and this reduces the amount of waste sent to landfills while generating renewable energy (Otukoya, 2024). Similar initiatives could be explored in Mangaung, particularly given the large volume of organic waste generated by households and businesses. Waste-to-energy projects, while costly to implement, could provide long-term environmental and economic benefits by reducing landfill use and generating sustainable energy for the municipality.

5.5 Sustainability and the environmental impact of waste management

Sustainability is at the core of modern waste management practices, yet Mangaung's current system does not prioritize environmental sustainability. The irregular collection of waste, coupled with poor landfill management, contributes to significant land, water, and air pollution. As waste piles up in informal settlements and on open spaces, it creates a breeding ground for pests and contributes to the spread of disease (Görgens and Ramutsindela, 2016; Moffat, 2021). In addition, the burning of waste in certain areas exacerbates air quality issues, posing serious public health risks.

The environmental impact of waste mismanagement in Mangaung can be mitigated by adopting sustainable practices such as composting, recycling, and waste-to-energy conversion. In the United States, composting programs have become a vital component of municipal waste management systems. Organic waste, which would

otherwise contribute to landfill mass and methane emissions, is diverted to composting facilities where it is processed into nutrient-rich soil amendments (Khan, López-Maldonado, Khan, Villarreal-Gómez, Munshi, Alsabhan and Perveen, 2022b). This does not only reduce the burden on landfills but also provides a valuable resource for agriculture and landscaping.

In Mangaung, composting programs could significantly reduce the amount of organic waste sent to overburdened landfills. Furthermore, the municipality could explore public-private partnerships to establish composting facilities that cater for both residential and commercial organic waste streams. The adoption of composting combined with better recycling infrastructure will also reduce the environmental footprint of Mangaung's waste management system and contribute to the city's sustainability goals (Farhidi, Madani and Crichton, 2022).

Furthermore, the maintenance of environmental sustainability has been discovered to be facilitated by community sensitisation campaigns as well as training on solid waste reuse and recycling aspects (Andrews, 2014a). As such, municipality employee training and awareness, community awareness of buy-back centres, a positive attitude towards and knowledge of recycling, and knowledge about the most types of waste being generated play a crucial part. Moreover, the training of employees in waste management ensures effective management and handling of waste. Andrews (2014b) points out that training and awareness programs are crucial for efficient waste management practices. He also emphasizes the need for educational initiatives to build awareness and cultivate responsible practices, arguing that this will provide a foundation for the promotion of recycling programs as awareness and training facilitate high rates of recycling. The introduction of successful recycling programs is supported by Andrews (2014a), who underscores the importance of reducing waste generation through recycling and reuse.

5.6 Conclusion

This chapter critically examined the challenges, opportunities, and strategies for enhancing solid waste management in the Mangaung Metropolitan Municipality. With reference to inefficiencies in collection, stakeholder engagement, and technological integration, the chapter highlighted critical gaps in the current waste management system in this municipality. Drawing on global comparisons from countries like Rwanda, China, and the United States, the discussion identified actionable strategies to address these challenges while emphasizing the importance of stakeholder participation, robust policy frameworks, technological innovation, and sustainable practices. These insights provide a pathway for improving Mangaung's waste management system while minimizing environmental impacts and promoting long-term sustainability.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Introduction

This research study explored strategies to enhance waste management practices in Mangaung Metropolitan Municipality in the Free State province to ensure sustainable and environmentally friendly solutions. The objectives of the study were to:

- Conduct a comprehensive assessment of current waste management practices and infrastructure in the Mangaung Metropolitan Municipality;
- Identify and analyse the key challenges, barriers, and shortcomings affecting efficient waste management in the study area;
- Investigate the role of stakeholder engagement, community participation, and existing policy frameworks that shape waste management practices in the study area; and
- Explore and recommend innovative technologies, best practices, and strategies that can be implemented to enhance waste management efficiency and sustainability and ensure the limited environmental impact of waste in the study area.

This chapter provides a summary of the key findings on solid waste management practices in the Mangaung Metropolitan Municipality and suggests recommendations to improve the system. According to the research findings, global best practices, and the challenges identified, this chapter provides a roadmap for sustainable and efficient waste management services in Mangaung. The aim is to ensure that all waste management practices are in line with national and international frameworks while promoting environmental sustainability, technological innovation, and community engagement.

6.1 Conclusions

This section highlights the key findings pertaining to municipal solid waste management practices in the study area with respect to the research objectives.

