EVALUATION OF MUNICIPAL WASTE SERVICES IN MATJHABENG LOCAL MUNICIPALITY, FREE STATE PROVINCE

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DECLARATION OF INDEPENDANT WORK

I, Kelebohile Andronica Moleko, student number , hereby declare that this research document submitted to the Central University of Technology, Free State is my own independant 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.

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STUDENT SIGNATURE DATE

ABSTRACT

The study evaluated the degree of effectiveness, efficiency, safety and sustainable solid waste management service delivery in the Matjhabeng Local Municipality and to recommend possible measures to improve the services delivered.

Six towns in the Matjhabeng Local Municipality were included in the study and English questionnaires were completed by 50 respondents in each town.

Results of the study indicated that no plastic bags or bins were provided for storage and sorting of waste generated by the residents. There was a lack of routine collection of waste and no communication with the residents with regards to solid waste occurred. It was observed that the majority of residents dumped their waste in open spaces and very few residents recycle and compost their waste and a need exists to educate the residents regarding the importance of recycling and composting waste.

The study indicated that the current solid waste management system in Matjhabeng Local Municipal area is not sustainable and it should be improved. It is recommended that adequate transport and collection of waste, improved communication with residents (meetings), promotion of reduction, reuse and recycling of waste be emphasized. Community based composting as well as municipal assistance being provided by the local municipalities with segregation and collection of waste, will lead to a more sustainable solid waste management system.

LIST OF ACRONYMS

MLM	:	Matjhabeng Local Municipality
MSW	:	Municipal Solid Waste
NEMWA	:	National Environmental Management: Waste Amendment Act 2014 (Act 26 0f 2014)
USA	:	United States of America
NYDEC	:	New York Department of Environmental Conservation
MSWMS	:	Management Systems Municipal Solid Waste
SAWIC	:	South Africa Waste Information Centre
CSIR	:	Council Scientific and Industrial Research

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CHAPTER 1

GENERAL BACKGROUND

1.1 Introduction

Worldwide, definitions of waste depend on each country's waste and environmental control measures that are entrenched in its legislative framework. In South Africa, waste and environmental control measures are embedded in the National Environmental Management Act (NEMA) of 1998 (South Africa, 1998a). This Act is the foundation of various amendment Acts such as the National Environmental Management: Waste Amendment Act No. 26 of 2008 (NEMWA) (hereafter referred to as the Waste Amendment Act). This latter Act defines waste or discarded materials as "any substance, whether or not the substance can be reduced, reused, recycled and recovered" (South Africa, 2008). Waste is therefore considered to be any material that is unwanted, rejected, disposed of and which is of no further use to the generator.

Waste is categorised according to two main criteria: primary waste of material that was originally used by someone or a larger concern, and secondary waste when the waste becomes somebody else's raw material. However, unwanted waste is defined by the Waste Amendment Act as "any substance rejected by the holder of the object, whether or not such object can be re-used, recycled or recovered" (South Africa, 2014).

The Environmental Public Health Act (EPHA) of Singapore is similar to the South African Waste Amendment Act (Oelofse & Godfrey, 2008) as it stipulates that waste is scrap material, effluent or surplus substances/materials/articles generated as a result of any process and [comprising] articles requiring disposal because they are broken, worn out, contaminated or spoilt. According to Oelofse and Godfrey (2008), US environmental legislation classifies waste in terms of:

- waste products generated at water supply;
- waste originating from treatment plants (sludge);
- air pollution control facilities;
- solids, liquid and semi-solid materials;

- gaseous waste that is generated by industries, commerce, mining and agriculture; and
- waste generated by communal activities.

The New York Department of Environmental Conservation (NYDEC) (2015:1) defines solid waste as “any refuse discarded from various facilities and originating from the activities of people in the community”.

Solid waste is classified into two main categories: general waste and hazardous waste. This classification is further broken down according to the origins of the production of the material, the level of toxicity, and the composition of the substances and the materials a product is made of. General waste is waste which does not negatively affect people or the environment, for example municipal solid waste (MSW) which includes residential waste, garden waste and builders’ waste (South Africa, 2014). However, general waste could pose a threat to people’s health and the environment as a result of changes in its composition. Hazardous waste comprises six classes: explosive substances (such as flares and blasting caps); corrosive substances (such as industrial cleaning agents and drain cleaners); highly reactive chemical substances that ignite easily (such as paints and solvents); poisonous by-products of industries and laboratories; medical waste (such as human body fluids, laboratory waste and sharps); and cancer-causing solvents (such as pesticides) (South Africa, 2014).

MSW is waste that is generated by households and collected by municipal waste collection services. Such waste includes office waste, waste from restaurants, waste derived from street sweeping and cleaning, and organic waste that are generated in parks and gardens (Sokka et al., 2007).

1.2 Municipal Solid Waste Management Systems (MSWMS)

Municipal solid waste management systems (MSWMS) comprise waste generation, the separation of waste at the point of generation and the collection, transportation and disposal of waste to landfill sites (Cointreau, 2006; Puopiel, 2010). Solid waste

management is one of the basic services that South African citizens are entitled to and it has to be provided by municipalities as stipulated in the Constitution of the Republic of South Africa (South Africa, 1996a) and the Municipal Structures Act No. 117 (South Africa, 1998b).

Waste management is a continuous process in urbanised settings. As the number of residents in urban areas has increased, villages have become towns which in turn have developed into large cities. This demographic reality is a process that has resulted in a concurrent increase in the generation of waste. A rapid increase in quantities of waste has been a challenge for local authorities for many years due to an expanding population. More people inevitably lead to increasing consumption rates and thus to larger waste generation rates (SAWIC, 2012).

The global population figure reached the seven billion mark in 2011 and this figure is predicted to escalate to eight billion by 2024 to 2030 with 54% of the population living in urban areas. This percentage is expected to increase to 66% by 2050 (Adeniyi, Aremu, Sule, Downs, & Mihelcic, 2012). The human population produces over 2.12 billion tons of solid waste annually and, as the population increases, more waste is produced (Ahmed & Ali, 2006; Piipo, 2013).

In 2011, an estimated 19 million tons of municipal waste was generated in South Africa (Council for Scientific and Industrial Research [CSIR], 2012). Waste is often indiscriminately discarded in waterways, on vacant land and on access roads. This uncontrolled dumping of waste may result in hazardous conditions that could, in the absence of a waste management strategy, lead to epidemics such as the Black Plague which killed large numbers of the European population between the 14th and 17th centuries. Currently large populations in Africa have been threatened by outbreaks of Ebola (World Bank, 2014). The uncontrolled dumping of waste is not unique to South Africa. For example, Ezeah and Roberts (2012) report that in Nigeria piles of waste are found in many spaces around towns and in urban areas.

According to Brunner and Fellner (2007), the key objectives of solid waste management are to ensure the well-being of humans and to protect and conserve the environment.

Therefore, in order to overcome the many problems associated with inconsiderate waste dumping and poor waste management practices, efficient waste management practices should be employed. Such practices require the provision of adequate numbers of refuse bins in appropriate areas, regular removal of waste from households and industries, and suitable solid waste disposal methods. Countries have different approaches towards waste management depending on their respective budgets (Menon, 2010) and these differences, of necessity, result in variations in the effectiveness and efficiency of their waste management practices (Poerbo, 1991).

In the African context, Achankeng (2003) states that 20% to 50% of African countries' budgets are allocated to waste removal but that only 20% to 80% of waste is effectively removed in countries on this continent. It is for this reason that many African communities are no longer solely depending on governmental services for waste removal and non-governmental organisations (NGOs) and community-based organisations (CBOs) involve members of the community in waste management schemes (Godfrey, 2007). For example, in Nigeria communities work with the government to minimise littering and pollution. Movable containers are placed at selected service points for the storage of municipal waste and waste generators are encouraged to place their waste in the containers provided. This requires municipalities to distribute waste bins to different parts of the city and to collect and dispose of the contents (Adeniyi et al., 2012).

Research has shown that the problems related to solid waste management are more serious in developing than in developed countries (Zerbock, 2003). For example, the shortage of financial resources to manage solid waste in African countries has led to low quality service provision, and the acceleration of population growth and urbanisation on this continent has resulted in ever increasing volumes of waste. Moreover, rapid urbanisation has resulted in the mushrooming of unplanned informal

settlements which, in turn, has resulted in poor service delivery and hygiene problems. The efficiency of MSW management can only be increased if all role players are actively involved in the process. Zerbock (2003) and Ezeah and Roberts (2012) are thus of the view that community members and municipal and government officials need to work collaboratively in order to improve waste management services.

1.3 Problem Statement

It is undeniable that the volumes of waste that are generated increase concomitantly when the population increases. This phenomenon has been growing steadily globally, but it is particularly evident in African countries. It has therefore become vital to apply workable and financially sustainable solid waste management practices in all contexts of human settlement, but particularly in urban settings where poor waste management practices may compromise the health of thousands of people. The need was therefore identified to investigate various solid waste management concerns and to illuminate strategies that are effective in the implementation of sustainable methods of waste reduction in various parts of the world with the view to applying similar strategies in the South African context.

A main concern is that littering tends to cause severe waste management and health challenges in South Africa. Littering as a form of 'waste disposal' occurs in all areas in South Africa but is most prevalent in informal settlements where the lack of adequate waste disposal strategies has become a crisis. Illegal dumping causes bad odours and is a health risk for people who live in close proximity to illegal dumping and landfill sites. Moreover, irregular collection of waste at pre-determined waste collection sites where local people leave their waste for municipal collection causes the accumulation of waste. Torn bags, rotting food, bad odours and the unmanageable presence of vermin and pests cause a severe health hazard in these locations. In an effort to contain the unpleasant situation, some residents burn the waste which causes clouds of foul smelling smoke and air pollution (Kumar & Khanna, 2009). Waste collection services are persistently insufficient and often absent in low income areas and townships where fed-up residents resort to discarding their waste in the streets without placing it

in plastic bags or in bins (Kumar & Khanna, 2009). Moreover, placing their waste in bins is often a futile exercise as these bins are rarely, if ever, emptied or collected.

1.4 Aim and Objectives

The aim of the study was to evaluate the waste management practices that were employed by the Matjhabeng Local Municipality in the Free State Province of South Africa by eliciting the views of residents.

The objectives of the study were to:

- Review relevant literature and the legislative framework that guides waste management in South Africa to determine best waste management practices;
- Assess the views of and level of satisfaction of the community regarding waste management service delivery in their area;
- Obtain information regarding waste management in the study area from a municipal official and to integrate this information with the views of residents;
- Identify critical issues that may inform the development of sustainable waste management service delivery practices in the area under study; and
- Make recommendations to municipal management in the study area which can be used to educate residents on maximising waste recovery, reducing waste generation and ensuring safe collection and disposal of all waste.

1.5 Study Area

This study was undertaken in a selected area in the Free State Province of South Africa. The study area comprised six towns, namely: Allanridge, Hennenman, Odendaalsrus, Ventersburg, Virginia and Welkom which all resort under the area of responsibility of the Matjhabeng Local Municipality. Each of the six towns has an official landfill site which was established in the apartheid era close to the black townships on the outskirts of the towns. The dwellings and houses in the townships are

owned by or rented black community members. The study was prompted by concerns that, in the likely event of poor waste management services in the study area, the many people living in close proximity to the landfill sites will be affected most adversely.

1.6 Structure of the thesis

The discourse in this study report includes a general background of the problem, a review of related literature, a brief description of the study area, an elucidation of the methodology that was employed, and a discussion of the findings and the results. The delimitations and limitations of the study are acknowledged and it is concluded with relevant remarks pertaining to the findings and a number of recommendations are offered.

Chapter 1: General background

In Chapter 1 various forms of waste are defined. This chapter serves as an introduction to the study report and highlights the challenges of ever increasing waste generation as well as the need to implement measures to minimise waste. After having defined what waste is, the problem statement, the aim and objectives of the study and the layout of the different chapters are presented.

Chapter 2: Literature review

Chapter 2 presents a review of related literature and focuses on best MSW management practices. Legislation related to MSW management and relevant regulations that have been issued at global, national and regional levels are reviewed in an attempt to address the first objective of the study.

