

MUNICIPAL SOLID WASTE MANAGEMENT PRACTICES IN THABO MOFUTSANYANA DISTRICT, EASTERN FREE STATE

by

Teele Lepheana

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SUPERVISOR: Dr H.A. Roberts

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DECLARATION OF INDEPENDENT WORK

I, Teele Lepheana, student number #####, hereby declare that this research document submitted to the Central University of Technology, Free State is my own independent work and has not been submitted before to any institution by myself or any other person to any other institution in fulfilment of any requirement for the attainment of any qualification.

.....

STUDENT SIGNATURE

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ABSTRACT

Improper solid waste management is a global problem, and it is evident that in developing countries municipalities are struggling to manage waste effectively. The availability of illegal dumping sites and windblown litter in communities is overwhelming. Poor adherence to waste collection schedules by the waste management directorate has left residents with no choice but to resort to open dumping.

The study focused on solid waste management practices and the negative impacts on the environment due to poor waste management in the Thabo Mofutsanyana District (TMD). The objectives of the study were to assess the provision of waste management services and to determine residents' level of satisfaction and their practices in separation of waste at source. Data were collected in five towns in the TMD and two sets of questionnaires were provided to both residents and employees working in the solid waste management division. A total of 186 questionnaires were completed, 100 by residents and 86 by employees.

The results indicated that 81% of residents did not receive waste containers from the municipality. The municipalities do not adhere to the waste collection schedules (WCS), and there is no communication when the waste will not be collected. The residents indicated that adherence to the waste collection schedule is only 10% and waste can remain uncollected for weeks, and the most practiced waste collection method is kerbside collection.

The study indicated that the solid waste management systems under TMDM are not satisfactory. There is a need for the residents to be included in the planning of waste management activities and more resources should be allocated to the waste management directorate to remedy the current situation.

Keywords: Solid waste management, Thabo Mofutsanyana District Municipality, illegal dumping, municipalities, landfilling.

LIST OF ACRONYMS

C&T	Collection and Transportation
CARP	Capacitated Arc Routing Problem
CoJ	City of Johannesburg
DEA	Department of Environmental Affairs
EPL	Environmental Protection Law
EU	European Union
GAP	Garbage Accumulation Points
GDP	Gross Domestic Product
GHG	Green House Gas
IDP	Integrated Development Plan
ISWM	Integrated Solid Waste Management
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NEMA	National Environmental Management Act No. 107 of 1998
NEMWA	National Environmental Management: Waste Act No. 59 of 2008
NGOs	Non-Governmental Organizations
PAYT	Pay as You Throw
PCMSW	Per Capita Municipal Solid Waste
RSA	Republic of South Africa
SLM	Solid Waste Management
SWG	Solid Waste Generation
SWG I	Solid Waste Generation Intensity
TMD	Thabo Mofutsanyana District
TMDM	Thabo Mofutsanyana District Municipality
WC	Waste Collection
WCS	Waste Collection Services

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CHAPTER 1

GENERAL BACKGROUND

1. Introduction

In South Africa, waste volumes have increased dramatically at a rate of about 62.5% over the last decade. This figure represents annual growth rate in municipal solid waste (MSW) generation of 4.8%, with the highest growth rates estimated for the Free State and Mpumalanga provinces (South Africa, Department of Environmental Affairs, 2012). This study aimed to investigate the efficiency of MSW management in a demarcated district in the Free State Province in South Africa.

The selected district, namely Thabo Mofutsanyana (DC19), is the largest of five districts in the Free State Province. It consists of six local municipalities, namely: Maluti-A-Phofung (MAP), Nketoana, Dihlabeng, Phumelela, Setsoto and Mantsopa. According to the Department of Environmental Affairs (2005), Thabo Mofutsanyana is the most under-serviced of all the districts in the Free State Province with regards to sanitation and refuse removal. During an earlier survey, it was found that the total percentage of people receiving basic solid waste management (SWM) services was 77%, while the total percentage of manpower in the solid waste management division in the whole Free State Province was 13% (South Africa, Department of Environmental Affairs, 2005).

The TMDM services most rural areas and small towns; however, few of these areas receive solid waste management services and there is minimal generation of revenue from the provision of these services. Municipal solid waste (MSW) constitutes a large percentage of the total waste generated in both rural and urban areas, but waste management services ultimately remain the responsibility of the municipality.

The Thabo Mofutsanyana Integrated Development Plan (IDP) indicated that weekly refuse removal in 2011 was 49.2% compared to 42.4% in 2001 (Thabo Mofutsanyana Final IDP, 2012-2016). This Thabo Mofutsanyana IDP also lists the following core issues relating to waste management: poor management of dumping sites, poor

management of waste, limited regional waste disposal facilities, and unlicensed landfill sites.

Local municipalities in the study area render solid waste collection and disposal services in all the towns; however, not all the municipal managers comply with the minimum requirements and standards for solid waste disposal sites. There is currently no regional solid waste disposal facility in the TMD, yet such a facility may be needed soon, and it will then be the responsibility of the district to ensure that the facility and the management thereof comply with related legislation. Moreover, as the current recycling of waste does not occur on a large scale and will possibly be even less effective in the future, it was necessary to investigate, devise, and implement cost-effective ways to increase the management and recycling of waste in the study area (Thabo Mofutsanyana Final IDP, 2012-2016).

1.1 Waste management phenomenon

SWM is a major challenge in both cities and rural areas around the world, and it is especially challenging in fast-growing cities in developing countries. Population growth, coupled with increasing per capita income, has increased the amounts of waste being generated, and these waste volumes do not tend to increase the management capacity of municipalities in developing countries (Kayamo, 2022). The quality and quantity of MSW depend on factors such as life expectation of a landfill site, the level of education of residents, and human development opportunities (Kundariya, Mohanty, Varjani, Ngo, Wong, Taherzadeh, Chang, Ng, Kim, and Bui, 2021). Also, as the volume, weight, and density of solid waste vary from place to place, geographical factors like location of the country, climate and weather conditions, and socio-economic conditions (income, living conditions and lifestyle) also play a significant role in the volumes of waste that are generated (Kundariya *et al.*, 2021).

Municipalities throughout Gauteng and other South African provinces are facing a crisis in solid waste disposal and management services, and this issue is primarily due to the lack of landfill capacity. For instance, the city of Johannesburg's population growth has resulted in limited space being available to hide solid waste, and this has led to illegal

dumping and an increase in the number of unsightly waste disposal sites that appear in a short space of time. More broadly speaking, on the African continent less than half of the volumes of solid waste being generated is collected in urban centres. It is estimated that, on this continent, about 95% of waste is neither contained nor recycled, but it is discarded in waste dumps where it pollutes the air and water sources in the vicinity (Rasmeni and Madyira, 2019).

The lack of on-site solid waste handling practices, such as source separation and recycling, adds to this burden as the volumes of waste that need to be collected by urban municipalities for disposal are increasing, yet their capacity to do so is diminishing. This issue is not unique to the African continent. For instance, a Bangkok study found that factors that affected source segregation and recycling by residents were lack of exposure to training and continuous awareness campaigns, while it also suggests that age has a positive influence on households practicing source segregation and recycling (Zikali, Chingoto, Utete, and Kunedzimwe, 2022). However, persistent improper waste disposal practices have contributed to environmental and public health hazards in developing countries. In addition, financial constraints, especially in developing countries, and disputes over land use among different groups of stakeholders have complicated the transition from improper to proper waste disposal practices (Talang and Sirivithayapakorn, 2022).

The management of solid waste in developing countries continues to display a range of inefficiencies that are characterized by unfavourable economic, institutional, legislative, technical, and operational constraints such as low collection coverage, irregular collection, pollution from uncontrolled waste, the dumping of domestic waste, uncoordinated private sector involvement, and the lack of a basic solid waste management infrastructure, and these problems often result in the prevalence of rotten waste in drains and on the streets (Abba, Noor, Yusuf, Din and Hassan, 2013; Phonchi-Thekisho, Mmopelwa, and Chanda, 2020). Currently, the overall large volume of municipal solid waste (MSW) being generated, coupled with inappropriate waste disposal methods, is the most challenging environmental problem faced by countries all over the world.

MSW management is concerned with the generation, monitoring/regulation, storage at source, collection, transportation/movement/evacuation, processing, and disposal of solid waste. In developing countries, the final destination of MSW is generally a landfill site, and to manage and sustain this process requires proper legislation, health regulations, an economic framework, and the implementation of rules and regulations to attain environmental sustainability (Bello, Al-Ghouti, and Abu-Dieyeh, 2022; Liu, Ren, Lin, and Wang, 2015). However, despite the importance of sustaining a healthy and aesthetically pleasing environment, solid waste management in most African cities remains highly unsatisfactory (Phonchi-Thekisho, Mmopelwa, and Chanda, 2020). Littering, which is a global problem, has unpleasant aesthetic consequences for the landscape and has become an environmental as well as a health threat because of the toxic pollutants it releases into water, the soil, and the air (Farage, Uhl-Haedicke and Hansen, 2021).

In South Africa, estimated waste collection rates range from as low as 39% to about 70%, which means that the high rate (30%) of unmanaged solid waste has significant harmful consequences for the environment as well as the health of humans and animals. This low collection rate can, among other things, be explained by the poor servicing of municipal solid waste collection vehicles, a lack of capital, limited technical expertise, persistent urban migration, the poor state of urban infrastructure, bad waste management systems, unconcerned household behaviour, and geo-environmental constraints such as the topography of African cities (Sotamenou, de Jaeger and Rousseau, 2019). Literature indicates that solid waste management is in crisis due to different and often ineffective collection methods, poor transportation, inefficient treatment regimes, and inappropriate final waste destinations such as littering, landfilling, or dumping in open areas (Nguyen, Nguyen, Phung, and Yen-Khan, 2023; Reyna-Bensusan, Wilson, and Smith, 2018; Roberts, 2013). All the latter have serious environmental and health impacts as depicted in Figure 1.1.

Illegal dumping, open waste burning, and uncontrolled disposal commonly occur in developing countries. If these practices are not eradicated, dumpsites will account for eight to 10% of global anthropogenic greenhouse gas (GHG) emissions by 2025, and

this will continue to increase marine littering, health risks, and massive environmental degradation (Ferronato, Alarcon, Lizarazu, and Torreta, 2021).

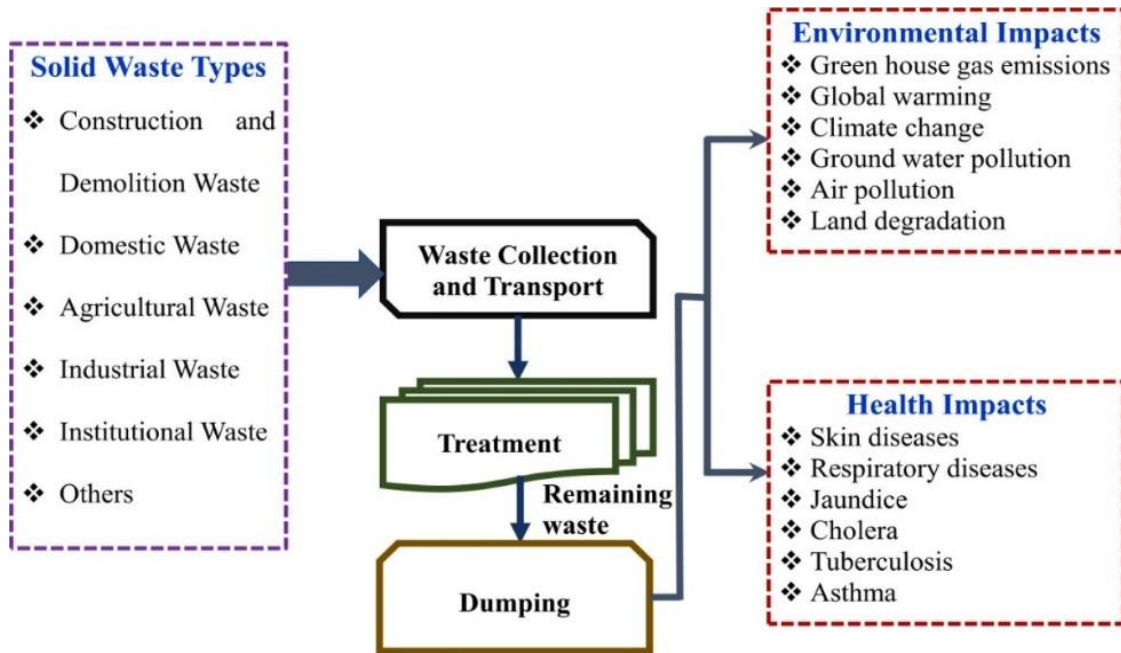


Figure 1: Diagram of environmental and health impacts of dumped solid waste (Kundariya *et al.*, 2021)

It is estimated that approximately 80 to 90% of municipal waste is disposed of at landfills without proper management practices. For instance, open burning is often practiced, and this leads to air, water, and soil pollution. Most citizens are not aware of waste management related issues and what the impact and challenges of their careless attitude towards waste disposal entails (Kumar and Agrawal, 2020). For instance, open burning is a common practice to reduce waste volumes and odours, and this practice occurs at municipal level at controlled landfills and dumpsites and at individual households in most developing countries (Krecl, Hatada de Lima, Dal Bosco, Targino, Hashimoto, and Oukawa, 2021). Moreover, direct combustion and the decay of MSW in open spaces cause gaseous emissions, mixing of particulate and volatile matter in the air, and the chemical and biological contamination of soil and groundwater due to seepage. Also, the decomposition of organic waste produces huge amounts of methane GHG that increases the global temperature and changes climatic conditions (Pujara, Pathak, and Govani, 2019). The generation of odorous compounds releases substances that can cause unpleasant sensations and feelings when detected by the olfactory sense in humans, and this is a main concern related to olfactory annoyance and health risks.

Unpleasant odorous compounds not only cause a variety of emotional and undesirable reactions in people, but also increase the risk of medical conditions that are characterized by fatigue, headaches, irritability, respiratory tract damage, and central nervous system damage resulting from long-term exposure (Fang, Huang, Ding, Qi, Liu, and Bi, 2022). Against this backdrop, (Talang and Sirivithayapakorn, 2022) argue that a holistic view and an emphasis on inclusivity are crucial in ensuring sustainable MSW management.

1.1.1 Defining Waste

In South Africa, waste is defined by the National Environmental Management: Waste Act of 2008 (Republic of South Africa, 2008) as follows:

- (a) “any substance, whether or not that substance can be reduced, re-used, recycled and recovered-
- (b) that is surplus, unwanted, rejected, discarded, abandoned or disposed of;
- (c) which the generator has no further use for the purposes of production;
- (d) that must be treated or disposed of; or
- (e) that is identified as a waste by the minister by notice in the *Gazette*, and includes waste generated by the mining, medical or other sector, but---
- (i) a by-product is not considered waste; and
- (ii) any portion of waste, once re-used, recycled and recovered ceases to be waste” (South Africa, 2008).

1.1.2 Waste categories

There are different categories of waste. For instance, solid waste includes domestic, commercial, industrial, agricultural, institutional, and miscellaneous waste, while municipal solid waste is a combination of household and commercial refuse which is generated by the community and industries. Municipal solid waste generally includes degradable (paper, textiles, food waste, straw and garden waste), partially degradable (wood, disposable napkins and sludge), and non-degradable materials (leather, plastics, rubbers, metals, glass, and electronic waste) (Kolekar Hazra and Chakrabarty, 2016).

1.1.3 Waste generation

Increasing waste generation is a global burden. The waste generated by households, forms part of municipal waste and the removal/disposal thereof is a municipal responsibility that has increased enormously in the last decades due to urbanisation, changes in social lifestyles, economic growth, and inefficient waste collection and disposal practices. Scholars have argued that some municipal authorities are either unable or unwilling to provide waste collection services to residents (Al-Khatib, Monou, Zahra, Harez, Shaheen, and Kassinos, 2010). Due to population growth, municipal solid waste generation in Asian and African developing cities ranges from 0.5 to 1.4 kg per capita in Palestine (West-Asia) (Al-Khatib *et al.*, 2010) to 1.14 kg in Israel and 0.47 kg/person/day in Ghana (Palatnik, Ayalon, and Shechter, 2006).

1.2 Waste management and legislation: An international perspective

In Bahir Dar, Ethiopia, waste is collected by providing kerbside collection and waste is transported in large plastic bags to one semi-official collection point. The collectors wait for the collection trucks to arrive and load the bags onto the beds of the trucks (Lohri, Camenzind, and Zurbrügg, 2014). Waste collection in this region is outsourced and residents are required to pay a monthly flat rate of 0.59 \$US in cash directly to waste collectors. Commercial and industrial waste removal service rates are negotiated per quantity and frequency of collection (Lohri, Camenzind, and Zurbrügg, 2014). Selangor in India has a sanitary landfill approach, and this operational site has a lifespan of 25 years. This landfill receives approximately 1 000 tonnes of SMW per day, six days a week (Omar, Karuppanan, and AyuniShafiea, 2012). In the Netherlands, the external collection costs are estimated at 4.26 euros per ton for landfill and 18 euros per ton for incineration. In the United Kingdom, the estimated cost of waste disposal generally ranges between 5.39 and 8.76 British pounds per ton. In developing countries such as Malaysia, community members pay approximately 3.42 Malaysian ringgit per month for waste removal compared to low-income households in Nigeria that pay a maximum of 1.80 naira per month (Thomas, 2009).

In terms of the management of resources, the Nigerian government retains power and decision-making for the benefit of society and the overall management of the country. Environmental governance aims to protect every aspect of human rights, and these

rights include political and legal rights while the responsibilities of every member of the Nigerian society are highlighted (Ogunkan, 2022). Environmental governance is driven by rules and regulations that nations use to address environment-related issues and concerns. Forms of environmental governance include international treaties, national legislation and regulations, and local decision-making frameworks, while transnational institutions and environmental non-governmental organisations accept responsibility for environmental sustainability (Ogunkan, 2022).

Table 1.1 indicates some of the rules and environmental regulations that govern waste management in various countries. Only a few countries from the developing and developed world are highlighted.

Table 1.1: Legal frameworks that govern solid waste management in various countries

Country	Legislation	Source
Malaysia	Environmental Quality Act, 1974 and regulations (16 sets of regulations)	Badgie, Samah, Manaf, and Muda, 2012
	- Cleansing Management Act 2007. - Solid Waste and Public Cleansing Management Corporation Act 2007.	Filho, Brandli, Moora, Kruopiene, and Stenmarck, 2016
Brazil	- National Policy for Solid Waste 2010 (Law 12.305/2010) - National Environmental Policy (Law 6.938/81) - National Policy on Sanitation (Law 11.445/07) - National Environmental Education Policy (Law 9.795/99)	Filho <i>et al.</i> , 2016
China	- The Prevention and Control of Environmental Pollution by Solid Waste 2005. - Standard for Pollution Control on the Landfill Site for Municipal Solid Waste 2008. - Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes 1996	Filho <i>et al.</i> , 2016 Liu, Ren, Lin, and Wang, 2015
The Netherlands	- Soil Protection Act 1987, revised in 2008. - Decree No. 39 of 1995 concerning the discharge of water for purposes of soil protection - Decree No. 649 of 1997 relative to the discharge of liquid substances into the soil	Liu <i>et al.</i> , 2015

	Decree No. 469 of 2007 containing rules relative to quality of soil	
Denmark	Environmental Protection Act (effective 1974, Consolidated Act No. 879, 2010)	Liu <i>et al.</i> , 2015
Germany	Basic Law (Grundgesetz) Article 74 Number 24 (promulgated in 1949)	Liu <i>et al.</i> , 2015
The United States (US)	- Resource Conservation and Recovery Act 1976 40 CFR Part 256: Guidelines for Development and Implementation of State Solid Waste Management Plans 40 CFR Part 258: Criteria for Municipal Solid Waste Landfills 40 CFR Part 260: Hazardous Waste Management System 40 CFR Part 268: Land Disposal Restrictions	Liu <i>et al.</i> , 2015
Taiwan	- Waste Disposal Act 1974 (latest revision 2013) - Methods for Normal Waste Cleaning, Treatment, and Recycling 2013 - Standard for Hazardous Waste Identification 2013	Liu <i>et al.</i> , 2015
Japan	- Waste Management and Public Cleansing Law 1970 - Standards on Transfer of Municipal Solid Waste - Technical Standards on Municipal Solid Waste - Standards of Facilities for Recycling	Liu <i>et al.</i> , 2015
South Korea	- Waste Control Act (enacted 1986, amended 2007) - Volume-Rate Waste Disposal System. - Reporting System for the Import and Export of Waste	Liu <i>et al.</i> , 2015
Singapore	Environmental Protection and Management Act 1999, revised 2002	Liu <i>et al.</i> , 2015
Finland	Environmental Protection Act of Finland (527/2014), Section 49 and 5	Thorén, Soininen and Kotamäki, 2021

Waste disposal at a facility is the final stage in the whole process of waste management in the waste hierarchy. Different options of waste disposal exist globally, and this includes on-site disposal, communal disposal, landfill sites, and composting and recycling facilities. Despite the existing disposal options, landfilling remains the preferred option for waste disposal (Mathivha, 2023).

Municipal solid waste poses serious environmental and health threats world-wide if not managed properly. Indiscriminately littered waste contributes to the prevalence of

unsanitary conditions and all forms of pollution. However, disposal sites easily become sources of contamination due to increasing numbers of flies, mosquitoes, and rodents, which in turn are disease transmitters that affect people's health (Makhale, 2016). In Ghana, it is estimated that, throughout the country, only about 10% of the solid waste that is generated is properly disposed of. Hence, large proportions (between 30 to 50%) of the solid waste generated by the residents of this country are never collected for disposal and are dispersed on the streets, in drains, and in streams, thereby creating breeding grounds for disease-spreading insects and vermin (Douti, Abanyie and Ampofo, 2017).

The primary challenges that MSW officials face are specifically related to preventing environmental leakage by collecting, sorting, and recycling waste so that it is repurposed. This directly contributes to the energetic valorisation of waste and relegates sanitary landfill disposal to a last resort (Bernache-Pérez, de Medina-Salas, Castillo-González, and Giral-di-Díaz, 2023). In Mexico, two disposal systems are approved by environmental laws: (i) landfilling, which involves specific engineering work to control leachate, leakage, and biogas generation; (ii) final disposal sites or landfills that do not fulfil the specifications of infrastructure to control leachate runoff. It is worth mentioning that open dumping remains the most common final disposal method in Mexico (Bernache-Pérez *et al.*, 2023).

Zon, Leopoldino, Yamane, and Siman (2020) argue that increasing the coverage of selective waste collection in municipalities may lead to further diversions of recyclable materials from landfills globally, and this will contribute to lower disposal costs while extending the lifespan of landfills.

From the public perception, the worst impacts of current solid waste disposal practices are those that directly affect people living in the vicinity of landfills. These areas in developing countries are fraught with challenges such as the uncontrolled breeding of pests and a decline in property values. For instance, people living close to the landfill in Mthatha town in Eastern Cape, South Africa, tend to burn tires and other objects at night for warmth, and these burning tires release pungent smoke that permeated the air and

affect people's health and well-being. Paper and plastic are also blown towards dwellings and result in a dirty and unsightly environment at so-called landfills that are actually open dumps (Buso, Nakin, Abraham, and Musampa, 2015).

A shortage of waste disposal capacity, especially landfill capacity, continues to be a major reason to drive waste volume reduction and waste diversion from landfills in African and Asian countries. In the city of Mthatha, space for landfilling has been a challenge for many years, as the landfill site in Mthatha was in the middle of a residential area and next to a school (Buso *et al.*, 2015). The proximity of landfills and dumpsites to residential dwellings is therefore a matter of serious concern, internationally and locally. For instance, the distances to official disposal sites in Hambantota, Sri Lanka, vary from five to 50 km and in Beijing some waste disposal sites are not far from city centres either (Guerrero, Maas and Hogland, 2013).

1.3 Problem Statement

Waste generation has increased considerably due to population growth and poor waste management practices. Uncontrolled waste disposal practices that are prevalent in many areas in South Africa result in waste being left unattended in streets, on open lots of land, and even at waste disposal sites, and this lack of appropriate waste treatment practices and poor disposal measures attract birds, rodents, fleas, waste pickers, and children who play on open dumps and even collect waste articles they deem useful (Suthar and Singh, 2015). This situation creates unhygienic conditions such as unpleasant odours, the release of airborne pathogens and GHG emissions, and the breeding of disease-inducing vectors in the vicinity of human dwellings. The illegal dumping of litter and waste, and waste that is left in streets and dumped in watercourses are major causes of persistent public health risks (Suthar and Singh, 2015). Residents who live on or near uncontrolled dumping sites can experience unpleasant risks that range from emotional stress and anxiety to physical symptoms such as headaches, eye irritation, respiratory problems, and nausea or vomiting (Palmiotto, Fattore, Paiano, Celeste, Colombo, and Davoli, 2014). Inadequate waste collection practices due to inefficient waste transportation could also evoke frustration to the point that residents take matters into their own hands, and they then dump and burn waste indiscriminately. The burning of refuse and the inappropriate dumping of waste contribute to air and water

pollution as decomposed waste causes soil and water pollution due to polluted leachate (Naidoo, 2009).

Poor waste management by municipalities occurs when they do not provide waste bins and when residents must travel long distances to communal containers or open dumping areas to get rid of their waste. Generally, waste management is assumed to be solely the responsibility of the local authority, which is an erroneous perception as different stakeholders with different levels of expertise must play a role in effective waste management (Guerrero, Maas and Hogland, 2013). In developing countries, this often does not occur, and poor solid waste management is characterized by highly inefficient waste collection practices, inadequate levels of service delivery due to inadequate resources, a lack of environmental control systems, indiscriminate dumping, littering and scavenging, and poor environmental and waste awareness among the general public (Matete and Trois, 2008). Community and business leaders in some areas encourage community-driven recycling efforts which include organized waste picking, communal waste drop-off points, and buy-back centres. However, these recycling efforts contribute very little to waste reduction as high volumes of waste still end up in the waste stream that is discarded at landfills. Such waste is also collected manually, which poses a risk to waste collectors. The financial gains from recycled waste are also mostly insufficient to meet the basic needs of waste pickers, and most communities also do not see the need for recycling waste (Matete and Trois, 2008).

Solid waste management is a basic service that should be rendered to all communities without favour, yet it is evident that there is a dire need in all municipal areas in South Africa to improve the implementation of the solid waste strategy and to ensure effective and sustainable waste removal and disposal.

1.4 Aim and Objectives

The aim and the objectives of the study are discussed in sections 1.4.1 and 1.4.2.

1.4.1 Aim

The aim of the study was to evaluate the efficiency of MSW management services provided by the selected municipalities at community level, and to determine the negative impact of informal waste dumping, affecting communities and the environment, including the level of satisfaction with services.

1.4.2 Objectives

The **objectives** of the study were to:

- Assess current municipal waste service delivery to determine what types of waste were generated per household; and to clearly understand household members' knowledge of the need for and the implications of the reduction, re-use, recycling, and landfilling of waste;
- Determine the selected municipalities' commitment to provide proper solid waste management to residents and evaluate the waste disposal practices of communities in each area;
- Evaluate the level of compliance with policies and legal frameworks that guide the management of municipal solid waste services; and
- Develop and recommend an efficient waste management strategy that may be implemented in the study area.

To achieve these objectives, the following **research questions** were posed to guide the execution of the study:

- Does the municipality collect solid waste as per collection schedule and residents practice waste separation at source?
- Are residents satisfied with municipal solid waste management in each local municipality?
- Do municipalities comply with minimum requirements related to policies and legal framework that guide the management of municipal solid waste services?

1.4.3 Significance of the study

The aim of the study was to assess current waste management services provided at community level and to determine residents' level of satisfaction with waste disposal services in the area under study. The research focused on communities residing near landfill sites and any other residents exposed to the illegal dumping of waste. It was envisaged that, by observing if and how local municipalities neglected their solid waste management mandate, this study would be able to offer advice on how revised strategies could be devised and implemented to positively change MSW management in the study area.

The study took cognizance of the value of regular community meetings/imbizos to address waste management issues, and it thus evaluated the selected municipalities' relationship with their communities in terms of consultation and information dissemination practices concerning effective waste management. The study also needed to determine whether the selected municipalities outsourced waste management services in the form of long- or short-term contracts or not. The involvement of non-governmental organisations (NGOs) in the promotion of proper waste handling from the point of generation to landfilling was also investigated, and the study tried to determine if these organisations informed households of the financial gains associated with waste recycling and selling. The availability of waste management resources, the conditions of current waste management infrastructure in the respective local municipalities, and their ability to provide effective services (such as improving the condition of access roads) were also determined.

It was envisioned that the results of the study would provide updated information regarding the waste management sector in TMD and that it would be possible to use the findings as a guide for the enforcement of environmental regulations to ensure improved waste management strategies in the study area.

1.5 Delimitations and limitations of the study

The study was delimited to one district in the Free State Province and a suitable sample was drawn from the five local municipalities in the selected district.

A limitation that impacted the study was that data were obtained from a sample that was drawn from major towns in only the TMDM, and thus not all local municipalities in the Free State were assessed. The findings may therefore not be generalised to all the municipalities in the Free State Province.

Moreover, the study was conducted soon after the outbreak of COVID-19, and environmental health practitioners' workload had been increased due to this pandemic; thus, many potential respondents declined participation in the study. One targeted municipality was also unwilling to participate in the study, and thus a smaller proportion of the study population than was originally envisaged was represented. However, sufficiently rich data were obtained, and this limitation did not impede the study.

1.6 Structure of the dissertation

The format followed in this study report includes general background of the problem in chapter one, literature review in chapter two, a brief description of the study area and the methodology that was used in chapter three. Discussion of the findings and the results in chapter four and five. Recommendations and conclusions are discussed in chapter six.

Chapter 1: General Background

This chapter introduces different types of waste categories and waste generators and discusses the effects that poor waste management has on human health and the environment. The discourse emphasise that population growth has resulted in increased waste generation and that this has caused negative impacts on the environment and the general living conditions of communities, particularly those who live near waste dumps and landfills in developing countries. The discourse acknowledges that environmental laws and regulations that govern SMW around the world exist but argues that it is doubtful whether the implementation of these legal frameworks is effective in developing parts of the world, and in South Africa in particular.

Chapter 2: Literature Review

This chapter mainly focuses on municipal solid waste handling practices. The types of waste that are generated and the different volumes according to household income are discussed, while the discourse also explores MSW collection according to waste types and the management strategies that are required for effective SWM across the world. Issues related to waste management, the environmental impact of poor waste management, and the legislative framework that governs waste management practices in South Africa are addressed in detail. The discussion also refers to environmental awareness campaigns that have been launched to enhance waste handling at international level as well as those that are currently employed in South Africa. Available waste management data that were published in recent journal articles are also presented and discussed in this chapter.

Chapter 3: Methodology

The research methodology that was employed to collect data from the various municipalities in the TMD is discussed. Participants who lived near landfills and dumpsites were recruited to establish whether waste handling and recycling practices were prevalent at household level and to determine whether the municipalities had appropriate waste management strategies pertaining to collection frequencies and adherence to waste collection regulations. Important issues this article addresses are the availability, functionality, and types of waste collection vehicles per local municipality as the study tried to establish whether the available vehicles would be able to effectively support waste management in terms of collection, transportation, and disposal.

Chapter 4: Results and Discussion

This chapter presents a published questionnaire-based article in which the data that had been elicited from both residents and waste management officials were analysed. Data was also obtained using a landfill and illegal dumping site checklist that was completed by the researcher during site visits. This data was analysed to evaluate the impacts resulting from illegal dumping and improper landfilling practices.

Chapter 5: General Discussion

In this article (chapter), the researcher discusses the importance of educational campaigns to enhance waste management awareness across the globe. The overview compares and evaluates waste awareness campaigns conducted in developed and developing countries with those conducted in South Africa. The chapter addresses key aspects that need to be considered to improve waste management, such as privatization, SMW management strategies, the role of waste pickers, waste management in rural areas, and the need to enforce waste regulation and international agreements.

Chapter 6: General Conclusions and Recommendations

This chapter highlights important factors associated with waste management and addresses the needs of communities regarding the handling, collection, and disposal of municipal solid waste. The researcher offers recommendations for the improvement of current ineffective and inappropriate waste management services in the study area. Topics for further research are also proposed, and it is argued that such studies could improve the lives and health of communities that are negatively affected by poor waste management services.

1.7 Conclusion

Increased waste generation by increasing populations has placed enormous strain on municipalities across the globe, and the literature clearly argues that current plans by municipalities in developing countries for waste management do not cater effectively for the large volumes of waste being generated. Both the metro and local municipalities are fighting a losing battle in their efforts (or lack of efforts) to effectively dispose of waste at all levels. Lack of sufficient infrastructure, limited skilled personnel, cuts in budgets, ineffective and poorly maintained machinery, and various other factors have resulted in increasingly poor adherence to waste collection schedules in South Africa. These factors, coupled with unprecedented municipal strikes in many local municipalities in South Africa (the latest occurred in March 2024 as observed by the author) have resulted in unsightly stockpiles of uncollected waste on illegal dumping sites that have mushroomed in both formal and informal locations.

Section 14 of the National Environmental Management Act No. 107 of 1998 (Republic of South Africa, 1998) mandates municipalities to devise and publish an integrated waste management plan (IDP) that must be effectively implemented to address the waste management needs of their respective communities. One of the most fundamental rights that is entrenched in the Constitution is the right to a clean and safe environment (Republic of South Africa, 1996). The Constitution therefore also provides the legal basis for this right by mandating various spheres of government to ensure a safe environment for all living creatures.

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CHAPTER 2

MUNICIPAL SOLID WASTE LEGISLATION AND PRACTICES

2.1 Introduction

Solid waste management (SWM) is currently one of the most challenging issues that face modern societies as it is associated with changes in consumption patterns, uncontrolled urbanization, and industrialization. Municipal solid waste (MSW) includes household, commercial, institutional, fresh market, street sweeping, and construction and demolition waste, but excludes hazardous and infectious waste. MSW is composed of organics, paper, plastics, glass, metal, and other solid waste (Kolekar, Hazra, and Chakrabarty, 2016; Sun and Chungpaibulpatana, 2017). Liu, Wang, and Wu (2021) state that estimating future MSW volumes is complex as the generation of waste volumes is affected by various factors while the management of MSW is associated with various social, economic, and demographic challenges. Some social indicators that affect solid waste management are household size, household education level, and urban greening coverage (Du, Niu, Chen, Wang, and Bi, 2022). Economic indicators in the SWM sphere include gross domestic product (GDP), per capita GDP, per capita consumption expenditure, per capita disposable income, household income, residential consumption level, and total retail sales of social consumer goods. Demographic indicators include population size and various education levels. Policy and individual factors also impact waste generation rates but their impact on municipal solid waste generation is difficult to measure quantitatively (Du, Niu, Chen, Wang, and Bi, 2022); hence, the latter factors were not included in this study.