6.1.1 Waste collection and transportation challenges

A major finding is the inefficiency of Mangaung's waste collection and transportation system. The municipality currently relies extensively on traditional waste collection methods that are not adequate for the needs of the city's growing population. In addition, it was observed that the transport distances to landfill sites are very long, and this results in increased operational costs and reduces the frequency of waste collection in outlying areas. This has led to illegal dumping and increased environmental pollution which both pose serious health risks to residents. The absence of modern waste collection technologies exacerbates the problem. The manual nature of waste collection in Mangaung is outdated compared to global standards, where cities use automated trucks and smart bins to optimize waste collection routes and minimize costs. The lack of such innovations in Mangaung leads to slower waste collection, inefficiency, and high labour costs.

6.1.2 Low levels of recycling and waste diversion from landfills

According to the findings, there are minimal recycling efforts in the study area. This is a result of a lack of adequate infrastructure and a lack community awareness about the importance of recycling. The municipality does not conduct enough and effective waste separation programs and, as a result, most of the waste that is generated is sent directly to landfills. This contributes to the rapid filling-up of landfill sites and leads to environmental degradation through air, water, and soil pollution. Even noise pollution emanating from activities at landfill sites was highlighted as a concern.

Global best practices have demonstrated that recycling plays a crucial role in reducing the volumes of waste sent to landfills. Countries like the United States and China have

adopted large-scale recycling programs, with strict policies to ensure that waste is separated at source. However, Mangaung lacks the infrastructure to support such initiatives, and there is minimum community participation in the recycling of waste.

6.1.3 Inadequate policy implementation and enforcement

South Africa has wide-ranging waste management policies and laws, of which the National Environmental Management Waste Act (NEMWA) of 2008 is key. However, waste management policy implementation in the study area is neither robust nor consistent. Limited resources, a weak regulatory framework coupled with poor implementation, and the lack of political will have massively contributed to poor MSWM in the study area. Failure to enforce policy has led to non-compliance with national waste management standards and has promoted persistent illegal dumping and poor waste management practices.

Furthermore, the absence of strict enforcement mechanisms limits the effectiveness of Mangaung's waste management system. This is contrary to the practices in cities like Kigali in Rwanda and Beijing in China, which have both demonstrated improved waste management outcomes due to robust policy enforcement combined with community engagement.

6.1.4 Environmental and health impacts

It was established that problems such as irregular collection of waste, inadequate landfill management, and illegal dumping have significant environmental and public health consequences in Mangaung. It was found that many residents tended to leave piles of unattended waste in open spaces, thus contributing to land, air, and water pollution and increasing the risk of disease outbreaks, particularly in and around informal settlements. Furthermore, some residents burn waste in certain areas, thereby releasing potentially harmful pollutants into the atmosphere that could lead to air pollution and respiratory problems.

Mangaung's current waste management practices are not aligned with global environmental sustainability standards. It is noteworthy that countries like Germany and the Netherlands implement zero-waste strategies that place much emphasis and priority on recycling, composting, and waste-to-energy initiatives, all of which significantly reduce environmental impacts. The study area, on the other hand, does not have adequate infrastructure or the political commitment to implement similar sustainable practices.

6.1.5 Lack of stakeholder engagement and community participation

The research revealed that there is minimal community participation in waste management in the study area. It was found that the residents lacked awareness of appropriate waste disposal methods, while public education campaigns on recycling and waste separation were found to be infrequent and ineffective. In addition, it was established that the collaboration between the municipality and private sector stakeholders was limited. This lack of collaboration results in a weak waste disposal system. On the other hand, Rwanda has adopted community-driven waste management programs that have positively contributed to raising waste recycling awareness among community members and have promoted sustainable waste management practices. However, Mangaung has yet to fully engage its residents in meaningful ways, and this lack of community involvement hinders progress in improving waste management efficiency.

6.1.6 Technological lag

Based on the findings of the study, it is noteworthy that Mangaung is experiencing a technological lag in terms of adopting technological innovations in waste management. Globally, many cities are transitioning to smart waste management systems that use data analytics, automated waste collection vehicles, and waste tracking technologies to improve efficiency. Mangaung's dependence on manual collection methods is inefficient and costly and contributes to poor service delivery.

Technological innovation can transform waste management by reducing costs, improving efficiency, and minimizing environmental impacts. Cities like Singapore and New York have adopted smart bins, GPS-enabled waste collection vehicles, and automated waste sorting systems to streamline their waste management processes. Mangaung has yet to explore these innovations, and failure to do so has limited its ability to address its growing waste management challenges.