Chapter 3: Study area and methodology

Chapter 3 provides a description of the study area and elucidates the methodology that was employed.

Chapter 4: Results

The results of the investigation are presented and discussed. The findings pertain to current waste management practices by the local municipalities and the chapter illuminates selected citizens' views regarding waste management practices in their respective areas. Information that was obtained from a municipal official is also presented and the delimitations and the limitations of the study are acknowledged.

Chapter 5: Conclusion and Recommendations

This chapter presents a final evaluation of the findings and recommendations based on the results conclude the report. Based on an integration of the findings pertaining to actual waste management practices and the public's views and perceptions of this service, suggestions are offered that may be used to disseminate information to local authorities for consideration in collaboration with environmental health practitioners in order to supply communities with updated information regarding good waste management practices in their respective areas.

1.7 Definitions of key concepts

Terms that are pertinent to this study are defined as follows:

Compliance: Actions that comply with environmental policies, laws, regulations and procedures (Okibo & Kamau, 2012).

Effectiveness: When assessing a certain activity it must align with the desired outcome (Grimshaw et al., 2004).

Environmental risk: A threat to the environment that could be caused by human activities or the manner in which people behave that can be a threat to the environment or that may affect the environment due to citizens' non-compliant waste disposal practices (DEAT, 2007).

Municipal waste: Waste that is generated by households, businesses, industries and institutions (Couth & Trois, 2012).

Waste management: The collection of waste from different sources, the transport of waste to different treatment and disposal areas, and the treatment and disposal of waste (DEA, 2010).

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

The requirement for waste disposal and management has a long tradition that is associated with human habitation. In modern societies, municipal solid waste (MSW) is an issue in most countries globally, yet it is defined differently in various countries. In countries in Europe, MSW is defined as “all waste arising within a municipal boundary, including any commercial, industrial, construction and hazardous waste” (United Nations Environmental Protections [UNEP], 2010; Agbesola, 2013). This definition focuses on the origins of waste that is generated in a municipal area, but it differs from the definition used in the United States of America (USA) and by the Energy Information Administration (EIA) which both refer to the term “total waste” in their definitions of waste. However, industrial and agricultural waste and sewage sludge are excluded from this term (Fred, 2008).

MSW has become a concern of global proportions due to the increase in waste volumes and the effects increasing volumes of waste have on the environment (McCarthy, 1994). In developing countries such as South Africa, rising standards of living have been associated with serious environmental challenges regarding solid waste arising from domestic, social and industrial activities. The world is concerned about the issue of and the challenges associated with climate change, yet waste has a more visible impact on the environment and is a health risk when it is not disposed of in the correct manner or handled in the correct way (Earth Link and Advanced Resources Development [ELARD], 2009). It is for this reason that solid waste management programmes have to be designed and implemented to ensure that the risks associated with waste disposal are minimised and ultimately eradicated both on developed and in developing countries.

Sustainable solid waste management programmes will not only minimise pollution of the environment, but such programmes will also ensure that waste is used as a valuable resource. South Africans have the right to live in an environment that is not detrimental to their health, which is a right that is entrenched in the Constitution (South Africa, 1996a). However, low income areas are generally characterised by high population density, yet waste removal and treatment in these areas receive low priority and are often neglected by municipalities and government officials who are responsible for public health and safety. This is one of the issues that is addressed by the National Waste Management Strategy as it is argued that public issues such as the minimisation, generation, storage, collection, transportation, treatment and disposal of waste must receive consideration in all waste management practices as stipulated in the draft White Paper on integrated pollution and waste management for South Africa (Institute of Waste Management [IWM], 1999).

2.2 Classification of waste

South Africa uses the global harmonised systems (GHS) approach for the classification of waste and the South African National Standards (SANS 10234) for the classification and labelling of chemicals is mandated with this responsibility (South Africa, 2013). Waste must be classified within a period of 180 days of generation and, according to SANS 10234, even waste that has already been treated has to be re-classified (South Africa, 2014). Because of the diverse nature of waste, it is classified into different categories and a distinction is made between MSW and industrial or hazardous waste (Table 2.1). The differences between the categories depend on the volume, content and toxicity of the waste which are features that require that each waste category is handled in a specific way (South Africa, 2014). Moreover, waste is generated from different sources at different locations and these factors must be considered in the design and implementation of waste management strategies (South Africa, 2014).

Table 2.1: Waste generation facilities and locations associated with various sources of solid waste

Source	Agricultural	Industrial	Open/vacant areas	Municipal areas	Treatment plants
Location	Fields and farms	Construction and mining areas	Streets and beaches	Single- and multiple family dwellings	Water and waste treatment processes
Types	Spoiled food wastes and agricultural waste	Demolition and construction waste	Special waste	Food waste; rubble	Treatment plant waste such as residual sludge

Source: Adapted from Tchobanoglous et al., 1993

2.3 The waste hierarchy

Waste management strategies differ from country to country, but there is a common goal which is waste management through prevention and reuse (Gauteng Provincial Integrated Waste Management Policy, 2006; EEA, 2013b). The waste hierarchy (Figure 2.1) is used globally as a strategy to minimise waste as it encourages the generation of minimum quantities of waste as well as reusable waste. The waste hierarchy thus focuses on waste avoidance and reduction strategies and is the foundation of the ultimate zero waste challenge (Menon, 2010). Menon (2010) argues that even though the waste hierarchy has taken many forms, the main concepts have remained the foundation of most waste minimisation strategies, whereas Al Ansari (2012) refers to a new hierarchy in integrated municipal waste management schemes with the purpose of eco-friendly waste management strategies. Waste management thus requires waste minimisation through the reduction of waste generation.

The waste hierarchy encourages a circular economy and it helps sustainability because it opens up opportunities for waste minimisation. The quantities of waste that are generated globally can be reduced by reuse and recycling.

Figure 2.1: The waste hierarchy

Source: Lansink (1979)

2.4 Waste generation

The generation of waste varies among countries as it is generally based on their prevailing cultures, level of public awareness, and management strategies (Abel, 2007; United States Environmental Protection Agency [USEPA], 2016). Humans generate more waste that is derived from living matter now than ever before, and the production of organic waste has to a large extent been replaced by plastic and chemical waste. Historically, humans created tools and consumed food derived from nature and the waste that was generated decomposed naturally (Abel, 2007). Organic waste was used for various purposes such as fertilizer and people sold or exchanged unwanted items in the market when they no longer wanted them. Very little was wasted, and the environment was preserved through a natural circulation process in which waste was revitalised when it entered the ecosystem, creating a natural and sustainable life cycle (Abel, 2007). However, the global mass production of plastics, which are generally non-biodegradable, is estimated to reach 12 billion tons by 2050 (Wallace, 2017). Since the 1950s, approximately 8.3 billion tons of plastic have been produced and about 4.9 billion

tons (60%) of plastic waste go to landfills or pollute the environment (Geyer, Jambeck & Law, 2017).

2.4.1 Global waste generation

Internationally, municipalities are faced with challenges in terms of solid waste management as a result of growing populations, increasing waste generation and limited resources for efficient solid waste management (Omran & Read, 2008). Improper management of MSW is a complex issue, and this problem will be exacerbated as the middle class is predicted to grow to 4.9 billion by 2030 world-wide (Waste crisis looms, 2013).

Research has shown that economically prosperous countries generate more waste per capita than less developed countries (Navarro, 2003). To create a backdrop of this disparity, three developed countries − Germany, Denmark and the United States of America − and three developing countries − India, the Philippines and Lagos – will be reviewed. It is indisputable that developing countries are less industrialised and have lower living standards than developed countries (United Nations, 2012), yet waste management is a challenge in both worlds.

European countries that are generally regarded as highly developed generate higher quantities of waste than their developing counterparts (Intergovernmental Panel on Climate Change [IPCC], 2006). The per capita quantity of municipal waste that was generated in countries in the European Union (EU) was reduced to 481 kg per person per annum from 527 kg. In Asia, areas such as Hong Kong and Japan reportedly generate more waste compared to developing countries such as India and Nepal. The annual waste generation in East Asia and the Pacific Region is approximately 270 million tons per year compared to 2 503 tons per year recorded for EU countries (Hoornweg & Bhada-Tata, 2012).

Waste generation in developed countries such as Canada and the USA varies between 0.9 kg to 2.7 kg per person per day, while in some developing countries such as India

and Thailand between 0.3 kg to 1 kg of waste is generated per person per day (Körner (2006).

Although the per capita quantity of waste that is generated by developed and developing countries may be more or less the same, an important difference is the manner in which the waste is handled, and this depends on the knowledge of the impact of waste on the environment and human heaölth (Körner, 2006). In Canada, close to 50% of the waste that is generated is MSW. About 56% of the waste that is generated in the USA is disposed of in landfill sites, whereas all the waste that is generated in India is disposed of in landfill sites (Kuniyal, 2010).

In 1950, only 30% of the world's population lived in urban areas compared to 54% in 2014, and it is predicted that urban populations will reach 66% of the world population in 2050 (United Nations Department of Economic and Social Affairs [UNDESA], 2014). According to the Global Waste Management (GWM) Market Report of 2007, MSW generated globally increased by 7% annually from 2003 to 2006 and by about 37% in the period of five years from 2007 to 2011.

2.4.1.1 Waste generation rates in developed countries

Germany

Germany was the first country to introduce producer responsibility in 1991. Germany is a federal republic consisting of sixteen federal states. These states, local authorities and the national government all share the responsibility for waste management (Kesselman et al., 2012; Fischer, 2013). Germany had approximately 50 000 landfill sites in the 1970s, but in 2005 only 300 of these landfills remained (Bersi-Kathimerini, 2005). Table 2.2 reflects the waste quantities that were generated in Germany between 2000 and 2015. In 2000, the total waste volume that was generated was 406.7 million tons, which decreased to 322.2 million tons in 2009 but increased again in 2011 from 322.2 million tons to 342.7 million tons.

Table 2.2: Waste generation rates in Germany from 2000 to 2015

Year	Waste generated (million tons)
2000	406.7
2003	366.4
2006	340.9
2009	322.2
2011	342.7
2012	333.5
2013	338.5
2014	350.3
2015	351.2

Source: German Federal Statistical Office, 2017

MSW generation in 2001 was recorded at 52.1 million tons, but this figure decreased to 46.4 million tons in 2006. However, between 2006 and 2009 MSW generation increased to 48.5 million tons, but it decreased again to 47.7 million tons in 2010. This may be due to recycling which increased to 62% during this latter period. In 2010, landfilling was nearly 0% while incineration had increased to 37% (European Environment Agency, 2013).

Denmark

Denmark consists of five states which are also referred to as regions. The public sector (local and regional councils) is tasked to collect and treat waste, to ensure a high recycling rate, and to deal with the general administration of waste management. Denmark produced an average of about 709 kg/capita waste per year over a period of ten years. The lowest figure of MSW was 650 kg/capita in 2001 and the highest was 830 kg/capita in 2008 (Kjaer & Reichel, 2013). The volumes of waste that were generated between 2001 to 2008 increased and then decreased between 2009 and 2010 due to amended waste regulations and a change in the definition of MSW (Kjaer & Reichel, 2013).

The resource plan for waste management from 2013 to 2018 was to recycle the waste generated by households and the ultimate goal is to reach a “Denmark without waste’’ status in 2022 (Kjaer & Reichel, 2013).

The United States of America (USA)

In the United States of America (USA), MSW generation increased by more than 193% from 1960 to 2014. In 1960 only 6% of MSW was recycled when the preferred methods of waste management were landfilling and burning whereas, in 2014, 26% of MSW was recycled, 53% was landfilled or disposed of using other methods, 9% was composted, and 13% was combusted for energy recovery (USEPA, 2016). MSW generation increased by 20% from 3.7 to 4.4 pounds per person per day from 2010 to 2011(US EPA, 2013).

Table 2.3 reflects the municipal waste volumes that were generated in 2014 in Denmark, Germany and the USA per capita in kilograms. The USA had the highest waste generation rate per capita whereas Germany had the lowest.