2.1 The generation of municipal solid waste

The National Environmental Management Waste Act (Republic of South Africa, 2008) has different definitions for the various types of solid waste that are typically generated. For instance, it differentiates between domestic waste and hazardous waste. General domestic waste is thus deemed waste that does not pose an immediate hazard to health and the environment such as domestic waste, building and demolition rubble, waste generated by businesses, and inert waste, while hazardous waste is waste that is generated by health care facilities such as sharps and blood. The act offers an “umbrella” term for waste as follows:

- (a) “any substance, whether or not that substance can be reduced, re- used, recycled and recovered-
- (b) that is surplus, unwanted, rejected, discarded, abandoned or disposed of;
- (c) which the generator has no further use for the purposes of production;
- (d) that must be treated or disposed of; or
- (e) that is identified as a waste by the minister by notice in the *Gazette*, and includes waste generated by the mining, medical or other sector, but---
- (i) a by-product is not considered waste; and
- (ii) any portion of waste, once re-used, recycled and recovered ceases to be waste” (Republic of South Africa, 2008).

Waste is further defined as the range of waste that is generated by human and animal activities, that is disposed of as unwanted material, and that has no further significant use (Leblanc, 2017; Cunningham, 2003). It is generated by residential, industrial, and commercial activities in each locality and may be handled in different ways. Waste is also commonly called ‘trash’ and ‘garbage’ and includes everyday items such as broken household items, spoilt food, wrapping or packaging materials, or simply any other item a person may no longer need or want. MSW includes household, commercial, institutional, street sweeping, construction and demolition, and sanitation waste. MSW also contains recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), compostable organic matter (fruit and vegetable peels, food waste) and soiled medical waste (blood-stained cotton, sanitary napkins, disposable syringes) (Kolekar, Hazra, and Chakrabarty, 2016).

2.2.1 International MSW generation rates and types of waste

The current global population is estimated at 7.6 billion people and this figure is expected to increase to between 9.5 and 10 billion in 2050 (Singh, 2019). Urbanisation is also increasing rapidly due to population growth, which increases the need for work and has led to a substantial increase in the generation of municipal solid waste in recent time. Globally, MSW generation will increase from the current 2.01 billion to 3.40 billion tons by 2050, particularly in the East Asian Pacific regions where waste is being produced at an alarming rate. The economies in this region account for nearly a quarter of the global total waste generation. Current global waste generation is 3.3 million tons per day and is already difficult to manage, and it is expected to increase to 11 million tons per day by

2100 (Huang, Zhang, Zou, Tai, Shi, Fu, Zhao, and Qian 2021; Johnson, Laniuk, Cazap, Liu, Starobin, Dobler, and Ghandehari, 2017).

2.2.2 MSW generation in developed countries

Per capita municipal solid waste (PCMSW) generation in developed countries such as the United States and Germany is higher than in developing economies. This is due to increasing socio-economic development in these countries which promotes people's consumption patterns and thus increases MSW generation. Economic growth in countries in the European Union has resulted in unprecedented waste generation problems. The EU generates 392 million tonnes of municipal solid waste and was the second highest waste generator among countries in the developed world (Huang *et al.*, 2021; Gardiner and Hajek, 2020). In Kuala Lumpur, the capital city of Malaysia, MSW generation is estimated at 1.62 kg/capita with a national average of 0.8-0.9 kg/capita. This is expected to increase to about 2.23 kg/capita by 2024 (Saeed, Hassan, and Mujeebu, 2009).

2.2.3 MSW generation in developing countries and types of waste

As the cities of developing countries continue to expand, the challenge of municipal waste management becomes more serious. High population density and growing affluence require money for constant and effective MSW management. However, in most of these countries where institutional capacity is lacking, increasing waste generation and inadequate disposal facilities are evident (Chen and Urpelainen, 2015). Methodologies to collect data on solid waste generation in these countries have been impeded by a lack of available data, and this has led to uncertainty regarding the exact number of inhabitants generating waste in certain locations, unrepresentative samples of inhabitants to represent large populations, misallocation of population groups belonging to certain spatial levels, solid waste generation (SWG) data being collected from multiple unreliable sources, incomplete historical records of quantity and quality of SWG, and the use of old data as updated data (Torrente-Velasquez, Ripa, Chifari, and Giampietro, 2021). To mitigate these challenges, solid waste generation in developing countries is commonly obtained from the solid waste generation intensity indicator (SWGII).

Since 2019, the population size in sub-Saharan Africa has increased to approximately one billion people and MSWG is estimated at 180 million tonnes at a rate of 0.5% per capita per day. Openly dumped waste is estimated at 70% while plastic waste generation is about 17 million tonnes per year in this region (Ayeleru, Dlova, Akinribide, Ntuli, Kupolati, Marina, Blencowe, and Olubambi, 2020). It is commonly accepted that households generate an important fraction of MSW, and it is expected that, in less than a decade, SWG measured in tons per day in Africa and Latin America will have increased by 160% and 66% respectively. In the southern Asian and sub-Saharan African regions, the average waste generation rates are 0.45 and 0.65 kg/capita/day respectively (Padilla and Trujillo, 2018).

Waste generation in Nigeria is estimated at 0.49 to 0.58 kg per capita/day, which amounts to 86 000 tonnes of MSW per day for the entire country. The average waste generation per capita per day is therefore about 0.53 kg while the average daily waste generation for the entire country per day is 74 428.85 tonnes. These figures are based on a population census that was conducted in Nigeria in 2006 (Abila, 2014).

MSWG in Ghana is estimated at between 150 kg and 200 kg/capita/annum. In Accra, the capital city of Ghana, approximately 760 000 tonnes of MSW are produced annually, which translates to about 2 000 tonnes of waste per day at a daily per capita rate and density of 0.40 kg and 0.47 tonnes per cubic meter respectively. The MSW that is generated in this country is not sorted at source and there is a high cost attached to waste collection. Untreated MSW results in the pollution of the air, soil, and water. The organic content of the waste attracts viruses, germs, and other vectors that may cause severe infections in living creatures (Abila, 2014; Nketiah, Song, Cai, Adjei, Adu-Gyamfi, and Obuobi, 2022).

Based on the findings of a research study (Nxumalo, Mabaso, Mamba, and Singwane, 2020) suggest that, in the urban areas of Eswatini, about 80% of general waste is combustible material such as food packaging, paper, and cardboard. Limited to no waste management systems exist in this mountainous rural country, and the waste volumes are difficult to determine as disposal is random, while many households resort to

backyard waste burning. Population census data indicate that the total amount of waste generated in this country per annum is 238 341 tonnes, with 100 933 tonnes (42%) being generated in urban areas while 137 409 tonnes (58%) are generated in rural areas. It is noteworthy that high-earning urban households do not generate a high percentage of MSW, and neither do people who live in some peri-urban and rural areas that are close to the towns and cities (Nxumalo *et al.*, 2020).

Generally, MSW management in developing countries is a major problem, as in most of these countries only 50 to 70% of the waste generated is collected while the remainder is disposed of in an environmentally unsound manner. Waste thus ends up in gutters, streams, rivers, and open spaces, and polluted rivers often flood during the rainy season. Moreover, the current infrastructure for handling waste in these countries is not effective enough to keep up with their escalating waste generation rates, and this has resulted in open dumping and burning of refuse as well as an increase in the prevalence of unregulated landfill sites. Over 80% of the waste that is collected in Africa, Latin America, and the Caribbean (West Indies) is disposed of on landfills. For example, about 74% of the waste that is generated in Nigeria is landfilled while 80 to 90% of the waste that is generated in South Africa and Malaysia is landfilled (Alao, Popoola, and Ayodele, 2021).

2.2.4 MSW generation in South Africa

The waste volumes and types that are generated per household are commonly influenced by monthly income and socio-economic status, and it is argued that rural households generate more organic waste than urban households (Gupta, Yadav, and Kumar, 2015). Conversely, higher income households seemingly generate more waste than poor households and the former are therefore more likely to afford the transportation of waste to a central collection point from where it will be collected for disposal. Moreover, residents with a high income usually live in areas where there is easy access to refuse trucks and these residents generally generate more MSW than their poorer counterparts, but they are also reportedly more satisfied with the waste removal services rendered by their local municipalities than poorer households (Cheng and Urpelainen, 2015).

A study that was conducted in the City of Johannesburg by the Gauteng Department of Agriculture Conservation and Environment (GDACE) and Alao, Popoola, and Ayodele (2021) indicated that waste amounted to 1 492 000 tonnes per annum. This figure was based on disposal data and the authors argue that it may not be a true reflection of municipal waste generation rates. This suggests that waste generation rates may be questionable where there is no meticulous record-keeping and data capturing due to the absence of weighbridges or any other weighing devices. In such instances (which are common), waste generation estimations are made based on waste disposal volumes recorded at landfill sites, if they are recorded at all. There is thus no indication of the volumes of waste generated at household level or in areas that do not have a formal waste collection service. There is also no information available on the volumes of waste that are being diverted from landfill by means of reuse and recycling practices or illegal dumping (Rasmeni and Madyira, 2019). Cape Town, which is the third largest city in South Africa, has a population of 3.7 million people and a growth rate of 2.6%, and this city generates over two million tonnes of MSW each year (Statistics South Africa, 2016).

Building and glass are types of rubble that are commonly generated by the construction industry and households respectively. Construction and demolition companies often do their own crushing for use of this rubble in the same location, which is essentially part of unmeasured construction and demolition (C & D) recycling rates. For instance, the City of Cape Town generates about one million tonnes of C & D waste as well as an estimated 150 000 to 300 000 tonnes of glass waste per year (Vossberg, Mason-Jones, and Cohen, 2014).

The serious scarcity of waste management infrastructure has resulted in continuous and acute MSW generation becoming an issue for policymakers and stakeholders both locally and globally, particularly in fields where public health and the environment are under serious threat. To ensure effective management of MSW, it is important to generate reliable forecasts of MSW rates and the composition of this waste. In developing countries and in some developed nations, there are usually unavailable historical statistics on MSWG, and the composition of waste attributed to waste management practices. The projection of MSW generation in the city of Johannesburg in 2021, with a population size of 5 369 318, was estimated at 1 614 800 tonnes, and

with a population size of 8 425 519 it is estimated to reach 1 951 139 tonnes in 2050 (Ayeleru *et al.*, 2021). Waste generation information for the Free State Province is also recorded in the South African Waste Information data base (South Africa. Department of Environmental Affairs, 2015) with expected increased volumes of municipal solid waste generated in the local municipalities of Dihlabeng, Masilonyana, Metsimaholo, and Tswelopele in the Lejweleputswa district in the Free State Province. In 2015, this region generated approximately 894 787.40 tons of waste per annum.

In Lusikisiki and Flagstaff in the Ingquza local municipality in Eastern Cape, South Africa; finding a space for landfilling was fraught with both political and environmental pressure because the available land is communal, and to use that land for municipal purposes is prohibited as they cannot get environmental authorization, yet the current landfill site borders a residential area (Buso *et al.*, 2015).

Litter in Khayelitsha in Gauteng is a serious problem for households and individuals who do not like the way in which people litter in the community, and households prefer that waste is discarded in waste containers. However, the community in Khayelitsha persists in burning their waste on unoccupied land and open spaces, while others may bury their waste. Households normally burn waste such as paper and plastic and they bury food, cans, and bottles or any other unwanted items such as TVs, radios, and garden waste. Rubble from renovations or buildings is also dumped on unoccupied lots and open spaces (Tahulela, 2017).

South Africa faces many challenges in its efforts to attain high service delivery standards as the waste management sphere is hampered by limited resources (Matete and Trois, 2008). Improper municipal waste management systems result in considerable amounts of waste ending up on open dumps and this causes harmful exposure to humans and animal scavengers (Getahun, Mengistie, Haddis, Wasie, Alemayehu, Dadi, van Gerven, and Bruggen, 2011).

South Africa is therefore one of many developing countries that struggle when it comes to waste management, particularly as limited volumes of municipal solid waste are

recycled or recovered. For instance, the Thabo Mofutsanyana local municipality is one of the most under-serviced municipalities in the five Free State districts with regards to sanitation and waste removal. From June 2005 to 2007, only 19.1% of the Thabo Mofutsanyana population received free and basic solid waste management collection services (South Africa, 2007). This poor waste management record may be attributed to the inadequate provisioning of waste disposal services.

Municipal solid waste collection strategies consist of various aspects including the following:

- A needs analysis
- Types of waste to be collected
- Types of vehicles used for waste collection
- Frequency of waste collection
- Door-to-door waste collection
- Kerbside waste collection
- Dumping of waste at designated sites
- Backyard waste collection and
- Pneumatic waste collection.

2.3.1 Needs analysis

Both municipalities and communities should play a key role in supporting sustainable development in the areas they serve and where they live and work respectively. Metros and municipalities are responsible for infrastructure development, the procurement of resources to serve the public, and waste management (Zotos, Karagiannidis, Zampetoglou, Malamakis, Antonopoulos, Kontogianni, and Tchobanoglous, 2009). Sectors such as education, social welfare, and physical planning also fall under their auspices. In terms of waste management, many municipalities prioritise waste collection but often consider waste treatment or disposal a second priority (Zotos *et al.*, 2009). Local authorities should work towards the adoption of waste reduction targets, the promotion of source separation, and the achievement of zero waste generation to ease and limit MSW disposal requirements. However, the common causes of the lack of effective waste minimization practices in developing countries are rapid urbanization, a public that is relatively uneducated about sustainable consumption practices, the non-

implementation of the polluter pays principle, and monitoring and enforcement inefficiencies (Zotos *et al.*, 2009). To implement a successful waste hierarchy, local municipalities and communities should co-operate with several governmental and non-governmental schemes and systems in both the public and private sectors (Zotos *et al.*, 2009).

The primary purpose of devising solid waste disposal strategies is to address concerns related to health, environmental sustainability, aesthetics, land-use, resource utilisation, and economic concerns associated with the improper disposal of waste (Marshall and Farahbakhsh, 2013). These issues are ongoing concerns that affect all nations, municipalities, corporations, and individuals. In developing countries, the volumes of waste that are generated in rapidly growing cities are too much for municipalities and national governments to manage (Marshall and Farahbakhsh, 2013). Waste generation volumes vary according to the days of the week, month, and year, which makes it difficult to accurately predict the volumes of household waste destined for landfill disposal. This problem is exacerbated by the ineffective implementation of processes such as waste sorting and recycling that could take place at the point of generation until final disposal. Different access conditions, the nature of the residential areas being served, waste types, and frequency of waste generation require different collection strategies such as separating, storing, collecting, transporting, processing, and recovering. Moreover, the disposal of solid waste requires multidisciplinary skills and the participation of public authorities, the community, and municipality workers and managers. To prevent waste accumulation, waste should be fully reused/recycled and recovered. To achieve this goal, processes to recover energy from waste should be prioritised (Batista, Caiado, Quelhas, Lima, Filho, and Yparraguirre, 2021). In developed countries, MSW is a resource for energy production, whereas in developing countries collection, transportation, and disposal of waste are still prevalent where energy recovery is marginalised (Batista *et al.*, 2021).

The removal/collection of waste is managed in various ways so that waste can be recycled, reused, or taken to a final disposal point. The latter is generally a municipal function. In South Africa, several waste collecting strategies are used, of which the most common is the communal collection method which is mostly applied in poorly developed

areas where community members have to place the waste in containers, and it is then collected by municipal or contract workers in large refuse vehicles and transported to disposal sites (usually landfills). Another method of collection is kerbside collection where the householder places either a black bag or a waste container on the kerb (pavement) of the road for collection and retrieves the container after municipal/contract workers emptied it (Getahun *et al.*, 2011).

2.3.2 Types of waste that need to be collected

MSW generation affects three key domains, namely the economy, the environment, and society. Sustainable municipal waste management is necessary for: (i) conservation of energy and natural resources; (ii) the prevention of greenhouse gas (GHG) emissions; and (iii) the protection of public health. To have a functional MSW management system, all activities, starting from generation to final disposal, should be well executed. The functional elements of these systems may be categorised as: (i) generation; (ii) separation and storage at source; (iii) collection and transportation (C&T); and (iv) final disposal. The focus of this section is on C&T, which is impacted by costs and may affect public health due to GHG emissions. Other factors that affect C&T are recycling and the depletion of resources. A major portion of waste expenditure is accountable for C&T costs. According to Yadav and Karmakar (2020), 70 to 85% of total waste management costs is spent on C&T in developing countries while developed countries spend 50 to 75% on this component. This is due to the different collection systems that are employed in developing and developed countries.

The main considerations at MSW collection planning level are to determine the types of waste to be collected, the way waste collection needs to be organised, and the vehicles that should be used or can be afforded. Generally, there are two types of collection locations for municipal solid waste: either residents can place their waste on the kerbside, or they can drop it off at a central collection point. In Spain, waste that is not sorted is usually collected in kerbside bins, while paper/cardboard, glass, and other lightweight packaging materials are brought to drop-off points. In the UK, municipalities utilise three common schemes: (i) kerbside sorting: recyclables are separated at the kerbside into different compartments of a specialised collection vehicle; (ii) single-stream co-mingled: materials are collected in a single-compartment vehicle and the sorting of

these materials occurs at a material recovery facility (MRF); and (iii) two-stream co-mingled sorting: residents are provided with two recycling containers and are asked to place specific materials in each container. These materials are stored separately but collected by one vehicle which has two chambers (Bing, Bloemhof, Ramos, Barbosa-Povoa, Wong, and van der Vorst, 2016).

Municipalities either manage waste collection themselves or make use of outsourced contractors. In the Netherlands, for instance, each municipality is responsible for organizing its own waste collection. Some municipalities may share the waste collection services of the same company (Bing *et al.*, 2016).

2.3.3 Types of vehicles used for waste collection

Waste collection trucks with a hydraulic function are commonly used in the Netherlands, the UK, Germany, and Portugal. For kerbside collection, a rear-loaded truck is used while drop-off containers are collected by a top-loaded truck with a single compartment and no hydraulic (pressing) function. Some collection vehicles have multiple compartments for specific waste types, while others are equipped with vacuum pipes to avoid heavy lifting. Different types of trucks are thus used for different collection methods and different waste types (Bing *et al.*, 2016).

According to (Bing *et al.*, 2016), various waste collection approaches were explored in the past to facilitate the easy collection of waste according to type, volume, collection frequency, and the dynamics and characteristics of the targeted area. MSW collection typically targets two different routing models, namely arc-routing and node-routing approaches. However, both these approaches are problematic. Kerbside collection is modelled as an arc-routing approach. To allow waste collection in every street of a city, all arcs in the graph must be visited, but waste collection vehicles sometimes have to take forbidden turns at some street junctions and traffic signals, particularly in Spain (Bing *et al.*, 2016). The waste collection vehicle routing problem is referred to as a capacitated arc routing problem (CARP) and waste collectors are expected to devise strategies to solve the problems they encounter. On the other hand, node routing is problematic as various central spots must be visited by the vehicle while some

challenges may occur at various nodes (intersections). One important point to consider when waste is collected is the number of waste streams that are collected on the same route.

2.3.4 Waste collection frequencies

The waste collection stage is a component of the integrated waste management system that influences the economy of operation significantly as the type of waste and the frequency of collection determine collection costs (Sebastian and Louis, 2022). Minimizing these costs can be achieved if suitable collection routes are used and municipal pickup operations are effectively executed. Canadian municipalities usually inform residents of collection days and frequencies, and these schedules usually depend on whether residents have access to collection services by means of suitable infrastructure, efficient and sufficient staff, and special waste collection approaches such as yard waste collection and kerbside collection. Collection frequencies also depend on the type of terrain, climate and seasons, and local preferences. Collection frequencies vary from five to one day a week, but in some developing countries it may occur only once or twice a month. The types of waste trucks used also influence the efficiency and frequency of waste collection (Sebastian and Louis, 2022).

2.3.5 Door-to-door waste collection

Where this system is used, residents give their MSW to collectors at their doorstep. There is a schedule that collection vehicles follow, and their presence is often marked by a specific alarm sound such as the ringing of a bell. This technique requires someone to be present at home to hand the MSW to the collector. Generally, it is an economic system that is convenient for residents, and it avoids nuisance caused by stray animals. It is generally practiced in South Asian countries (Yadav and Karmakar, 2020).

2.3.6 Kerbside waste collection

On the day of collection, residents place their MSW in special containers on the kerb or pavement and the waste collectors remove the waste in special vehicles. It is economical and does not need someone to hand over the waste. It also allows waste collectors to work rapidly and efficiently. However, a delay in the arrival of the waste collection vehicle

can result in nuisance due to stray animals and flies. This system is suitable for developed countries such as those in Europe and North America (Yadav and Karmakar, 2020).

2.3.7 Dumping of waste at designated sites

The dumping of waste at designated sites is used in congested areas in urban centres that are inaccessible to waste collection vehicles or where the system has broken down. Municipalities identify sites on access roads near congested areas. The waste is mixed and is sometimes dumped in large community bins or on heaps. This technique is the least expensive and requires less manual labour; however, it can result in nuisance caused by flies and animals on these dumping sites. They are also usually quite unsightly. This type of C&T is usually found in developing countries such as Pakistan and Cameroon (Yadav and Karmakar, 2020).

2.3.8 Backyard waste collection

Collectors enter the property to collect MSW by tote barrel and transfer it to the collection vehicle. This technique does not require any bins and is convenient for residents. However, it is very expensive and requires intense manual labour. It is suitable for societies with a small population and sparse housing conditions, such as in Watsonville (USA) and Dublin (Ireland) (Yadav and Karmakar, 2020).

2.3.9 Pneumatic waste collection

Waste is collected and transported through pipelines using pressurized air. This technique requires skilled labour, high initial capital investment, and a well-planned urban structure which makes it suitable for developed economies. If this structure of C&T is appropriately designed and implemented, it significantly reduces GHG emissions and air and noise pollution, but it uses high energy and causes problems such as pipe blockages due to bulky waste. It is utilised in smaller residential areas and does not replace the collection of waste using trucks. This system is used in areas in New York, for instance (Yadav and Karmakar, 2020).

Collection and transportation techniques that need high capital investment such as pneumatic, backyard and kerbside strategies are prevalent in developed countries, whereas door-to-door waste collection and dumping at a designated site are usually employed in developing countries. However, it should be noted that lower initial investment can result in higher environmental costs in the future (Yadav and Karmakar, 2020).

2.4 Waste disposal strategies

Waste is disposed of by implementing different disposal strategies which include landfill, waste dumpsites, open burning,

2.4.1 Landfilling

Municipalities in developed and emerging nations alike experience several issues in their efforts to effectively manage the disposal of solid waste and the diversion of generated waste. Several countries have relied for years on landfilling as the traditional and often more profitable method of waste disposal compared to incineration, as the latter requires large capital expenditure and extensive infrastructure together with material recovery innovations such as pyrolysis, anaerobic digestion, liquefaction, gasification, and composting that are all processes that necessitate significant labour and material costs.

Landfills can be classified according to the characteristics of the waste they accept such as soil disposal (class 1), nutrient disposal (class 2), renovation waste disposal (class 3), municipal solid waste disposal (class 4), industrial and commercial waste disposal (class 5), toxic waste disposal (class 6), and underground toxic waste disposal (class 7). Landfills can also be classified according to their functionality (Vyas, Prajapati, Shah, and Varjani, 2022). For instance, monofil landfills refer to those that contain waste that cannot be incinerated, recovered from the surroundings, or composted. Reusable landfills, on the other hand, enable waste to be stabilised for a prolonged duration of time before it can be excavated for plastics, metals, glass, and compost. Lastly, bioreactor landfills are engineered landfills with liners and leachate extraction. Such a system recirculates and maximizes microbial waste decomposition while reducing environmental consequences (Vyas *et al.*, 2022).

Landfilling is the final waste disposal route in most developing countries and is deemed an 'easy' approach considering the lack of infrastructure, the remoteness of most landfills, and the poor segregation practices that are often employed (Sebastian and Louis, 2022). Moreover, landfilling is still practiced globally because of its convenience of execution, but many landfills are left unattended due to high management costs and these sites cause severe pollution. Developed countries use an improved type of landfilling referred to as sanitary landfilling. A sanitary landfill is a contemporary landfilling technology that ensures optimum utilization of solid waste with minimal pollution hazard (Reyna-Bensusan, Wilson, and Smith, 2018; Sebastian and Louis, 2022). Conversely, landfills with high concentrations of methane, metals, other toxic components, and the evacuation of prolonged leachate cause the contamination of soil, surface water, and groundwater; hence, the efficient landfilling of pollutants is crucial to prevent leachate and the leakage of landfill gases that can result in increased risks of fire and long-term global warming. Heavy metals, inorganic salts, ammonia, xenobiotic organic substances, and minerals with excessive levels of organic materials like dissolved solids and carboxylic acids can cause major environmental challenges which are difficult to clean up (Das, Lee, Kumar, Kim, Lee, and Bhattacharya, 2019; Vyas *et al.*, 2022).

MSW and landfills are the third anthropogenic source of global methane gas emission and annually release about 800 tons of carbon dioxide into the atmosphere. Moreover, solid waste generation poses significant health risks to humans due to increased incidences of several diseases like malaria, dermatitis, gastrointestinal disorders, bronchitis, and asthma occurring in residents living near disposal sites (Das *et al.*, 2019).

2.4.2 Waste dumpsites

Another environmental issue that is prevalent due to poor waste management is open dumping. Open dumping of solid waste is a common practice in poor and developing countries and this affects many components of terrestrial ecosystems. Open dumps are found on large stretches of land where solid waste is dumped or piled without covering. Many open dumps are found across the world in developing areas, but their extent and number are difficult to determine (Das *et al.*, 2019).

2.4.3 Open burning

The combustion and decay of MSW that is dumped in open spaces cause gaseous emissions, mixing of particulate matter, volatile matter being released into the air, and the chemical and biological contamination of soil and groundwater due to seepage (Pujara, Pathak, and Govani, 2019). Moreover, the decomposition of organic waste produces huge amounts of methane (greenhouse) gas, and this increases global temperatures and results in changes in climatic conditions. Furthermore, the high organic content of MSW increases the growth of microbial pathogens and may lead to infectious and chronic diseases in waste workers, rag pickers, and people living near dump sites. Numerous health issues like respiratory problems, skin irritation, infection of the eyes and nose, gastrointestinal problems, allergies, and psychological disorders are associated with the burning of MSW (Pujara, Pathak, and Govani, 2019).

Solid waste disposal is a worldwide issue and poses a serious risk to public health and the environment. On a global scale, two billion people lack access to MSW collection services, and they typically dispose of household waste by means of open burning, burial, or dumping on open spaces or in watercourses. Open burning of waste is characterized by low temperature combustion with high contaminant emissions (such as black carbon) that contribute significantly to air pollution and cause both health and environmental problems. Open burning also releases gaseous emissions near ground level, and these gases are scattered spatially and temporally in a non-uniform manner over large areas. The lack of control over waste being burnt and the difficulty in enforcing regulations against open burning, especially in remote areas and among indigenous communities, are serious challenges in the waste disposal sphere (Reyna-Bensusan *et al.*, 2018 and Sebastian and Louis, 2022).

Dumpsites contaminate soil and water due to leachate infiltration and run-off and these processes deteriorate vegetation and contribute to global warming and air pollution (Krecl, Hatada, de Lima, Dal Bosco, Targino, Hashimoto, and Oukawa, 2021). Both spontaneous fires and deliberate burning of waste are also severe challenges as discussed above. In most developing countries, it is common practice to reduce the volumes of waste and the odours emanating from dumped and unprocessed waste by burning it. The open burning of MSW is a very inefficient combustion process due to low

temperature and limited oxygen supply. Moreover, as no air pollution control equipment is used, a variety of chemical components with different levels of toxicity are emitted into the atmosphere. Municipal solid waste is highly heterogenous and, if the burning conditions are uncontrolled, the number of the emitted components can vary largely. Typically, particulate matter, carbon monoxide, greenhouse gases, and polycyclic aromatic hydrocarbons are emitted into the atmosphere by the burning of MSW, and these have harmful effects on human health (Krecl *et al.*, 2021).

2.4.4 Odours associated with open dumping and landfilling

Odour is a nuisance factor that is closely related to solid waste dumping and landfilling. It is challenging to control odours and contain this nuisance because of sampling and quantification difficulties caused by huge amounts of compounds present and the detection limits of measuring instruments (Das *et al.*, 2019). Odour pollution is generally considered a nuisance, particularly in developing countries that are afflicted by rapidly increasing waste generation. Odour pollution has been a limiting factor in MSW management for both existing and developing facilities in cities (Zhao, Lu, and Wang, 2015).

2.5. Strategies for waste utilization, reduction, and recovery

A key driver of sustainable development is the utilisation of an integrated waste management strategy that considers all stages of waste handling, from the point of generation to the final disposal method (Oribe-Garcia, Kamara-Esteban, Martin, Macarulla-Arenaza, and Alonso-Vicario, 2015). Efficient waste treatment goes hand in glove with waste quantities and quality, waste composition, and an accurate estimation of the volume of waste that must be managed. If waste generation is either under- or over-estimated, it has significant consequences in terms of additional costs and environmental impacts. To develop waste management strategies, a thorough analysis of waste generation is required, and this data should be used to successfully plan waste management operations either for the short or long term (Oribe-Garcia *et al.*, 2015).

To achieve a waste management system that is sustainable, appropriate practices should be devised and properly implemented. Moreover, suitable technologies, tools, and effective infrastructure should be available.

According to the principles of integrated solid waste management (ISWM), every waste management schedule must include the following: measures to prevent the generation of avoidable waste; the reduction of waste through recovery and reuse; recycling of recyclables; composting of organic waste for energy generation; and finally, the disposal of waste at sanitary landfills. These waste management processes render the environment cleaner, minimize air and water pollution, create employment, and save resources for future use (Ogwu, Ozoegwu, Ozor, Agwu, and Mbohwa, 2021).

2.5.1 Waste reduction



Figure 2.1: Solid Waste Management Hierarchy Model (Oyenuga and Bhamidimarri, 2017)

Waste should be reduced at the point of generation and along various processes before disposal. An important strategy to achieve waste reduction is to separate waste at source by placing it into different containers at designated places for collection. These containers should be clearly labelled or coded to ensure the proper disposal of particular waste streams (Ogwu *et al.*, 2021).

2.5.2 Waste reuse

This involves the reuse of discarded materials/items in their original form without transforming or making good use of them. Materials that can be reused include glass containers of all kinds such as bottles, polyethylene terephthalate (PET) bottles, clothing,

paper and cardboard, leather, food leftovers, metal, and anything that can be repurposed (Ogwu *et al.*, 2021).

2.5.3 Recycling

Recycling involves the reprocessing or transformation of waste materials into other forms before use. Recycled or treated waste becomes a valuable resource and is no longer categorised as waste. For example, paper waste can be transformed into new paper products while metal and glass items can be melted and transformed into useful metal and glass products (Ogwu *et al.*, 2021).

2.5.3 Composting

Composting is when microbes such as bacteria, fungi, and actinomycetes are utilised to decompose organic waste materials in particular vessels to produce humus-rich compost. Composting is widely used in rural areas where organic waste is processed according to the traditional pit composting (aerobic and anaerobic) and heap composting (aerated) methods, or according to modern large-scale composting methods such as in-vessel composting, windrow composting, and effective microorganism-based quick composting. Other types of composting approaches are also used, such as vermicomposting or earthworm-mediated composting, which are popular techniques around the world because of the fast decomposition of the waste materials, significant improvements in the end products, and overall biological sustainability. Composting is an organic waste diversion technique that is beneficial for managing biodegradables as it relies on the biodegradation of organics by bacteria and fungi under aerobic and thermophilic conditions that allow these biodegradables to become nutrient-rich compost. Unfortunately, the volumes of waste that are transformed by composting methods are currently low in developing countries (Das *et al.*, 2019). The following advantages are associated with composting: the reduction of leachate quantities; the low pollution potential of compost; a large reduction in GHG emissions compared to land disposal; improvement of landfill lifespan; and various applications of composting in agriculture and smallholder farming (Das *et al.* 2019; Ogwu *et al.*, 2021).

2.5.4 Energy recovery technologies

Global energy demand is increasing and is even more pressing in developing countries than in developed ones according to a report by the International Energy Agency (IEA) (Das *et al.*, 2021). Waste to energy (WTE) transformation methodologies are therefore encouraged because they offer a clean mode of energy generation and can help avoid the emission of carbon dioxide (from fossil fuels) and methane (from landfills). Such methodologies are widely used globally as the latent energy of solid waste types is appreciable and can be utilised through waste processing and conversion technologies to generate heat, gas, oil, or electricity (Das *et al.*, 2019). The two classes of WTE conversion technologies are thermo-chemical and bio-chemical conversion. Energy is produced by thermo-chemical conversion through the thermal decomposition of waste materials, while incineration, gasification, combustion, pyrolysis, carbonisation, and mechanical extraction are examples of thermo-conversion. These processes are described by Das *et al.* (2019) and are briefly summarised as follows: Incineration: the direct burning of solid waste with sufficient oxygen supply to produce heat; Pyrolysis: the thermal decomposition of organic materials at relatively high temperatures in an oxygen-limited environment; Gasification: the thermal decomposition of waste in the presence of limited oxygen to yield a mixture of both combustible and non-combustible gases; Hydrothermal carbonisation: a new thermal conversion technique that utilizes a temperature range of 180 to 350⁰C in a water-based environment to convert solid waste into carbonaceous residues; and mechanical extraction: used for organic wastes such as seeds, pulp, and peels that are mechanically pressed at 170-190⁰C for oil production.

Bio-chemical conversion, which is a process based on enzyme/microbe-assisted denaturation of waste substances, is also used. Anaerobic digestion and fermentation are two major biochemical conversion technologies. Das *et al.* (2019) describe these processes as follows:

- Anaerobic digestion or bio-methanation: This process utilizes specific reactors (which are biogas digesters) where the organic fraction of solid waste is fed in oxygen dioxide-devoid conditions to produce biogas (i.e., methane plus carbon dioxide) and sludge.
- Bioethanol production: Microbial agents are used in the hydrolysis of solid waste like kitchen and vegetable waste.
- Industrial enzymes and chemicals: Biotechnical processes have recently gained momentum as suitable pathways to produce several enzymes on an industrial

scale. Similarly, microbe-assisted production of several enzymes like amylases, pectinases, and proteases from solid waste has been reported.