6.2 Recommendations

Based on the findings of this research study, the following recommendations are proposed to improve solid waste management practices in the study area:

6.2.1 Investment in modern waste collection infrastructure

This study recommends that the Mangaung Municipality invests in upgrading its waste collection infrastructure to meet the needs of its growing population. The use of automated waste collection vehicles, smart bins, and digital tracking systems will enhance efficiency and reduce operational costs. The use of automated trucks, as seen in cities like Johannesburg and Durban, can significantly improve the speed and efficiency of waste collection, reduce illegal dumping, and improve service delivery.

In addition, the municipality should explore decentralized waste collection systems, particularly for outlying areas, to reduce transportation costs and improve collection frequencies. By establishing smaller, localized waste collection centres, Mangaung can ensure more efficient service delivery across the municipal area.

6.2.2 Strengthening recycling programs and infrastructure

To address the low levels of recycling, it is recommended that Mangaung invests in developing a comprehensive recycling infrastructure. This includes setting up waste separation facilities, providing recycling bins to households, and creating drop-off

centres for recyclable materials. The municipality should also launch public education campaigns to raise awareness about the benefits of recycling and encourage residents to participate in waste segregation at source.

Incentive programs should be introduced to reward residents and businesses that actively participate in recycling initiatives. For example, implementing a 'pay-as-you-throw' system is proposed, where households are charged based on the volume of waste they produce. This could encourage waste reduction and increase recycling rates. This model has been successfully implemented in cities like San Francisco in the USA and could be adapted in Mangaung's context.

6.2.3 Implementing waste-to-energy projects

The Mangaung Municipality is encouraged to implement waste-to-energy projects that are aimed at minimizing the amount of waste sent to landfills and generate renewable energy. Organic waste, which constitutes a significant portion of municipal waste, can be converted into biogas through anaerobic digestion. This process does not only reduce landfill volumes but also provides a sustainable source of energy for the municipality that implements it.

Rwanda's biogas plants have demonstrated the potential of waste-to-energy projects by relying on landfills to generate energy. Mangaung could collaborate with private sector partners to establish similar projects, focusing on organic waste from households, markets, and agricultural sources.

6.2.4 Strengthening policy enforcement and governance

Stricter enforcement of waste management policies is critical to improving Mangaung's Municipality's waste management system. Therefore, it is recommended that the municipality fully implement the National Environmental Management: Waste Act (NEMWA) of 2008, with stricter penalties for non-compliance. This includes enforcing

regulations on illegal dumping, waste separation at source, and proper landfill management.

To ensure effective policy enforcement, Mangaung Municipality should invest in capacity-building programs for waste management personnel. This includes training staff on waste collection best practices, encouraging recycling, and ensuring environmental sustainability. Additionally, the municipality should establish a dedicated waste management task force responsible for monitoring compliance with waste regulations and addressing waste-related challenges in real time.

6.2.5 Engaging the community and private sector

Community participation is important for the success of any waste management program. As such, the study recommends that Mangaung must launch and sustain public education campaigns to raise awareness about the importance of recycling, waste separation, and responsible waste disposal. These campaigns should target schools, households, and businesses and encourage residents to take ownership of waste management initiatives.

In addition, Mangaung Municipality should actively involve the private sector in its waste management programs. Public-private partnerships can help provide the necessary funding and expertise to improve waste collection, recycling, and landfill management. Businesses should be incentivized to adopt eco-friendly practices, such as reducing packaging waste, using recyclable materials, and participating in waste-to-energy projects.

6.2.6 Adopting smart waste management technologies

The study recommends that Mangaung invests in smart waste management technologies to modernize its waste management practices. This includes deploying

sensor-equipped bins, deploying GPS-enabled waste collection vehicles, and introducing automated waste sorting systems. These technologies will enable the municipality to optimize waste collection routes, reduce fuel consumption, and minimize operational costs.

6.2.7 Fostering a circular economy

It is recommended that Mangaung adopts a circular economy approach to waste management by focusing on waste reduction, reuse, and recycling. This includes promoting the use of recyclable materials, encouraging product designs that minimize waste, and supporting businesses that operate in the recycling and remanufacturing sectors. The European Union has successfully implemented circular economy strategies and has consequently significantly reduced waste generation while promoting sustainable resource use. Mangaung can learn from these examples by introducing policies that support the reuse of materials and promote eco-friendly manufacturing practices. At the same time, it should provide businesses with incentives to reduce their waste footprint.