Table 2.3: MSW generation rates in developed countries (kg per capita)

Country	Waste generated per year (kg per capita)	Year
Denmark	789	2014
Germany	618	2014
USA	926	2014

Source: Eurostat, 2016

2.4.1.2 Waste generation rates in developing countries

In many developing countries local authorities are challenged by limited budgets and therefore a more effective application of waste management strategies is required in these countries (Van Beukering, 1999; Omran & Read, 2008). It has become urgent that

these countries develop a reliable tool to facilitate more appropriate and effective MSW management practices (Omran & Read, 2008).

The Philippines

In this country the waste management challenge is exacerbated by rapidly increasing urbanisation (World Bank, 1999a; Zurbrugg, 2002). In 2005, the Philippines had a population of 82.8 million of which 63% lived in urban areas. It is estimated that by 2030 about 70% of the population of this country will live in urban areas. Thus more waste is being generated as the population is increasing (Kojima & Machida, 2011). Since 2005, about 10 million tons of MSW have been generated annually, which is equivalent to between 0.3 kg to 0.7 kg per capita per day.

India

A lack of efficient MSW management is one of the major reasons for the environmental problems experienced in megacities in India today (Okyere, 2014). In 1995, MSW generation ranged between 0.2 kg and 0.6 kg/capita/day in cities in India, which amounted to 46 million tons in total in this year alone (World Bank, 1999b; Strivastava, 2012). Waste generation per capita in India has slightly increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011. Annepu (2012) argues that this phenomenon has been exacerbated by changing lifestyles and increased purchasing power in urban areas. It is estimated that the MSW volume will probably increase to 13 750 000 tons in 2030 and, by 2041, the volume will be 160.5 million tons. It is also estimated that this volume will exceed 260 million tons by 2047, which will be more than five times the current levels of waste that is generation in India (Energy and Resource Institute, 2012; Annepu, 2012).

2.4.2 Waste generation in Africa

Africa is generally considered the least developed continent compared to others, with an urbanisation rate of 38%. African countries are experiencing rapid development with an overall growth rate of 4% per annum and this rate is expected to grow even higher between 2020 and 2050 (Williams, 2005). African countries now face the challenge of extremely large volumes of MSW, which has a direct effect on the health and safety of

humans and the sustainability of the environment because, as the population increases, more waste is produced (Bello et al., 2016).

Lagos generated 13 000 tons of MSW per day in 2014, of which 44% was biodegradable (Oresanya, 2014). The latter author argues that rapid urbanisation and growing economic activities in Lagos contribute to increasing volumes of waste in this country. The World Bank projects that the population of this state will reach 25 million by 2030 at a growth rate of 8.5%; therefore the need to design an efficient waste management system for this state has become urgent.

Karagiannidis (2012) argues that increasing waste volumes are not only due to an increasing population, but that the rate of economic development in African states also contributes to greater volumes of waste. Achankeng (2003) states that MSW volumes range between 0.3 kg to 1.9 kg/capita/day in various African cities. For example, in North Africa solid waste, of which approximately 70% consists of organic content, amounts to 63 million tons per year at a daily rate of 0.16 kg to 5.7 kg per person (Hoornweg & Bhada-Tata, 2012).

2.4.3 Waste generation in South Africa

Based on statistical evidence, it has often been argued that the management of MSW in South Africa is about 20 to 30 years behind that of countries in Europe. For example, according to SAWIC (2017), South Africa generated about 42 million tons of general waste in 2017, which was the 15th highest rate in the world. However, this estimate is substantially less than the approximate volume of 54.2 million tons of general waste according to the South African State of Waste report (DEA, 2018). South Africa also produces some of the highest volumes of waste per capita per household per day (2 kg), placing it at number 38 of the highest waste generating countries globally. The Gauteng Province, with the highest population density in the country of 785.5 per km^2, generates close to 45% of the total MSW in South Africa, which means that the other eight provinces together generate approximately 65% of MSW (Hoornweg & Bhada-Tata, 2012; Statistics South Africa, 2017). The City of Johannesburg alone generates approximately 1.5 million tons of waste per year. This figure includes about 226 899 tons of waste that are dumped

illegally as well as an estimated 88 869 tons that are collected from the streets (Chisadza, 2015). The collection of illegally dumped waste and street litter costs the country a whopping R150 million per annum (Chisadza, 2015).

Table 2.4: Municipal solid waste generation in the provinces of South Africa in 2012

Province	Population density per km^2	Waste generated per annum (%)
Gauteng	785.5	47
Western Cape	50.3	20
Mpumalanga	58.1	10
KwaZulu-Natal	117.4	9
Eastern Cape	38.5	4
Northern Cape	3.3	3
Free State	22.1	3
Limpopo	45.9	3
North West	36.8	1

Sources: Hoornweg & Bhada-Tata, 2012; SoWR, 2017

Overall, the largest volume of MSW was generated in 2013 at 31 557 618.7 tons, and the lowest volume was generated in 2011 at 3 925 607.5 tons (SAWIC, 2014). It is noteworthy that the MSW that is generated through both formal and informal waste streams consists of different types of waste.

2.5 Types of waste generated

The volume of waste that is generated is growing faster than the rate of urbanisation. Different types of waste are generated on a daily basis from different sources such as households, commercial and industrial enterprises and demolishing or construction activities. The types of waste are food waste, yard waste and green waste as well as waste comprising paper, glass, plastic and metal materials (USEPA, 2010). It is particularly plastic waste that has been exposed as a global problem recently, with evidence that this material is not biodegradable and that it poses a severe threat to our oceans and other water resources (Atkin, 2018; Haward, 2018).

2.5.1 Types of waste generated in Hong Kong, the US and Japan

The South African Waste Information Centre (SAWIC) classifies the types of MSW according to their origin or the sources that generate the waste; for example residential waste and waste from commercial establishments such as hotels, restaurants, abattoirs and others businesses enterprises (SAWIC, 2015). The types of waste that are generated comprise items that are used on a daily basis and that are then discarded, such as food and food scraps, ashes and residues, demolition and construction waste, agriculture waste, packaging, grass clippings and general garden waste, furniture and clothing, bottles, newspapers, appliances, paint, and batteries (Tchobanoglous et al.,1993; USEPA, 2013).

Conversely, the major types of MSW that are generated in Hong Kong are food waste that is generated during food production and preparation and expired food products (Environmental Protection Department [EPD], 2017). According to the latter source, Hong Kong “is a highly sophisticated society with a well-developed infrastructure and has a functional local government system in place as compared to Matjhabeng local municipality due to the lack of effective solid waste management. The situation in the US is slightly different, as is depicted by the summary in Table 2.5. Twenty eight per cent of waste generated in USA consists of paper and paperboard followed by food waste with 14,5 %, household-like commercial waste with 14% , 13% yard trimming and 12,7% is plastics Table 2.5).

Table 2.5: Types of MSW generated in the United States of America in 2015

Types of waste	Waste generated (%)
Household and household-like commercial waste	14.1
Biodegradable garden and park waste	5.8
Bulky waste	2.5
Waste of electrical and electronic equipment	2.1
Paper	8.1
Glass	2.5
Plastic/light packaging waste	6.0
Waste from bio-bins	4.2
Other	0.6
Metal	8.8
Rubber, leather and textiles	8.2
Yard trimmings	13.5
Food waste	14.5
Paper and paperboard	28.0
Glass	4.6
Plastic	12.7
Wood	6.4

Sources: US Environmental Protection Agency, 2010; US Federal Statistical Office, 2017

In Japan, the predominant types of MSW are food waste, paper, plastic, textiles, wood, and glass. In this country, about 36% of the waste consists of paper (Cointreau, 2006). Similar types of waste, including organic waste, are generated in Africa.

2.5.2 Types of waste generated in African countries

Residential waste is generally generated by households and usually comprises discarded products such as paper, tin, plastics, clothing, glass, metals, e-waste and hazardous waste such as paint and aerosol containers (Bello et al., 2016).

In Uganda, about 80% of the waste is residential food waste (Okot-Okumu, 2012). Cities and towns in Kenya such as Nairobi, Nakuru, Mombasa and Kisumu produce about 61% residential waste whereas in Egypt, Ethiopia and Botswana more textile-type waste is produced. In Nigeria, Senegal and South Africa, food waste is the predominant waste

whereas Tunisia generates predominantly textile-related waste (Bello et al., 2016). The City Council of Nairobi (2010) reported that 78% of the waste that was generated in Kenya at the time was organic waste. In South Africa, mainly two categories of waste are generated, namely general and hazardous waste.

2.5.3 Types of waste generated in South Africa

The Waste Amendment Act (South Africa, 2014) classifies waste in South Africa as hazardous waste and general waste. NEMWA was amended on 2 June 2014 by removing the "by-product" concept and amending the definition of waste in Schedule 3 of the Amendment Act (MacRobert Attorneys, 2014).

Section 18 (Schedule 3, Category A) of the Act defines hazardous waste as:

> "…any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment and includes hazardous substances, materials or objects within business waste, residue deposits and residue stockpiles."

The definition of business waste was expanded to specify 17 categories of waste (South Africa, 2014), whereas general waste was included in Category B as: "…waste that does not pose an immediate hazard or threat to health or to the environment, and that includes:

(a) domestic waste;
(b) building and demolition waste;
(c) business waste;
(d) inert waste; and
(e) any waste classified as non-hazardous waste in terms of the regulations made under section 69, and includes non-hazardous substances, materials or objects within business, domestic, inert, building and demolition waste…".

Domestic waste is defined as "waste, excluding hazardous waste that emanates from premises that are used wholly or mainly for residential, educational, health care, sport

or recreational purposes which include, garden and park wastes, municipal and food waste" (South Africa, 2014).

General types of waste that are generated by domestic households are food waste, garden waste, paper, cardboard, plastic, glass, metal, ash, household hazardous waste, yard waste and special waste such as bulky items, batteries and tyres. The types of waste that are generated by industries include products such as food waste, special waste, ash, construction and demolition waste, packaging, cardboard, glass and metals (South Africa, 2014; Nkosi et.al, 2013). The types of waste that are generated determine the handling and disposal practices that are required to ensure that health hazards and negative environmental impacts are minimised.

Generally, the types of waste that are predominantly generated in South Africa are non-recyclable municipal waste (34%) followed by construction and demolition waste (21%), paper waste (7%), plastic waste (6%), glass waste (3%), metal waste (14%), organic waste (13%), and vehicle tyres (1%) (DEA, 2012). South Africa's waste management practices rely mostly on landfill facilities for the disposal of waste as about 90% of this country's waste is disposed of at landfill facilities (DEA, 2012).

In Gauteng Province, the volume of waste that is disposed of at landfill facilities has increased to approximately 66% since 2004, while the annual waste that is generated in this province averages 37% (DEA, 2011). In 2017, the highest waste generation rate (35%) in Gauteng Province was categorised as "other" (e.g., waste that consisted of products from sawmills and biomass from sugar mills), followed by 16% organic waste, 13% construction and demolition waste, 8% paper waste, 8% metals waste, 7% commercial and industrial waste, 5% plastic waste, 4% MSW, 3% glass waste, and 1% vehicle tyre waste (SoWR, 2017).

According to Godfrey (2007), DEA (2011) and Oelofse & Godfrey (2008), there are approximately 2 000 waste handling facilities in South Africa, and of these facilities only 530 are licensed. The number of licensed landfill facilities in rural areas is limited (13%), whereas 68% is located in or near urban areas (DEA, 2012).

2.6 MSW practices in terms of health and the environment

Inappropriate MSW disposal and management practices cause pollution of the air, soil and water (Tchobanoglous et al., 1993). When MSW is burnt, the result is air pollution whereas untreated leachate pollutes surrounding soil and water bodies. Insects and rodents thrive on landfill sites as they are attracted to poorly treated waste and such infestations can spread diseases such as cholera (Tchobanoglous et al., 1993; Sharholy et al., 2008; Singh, 2013). It is therefore the responsibility of each municipality to ensure that waste is managed as is stipulated by legislation (McDougal, 2001; South Africa, 2012).