2.5.5 The Impact of Waste on the Environment and Poor Waste Disposal

Literature affirms that more than 90% of the total volume of MSW is disposed of in an environmentally unsound manner and that this creates environmental degradation and human and even animal health issues. Poor solid waste disposal has a negative impact on communities and is exacerbated by urbanization. It is therefore not surprising that poor solid waste management in developing countries has escalated from a matter of limited concern to a situation that is regarded as hazardous (Singh, 2019). During the rainy season, waste can block drains which can cause floods and create breeding areas for insects. Improper management of municipal solid waste, for example burning of waste, could also result in environmental pollution which renders municipal solid waste one of the major environmental pollutants (Liao and Chiu, 2011).

Poor service delivery due to low municipal budgets and untrained manpower in developing countries result in open dumping and cause dissatisfaction and irritation among residents who are affected by unsightly waste dumps and unpleasant odours. Multiple factors contribute to increased costs of waste collection, such as the size and density of the population, the characteristics of the area to be serviced, the quantity and quality of the waste being handled, and the technical facilities (such as vehicles) that are used to collect and transport waste (Greco, Allegrini, Lungo, Savellini, and Gabellini, 2015). Though municipal solid waste management in some European countries remains the priority of a local or national government, these services are often contracted out to private firms (Thomas, 2009; Lohri, Camenzind, and Zurbrügg, 2014).

Solid waste disposal is a worldwide issue and poses risks to public health and the environment. Globally, two billion people lack access to MSW collection services and dispose of household waste typically by open burning, burial, or dumping it on open ground or in water courses (Reyna-Bensusan *et al.*, 2018).

Negative environmental impacts resulting from poor MSW include odours mixed with the smell of stagnant water and human and animal excreta. Decomposed household waste creates conducive conditions for disease vectors to thrive and breed, as was evident in the streets of cities and towns in the Middle Ages (Nhubu, 2019). The Black Death was a vector-induced pandemic that raged in Europe in the 1300s and even later. This deadly disease was attributed to the disposal of organic or biodegradable waste fractions in streets as well as the rats that thrived in these unhygienic conditions (Nhubu, 2019). Early initiatives to clean streets were temporary and not sustainable as the poor concentrated on looking for food to feed themselves while the rich did not see any justification for paying to clean the streets for the poor (Nhubu, 2019).

In most cities and towns in India, approximately 90% of MSW is directly discarded in an unscientific manner. The unscientific disposal of solid waste directly affects human health and the environment. More specifically, it creates environmental hazards and health risks from flies and rats, the pollution of water bodies through runoff during rainfall, pollution of groundwater from leachate, air pollution from burning of waste, and poor aesthetics (Khan, Sharholy, Alam, Al-Mansour, Ahmad, Kamal, Alam, Pervez, and Naddeo, 2022).

Solid waste management is an important sustainability issue as poorly managed waste can harm public health and the biosphere at multiple levels. In most low- and middle-income African countries, the responsibility for and costs of waste management tend to fall on the shoulders of local governments; however, most are burdened by limited capacity to address this issue, and more than 90% of generated waste on the continent goes to uncontrolled dumpsites and landfills. Simultaneously, poorly managed waste is tantamount to lost economic opportunities as it is estimated that 70% of the waste in African regions is recyclable but only 4% is recycled, mostly by informal waste pickers. This challenge prevails in Kisumu, Kenya, which is a city located on the shores of Lake Victoria, and which is the capital of Kisumu County (Mascarenhas, Ness, Oloko, and Awuor, 2021). Some studies found that certain demographic characteristics have an impact on waste disposal choices. A study in Uganda conducted in regions around Lake Victoria found evidence that demographic characteristics may influence waste management behaviour. These characteristics, that included gender, geographic

location of home, and being a member of an environmental organization, significantly affected the willingness of people to separate solid waste at household level.

2.5.6 The role of education in improving waste generation practices

Based on a study conducted in India, it is argued that environmental education should be a key approach by governments to educate communities to reduce waste and utilize it as a resource. If this call is answered, college and primary and secondary school education can have a significant influence on sustainable waste management practices (Pujara, Pathak and Govani, 2019).

However, currently waste management is not environmentally sustainable in developing countries due to problems that include low collection coverage; inadequate collection services; open dumping; burning to reduce waste; lack of water, soil and air pollution control measures; and poor informal waste handling. These issues are prevalent in several regions such as in Asia, Palestine, Kenya, Cameroon, Bangladesh, South Africa, and Malaysia (Cetrulo, Marques, Cetrulo, Pinto, Moreira, Mendizabal-Cortes and Malheiros, 2018).

2.5.7 Waste management legislation

Waste management legislation is promulgated and implemented by authorities all over the world. International and waste management legislation and enforcement in Africa is included in this study.

2.5.7.1 International waste management legislation

Sustainable development has emerged as a major objective of governments and businesses worldwide. Firms face increasing scrutiny for engaging in activities that damage the environment, and many have started to choose green innovation as an effective strategy to achieve cleaner production and stronger competitiveness (Liu, Wang, and Wu, 2021). Enforcing environmental regulations is an important factor that affects corporate green innovation. To examine the effects of environmental regulations on green innovation, previous studies have used pollution abatement control

expenditures as well as prices of energy and different types of policy instruments as a proxy for the stringency of environmental regulation (Liu, Wang, and Wu, 2021). For instance, on 24 April 2014, China passed an amendment to the Environmental Protection Law (EPL) which came into effect on 1 January 2015, and it is considered China's most stringent EPL to date. The new EPL highlights the principles of 'public participation' and 'liability for damage'. It enforces significant reforms in at least three areas as follows:

- Firstly, it expands plaintiff entities with respect to environmental public interest lawsuits. According to article 58 in the new law, any social organization that is registered with the Civil Affairs Department of the government at municipal level or above, and that has engaged in environmental protection and public welfare activities for more than five consecutive years and has a good reputation, can file an environmental public lawsuit against polluting firms that engage in illegal and environmental damaging behaviour.
- Secondly, the accountability of government institutions/officials is affirmed. The new law clearly states that the government is responsible for environmental quality in each administrative region. The red ecological protection line in the law stipulates the bottom line of environmental protection standards and provides important criteria for assessing the accountability of government officials with respect to environmental protection during their contracts. Moreover, local environmental agencies have the power to shut down operations that violate environmental laws.
- Thirdly, it dramatically increases the accountability of polluters to reduce and ultimately prevent environmental pollution and ecological damage. This means that firms that cause any pollution will have to bear responsibility for the damage they have caused. Firms that cause extensive pollution must disclose more specific environmental information to the public, including the names of the pollutants discharged, the discharge method, the discharge concentration and emission levels, the total amount of discharge of the main pollutants and the excessive discharge, as well as details of the concentration and operation of pollution prevention and control facilities (Liu, Wang, and Wu, 2021).

Many countries have formulated stringent environmental policies in response to climate change and environmental sustainability concerns. However, stringent environmental

policies do not guarantee policy implementation. Regardless of how well an environmental policy has been designed, it cannot succeed without an effective government enforcement mechanism as firms are highly likely to violate environmental policies without fear of sanctions, if an effective governance mechanism to curb their activities does not exist (Choi, 2022). Pollution in one country can often negatively affect human and ecosystem health in neighbouring countries that share the same air, water, and climate.

Most countries do not charge their citizens for MSW collection, and in these countries the waste system is funded by public subsidies. This practice is the simplest one and hides the true costs of waste management services, leaving the impression that waste collection services are free. A common fee that is charged in developing countries and that has been gaining momentum because of the simplicity of its application, its constant and predictable revenue generation, and the fact that it is easily understood by the population is called a 'flat rate' (Alzamora and Barros, 2020). It is often linked to a particular variable, such as property area, property value, collection frequency, or simply dividing the cost of service by the number of households. This type of payment provides funds but does not offer any incentives for change of behaviour, such as waste reduction, because the same amount of money will be paid regardless of the quantity of waste generated.

Another fee system commonly used is known as 'variable charging' (or 'pay as you throw') (PAYT) and unit pricing. PAYT is based on the 'polluter pays' and 'shared responsibility' principles, which means that the user is a part of the chain of solid waste generation and should also have a share of responsibility for the impacts of waste. This means that the PAYT system charges those who pollute more while those who pollute less are charged less. It is therefore possible for residents and other waste generators to save money by generating less waste. PAYT also offers a significant economic incentive to reduce pollution. A well-established PAYT system promotes the reduction of MSW generation and increases recycling rates. This system should operate as follows: (i) identify the SW generator; (ii) measure the volumes and types of SW generated; and (iii) determine unit prices, or the price of a transformed unit that will have less impact on the environment (Alzamora and Barros, 2020).

Some developing countries, such as Kenya, Cameroon and South Africa, have implemented policies that address waste management, but the application of these policies has been found to be inconsistent (Cetrulo *et al.*, 2018). Policies intend to ensure environmental, human, and animal health and should be adhered to in municipal solid waste management plans and strategies. To ensure that the goals of WM policies are achieved, it is necessary to monitor SWM results and to identify the need for further government intervention where necessary. Cetrulo *et al.*, 2018, state that environmental policies can be evaluated according to their relevance, persistence, flexibility, efficiency, and effectiveness, and environmental policies are associated with three desirable outcomes: (i) output (performance of policies); (ii) outcomes (social change), and (iii) impact (environmental change). Considering that the output, outcomes, and possible impact of policies can differ significantly over time, establishing a time frame within which an effectiveness evaluation must be performed is crucial. For example, in WM the reduction in waste generation is a possible outcome if the output has been an environmental education program, while a reduction in the pollution of soil, water, and air may be the impact or effect of such a program.

2.5.8.2 Waste management legislation and enforcement in Africa

Waste management is legislated globally and most countries in Africa have environmental regulations to govern municipal solid waste management. However, most of these regulations are not enforced (Badgie, Samah, Manaf, and Muda, 2012). In Nigeria, for instance, the National Environmental Policy is a set of actions centred around a conceptual model that establishes links among environmental problems and their causes, effects, and solutions. The policy, as a framework document, specifies sector-specific and cross-sectoral strategic policy statements and actions for environmental management in this country (Ogunkan, 2022).

South Africa has comprehensive environmental acts, regulations, and bylaws that regulate and control waste management. This legislative framework is enforced by various related governmental departments. The National Environmental Management Act (NEMA) 1998 is the most important legislation that supersedes all environmental legislation. Various other legislation has been promulgated and are enforced in South Africa to govern waste handling and disposal (Republic of South Africa, 1998).

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CHAPTER 3

RESEARCH METHODOLOGY

Abstract

Solid waste management has become a major challenge in urban areas due to population growth, an increase in consumption patterns, and expanding amounts of various waste streams. These factors put a strain on municipalities who must manage solid waste effectively. In developing countries specifically, there is uncontrolled illegal dumping and waste burning that have serious impacts on human and animal health as well as the sustainability of the environment (Ngalo, and Thondhlana, 2023; Haywood, Kapwata, Oelofse, Breetzke, and Wright, 2021). The cleaning of illegal dumping is regarded as more expensive than the formal waste collection and management by governments (Niyobuhungiro, and Schenk, 2021).

Dumpsites will account for 8-10% of global anthropogenic greenhouse gas (GHG) emissions by 2025 and marine littering, health risks, and massive environmental degradation will prevail due to irresponsible and poor MSW management (Ferronato, Alarcon, Lizarazu, and Torreta, 2021). To investigate these impacts, the current qualitative study collected data by means of questionnaires to answer the research questions in chapter one and address the research objectives. Field observations were also conducted and recorded by the researcher. Two questionnaires were developed for administration to a total of 100 residents and 86 municipal employees respectively. During the field work phase of the study, 25 dumpsites and five landfill sites were visited, and an observation checklist was completed for each site. The towns in the study area that were involved were Bethlehem, Ficksburg, Ladybrand, Phuthaditjhaba, and Warden. A direct door-stepping approach was used to recruit respondents and a structured interview was conducted with those who were willing to complete the questionnaire.

Descriptive statistics that determined frequencies and percentages were used as numerical data and are presented in Chapter 4 and Chapter 5 in tables and graphs. Analytical statistics were used to compare the residents' and employees' responses while the observations that had been recorded at the dumpsites and landfills by the

researcher were integrated with the quantitative findings in the discussions and conclusions.

Keywords: Solid waste management, illegal dumping, greenhouse gas, field observations and statistics

3.1 Introduction

The Constitution of South Africa supersedes all laws in South Africa. For instance, in Section 24 and Section 25 in the Bill of Rights (Chapter 2 of the Constitution) it is clearly stated that every human has the following basic rights:

- “(a) to an environment that is not harmful to their health or well-being; and
 - (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that-
 - (i) prevent pollution and ecological degradation;
 - (ii) promote conservation; and
 - (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development”
- (Republic of South Africa, 1996).

According to Al-Salem, Al-Salem, Al-Nasser, and Al-Dhafeeri (2018), MSW can be defined as “discarded and used products, items and undesired materials that result from the various human activities occurring within households and localities”. Solid waste management is a challenging issue in modern societies due to ever-changing consumption patterns and uncontrolled urbanization and industrialization. Municipal solid waste includes household, commercial, institutional, street sweeping, construction and demolition, while sanitation and household waste constitute an important part of the MSW stream. The MSW volumes that are generated have increased significantly in the urban centres of developing countries in the past few decades. Moreover, an unprecedented increase in population growth in urban areas is due to the influx of rural migrants, changing lifestyles of urban populations, economic growth, and social improvements that are all important drivers of the enormous growth in MSW volumes in developing cities in Asia and Africa (Kolekar, Hazra, and Chakrabarty, 2016).

Poor solid waste management in developing countries is characterized by highly inefficient waste collection practices, inadequate levels of service delivery due to inadequate resources, lack of environmental control systems, indiscriminate dumping,

littering, scavenging, and poor public awareness of environmental and waste management requirements (Matete and Trois, 2008). South Africa's commitment to subscribe to sustainable development is aimed at balancing the broader economic and social challenges of a developing and equal society while protecting environmental resources. For the waste sector in South Africa, this means attention must be given to raw material use, product design, resource efficiency, and waste prevention and minimization where avoidance is impossible. However, several issues continue to impede effective waste management, such as ineffective data collection systems, a lack of compliance and enforcement capacity, a lack of education and awareness amongst stakeholders within the waste sector, high operational costs to manage waste, poor support for waste reduction at local government level, a lack of suitable land spaces for waste disposal, a lack of structured incentives for waste reduction, and poor waste recycling and/or reuse practices (South Africa, 2012).

South Africans dispose of enough municipal solid waste to fill an entire football field 10 metres deep, every day. On average, every person in a total population of 57 million generates up to 2.5 kilograms of waste per day depending on his/her level of income. South Africans generate roughly 54.2 million tonnes of general (municipal, commercial, and industrial) waste per year and a maximum of only 10% is recycled or recovered for other uses. A matter of serious concern is that about 90% of MSW is landfilled or dumped (Jaligot and Chenal, 2018). These figures suggest that South Africa is drowning in waste; and the fact that the problem continues unabated poses the questions whether waste regulators are taking their mandate seriously. The growing volumes of municipal solid waste that have mushroomed in the past few decades have put a strain on waste disposal capacities and the environment. For instance, the total volume of MSW generated globally in 2012 was approximately 1.3 billion tonnes. If this level of waste generation should continue at this current rate in high-income countries, total waste generation could reach 5.9 billion tonnes by 2025 (Jaligot and Chenal, 2018).

Reports dating back to 2007 and 2008 state that municipalities in South Africa are faced with four waste-associated challenges, namely: financial management, equipment management, labour management, and institutional behaviour. These challenges manifest as ineffective utilization of municipal resources (financial, equipment, capacity),

non-compliance with environmental legislation, no or poor levels of service delivery, and potential environmental and human health impacts (UNEP, 2020). According to a report by the United Nations Environmental Programme, the overlap of functions between districts and local municipalities is a challenge that results in a lack of accountability that hampers effective solid waste management in small municipalities (UNEP, 2020). Unscientific waste disposal practices remain widely prevalent, which means that waste is left unattended at disposal sites where it attracts birds, rodents, flies, and other vectors. This situation exacerbates prevalent unhygienic conditions and unpleasant odours. Such poorly treated waste dumps also release airborne pathogens and emit greenhouse gases. Moreover, waste that is dumped indiscriminately in streets block drainage channels and is a major cause of public health risks (Kolekar, Hazra, and Chakrabarty, 2016; Suthar and Singh, 2015). Residents who live near uncontrolled dumpsites can also experience unpleasant reactions ranging from emotional stress, anxiety, and unease to physical symptoms such as headaches, eye irritation, respiratory problems, and nausea or vomiting. Moreover, increasing solid waste volumes that originate from vital sectors such as various institutions, municipalities, and agricultural and industrial settings have become a matter of serious concern in developed and developing countries alike (Palmiotto, Fattore, Paiano, Celeste, Colombo, and Davoli, 2014).

Poor waste management can also be attributed to the slack attitude of municipalities that do not provide waste bins or other containers for the effective removal and transportation of MSW. Therefore, residents who must travel some distance to communal containers to dump their household waste refuse to do so, and they simply leave their waste on open dump sites. Local authorities are generally responsible for waste management in their demarcated areas. The involvement of various stakeholders who have some expertise should therefore play a major role in effective waste management (Guerrero, Maas, and Hogland, 2013). In some areas, community-driven recycling efforts include organized waste picking and well-managed drop-off and buy-back centres. Unfortunately, these recycling efforts contribute very little to reducing the waste stream that ends up at landfills as the financial gains of recycling waste are insufficient and do not meet the needs of those who engage in waste recycling. It is for this reason that communities do not see the need to recycle their waste (Matete and Trois, 2008).

3.2 Aims and objectives

The aims of the study were to evaluate the provision of MSW management services provided by the selected municipalities at community level, and to determine the negative impacts of informal waste dumping, affecting communities and the environment, including the level of satisfaction with services.

3.2.1 The objectives of the study were to:

- Review previous studies' findings on solid waste management service provision and impacts on communities and the environment including waste dumping.
- Identify and evaluate the current waste management services and assess their level of satisfaction, and determine household members' knowledge of the reduction, re-use, recycling, and landfilling of waste;
- Determine the communication methods between the municipalities and the communities;
- Assess municipal workers' level of satisfaction with waste management training opportunities and the issue of personal protective equipment and
- Recommend more effective waste management strategies in the study area.

The findings of the study will be offered as recommendations to the TMD for consideration when its Integrated Waste Management Plan (IWMP) and its Integrated Development Plan (IDP) are updated and/or revised. The results will also be used to educate residents on the importance of waste separation at source and the benefits of recycling. The results will also be disseminated to academics who work in the waste management field through publications and conference presentations, while it is also envisaged that the current study will inform future research endeavors.

3.3 Ethical considerations

Before conducting the study, the research proposal was submitted to the Health Sciences Research Committee (HSRC) of the University of the Free State for ethical approval. This committee issued an ethical clearance certificate, and the researcher could commence with the study. During the execution of the field work phase of the

study, respect for human dignity was paramount. Also, prior to publishing this article, it was scrutinised by peers and the research supervisors to ensure that it complied with university policies and publication standards.

The researcher ensured that the questionnaires were not completed before the respondents had signed an informed consent form. The participants were not required to disclose any confidential or personal information on the questionnaire and were informed that their participation would be voluntary (Maluleke, 2021). They were also informed that there were no right or wrong answers to the questions and that the responses and opinions they offered would be specific to their views and experiences. The participants were assured that, should any question cause them any discomfort, they did not have to answer it and that the interview would be terminated at any stage if they no longer wished to participate (Tahulela, 2017).

3.4 Description of the study area

The TMD is in the north-eastern part of the Free State Province and is one of four district municipalities in this region. It is bordered by all the other district municipalities of the province, namely Lejweleputswa District in the west, Fezile Dabi District in the north, Xhariep District in the south, and the Mangaung Metro in the southwest. Its borders are also shared by the Kingdom of Lesotho in the southeast, KwaZulu-Natal Province in the east, and Mpumalanga Province in the northeast. Topographically, this district is bordered in the east by the Maluti and Drakensberg mountains. The district is located between the Vaal River to the north and the Orange River to the south, and various rivers that run through this area converge with these larger rivers (Thabo Mofutsanyana Draft Integrated Development Plan, 2023).

3.4.1 Location

Thabo Mofutsanyana consists of six local municipalities: Setsoto to the southwest, Dihlabeng in the central area to the south, Nketoana in the middle section to the north, Maluti-a-Phofung in the south-eastern section, and Phumelela in the north-eastern section. The district includes a former homeland that was known as QwaQwa (Thabo Mofutsanyana Draft Integrated Development Plan, 2023).

Table 3.1: Summary of the local municipalities in the Thabo Mofutsanyana District

Mantsopa	Setsoto	Dihlabeng	Nketoana	Maluti-A-Phofung	Phumelela
Hobhouse Ladybrand Excelsior Thaba-Patchoa Tweespruit	Clocolan Ficksburg Marquard Senekal	Rosendal Paul-Roux Fouriesburg Clarens	Lindley Arlington Petrus Steyn Reitz	Kestel Harrismith Qwa-Qwa Tshiame	Vrede Warden Memel

3.4.2 Demographics

According to census results, the TMD has a population of about 736 238 and 197 018 households with an average household size of 3.4, while 77.3% of the residents live in formal dwellings (Thabo Mofutsanyana Draft Integrated Development Plan, 2023).

3.4.3 Weekly refuse removal

Only 49.2% (96 932.8) of the 197 018 households receive weekly waste service removal and there is a backlog of 50.8%, which translates to a backlog for 100 085.14 households. The TMD municipality is mandated to provide housing and to improve the quality of life of its residents by addressing infrastructure and basic services backlogs in affected settlements (Thabo Mofutsanyana Draft IDP, 2023).

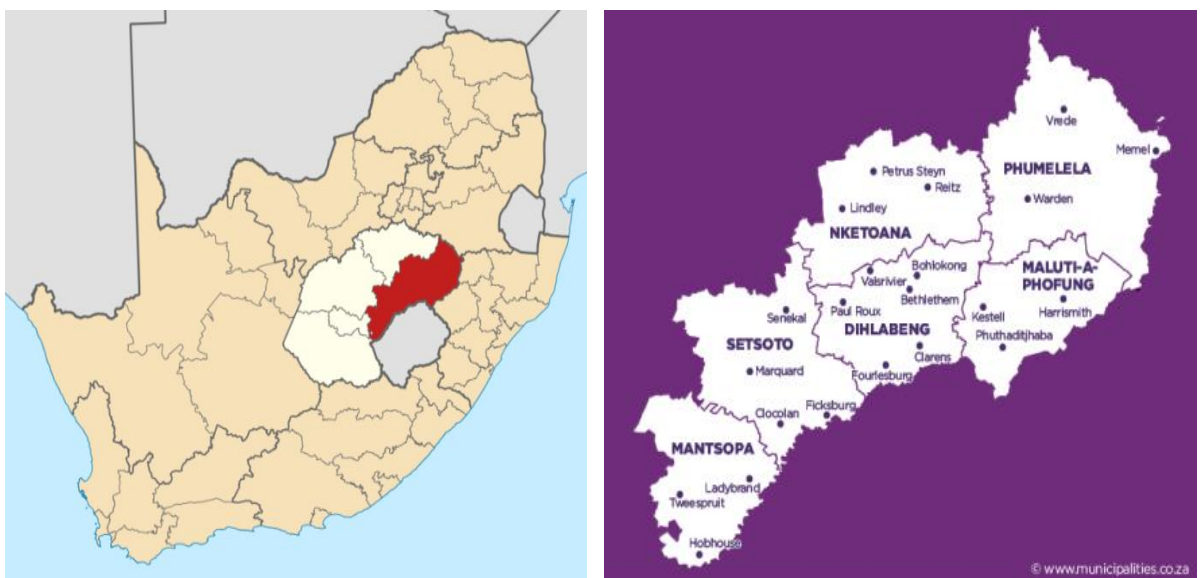


Figure 3.1: Adapted map of the Thabo Mofutsanyana District Municipality (TMD)

3.5 Research methodology

The study was conducted in the Thabo Mofutsanyana District Municipality in the eastern part of the Free State Province. This district consists of six local municipalities of which five were included in the study, as Nketoana Local Municipality was not involved. The standards of municipal solid waste management practices in the TMD were assessed by making use of questionnaires and observation checklists. The questionnaire that was administered to residents was presented in Sesotho and English, while the questionnaire that the municipal workers completed was presented only in English. Checklists to record the researcher's observations of the illegal dumpsites and landfills that were visited were also used.

3.5.1 Study design and data characteristics

The aim of the study was to evaluate current waste management practices in the various towns in the district and to determine the level of satisfaction of residents and municipal workers regarding the solid waste management services that were rendered in the respective municipalities. The involvement of the various communities that were visited in waste management practices and the extent of waste segregation at source were also assessed. The study purposively involved municipal personnel who worked in the waste management division to determine whether top management required and facilitated continuous professional development and provided workers with proper protective equipment.

A quantitative study design was employed to generate data that would address the study objectives. The questionnaires (one for residents and one for municipal workers) required both open- and closed-ended responses. An observation checklist was completed at every illegal dump site and landfill site. One checklist per local municipality was completed by the researcher and this aided in assessing the current conditions at the landfill sites that were visited.

Table 3.2: Distribution of total population, number of households, and average household size in each municipality

2011 Census				2016 Survey		
Municipality	Total Population	Households	Average household size	Total Population	Households	Average household size
Setsoto	112 597	33 687	3.3	117 632	37 388	3.1
Dihlabeng	128 704	38 593	3.3	140 044	46 857	3.0
Nketoana	60 324	17 318	3.5	64 893	19 664	3.3
Maluti-a-Phofung	335 784	100 228	3.4	353 452	110 725	3.2
Phumelela	47 772	12 888	3.7	50 054	14 586	3.4
Mantsopa	51 056	15 170	3.4	53 525	16 951	3.2
Thabo Mofutsanyane	736 238	217 884	3.4	779 600	246 171	3.2

Data source: Statistics South Africa, Census 2011 and Community Survey 2016 (Census 2011 and the 2016 survey aligned with 2011 municipal boundaries).

3.5.2 Data collection and research instruments

Data was collected using questionnaires and checklists. The questionnaires were presented to the respondents by the researcher (i.e., no assistants were recruited to assist in the collection of data in the local municipalities) and to the waste management directorate in the municipalities that agreed to be involved in the study. Township residents who were affected by illegal dumping sites and the mismanagement of waste disposal processes at landfill sites were also included as respondents in the study. It is reiterated that the residents' questionnaire was available in English and Sesotho while the questionnaire the employees completed was presented only in English. Data were collected in five towns (Bethlehem, Ficksburg, Ladybrand, Phuthaditjhaba, and Warden) which were representative of each local municipality.

3.5.3 Selection of participants

The researcher selected participants whose responses would ensure that the study findings would be valid as they would be knowledgeable of the research topic and would be able to provide the required information. The inclusion criteria were as follows:

- Respondents between the ages of 18 and 75 years.
- People residing in TMD.
- Residents who could or could not read.
- Residents living near an illegal dumpsite or landfill; and
- Municipal personnel (managers, drivers, and waste collectors/cleaners).

This was a quantitative study that utilised both primary and secondary data sources. The primary data was collected using field observations and questionnaires. Secondary data were collected from peer-reviewed publications and other un/published sources such as government gazettes, the Internet, waste management reports, library databases, and development plans, among others (Owojori, 2020).

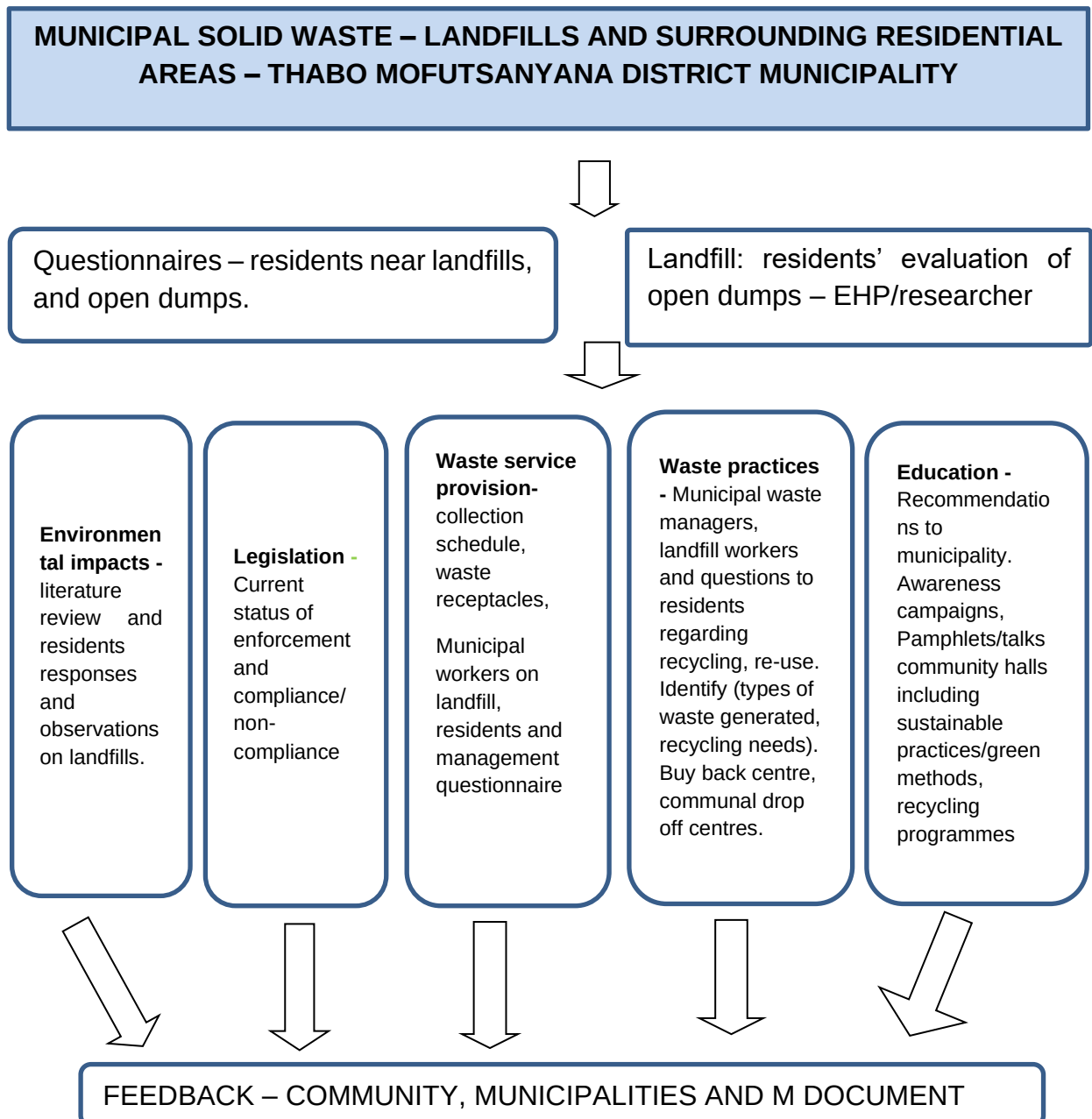


Figure 3.2: Content of questionnaires that evaluated the status of municipal solid waste services at landfills and surrounding residential areas in the TMD (Source: Researcher).

3.5.4 Questionnaires and observation checklists

The researcher developed two questionnaires (one for residents and one for waste management division employees) and observation checklists for data collection.

3.5.4.1 Validating the questionnaires by means of a pilot study

The two questionnaires were administered to respondents in a pilot study (five questionnaires were administered to residents and five were administered to municipal waste management employees). The pilot study was conducted in Ladybrand prior to the commencement of the main study. The purpose of this pilot study was to test the reliability of the questionnaires. The process allowed the participants to express their views on the efficacy of the questions, and their views and advice allowed the researcher to resolve any difficulties with the wording of the questions, their structure, and the time taken to complete the questionnaire, while it was also possible to identify any questions that might make respondents feel uncomfortable. The data collected from the pilot study were not included in the analysis.

3.5.4.2 Structured interview questions

Data was generated in the field work phase of the study using a questionnaire survey that was administered face-to-face during on-site visits to residents' houses. The body of primary data that was generated was supplemented with information obtained from the field observations, as proposed by (Douti, Abanyie, and Ampofo 2017).

During the house visits, the researcher explained the purpose of the survey. Some residents were not interested, but many really supported the study. The questionnaires were administered on a one-on-one basis and only one person per household was recruited to avoid skewing the data. The questionnaire had been developed in such a way that the respondents had to choose an option from those provided by marking their choice using a pen provided by the researcher. The respondents were randomly selected by walking from house to house and a total of 100 questionnaires were administered to residents.

To recruit municipal employees, the researcher sent an email to the District Waste Management Officer requesting permission to conduct the study in the TMD and access employees, and this request was granted. Communication was established with six waste management officers responsible for their respective local municipalities' waste management services. Only one municipality was not willing to participate in the study

but did not disclose any reasons. The other municipalities were very helpful and willing to participate in the study and appointments were made to meet the relevant managers. Each municipality allowed the researcher time to do a presentation on the nature and purpose of the study. After this had been done, 86 questionnaires were administered to personnel who were willing to participate in the study. The respondents were allowed to complete the questionnaires in the researcher's presence so that any queries could be addressed.

During the field observation phase, a total of 25 observation checklists were completed by obtaining the views of residents who were directly affected by illegal dumpsites. A checklist was also completed for each of the waste disposal sites of the five selected towns in the TMD.