6.2.8 Improving landfill management

Mangaung's landfill sites are currently operating beyond capacity, leading to environmental degradation and health risks for communities living close to them. The municipality should invest in upgrading its landfill management practices by ensuring compliance with national regulations on landfill operations. This includes implementing stricter monitoring systems to prevent illegal dumping, improving landfill infrastructure, and exploring alternatives to landfill use, such as recycling and composting. The introduction of waste diversion programs, where materials like organic waste and recyclables are diverted from landfills, can also significantly reduce the pressure on existing landfill sites. This will help extend the lifespan of landfills and mitigate their adverse environmental impacts.

6.2.9 Funding and resource allocation

Sustainable waste management requires adequate funding and resource allocation. The study urges the Mangaung Municipality to explore various funding options, including public-private partnerships, government grants, and international aid to support its waste management initiatives. Additionally, the municipality should allocate resources more efficiently and prioritize the development of recycling infrastructure, waste-to-energy projects, and public education programs. By reallocating funds from inefficient waste management practices (such as excessive reliance on traditional waste collection methods) to more sustainable and cost-effective solutions, Mangaung Municipality can improve the overall efficiency of its waste management system.

6.2.10 Long-term planning and sustainability

Mangaung should develop a long-term waste management plan that addresses future challenges related to population growth, urbanization, and climate change. This plan should incorporate sustainable waste management practices, such as recycling, composting, and waste-to-energy initiatives to ensure that the municipality's waste management system remains efficient and environmentally responsible in the long term. The plan should also include provisions for regular monitoring and evaluation to assess the effectiveness of waste management initiatives and make the necessary adjustments. By adopting a long-term, sustainable approach to waste management, Mangaung Municipality may ensure that it meets the needs of its residents while minimizing environmental impacts.

6.2.11 Further research

There is a need for further research so that the gaps identified in this study, particularly in areas related to technological adaptation, community engagement, policy enforcement, implementation of circular economy processes, and the financial sustainability of waste management in Mangaung can be addressed. By exploring

these areas, future research can provide the necessary insights and recommendations to transform Mangaung Municipality's waste management system into one that is efficient, sustainable, and aligned with global best practices.

6.3 Conclusion

The discourse in this chapter concluded the findings and offered recommendations. The findings revealed that significant challenges are experienced by the Mangaung municipality in managing its solid waste. Hence, with the right investments, policy implementation, and community engagement, the municipality can and should transform its waste management system. By adopting modern technologies, strengthening policy enforcement, and promoting sustainability, Mangaung can reduce its reliance on landfills, improve recycling rates, and create a cleaner, healthier environment for its residents. The recommendations offer a comprehensive roadmap for achieving these goals and ensuring that Mangaung's Municipality's waste management practices align with global best practices and contribute to long-term environmental sustainability.

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Annexure 1: Ethical approval



Health Sciences Research Ethics Committee

04-Jun-2020

Dear **Tshitso Mohatlane**

Ethics Clearance: **Municipal solid waste management in the Mangaung Metropolitan Municipality, Free State province**

Principal Investigator: **Tshitso Mohatlane**

Department: **CUT - Central University of Technology**

APPLICATION APPROVED

Please ensure that you read the whole document

With reference to your application for ethical clearance with the Faculty of Health Sciences, I am pleased to inform you on behalf of the Health Sciences Research Ethics Committee that you have been granted ethical clearance for your project.

Your ethical clearance number, to be used in all correspondence is: **UFS-HSD2019/1604/3006**

The ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the HSREC for approval to ensure we are kept up to date with your progress and any ethical implications that may arise. This includes any serious adverse events and/or termination of the study.

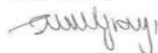
A progress report should be submitted within one year of approval, and annually for long term studies. A final report should be submitted at the completion of the study.

The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act, No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

For any questions or concerns, please feel free to contact HSREC Administration: 051-4017794/5 or email EthicsFHS@ufs.ac.za.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours Sincerely



Dr. SM Le Grange

Chair : Health Sciences Research Ethics Committee

Health Sciences Research Ethics Committee

Office of the Dean: Health Sciences

T: +27 (0)51 401 7795/7794 | E: ethicsfhs@ufs.ac.za

IRB 00011992; REC 230408-011; IORG 0010096; FWA 00027947

Block D, Dean's Division, Room D104 | P.O. Box/Postbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa
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Annexure 2: Request to conduct study letter



Office of the City Manager

06-06-2019

Mangaung Metropolitan
Municipality

Tshitso Mohatlane
677 G Section
Botshabelo
9781
30 May 2019

Mangaung Metropolitan Municipality
Office of the City Manager
PO Box 3704
Bloemfontein
9300

Dear Sir.