2.6.1 A global perspective on MSW practices in terms of health and the environment

UNEP (2000) states that if waste is not properly managed, it causes a serious health hazard and could lead to the spreading of diseases. Waste lying around unattended attracts flies and rats and wet waste that decomposes releases a bad odour, spreads diseases and affects people who reside near a dumpsite or who live near locations where waste is dumped in the streets. In most cases, waste workers or waste pickers in developing countries come in contact with waste without wearing protective clothing, and this poses a serious health threat. Large numbers of the community habitually pick waste at landfill sites, and health surveys have indicated that numerous health problems such as respiratory symptoms; irritation of the skin, nose, and eyes; gastrointestinal problems; and allergies have been identified due to poorly managed waste disposal practices (Rathi, 2006). A shocking finding by the US Public Health Service linked 22 human diseases to poor MSW management (Rathi, 2006; Sharholy et al., 2008; Tchobanoglous et al., 1993; Singh, 2013).

2.6.2 MSW practices that impact health and the environment in South Africa

Wright and Godfrey (2010) and CSIR (2012) indicate that there is a clear link between the state of the environment and human health and well-being. About 23% of deaths in Africa occur due to contaminated water, poor hygiene, inadequate sanitation and

atmospheric pollution (World Health Organization [WHO], 2008). In developing countries such as South Africa, people who are most susceptible to such infections are the poor who are highly prone to diseases such as diarrhoea and respiratory afflictions that are exacerbated by exposure to environmental factors. Food-borne diseases such as salmonellosis are common, particularly in areas where rat infestation is on the rise such as in the Tshwane area in Gauteng. Air pollution is also a serious problem in many industrialised cities such as Johannesburg (CSIR, 2010).

Worldwide, four million children die every year of diarrhoeal diseases because of contaminated water (Hardoy et al., 1992; Ramphele, 1990; Nkosi, 2013). In South Africa, as everywhere else, leachate from open dump sites during rainy seasons causes the serious pollution of groundwater which is used for irrigation. Aquatic organisms die from contaminated water as the availability of oxygen in the water is reduced (Palmer Development Group, 1996). Naidoo (2009) states that unless people are made aware of the results of inappropriate waste management practices such as littering, illegal burning of waste and air pollution, they will not stop disposing of waste wherever they please, and this means that the problems of water contamination and pollution will persist in South Africa. In addition to pollution, ineffective collection and transportation of waste contribute to health hazards.

2.7 The collection and transportation of waste

Solid waste is usually collected from the place of origin such as residences, industries or institutions. Various types of collection of waste include house to house collections, collection from community bins, curb-side (pavement) pick-ups, self-delivered waste such as garden waste, and waste that is collected from various sites by contracted or delegated service providers (Hoornweg & Bhada-Tata, 2012). Waste that is generated by residents can be collected from allocated sites on pavements or centralised points. Sorted or separated waste can be collected separately if it is placed in colour-coded bags or bins. Garden waste is often handled separately and taken to transfer stations by residents themselves. Waste that is produced by households, street sweeping and commercial enterprises is usually transferred to communal bins before collection, and

different modes of transport are used depending on the size of the area and the nature of the waste (Kumar and Khanna, 2009).

2.7.1 The collection and transportation of waste globally

Many European countries follow the “waste separation at source” strategy for plastic and metal cans. Waste is also placed in collection receptacles in shopping malls and residential areas and individual households or business concerns receive rebates depending on the volume of the recyclable materials they discard (Mohee & Simelane, 2015). A system of colour-coded waste containers was implemented by some local government units (LGUs) in 2013 to make separation easy. The slogan “no separation, no collection” was used to drive this initiative (NSWMC, 2015). In Sweden, waste generated by households is taken to nearby disposal centres (Mohee & Simelane, 2015). It is undeniable that improved collection systems will reduce the volumes of waste that need to be transported to landfill or other disposal sites, and this will also provide more recyclable materials for waste recovery companies in the region (Mudhoo, Mohee & Simelane, 2015).

Historically, the collection and transportation processes of MSW by local municipalities in China were not efficient. Therefore, to improve the efficiency of the transportation of waste, three private companies were appointed in large cities such as Beijing and Shanghai (Zhang et al., 2012). In Linkoping, MSW is transported by companies that are authorised by the municipality to provide waste disposal services to each household where biodegradable waste is placed in a designated waste container. Staff collects the waste every second week and the cost is determined by weight (Agbesola, 2013).

In Germany, the actual collection and separation processes of waste are performed on behalf of the Duales System Deutschland (DSD) by private or municipal waste management companies (Quoden, 2004). The system operates as a public, non-profit organisation and must meet specified collecting, sorting and landfilling objectives set by the government. Separate collection pilot projects have also been launched in Lebanon, Jordan and Saudi Arabia (Nassour et al., 2011). According to Kreith (1994), the most common type of residential collection service in the US is the “curbs and backyard carry”

approach. However, the UNEP report places the average collection rate in urban areas in this country at only 31% (Hoornweg & Bhada-Tata, 2012).

In middle-eastern countries open-bed, covered and compactor vehicles are generally used to transport waste in urban areas. However, transfer stations are generally not used in the Arab world but “vehicle-to-vehicle transfer, open lot and formal state-of-the art transfer stations” are mostly utilised (El-Sherbiny et al., 2011).

2.7.2 The Collection and transportation of waste in African countries

In Kampala, Uganda, household waste is collected from street pavements, but about 95% of waste is not collected on a regular basis because of how the roads are designed. Some roads are narrow, unpaved or slippery during the rainy season, which does not allow vehicle access for the collection of waste in some areas (Simatele and Simatele, 2014). At the time of their study, Kubanza and Simatele (2015) found that only 15% of solid waste had been collected in Lusaka and 13% in Kinshasa because of a limited number of refuse trucks. In a similar study, Mbuligwe and Kassenga (2004) found that only a few areas could be reached easily when trucks and trailers were used.

Based on the findings of their study, Douti, Abanyie and Ampofo (2017) revealed that in the Bawku Municipality in Ghana, mechanical and manual means of waste transportation consisted of skip loader trucks and tricycles respectively. In the latter municipal area, some communities had no access to skips which had a negative impact on waste management (Douti et al., 2017). Where skips were available, the numbers were inadequate as the skip to population rate was in the region of 1:3 136 (i.e., one bin for every 3 136 members of the population) instead of the required 1:700 (Douti et al., 2017). Thus the number of people that a skip was expected to serve was four times larger than the stated maximum skip to population ratio. It came as no surprise that residents reverted to discarding their waste in their backyards, on the roadside and on vacant land, which caused an environmental and health threat (Douti et al., 2017). The system of a fee per waste removal unit worked well when residents wanted to get rid of

their waste and could afford the fee, but it was inappropriate for the many people who could not afford to pay (Douti et al., 2017).

2.7.3 The collection and transportation of waste in South Africa

South Africa faces the same challenges as other developing countries on the African continent with regards to the collection and transportation of MSW. Simelane and Mohee (2012) suggest that the starting point to improve the system is source separation at household level and the introduction of transfer stations which will have the potential to reduce the costs, as collection trucks will not be collecting from each household. However, Chimuka and Ogola (2015) observe that transfer stations could be subjected to vandalism by waste pickers and even stray dogs, which will render them hazardous to humans and the environment.

Medina (2011) observes that approximately 90% of MSW ends up in open area dumps and that only a small fraction of the waste is disposed of in an appropriate manner, while the remaining fraction is improperly disposed of. This results in severe ecological and health problems (Mohee & Bundhoo, 2015). For instance, in Lesotho the situation has become untenable as only 7% of urban household waste is collected and the rest is dumped on vacant land. In Gaborone (Botswana) and Maputo (Mozambique), household waste is also disposed of on open dumps rather than at regulated landfill sites.

Statistics South Africa (2012) indicated that, in 2012, refuse removal services that were provided by municipalities were more efficient in the more urbanised provinces of Gauteng (90.9%) and the Western Cape (90.8%) compared to the lower levels of efficiency in rural Eastern Cape (43.2%), Mpumalanga (39.2%), Limpopo (20,8%) and the Free State (79,2%).

2.8 Legislative frameworks for Municipal Solid Waste Management

Waste management legislation has been formulated in accordance with the types of waste or waste management practices at international, national and regional levels. Countries such as the US and UK have established their own MSWM laws, and European countries follow the waste directives of the EU (Dubois, 2004). Environmental protection is the practice of protecting the environment at household level for the benefit of the natural environment. Governments across the globe therefore recognise the importance of people's right to live in a healthy environment, but this seems paradoxical as this right is often in conflict with the reality of the threat posed by inappropriate waste management practices that put people's health at risk (Marshall & Farahbakhsh, 2013).

2.8.1 Solid waste management legislation from an international perspective

International environmental protection organisations such as the United Nations Environmental Programme (UNEP) aim to protect the right of people to live in a clean and healthy environment. The EU is very active in environmental policy regulations, the establishment of effective strategies for managing waste, and achieving compliance with EU policies and legislation. Thus municipalities and other service providers involved in managing waste should comply with various provisions in international instruments (UNEP, 2010). The EU policy on waste management is comprehensive and, according to EU (2011), embodies the following:

> "…The Community Strategy for Waste Management is embodied in the Waste Framework Directive (2006/12/EC) and the supporting Hazardous Waste Directive (91/689/EEC, as amended) as well as in the Waste Shipment Regulation ([EC] No. 1013/2006, repealing Regulation 259/93 and Decisions 94/774 and 1999/412). Specific directives on numerous waste streams complement this framework."

The EU waste policy has progressed from dealing with specific streams of waste to a more integrated approach to waste management and to resource management as a whole, with a focus on producer responsibility (EU, 2011) The EU waste policy also led to discontinuing the handling of individual waste streams separately but deals with the specific waste streams according to a holistic approach, which includes the management

of resources as well as honing in on the responsibility of the producer (European Union (EU), 2011).

2.8.1.1 Waste management legislation in the US

Government policies discourage the US from using fossil fuel and facilitate a focus on waste-to-energy strategies for fuel generation. All levels of government are involved in regulating solid waste in the US. Proper waste management extends from solid waste collection, segregation, transportation, storing, treatment and disposal to education, labelling, trading and interstate and intercontinental movement of waste. The United States Environmental Protection Agency (US EPA, 2010) is an agency of the federal government of the United States and was created to ensure that public health and the environment are not compromised. It thus promulgated and implemented regulations to comply with legislation developed by Congress (US EPA, 2010).

Important legislative documents that affect MSW in the United States are the following:

- The Rivers and Harbours Act of 1899;
- The Solid Waste Disposal Act of 1965;
- The Clean Air Act of 1970; and
- The Comprehensive Environment Response Compensation and Liability Act of 1986.

2.8.1.2 Waste management legislation in China

Chinese cities produce hundreds of millions of tons of solid waste each year and the majority of this waste ends up in landfills. In 2005, China made a commitment to improve waste management by adopting a renewable energy law which recognises the use of MSW as a source of energy, and currently more than 30% of MSW in China is converted to energy. This initiative serves as an example for the South African government that should adopt legislation that will limit the production of waste and compel municipalities to reduce the volumes of MSW that are being disposed of at landfills (Zhao, 2017).

The Chinese have become adept at supporting the development of waste management and waste-to-energy sectors, and in this context the government plays a vital role in

establishing legislation that will support these processes. Government policies support the waste-to-energy approach which is regarded as a solution to the growing problem of waste caused by increasing urbanisation. The renewable energy law was passed in 2005 and came into effect on 1 January 2006 (Zheng, Dong, Lou, Meng & Qui, 2014).

According to Zheng et al. (2014), the policies that support the waste-to-energy approach in China are the following:

- The National Garbage Disposal Facilities Construction Plan;
- Regulations guiding the administration of renewable energy power stations; and
- MSW disposal and pollution control technology.

2.8.2 South African waste management legislation

MSW in high income countries is primarily driven by factors such as public participation and awareness of waste management and the need to preserve the environment. Changes in public and political agendas and resource scarcity also impact waste management strategies and perceptions (Environmental Protection Agency (EPA), 2013). In South Africa, the National Environmental Management Waste Act 59 of 2008 (South Africa, 2008) states that no person may recycle, recover, treat or dispose of priority waste unless it is permissible according to the Act. New obligations have also been added to the Act, including waste avoidance and waste minimisation. Local municipalities in South Africa face many challenges in the waste management field as it has become increasingly difficult to enforce policies, which has resulted in ineffective waste management in many areas.