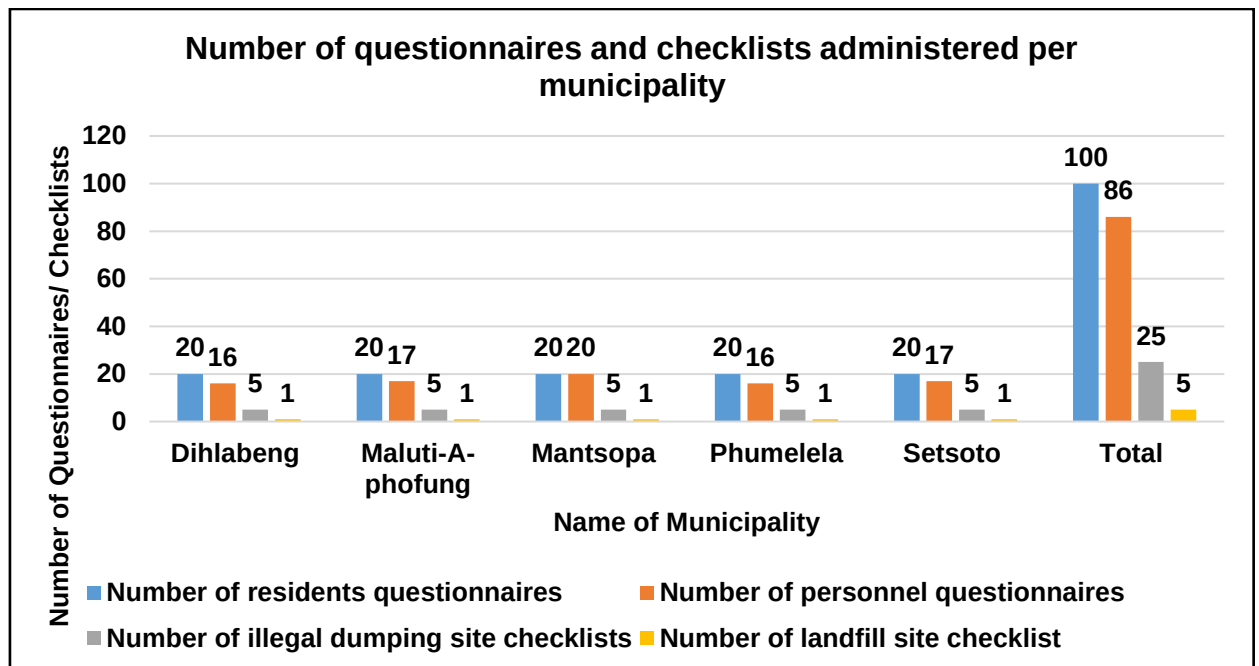


Figure 3.3: Number of respondents per local municipality who participated in the study

3.5.5 Questionnaire formulation and administration

The questionnaires (Annexure A for residents and Annexure B for municipal personnel) were used to collect data to address the following research objectives:

- Assess current municipal waste service delivery in the study area to determine what types of waste were generated per household and
- Evaluate the waste disposal practices of communities in each area.

Based on the generated data and the findings, the researcher further intended to:

- Develop and recommend an efficient waste management strategy that may be implemented in the study area and
- Evaluate the level of compliance with policies and legal frameworks that guide the management of municipal solid waste services.

3.5.6 Questionnaire breakdown

The data that emerged from the questionnaires were recorded and are presented and analysed in Chapter 4. The breakdown of questions was done according to the following categories:

3.5.6.1 Breakdown of the questionnaire administered to residents

Section A: Services and health-related issues: Q1 to Q3

Section B: Waste collection methods: Q4 to Q11

Section C: Waste management operations and campaigns: Q12 to Q15

3.5.6.2 Breakdown of the questionnaire administered to municipal personnel

Section A: Employee information: Q1 to Q2

Section B: Solid waste collection methods: Q3 to Q11

Section C: Employees and equipment: Q12 to Q14.

3.7 Checklists

The researcher conducted field visits and evaluated the conditions at both illegal dumpsites and landfill sites using observation checklists. Pictures were taken of the sites and are presented in this dissertation. Checklists were only used for dumping and landfill sites in the area which matched the selection criteria. The checklists were completed by the principal investigator and all checklists were completed at the selected sites.

3.5.7.1 Breakdown of observation checklists for dumping sites

Section A: Collection methods: Q1 to Q5

Section B: Nuisances and other environmental degradation factors: Q6

3.5.7.2 Breakdown of observation checklist for landfills

Section A: Sign posting and road access: Q1 to Q 2

Section B: Access control, collection of disposal tariffs and security: Q3

Section C: Landfill site resources and sanitary landfilling: Q4

Section D: Nuisances and other environmental degradation factors: Q5

3.6 Ethical considerations

Prior to data collection, the researcher made appointments with the Waste Management Officers in the District Waste Management Directorate and access was also granted by the Executive Mayor of the TMD to conduct the study in the area as requested. Prior to conducting the study, an appointment was made with the Executive Mayor of TMD who sanctioned the study.

Respecting language and culture were important as the TMD is rich in cultural diversity; hence, priority was given to the norms and standards that define the population. Patterns of human behaviour include language, communication, actions, customs, beliefs, values, race/ethnicity, religion, and age. Cultural awareness and respect facilitated rich results, and the findings may be deemed a true reflection of current waste management conditions in the study area. The researcher, who conducted the field work, is proficient in both English and the indigenous languages spoken by the participants and there was no language barrier.

3.7 Statistical analyses

The results were analysed by a biostatistician, Mrs Viljoen, using the SAS Version 9.2. Descriptive statistics, namely frequencies and percentages, were calculated for categorical data. Means and standard deviations or medians and percentiles were calculated for numerical data. To compare the responses of the residents with those provided by management and landfill workers and the observations made at dumpsites and landfills by the researcher, analytical statistics were used.

Likert-scale measurements were utilized as questions had been compiled to capture the perceptions and knowledge of residents and municipal officials regarding the waste management services provided in their respective areas.

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CHAPTER 4

RESULTS AND DISCUSSION

Abstract

Solid waste removal is one of many basic services rendered to communities that reside in municipalities across the country. Waste management services aim to protect human health and the environment and are necessary to conserve natural resources. This study aimed to assess waste management practices by selected municipalities in the TMD, with a particular focus on the negative impacts caused by illegal dumping sites and the poor and ineffective management of landfills.

The study adopted a quantitative approach, and the data were collected by means of questionnaires and observations to achieve the research objectives. Two questionnaires were developed, and the views of 100 residents and 86 municipal employees were elicited. Residents were randomly sampled in five local municipalities, namely in Dihlabeng (Bethlehem), Maluti-a-Phofung (Phuthaditjhaba), Mantsopa (Ladybrand), Phumelela (Warden), and Setsoto (Ficksburg). Nketoana LM is not included in the study, as no authorization could be obtained to include it in the study, but its exclusion did not affect the feasibility of the study as rich data were obtained from the five remaining municipalities. Descriptive statistics, namely frequencies and percentages, were calculated for categorical data. The responses of the residents and employees were analysed and evaluated and the observations that had been recorded at dumpsites and landfills were integrated with comparative data. Tables and graphs are used in this chapter to visually present the data.

The results indicated that the municipalities did not provide waste containers for residents' use; thus, the majority used plastic bags to store waste until collection, which was infrequent in most areas. The TMD Integrated Development Plan (2023) indicated that waste should be collected at least once a week in this district, and 69% of the residents indicated that waste was indeed collected once a week. However, it was found that there was also poor adherence to waste collection schedules in some areas. Most of the residents (85%) also indicated that the most common waste collection method

was kerbside collection. Residents admitted that they resorted to waste dumping due to poor adherence to waste collection schedules, and it was evident that those living near dumpsites and landfills were exposed to smoke and pungent smells emanating from these sites. These residents were therefore exposed to serious health hazards (Kanhai, Fobil, Nartey, Spadaro, and Mudu, 2021).

The municipal employees indicated that there was a lack of regular training to capacitate them in their field of work, but they did not indicate whether they had received adequate waste management training prior to employment in the waste management units where they worked. The municipalities also did not provide proper protective clothing and the employees felt that they were constantly exposed to health and safety risks.

The study concluded that only the Dihlabeng landfill was well managed, and adhered to more of the landfill requirements as it had sign posts that indicated the hours when the landfill would be accessible and what types of waste were accepted on-site. The other four landfill sites, when compared to Dihlabeng landfill, were in poor condition due to improper management. The waste streams entering these latter sites were not managed according to required procedures and were disposed of in an uncontrolled and inappropriate manner.

The municipalities under study should improve the waste collection services to reduce illegal dumping and waste burning. Residents should be empowered to actively participate in waste management decision-making and the municipalities should launch awareness campaigns to inform community households of the importance of waste separation at source. Moreover, municipalities in the TMD should consider allocating a larger budget to the Waste Management Directorate to remedy the current situation. This Directorate should oversee the improvement of solid waste management practices and the conditions at landfill sites so that these spaces can be restored to their former operational capacity in the interest of all residents and the environment.

Keywords: Waste removal, human health, natural resources, illegal dumping, landfill sites, awareness campaigns.

4.1 Introduction and background

Escalating urbanization in developing nations in Africa since the 1960s has increased waste production, which puts a strain on the availability of land in peri-urban areas where landfills might be established. The issue of poor landfilling capacity is exacerbated by the practice of rubbish disposal in open pits and on open spaces, particularly in slum areas in and around most African cities. Historically, some African governments allowed unregulated dumping in defunct quarry sites without converting them to hygienic landfills, and this resulted in severe health issues. In Ethiopian cities and towns, most solid waste disposal facilities are located near water sources, fault lines, agriculture fields, villages, and on the sides of roadways (Kebede and Ayenew, 2023). This inappropriate solid waste disposal tendency causes serious environmental contamination, health issues, surface and groundwater pollution, soil contamination, greenhouse gas emissions, environmental pollution and damage, damage to people and property, and a decline in tourism and business activities. As a result, many diseases such as cholera, diarrhea, and dysentery that are prevalent in some communities can be linked to inadequate environmental sanitation, tainted water, a lack of appropriate waste disposal sites, public latrines, and poor waste disposal management systems (Kebede and Ayenew, 2023).

In many developing countries, waste disposal sites are located in the vicinity of urban areas, and these mini dumpsites are a source of infection in both adults and children due to the incubation and reproduction of mosquitoes, flies, and rodents that cause gastrointestinal, dermatological, respiratory, genetic afflictions, and several other types of contagious infections. Moreover, residents who live near dumpsites complain of increasing incidences of stomach and cervical/uterine cancer in women as well as stomach, liver, lung, and prostate cancer in men. It is therefore argued that open dumping of MSW causes severe negative impacts on all aspects of the environment and human health (Akmal and Jamil, 2021; Meena, Dotaniya, Meena, Rai, Antil, Meena, Dotaniya, Meena, Ghosh, Meena, Singh, Meena, Moharana, Meena, Srinivasarao, Meena, Chatterjee, Meena, Prajapat, and Meena, 2023). The continuous indiscriminate disposal of MSW is linked to unscientific waste disposal practices, increasing rates of urbanization, growing population rates, poor ethics, and a lack of ecological responsiveness (Meena *et al.*, 2023). (Shammi, Hassan, Golder, Molla, and Islam, 2023) argued that improper waste disposal near residential areas contributes to severe health issues as individuals residing within a 100 m radius of dumpsites are more susceptible

to malaria, dengue, and asthma than those living at some distance (exceeding 500 m) from these sites.

A global issue that most municipalities must confront is the acute generation of municipal solid waste (MSW). Such waste is all material that the original generator does not want to keep any longer, but it excludes hazardous material, liquid waste, and atmospheric emissions. The increasing volume of MSW that is generated worldwide, that is inappropriately disposed of poses a dire threat to public health and the environment. The inappropriate disposal of MSW occurs mostly when waste remains uncollected due to low service coverage in some cities and most rural areas in developing countries (Ayeleru, Fewster-Young, Gbashi, Akintola, Ramatsa, and Olubambi, 2023). Appropriate solid waste management (SWM) should be conducted according to a series of interdependent stages that include limited waste generation, collection and segregation, storage, transfer and transit for appropriate treatment and processing, and final disposal. Growing population numbers and increasing urbanization have made WM procedures, particularly the collection system, increasingly challenging to manage because of escalating waste volumes (Mousavi, Hosseinzadeh, and Golzary, 2023). Most studies in this field seem to conclude that the sustainable management of solid waste (SW) requires a holistic approach that involves a broad range of stakeholders, and the active involvement of residents in the waste management hierarchy is a key factor in successful waste management (Salem, Raab, and Wagner, 2020).

Waste management challenges in developing countries such as Ghana can be briefly summarized as the following: an ever-growing urban population, lack of finances to develop improved infrastructure, inappropriate technologies to handle waste, and a flawed management system. The main reasons for limited investment in waste infrastructure include the following: uncertainty leading to poor planning, limited enforcement of national policies and by-laws, and poor co-ordination and implementation of waste management programs (Korley and Fianko, 2017).

Many previous studies that were conducted in both developed and developing countries explored households' behaviour regarding waste management, particularly regarding

waste disposal and recycling. Most of these studies conclude that education, gender, and age have a significant impact on the choice of waste disposal options. Moreover, socio-economic and demographic characteristics such as income, gender, and education significantly influence households' recycling behaviour. Socio-psychological factors such as social and personal norms as well as individual attitudes also affect recycling behaviour (Kumara and Pallegedara, 2020).

While local governments collect waste from households in urban areas, more than 50% of household waste is still managed by the households where it is generated. Households thus use various waste disposal systems such as openly dumping it in backyards or in the street, burning it, dumping it in public spaces, or processing it for composting (Kumara and Pallegedara, 2020). Therefore, Chu, Wang, Zhou and Huang (2019) argue that households are primary MSW generators and should thus bear the responsibility for the pollution waste causes and should be charged for its disposal. However, the conditions under which households make their waste-related choices are far from perfect in many areas, such as in Yaoundé, Cameroon (Sotamenou, de Jaeger, and Rousseau, 2019). In such areas formal recycling is often not available, financial incentives to reduce waste generation are non-existent, door-to-door collection is only available for a fraction of the population, and the availability of centralized drop-off containers is insufficient (Sotamenou, de Jaeger, and Rousseau, 2019). These challenges cause residents to illegally dump their waste in public areas as they see no other alternative. Although the use of these illicit disposal alternatives is prohibited by law, enforcement is generally weak and residents who engage in illegal disposal options are therefore seldom penalized (Sotamenou, de Jaeger, and Rousseau, 2019).

Hazardous household waste is also generated, and such waste is then disposed of on landfills along with general household waste. The impact of indiscriminate and unregulated disposal of such waste is unfortunately poorly understood, particularly as it is argued that the volume of such waste is limited and that the risks of its disposal are therefore negligible. However, this is far from the truth as MSW such as some batteries, paint, mercury-containing waste, pharmaceuticals, vehicle maintenance products, and other chemical substances that are inappropriately dumped pose serious hazards to human health and environmental sustainability (Abdel-Shafy and Mansour, 2018).

Although MSW disposal is the least desirable of all waste management strategies, it is inevitable due to the high volumes of waste that cannot be reused or recycled. Hence, waste disposal sites form an essential part of the waste management plan of any municipality in developed and developing countries (Aryampa, Maheshwari, Sabiiti, Bateganya, and Olobo, 2020). However, many landfills in African countries are open dumps that are operated without leachate or gas recovery systems, and most of these landfills are not properly lined at the bottom to prevent leachate and groundwater pollution. In South Africa alone, 247 of these unlicensed municipal sites are operated for extended periods of time outside their environmental permit conditions (Pholose, 2019).

4.2 Residents' perceptions and experiences of SWM

The first step towards establishing a proper municipal solid waste management (MSWM) process is to limit the generation of waste (Jerin, Sara, Radia, Hema, Hasan, Urme, Audia, Hasan, and Quayyum, 2022). According to the Constitution of the Republic of South Africa (1996), municipalities are responsible for the collection, transportation, and disposal of waste. The management of MSW is one of municipalities' largest budgetary items as solid waste collection and transportation are usually the most expensive components of a municipal management system. The entire process of SWM relies on the collection, transportation, recovery, and disposal in the best applicable or suitable manner to ensure that public health, socio-economic conditions, aesthetics, and environmental sustainability are not jeopardized (Maluleke, 2021; Etenegeng, 2012). The main sources of waste in Africa are households, various markets and institutions, streets, public areas, commercial areas, and industries. However, there is often indiscriminate waste disposal without concern for human health impacts or environmental degradation, hence MSW constitutes one of the most crucial public health and environmental problems in African urban environments (Okot-Okumu and Nyenje, 2011). Improved SWM should receive global attention because increasing waste generation does not correspond with collection rates and frequencies, particularly in developing countries. Already high waste generation is increasing, yet approximately 50% of urban waste remains uncollected in developing countries due to urban planning challenges (Muheirwe, Kombe, and Kihila, 2022). Lack of funds to finance high costs associated with improving SWM infrastructure and the lack of recycling and reuse of waste by residents are major causes of insufficient recycling of solid waste. Even though a large percentage of the MSW budget is devoted to waste management, in some

municipalities it is still characterized by poorly designed waste collection and ineffective disposal systems and these challenges result in air, water, and soil pollution (Kayamo, 2021). Efficient MSW service provision is key in diminishing the environmental impact of human activities on the environment. This requires responsible treatment and disposal of all generated waste and the recovery of reusable resources from waste (Rossit and Nesmachnow, 2022).

The presentation of the data and discussion of the results now follow. The data collection methodology was discussed in the previous chapter and the rest of this chapter will focus on the presentation, interpretation, and evaluation of the results. Of a total sample of 186 respondents, 100 residents ($n = 100$) and 86 municipal personnel ($n = 86$) were involved in the study. The data were collected from the two sample sets in five selected towns in the study area. A total of 20 residents were recruited per town so that each of the five towns was equally represented in the study.

The results are discussed under various subsections according to the various aspects of waste management explored by the questions in the questionnaires. The results were obtained from the views of municipal waste management representatives and residents, and the information that had been collected by means of checklists at landfills and illegal dumping sites are integrated with these findings.

4.2.1 Waste receptacles and the storage of waste at household level

Solid waste is comprised of the remnants (leftovers) of household activities and consumption that the holder intends to discard. The mismanagement of such waste is continuously emerging as a rising malpractice in most developing countries, especially in and around fast-growing cities. As waste generation in significant volumes is unavoidable, SWM has become a growing environmental issue globally, but it is especially challenging in developing countries (Tsheleza, Ndhleve, Kabit and Nakin, 2022). In the MSW logistic chain, waste is generated by households, commercial businesses, and various institutions. Various storage systems at point of generation have unique characteristics. The most common of these systems is the self-delivery system where waste generators carry their waste to disposal sites or transfer stations. In South Africa, this system is usually implemented for specific kinds of waste such as

hazardous waste, bulky waste, and yard waste that is produced at household level. Community bins are also used for this purpose, but waste drop-off facilities are usually large, and some provide additional services other than being a mere storage point in the supply chain, such as compaction and separation, or even final disposal (Rossit and Nesmachnow, 2022).

The current study posed questions to determine the provision and use of waste receptacles in the study area (Figure 4.1).

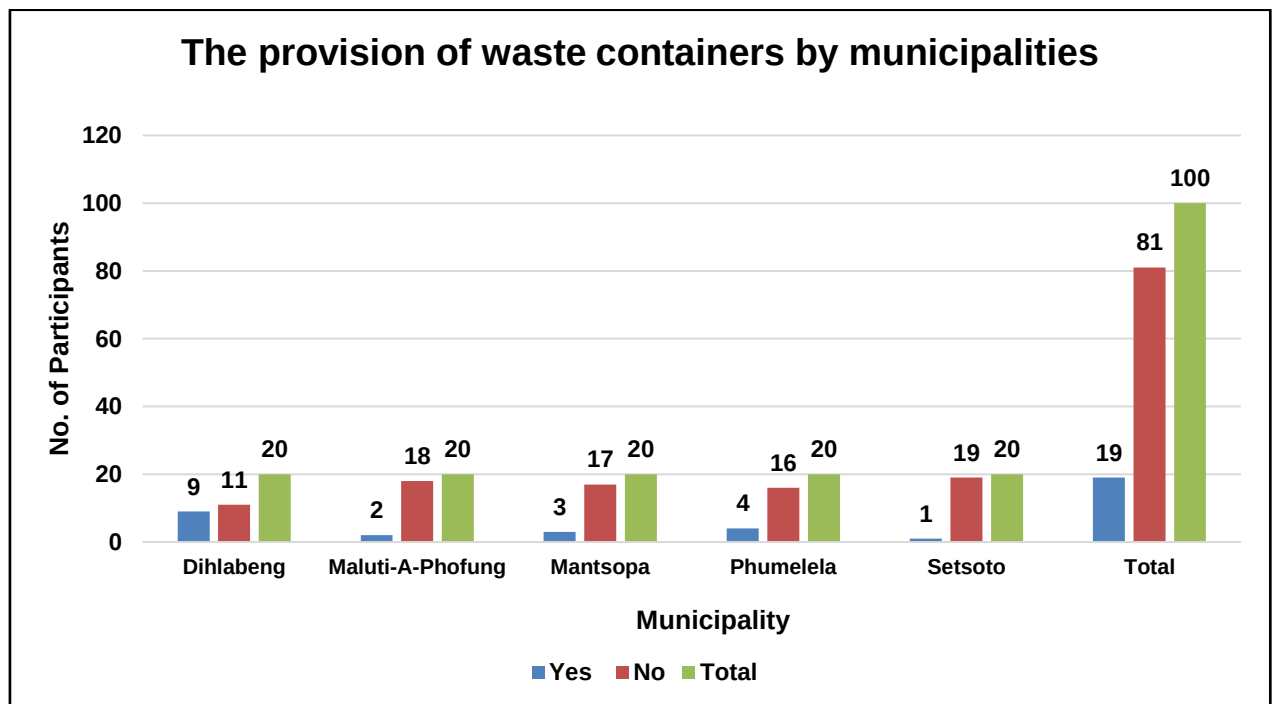


Figure 4.1: Waste containers provided to residents by municipalities

The results indicated a significant difference between people that were provided with containers compared to those that were not. In Dihlabeng, most residents were provided with containers/receptacles, while the other four local municipalities fell well behind with this service as limited provision of waste containers was evident. Overall, the provision of waste containers for use by residents was not satisfactory because 81 of the 100 households indicated that they did not receive any waste receptacle at all. Conversely, the literature reveals that waste storage containers are widely provided by local authorities in developing countries, for instance in Libya and Benghazi city where the community use public bins or metallic containers that are placed near major roads and near houses for temporary waste storage until collection. In India, the bins used for waste

storage at household level are for both decomposable and non-decomposable waste; these containers are classified as movable and fixed bins (Khodani, 2019).

Table 4.1: Types of waste storage containers used

Name of Municipality	Plastic n (%)	Bins n (%)	Other n (%)	Total n (%)
Dihlabeng	11 (55)	9 (45)	0 (0)	20
Maluti-A-Phofung	15 (75)	4 (20)	1 (0)	20
Mantsopa	10 (50)	10 (50)	0 (0)	20
Phumelela	8 (40)	12 (60)	0 (0)	20
Setsotho	13 (65)	7 (35)	0 (0)	20
Total: (n = 100)	57 (57%)	42 (42%)	1 (1%)	100

Table 4.1 indicates no significant difference between the waste container types used by residents in the study area. In Maluti-A-Phofung, only four residents indicated that they used a bin, and one resident used another type of container which was not specified. A total of 57 residents indicated that they used plastic bags to store their waste, which is deemed problematic as animals such as dogs tear these bags easily and scatter waste across a large area. This waste is quite unsightly and is often not picked up by waste collectors (Poswa, 2001).

In Addis Ababa in the central part of Ethiopia, waste is not stored in standardized bins. Instead, households use different types of storage containers such as baskets, cardboard boxes, containers made of bamboo, cans, plastic bags, and barrels. In Tha Khon Yan in the Maha Sarakham Province in northeast Thailand, waste storage bins are provided by private businesses in residential areas, while in Freetown, Sierra Leone, the residents use lid-less containers such as old buckets, plastic containers, baskets, dustbins, and polythene bags for solid waste storage. No litter bins are provided. In Pretoria and most other cities and towns in South Africa, most households use black refuse or plastic shopping bags while others store their waste in bins placed outside their gates for collection by municipal workers (Khodani, 2019).

One challenge is that the food and garden waste that are mixed with ordinary household solid waste in bins/bags is organic waste and decomposes very quickly, especially during the summer season when temperatures are high. This decomposing or decomposed food lures vermin, particularly flies, to the stored waste. Moreover, an offensive odor is likely to result, and this unpleasantness is exacerbated by a poor waste collection frequency.

4.2.2 Waste collection practices in the local municipalities in the TMD

Waste collection, transportation, and disposal are functions of the municipality but are sometimes extended to waste contractors that are appointed by the private sector and municipalities due to increasing waste volumes and a lack of municipal waste collection capacity. Municipalities face major challenges with regards to waste capacity, planning, administration, segregation at source, collection, and illegal dumping. The receptacles that are used for waste collection are usually wheeled bins, waste skips, compactors, trucks, and dumpsters. However, the mechanical breakdown of compactors and trucks, industrial and municipal strikes, and service delivery protests are some of the reasons why municipalities struggle to render sustainable waste collection services. Moreover, waste collection efficiency is also determined by manpower availability and transport capacity (Pholose, 2019), particularly in cities where waste collection faces a variety of safety, environmental, and economic challenges. One challenge is maneuvering collection vehicles in crowded streets which sometimes leads to accidents, and this should therefore be avoided if possible. In addition, certain roads may be approached only during certain time windows during rush hours. Waste collection vehicles are large and increase the already high volume of traffic, resulting in air pollution due to exhaust emissions in cities (Gläser, 2022). If there is only little space available for the collection of waste in densely built-up areas, the receptacles must be emptied at a correspondingly higher frequency, which increases traffic congestion, gaseous emissions, and waste collection costs (Gläser, 2022). For instance, the waste collection rate in Kisumu City, Kenya, is estimated to range from as low as 20 to 35%. In the CBD and the Dunga Beach area, a three-bin system is in place as the first point of waste collection and separation. These bins are labelled and color-coded to facilitate separation of waste at source. Organic waste is disposed of in green bins, while plastics and other litter bins are blue and brown respectively. In other locations, yellow bins are used to separate glassware and bottles, with white bins for paper. However, it was observed by other studies that

the culture of waste separation was not engrained in the public in this country (Sibanda, Obange, and Awuor, 2017).

In practice, there are different approaches to MSW collection. Two main approaches can be distinguished: (i) a pickup system, also called door-to-door collection or kerbside collection, where households dispose of their waste in bins placed on streets right next to their houses in accordance with a waste collection calendar. The second approach is a bring or drop-off system, where waste is accumulated at central collection sites with a large capacity and households have to only cover a short distance to dispose of their waste at these central locations. Both systems offer advantages and disadvantages. In the former, residents do not have to go any extra distance to dispose of their waste and there is no need for opening costly central collection sites. In the bring or drop-off system, the distance to be covered is reduced by various collection points and the waste collection vehicles no longer have to access every street or stop at every house leaving the engine running. Thus, common collection points and some distances to and from these waste collection areas decrease waste collection costs (Gläser, 2022; Leeabai, Areeprasert, Khaobang, Viriyapanitchakij, Bussa, Dilinazi, and Takahashi 2021).

4.2.2.1 Waste containers

The image in Figure 4.2 shows how residents placed their waste on the kerbside for collection.



Figure 4.2: Types of waste containers indicate how residents place their waste
(© Lepheana: 12/09/2023).

The respondents used bins provided by the municipality and plastic bags for containerisation. There was no spilled waste around these containers, and they were appropriately placed to avoid any nuisance.

Table 4.2: Collection waste services before 1990 to 2015

Name of municipality	Before 1990 n (%)	1991-2000 n (%)	2001-2010 n (%)	2011-2015 n (%)	Don't know n (%)	Total (n)
Dihlabeng	1 (5)	8 (40)	2 (10)	3 (15)	6 (30)	20
Maluti-A-Phofung	1(5)	0 (0)	3 (15)	5 (25)	11(55)	20
Mantsopa	3 (15)	7 (35)	4 (20)	0 (0)	6(30)	20
Phumelela	6 (30)	6 (30)	3 (15)	3 (15)	2 (10)	20
Setsoto	0 (0)	13 (65)	2 (10)	1(5)	4 (20)	20
Total (n = 100)	11 (11%)	34 (34%)	14 (%)	12 (%)	29 (29%)	100

Table 4.2. indicates that 11 residents had a waste collection service before 1990, while 34 residents indicated that they started receiving this service between 1991 and 2000. Unfortunately, 29 residents did not know when they started receiving a waste collection service. Dating from 1996, Table 4.3 indicates the waste collection service for the local municipalities under study. Note that Nketoana is included to provide data for the entire TMD area.

Table: 4.3: Distribution of households by type of refuse removal and municipality

Refuse removal and census	DC 19: Thabo Mofutsanyana	FS 191: Setsoto	FS 192: Dihlabeng	FS 193: Nketoana	FS 194: Maluti a Phofung	FS 195: Phumelela	FS 196: Mantsopa
1996							
Removed by local authority at least once a week	62 454	12 178	16 282	7 468	16 078	5 122	5 327
Removed by local authority (less often)	7 891	1 588	1 253	354	4 346	152	843
Communal refuse dump	8 536	4 631	1 005	345	473	57	1 380
Own refuse dump	75 975	5 900	5 758	5 023	52 802	3 097	3 395
No waste disposal	11 784	1 586	836	1 341	6 368	1 249	406
Other	52	2	11	-	25	2	12
Total	166 694	25 886	25 145	14 531	80 092	9 679	11 362

2001							
Removed by local authority at least once a week	83 221	17 039	20 812	9 483	20 112	7 275	8 499
Removed by local authority (less often)	6 317	3 920	611	239	551	178	818
Communal refuse dump	5 696	634	574	369	3 829	30	259
Own refuse dump	75 231	7 756	7 182	3 261	51 045	3 274	2 712
No waste disposal	26 554	3 395	3 936	1 552	14 812	1 374	1 484
Other	-	-	-	-	-	-	-
Total	197 018	32 746	33 116	14 904	90 349	12 131	13 772

2011							
Removed by local authority at least once a week	107 125	18 534	30 963	12 506	24 873	8 390	11 860
Removed by local authority (less often)	2 042	841	395	262	424	58	61
Communal refuse dump	8 245	808	1 031	545	4 591	586	683
Own refuse dump	86 680	10 961	4 965	3 225	6 1972	3 334	2 223
No waste disposal	12 254	2 323	1 088	682	7 414	460	286
Other	1 539	220	152	97	953	60	57
Total	217 884	33 687	38 593	17 318	100 228	12 888	15 170

CS 2016							
Removed by local authority at least once a week	120 155	21705	38 611	16 068	23 361	8 891	11 520
Removed by local authority (less often)	4 208	995	545	359	1 159	1016	133
Communal refuse dump	13 832	2 191	2 659	588	5 960	135	2 297
Own refuse dump	86 991	10 159	4 254	2 039	65 648	2 594	2 297
No waste disposal	17 327	1 792	656	355	12 181	1 734	609
Other	3 657	545	131	254	2 415	216	96
Total	246 171	37 388	46 857	19 664	110 725	14 586	16 951

Data source: Statistics South Africa, Census 1996, 2001 and 2011

Census 2011 and CS 2016 are aligned with 2011 municipal boundaries. Table 4.3 indicates the distribution of the type of refuse removal being utilised per household in the TMD for all census surveys and CS 2016. In 2011, 86 680 households used their own refuse dumps, and this figure increased to 86 991 in 2016, whereas households without any rubbish disposal dumps increased from 12 254 in 2011 to 17 327 in 2016. Households whose refuse was removed by the local authority increased in all the

municipalities. However, a significant number of households still used their own refuse dumps at the time this study was conducted.

4.2.2.2 Payment for refuse removal costs

Figure 4.3 indicates that the minority (35%) of the respondents pay for refuse removal.

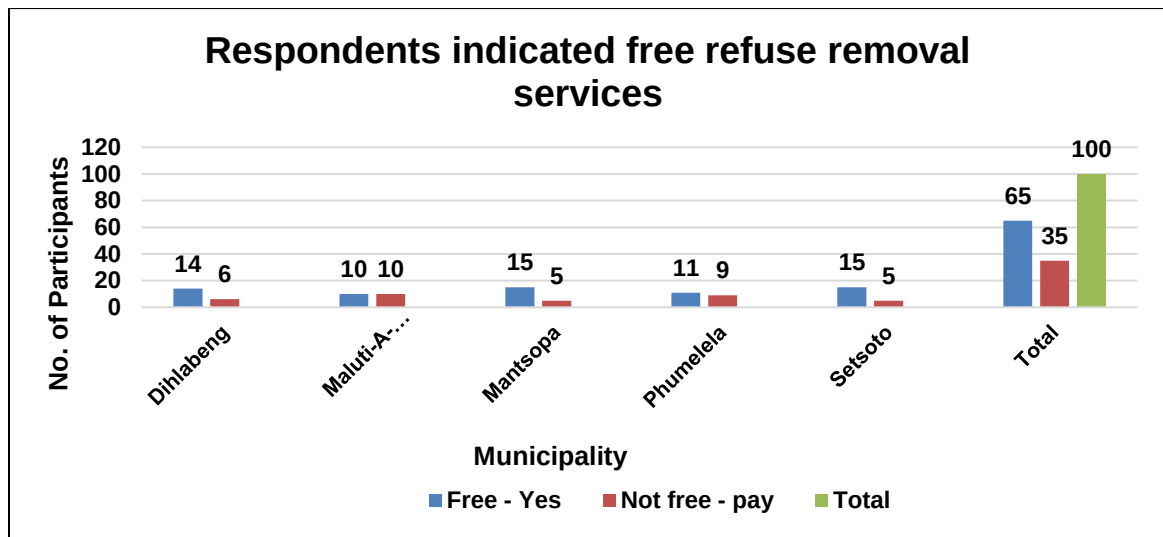


Figure 4.3: Cost of solid waste collection service in the study area

Most communities in the study area do not pay for a waste collection service as 65 respondents indicated that their waste collection service (WCS) was free while 35 indicated that they paid for waste collection (WC).

In most major urban settlements in Botswana (Gaborone) and for example towns Selibe, Phikwe, Jwaneng, Maun, and Lobatse, households' contribution to solid waste collection through user fee payments is still unknown, which suggests that the waste collection service in this country is solely dependent on financial support by the government (Bolaane and Isaac, 2015). Phonchi-Tshekiso, Mmopelwa, and Chanda (2020) argue that the lack of information on the frequency and cost of solid waste collection in this region suggests a potential lack of commitment by household waste generators to manage waste sustainably and to care for the environment as they are not paying for waste collection and might be unaware of the impact of solid waste on the environment.

4.2.3 Waste collection methods

Various types of waste collection methods are discussed in the study, including the preferred waste collection strategies, collection frequency, scheduling and separation at source.

4.2.3.1 Preferred waste collection methods

Figure 4.4 depicts that the majority (85%) of the residents indicated that kerbside collection was the most prevalent, while five residents indicated that communal collection was the method used by the municipality. Ten residents did not know which method of WC was used in their areas. In the house-to-house or kerbside collection method, waste collectors stop at each waste generator to pick up waste. Storage of waste is necessary inside the generators' premises until it is picked up. This storage period should be of short duration as households do not usually have a large storage capacity (Rossit and Nesmachnow, 2022).

When community bins are used, waste generators take their waste to conveniently placed community bins at waste garbage accumulation points (GAPs). These GAPs are usually located in accessible spaces that are not very far from the generators. The waste is then stored there until it is picked up by collectors according to a certain schedule (Rossit and Nesmachnow, 2022).