RE: Request for permission to conduct municipal solid waste research project.

My name is Tshitso Mohatlane; I am an employee of Mangaung Metropolitan Municipality, appointed as an Education and Awareness Officer, under Waste and Fleet Management Directorate. I am currently enrolled with the Central University of Technology; Free State for a Master of Health Sciences in Environment qualification and it is my final year.

Due to the rapid growth rate of the population, waste generation rate has reached alarming rates, which in return poses a threat for waste services delivery. Municipalities are unable to provide adequate waste services which lead to burning of waste at open dumping, increased exposure to polluted air and increased diseases due to prevalence of pest and vermin. The constitution stipulates that waste management services are vested on the municipalities, and community on the other hand believes that it is the municipality's responsibility to keep our areas clean, whereas it's not. Both the generator and the municipalities are responsible and littering is prohibited by the law.

In South Africa, most of the landfill sites are situated on the outskirts of the towns/cities, and this is where informal settlements are situated. Illegal dumps or open dumps provide breeding places for rats and vermin, which are the vectors for most disease. As waste starts piling up, the residents in the area burn the waste which in return contributes towards air pollution and climate change.

Many South Africans are immuno-compromised, including kids and woman of child bearing age who are more prone to diseases. These environmental impacts caused by waste also affect the health of people living nearby landfills and open dumps (Alam& Ahmed, 2013).

These environmental conditions also contribute towards climate change and this affects the country's investments in many ways, from agricultural sector to the energy sector (EPA, 2016). Limited recycling practices influences the availability of resources needed to create energy and manufactured packaging material which ends up in the waste stream. South Africa faces challenges of energy shortage and recycling will help with the availability of resources needed to create energy as it reduces consumption of resources used in manufacturing packaging material. Recycling will also reduce the quantity of waste reaching the landfills (reduced greenhouse gas formation). Recycling increase the life span of landfills sites. Poor handling of waste at landfill and dumpsites negatively

affects the environment. Increased recycling, efficient waste collection services and correct disposal of waste, would lead to cleaner and healthier environments.

I Tshitso Ivan Mohatlane, hereby write to request permission to conduct research project within Mangaung Metropolitan Municipality. The project will involve employees of Solid Waste Management and residents who will be interviewed one on one using a questionnaire. Participants will sign the consent form before partaking in the study and their identity will remain anonymous. The questionnaire will contain questions addressing issues of Municipal Solid Waste Management practices, human knowledge and perception on waste management and recycling. Two district municipalities will be sampled, namely Fezile Dabi District Municipality and Mangaung Metropolitan Municipality.

After completion of the study, the findings will be published in an accredited journal. Feedback will be given to both participants (municipalities and residents) by setting up feedback workshops and community meetings and the composition and distribution of an information brochure. Information attained could also be used by waste management service providers to improve service provision. This document will also provide information to residents on different ways to minimizing waste and recycle for economic benefit.

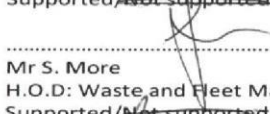
Below are my contact details and my Lecture Supervisor's contact details, should there be any information required. Your permission would be highly appreciated.

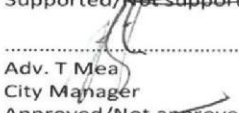
Yours truly


.....
Mr. T. Mohatlane
071 3983 101
mohatlanet@gmail.com

Lecture Supervisor:
Dr. H Robetrts
084 550 0621/051 507 0621
robertsh@cut.ac.za/drroberts@gmail.com


.....
Mr. T. Tshukudu
Manager: Education, Awareness and Compliance
Supported/Not supported


.....
Mr S. More
H.O.D: Waste and Fleet Management
Supported/Not supported


.....
Adv. T Mea
City Manager
Approved/Not approved

Annexure 3: Biostatistician letter



Maryn Viljoen
Statistics Consulting Services

maryn.viljoen@vodamail.co.za
082 823 5731

Protocol and research methodology consultation • Ethical consultation • Database construction and capturing of data
Analyzing data using statistical software packages (SAS Version 9.1.3) • Statistics consultation services to analyze and interpret data
Conveys results with statistical tables and figures where needed

The Chairperson: Health Sciences Research Ethics Committee (HSREC)

For Attention: Mrs. M.G.E. Marais
Block D, Room 104
Francois Retief Building
Faculty of Health Sciences
University of the Free State

24 October 2018

Title: "Municipal Solid Waste Management and Climate Change in
Mangaung Metro Municipality and Fezile Dabi District
Municipality, Free State Province."