It is stated in the South African Constitution (South Africa, 1996a) that waste management service delivery is a local government function. Municipalities are thus by law responsible for the removal, collection and disposal of domestic and commercial waste. However, due to capacity constraints, private companies are contracted by municipalities to assist in the provision of waste collection and disposal services.

Municipalities are also required by the National Environmental Management Waste Act No. 59 of 2008 (South Africa, 2008) to formulate and implement integrated waste

management plans and new waste management systems as proposed by the Department of Environmental Affairs, but there is evidence of a lack of waste management awareness among officials and administrators to plan and implement these initiatives (South Africa, 2008).

However, progress has been made by some municipalities that have formulated draft integrated waste management plans. These municipalities include the Mafikeng municipality in North West Province, the municipality of the City of Johannesburg in Gauteng, and the eThekwini Metropolitan municipality in KwaZulu-Natal. Nzeadibe and Anyadike (2012) state that good environmental government should reflect sound understanding of the structure and its functions, because without understanding it is impossible to make the right decisions. It is thus noteworthy that the administration of environmental laws and responsibilities in South Africa is obligatory for various provincial municipalities and state departments. The provincial government should thus ensure that municipalities draw up and adhere to environmental management plans and principles according to legislation and policies.

In South Africa, legislation pertaining to waste management and the environment includes the following (DEA, 2010):

The waste management legislative framework comprises the following**:**

- Constitution of the Republic of South Africa, Act No. 108 of 1996;
- National Environmental Management Act No. 107 of 1998;
- National Water Act No. 36 of 1998;
- National Water Amendment Act No. 45 of 1999;
- Water Amendment Act No. 27 of 2014;
- National Environmental Management: Waste Act No. 59 of 2008;
- Minimum Requirements for Waste Disposal by Landfill (2nd ed.) 1998;
- Minimum Requirements for Handling, Classification and Disposal of Hazardous Waste (2nd ed.) 1998;
- White Paper on Integrated Pollution and Waste Management for South Africa, 2000;

- National Waste Management Strategy, 2011; and
- Local Government Municipal Systems Act No. 32 of 2000.

Of all the Acts and regulations, the National Environmental Management Waste Act No. 59 of 2008 (NEMWA) is the most important in terms of MSWM, as it:

- provides for environmental law reform in South Africa;
- is the first comprehensive Act to regulate waste management in a proactive manner;
- is the foundation of the legislative framework for the regulation of waste management; and because
- its interpretation and application include a precautionary approach, duty of care, environmental justice, and the “polluter pays” principle.

The National Environmental Management Waste Act, No. 59 of 2008: Norms and Standards were promulgated in a government gazette on 23 August 2013 and include the following:

- GN No. R 634: waste classification and management regulations;
- GN No. R 635: national norms and standards for the assessment of waste for landfill disposal; and
- GN No. R 636: national norms and standards for disposal of waste in landfill sites.

The National Environmental Management Waste Act No. 59 of 2008 Norms and Standards Gazette of 29 November 2013 includes the following:

- Amendments to Environment Impact Assessment Regulations Listing Notice 1 of 2010;
- Amendments to Environment Impact Assessment Regulations Listing Notice 2 of 2010;
- National Standards for the Extraction, Flaring or Recovery of Landfill Gas;

- List of waste management activities that have, or are likely to have, a detrimental effect on the environment;
- National Standards for the Scrapping or Recovery of Motor Vehicles; and
- National Norms and Standards for the Storage of Waste.

To assist with the introduction of “waste-to-energy” technologies in South Africa, there is a need to have supportive policies and regulations. “Waste-to-energy” technologies comprise any waste treatment processes that use waste as feedstock and that produce energy in the form of electricity, liquid or gaseous fuels, or heat (World Energy Council, 2013). Any “waste-to-energy” advantages contribute to renewable energy production and improved waste management. There are a number of policies and regulations that govern waste management, renewable energy and sustainable development. The following bodies are at the forefront of driving sustainable energy usage and environmental conservation globally:

The World Resource Institute (WRI)

This organisation was established in 2015. Due to increasing gaseous emissions from landfill sites, South Africa is the 17th largest greenhouse gas (GHG) emitter globally. Emissions from the waste sector have increased by 6% from 2000 to 2010 (Musee & Witi, 2014).

The Department of Minerals and Energy, 1998

South Africa is a fossil fuel-intensive country and there have been urgent calls that future energy supplies should be gained from renewable resources for cleaner and more efficient technologies. Currently, over 70% of South Africa’s primary energy resource is derived from coal and about 90% of electricity generation is coal-based (Eberhard et al., 2014).

Table 2.6 presents a summary of South African policies and legislation that supports waste management and the waste-to-energy approach.

Table 2.6: Policies and legislation that support waste management and a waste-to-energy approach in South Africa

Act	General requirement	Waste management	Waste-to-energy approach
Constitution of the Republic of South Africa Act No. 108 of 1996	Encourages public participation in decision-making processes	Makes provision for aspects such as litter management	Proper waste management will generate energy and reduce air pollution, a human right for the health of community members.
The Municipal Structures Act No. 117 of 1998	Ensuring services are delivered, and ensures compliance with legislation	Collection and disposal of MSW	Compliance with this act will increase recycling and will result in less energy required to produce more products.
White Paper: Policy on Pollution Prevention, Waste Minimisation, Impact Management and Remediation (2000)	Provides reasonable measures for the prevention of pollution and waste minimisation	Compliance will lead to integrated waste management and the implementation of waste hierarchy.	It Initiates proper waste handling which has led to waste-to-energy processes.
White Paper on Renewable Energy (2003).	Improves efforts to meet energy efficiency goals and encourages renewable energy projects	Forms the basis of waste management to initiate and fund improved waste handling strategies	Focus on waste disposal is changed to use waste-to-energy processes (biogas plants)
National Environmental Management: Waste Act No. 59 of 2008	Focuses on the principles of sustainable development in addressing environmental aspects; promotes waste avoidance and separation at source	Initiates proper waste management and focus is placed on recycling by communities	Compliance will ensure that the environment (global and national) is not affected; for example, greenhouse emissions contributing to climate change will be reduced.
Waste Information Regulations (Notice 430 of 2009)	Enables the user to access the WIS framework and implementation guidelines.	Municipalities are required to provide information regarding waste handling processes	All facilities involved with waste-to-energy projects must supply information for the national data base.

		to be recorded nationally.	
National Policy on the Thermal Treatment of General and Hazardous Waste (2009)	Incorporates thermal waste treatment technologies into national waste management policy.	Provides guidelines on what type of thermal waste treatment is efficient for different types of waste, e.g., health care risk waste requires incineration	Commissioning of waste-to-energy plants by methane emissions from landfills
National Strategy for Sustainable Development and Action Plan (2011-2014)	Promotes the effective stewardship of South Africa's natural, social and economic resources.	Waste handled effectively will prevent environmental pollution which is part of sustainable development.	Focuses on waste-to-energy conversion

Source: Author adapted the list from various policies and legislations supporting waste management and waste-to-energy drivers in South Africa.

2.9 MSW treatment methods

Various waste disposal methods or treatment techniques are used to dispose of MSW. The most common methods are landfill, composting, incineration, recycling and waste-to-energy technology. A brief overview of these strategies is presented in the following section.

2.9.1 Landfill

The purpose of using the landfill disposal method is to dispose of solid waste as effectively and with as little impact on the environment as possible (South Africa, 2012). Sanitary landfill strategies are used to dispose of waste by compaction, restricting the waste to a small area with the smallest possible volume, and ensuring that it is covered daily with a soil or earth layer (South Africa, 2012). Well managed sanitary landfills should not cause any nuisances, affect the health and safety of the general public, or be hazardous to the environment (South Africa, 2012).

2.9.1.1 Landfill practices globally

In the Philippines, only four sanitary landfills existed before 2004. The country was operating 86 such landfill sites and another 51 were under construction in 2014 (NSWMC, 2015). In Japan, anaerobic landfill reactors have been built, and an aeration system has been used in Austria since 1991 (Hudgins et. al, 2011).

Wet landfill is associated with the organic material in the landfill, and the energy gasification of methane from landfills can decrease the environmental effects of GHG emissions by 95% (Landcare Research, 2007). The most important objective is to prevent environmental impacts by reducing pollution and preventing leachate and landfill biogas, and to utilise waste as a renewable energy source which is eco-friendly (Kurian, et. al, 2004). The European Landfill Directive and the UK's enabling Act, which is referred to as the Waste and Emissions Trading Act of 2003 (Amendment) Regulations 2011 (S.I. No. 2499 of 2011) focus on the diversion of biodegradable municipal waste (BMW) from landfill, and MBT systems have the potential to distract BMW from landfill. The EU adopted the Landfill Directive 1999 to prevent combustible waste from being landfilled: in 2001, which stated that the landfilling of MSW was to be reduced to 75% of the value of year 1995 by 2006 and to 50% by 2009". The third phase, which was to be implemented by 2016, required a reduction down to 35%.

In Germany, a Waste Avoidance and Management Act was introduced in 1986. This Act states that, instead of creating new landfill sites and incineration plants, the principle of waste avoidance is given precedence over waste disposal (EEA, 2009; Fischer, 2013). Since 1993, Germany has had landfill restrictions for municipalities and the volume of municipal waste that was sent directly to landfill sites without treatment thus dropped from 39% in 1997 to 1% in 2006 (Federal Ministry for Environment, 2006; EEA, 2009).

In the USA, about 54, 3% of the MSW that was generated was disposed of in 1 908 landfill sites (USEPA, 2010). However, the total number of landfill sites in the USA was reduced while the total capacity of waste increased. In 1989, there were about 7 300

landfill sites, but by 2007 there were 1 800 such sites. The reduction in landfill sites was due to the unavailability of suitable space for new landfill sites when existing ones had been filled to capacity (USEPA, 2010).

2.9.1.2 Landfill practices in Africa

Landfill is the most widely used waste management method in Africa, but most African countries experience shortages when it comes to financing resources to manage solid waste, and this has resulted in low standards of service provision. Table 2.7 provides an overview of the average volumes of MSW that had been disposed of at landfill sites in some African countries by 2015.

Table 2.7: Municipal solid waste disposed at landfill sites in Africa

Country	Waste (%)
Morocco	28
Mauritania	37
Tunisia	65
Mauritius	91
Madagascar	97

Source: Sharholy et. al, 2008; Chimuka & Ogola, 2015

The relatively high percentages of MSW that are disposed at landfill sites suggest that much work still needs to be done to encourage African countries to adopt other options in their treatment of MSW − such as composting and increased recycling − to minimise the disposal of waste at landfill sites (Sharholy et. al, 2008; Chimuka & Ogola, 2015).

In Botswana, waste disposal costs are very high which results in the problem that waste disposal receives very little attention. This in turn exacerbates the problem of poor waste management, because waste management policies are not implemented. In 2011 there were only about 220 registered dumpsites in this country (Botswana Government, 2011), which is a small number for a country such as Botswana.

2.9.1.3 Landfill practices in South Africa

South Africa produces approximately 108 million tons of MSW per year, and the largest waste disposal route is to landfills. However, space for landfill sites is rapidly becoming very limited (Sentime, 2014; Ezeah et. al, 2013). A total of 90% of the waste that is generated in this country ends up in landfill sites, which causes health, social and environmental concerns.

In 2007 the South African Minister of Environmental Affairs, Mr Marthinus van Schalkwyk, stated that there were 1 321 landfill sites of which 629 were unauthorised and 58 were regarded as hazardous (DEA, 2011). Four years later, the DEA (2011) reported that there was a total of 1 336 licensed waste management facilities of which 1 203 were general waste landfill sites. Of these general waste landfill sites, 432 were licensed and 56.4% was unlicensed. Citing Bredenhann (2006), Roberts (2013) stated that the Free State Province had 87 landfill sites of which 10 were medium non-leachate generating landfill sites, 67 were small, non-leachate generating landfill sites, and 8 were communal landfill sites which were also non-leaching sites.