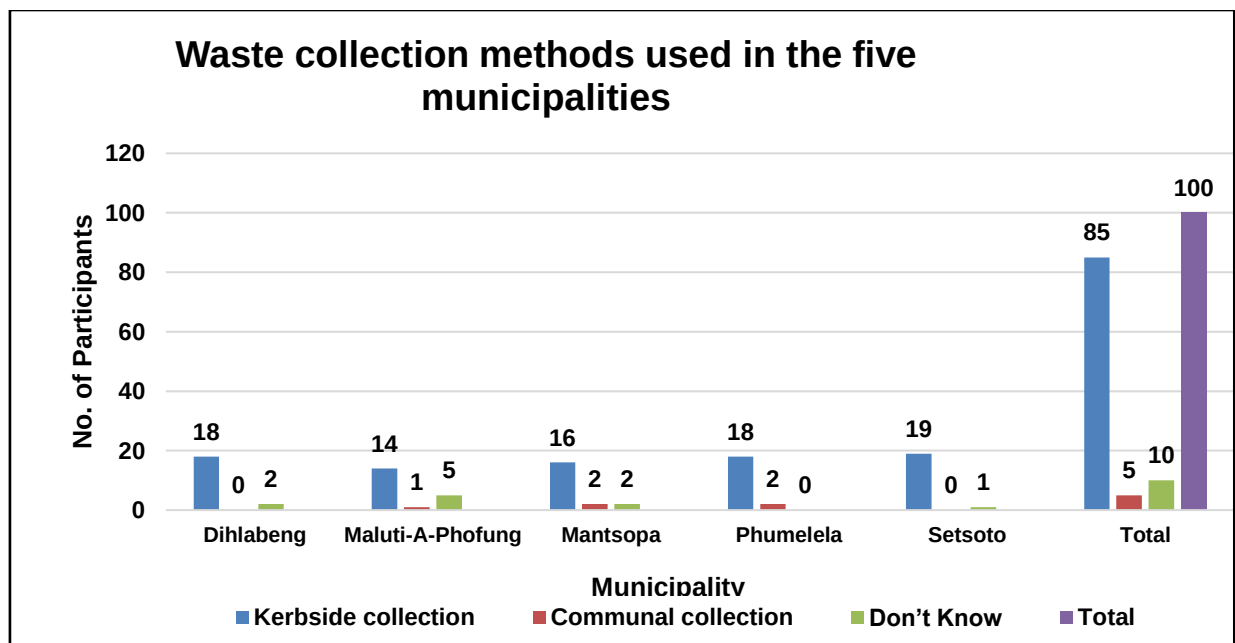


Figure 4.4: Waste collection methods used by local municipalities

4.2.3.2 Waste collection frequency and specific days of collection

Waste collection (WC) in the Thabo Mofutsanyana District was clearly not regular and adherence to a WC schedule was not deemed satisfactory. WC is supposed to occur at least once a week but, according to the responses, only 69% of the residents in the five local municipalities reported that their waste was collected at least once a week, whereas 39% of the respondents indicated that collection was either irregular or they did not receive WC services at all. The findings of the study indicated that usually WC should occur at least once in a five-day working period depending on the location.

The current study revealed that waste removal occurs once a week in most settlements in the municipalities under study. The waste was reportedly collected by municipal trucks and taken to landfill sites where some waste items were recovered by waste pickers who channeled it for recycling, as was observed by the researcher.

Table 4.4: Frequency of waste collection

Name of municipality	Once a week	Once in two weeks	Once a month	Other
	n (%)	n (%)	n (%)	n (%)
Dihlabeng	15 (75)	1 (5)	3 (15)	1 (5)
Maluti-A-Phofung	10 (50)	1 (5)	3 (15)	6 (30)
Mantsopa	20 (100)	0 (0)	0 (0)	0 (0)
Phumelela	10 (50)	5 (20)	4 (20)	1 (5)
Setsoto	14 (70)	2 (10)	1 (5)	3 (15)
Total (n = 100)	69 (69%)	9 (9%)	11 (11%)	11 (11%)

The waste was collected by municipal workers and placed in compression trucks or on the beds of collection trucks that transported their loads to landfill sites. The observations that the researcher made to corroborate this finding are affirmed by the images that are presented later in this dissertation. Waste separation/segregation at source was not observed or reported, and this observation is corroborated by (Tsheleza *et al.*, 2022) who argue that waste separation at source is not a common practice in South African households.

Table 4.5: Collection frequencies on the days of the week

Name of municipality	Monday	Tuesday	Wednesday	Thursday	Friday	Don't know
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Dihlabeng	3 (15)	3 (15)	1 (5)	3 (15)	6 (30)	4 (20)
Maluti-A-Phofung	1 (5)	2 (10)	3 (15)	1 (5)	5 (25)	8 (40)
Mantsopa	0 (0)	1 (5)	8 (40)	9 (45)	1 (5)	1 (5)
Phumelela	0 (0)	3 (15)	2 (10)	7 (35)	6 (30)	2 (10)
Setsoto	2 (10)	2 (10)	2 (10)	5 (25)	3 (15)	6(30)
Total (n = 100)	6 (6%)	11 (%)	16 (%)	25 (%)	21 (21%)	21 (%)

Percentage (%) of frequency is presented in brackets

Residents affirmed that waste was collected on the five working days of the week. Most of the waste was collected on Thursdays (25%) and Fridays (21%). However, 21% of the residents indicated that they did not know when the municipality collected waste, probably due to poor and erratic adherence to collection schedules (Table 4.5).

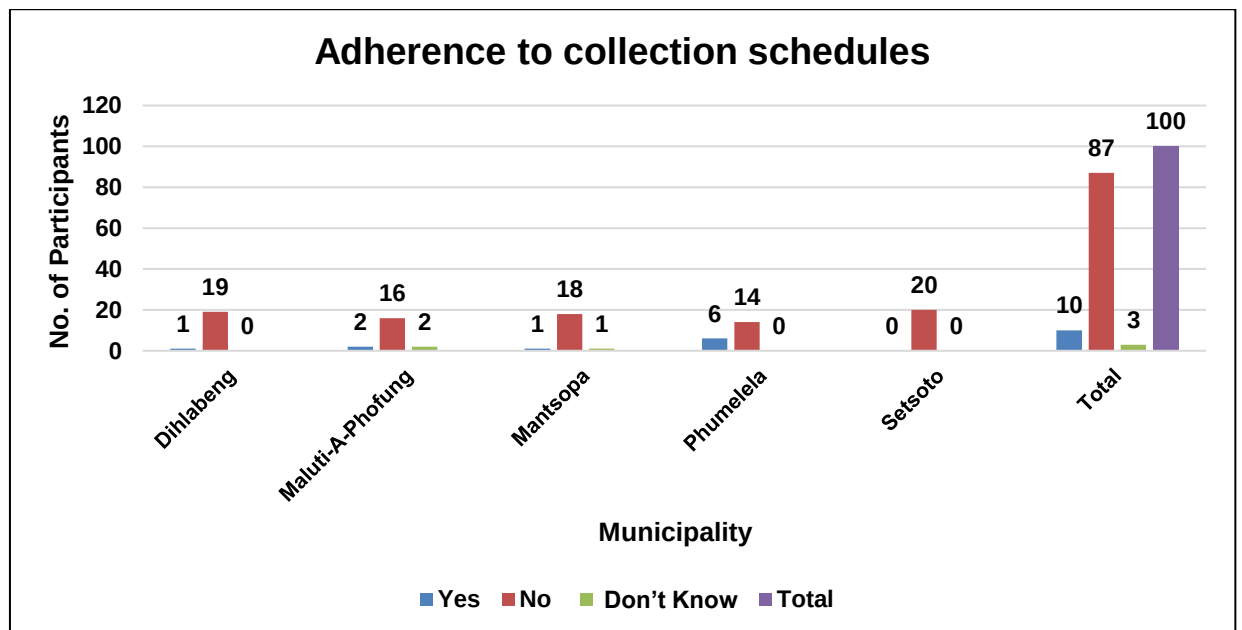


Figure 4.5: Daily collection of waste by the different municipalities

Adherence to the proposed WC schedules seemed a major problem as many, 87(%), of the respondents reported that they did not receive this service as regularly as scheduled. Phumelela was the only local municipality where some residents expressed satisfaction with the waste collection service they received, yet this rate was low at only 30% (6 of

20 respondents were satisfied). It may be argued that the municipalities did not meet their obligation in terms of the solid waste collection service they are mandated to provide. It is therefore not surprising that many residents had no option but to dispose of their household waste illegally. During informal discussions with the respondents after administering the questionnaire, the researcher noted the comments by various residents that there was usually no communication by the municipalities to inform residents that this service would be suspended for a certain time. It is important that municipalities sustain their waste collection schedules to reduce the number of illegal dumping sites and to ensure the health of residents and the aesthetics of the environment.

The clear inefficiency of the municipalities to ensure regular SW collection means that this service was disrupted in some areas, resulting in unsightly open dumps and the burning of waste. These practices were prevalent at an alarming rate as observed by the researcher. This finding corroborates (Sibanda, Obange, and Awuor, 2017) comment that waste collection rates in developing countries range between 30 to 50%, resulting in waste being disposed of on uncontrolled landfills and dumpsites.

4.2.3.2 Sorting of waste by residents at point of generation

The increasing generation of household solid waste increases the cost of municipal waste management and has led to a proliferation of environmental hazards, for example, environmental degradation, water and soil pollution, and negative impacts on the quality of human life. Waste management professionals in developing countries deal with continuous growth of slums, the lack of infrastructure, inadequate budget, corruption, ineffective education and community disbelief towards the government and this has negatively affected the solid waste management directorate and the cost of waste management (Lou, Wang, Cheng, Huili, and Niu, 2020; Azevedo, Scavarda, Caiado, and Fuss, 2021). Waste separation at source is a critical component of a successful waste management system. Besides this, it is also one of the most effective and economic ways to ensure the reuse and recycling rates of waste and to improve the quality of the waste that is finally disposed of on landfills. (Lou *et al.*, 2020) argue that the effective implementation of a waste separation policy will depend on a change in residents' waste disposal behaviour.

However, earlier studies have shown that municipalities do not have the equipment and programs in place to encourage waste separation at source (Khodani, 2019). For example, municipalities do not have recyclable receptacles to encourage separation at source and this unavailability of household waste receptacles encourage communities to mix recyclable materials with non-recyclable materials when they discard household waste (Khodani, 2019). Waste separation at source at household level should be mandated by providing households with two different colored bags for biodegradable and non-biodegradable waste respectively (Makhale, 2016). Households can play a significant role in minimizing waste and increasing the volume of recyclables by separating waste at source and changing their purchasing and consumption behaviour (Mathivha, 2023). However, a pilot project on separation at source was launched by Mantsopa local municipality in 2018. Comparatively, eight of the 31 municipalities in the Eastern Cape Province recently launched such programs (DEAT, 2018). These areas include Umzimvubu, Great Kei, Amahlabathi, Ngqushwa, Raymond Mhlaba, Blu Crane Route, Makana, and Ndlambe. In Gauteng, the City of Tshwane is the only municipality that has implemented a mainstream source separation program, and thus the program currently involves 40 000 households. However, Johannesburg City recently implemented mandatory source separation in selected suburbs (DEAT, 2018). The eThekweni Municipality launched the 'Orange Bag Recycling Project' to collect source separated mainline recyclables from approximately 800 000 households on a weekly basis. However, this program has collapsed as orange bags are no longer provided in the targeted suburbs, such as Amanzimtoti on the South Coast (Orange bag recycling program on the brink of collapse, 2023). In the Western Cape, separation at source programs have been implemented to varying degrees of success in twelve local municipalities (South Africa, 2018).

A total of 78% of the residents indicated that they did not separate their waste at household level. It was evident that waste separation and recycling were rarely practiced in the TMD and that residents were unaware of the benefits of waste separation at source for themselves and the environment (Figure 4.6).

Waste being separated at source is the most efficient method for salvaging high-quality materials for reuse or preparation for reuse (Esposti, Magrini, and Bonoli, 2023).

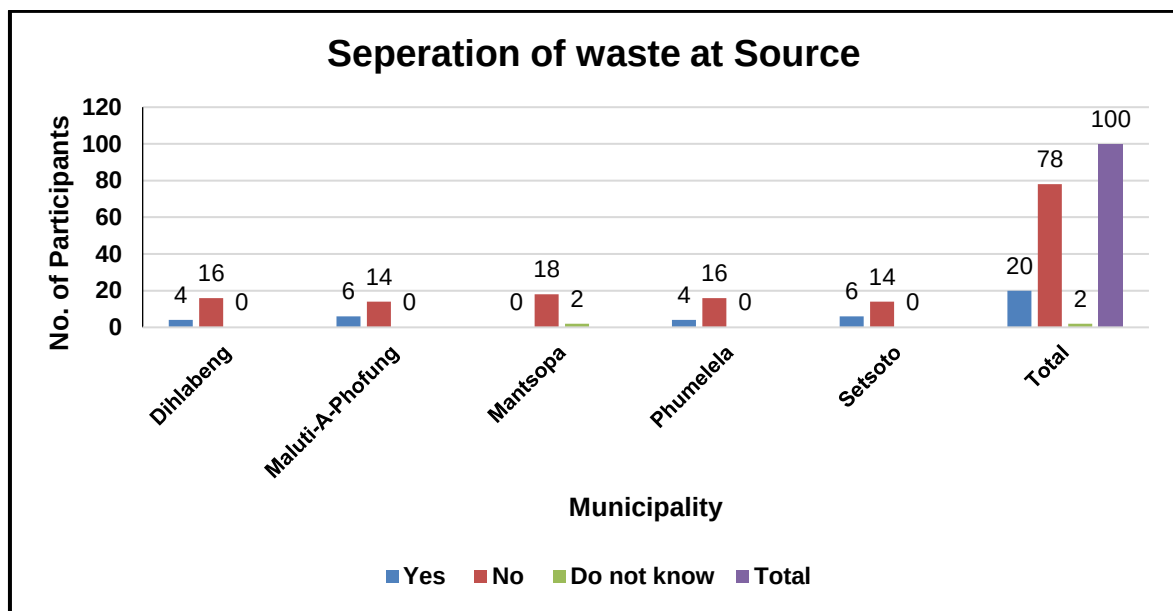


Figure 4.6: Rates of waste being sorted at source per municipality

Together with street cleaning, waste collection is the most important service provided at municipal level in terms of economic and environmental impacts on public health and citizens' quality of life, and this practice is therefore pivotal in any sustainable solid waste system.

In general, waste sorting is done by placing recyclable items and materials in bins that are used for this purpose. As most people who engage in recycling initially become aware of this scheme when they observe waste bins for waste, for example glass and paper which means that waste-sorting behaviour is strongly related to the perception of waste bins and their availability (Leeabai *et al.*, 2021). Therefore, waste segregation can be improved if appropriately designed waste bins are available as this will induce enhanced waste separation at source and thus reduce costs and the time spent on recycling processes at collection and disposal points. Moreover, composting can also be enhanced if the right biodegradable materials are recycled appropriately. The location and availability of waste bins impact on waste disposal behaviour as easy access to such bins will improve sorting efficiency in high-density residential buildings (Leeabai *et al.*, 2021). In most households and commercial sites, waste is mixed in one plastic bag before it is taken to the kerbside for collection, and there is thus no separation at source.

Some households try to separate what they can for collection by waste pickers in the streets, but unfortunately most waste ends up on landfills as unsorted waste (Etenegeng, 2012). This tendency was prevalent at the landfills and dumpsites that the researcher visited.

4.2.4 The impact of limited MSW management resources

It is unfortunate that many municipalities in developing countries are struggling with solid waste collection and transportation, and South Africa is no exception. The main reasons are the following:

4.2.4.1 Poor financial management, inadequate budgetary allocation, and incompetence

Sufficient funds are required for effective waste management while efficient personnel should be employed to drive this process. However, many local authorities in South Africa fail to properly manage solid waste due to the huge expenditure needed to provide this service. Inadequate financial management by incompetent officials consequently leads to the collection of a fraction of the waste that is generated, and the rest of the waste ends up on unauthorised dumping sites where it causes serious environmental and public health hazards (Sulemana, Donkor, Forkuo, and Oduro-Kwarteng, 2018). Incompetence seems to be a serious problem in some municipalities in South Africa. For instance, “the ‘unlawful’ appointment of a Mahikeng municipal manager who was hired despite being less qualified than his rivals, in a municipality battling R2-billion in wasted funds and crumbling infrastructure”, made headlines in the press in 2021 (Koko, 2021:1). Moreover, such appointments challenge the legal system as municipal regulations on minimum competency levels, which are entrenched in the Municipal Systems Act (South Africa, 2022), state that senior managers should be rated competent in financial and supply-management as well as managerial and occupational competencies.

4.2.4.2 Lack of political will, prioritising, and commitment

Following from the above, it is often assumed that waste management is the sole duty and responsibility of local authorities and that the public is not expected to contribute to this service. However, it is undeniable that the operational efficiency of solid waste

management depends on the active participation of both the municipal agency and citizens; therefore, socio-cultural aspects that impede SMW as mentioned by some scholars (Sulemana *et al.*, 2018) include people who refuse to participate in decision-making, a lack of community awareness of SMW requirements and the role they should play, and the general apathy of society and municipal managers. There is a lack of political will among municipal appointees, coupled with the political affiliation of municipal managers. The lack of fair and firm enforcement of waste disposal laws by the local authority and political interference contributes to the poor community attitudes towards waste disposal and management (Lissah, Ayanore, Krugu, Aberese-Ako, and Ruiter, 2021) which manifests in little to no commitment towards effective SWM regardless of demands such as the maintenance of infrastructure, ongoing education and training of municipal workers, and municipalities' healthcare obligations. Low-level waste workers are unfortunately associated with a low social status, and this demotivates them from giving their best (Sulemana *et al.*, 2018), while municipal managers of all parties bask in the comfort of their political affiliation. Low technical know-how on proper solid waste management processes by waste managers further contributes to the challenges regarding solid waste management (Lissah *et al.*, 2021). According to Table 4.7 only Mantsopa and Setsoto managers did not complete the questionnaire because of other work commitments however they were supportive of the study even though the questionnaire does not have the section that tackles directly their line of work.

4.2.4.3 Poor operational scheduling and vehicular routing

Waste collection and transportation are entrusted to low-level municipal workers and drivers who are scheduled for daily solid waste collection in their respective operational areas. However, studies have reported that waste collection, transfer, and transport processes are affected by a breakdown in collection schedules, improper bin collection systems, insufficient infrastructure, and low numbers of vehicles available for waste collection (Sulemana *et al.*, 2018). A poor road network system and development planning mean that roads are often inaccessible for waste transportation, and the inability of municipal managers to ensure suitable infrastructure that allows access not only to well-established suburbs, but to remote areas as well presents a challenge that municipal authorities must address. Mushrooming informal settlements and unpaved and narrow streets make it difficult for waste truck drivers to operate in many areas in South Africa (Sulemana *et al.*, 2018), and the researcher observed that this was also

one of many challenges in the study area, some of the roads were inaccessible and evident that maintenance was not conducted and in some areas of Mantsopa Local Municipality households are located far from the roads. Figure 4.7 shows a waste collection truck collecting the waste placed on the roadside by the residents. The road condition is satisfactory in this area and in the surrounding areas road maintenance is conducted regularly. This location is one of the oldest in Ladybrand and is easily accessible.

4.2.4.4 Inadequate waste collection vehicles and equipment

The types of vehicles that are generally used to collect municipal waste are waste compactor trucks and other trucks. The researcher observed such vehicles in operation in the Metampelong area in Ladybrand. The residents placed waste bins on the kerb on the day of collection by the municipal workers and the waste truck drivers. Apart from the driver, each truck was accompanied by at least three workers who collected the waste and loaded it into the truck (Figure 4.7). The collected waste was then transported to and disposed of at the waste disposal site (a landfill) in Ladybrand.



Figure 4.7: Waste collection compactor truck (©Lepheana: 12/09/2023)

An open tractor pulling a skip was also in use to collect waste, and it was observed that a tractor usually operated in conjunction with a compactor truck (Figure 4.8). Workers were observed sitting on the rear wings above the wheels of the tractor when it was

driven to the next loading point. Skips were placed at different locations and were loaded, using a hydraulic mechanism. When the waste skip was full, the workers covered the load using a net to prevent waste from being blown away by the wind, and the collected waste was transported to and emptied at the landfill site. The researcher observed that the waste tractor was collecting waste in Ladybrand town and was loading small volumes of waste because of the size of the skip. The tractor loads waste in conjunction with the solid waste compactor tractor. In Mantsopa local municipality only three residents indicated that a tractor with a skip is used to collect waste and in Phumelela local municipality 13 respondents indicated that they use a tractor to collect waste, and this is the only municipality with many respondents indicating the use of a tractor. A total of 17 respondents indicated that their mode of transport for collected waste is a tractor.



Figure 4.8: Waste collection tractor and skip in Joubert Street, Ladybrand (©Lepheana: 12/09/2023)

4.2.4.5 The nature of solid waste management and disposal options

The system of solid waste disposal and management is not uniform across countries and regions due to government-established mechanisms and differences in socio-economic factors such as location, gender, education, and income, among others (Padilla and Trujillo, 2018; Uma, Nwaka, Nwogu, and Obidike, 2020; Uwu, Ozoegwu, and Ozor, 2020). Solid waste management, from generation to final treatment, is complex and is usually processed in one of three ways: (i) landfilling, (ii) biological treatment, and (iii) thermal treatment. Landfilling is commonly preferred over the other two methods as approximately 95% of the MSW collected worldwide is landfilled due to

financial, social, and other urban development considerations (Hoque and Rahman, 2020). Among the different factors that are responsible for poor MSW management at final disposal sites are limited governmental capacity, lack of institutional preparedness, lack of human resources, lack of community awareness and involvement, staff mindset and commitment, lack of improved collection equipment, lack of human resources, land scarcity for landfill, inexperienced operation and maintenance of landfills, financial constraints, lack of staff training, lack of baseline information, and insufficient or no solid waste data (Hoque and Rahman, 2020). Most personnel that participated in the study are general workers with a total number of 73 and 54 of them were appointed between 2011 and 2018. The reason for their recent appointment may be because they are working on a contract basis, and the number of permanently appointed staff is limited.

4.2.5 The consequences of illegal dumping and unpleasant odours

The literature argues that large quantities of uncollected waste are often found along the banks of urban waterways, for instance in Bagmati and Bishnumati in Nepal. Sometimes uncollected waste is found near small-scale agricultural fields where it contaminates the soil and crops. In communities that are far from waste collection routes, refuse is commonly dumped on privately owned lots that are neither developed nor maintained (Das, Bhawe, Sapkota, and Byanju, 2018; Jerin, Sara, Radia, Hema, Hasan, Urme, Audia, Hasan, and Quayyum, 2022).

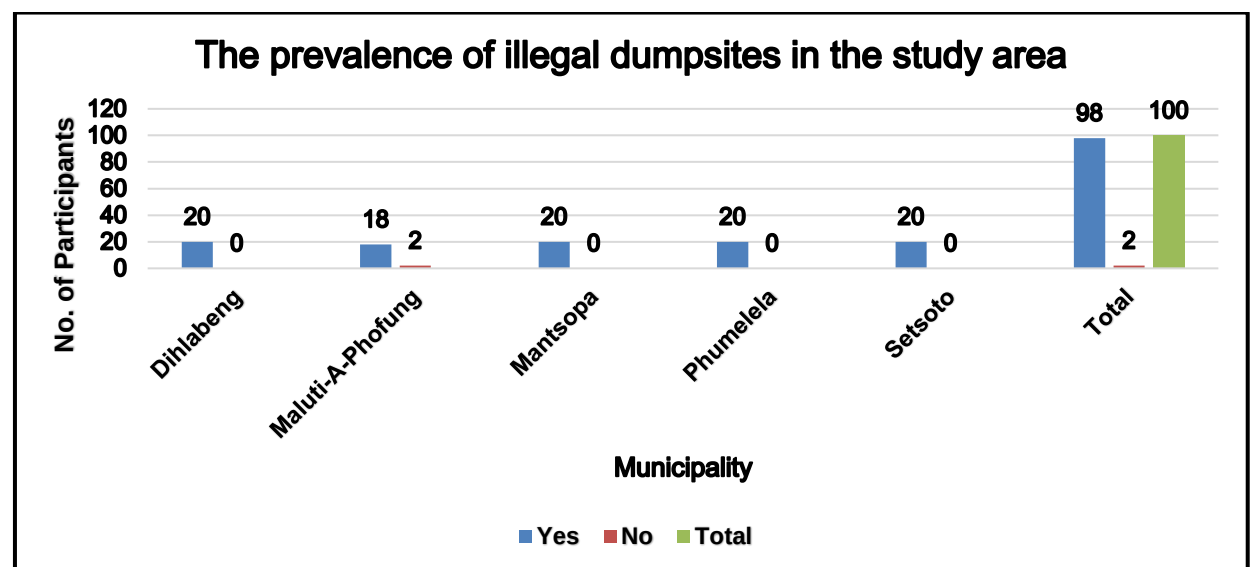


Figure 4.9: The prevalence of illegal dumpsites in the study area

Figure 4.9. indicates that by far most residents were aware of an illegal waste dumpsite in their respective residential areas as 98% indicated that they were exposed to the effects of illegal dumpsites. This phenomenon may be attributed to poor solid waste collection practices by the various municipalities, and managerial apathy and/or incompetence which has resulted in an exponential increase in the number of illegal dumpsites near residential areas. The prevalence and frequency of illegal waste dumps is a serious problem in TMD as it affects communities negatively. Some residents complained that dead animal carcasses were discarded at these sites and, when these animals decomposed, a bad odour permeated the air which exposed residents and scavenging animals to health risks. Any waste that remains uncollected after a few weeks of biodegradation emits a foul odour, which prompts residents living in the vicinity to burn it. In informal settlement areas, the situation is much worse than in urban residential areas (Das *et al.*, 2018; Jerin *et al.*, 2022). The researcher observed that this was the case in the study area, and almost all the respondents flagged unsightly waste dumps as a serious issue.

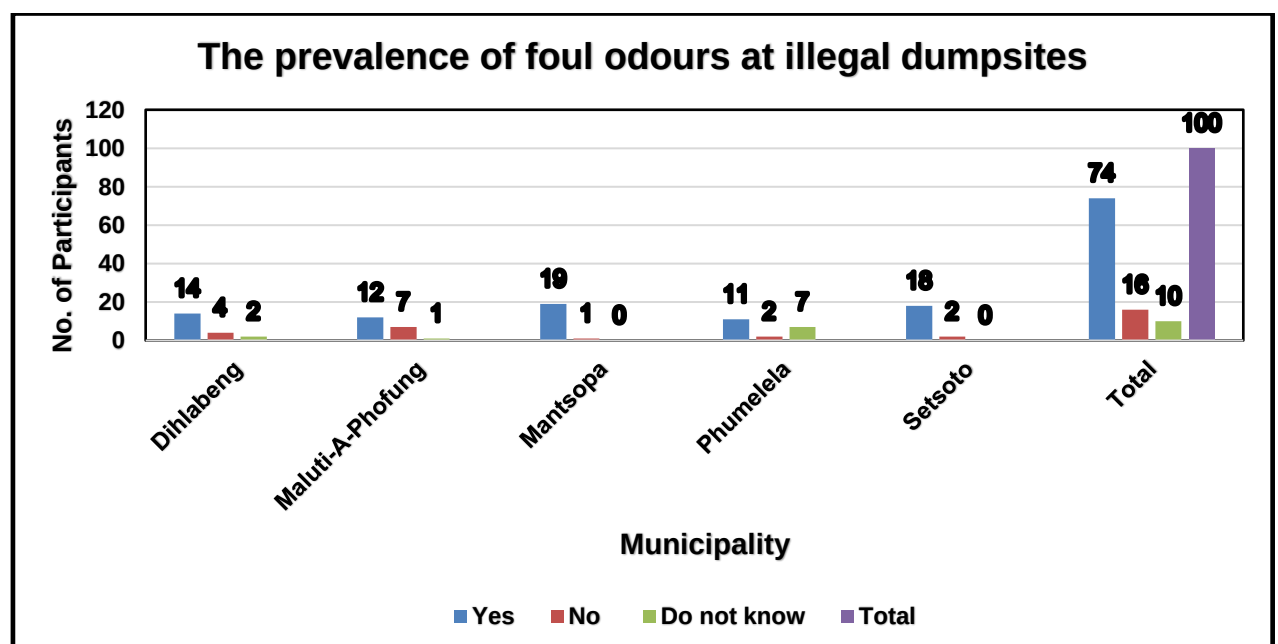


Figure 4.10: Awareness of odors emitted by illegal dumpsites

Figure 4.10 indicates that most residents were aware of a constant odor being emitted by the open waste dumps in their respective areas. Whilst driving in the area, the researcher and his supervisor observed that these odors were worse during hot summer

days, and, in some instance, the foul smell was unbearable. Families, especially young children and the elderly, tend to suffer from skin and upper respiratory-related conditions (Reyna-Bensusan, Wilson, and Smith, 2018). In Mantsopa, 19 respondents indicated that they suffer from exposure to the foul smell, compared to Phumelela with 11 respondents and a total number of 74 participants indicated that they are exposed to odours and vectors. Observation from the researcher indicated that there were disease-carrying vectors, such as rodents and flies, while litter was strewn around by the wind at these sites, making the environment look unsightly and unhygienic. Such litter will be washed away in the rainy season as surface run-off and there is a definite chance that it will contaminate groundwater through seepage. It was observed that this dumpsite was near a cemetery and domestic dwellings (as is indicated in the photograph), which could have posed additional problems in terms of seepage and contamination.



Figure 4.11: Image of an illegal dumpsite near a cemetery and houses (© Lepheana: 17/09/2023)

It was also observed that MSW was discarded in conjunction with garden waste at the corner of an open field next to the cemetery (Figure 4.11). Environmental pollution was evident at this site, as there was windblown litter on the street and the grassland next to it. The municipality did not seem to clean the area frequently because accumulated waste had become an unsightly heap. It was apparent that the residents also did not care as no-one had attempted to remove the waste or contact the municipality to do so.

Indiscriminate dumping of waste, also referred to as fly-tipping and illegal dumping, or any form of unlawful disposal of waste is a difficult waste management problem throughout the world. Such practices pose hazards for human health and the ecosystem alike. Niyobuhungiro and Schenck (2021) argue that indiscriminate dumping is a highly visible, ongoing, and costly waste management problem that needs to be addressed as a matter of urgency, and this study affirms this notion. Cleaning up indiscriminate dumpsites is often more expensive than formal waste collection and disposal as additional time and personnel must be invested in this process.

A comprehensive waste management policy requires recognition not only of waste management at generation point, but of the subsequent behaviour of households and residents as well. Unrealistic waste collection and disposal charges can discourage waste generation by households, yet paying a fee for illegal dumping will encourage households to re-consider their options to avoid paying a fee (Liu, Kong, and Gonzalez, 2017). Unfortunately, in the researchers' experience, identifying the perpetrators of illegal dumping is often a challenge.

Illegal waste dumping has become a habitual form of solid waste disposal in Asian cities, and this has resulted in solid waste becoming a common feature of the urban landscape as it is visible along roadsides and in rivers and open and public spaces. For instance, poor urban neighbourhoods in Kinshasa have limited or no access to SWM services and, when available, they are irregular. Residents in Kinshasa who have no access to waste services are thus compelled to dump their waste at any available space (Kubanza and Simatele, 2018).

4.2.6 Open burning of waste

Open burning is a common practice to reduce the volume of waste and to mitigate the odors emitted by decomposing waste at dumpsites. MSW contains 50 - 60% organic food waste.



Figure 4.12: Open burning at an illegal dumpsite in Warden (© Lepheana: 03/02/2021)

The uncontrolled decomposition of such waste causes rotting and this has a severe impact on residents' health and the environment due to a foul odor and methane which causes greenhouse gas (GHG) emissions. Furthermore, waste can pollute the atmosphere through physical agents such as the wind, leachate, and effluent (Krecl, de Lima, Dal Bosco, Targino, Hashimoto, and Oukawa, 2021; Prajapati, Yadav, Singh, Parikh, Pareek, and Vivekanand, 2021; Salam, Alam, Dezhi, Nabi, Shahzadi, Hassan, Ali, Muhammad, Saeed, Hassan, Ali, and Bilal, 2021).

The image in Figure 4.12 clearly shows what the researcher observed near Warden. The smoke hovering in the air smelt unpleasant, while the proximity of this burning heap of waste near residences is evident in the photograph. Residents mentioned to the researcher that they resort to waste burning as a method to reduce the volume of waste because the municipality takes long periods to collect waste.

4.2.7 The need for municipalities to conduct waste disposal awareness campaigns

Awareness as conceptualised in this study refers to attitudinal concerns about the environment when dealing with waste and the willingness to engage in waste separation, recycling, and paying for a clean and safe environment. It was assumed that the ability of households to correctly manage generated waste and convert it into a valuable resource had fostered adherence to proper and appropriate waste management practices at household level, as proposed by Tsheleza *et al.* (2022).

The literature argues that people's level of education is related to their willingness to engage in waste segregation as, strangely enough, people with a low education are more willing to segregate their waste compared to those with a higher level of education (Fadhullah, Imran, Ismail, Jaafar, and Abdullah, 2022). The reason for this phenomenon could be attributed to their different lifestyles, the need for recyclable material and items for survival, and time constraints when busy working people are required to sort waste. People with a higher education level may also spend most of their time at the workplace and not at home (Fadhullah *et al.*, 2022). However, continuous educational campaigns should be undertaken to emphasize the benefits of waste segregation at source among people of all walks of life. Enhancing residents' knowledge of the threats posed by and the benefits of waste management in flyers can increase the probability of changed waste separation behaviour. Therefore, to alleviate prevailing environmental problems caused by waste in developing countries, more focused and sustained public awareness programs, integrated with an enabling infrastructure, are required to change residents' perceptions regarding waste separation at source (Fadhullah *et al.*, 2022). Members of the public are often uninformed of the lifecycle of waste and the subsequent pollution impacts of their daily activities, such as putting out a bag or bin of waste for collection. Municipalities must therefore create awareness amongst households about the types of waste, and the need to separate these at source, the unacceptability of illegal dumping and littering, measures to be taken against individuals that litter and dump waste illegally, the cost of cleaning up illegal dumping and littering, the need to pay a household waste collection levy, and the advantages of reporting illegal dumping activities (Maluleke, 2021).