Researcher: Tshitso Ivan Mohatlane
Master in Health Sciences: Environment
Faculty of Health and Environmental Sciences
Central University of Technology, Free State

I have seen and read through this protocol. I gave input and recommendations
and will be the biostatistician responsible for the analysis of the data.

Maryn Viljoen
M.Sc. Risk Analysis (UFS)
maryn.viljoen@vodamail.co.za
082 82 35 731

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Annexure 4: Informed consent form



FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES

INFORMED CONSENT FORM

“Municipal solid waste management in Mangaung Metropolitan Municipality, Free State Province.”

I, the undersigned, confirm that (please tick the appropriate box)

1.	I have read and understood the information about the research project	
2.	I have been granted opportunity to ask questions about the research project	
3.	i voluntarily agree to participate	
4.	I understand I can withdraw any time without giving reasons and that I will not be penalized for withdrawing nor will be questioned on why I withdraw	
5.	The procedure regarding confidentiality have been explained	
6.	the use of data in research, publication, sharing and archiving have been explained to me	
7.	I have read and understood that my name will not appear in this project	

Participant

.....

.....

.....

Name of participant

Signature

Date

Researcher

.....

.....

.....

Name of researcher
Date

Signature

Annexure 5: Residents questionnaire



FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES

Questionnaire no:

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MUNICIPAL SOLID WASTE MANAGEMENT IN THE MANGAUNG METROPOLITAN MUNICIPALITY, FREE STATE PROVINCE

I am Tshitso Ivan Mohatlane, currently studying for a Master of Sciences in Environment qualification at Central University of Technology, Free State. The purpose of the questionnaire is to evaluate solid waste service rendered and the effect of poor waste management to the environment and health.

The participants are requested to please answer truthfully to obtain the correct results for the research. The names of the participants will be kept confidential and please be aware that there is neither a correct nor incorrect answer.

Your participation in this study is very important and is highly appreciated because it will contribute to make recommendations to improve the current waste collection system.

Instructions

Please use a pen and mark each answer with "X". A space at the end of your questionnaire is provided for comments. Thank you for your co-operation and participation in the study.

Address

Date

Signature:

Cell no:

RESIDENT QUESTIONNAIRE FOR STRUCTURED INTERVIEW

SOLID WASTE SERVICE RENDERING

PERSONAL INFORMATION

SECTION A: DEMOGRAPHIC INFORMATION

1. How old are you?

18-25 years		1
26-35 years		
36-45		3
46-55		
56 years and older?		5

2. What is your gender?

Male		6
Female		

3. What is your ethnicity?

African		8
Asian		
Colored		10
White		

4. What is your highest level of education?

No education		12
Primary education		
Secondary education		
Matriculation Certificate		15
Post matriculation qualification, please specify: _____		16

5. How many years have you been residing in Mangaung?

0-5 years		17
6-10		
10 years and more		19

6. How many people are you living in your house? _____ people

1		20
2, but below 4		
5 and above		22

7. Are you a permanent resident in this municipality?

Yes		23
No		
(Specify).....		

SECTION B: SOLID WASTE REUSE AND RECYCLING

8. Do you know what recycling is?

Yes		25
No		26

9. Do you know of anyone who collects recyclables?

Yes		27
No		

10. Do you know of any buy back center within your area?

Yes		29
No		

11. Do you segregate (separate) waste?

Always		30
Sometimes		
Never		32

12. Which type of solid waste do you generate **most**? (May only select ONE option)

Plastic		33
Paper		34
Glass		
Metal		
Cardboard		
Other (specify)		
.....		

13. Do you think there is a need for recycling?

Yes		38
No		39

SECTION C: SOLID WASTE SERVICES

14. Do you know the collection schedule for solid waste in your area?

Yes		40
No		41

15. Do you get informed when collection is not going to be made?

Always		42
Sometimes		
Never		44

16. What do you do with your waste when there's **no** collection? (May select more than one option.)

Dump it at an open field		45
Burn it		
Leave it on the side walk until collection is made		48
Take it back to your receptacle?		