The function of the National Compliance and Enforcement Operation is to close down illegal sites if required. According to a compliance exercise that was conducted in 2011, all unlawful sites were prioritised for enforcement action based on the level of non-compliance that was detected. The actions that were taken ranged from immediately closing down operations to implementing measures to ensure environmental protection (South Africa, 2013). News24 reported in 2014 that, according to Environmental Affairs Minister Molewa, 178 of the 341 illegal sites that were identified in 2011 were in the process of being licensed in the different provinces. More recent information on the SAWIC site indicates that 750 licences were issued for the disposal of general waste on land in all nine provinces of South Africa. These licences were issued as original waste management licenses that included closing of landfills) (SAWIC, 2018).

According to Roberts (2013), at the time of her study few waste disposal sites in the Free State Province complied with the minimum legal requirements for waste disposal by landfill (South Africa, 1998a). Roberts (2013:39) argues that correct waste handling

practices “should be enforced on landfill sites as some of the waste is dumped at the gates of the landfills due to no access control. This may be overcome by training all municipal workers on site to segregate the waste”.

Moreover, there are strong arguments that the burning of waste at landfill sites should be prohibited and that the burning of waste should be replaced by composting as municipalities should comply with air quality legislation. If sites are non-compliant, they should be prosecuted according to the law (South Africa, 2004).

2.9.2 Composting

Compost is a highly recommended natural fertiliser globally. The main benefit of compost is that it greatly influences the condition of the soil by its ability to regenerate poor soil conditions and it enriches soil to promote higher yields of vegetation, including crops (EPA, 1997). Compost reduces the potential for the production of both leachate and gas formation at landfill sites (Diaz, Bertoldide, Bidlingmaier, & Stentiford, 2007). Composting is more environmentally acceptable for sustainable development than chemical fertilisers that may have harmful effects on the natural environment. Bin compost, bacteria, fungi and earthworms break plant and animal remains down into simpler components, thus releasing nutrients into the soil (Collins & Maneveldt, 2001).

When green waste is removed from a landfill site, leachate and contaminant volumes are reduced. Other benefits are that expensive treatment and monitoring processes of the leachate are avoided. Moreover, the generation of methane gas and expensive methane harvesting systems are limited and the closure and post-closure costs of a landfill site are reduced. All these will extend the lifespan of the landfill site as it takes approximately 30 to 40 years to mitigate the potential environmental damage that can be caused by a landfill site (Boswell, 1997). Moreover, municipalities could sell the compost or it could be used to maintain and beautify parks and vacant areas, and this will provide a number of benefits for urban and semi-urban residents.

2.9.2.1 Composting practices globally

Creating and maintaining public garden sites are common practices in the UK, other countries in Europe and the USA (EPA, 1997). In the USA, composting is widely used as a waste reduction method. For example, the California Compost Quality Council (CCQC) “is a unique alliance of compost producers, scientists, farmers, landscape contractors, and recycling advocates formed to administer compost quality guidelines in California” (CalRecycle, 2010).

In Denmark, small volumes of organic waste do not reach the municipal waste stream but are composted at household level (Petersen & Kielland, 2003). It has also been suggested that some garden waste be incinerated in waste-to-energy plants in order to generate energy and reduce the use of fossil fuels (Petersen & Kielland, 2003).

Moreover, the European Composting Network (ECN) is an organisation for “the collaboration of partners promoting sustainable practices in composting, anaerobic digestion and other treatment procedures for organic waste across Europe” (ECN, 2006. The development of composting facilities in Bangladesh, Pakistan and Vietnam was supported by the UN Economic and Social Commission for Asia and the Pacific (ESCAP) (UNESCAP, 2009).

2.9.2.2 Composting practices in South Africa

In South Africa, large quantities of organic waste are generated by low income communities (Hoornweg & Bhada-Tata, 2012). Therefore any form of treatment will be beneficial for volume reduction, waste stabilisation and resource recovery (Trois & Polster, 2007). Also, because a high percentage of green waste (10% to 35% of waste) is deposited at landfill sites, there is a huge potential for composting in South Africa where garden refuse is primarily disposed of at domestic landfill sites (World Bank 1999b).

The most important requirement for the conversion of green waste into compost is that it needs to be separated at source in order to have a clean, uncontaminated product

suitable for treatment/processing (Du Plessis, 2008). In the eThekwini Metro in KwaZulu-Natal, special bags have been used for green waste collection since the early 1990s and the composting of garden waste and biodegradable refuse has been encouraged (eThekwini Municipal Communications Department, 2008). This local authority thus views composting as an important aspect in the waste minimisation and recycling processes.

The City of Cape Town also initiated the diversion of green waste from landfill sites by creating collection points at conveniently located garden sites in April 2001. This initiative aimed to reduce landfill space (Furter, 2004) and private companies were encouraged to collect the green waste for composting from various facilities. Wei et al. (2000) support this process, stating that the environmental impact of the conversion of green and biodegradable waste into compost should be given more attention. Snyman (2007) found that, in Pretoria, about one third of household waste was made up of garden waste and that efforts were made to divert this waste to composting.

The National Waste Management Strategy promotes composting towards achieving the objectives of the waste management hierarchy, amongst other measures. The National Organic Waste Composting Strategy (NOWCS) was initiated by the DEA with the aim of developing and promoting the diversion of organic waste from landfill sites for soil beneficiation and other uses through composting (South Africa, 2012). The National Waste Information Baseline Report (NWIBR) (South Africa, 2012) estimated that the total volume of organic waste (garden and food waste) that was generated in South Africa in 2011 was in the region of 3 million tons, of which approximately 35% was recycled and the remainder (about 2 million tons) was landfilled. The percentages of organic waste generated in the nine provinces in 2011 are presented in Table 2.8.

Table 2.8: Organic waste generation by province (2011)

Province	Organic waste (%)
Gauteng	24
KwaZulu-Natal	20
Eastern Cape	13
Western Cape	11
Limpopo	10
Mpumalanga	8
North West	7
Free State	5
Northern Cape	2

Source: South Africa, 2012

The largest percentage of organic waste was generated in Gauteng and the second largest volume was generated in Kwazulu-Natal. The lowest percentage of waste was generated in the Northern Cape Province.

A programme to develop indigenous gardens at schools to raise awareness of waste reduction and to create environmental responsibility among school children was recently initiated. This programme aims to equip teachers and learners with basic horticultural skills and, to date, 57 school gardens have been developed throughout the Free State Province (South African National Biodiversity Institute [SANBI], 2015).

2.9.3 Incineration

Incineration is defined as “the treatment of waste material by combustion of organic substances present in the waste materials. It converts the waste material into heat, flue gas and gash which are released into the atmosphere without any further treatment for usage” (Nidoni, 2017). There are different types of incineration technologies such as rotary kiln furnaces, fluidised bed furnaces, electric furnaces, plasma arc furnaces and cement (World Bank 1999b).

The main purpose of incineration is to minimise the volume of combustibles by 80-90%, Decision Makers’ Guide to Municipal Solid Waste Incineration (World Bank, 1999b), and this improves the reduction of solid organic waste by 80-85% and its volume by 95-96%

(Nidoni, 2017). The advantages of incineration are that the volume of waste deposited at landfill sites is reduced and that energy is generated by the heat that is produced during combustion.

2.9.3.1 Global incineration practices

European countries have been moving away from incineration and countries world-wide have been investigating alternative waste management systems to landfill since 2000. However, regulations by the Commission of European Communities impose stringent controls with regard to landfill practices (Salminen & Rintala, 2002) and recommended incineration as an alternative.

The advantage of the incineration method is energy recovery, as the energy that is generated from incineration has the potential to provide in future energy requirements (Ipsen, 2005). However, waste incineration for energy recovery is not widely accepted in Europe due to environmental concerns (Bogner et.al, 2007), and many experts disagree with the incineration method for waste management even though it does not require such large areas as landfilling does and it has a smaller impact on the environment compared to landfilling. According to Bogner et. al (2007), high rates of incineration are found in Sweden, France and the Netherlands.

The disadvantage of incineration is that developing countries cannot afford the costs of building incinerators and therefore landfill is still the most preferred MSW treatment technology in these countries (Ipsen, 2005). According to USEPA (2010), the USA incinerates about 10% of its MSW which is a low incineration rate compared to that of other developed countries. In 2011, the USA recovered energy from 11.7% of generated waste.

2.9.3.2 Incineration practices in Africa and South Africa

The general rule in South Africa is that municipal waste must not be mixed with health care waste; thus incineration is juxtaposed to landfill (William, 2005). The main problems associated with MSW incineration are that it causes atmospheric pollution and that incineration ash, which is toxic, is deposited at landfills sites which increases the toxicity

of leachate (Goodstein, 2005). Emissions of flue gases also carry residues that are caused by incomplete combustion (Nidoni, 2017). Moreover, the gases that are emitted by municipal incineration are toxic enough to cause severe and persistent respiratory and cardiovascular health problems as well as skin and eye disorders. In South Africa, incineration is mostly used for the treatment and disposal of health care risk waste and other hazardous waste World Bank (1999b) and therefore the costly incineration of MSW and air pollution control measures limit incineration as an option for the treatment of MSW in South Africa (World Bank 1999b). The majority of waste that is generated in developing countries, including South Africa, is organic waste which has a high moisture content. In this context, Qu et al. (2009) and Zhang et al. (2012) argue that organic waste should be composted and used to enrich the soil for use in sustainable agriculture systems, as incineration is not a viable waste disposal option in Africa and in South Africa.

Industrialised countries produce waste with a lower moisture content than developing countries. As it is easier to burn organic waste with a low moisture content, and because some waste products are not suitable for composting due to their composition, Qu et al. (2009) and Zhang et al. (2012) argue that recycling should be considered as an alternative to landfilling and incineration in African countries, with particular reference to South Africa.

2.9.4 Recycling

Recycling is an efficient and effective method of minimising waste that is generated by households. Recycling could also provide much needed raw materials for industries as raw materials are returned and recycled for use. Thus the separation of reusable products from the rest of the municipal waste stream is strongly encouraged (Jowit, 2010; EPA, 2015). Recycling is practised on an international, national and provincial level in most countries, but the levels are still low in most developing countries where MSW continues to be generated in unacceptably high volumes.

2.9.4.1 Global recycling practices

Worldwide, recycling is recommended for MSW management in urban and rural areas as this practice will reduce the volumes of waste which will otherwise have to be disposed of at landfill sites (UNEP, 1996). The United States Environmental Protection Agency (USEPA) (2000) in particular recommends waste recovery for recycling as one of the most effective waste management techniques.

Most cities in the Arab world such as Aden, Aleppo, Amman, Bahrain, Cairo, Kuwait, Riyadh and Tunis are still at the initial stages of recycling, reuse and recovery as only about 1-3% of the total volume of generated waste is recovered as recyclable materials and recycling is thus only partially practiced (El-Mabrouk, 2014). Recycling activities in this region are mostly manual and labour intensive (El-Sherbiny et al., 2011). According to Nassour et al. (2011), in many of these countries scavengers pick waste from waste containers and disposal sites and the sorted waste materials are sold to local recycling facilities. For example, the Philippines recycle about 27.78% of its MSW (Zhao, 2017).

In Europe, Germany had a MSW recycling rate of 48% in 2001 which increased steadily to reach 64% in 2008 (Federal Ministry for Environment, 2006; EEA, 2009; Fischer, 2013). The level of recycling in Germany continued to increase, but organic recycling increased very little: from 15-17% in 2010. Germany aims to achieve a high recovery rate of municipal waste by 2020 (Federal Ministry for Environment, 2006; Fischer, 2013).

2.9.4.2 Recycling practices in Africa

According to Mbuligwe & Kassenga (2004), the residents of Dar es Salaam in Tanzania were given storage bags of different colours to separate waste at household level. This initiative was very successful and demonstrated that when residents are provided with the necessary storage bags, the sorting process for recycling is not a problem.

The Lagos State Waste Management (LAWMA) initiative introduced recycling banks in some areas and households in this country are encouraged to deposit their recyclable materials in these receptacles.

In Nigeria, recycling activities take place in the informal sector where waste buyers or scavengers have a direct impact on the reduction of waste. Materials that are extracted for recycling making use of a MBT process may include glass, metal and hard plastic objects. However, some materials that are extracted in this manner have market limitations as they are derived from a mixed MSW source and may thus be contaminated.