The literature proposes that environmental education should be improved by starting with pre-school children and instilling awareness in them of their responsibility to play an active role in caring for the environment (Zamri, Azizal, Nakamura, Okada, Nordin, Othman, Akhir, Sobian, Kaida, and Hara, 2020). An educational approach plays an important role in raising awareness about the importance of food waste issues, environmental impacts, and huge economic losses due to indiscriminate waste disposal. Environmental education that starts at a young age and continues among adult residents is an effective and economically viable method to reduce food waste. Tools to get people involved in environmental awareness are various media outlets (e.g., radio broadcasts, national and local articles, press releases), events, printed documents (e.g., brochures and flyers), mediators, community meetings, television programmes, and websites (Zamri *et al.*, 2020; Sinthumule and Mkumbuzi, 2019). To ensure the effectiveness of such initiatives, all waste management stakeholders must contribute to changing consumption and waste disposal patterns. Behavioural changes will also be best motivated by enhancing people's environmental awareness instead of issuing compulsory regulations. Internal facilities are also very important to increase recycling rates, such as householders' awareness of environmental impacts and households' knowledge of the value of recycling (Saladie and Santos-Lacueva, 2016).

Table 4.6 indicates whether the respondents were exposed to awareness campaigns conducted by their respective municipalities. Of the 100 respondents, 62 indicated that the municipalities never conduct awareness campaigns related to effective and correct waste management.

Table 4.6: Municipalities' investment in conducting waste awareness campaigns

Name of Municipality	Never	Sometimes	Often	Always	Total (%)
	n (%)	n (%)	n (%)	n (%)	
Dihlabeng n=20	12 (60)	7 (35)	0 (0)	1 (5)	100
Maluti-A-Phofung n= 20	12 (60)	5 (25)	3 (15)	0 (0)	100
Mantsopa n=20	15 (75)	4 (20)	0 (0)	1 (5)	100
Phumelela n= 20	8 (40)	11 (55)	1 (5)	0 (0)	100
Setsoto n= 20	15 (75)	4 (20)	1 (5)	0 (0)	100
Total (n = 100)	62 (62%)	31 (31%)	5 (5%)	2 (%)	100

Only two residents, one in Dihlabeng and one in Mantsopa, confirmed that their municipalities always exposed residents to awareness campaigns, while overall only five residents stated that they were often exposed to awareness campaigns. The obviously wide contradiction in the responses of residents from the same area cannot readily be explained, except to argue that the smaller group possibly misinterpreted the question, or they offered a response that they thought the researcher might want to hear.

4.3 Municipal waste management employees' perceptions and experiences of SWM

The results that were elicited from the municipal employees and the observation checklists will be discussed in this section. The data are presented in tables and graphs in conjunction with textual discussions, as in the former sections. The data were elicited from 86 waste management officers (WMOs) from the five municipalities that were willing to participate in the research. Prior to visiting the local municipalities, the researcher made appointments with the identified WMOs who were willing to complete the questionnaire. No problems were encountered during the data collection phase. Before the questionnaires were administered to the employees individually, the nature of the study and its aims were presented to the respondents at each local municipality, and they were informed of their right to anonymity. They were also informed that the data would not be used for any purpose other than the specific research study.

4.3.1 Allocation of personnel in the waste management directorate

Figure 4.13 indicates the number of employees interviewed at each local municipality. Compared with the equal distribution of resident respondents per municipal area, the questionnaires that were administered to the municipal employees were distributed according to the number of personnel available at each local municipality when the researcher visited it.

Eventually, the highest number of respondents ($n = 20$) was recruited in Mantsopa LM and the fewest participants were recruited in Dihlabeng and Phumelela local municipalities at 16 respondents each. MAP and Setsoto were each represented by 17 respondents.

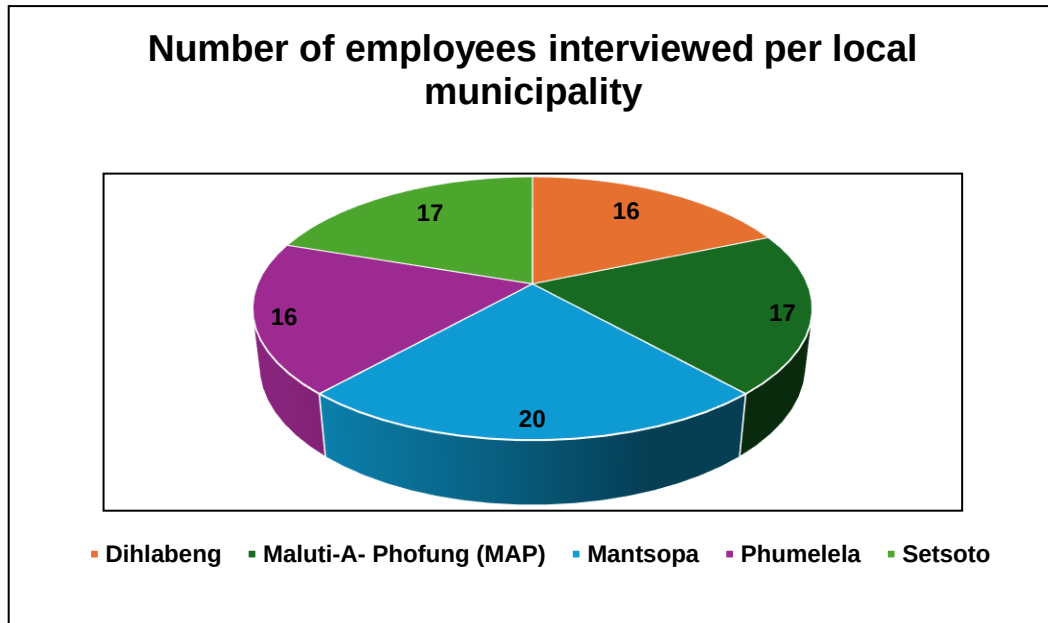


Figure 4.13: Number of employees interviewed in each local municipality

The time that the researcher arrived at the various municipalities influenced the available number of respondents as some employees had already left to engage in field work.

The category that had the highest representation was general workers at 73%. This was deemed a satisfactory rate as these workers generally function at ground level where they are exposed to many challenges while on duty.

Table 4.7: Number of recruited respondents and their employment levels

Name of municipality	Manager n (%)	Truck driver n (%)	General worker n (%)	Other n (%)	Total (n)
Dihlabeng	1 (6.25)	1 (6.25)	14 (87.50)	0 (0)	16
Maluti-A-Phofung	1 (5.88)	2 (11.76)	14 (82.35)	0 (0)	17
Mantsopa	0 (0)	0 (0)	17 (85)	3 (15)	20
Phumelela	2 (12.50)	1 (6.25)	12 (75)	1 (6.25)	16
Setsoto	0 (0)	1 (5.88)	16 (94.12)	0 (0)	17
Total (n = 86)	4	5	73	4	86

Table 4.8 indicates that a very small percentage of the participating personnel were employed before 2000 and that only 27 of the respondents commenced their employment between 2001 and 2010. The fact that 54% of the personnel were employed in 2011 and thereafter, shows that more posts became available as the years progressed.

Table 4.8: Duration of employment

Name of municipality	Appointed before 2000	Appointed 2001-2010	Appointed 2011-2018	Total n (%)
	n (%)	n (%)	n (%)	
Dihlabeng	0 (0)	8 (50)	8 (50)	16 (100)
Maluti-A-Phofung	2 (11.76)	13 (76.47)	2 (11.76)	17 (100)
Mantsopa	0 (0)	4 (20)	16 (80)	20 (100)
Phumelela	2 (12.50)	0 (0)	14 (87.50)	16 (100)
Setsoto	1 (5.88)	2 (11.76)	14 (82.35)	16 (100)

Other factors could have contributed to the low number of older and more experienced employees in the waste management domain, such as that some may have passed away while others may have resigned or retired.

A non-linear model was used to calculate manpower requirements for kerbside refuse collection. According to this model, the refuse tonnage to be collected each day of the week determines the requirement for truck and staff availability. This model was tested about 10 years ago in some districts in New York City (Ghiani, Guerriero, Manni, Manni, and Potenza, 2013). It mainly focuses on the definition of optimal personnel and vehicles required for shift schedules to perform a set of tasks such as street sweeping and separate refuse collection with the purpose of minimizing overall costs. Solid waste management services are associated with costs just like any other service provided by the public sector. These service all required skilled personnel, appropriate equipment, adequate infrastructure, and proper maintenance (Zon, Leopoldino, Yamane, and Siman, 2020).

4.3.2 Crew management and transportation

To ensure effective municipal solid waste management, the design of such a system requires the efficient planning of various activities related to the waste life cycle, i.e., waste generation volumes, collection frequencies, waste transformation by recycling, waste disposal, and the manpower required to execute the tasks (Ghiani, Guerriero, Manni, Manni, and Potenza, 2013). Each of these stages involves a number of strategic (long-term), tactical (mid-term) and operational (short-term) decisions, such as the selection of solid waste treatment technologies, the location of treatment sites and landfills, future capacity expansion strategies to ensure the sustainability of waste disposal sites, waste flow allocation to processing facilities and landfills, service territory partitioning, allocation of collection days for each district and for each waste type, fleet composition determination, the scheduling of collection vehicles, and crew management (Ghiani *et al.*, 2013). The use of waste collection vehicles was discussed in the section that addressed the residents' responses, but this factor is also addressed in the discussion on the views of municipal employees, as such vehicles are pivotal to their efficiency.

Table 4.9: Types of vehicles used to collect waste

Name of municipality	Compactor truck	Tractor	Bakkie	Other	Total n (%)
	n (%)	n (%)	n (%)	n (%)	
Dihlabeng	12 (75)	1 (6.25)	3 (18.75)	0 (0)	16 (100)
Maluti-A-Phofung	17 (100)	0 (0)	0 (0)	0 (0)	17 (100)
Mantsopa	17 (85)	3 (15)	0 (0)	0 (0)	20 (100)
Phumelela	1 (6.25)	13 (81.25)	2 (12.50)	0 (0)	16 (100)
Setsoto	15 (88.24)	0 (0)	0 (0)	2 (11.76)	17 (100)

Table 4.9 indicates that a total of 62 employees understood that compactor trucks were used for WC. MAP and Setsoto did not use tractors or bakkies for WC, as two of the respondents in Setsoto indicated that they used other means of waste collection, but they did not indicate what method they used as the option to list alternative methods was not available in the questionnaire, which was a slight limitation.

A key logistical challenge associated with waste collection is that collected waste must be transported to processing facilities without mixing different waste categories (Mohammadi, Rahmanifar, Hajiaghaei-Keshteli, Fusco, Colombaroni, and Sherafat, 2023), and this process must be effectively handled by the waste collection crew. Although a separate vehicle for each type of waste can maintain waste segregation, it necessitates sending multiple trucks to a single location, thereby increasing environmental impact and transportation costs. To reduce costs, different waste categories can be collected in one visit, and each compartment in a waste collection truck can be dedicated to a specific waste type, resulting in preserving segregation during transportation. However, this process requires the use of relatively sophisticated equipment which was not generally available in all the municipalities under study.

For the above and various other reasons, it was concluded that the municipal solid waste collection service in the study area was generally not efficient because collection schedules favoured central business areas while vehicle fleets relied on old models that were not maintained. Moreover, none of the municipalities had a strategic plan to separate municipal solid waste materials for recycling. Most commonly, the practice was to bury the collected waste on an open dump as only one municipality had a relatively successful landfill facility. Moreover, waste management personnel did not receive systematic training, and many had limited experience of efficient waste management processes. It was concluded that the municipalities under study performed basic routine waste collection and transport service that were focused on waste dumping rather than waste management, which is a finding that (Bernache-Pérez, de Medina-Salas, Castillo-González, and Giraldi-Díaz, 2023) also highlighted in their study.

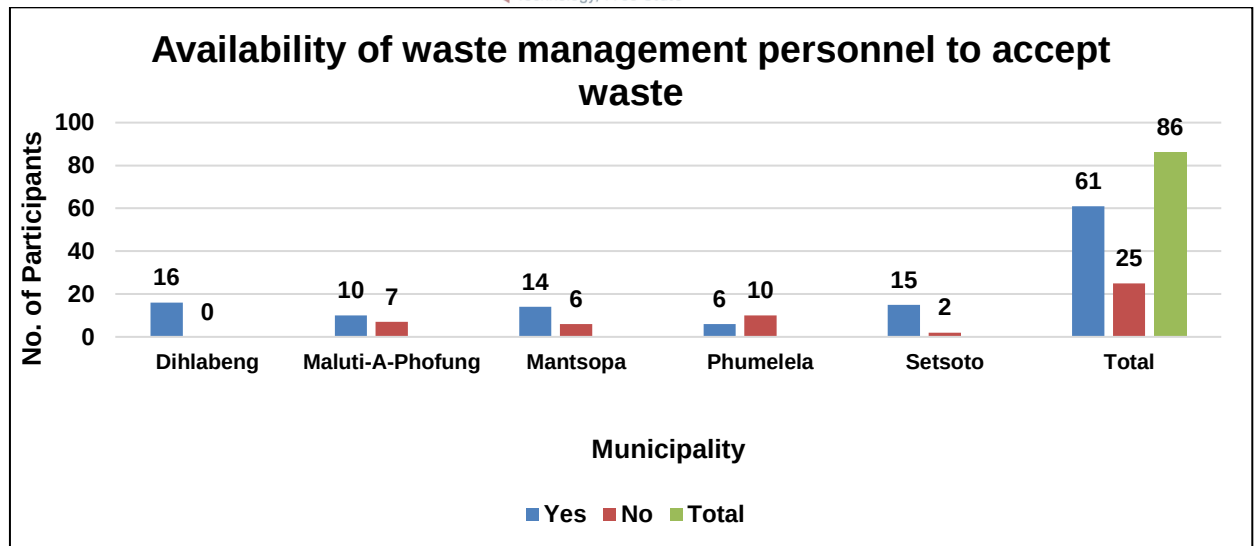


Figure 4.14: Presence of waste acceptance personnel at the waste disposal sites

Sixty of the 86 respondents noted that waste acceptance personnel were available when waste arrived at final disposal sites, while 25 indicated that no personnel were available at the site in their respective areas, except when waste was dropped off. In most instances, the people who accepted waste were waste reclaimers who immediately sorted the waste and took what they deemed valuable without processing the residue waste. Therefore, access to any landfill site needs to be strictly controlled and monitored to reduce the unauthorized movement of waste pickers as landfills are official premises, and there should be a designed space for entrepreneurs to sort and collect recyclable or reusable items (Nkosi, 2014).

Solid waste collection workers are potentially exposed to health, environmental, and safety risks due to the weight of the collected waste they must handle and various chemical and biological materials that are sometimes present in the waste stream. Typical rear loader operations require manual lifting of materials into the collection vehicles. In general, this heavy, repetitive, manual lifting, combined with an ageing workforce, tends to generate an increasing number of injured staff. Exposure to certain chemicals and biological materials can result in musculoskeletal, dermal, respiratory, and gastrointestinal problems (Rogoff and Biderman, 2015).

To collect waste efficiently and safely, appropriate collection vehicles and a team of workers are required. This team typically consists of a driver and one or two loaders, but the tasks of waste collectors may vary from one country to another. Municipal waste collectors usually pick up waste or waste containers from residential, business, and industrial areas and carry them to a truck where waste is manually or mechanically loaded. Loading can occur at the front, rear, or side of the truck where refuse bags/bins are emptied into the vehicle for disposal at a landfill site. The operation is repeated from house to house or collection point to collection point. Workers usually climb into the cab of the truck, or they stand on a small platform at the rear end of the truck during transportation (Madsen, Raulf, Duquenne, Graff, Cyprowski, Beswick, Laitinen, Rasmussen, Hinker, Kolk, Gorny, Oppliger, and Crook, 2021; Tshivase *et al.*, 2022). Waste collection workers also walk alongside the truck when they empty bins and they mostly get on and off the truck repeatedly, and these movements potentially increase the risk of exposure to accidents (Madsen *et al.*, 2021).

The optimum crew size for waste collection depends on labour and equipment costs, collection methods, route characteristics, size and type of collection vehicle, space between houses and waste generation and collection efficiency. In Gaborone, both the private and public sector use similar sizes of compactor trucks with loading volumes, ranging between 12 and 13 m³, but with varying crew sizes. Public sector compactor trucks have a driver and six crew members, while those of the private sector had a driver and two crew members. However, a time and motion study established that on average, with six crew members, the public sector with two crew members collected 5.76 tons/day, while the private sector with two crew members collected 5.76 tons/ day. Thereby, the collection rate by the public sector was 0.96 tons/day/man, while that of the private sector was 5.01 tons/day/man, which meant that the private sector was five times more efficient than the public sector (Bolaane and Isaac, 2015).

4.3.3 Communication

Communities can be reached collectively by utilizing radio stations and by launching awareness programs such as public group meetings, seminars, and workshops. The use of newspaper articles, leaflets, and the mass media, such as radio and television networks, can also ensure the active participation of local groups and individuals in

waste management programs (Prajapati *et al.*, 2021; Matete and Trois, 2008). Awareness campaigns are key to community-based solid waste management practices and can have a positive impact on communities' attitude towards waste management. However, in economically poor residential areas, access to mass media is limited, therefore public gatherings and programs should be used for information dissemination. Public gatherings called by the village chief or councilor and notifications at community centres are useful and effective strategies to keep communities informed. In fact, the current study identified these strategies as the preferred methods of sharing information with communities. If local councils use these platforms, they will capacitate residents with knowledge regarding the impact of open burning and the indiscriminate dumping of waste (Motaung, 2020).

Table 4.10: Mode of communicating waste disposal issues in the TMD

Name of municipality	Loudhailer	Local newspaper	Local radio station	Don't know	Other	Total n (%)
	n (%)	n (%)	n (%)	n (%)	n (%)	
Dihlabeng	14 (87.50)	0 (0)	1 (6.25)	0 (0)	1 (6.25)	16 (100)
Maluti-A-Phofung	1 (5.88)	0 (0)	16 (94.12)	0 (0)	0 (0)	17 (100)
Mantsopa	17 (85)	3 (15)	0 (0)	0 (0)	0 (0)	20 (100)
Phumelela	13 (81.25)	0 (0)	0 (0)	2 (12.50)	1 (6.25)	16 (100)
Setsoto	6 (35.29)	0 (0.0)	10 (58.82)	0 (0)	1 (5.88)	17 (100)

Figure 4.11 indicates that most respondents (51) agreed that their respective municipalities used a loudhailer to communicate with residents, while 27 stated that they received information by means of a local radio station. The respondents indicated that messages to the community were usually shared in the evening when most people were at home.

Awareness campaigns that disseminate information to the community could utilize public address systems (radio, television, town meetings) to educate the public on the dangers of keeping waste on their premises rather than disposing of it in an appropriate manner, because decomposing or untreated waste is hazardous to human health (Uba, Efut,

Obeten, Asuquo, and Uba, 2023). Conventional and contemporary media channels should be used to effectively disseminate information about the environment, communicate societal expectations, and foster a pro-environmental social climate. Citizens who adopt strong views about waste management are likely to develop strong personal morals that will result in protection of the environment (Nketiah, Song, Cai, Adjei, Adu-Gyamfi and Obuobi, 2022). A message that littering is harmful that is presented on signboards or communicated through media such as the radio and national television may also reach a broad audience and become common knowledge for many (Farage, Uhl-Haedicke, and Hansen, 2021).

There is also a strong need to establish a monitoring committee at district level in the TMD to assess the operations and management of landfill sites. Such a committee should also be responsible for post monitoring after a landfill site has reached its lifespan (Nefale, 2018).

4.3.4 Training and the provision of personal protective equipment (PPE)

Most municipalities are plagued by staff turnover, particularly in the waste management sphere as trained personnel often resign to go to greener pastures and maintenance staff are often replaced with untrained people who are unable to manage solid waste facilities (Sebastian and Louis, 2022).

Even though it seems that waste collection is just a laborers' job, it involves a lot of occupational health hazards and sound management practices. The unsafe behaviour of employees, a working environment that is often dangerous, and demanding managerial practices often cause occupational accidents and challenges. Research has revealed that training and education have a positive impact on health and safety practices of workers; yet most municipalities in developing nations face severe economic challenges, and there is a need to develop low-cost measures to train waste handlers (Rajapaksha, de Silva, Basnayake, Jayakody, Ariyawansa, Siriwardena, Nolle, and Pennie, 2017; Tshivase, Mashau, Ngoben, and Ramathuba, 2022).

In developed countries, occupational safety and health enforcement agencies can impose heavy fines if employers are found guilty of negligent behaviour during an inquiry

or after the death of an employee. In addition, workers' compensation insurance premiums are set based on a company's safety record. Consequently, all municipalities and private companies that handle MSW should conduct routine employee safety training as a constant reminder of the importance of safe work practices and using and maintaining appropriate personal protective equipment (PPE) (Ross and Pons, 2013).

Table 4.11: Training exposure in the 12 months prior to the study

Name of municipality	Health and Safety		Total n (%)	Waste management		Total n (%)
	Yes n (%)	No n (%)		Yes n (%)	No n (%)	
Dihlabeng	10 (62.50)	06 (37.50)	16 (100)	12 (75)	4 (25)	16 (100)
Maluti-A-Phofung	13 (76.47)	4 (23.53)	17 (100)	13 (76.47)	4 (23.53)	17 (100)
Mantsopa	6 (30)	14 (70)	20 (100)	11 (55)	9 (45)	20 (100)
Phumelela	3 (18.75)	13 (81.25)	16 (100)	9 (56.25)	7 (43.75)	16 (100)
Setsoto	12 (70.59)	5 (29.41)	17 (100)	13 (76.47)	4 (23.53)	100 (100)

It is evident in the data analysed that the local municipalities under study did not expose their employees to regular training, as the total number of employees trained in health and safety in a period of 12 months prior to the study was 44 (51%). Those trained in waste management were 58 (67%), which indicated that a significant portion (33%) of the municipal waste management employees remained untrained.

Training and development are regarded as one of the roles that the human resources unit plays in the improvement/advancement of municipal employees and the services they provide. Training is a learning process that allows employees to acquire new skills, knowledge and an improved attitude that will lead to more efficient performance. People receive knowledge and acquire the necessary skills to perform their job satisfactorily through the formal process of training (Setsoto Integrated Development Plan (2021/2022)).

In many low-income countries, municipal solid waste is collected and sorted manually, for instance in Addis Ababa in Ethiopia (Melaku and Tiruneh, 2020). The poor provision of modern waste management technologies and a lack of appropriate training programmes for municipal solid waste collectors and supervisors by the Addis Ababa Solid Waste Administration Agency have left solid waste handlers at risk of exposure to several occupational health risks, as (Melaku and Tiruneh, 2020) propose. These authors found that the waste workers were not provided with suitable personal protective equipment and clothing and that most municipal solid waste was not safely contained in liftable load sizes. In addition to this, the city could not afford early check-ups and treatment when the staff had health problems. There was also inadequate credible evidence of occupational health risks and associated hazards in the city, yet this information was vital when mechanisms needed to be designed to protect municipal workers.

A lurking risk that is often ignored is sharps that are generated due to in-home medical use. When collected by public waste workers in flimsy plastic bags, these objects can pose significant problems as any piercing can cause severe infection. Waste collection and disposal personnel often have difficulty disposing of sharps because of the limited number of collection locations where these objects can be discarded (El-Gilany, Abou-Elwafa, El-Bestar, and Zaki, 2013).

4.3.5 Exposure to waste-related pathogens and health risks

The handling of waste is a main source of municipal workers' exposure to microorganisms that are often harmful to human health. Household waste generally consists of many different elements and materials such as plastic, paper, cardboard, metal, glass, organic waste, and residual decomposing food, and handling these materials safely depends on consumer habits as well as adherence to sorting regulations for household waste (Madsen *et al.*, 2021).

The main channels of exposure to harmful substances for waste collectors are the inhalation of particulates such as airborne microorganisms and microbial components and the contact of contaminated hands with the mouth and eyes. Inhalation and hand-face contact, and further ingestion of microbial pathogens and toxins may be the cause

of gastrointestinal symptoms in sensitive workers (Madsen *et al.*, 2021). During the collection of domestic waste, workers usually pull and push the waste containers, walk quickly, and many sometimes run, which may result in increased pulmonary ventilation and a higher-than-normal heartbeat. Such increased physiological activities may induce the deposition of particles far down into the lungs as well as the deep inhalation of high doses of microbial particles (Madsen *et al.*, 2021).

Occupational exposure to bioaerosols occurs during loading and unloading of waste as workers stand next to waste during these operations. Exposure may also occur during non-loading times when workers stand on the back of the truck. Exposure may also occur in the truck cab as contaminated airborne microorganisms may be carried by workers on their contaminated clothes from the outdoor unloading process into the cab (Madsen *et al.*, 2021).

The risks associated with solid waste management can be divided into the following categories: occupational accidents, physical risks, chemical risks, ergonomic risks, psychological risks, and biological risks (Jerie, 2016). Health risks may directly affect waste workers or other waste operators and nearby residents, and these risks are associated with various factors, which include the following:

- The nature of raw waste, its composition (e.g., toxic, allergic, and infectious substances), and its components (e.g., gases, dust, leachate, and sharps);
- The nature of waste as it decomposes (e.g., gas emissions, dust, leachate, and toxic particles that can cause a toxic, allergic, or infectious health response);
- The manner in which waste is handled (e.g., shovelling, lifting, and equipment vibrating);
- Accidents occurring as a result of waste management;
- The processing of waste (e.g., odour, noise, vibration, accidents, gaseous air emissions, water and soil pollution, residuals, explosions, and fire); and
- The disposal of waste (e.g., odour, noise, vibration, stability of waste piles, leachate that seeps into water and soil, gaseous emissions, explosions, and fires).

Table 4.12: Provisioning of personal protective equipment (PPE)

Municipality	Overalls		Gloves		Safety shoes		Face masks	
	Yes n (%)	No n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)
Dihlabeng	1 (6.25)	15 (93.75)	6 (37.50)	10 (62.50)	1 (6.25)	15 (93.75)	3 (8.75)	13 (81.25)
Maluti-A-Phofung	0 (0)	17 (100)	1 (5.88)	16 (94.12)	1 (5.88)	16 (94.12)	2 (11.76)	15 (88.24)
Mantsopa	3 (15)	17 (85)	2 (10)	18 (90.0)	7 (35.0)	13 (65.0)	4 (20.0)	16 (80)
Phumelela	2 (12.50)	14 (87.50)	3 (18.75)	13 (81.25)	5 (31.25)	11 (68.75)	4 (25.0)	12 (75.0)
Setsoto	12 (70.59)	5 (29.41)	9 (52.94)	8 (47.06)	15 (88.24)	2 (11.76)	10 (58.82)	7 (41.18)
Total	18	68	21	65	29	57	23	63

Table 4.12 shows the number of employees that indicated that they either received or did not receive personal protective equipment (PPE) from their employers. The types of equipment that are generally issued are overalls, gloves, safety boots, face masks, or any other type of PPE that needs to be replaced within a year. Setsoto LM was the only municipality that provided 12 (70.59%) of their employees with overalls and gloves, while nine (52.94%) workers were issued with safety boots, and 15 (88.24%) and 10 (58.82%) with face masks. The other municipalities provided none to very limited PPE and thus exposed their employees to dire safety risks. It is the responsibility of the employer to comply with section 8 of the Occupational Health and Safety Act No. 85 of 1993 (South Africa, 1993).

4.4 Integrated results based on illegal dumpsites and landfill checklists

The researcher travelled to and visited various illegal dumpsites and landfills in the study area, as described earlier. Pertinent data that emerged from the checklists and images of the sites that were visited are presented in this section. These results are presented in-text in the past tense as the observations were made some time ago, although it is doubtful that any of the conditions have changed since the visits.

4.4.1 Observations, location information, and images of dumpsites and landfills

The names of the five representative towns, landfills and checklists are shown in Table 4.13.

Table 4.13: Number of landfill checklists per town

	Name of representative town	Number of landfill/s	Number of Checklists
Dihlabeng	Bethlehem	1	1
Maluti-A-Phofung (MAP)	QwaQwa	1	1
Mantsopa	Ladybrand	1	1
Phumelela	Warden	1	1
Setsoto	Ficksburg	1	1

The researcher focused on the largest town in each local municipality to yield rich results as each of these towns has one official waste disposal site.

Observations indicated that the conditions of the waste disposal sites in the TMD were generally unsatisfactory. Only three landfill sites were fenced while two were not fenced at all, but the condition of the fences was no longer good at Setsoto and Mantsopa landfills. There was uncontrolled access at these sites and animals were scavenging on the rubbish. The only municipality that still had a fence that was in good condition was Dihlabeng landfill, where the fence was constructed from wire.

At Dihlabeng landfill the signboard was well positioned and indicated the permit holder requirements and informing residents that the municipality remained the custodian of the disposal site (Figure 4.15).



Figure 4.15: Dihlabeng LM: Information board at the landfill site (© Lepheana: 14/06/2023).

The following information was reflected on the board: operating hours, emergency telephone numbers, types of waste that would be accepted (i.e., household and garden waste), and the types of waste that were not accepted (chemicals, medical waste, and oil) as indicated in Figure 4.15. The Dihlabeng landfill was the only one in the study that still complied with some of the minimum requirements for landfilling as indicated in Table 4.14.

Table 4.14: Information and signs posted at the landfill sites

Name of municipality	Sign: two official languages Yes/No	Landfill name on sign Yes/No	Municipality	Hours of site operation	Names, address, permit holders telephone numbers	Waste class indicated	Types of waste accepted
Dihlabeng (Bethlehem)	Yes	Yes	Yes	Yes	Yes	Yes	Household
Maluti-A-Phofung (QwaQwa)	No	No	No	No	No	No	Household
Mantsopa (Ladybrand)	No	No	No	No	No	No	Household
Phumelela (Warden)	No	No	No	No	No	No	Household
Setsoto (Ficksburg)	No	No	No	No	No	No	Household

Table 4.15 indicates that the roads leading to landfill sites are not in a good condition and mostly gravel roads.

Table 4.15: Access control, collection of disposal tariffs, and security at landfill sites

Name of Municipality	Road in good condition to allow vehicles	Types of access road	Two-way road to allow access	On-site entrance limited to one gate	Is the landfill site fenced?	Type and condition of fence
Dihlabeng (Bethlehem)	Yes	Tarred	Yes	Yes	Yes	Wire fence
Maluti-A-Phofung (QwaQwa)	No	Gravel	No	No	No	No fence
Mantsopa (Ladybrand)	No	Gravel	No	No	Yes	Poor condition
Phumelela (Warden)	No	Gravel	No	No	No	No fence
Setsotho (Ficksburg)	No	Gravel	No	No	Yes	Poor condition

There is no access control and everybody entering the sites can dispose of waste anywhere they wish because there is no one managing the landfills. Maluti-a-Phofung and Phumelela are not totally fenced whereas Mantsopa and Setsotho landfill sites fence are not in good condition.



Figure 4.16: Setsotho LM: Cows scavenging on the landfill site (© Lepheana: 14/06/2023)



Figure 4.17: Dihlabeng LM: Guard house for security personnel and access control at landfill (© Lepheana: 14/06/2023)

Figure 4.16 shows that the entrance to the Setsoto municipal landfill site, is not controlled, cattle are scavenging onsite, and waste is dumped anywhere as there is no staff supervising and indicating where waste should be offloaded. A security guard controls access at the Bethlehem landfill site, which leads to better site management (Figure 4.17).



Figure 4.18: Phumelela LM: Warden waste disposal site (© Lepheana: 03/02/2021)

Burning of waste was observed which causes air pollution (Figure 4.18). Waste is not covered, as required, which results in windblown litter scattered all over the site.



Figure 4.19: Mantsopa LM: Dumped MSW being recycled and burnt (©Lepheana, 07/10/2023)

The road condition, Figure 4.19, is satisfactory. However, during data collection, a heap of waste was blocking the access road, which indicates poor waste management.



Figure 4.20: Mantsopa LM: waste sorting on the roadside (©Lepheana: 07/10/2023)



Figure 4.21: Setsoto LM: Waste sorting on-site (© Lepheana: 14/06/2023)



Figure 4.22: Dihlabeng LM: Sorted recyclables in waste bags for collection (©Lepheana: 14/06/2023)

Figure 4.18 indicates a lack of recycling and burning of waste on the Phumelela LM landfill site (Warden). Figures 4.19, 4.20, 4.21 and 4.22 depict waste recycling, where

waste pickers sort waste according to type and place it in bags. The sorted recyclables are sold to waste buyers for living costs.

A compactor/bulldozer was used to load and dispose of waste on the landfill site (Figure 4.23). This bulldozer is not in a working condition, due to poor maintenance resulting in ineffective waste management.



Figure 4.23: Setsoto LM: Waste processing equipment on-site (© Lepheana: 14/06/2023)

Dumpsites can contaminate soil and water by leachate infiltration and run-off, and these factors deteriorate vegetation. Burning of and gaseous emission from untreated waste also contributes to global warming and air pollution mainly through spontaneous fires or deliberate burning (Krecl *et al.*, 2021).

The observation checklists indicated that the dumpsites and landfills were approximately one to 120 meters from the nearest dwellings. No significant differences were noted when this factor was compared with findings by earlier authors who gathered information in other areas (Aryampa *et al.*, 2022).

4.4.2 Proximity of illegal dumpsites to nearest residences

Table 4.16 indicates the proximity of illegal dumpsites to the closest residences, of which Maluti-A-Phofung (MAP) is less than one kilometre from the landfill.

Table 4.16: Proximity of illegal dumpsites to nearest residences

Name of municipality	Name of town	Approximate distance closest to residence (Metre)
Dihlabeng	Bethlehem	2
Maluti-A-Phofung (MAP)	QwaQwa	1
Mantsopa	Ladybrand	5
Phumelela	Warden	3
Setsoto	Ficksburg	25

Table 4.16 indicates the distances between dumpsites and residential dwellings. Some dumpsites were located as close as 5 to 25 metres from the closest residences. It was found that seven dwellings were within 10 m from a dumpsite, while some were between 30 to 120 metres from a dumpsite. It was evident that a significant number of residents live near an illegal dump, and they were quite clearly exposed to potential health and safety risks as the waste was left untreated. Animals were also at risk as cows scavenged on dumpsites where they were at risk of ingesting plastic and other life-threatening materials.