17. Where do you store your waste?

Plastic		50
Glass		
Cardboard		
Paper		
Metals		54
Other		

18. Do you segregate recyclables from the rest of your waste?

Yes		56
No		57

19. Do you have means of reducing the quantity of waste you generate?

Yes		58
No		

20. Do you reuse any of your unwanted waste?

Yes		60
No		61

21. Are there any awareness campaigns conducted by municipality with regard to solid waste?

Yes		62
No		63

SECTION D: SOLID WASTE LEGISLATION

22. Are you aware of existing solid waste legislation?

Yes		64
No		
Not sure		66

IF **YES** IN QUESTION 22, PLEASE CONTINUE WITH QUESTIONS 23 – 24.

IF **NO** IN QUESTION 22, PLEASE CONTINUE WITH QUESTIONS 25.

23. How long have you been aware of solid waste legislation?

1 year	
Between 1 and 3 years	
Between 3 and 5 years	
Above 5	

24. Are there any prosecutions in your area for the transgressors of solid waste legislation?

Yes	
No	

25. Do you know of any transgressions stated in your solid waste legislation?

Yes	
No	

26. Have you ever received any notice for transgression of waste by laws legislation?

Yes	
No	

27. Do you know of any person prosecuted for transgressing waste legislation?

Yes	
No	

Any other general comments?

Thank you for your time and participation.

Annexure 6: Employee questionnaire

FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES



Questionnaire no

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MUNICIPAL SOLID WASTE MANAGEMENT IN THE MANGAUNG **METROPOLITAN MUNICIPALITY, FREE STATE PROVINCE**

I am Tshitso Ivan Mohatlane, currently studying for a Master of Sciences in Environment qualification at Central University of Technology, Free State. The purpose of the questionnaire is to assess solid waste service rendered and the effect of poor waste management on the environment and health.

The participants are requested to please answer truthfully to obtain the correct results for the research. The **names** of the **participants** will be kept confidential and please be aware that there is **neither a correct nor incorrect answer**.

Your participation in this study is very important and is highly appreciated because it will contribute to making recommendations to improve the current waste collection system.

Instructions

Please use a pen and mark each answer with "X". A space at the end of your questionnaire is provided for comments. Thank you for your co-operation and participation in the study.

.....

Address:

.....

Date:

.....

.....

Signature:

Cell number:

MUNICIPAL EMPLOYEE QUESTIONNAIRE FOR STRUCTURED INTERVIEW

SOLID WASTE SERVICE RENDERING

PERSONAL INFORMATION

SECTION A: DEMOGRAPHIC INFORMATION

1. How old are you?

18-25 years	
26-35 years	
36- 45 years	
46 -55 years	
56 years and older	

2. What is your gender?

Male		6
Female		7

3. What is your ethnicity?

African	
Asian	
Colored	
White	

4. What is your highest level of education?

Primary education		12
Secondary education		
Post matriculation qualification, please specify:		

5. How many years have you been working for Solid Waste Directorate?

Less than 5 years	
5-10 years	
10 years and more	

6. What is your job title?

7. Where do you reside?

Within the municipality		23
Outside the municipality		24

5. Was there any training on waste management when you were appointed?

Yes		25
No		26
Cannot remember		

SECTION B: SOLID WASTE REDUCE, REUSE AND RECYCLING

9. Do you know of any buy-back center within the municipality?

Yes		28
No		

10. Do you know of any person who collects recyclables?

Yes		30
No		

11. Do you think there is a need for recycling?

Yes	32
No	
Please elaborate on your answer in question 11 above:	

12. Do you think recycling generates reliable revenue in your area?

Yes	
No	

35

SECTION C: SOLID WASTE SERVICES

13. How often does the municipality collect waste?

	36
Once a week	
Twice a week	
Monthly	
Never	
Other (Specify)	

14. In cases of shortage of resources, who collects waste on behalf of municipality?

Contractors	42
Waste pickers	
No collection	
Other (specify)	
.....	45

15. Are there any monitoring done after collection, at the end of each day?

Yes	46
No	

16. Is there a well know collection schedule in the municipality?

Yes	
No	
Don't know	

17. Are there any disturbances during collection between the recyclable collectors and solid waste workers during collection?