2.9.4.3 Recycling in South Africa

The National Waste Management Strategy that was introduced by the Department of Environmental Affairs aimed to ensure that all metropolitan municipalities, secondary cities and large towns initiated separation-at-source programmes by 2016. Research indicated that about 90 000 waste pickers earn a livelihood from the recovery of recyclables from municipal waste, and it has also been argued that if waste pickers are taken seriously by municipalities and companies, informal waste recycling could contribute to waste minimisation and more effective management of the waste stream (Sentime, 2014).

South Africa committed itself to the Polokwane Declaration of 2001, not enough awareness about recycling has been created in this country (Groundwork South Africa, 2017). The Declaration envisages that, by 2022, there will be a 75% diversion of recyclable materials from landfill sites (Groundwork South Africa, 2017). According to the DEA, the estimated number of waste pickers in South Africa ranges between 18 000 and 100 000 (DEA, 2013). It therefore goes without saying that if the impact that these people may have on the availability of recyclable materials is harnessed, a considerable reduction of landfill site waste volumes may be the result.

2.10 Waste-to-Energy technology

MSW has the potential to become a precious resource as it may provide future sustainable energy. The development of waste-to-energy technologies has the ability to convert the energy content of different types of waste into various forms of valuable energy (Rotter, 2011). Such technologies already generate heat and electricity in many developed countries. However, the choice of an energy recovery option depends on existing markets in European countries, the US and in developing countries (Branchini, 2015). Different techniques can be utilised for the treatment of municipal waste to produce fuel such as mechanical treatment and thermal treatment (Branchini, 2015). Producing fuel from waste has been a well-known waste management and energy recovery option. The main goal is to break organic substances down biologically or thermally before landfilling and thus to reduce the volume of waste that is sent to landfill sites (South Africa, 2013).

2.10.1 Waste-to-energy in developed countries

In every phase of the cycle of waste and energy production, energy production and MSW generation are interdependent on each other in the waste-to-energy conversion process (South Africa, 2013).

The largest European markets that established MBT plants include Germany, Austria, Italy, Switzerland and the Netherlands, with others such as the UK growing fast. There are over 330 MBT facilities in operation throughout Europe. The Environment Agency released a Waste Infrastructure Report (2010) in which it was stated that 19 authorised mechanical biological treatment (MBT) facilities existed in England with a total annual capacity of 2 728 300 tons, and with plants' total capacity ranging between 50 000 to 305 000 tons per annum (Siefert, 2010). Regions outside Europe that are also using this technology include USA (West Virginia in particular) and countries North Africa.

2.10.2 Waste-to-energy in developing countries

In South Africa, the provision of energy has been in crisis for some time. In 2015, the energy provision commission, Eskom, stated that it would continue to roll out its load-shedding schedule over two years (Department of Energy, 2015). According to Statistics South Africa (2016), this country's population growth rate increases on a yearly basis which places a heavy burden on the country's energy resources. Increasing urbanisation also leads to higher energy demands and this is associated with numerous problems to supply energy to low-income peri-urban settlements (Allen et al., 1997; South Africa, 2013). The Integrated Resource Plan for Electricity Update (2013) and the Integrated Energy Plan of 2012 (IEP) (South Africa, 2013) are the two main government energy strategies aiming to resolve energy challenges in South Africa. The Integrated Resource Plan for Electricity Update (2013) estimates that South Africa's electricity demand will range between 345 to 416 kilowatts/hour by 2030 (South Africa, 2013).

To meet these demands, South Africa has started to introduce operational waste-to-energy schemes, but the process is in its infancy. Existing plans incorporate mainly landfill gas-to-electricity schemes. There is the potential for waste-to-energy development in some provinces such as Gauteng, the Western Cape and Mpumalanga where considerable volumes of waste are generated given their population and economic activities (South Africa, 2013).

2.11 Littering and dumping of MSW

Litter originates from various sources but it is mainly derived from paper, glass, plastic and metal objects that are discarded by pedestrians and households (Armitage, 2007). The highest volumes of litter are mostly generated during community events because too few bins are strategically placed to make it easy for spectators to deposit their litter (South Africa, 1999). Some reasons for littering are:

- ignorance;
- the high cost of bulk landfill waste;
- the distances to legal landfill sites; and
- poor law enforcement.

People do not know where the nearest landfill sites or recycling centres are situated and sometimes the operating hours are inconvenient for them. According to the Department of Environment and Conservation (South Africa, 2007), it is easier for residents who reside near illegal dumping sites to dump their waste at such sites than to find out where the legal dumping sites are.

2.12 Conclusion

In this chapter the status of MSW practices was illuminated with reference to both national and global regions. The discourse revealed that, in developing counties such as South Africa, solid waste generation is higher than current levels of waste processing. MSW management challenges that are experienced in developing countries as well as ways for improving MSW management were elucidated. In this context, waste recovery and recycling, composting, incineration and the transformation of waste to produce energy were discussed.

In South Africa, various conditions such as poverty, unbridled urbanisation and slow economic and technological development impact technological advancement in the waste management process, but many similarities with developed countries exist that could pave the way towards developing appropriate, efficient and sustainable waste management practices.

In light of the challenges that South Africa experiences in the MSWM field, the review of the legislative framework that guides MSWM in South Africa suggests that the most important factors that will ensure the improvement and success of waste management practices are government involvement and the provision of financial incentives.

CHAPTER 3

RESEARCH METHODOLOGY AND ANALYSIS OF DATA

3.1 Overview

The previous two chapters focused on the generation, handling, collection and disposal of MSW as well as the types of treatment used for solid waste management in developed and developing countries. Incorrect practices impact the environment and lead to pollution, and thus this study aimed to determine the solid waste practices used by households and the current practices employed by municipalities in the study area. The sample was divided into two groups: one group comprised household residents who were deemed to be directly affected by the type of waste services provided, and one group comprised representative municipal managers and waste workers responsible for supplying waste services to the communities of the six towns under study.

This chapter elucidates the methodology that was used to obtain the primary data that informed the study findings. A questionnaire was administered to each group of the selected participants to obtain the data. Thus the questionnaire design, the sample size and selection, and the manner in which the data were captured and analysed are discussed. The delimitations and limitations of the study are briefly explained in Chapter four.

MSW is defined as waste that is generated by households and by commercial and industrial concerns and that is collected by a local municipality (Naidoo, 2009). Municipal waste management has always been a global challenge, especially in rural areas. The manner in which waste is handled, separated, stored and processed differs from country to country. Incorrect practices result in environmental problems such as serious land, water and air pollution (Nkwachukwu et. al, 2010). The Constitution of the Republic of South Africa (1996a) states that “everyone has the right to a clean and protected environment for the benefit of present and future generations”, and that can only occur

when local municipalities comply with legislation and have adequately trained staff to implement and manage the waste management process.

3.2 Design of the study

The overarching aim of the study was to highlight the current waste management practices of the various towns in the municipality under study and to determine community members' perceptions regarding these practices. To this end, the study utilised a qualitative study design which generated rich data that addressed the study objectives.

The study was designed to include a comprehensive literature review which served as a lens through which waste management practices were explored as a backdrop to the study, and a questionnaire survey that would elicit the actual views of residents and one municipal official regarding the nature of the waste management services they respectively experienced or rendered in the study area. Two questionnaires were designed to elicit frank closed- and open-ended responses in order to obtain rich data that would address the objectives of the study.

A peripheral aim of the study was to utilise the data to design an information leaflet that could be disseminated to communities as a guideline to inform residents of available services and opportunities such as recycling, composting and correct waste handling strategies and practices. This initiative would only come to fruition on completion of the study.

3.3 Aim, objectives and value of the study

The overarching aim of the study was to evaluate the current waste management practices provided in the Matjhabeng Local Municipality with reference to the views of one municipal manager and community members as the recipients of waste management services.

The objectives of the study were to:

- Review scholarly literature and the legislative framework that guides waste management in South Africa to determine best waste management practices;
- Identify waste management practices in the area under study through information provided by a municipal official responsible for all six the towns under study;
- Identify the waste management practices and perceptions of community members and assess the level of their satisfaction regarding waste management service delivery in their respective areas;
- Integrate current waste management strategies as revealed by a municipal official with information elicited from the respondents in order to identify critical issues that may inform the development of sustainable waste management service delivery practices in the area under study.

The value of the study lies in the fact that the findings will be utilised to make recommendations to municipal management in the study area with the aim of educating residents on maximising waste recovery, reducing waste generation, and ensuring safe waste disposal practices. Moreover, the results and the findings will be disseminated to and shared with academics and professionals in the waste management sphere through publications and conferences.

3.4 Study demographics and sample selection

South Africa is divided into nine provinces: the Eastern Cape, the Free State, Gauteng, Kwazulu-Natal, Limpopo, Mpumalanga, North West, the Northern Cape, and the Western Cape. The Free State Province is located in central South Africa north of the Orange River and the provincial capital is Bloemfontein. Figure 3.1 presents a map of South Africa indicating the geographical position of each of the nine provinces.

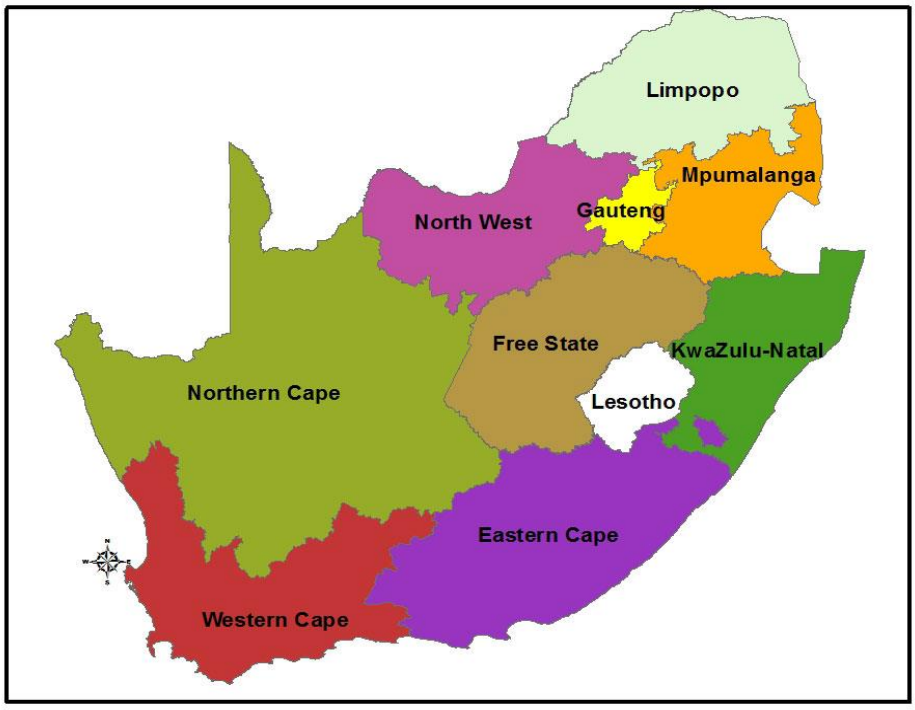

Figure 3.1: Map of South Africa's nine provinces

Source: Maps of world

Figure 3.2: Demarcation of Matjhabeng Local Municipality in the Free State Province.

Source: Matjhabeng Local Municipality

The study was conducted in a selected municipal area in the Free State Province, which is indicated on the map in Figure 3.2. Figure 3.2 depicts the location of the Matjhabeng Local Municipality area which is one of five municipalities in the Free State Province (Matjhabeng Local Municipality, 2012). Matjhabeng has a population of almost half a million. The following towns that are served by this municipality were included in the study, namely: Welkom, Virginia, Odendaalsrus, Hennenman, Ventersburg and Allanridge. Only the three largest of these towns are indicated on the map.

3.4.1 Historical overview of the towns in the Matjhabeng Local Municipality

The municipality's area of responsibility includes the six towns that were surveyed in the study. The background of each town is briefly discussed below.

Welkom (meaning welcome) is located in the centre of the Free State Goldfields. It was founded in 1947 and it is pivotal to the services rendered to various gold and uranium mines. Welkom received municipal status in 1968 (Matjhabeng Local Municipality, 2012).

Virginia (Meloding) is located on the banks of the Sand River. The town is well-known for its gold mining industries and became the second largest town in the Goldfields Area within a short space of time. It is also well-known because the world's deepest pipe-mine is located in its vicinity. Commercial farmers in the surrounding area primarily grow maize and raise livestock (Matjhabeng Local Municipality, 2012).