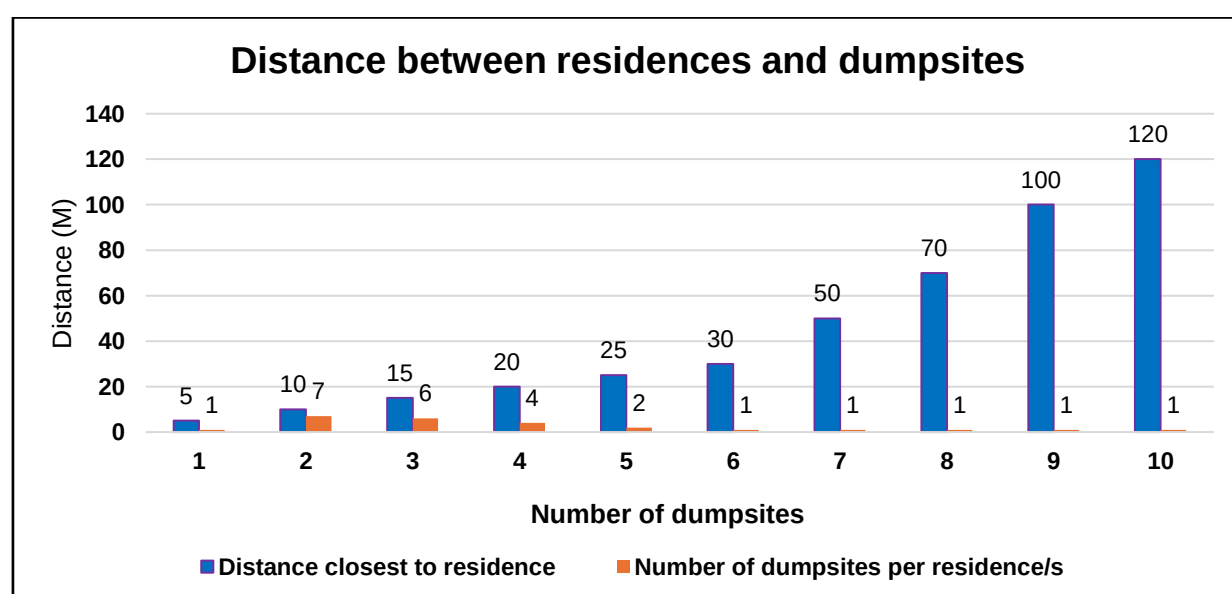


Figure 4.24: Distance between illegal dumpsites and closest residences (metres)

One dumpsite was only five metres from the residences, while seven and six dumpsites respectively were 10 to 15 metres away. A total of seven dumpsites were situated between 20 to 30 metres, while four dumpsites were observed at 50, 70, 100 and 120 metres, respectively.

Many researchers have suggested that the appropriate distance from the border of an urban area to a landfill site should be more than five kilometers, while one kilometer from villages is deemed suitable. Important factors when developing or establishing residential dwellings near a landfill are noise, decreasing property value, odour, aesthetics, and the potential of the area to expand in the future (Chabuk, Al-Ansari, Hussain, Knutsson, and Pusch, 2016). (Amkieh, 2021) stated that according to standards and regulations, the criteria used to select a landfill site are mentioned as follows:

- Economic criteria: that include five sub-criteria: elevation, slope, distance from main roads, distance from railway, and land value.
- Geology criteria: that provides for two sub-criteria: soil formations and groundwater depth.
- Eco-sociology criteria: that includes five sub-criteria: distance from settlements, distance from protected areas, land use, distance from airfields, and distance from secondary collection points and
- Hydrology or climate criteria: aspect (wind direction), distance from river and canal, and distance from surface water body.

Table 4.17: Nuisances and other environmental degradation factors observed at landfill sites

Municipalities	Waste burning taking place n = 25 (Yes, No)	Prevalence of wind-blown litter n = 25 (Yes/No)	Foul smells emanating from sites n = 25 (Yes, No)	Vermin and disease-carrying vectors n = 25 (Yes, No)
Dihlabeng (Bethlehem)	Yes 5	Yes 5	Yes 5	Yes 5
Maluti- A- Phofung (QwaQwa)	Yes 5	Yes	Yes	Yes
Mantsopa (Ladybrand)	Yes 5	Yes 5	Yes 5	Yes 5
Phumelela (Warden)	Yes 5	Yes 5	Yes 5	Yes 5
Setsotho (Ficksburg)	Yes 4, No 1	Yes 5	Yes 4, No 1	Yes 4, No 1
All municipalities	Yes 24 (96%) No 1 (4%)	Yes 25 (100%)	Yes 24 (96%) No 1 (4%)	Yes 24 (96%) No 1 (4%)

During the study the researcher completed the observation checklists and the Setsoto local municipality was the only dumping site of the five selected, which indicated that there is no waste burning, no foul smell and no vermin and disease-carrying vectors during the time of the research.

Table 4.18: Uncontrollable dust and stagnant water on site in Thabo Mofutsanyana Municipalities

Municipalities Thabo Mofutsanyana	Uncontrollable dust n = 5	Stagnant water n = 5	Blocked stormwater drains n = 25	Waste heaps n = 25	Children playing on- site n = 25
Dihlabeng (Bethlehem)	Yes	No	Yes= 0 (0.00 %) No= 5 (100%)	Yes= 5 100% No= 0 (0%)	Yes= 3 (60%) No= 2 (40%)
Maluti-A- Phofung (QwaQwa)	Yes	No	Yes= 1 (20%) No= 4 (80%)	Yes= 3 (60%) No= 2 (40%)	Yes= 4 (80%) No= 1 (20%)
Mantsopa (Ladybrand)	No	Yes	Yes= 0 (0.00%) No= 5 (100%)	Yes= 5 (100%) No= 0 (0.00%)	Yes= 2 (40%) No= 3 (60%)
Phumelela (Warden)	No	Yes	Yes= 0 (0.00%) No= 5 (100%)	Yes= 4 (80%) No= 1 (20%)	Yes= 1 (20%) No= 4 (80%)
Setsoto (Ficksburg)	No	Yes	Yes= 2 (40%) No= 3 (60%)	Yes = 4 (80%) No= 1 (20%)	Yes= 1 (20%) No= 4 (80%)
All municipalities	Yes 1 (25%) No 4 (75%)	Yes 4 (80%) No 1 (20%)	Yes 3 (12%) No 22 (88%)	Yes 21 (84%) No 4 (16%)	Yes 11 (44%) No 14 (56%)

During landfill site inspections, the researcher observed that at Dihlabeng and Maluti-A-Phofung landfill sites, uncontrollable dust was emitted. There was no stagnant water on these sites, while stagnant water was observed on Mantsopa, Phumelela and Setsoto landfill sites. Living close to a landfill site causes severe problems for residents, such as air pollution, water and soil contamination and impact on community health. The causes of the health problems are caused by continuous exposure to chemicals, inhalation of toxic vapours and fumes emitted from the landfill sites (Amkieh, 2021; Njoku, Edokpayi, and Odiyo, 2019).

4.4.3 Environmental degradation and gaseous emissions at waste disposal sites

The almost exclusive reliance on landfilling for waste disposal exacerbates inefficient waste management and service delivery in South Africa. In 2018, about 75% of the waste generated in South Africa was landfilled. This practice was then and is still used due to the slow response to the National Waste Management Strategy and the lack of

adequate measures to use waste as a resource through re-use, recycling and recovery, and to devise measures to protect the environment while enhancing economic and social development as proposed by the United Nations Environment Programme (UNEP) (2020). Landfilling and open dumping have been common MSW disposal practices all over the world for many years. For example, in 2018/2019, MSW landfilling in the USA was 52.6%, in Brazil it was 59.1%, in The Kingdom of Saudi Arabia (KSA) it was 85%, in Malaysia it was 94.5%, in China it was 79%, and in Venezuela sanitary landfilling was 32% for controlled and 43% for non-controlled disposal, and in Mexico, MSW sanitary landfilling was 65%, while uncontrolled and open dumps amounted to 30% and 27% was recorded in Thailand 27% (Vaverková, 2019).

Landfilling is as old as mankind and still seems to be the most common and popular waste management choice in most developing countries. However, landfilling has been highly criticized as this waste disposal method is regarded as the opposite of sustainability because of the health hazards and environmental burden they pose.

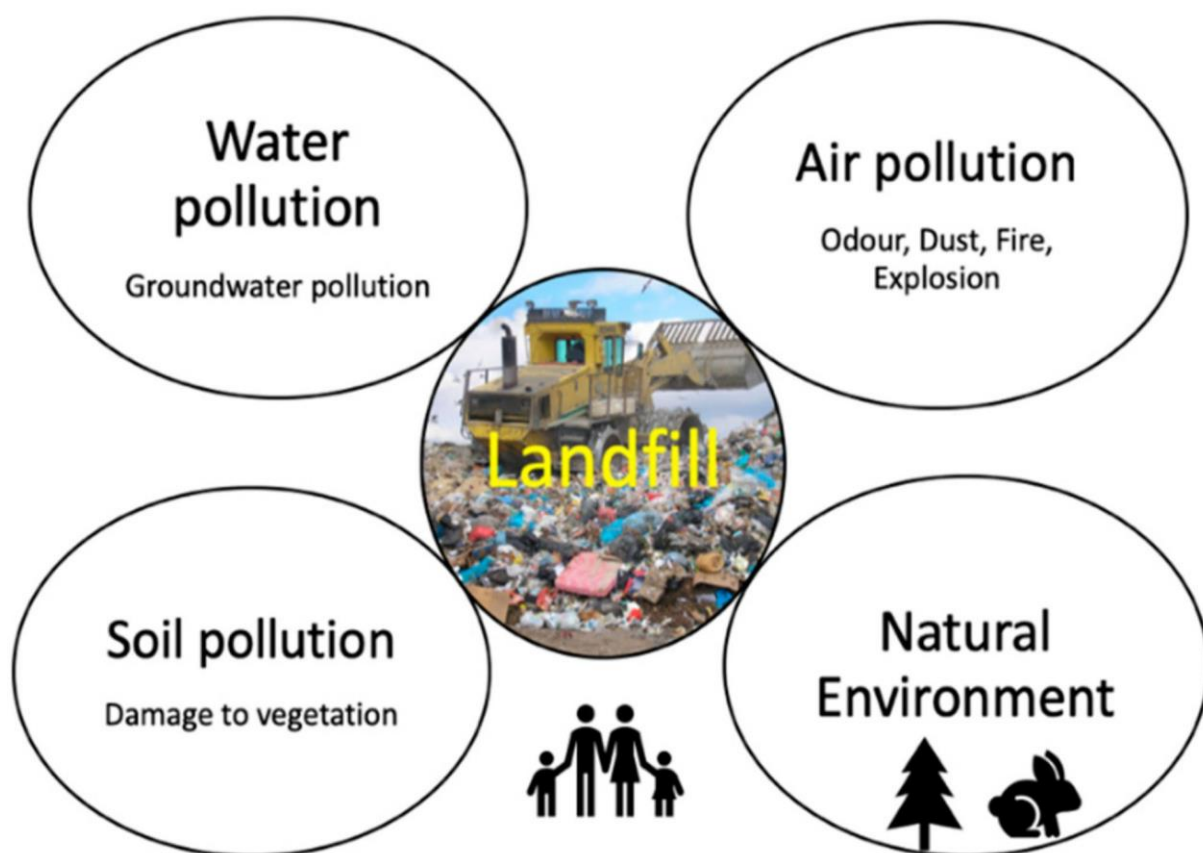


Figure 4.25: Potential impact of landfills on the environment (Vaverková, 2019)

Tables 4.17 and 4.18 clearly indicate that soil pollution, for example uncontrollable dust occurs on two landfill sites, while stagnant water at three landfill sites contributes to water pollution. The natural environment is negatively affected by windblown litter on all five landfills.

The primary cause of the harmful nature of landfills is the accumulated quantity of waste which generates methane, a high volume of leachate, and the indiscriminate dumping of hazardous and decomposing waste (Osazee, 2021).

The most common methods of waste disposal in informal areas in African countries is to dump it near streams or at uncontrolled and semi-controlled open dumping sites without precautionary measures to limit the leachate or protect the groundwater. Engineered landfills that ensure gas recovery, proper waste collection, and a scientific infrastructure are a viable alternative to open dumping as they mitigate environmental impacts while they recover energy as well (Adeleke, 2021). The groups of people who are most at risk due to the unscientific disposal of solid waste include residents in areas where there is no suitable waste disposal facility, and those most affected are pre-school children, the elderly, and waste workers. Other groups that are at high risk include people who reside adjacent to a waste dump or landfill as well as those whose water supply has become polluted because of leakage or leachate from dump or landfill site (Khodani, 2019).

Biological, physical, and chemical transformation occurs in buried waste, to the extent that a landfill is referred to as a reactor and, due to these reactions, gas and leachate are produced at landfills sites. Although methods such as insulation of the landfill and daily covering are used to reduce the environmental consequences of landfilling, the characteristics of the leachate may have dire consequences for the environment. Leachate is a liquid that is generated by decomposing solid waste and it is produced due to moisture in the landfill and chemical and physical reactions. Leachate has been flagged as a severe source of environmental pollution due to the presence of organic and inorganic substances and heavy metal particles in it, that affect groundwater (Beinabaj, Heydariyan, Aleii, and Hosseinzadeh, 2023).

Table 4.19: Additional observations at landfills

Municipalities	Site boundaries demarcated/ No unauthorised access	Notice boards display tariff	Security guards at gate	Waste and squatting on-site
Dihlabeng (Bethlehem)	Yes	Yes	Yes	Yes
Maluti-A- Phofung (QwaQwa)	No	No	No	Yes
Mantsopa (Ladybrand)	No	No	No	Yes
Phumelela (Warden)	No	No	No	Yes
Setsoto (Ficksburg)	No	No	No	Yes
Landfill site resources and sanitary landfilling practices				
Municipalities	Mobile plants on-site	Adequate staff available	Compaction Practised	Is waste covered daily?
Dihlabeng (Bethlehem)	Yes	Yes	Yes	Yes
Maluti-A- Phofung (QwaQwa)	No	No	No	No
Mantsopa (Ladybrand)	No	No	No	No
Phumelela (Warden)	No	No	No	No
Setsoto (Ficksburg)	Yes	No	No	No

The researcher completed observation checklists at five landfills. Dihlabeng landfill site is almost compliant with minimum requirements and four other landfills are not compliant and aesthetically unsatisfactory (Table 4.19). Only Dihlabeng landfill site is fenced with wire and has security personnel present at the gate and has a notice board displaying the types of waste accepted and operation hours (Figure 4.13). Mobile plants were available for waste compacting at Dihlabeng and Setsoto landfill sites. During the visits to the other four landfills, it was observed that they were non-compliant and waste burning was taking place at Phumelela (Figure 4.16), Mantsopa (Figure 4.17), and no waste compaction was done and there was litter blown around by the wind. Due to the poor quality of fencing at Setsoto landfill, cattle were observed scavenging onsite (Figure 4.19). Only Dihlabeng landfill is compacting waste daily. There are people reclaiming waste at all five landfills and they are selling waste to buy back centres. The observation checklists proved that the general condition of landfill sites is unsatisfactory and unacceptable. Priority should be given to landfill sites and to ensure that the final disposal of waste is compliant and environmental degradation minimized.

4.4.4 Recycling in the study area

In the MSW management process, recycling is divided into the formal waste recycling sector and informal recycling by waste pickers. The municipal waste treatment system comprises a complete industrial chain, from collection to decomposition/disposal to disposal/recycling, and there are some professional waste recycling companies that perform these tasks at a highly professional level. The informal sector, which mainly includes waste pickers, waste traders, and buy-back centres, is unable to sustain a comprehensive industrial chain and, instead, deals with two links of the chain: collection and the simple classification and sorting of waste which is purchased by buy-back centres. In fact, some municipal cleaners also pick recyclables from streets or waste transfer stations and then sell these to buy-back centres. The waste that is recycled by buy-back centres eventually flow back into the formal waste recycling sector. Thus, the informal waste recycling sector complements the formal sector, and it not only relieves the disposal pressure of MSW but also enhances the economic value of recyclable waste in the MSW management chain (Chen, Luo, and Ma, 2018).

Recycling endeavors by both waste pickers and larger enterprises that sorted and collected recycled waste from both dumps and landfills, is evident in the study area. It was observed that these waste streams generally comprised of plastics and glass, and these items were placed in large waste receptacles for transportation to buy-back centres. This informal form of recycling ensured both a livelihood for the pickers and resulted in large volumes of MSW being removed from the landfills and dumpsites.



Figure 4.26: Mantsopa LM: Buy-back centre (© Lepheana: 20/09/2023)

Figure 4.26 depicts the types of waste which is accepted at the buy back centre in the Mantsopa local municipality.

However, as there is no formal control of these workers or evidence of the volumes of waste they removed, it is argued that no scientific calculations can be made to determine the actual impact that these operations might have on the nature of the remaining landfill and dumpsite waste and its composition.



Figure 4.27: Mantsopa LM: Waste sorted according to type outside the buy-back centre (© Lepheana: 20/09/2023).



Figure 4.28: Dihlabeng LM: Dilapidated waste recycling centre (© Lepheana: 14/06/2023).

The recycling centre at the Dihlabeng local municipality is no longer functional, (Figure 4.28) and waste reclaimers are dependent on companies to come and buy recyclables and have indicated to the researcher that sometimes they have to wait for a long time, having to store their collected waste because there are few people who buy waste and there are many of them recycling waste at the landfill site.

4.5 Conclusion

This study that was conducted in the TMD found that the residents who lived in the vicinity of dumpsites and landfills were aware of waste collection services, but they did not actively engage in waste separation at source as they deemed it the sole responsibility of the municipality. Most of the respondents expressed their dissatisfaction with current waste collection services, arguing that the municipalities did not collect waste regularly; hence, they resorted to open dumping. There was evidence of prolific illegal dumping in the district as is indicated in the images in Chapter 4 and Chapter 5, and it was evident that the municipalities did not do enough (or anything) to remedy this situation and to adhere to their mandate of ensuring a clean environment for all.

Personnel working in the waste management field indicated that the employers (municipal managers) did not provide regular training to improve their professional development. The provision of personal protective equipment was also not satisfactory as employees were working without proper PPE.

Literature affirms that waste management in developing countries is unfavourable, unsatisfactory, and unacceptable (Zohoori and Ghani, 2017). The inappropriate management of solid waste causes air, land, and water contamination and poses hazards to human health and the environment. Therefore, despite high expenditure and lip service, the situation will continue to degrade further because of the unprecedented growth of urban areas that will continue over the next few decades. Globalization also exacerbates the volumes of mounting waste that need to be collected, transported, and disposed of, further straining the SMW capacity of cities in developing countries in Africa, Asia, and Latin America (Zohoori and Ghani, 2017).

When municipal workers go on strike in South Africa as was referred to earlier, they resort to upturning waste and strewn litter around city centres and even residential areas. Striking MSW collection workers express their rage against municipal authorities and city managers for what they describe as these people's arrogance and lack of unaccountability in ensuring sustainable livelihoods and appropriate salaries for workers. The waste that is dumped in city centres is an expression of a class struggle and class power, and workers resort to this behaviour as their most effective weapon. Such actions are indicative of a frictional society, and this culture of littering occurs at the public's expense due to associated remedial costs and public health risks (Valavanidis, 2023).

Solid waste management is a major problem for the governments of developing nations, and it is one of the biggest challenges that municipalities face. Many factors need to be considered when waste management is planned, ranging from activities like waste generation, waste minimisation and avoidance, source separation, storage, handling, transportation, recovery and recycling, treatment, and disposal. Other factors include distribution of bins, the size of waste receptacles compared to waste generation capacity, population growth and population density, educational level or environmental awareness, data management of the waste information system, law enforcement, collection methods/models, road networks and infrastructure, collection time frames, collection vehicles, visibility of workers (waste pickers, street sweepers, and municipal collectors), solid waste visibility, cleanliness, greening initiatives, sewage spillages, illegal dumping, and waste disposal facilities (landfill sites). The manner in and the effectiveness with which these parameters are managed determine how the system of waste management should be coordinated and conducted (Buso *et al.*, 2014). The rapid growth of urban populations and increasing volumes of waste have made many cities dirty and unsightly, which poses a challenge to residents. To keep the environment hygienic, clean, and green, the monitoring of waste and the way it is treated and disposed of are vital (Gläser, 2022).

Solid waste collection is currently the fifth most dangerous job in the United States due to the number of fatal accidents involving employees. Shocking statistics have shown that thousands of solid waste workers suffer waste-related injuries and illnesses

annually, and waste collection vehicles are involved in thousands of accidents each year. As a result, the solid waste industry has developed safety education programs for workers and for the general public (Rogoff and Biderman, 2015). A widely accepted notion is that solid waste collectors do not need training on the basis that the qualification of being a collector is the willingness to work under unsanitary conditions which needs to change (Poswa, 2001). Moreover, waste segregation at household level needs to be implemented by all households, not just a few, and waste collection efficiency needs to be improved by increasing door-to-door collection (Choudhary, Kumar, Kumar, and Verma, 2022).

According to the minimum requirements for waste disposal by landfill, site selection is a fundamental step in the development of a landfill. This step has far reaching-economic, environmental, and public acceptance implications (Mathivha, 2023). Solid waste management facilities should be environmentally friendly, economically sound, and socially acceptable because, if they are not, their existence may be opposed. Municipalities and businesses have yet to implement waste management measures that guarantee environmental protection and sustainability as they are still attached to the old system of collection and disposal. Informal waste pickers play a vital role in recycling and have already started implementing environmentally friendly waste management outcomes by reducing waste at dumpsites and landfills (Mathivha, 2023). However, the current study questions the real impact of their activities as there are no official data to determine the outcomes of their operations in terms of the volumes and waste streams, they recycle versus the residue of untreated waste left at landfills and dumpsites. Future studies should therefore explore this gap in the pool of knowledge as a matter of urgency.

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CHAPTER 5

GENERAL DISCUSSION

5.1 Introduction

This chapter covers aspects that were not discussed in depth in the previous chapters. A key point that is raised is that proper solid waste management is neglected by municipalities as well as communities. The discourse in this chapter addresses the broader context of proper waste management systems within communities and highlights the disadvantages of such systems if they are not properly implemented.

Various factors that contribute to waste diversion for a circular economy are highlighted, such as:

- The privatization of MSWM services;
- Municipal solid waste management strategies;
- Recognition of waste recyclers;
- Management of waste in rural areas; and
- Enforcing waste legislation and international agreements.

5.2 The privatization of municipal solid waste management (MSWM) services

Regardless of its importance to a healthy and aesthetically pleasing environment, appropriate solid waste management in most African cities remains highly unsatisfactory. Cities and towns that experience rapid population growth and expansion in developing countries often lack resources and institutional capacity to provide adequate solid waste management services (Phonchi-Thekisho, Mmopelwa, and Chanda, 2020). For instance, the Lobatse Town Council, who is responsible for the management of this town in the southern district of Botswana, has taken steps towards the privatization of waste management services to reduce the cost and improve the efficiency of solid waste collection, and the Council has committed itself to guaranteeing a frequent and efficient solid waste collection service (Phonchi-Thekisho, Mmopelwa, and Chanda, 2020).

Although local governments are obliged to execute their waste management mandate efficiently and equitably, municipalities in developing countries, including Oman in West Asia, are often burdened by increased demands for proper waste management due to insufficient capacity, insufficient manpower, and lack of financial and technical capacity (Al Zadjali and Jantan, 2022). Solid waste management costs are estimated to range between 20 to 50% of municipal revenue. However, collection rates remain low, with only between 50 to 70% of the population receiving a waste collection service (Al Zadjali and Jantan, 2022).

As previously discussed in chapter 4, in Figure 4.5, the total number of people that indicated that they receive regular collection is only 10% and most of these respondents, 87%, indicated they do not receive regular waste collection and only 3% are not aware whether the service is regular or not. Dihlabeng, Phumelela and Setsoto recorded no respondents out of 20, who were satisfied with waste removal. Waste collection in communities remains very low and one of the reasons for this is because residents do not pay for waste removal services. Figure 4.3 indicates that 35% of residents do not pay for waste removal and they depend on municipalities for waste collection. Every town in the study has many dumping sites and it is evident that the municipality alone is failing in the function of waste collection.

The consequence of this is that many local governments engage private municipal waste service providers instead. The privatization of waste collection requires private sector participation and the devolution of power to local government/city councils. Some countries pursue employment partnerships that allow the private and public sectors to jointly develop plans and share the responsibility for providing waste management services, and their agreements include contracts, franchises, divestment, concessions, and open competition (Al Zadjali and Jantan, 2022). The two most applied privatization methods for waste management are contracts and franchising, and these services include waste collection, disposal, cleaning, and transportation to disposal sites. Some countries pursue private-public partnerships that allow the private and public sectors to jointly develop a plan and share the responsibility for providing solid waste management services to all citizens (Al Zadjali and Jantan, 2022; Phonchi-Thekisho, Mmopelwa, and Chanda, 2020). One of the classic arguments for contracting in a private service is that

it saves costs for the government, which affirms the efficiency of the private sector. There are two main debates around the privatization of waste management services. On the other hand, the philosophy that private firms provide relatively cheaper and better services than the public sector is based on the assumptions that there is competition between private firms, that public officials have the capacity to monitor and enforce service contracts between government and private firms, and that contracted private companies will provide cheaper and better public services than the government (Phonchi-Thekisho, Mmopelwa, and Chanda, 2020).

While privatization has been implemented in different ways by various public agencies, a structured approach consisting of the following three basic steps tends to improve the chances of successful privatization:

- A performance-oriented statement of work is prepared describing solid waste service requirements and the work to be executed
- The agency performs a comparison study of in-house versus contactor costs and
- A thorough contract monitoring system is developed (Rogoff, Moyers, Leonard, and Gardner, 2015).

Proponents of waste services privatization argue that, in contrast to the public sector, the private sector improves efficiency and lowers costs by adhering to commercial principles. However, some of the constraints associated with the privatization of waste management services are a lack of sufficient information about the contracted services and an inadequate regulatory framework, and these factors often result in inefficiency. Rather than creating greater cost control, the privatization of WM services considerably diminishes the ability of governments to control costs as it leads to monopolistic markets and wily contractors that dictate prices (Bolaane and Isaac, 2015). Furthermore, it was found that the major challenges of local authorities that contracted out waste collection services were weaknesses in the implementation of formal contracts, ineffective monitoring of the performance of contractors, and the inability to define the scope of contractors and set performance targets. Privatization alone may therefore not necessarily provide a solution to waste management challenges in developing countries; hence, advocates for a tripartite arrangement propose a collaborative system that

involves the public sector, the private sector, and community representatives (Bolaane and Isaac, 2015).

5.3 Municipal solid waste management strategies

A waste management strategy is a plan or policy to achieve the overall aim of sustainable waste management from the point of generation to final disposal. SWM strategies are applied alongside the waste management hierarchy that includes waste prevention, reduction, recycling, recovery, and disposal (Jolie, 2021).

Strategies for waste utilization and reduction involve the selection and implementation of appropriate practices, technologies, tools, and infrastructure as all these are necessary to achieve a sustainable waste management system. According to the principles of the Integrated Solid Waste Management (ISWM) approach, every sustainable waste management schedule must include the following strategies:

- Prevention of the generation of avoidable waste;
- Reduction of generated waste through recovery;
- Reuse of recovered waste;
- Recycling of recyclable waste;
- Composting of organic waste for energy/electricity generation; and
- Disposal at sanitary landfills.

Many communities around the Thabo Mofutsanyana District are not aware of the importance of separation of waste at source and the benefits that comes with it, as according to Figure 4.6, only 20 participants from the study separate waste at source, and in Mantsopa local municipality no interviewed participants separate their waste at source. A total of 78 respondents do not separate waste and are probably not even aware of the benefits that come with proper waste management from point of generation. Many residents still believe that it is the responsibility of municipalities to manage and collect waste. Regular awareness campaigns should be conducted in communities to sensitise residents about waste management strategies and waste hierarchy.

When proper consideration is taken of the environmental, economic, and social factors peculiar to a particular location, these principal aids waste managers with the implementation of a sustainable SMW management system (Ugwu, Ozoegwu, Ozor, Agwu, and Mbohwa, 2021). Moreover, the proper characterization of MSW is crucial if efficient and sustainable waste management strategies that address the challenges of energy security and environmental sustainability are to be employed (Zargar, Alam, Khan, Alam, Abutaleb, Hasan, and Khan, 2023).

5.4 The role of informal waste recyclers and waste pickers

Municipal solid waste management is referred to as formal waste management, while unregistered citizens who are involved in waste collection are referred to as informal waste collectors, or waste pickers. Informal and formal waste collectors have a mutually beneficial relationship because their functions promote environmental sustainability while their waste recycling activities reduce poverty in marginalised communities (Tshifularo, 2021).

Table 5.1: Waste pickers collecting waste in communities

Name of municipality	Never n (%)	Sometimes n (%)	Often n (%)	Very often n (%)	Total n (%)
Dihlabeng	16 (80)	2 (10)	1 (5)	1 (5)	20 (100)
Maluti-A-Phofung	8 (40)	6 (30)	3 (15)	3 (15)	20 (100)
Mantsopa	17 (85)	3 (15)	0 (0.0)	0 (0.0)	20 (100)
Phumelela	7 (35)	10 (10)	3 (15)	0 (0.0)	20 (100)
Setsoto	17 (85)	2 (10)	0 (0.0)	1 (5)	20 (100)

In many communities there are usually waste recyclers who separate and collect waste at the kerbside or collect waste for selling. Table 5.2 indicates that many respondents said they never saw any people separating and collecting waste and Mantsopa and Setsoto recorded a total of 17 respondents each accounting to 85% of the respondents of these areas respectively. Phumelela has recorded the least number, seven respondents, that has never seen waste pickers collecting waste, a total of 10

respondents who confirmed that they sometimes see people collect waste and has recorded a high number when compared to other local municipalities. Maluti-a-Phofung has most respondents that have seen waste pickers very often with 15%, even though it is a small fraction but at least there are people who make a living through waste recycling. The role waste pickers play in reducing the amount of waste joining the waste stream is important and has financial and environmental benefits.

The flow of waste in South Africa is divided into two components: the service chain and the value chain. The value chain involves the generation, collection, and disposal of waste at municipal level. Value chain processes involve adding value to generated waste by recovering it for reuse and recycling it by selling it to buy-back centres, exporting waste for further use, and the reuse of recycled end-products. The informal sector is essential in bridging the service and value chains through its role in supplementing municipal waste services and promoting reuse and recycling through waste picking (Nyika, Onyari, Mishra, and Dinka, 2019). This study indicates that there are not many waste recyclers in the communities and there is still a need to make residents aware of the benefits that proper waste management can bring to residents.

Waste pickers have become part of South African cities' urban lifestyle. For instance, we see numerous people pulling trolleys and shopping carts down the streets in various urban areas with their trolleys filled with recyclable materials picked up from the kerbside, extracted from waste landfill sites, and harvested from household dustbins across Johannesburg's suburbs. These waste pickers all share one goal: selling these recyclables at buy-back centres to make a living (Mvuyane, 2018). In this study the researcher has observed people living at landfill sites solely for the purpose of reclaiming waste. They put recyclables in bags and sell them to buy back centres to earn a living.

Waste pickers collect waste and waste materials from landfills, waste bags, and bins on streets or from dumpsters. Sometimes they have an arrangement with businesses and gain access to materials that have especially been set aside for collection. A report compiled in 2009 estimated that the number of waste pickers in South Africa's informal economy was between 45 000 and 85 000. This number has increased significantly over

the years (Xulu, 2018). In 2016, it was estimated that South African waste pickers formed part of this informal industry in developing countries that had over 15 million waste pickers (Mvuyane, 2018).

Table 5.2: Waste picking and squatting on landfill sites

Name of municipality	Yes n (%)	No n (%)
Dihlabeng	1	0
Maluti-A-Phofung	0	1
Mantsopa	0	1
Phumelela	1	0
Setsoto	1	0
Total (n)	3	2

During the visits at landfill sites, it was observed that only two sites did not have people squatting onsite and three other sites were having waste reclaimers (Table 5.2). A total of five landfill sites were visited where each town is disposing of their waste. There was quite a high number of waste pickers at Dihlabeng, and according to the size of the town, there were many people doing waste picking, when compared to other local municipalities.

The environment in which waste pickers conduct their business is often described as hazardous and dangerous to their health and safety. The biggest challenges that waste pickers face are harassment, forcible removal, abuse, and arrest by local municipal officials. They are often treated as a nuisance by local municipal officials and community members, and they are therefore often manhandled violently by the police. Furthermore, waste pickers sell their collected materials to middle agents who often intimidate and exploit them (Xulu, 2018). Many waste pickers in Dihlabeng and Maluti-a-Phofung reported to the researcher that middle agents who buy waste do not give them enough money for the kilograms per waste type they sell, because they are actually the ones doing hard labour but only receive a small fee for their hard work and middle agents sometimes take a while before they come to buy from them, which means that they end up struggling to provide for their families.

The informal solid waste management sector's structure resembles that of a pyramid. At the base of the pyramid are the waste pickers who actively engage in the collection of recyclable solid waste, above them are the buy-back centres that purchase these recyclables from them, and on the top of the pyramid the big corporate re-processors are located, who gain huge profits from the hard labour of the forgotten 'grass rooter', or waste picker. The low social status of solid waste pickers has led to misrepresentation of the role of waste pickers which caused bias of businesses towards these people who provide a crucial service to the country (Mvuyane, 2018).

Over and above these above challenges, waste pickers face occupational hazards. Many of them lift and haul heavy loads and work with machinery and equipment that can cause physical harm. The health risks they face include contact with fecal matter, handling paper saturated with toxic materials, collecting bottles and containers with chemical residues, being pricked with dirty needles, and touching and handling heavy metals released from batteries (Xulu, 2018). Studies have stated that formal waste pickers are often far more protected compared to informal waste pickers (Mohale, 2021). Formal waste pickers are normally provided with training, hygienic tools, and personal protective equipment (PPE), while informal waste pickers cannot afford any protective gear (Mohale, 2021).

All five local municipalities, as shown in Table 4.12, provide their municipalities with PPE though it is not sufficient, and many employees were complaining to the researcher that they end up buying PPE from their salaries because the employer takes their time to provide it. The Setsoto municipality is the municipality in this study that provided most of the PPE (overalls, gloves, safety boots and face masks).

Plastics SA, 2019, South African plastic recycling manufacturing provided approximately 58 750 people with informal income opportunities in 2019, which suggests that investment in recycling can reduce the amount of waste and provide employment opportunities, which can be a key livelihood contributor that helps marginalised communities to gain employment (Ngalo and Thondhlana, 2023). Recycling strategies should consider the valuable prevalence of informal waste pickers as recent studies

have suggested their role in the waste management hierarchy is more important than ever; yet they are continuously marginalised in the formulation of waste management policies and strategies (Ngalo and Thondhlana, 2023).

5.5 Waste management in rural areas

The solid waste generated in rural areas contains more than 50% organic waste, while the rest is inorganic. The average waste generation rate is 0.3 to 0.9 kg/capita/day in various rural areas of different countries. Agricultural and animal waste are major components of the organic proportion of rural waste (Patwa, Parde, Dohare, Vijay, and Kumar, 2020). This study was conducted in the Thabo Mofutsanyana District and mostly comprised of rural towns where the researcher observed that a larger percentage of inorganic waste, cardboard, plastic bottles and other types of waste was generated, contrary to other studies where more organic waste was generated.