Yes	52
No	53
Sometimes (specify)	

18. After collection where do you dump collected solid waste?

Landfill site	55
Open space	
Don't know	
Other (specify)	

19. Is compacting done at the landfill site?

Yes	59
No	
Don't know	

19.1 If **YES** in question 19, how regularly is compacting done?

Daily	
-------	--

Every other day	
Twice a week	
Once a week	
Other (specify)	

20. Do you have waste acceptance personnel at the gate of your landfill sites?

Yes		67
No		68
Don't know		

21. What type of waste do you accept at your landfills? (May select more than one option)

Household		70
Construction		
Agriculture		
Institutional		
Healthcare		74
Industry		
Commercial		

76

22. How far is your landfill site from the collection area?

Less than 10 km		77
Between 10 km and 25 km		
Between 25 km and 40 km		
Above 40 km		

23. Does your landfill site operate on public holidays?

Yes		81
No		
Don't know		83

24. Is there odor emanating from the site?

Yes	84
No	
Don't know	

25.

Is there burning of waste at the landfill site?

Yes	87
No	
Don't know	

26. Is there any noise resulting from operations at the site?

Yes	90
No	
Don't know	

SECTION D: SOLID WASTE LEGISLATION

27. Do you have existing solid waste legislation?

Yes	93
No	
Not sure	95

28. Do you know of any disobedience stated in your solid waste legislation?

Yes	
No	
If yes specify	

29. Are there any prosecutions for the transgressors of your solid waste legislation?

Yes	
No	

Not sure	
----------	--

30. Are the community members aware of the solid waste legislation?

Yes	
-----	--

No	
----	--

Not sure	
----------	--

Any other general comments?

Thank you for your time and participation.

Annexure 7: Residents area observation checklist



FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES

Municipal solid waste management in the Mangaung Metropolitan Municipality, Free State Province

SAMPLING AREA CHECKLIST:

The observation checklist covers the area within 100 meters radius from the sampling area

Date	
Town	
Sampling area, or location	
Name of Researcher	
Name of Supervisor	

Mark the correct answer with an X

Take pictures of the site

Nuisances and other environmental degradation factors

Is waste burning practiced?	Yes	No
Is there any wind-blown litter?	Yes	No
Is there any foul smell emanating on illegal waste heap site?	Yes	No
Is there any uncontrollable odor emanating on- site?	Yes	No
Is there any vermin and disease vectors?	Yes	No
Is there any uncontrollable dust emanating on-site?	Yes	No
Is there a different type of waste other than domestic waste?	Yes	No
Are the kids having access to the site?	Yes	No

Comments:

.....

Annexure 8: Landfill site observation checklist

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Municipal Solid Waste Management in the Mangaung Metropolitan Municipality, Free State Province

LANDFILL SITE CHECKLIST:

Date	
Town	
Name of Landfill Site	
Name of Researcher	
Name of Supervisor	

Landfill site requirements Checklist

1. Sign posting and road access.

Is the landfill site well fenced?	Yes	No	1
Does the landfill have a sign post?	Yes	No	
Written in two official languages?	Yes	No	
Stating the names, addresses and telephone numbers of the Permit hold and responsible person?	Yes	No	4
Hours of operation?	Yes	No	
Waste class indicated?	Yes	No	
Types of waste accepted?	Yes	No	6
Road in good condition to allow vehicles?	Yes	No	
Two way traffic available to allow traffic flow?	Yes	No	

2. Access control, collection of disposal tariffs and security

On-site entrance limited to a single controlled gate?	Yes	No
Is the portion of the site in use adequately fenced?	Yes	No
Site boundaries clearly demarcated and measures in place to prevent unauthorized vehicles.	Yes	No
Tariffs displayed on notice boards?	Yes	No
If yes. Are tariffs based on mass, where there is weigh bridge/ estimated volumes?	Yes	No
Are there security personnel at the gate	Yes	No
Is there waste picking and squatting on-site.	Yes	No

3. Landfill site resources and sanitary landfilling

Is there any mobile plant onsite to aid with environmentally acceptable waste operations?	Yes	No	17
Is there adequate site staff available?	Yes	No	
Is waste compaction practiced?	Yes	No	
Is waste covered daily?	Yes	No	

4. Nuisances and other environmental degradation factors

Is waste burning practiced ?	Yes	No	21
Is there any wind-blown litter?	Yes	No	
Is there any foul smell emanating on site?	Yes	No	
Is there any uncontrollable odor emanating on- site?	Yes	No	23
Is there any vermin and disease vectors?	Yes	No	
Is there any uncontrollable dust emanating on-site?	Yes	No	
Is there any stagnant water on site?	Yes	No	25

Comments