People in rural areas use various methods to manage their solid waste, but some of these may have significant effects on the ecosystem, and this situation will not improve if the status quo persists (Rabonda, 2023). For instance, not all the local municipalities in the Ngaka Modiri Molema District Municipality, in North-West Province receive solid waste collection services of the same standard. It seems that this issue is associated with the categorization of residents' housing status that may range from those who live in low-cost homes and informal settlements in rural areas to those who have homes that can be afforded by the middle class and the affluent (Tsotetsi, 2023). The study mainly focused on township residents because in most cases they are not paying tariffs for basic services, solid waste removal being one of them.

The absence of formal waste collection systems in the rural communities of Lesotho is a concern from both environmental and health perspectives. Uncollected and inappropriately discarded household waste, including soiled nappies, food waste, sand and gravel, paper, plastics, packaging, metal, and glass, are known to contribute to several environmental impacts while also posing human health risks (Senekane, Makhene, and Oelofse, 2022).

The literature reveals various gaps in our knowledge of the waste management phenomenon. For instance, light still needs to be shed on aspects that affect rural areas such as a lack of waste information systems (WISs), a lack of health education regarding the proper management of waste, the lack of legislative frameworks that govern SWM, insufficient management of solid waste due to poor implementation of laws and policies, and the negative impacts of waste on humans' well-being and the environment (Senekane, Makhene, and Oelofse, 2022). Table 4.6 indicates that there is a need for the municipalities to conduct regular awareness campaigns in communities, as a total of 62% of the respondents indicated that they have never been exposed to any awareness campaigns and only two percent said they always receive campaigns, one respondent in Dihlabeng and one in Mantsopa local area.

Dumping solid waste in open areas without treatment is common in rural areas, more specifically in developing countries. In China, between 30 and 60% of solid waste is dumped in rural areas, depending on the region. The rapid escalation of solid waste generation in rural areas of developing countries has led to rapid deterioration of rural environmental quality. The inappropriate disposal of solid waste causes diseases and secondary water pollution and leads to the emission of harmful substances that endanger the health of rural residents (Wang, Cheng, Reisner, and Liu, 2018). Moreover, most rural residents in developing countries do not follow recommended waste collection practices due to factors such as low environmental awareness and lack of information on the hazards posed by waste. They also have diverse and very traditional cultural beliefs and practices that are inappropriate in current conditions, or they are affected by structural challenges such as a lack of waste collection facilities in small villages (Wang *et al.*, 2018). Therefore, due to different socio-economic conditions, climate, geography, culture, and population density, considering those factors that influence domestic waste characteristics has become very important in the management of solid waste and in implementing waste reduction and recycling strategies in the rural areas of developing countries (Han, Liu, Zhong, Shi, Li, Zeng, Zhang, Fei, and Xie, 2018). In the study the researcher observed that the municipality is not sufficiently collecting waste within communities and the residents are aware of waste collection schedule/days, but the municipality fails to deliver the service. Most of the roads are accessible and streets are wide enough for waste collection trucks to maneuver. There are no specific waste tradition techniques that were observed during the study.

It seems inevitable that a reasonable and affordable fee system for domestic waste management needs to be developed. Urban residents are already accustomed to paying for waste disposal fees; however, the income of rural residents is generally much lower than that of urban residents, and most rural residents lack environmental awareness and still entertain the idea that environmental sanitation is the responsibility of the local government. Many are thus not willing to pay for waste disposal, and this attitude should be clearly understood and appropriately addressed to achieve sustainable waste management in rural areas (Xu, He, Qing and Zhang, 2023). There is a no payment system, and everybody just comes and dump waste and no one is controlling where waste should be dumped in four of the municipalities in the study, except for Dihlabeng.

5.6 The need to enforce waste legislation and international agreements

Escalating waste volumes and the complexities of MSW that are associated with a modern-day economy and rapid urbanisation pose a severe risk to ecosystems and human health. Efficient management of MSW has been a serious problem for government departments, pollution control agencies, regulatory bodies, and the general public, especially in developing countries. Consequently, governments in high-, middle- and low-income countries have adopted various policies and legislative frameworks to minimise and control the overwhelming increase in MSW. In Kenya, the government has implemented several policies and acts to address the increasing solid waste management challenges that are experienced in the country's urban centres (Amugsi, Muindi, and Mberu, 2022). Earlier, in 2021, the Ethiopian government adopted MSWM policies and legal frameworks to reduce and hopefully eradicate the environmental and human health impacts caused by improper waste management practices (Hirpe and Yeom, 2021). Developing countries have prepared policies to ensure more effective waste management, but the application and implementation of these policies have been inconsistent. For example, in Kenya, Cameroon, and South Africa, the poor implementation and limited enforcement of well-designed waste management frameworks have been critiqued by various authors (Kubanza and Simatele, 2019; Ike, Ezeibe, Anijiofor, and Nik Daud, 2018; Makamba, 2022). Therefore, although various related policies are an effort to ensure improvement in environmental and public health quality, they have not been successful in terms of MSWM. To ensure that the goals of WM policies are attained, it is necessary to monitor the results that have been achieved so that further government interventions can be planned and implemented (Cetrulo,

Marques, Cetrulo, Pinto, Moreira, Mendizabal-Cortes, and Malheiros, 2018). The success of environmental policies is generally evaluated according to their relevance, persistence, flexibility, and efficiency, while determining their output (performance levels), outcome (social change), and impact (environmental change) is also important (Cetrulo *et al.*, 2018).

The main objective of waste management policies is to exploit the critical resources that are embedded in obsolete products (D'Adamo, Mazzanti, Morone, and Rosa, 2022). During the last few decades, experts have developed several guidelines to improve the design and implementation of waste and water management policies with the aim of protecting the environment and saving natural resources through recycling (D'Adamo *et al.*, 2022). Policies, rules, and guidelines at both global and national levels are vital for MSWM, but unfortunately policy barriers in developing countries impede about 75% of the efficacy of solid waste mismanagement outputs (Muheirwe, Kombe, and Kihila, 2022). A critical component that ensures the operation of a highly advanced SWM system is the government's ability to implement existing policies/regulations and to issue new regulations and laws in line with requirements for the transition towards adopting sustainable solutions within the framework of waste management and the circular economy (Hemidat, Achouri, Fels, Elagroudy, Hafidi, Chaouki, Ahmed, Hodgkinson, and Guo, 2022).

It is noteworthy that rural residents are direct beneficiaries of and important participants in domestic waste management, yet (Xu, He, Qing, and Zhang, 2023) state that a payment system for domestic waste management in many rural areas has not been implemented or enforced in China, arguing that it is an oversight that is possibly exacerbated by residents' relatively weak environmental awareness and low-income levels. Many people in South Africa rely on social grants as an important source of income, as well as pensions, disability and child support payments and cannot afford to pay waste disposal services (Omotayo, Omotoso, Daud, Ogunniyi, and Olagunju, 2020).

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CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This study was conducted to address the issues related to poor solid waste management within local municipalities in the TMD and to explore the negative impacts these challenges have on people and the environment. The targeted population was residents who lived near illegal dumps and landfill waste disposal sites as well municipal employees in the respective solid waste management directorates of the municipalities under study.

6.2 Aims and objectives of the study

The main aim was to determine if satisfactory waste management services were rendered to residents in the selected municipalities. A secondary aim was to explore the negative impacts resulting from improper waste management on residents in these communities, particularly in terms of their exposure to potential health-threatening infections resulting from illegal dumping. It was therefore important to determine which improper practices were conducted by community members, particularly as heaps of accumulated and untreated waste near homes were evidence of poor waste management strategies and limited awareness of the implications of this practice. These unsightly heaps of waste also suggested irregular or limited waste collection by the municipalities regardless of their mandate to do so. Other topics were the assessment of the level of awareness of waste management among residents, the frequency of awareness campaigns conducted by municipalities, and the awareness of residents regarding waste recycling. The key objectives were thus to:

- Determine the best mode of communication to inform residents about waste management-related issues;
- Determine the frequency that waste was collected in the respective local municipalities;
- Determine whether waste management personnel had received any training or professional development during the year prior to the study;
- Determine if personal protective equipment (PPE) was issued to municipal waste workers to avoid occupational health and safety risks;

- Evaluate environmental-related issues due to the non-compliance of illegal dumping and poor landfill practices near houses; and
- Utilize the data to make informed recommendations to improve waste management practices in the district under study.

6.3 Conclusions

The findings that are discussed in this section relate to the study objectives that were achieved.

6.3.1 Poor adherence to waste collection schedule

The provision of waste management services was found to be unsatisfactory in all the municipalities that were included in this study, possibly except for the Dihlabeng local municipality where the landfill was operated relatively efficiently. All the municipalities had to operate waste collection according to a weekly schedule (Monday to Friday) and the day of collection depended on the area. However, residents expressed a high level of dissatisfaction with waste collection frequencies as, in some areas, no waste collection had been done for a month and even longer. There was no mode of communication between the residents and the municipalities, and, in most instances, there was the frustrating tendency not to inform residents in advance when no waste collection occurred. They thus put waste containers on the kerbside as required, but these were often not emptied for a long period. It was observed that dogs scavenged on and scattered waste and this made the environment look aesthetically displeasing and dirty.

6.3.2 The prevalence of illegal dumping sites and waste burning in residential areas

The high prevalence of unsightly and illegal dumping sites in residential areas in all the municipalities was visible and this was an indication of poor municipal waste collection. Most residents complained that the municipalities did not provide sufficient waste containers and those that received any argued that they were not large enough for waste storage due to irregular collection frequencies. Most residents resorted to dumping waste in available open areas and this waste accumulated into unsightly and unpleasant smelling waste heaps. In some areas, children were observed playing on these waste

dumps and unintentionally exposed themselves to serious health and safety risks. The residents living near these waste dumps complained of constant headaches, eye irritation, respiratory infections, and other minor health-related conditions.

The residents also resorted to waste burning as a method of waste reduction and those that were directly affected by this practice complained that smoke permeated their households and that they were constantly exposed to odours wafting from these sites. The residents also mentioned that the people that discarded their waste at illegal dumps were usually residents who lived far away, and they were thus not directly affected by the appearance and consequences of these sites. Despite numerous attempts to stop residents from discarding waste at illegal dumps, these attempts were in vain because the complainants never received support from the municipality or ward councilors.

6.3.3 Poor management of waste disposal facilities

It was obvious that the waste disposal sites that were visited, bar one, did not comply with the minimum requirements for waste disposal at landfill. The conditions of and practices at most of the landfill sites were unsatisfactory for various reasons. For instance, there was no supervisor to specify where the waste should be discarded; there was no waste coverage due to inadequate or no mobile plants on-site; no records were kept of the waste entering the landfills; there were no weighbridges to determine waste volumes; and waste generators who came to dump their waste were not required to pay a fee. The fencing around four landfills was in poor condition and this caused unrestricted access to all and sundry while it was observed, and animals roamed and scavenged on these sites. Windblown litter was scattered over surrounding areas and waste was inappropriately burnt on-site. Some waste recyclers were observed, who separated and collected recyclables to make a living. However, these people were exposed to various potential health and safety risks because the environment in which they worked was contaminated with hazardous and decomposing materials and they were also exposed to polluted air.

No scientific equipment was used to measure the volumes of greenhouse gases being emitted into the air and there was also evidence of the possibility of contaminated

underground water due to visible seepage of obviously polluted water. Testing of leachate was not performed as it was beyond the scope of this study.

6.3.4 Limited training of waste management personnel

The municipal personnel indicated that they had received minimum training on health and safety as well as waste management practices. No ongoing/regular training was provided, and some employees had no information about proper waste management at their disposal. The municipalities obviously did not prioritize training or the protection of their workers as the wearing of PPE was not observed.

6.4 Recommendations

Municipalities in South Africa and many developing countries are faced with various challenges related to waste management, and this is more severe in some areas than in others. The communities under study were not satisfied with the waste services provided by their respective local municipalities, and it was evident from the high prevalence of illegal dumpsites that many residents were exposed to an ugly and health-compromising environment while the municipalities rested on their laurels. These municipalities should adhere to their legal mandate and improve the waste services they render to the communities in their areas of responsibility.

6.4.1 Provision of waste receptacles and adherence to waste collection schedule

The residents should be provided with sufficient waste storage receptacles and such receptacles should only be used for the intended purpose. Residents should also receive regular information on how to properly store their waste. Residents must be informed that they will be fined if they use their bins for anything other than storing waste, and this warning should be acted upon decisively if residents transgress.

6.4.2 Conducting waste minimisation and awareness campaigns

Effective solid waste management can be achieved through community participation in waste management activities, and the community should be involved in collaborative decision-making together with other stakeholders. Moreover, local governments should

conduct waste minimization programmes that target affected communities, and they should consider financial incentives to encourage recycling. This will make communities more conscious of proper waste disposal practices and will positively change recycling behaviour at household level.

The municipalities should also run awareness and educational campaigns using multimedia platforms and face-to-face contact to educate the public on the importance of clean-up campaigns and how to dispose of waste in a way that will not compromise the environment and the health of residents. The importance of composting and other waste minimisation strategies should be brought to the attention of residents.

Incorporating solid waste management education in primary, secondary, and tertiary curriculums should be urgently considered to make young people aware of how a positive attitude towards sound waste management practices can enhance the aesthetics and sustainability of the environment.

6.4.3 Training of personnel and the provision of PPE

Municipalities should provide regular training to ensure skills development, and they should provide certification to boost confidence among their workforces. Municipalities should also engage in periodic health assessments by ensuring that waste workers who are directly and constantly exposed to solid waste are regularly examined to determine their health status.

Waste collectors should be provided with proper protective clothing, which should include a respiratory mask, gloves, safety shoes, and overalls. The wearing of PPE during waste collection should be enforced to limit exposure to hazardous substances and injuries on duty.

6.4.4 Allocation of resources and budgetary compliance

It was noted that the enforcement of waste management by-laws was limited in some and non-existent in other areas as illegal dumping occurred everywhere with impunity

as offenders got away with this behaviour and no penalties were ever charged. It seemed evident that sufficient budgets were not allocated for SWM in most municipalities under study as equipment generally appeared old and worn, fencing was a terrible state, and insufficient staff were observed at the landfill sites, and proper waste covering was non-existent. One can only surmise that, if the budgets that were allocated were deemed sufficient, this money was obviously maladministered or the municipal managers had no idea what they were doing as they were mere political puppets, as was alluded to in the discussion earlier.

It was also observed that access to all the landfill sites was uncontrolled. Improving the security of and access to landfill sites by hiring security guards and caretakers and making use of proper, well-maintained perimeter fencing to limit access to everyone coming in and out of landfill sites is recommended.

6.4.5 Law enforcement

The municipalities need to enforce MSW by-laws and other relevant legislation to combat illegal dumping and to enforce compliance. The availability of human resources plays a key role in active compliance and enforcement. The municipalities should employ officers who are responsible for waste management by-law enforcement, and they should fill all vacancies in waste-related posts to enhance capacity.

6.5 Recommendations for further research

Proper solid waste management seemed to be declining in the study area as was evidenced by the presence of sprawling illegal dumpsites near homesteads, obvious environmental degradation, and the collapse of fencing and security measures at the landfills. More research needs to be conducted on the following topics:

- Waste minimization strategies at the point of generation before waste becomes part of the waste stream;
- The nature and role of the circular economy in waste management in this and similar study areas; and
- The proper management of landfill sites and the provision of resources. Future studies should thus explore the absence of the recording of volumes and types of waste that

enter landfill sites and propose strategies to generate revenue and manage landfill gas and odour emissions.

ANNEXURES:

Annexure A: Residents' Questionnaire

FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES



Questionnaire no:

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RESIDENTS QUESTIONNAIRE

MUNICIPALITY SOLID WASTE SERVICE DELIVERY QUESTIONNAIRE IN THABO MOFUTSANYANA DISTRICT, FREE STATE PROVINCE

I, Teele Lepheana, are 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 delivery in Thabo Mofutsanyana District. The questionnaires will be used to assess municipal services within your local area.

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 within the district.

I understand that:

I confirm that I have read and understood the information for the above research.

Even if I agree to participate in the research, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

I will not benefit directly from the research.

I undertake to ensure that the information I provide for this research will be treated with confidentiality.

I am free to contact any of the people involved in the research to seek further clarification and information.

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.

I, _____, give permission to Central University of Technology, Free State to use the information collected only or for the purposes of the study.

Age _____

Address _____

Cell No: _____

Signature: _____

_____ Date

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SERVICES AND HEALTH RELATED ISSUES

Question 1: Does municipality provide waste containers?

1.1 Yes		1
1.2. No		2

Question 2: Indicate in what type of container you store your waste before collection?

2.1. Plastic		3
2.2. Bin		4
2.3. Other (specify)		5

Question 3: Indicate since when have your municipality been collecting waste?

3.1. Before 1990		6
3.2. 1991 - 2000		7
3.3. 2001 – 2010		8
3.4. 2011 – 2015		9
3.5. Do not know		10

COLLECTION METHODS

Question 4: Are solid waste collection services provided for free in your area?

4.1. Yes		11
4.2. No		12

Question 5: Indicate which type of collection method is rendered?

5.1. Kerbside collection		13
5.2. Communal collection		14
5.3. Don't Know		15
5.4. Other (Specify)		16

Question 6: How often is the waste collected?

6.1. Once a week		17
6.2. Once in two weeks		18
6.3. Once a month		19
6.4. Other (Specify)		20

Question 7: Indicate which day of the week does the municipality collect your waste?

7.1. Monday		21
7.2. Tuesday		22
7.3. Wednesday		23
7.4. Thursday		24
7.5. Friday		25
7.6. Don't know		26

Question 8: Does the municipality always collect your waste?

8.1. Yes		27
8.2. No		28
8.3. Don't know		29

Question 9: Does you sort your waste before collection?

9.1. Yes		30
9.2. No		31
9.3. Do not know		32

Question 10: Indicate which recyclables goods are collected by waste pickers?

10.1. Never		33
10.2. Often		34
10.3. Sometimes		35
10.4. Very often		36
10.5. Other (Specify)		37
.....		

Question 11: Are there any illegal dumping sites in the area?

11.1. Yes		38
11.2. No		39

WASTE MANAGEMENT OPERATIONS AND CAMPAIGNS

Question 12: Is there an official disposal site in your area?

12.1. Yes		40
12.2. No		41
12.3. Don't know		42

Question 13: Are there any illegal dumping sites in the area?

13.1. Yes		43
13.2. No		44

Question 14: Are there odours being emitted from the site?

14.1. Yes		45
14.2. No		46
14.3. Don't know		47

Question 15: Is the municipality responsible for solid waste reduction campaigns?

15.1. Never		48
15.2. Sometimes		49
15.3. Often		50
15.4. Very often		51
15.5. Always		52

Comments

**THANK YOU FOR YOUR CO-OPERATION IN COMPLETING THE
QUESTIONNAIRE**

Annexure B: Residents' Questionnaire: Sesotho

FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES



Patlisiso no.

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DIPOTSO KA DIPATLISISO MABAPI LE TSAMAISO YA DITHOLE LEBATOWENG LA THABO MOFUTSANYANA.

Ke nna Teele Lepheana, ke moithuti lefapeng la tikoloho le bophelo bo botle Unibesiting e bohareng ya technology, Freistata. Sepheo sa dipotso tsa dipatlisiso ke ho lekola maemo a ditshebeletso tsa tsamaiso ya dithole ka hare ho lebatowa la Thabo Mofutsanyana. Dipotso ka diplatlisiso ke ho sheba phano ya ditshebelo ka hara lekgotla la motse.

Ba nka karolo ba koptjwa ho fana ka dikarabo tsa nnete, ho thusa ho fihlela sephetho se nepahetseng dipatlisisong tsena. Mabitso a ba nka karolo a tla bolokwa ele sephiri, ela hloko hore ha ho karabo tse nkuwang di nepahetse kapa di fosahetse.

Ho nkeng karolo ha hao dipatlisisong tsena ho bohlokwa haholo ebile ho a ananelwa, hoba ho tla nehela ka dikgothaletso ho ntlafatsweng ha maemo ditshebeletsong tsa tsamaiso ya dithole.

Ke netefatsa hore ke badile le ho utlwisisa lesedi ka di patlisiso.

Ke a utlwisisa hore le ha ke dumetse ho nka karolo dipatlisisong tsena, ke nale tokelo ya ho ikgula nako engwe le engwe kapa ho hana ho araba potso ntle le ho labella ditla morao.

Ke a utlwisisa ha kena ho una letho dipatlisisong tsena.

Ke a utlwisisa ho re lesedi le ke tla fana ka lona le tla bolokwa ele sephiri.

Ke a utlwisisa ho re ke dumeletswe ho ikamahanya le batho nang le seabo diplatlisisong tsena nakong engwe le engwe bakeng sa tlhakisetsa.

Ditaelo

Ka kopo sebedisa pene ho tshwaya karabo e nepahetseng ka letshwao la "X". Qetellong ya dipotso ka dipatlisiso hona le sebaka seo oka fanang ka ditlhaiso ho sona.

Nna ke le _____, ke fana ka tumello ya hore Unibesti e Bohareng ya Tegnoloji Freistata ho sebedisa lesedi le bokelletsweng ka sepheong sa dipatlisisoso.

Nomoro ya Bodulo

Letsatsi

Tekena:

Nomoro ya mohala wa thekeng:

DITSEBELETSO LE DITLWAELO TSA TSAMAIISO YA DITHOLE

Potso ya 1: Na lekgotla la motse le fana ka setshelo sa dithole?

1.1. Eya		1
1.2. The		2

Potsa ya 2: O boloka dithole tsa hao setshelong se jwang?

2.1. Polasitiking		3
2.2. Mogomo		4
2.3. Mokgwa o mong (hlalosa)		5
.....		

Potso ya 3: Bontsha hore lekgotla la motse le qadile neng ho nka matlakala?

3.1. Pele ho 1990		6
3.2. 1991-2000		7
3.3. 2001-2010		8
3.4. 2011-2015		9
3.5. Ha ke tsebe		10

MEKGWA YA POKELLO YA DITHOLE

Potso ya 4: Phano ya ditshebeletso tsa ho tlosa dithole ke mahala?

4.1. Eya		11
4.2. Tjhe		12

Potso ya 5: Ke o fe mokgwa o sebediswang ho bokella dithole?

5.1. Pela heke		13
5.2. Sebakeng se kgethilweng ho sa ha bokella dithole		14
5.3. Ha kena tsebo		15
5.4. Mokgwa o mong (Hlalosa)		16
.....		

Potso ya 6: Dithole di nkuwa ha kae lapeng ho iswa thotobolong?

6.1. Ha ngwe ka beke		17
6.2. Ha ngwe bekeng tse pedi		18
6.3. Ha ngwe ka kgwedi		19
6.4. Makgetlo a makae (hlalosa)		20
.....		

Potso ya 7: Lekgotla la motse le nka dithole letsatsing lefe bekeng?

7.1. Mantaha		21
7.2. Labobedi		22
7.3. Laboraro		23
7.4. Labone		24
7.5. Labohlano		25
7.6. Ha ke tsebe		26

Potso ya 8: Na dithole di nkuwa ka nako tsohle?

8.1. Eya		27
8.2. Tjhe		28
8.3. Ha ke tsebe		29

Potso ya 9: Na bo ramotse ba kgetha dithole pele di nkuwa ke lekgotla la motse?

9.1. Eya		30
9.2. The		31
9.3. Ha ke tsebe		32

Potso ya 10: Dithole tse kgethilweng di nkuwa ke ba bokelli ba dithole?

10.1. Ho hang		33
10.2. Kgafetsa		34
10.3. Tshohanyetso		35
10.4. Ka nako tsohle		36
10.5. Mokgwa o mong (Hlalosa)		37
.....		

Potso ya 11: Na ho teng thotobolo tse seng molaong?

11.1. Eya		38
11.2. Tjhe		39

DITSHEBELETSA LE MATSHOLO A POKELLO YA DITHOLE

Potso ya 12: Na ho nale thotobolo e molaong?

12.1. Eya		40
12.2. Tjhe		41
12.3. Ha ke tsebe		42

Potso ya 13: Na sebakeng se o phelang ho sona ho teng thotobolo eseng molaong?

13.1. Eya		43
13.2. The		44
13.3. Ha ke tsebe		45

Potso ya 14: Na ho teng monkgo o seng monate ho tswa thotobolong eseng molaong?

14.1. Eya		46
14.2. Tjhe		47

Potso ya 15: Na lekgotla la motse le ikarabella letsholong la ho fokotsa dithole?

15.1. Ho hang		48
15.2. Kgafetsa		49
15.3. Ka tshohanyetso		50
15.4. Ka nako tsohle		51
15.5. Mokgwa o mong (Hlalosa)		52
.....		

Ditlatsetso/Ditlhaiso

RE LEBOHELA TSHEBIDISANO LE HO NKA SEABO HO ARABA DIPOTSO TSA DIPATLISISO

Annexure C: Employees' Questionnaire



FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES

Questionnaire no:

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PERSONNEL: SOLID WASTE DIRECTORATE QUESTIONNAIRE

MUNICIPALITY SOLID WASTE SERVICE DELIVERY QUESTIONNAIRE IN THABO MOFUTSANYANA DISTRICT, FREE STATE PROVINCE

I am Teele Lepheana, 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 delivery in Thabo Mofutsanyana District. The questionnaires will be used to assess municipal services within your local area.

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 within the district.

I confirm that I have read and understood the information for the above research.

I understand that even if I agree to participate in the research, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

I understand that I will not benefit directly from the research.

I understand that the information I provide for this research will be treated with confidentiality.

I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

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.

I, _____, give permission to Central University of Technology, Free State to use the information collected only or for the purposes of the study.

Work Address

Cell no

Signature

Date

Mark the applicable box with an X or write the appropriate answer in the space provided.

EMPLOYEE INFORMATION

Question 1: What is your Job title?

1.1. Manager		1
1.2. Truck driver		2
1.3. General worker		3
1.4. Other (specify).....		4
.....		

Question 2: How long have you been working for the municipality?

2.1. Before 2000		5
2.2. 2001- 2010		6
2.3. 2011-2018		7

SOLID WASTE COLLECTION METHODS

Question 3: Does the municipality have waste collection schedule?

3.1. Yes		8
3.2. No		9

Question 4: How often do you collect waste?

4.1. Once a week		10
4.2. Every two weeks		11
4.3. Once a month		12
4.4. Other specify.....		13

Question 5: Indicate which type of collection method is used?

5.1. Kerbside collection		14
5.2. Communal collection		15
5.3. Don't Know		16
5.4. Other (Specify)		17

Question 6: Does residents sort waste before collection?

6.1. Yes		18
6.2. No		19
6.3. Don't know		20

Question 7: Indicate which type of waste collection vehicle used?

7.1. Tipping truck with sliding mechanism		21
7.2. Tractor		22
7.3. Vehicle (bakkie)		23
7.4. Other (specify).....		24

Question 8: Was there any period of time when municipality did not collect waste? _____

8.1. Yes		25
8.2. No		26

Question 9: Where after collection do you dump collected waste?

9.1. Landfill site		27
9.2. Dumping site		28
9.3. Other		29
(specify).....		

Question 10: Do you have waste acceptance personnel at the entrance of the landfill site?

10.1. Yes		30
10.2. No		31

Question 11: What mode of communication with residents does the municipality use?

11.1. Loudhailer/ loudspeaker		32
11.2. Local newspaper		33
11.3. Local radio station		34
11.4. Don't know		35
11.5. Other		36
(specify).....		

EMPLOYEES AND EQUIPMENT

Question 12: Have you ever been trained on proper waste handling?

12.1. Yes		37
12.2. No		38

Question 13: Have employees received any other training in the past 12 months?

13.1. Health and safety training		39
13.2. Waste management training		40
13.3. Other(specify).....		41

Question 14: What type of personal protective equipment (PPE) are you provided with?

14.1. No PPE provided		42
14.2. Overalls		43
14.3. Gloves		44
14.4. Safety boots/shoes		45
14.5. Face masks		46
14.6. Other (specify)		47

Comments

.....

.....

THANK YOU FOR YOUR CO-OPERATION IN COMPLETING THE QUESTIONNAIRE

Annexure D: Illegal Dumping Site Checklist

FACULTY OF HEALTH AND ENVIRONMENTAL
SCIENCES



Central University of
Technology, Free State

MUNICIPAL SOLID WASTE MANAGEMENT PRACTICES IN THABO MOFUNTSAANYANA DISTRICT, EASTERN FREE STATE

ILLEGAL DUMPING SITE CHECKLIST:

DATE	
AREA OF ILLEGAL DUMP SITE (GPS SETTINGS)	
TOWN	
LOCAL MUNICIPALITY	
NAME OF RESEARCHER	
NAME OF SUPERVISOR	

Question 1: Distance to closest residence (Meter/s)

COLLECTION METHODS

Question 2: Is solid waste collection services provided for free?

2.1. Yes		1
2.2. No		2
2.3. Do not know		3

Question3: Indicate which type of collection method is rendered?

3.1. Kerbside collection		4
3.2. Communal collection		5
3.3. Other (Specify)		7

Question 4: How often is the waste collected?

4.1. Once a week		8
4.2. Once in two weeks		9
4.3. Once a month		10
4.4. Other (Specify)		11

Question 5: Indicate which day of the week does the municipality collect your waste?

5.1. Monday		13
5.2. Tuesday		14
5.3. Wednesday		15
5.4. Thursday		16
5.5. Friday		17
5.6. Don't know		18

Question 6. NUISANCES AND OTHER ENVIRONMENTAL DEGRADATION FACTORS

6.1. Does the municipality always collect waste?	Yes	No
6.2. Does residents sort waste before collection?	Yes	No
6.3. Is waste burning Practised?	Yes	No
6.4. Is there any wind-blown litter?	Yes	No
6.5. Is there any foul smell emanating on-site?	Yes	No
6.6. Are there vermin or any disease vectors?	Yes	No
6.7. Stagnant water present?	Yes	No
6.8. Blocked storm water drains?	Yes	No
6.9. Waste heaps observed?	Yes	No
6.10. Are there children playing on-site?	Yes	No

Comments

Annexure E: Landfill Site Checklist

FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES



MUNICIPAL SOLID WASTE MANAGEMENT PRACTICES IN THABO MOFUNTSANYANA DISTRICT, EASTERN FREE STATE.

LANDFILL SITE CHECKLIST

DATE	
NAME OF LANDFILL SITE	
TOWN	
LOCAL MUNICIPALITY	
GPS SETTINGS	
NAME OF RESEARCHER	
NAME OF SUPERVISOR	

Question 1: Distance to closest residence (km/m)

QUESTION 2: SIGN POSTING AND ROAD ACCESS.

2.1 Is the landfill site fenced?	Yes	No
2.2 Indicate the type of fencing Specify: 2.2.1 Wire fence 2.2.2. Concrete bar 2.2.3 Other type of fencing (specify)		
2.2. Is there a sign that indicates the name of landfill?	Yes	No
2.3. Is the sign written in two official languages?	Yes	No
2.2.1. Does the sign indicate:		
2.2.2. The names, addresses and telephone numbers of the Permit holder?	Yes	No
2.2.3. Name of the responsible person?	Yes	No
2.2.4. Hours of operation?	Yes	No

2.2.5. Waste class indicated? Specify	Yes	No
2.2.6. Types of waste accepted?		
2.2.7. Road in good condition to allow vehicles?	Yes	No
2.2.8. Two-way traffic available to allow traffic flow?	Yes	No

Question 3: ACCESS CONTROL, COLLECTION OF DISPOSAL TARIFFS AND SECURITY

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

QUESTION 4: LANDFILL SITE RESOURCES AND SANITARY LANDFILLING?

4.1. Is there any mobile plant on-site to aid with environmentally acceptable waste operations?	Yes	No
4.2. Is there adequate site staff available?	Yes	No
4.3. Is waste compaction Practised?	Yes	No
4.4. Is waste covered daily?	Yes	No

QUESTION 5: NUISANCES AND OTHER ENVIRONMENTAL DEGRADATION FACTORS?

4.5. Is waste burning Practised?	Yes	No
4.5. Is there any wind-blown litter?	Yes	No
4.6. Is there any foul smell emanating on site?	Yes	No
4.7. Is there any vermin and other disease vectors?	Yes	No
4.8. Is there any uncontrollable dust emanating on-site?	Yes	No
4.9. Is there any stagnant water on site?	Yes	No

Comments

Annexure F: Ethical Clearance Certificate

UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIBESITHI YA
FREISTATA



UFS-UV
HEALTH SCIENCES
GESONDHEIDSWETENSAPPE

Health Sciences Research Ethics Committee

12-Feb-2020

Dear Teele Lepheana

Ethics Clearance: **Municipal Solid Waste Management Practices in Thabo Mofutsanyana District, Eastern Free State.**

Principal Investigator: **Teele Lepheana**

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-HSD2019/1571/2502**

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/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa

www.ufs.ac.za



Annexure G: Submission Approval

UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIBESITHI YA
FREISTATA



UFS-UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

Health Sciences Research Ethics Committee

18-Mar-2021

Dear Teele Lepheana

Ethics Number: UFS-HSD2019/1571/2502-0007

Ethics Clearance: Municipal Solid Waste Management Practices in Thabo Mofutsanyana District, Eastern Free State.

Principal Investigator: Teele Lepheana

Department: CUT - Central University of Technology

[Submission Page](#)

SUBSEQUENT SUBMISSION APPROVED

With reference to your recent submission for ethical clearance from the Health Sciences Research Ethics Committee, I am pleased to inform you on behalf of the HSREC that you have been granted ethical clearance for your request as stipulated below:

- Extension of Timeline was granted until 17 March 2022.

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; International Council for Harmonisation (ICH) Harmonised Guideline, Integrated Addendum to ICH E6(R1), Guideline for Good Clinical Practice (GCP) E6(R1), 2016. S.AHPRA Guidelines 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 request for ethical clearance and we wish you continued success with your research.

Yours Sincerely



Prof. A. Sherriff

Chairperson : 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 H: Declaration by Statistician



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 Practices in Thabo Mofutsanyana District, Eastern Free State."

Researcher: Teele Lepheana
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

Annexure I: Mayor's approval to conduct study



Enquiries: Mr Matefu Mokoena

Contact: 058 718 1021

Date : 17 April 2019

TO: Mr Teele Lepheana
M31 Manyatseng
Ladybrand
9745

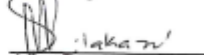
Dear Mr Teele Lepheana

RE: Request to contact municipal solid waste research project.

A permission is hereby granted to Mr Teele Lepheana to conduct research project within Thabo Mofutsanyana District Municipality in pursuant of Master of Health Science in Environment qualification under Central University of Technology, Free State.

Wishing you all the best.

Kind Regards



Me Malefu Vilakazi
Executive Mayor