Ventersburg (recently renamed Mmamahabane) was named after an Afrikaner pioneer, PA Venter, who died in 1857. Ventersburg Municipality was established in 1903 (Matjhabeng Local Municipality, 2012).

Odendaalsrus (Kutlwanong) was the first town to be recognised in the goldfields in 1912. In 1946 it was predominantly populated by traders as it boasted only 40 houses

and three shops. However, the town expanded after the discovery of the richest gold reef in the World in its vicinity in April 1946 (Matjhabeng Local Municipality, 2012).

Henneman (Phomolong) began to grow in 1946 after the discovery of gold between Henneman and Odendaalsrus and was declared a Municipality in 1947 (Matjhabeng Local Municipality, 2012).

Allanridge (Nyakallong) was named after an honourable person by the name of Alan Roberts who discovered gold in the area. Allanridge was established in 1947, although it was only declared a town in 1956 (Matjhabeng Local Municipality, 2012).

Table 3.3: Summary of settlements within the Matjhabeng Local Municipality (2012/2013)

SETTLEMENT TYPE	HOUSEHOLDS	POPULATION
TOWNS		
ALLANRIDGE	663	3 315
HENNEMAN	958	4 311
ODENDAALSRUS	2 213	9 959
RIEBEECKSTAD	3 092	15 400
VENTERSBURG	359	1 616
VIRGINIA	4 454	22 270
WELKOM	9 708	48 540
SUB-TOTAL	**21447**	**105 470**
TOWNSHIPS		
BRONVILLE	2 159	12 306
KUTLWANONG	11 966	70 599

MELODING	10 482	60 796
MMAMAHABANE	2 345	14 070
NYAKALLONG	4 010	24 060
PHOMOLONG	4 871	29 226
THABONG	27 637	157 531
WHITES	55	314
SUB-TOTAL	**36 573**	**211 130**
RURAL SETTLEMENTS		
SUB-TOTAL	**0**	**0**
INFORMAL SETTLEMENTS		
NYAKALLONG	177	974
KUTLWANONG	359	8 278
THABONG / BRONVILLE	976	20 691
MELODING	584	4 516
PHOMOLONG	0	2 965
MMAMAHABANE	530	2 085
SUB-TOTAL	**1 736**	**9 565**
TOTAL	**59 759**	**316 600**

Source: Rapid Assessment Report of HDA (September 2013)

Demographics

According to the most recently available data, Matjhabeng Local Municipality has the second largest population in the Free State Province with 429 113 people. About 2.3%

of the population resides on farms whereas 97.7% resides in urban areas or towns (Matjhabeng Local Municipality FS184, 2017).

Income

Between 2001 and 2011, about 16.09% of households had no income. In this period the percentage of people earning less than R3 500 per month dropped by 2.66% and the people earning between R3 500 to R12 801 per month increased by 9.84% (Matjhabeng Local Municipality, 2012).

3.5 Data collection

To address the objectives of the study, two questionnaires were formulated: one for municipal officials and one for community members. Both questionnaires contained questions that focused on biographical data, knowledge of the area, perceptions, attitudes, and behaviour. However, because the objectives of the two sets of questionnaires were different, some questions overlapped whereas other questions were dissimilar. The questionnaires were semi-structured in the sense that both open- and closed-ended responses were required. Open-ended responses were elicited to questions where the respondents could select the ‘other’ option and provide reasons for selecting this option.

Figure 3.3 presents a flow diagram of the data collection process.

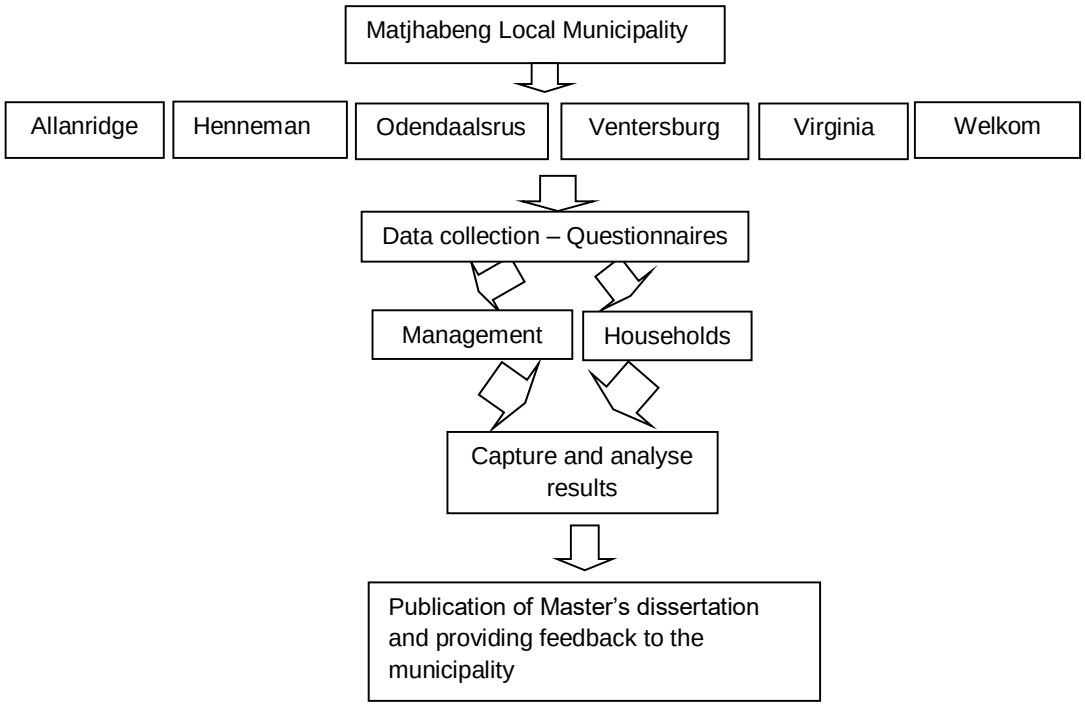

Figure 3.3: Schematic presentation of the data collection process

Source: Author

The six townships represented approximately 61 311 households according to Matjhabeng Local Municipality Annual Report (2015). A sample of 300 households (50 households from each of the six towns) was targeted. After the completion and return of the questionnaires, the waste management strategies of each town were assessed in terms of the feedback from the respondents comprising community members and local authority officials. Maps were obtained from the municipal offices to ensure that random selection of 50 households could take place in each section. A range of numbers was entered into a computer program which provided a series of random numbers which were used to select 50 households in each town. It is noteworthy that a 100% survey target was achieved as a neighbouring dwelling was visited when a household declined to participate in the survey until the target of 50 households per town had been met.

3.6 The Questionnaires

3.6.1 Validating the questionnaires by means of a pilot study

Two questionnaires (one aimed at residents and one aimed at municipal officials) were initially designed to elicit responses that would address the aim and objectives of the study. A pilot study was conducted in a residential area similar to the one where the main study would be performed. The pilot study involved community respondents who lived in similar conditions as the envisaged study sample and who were exposed to similar waste service practices as those who were eventually included in the survey. The feedback from the pilot study participants assisted the researcher in refining the questionnaires. Thus unnecessary questions were discarded and some questions were re-phrased to avoid ambiguity and misinterpretation. Two self-administered questionnaires targeting residents and one official were subsequently used in the study. The respondents could complete the questionnaire themselves, but the researcher was present during the completion of the questionnaires to assist with problems and uncertainties that could arise, as suggested by Katzenellenbogen et al. (1997).

3.6.2 Language used in the questionnaires

The questionnaires were presented in English. The researcher is proficient in the indigenous language used by the residents and in English and thus, when language barriers were experienced, she could offer translations to ensure that frank and unambiguous responses were obtained. One set of questions was presented to a municipal management official who was responsible for coordinating waste services in the entire municipal area, and the other set was completed by community respondents representing normal households in the various towns.

The qualitative nature of the study allowed the researcher to collect rich data that were required to understand MSW services in the Matjhabeng Local Municipality. Moreover,

the nature of the questions facilitated concise and specific responses that enabled the researcher to elicit the essence of the respondents' views. In this manner ambiguity and misunderstandings were avoided (Katzenellenbogen et al., 1997).

3.7 Questionnaire formulation and Administration

The questionnaires (see Residents Annexure A and the municipal official Annexure B) were used to collect data in order to address the following objectives:

- To determine residents' waste management practices and to assess the level of satisfaction of the community regarding waste management service delivery in their area;
- To identify current waste management practices in the area under study by means of information provided by a municipal official.

To achieve the study objectives, both independent (predicted) and dependent variables were included. Dependent variables may be viewed in terms of their effect. If the independent variable (predictor) is changed, it affects the dependent variable as it only changes in response to the independent variable (Statistics Solutions, 2018).

3.7.1 Independent variables (zero control variables)

These values can be controlled and do not depend on the state of any other variable, as it is the variable that is stable. The following independent variables were included in the study to determine the socio-demographic information of the participating residents:

- age
- number of persons in household
- gender
- educational qualifications and
- income.

3.7.2 Dependent variables

The variables that depend on other factors that are measured are expected to change as a result of an experimental manipulation. Thus the residents' responses in terms of the handling of waste from the point of generation to final disposal were dependent variables as they related to:

- handling of waste
- storage of waste
- collection of waste
- transporting of waste
- treatment of waste and
- disposal of waste.

The data that were obtained by recording the responses of the municipal official contributed to determining current waste handling procedures. The satisfaction level of the community regarding the waste delivery services provided by the municipality was determined by analysing the responses of the community members.

3.7.3 Application of the information obtained from questionnaires

As a consequence of the findings, recommendations will be made to the Matjhabeng municipal management in the form of general information regarding MSW practices that will benefit the community. Aspects covered in the recommendations will be applicable to educational programs that municipal environmental health practitioners (EHPs) can use in campaigns to motivate community members to reduce waste generation, to engage in re-cycling practices, and to maximise waste recovery.

3.7.4 Breakdown of questions

The results were recorded and the responses to the questions in the respective questionnaires were analysed (see Chapter 4). The questions were presented according to the following categories in the questionnaires:

3.7.4.1 Residents' questionnaire

Section A: Towns included in this study:

This section obtained and identified the data that were generated with reference to each of the six towns represented in the study.

Section B: Information of households: Q1 to Q15

The information that was obtained from individual members of various households included socio-demographic characteristics such as gender, marital status, level of education, occupation, income, and dwelling characteristics. It was important to know who was completing the questionnaire as a specific audience was targeted (Barnard, 2013). For example, the responses with regards to education enabled the researcher to compare the opinions of the respondents according to their educational level.

Section C: Questions relating to waste generation, transportation and collection were included in this section.

Waste generation: Q16 to Q18

Transportation and collection: Q19 to Q29

Waste handling, waste storage at home, waste minimisation, and waste recycling and composting: Q30 to Q36

Section D: Attitude of residents towards waste management (Q37 to Q44)

In terms of the community, participation with regards to environmental issues and organisations in the area, residents' opinions and suggestions towards improving the waste management system, and their attitude towards illegal dumping were assessed**.**

3.7.4.2 Waste management official's questionnaire

Section A: Towns included in this study: Q1 and Q2.

This section identified the towns that were surveyed.

Section B: Services and period of service: Q3 to Q4

The period that the official had been employed by the municipality was determined.

Section C: Collection methods: Q5 to Q7

Information regarding the collection methods that were used and the sites that were targeted − from point of collection to point of disposal – was elicited.

Section D: Workers and equipment: Q8 to Q13.

Questions pertaining to the equipment used by waste management workers were posed in the questionnaire. The literature revealed that in solid waste management operations, it is important that workers use protective clothing for their protection. For example, rubber gloves ensure that they are protected against hand injuries and diseases caused by pathogens; safety footwear (rubber boots) protects workers from foot injuries, wet conditions and sharp objects; safety coveralls protect workers from hazardous chemicals found in the waste being collected; respirators and dust masks protect workers from harmful substances causing respiratory problems; and safety hats protect them from head injuries stated in the Department of labour policy.

3.7.5 Ethical requirements and questionnaire administration

All ethical requirements pertaining to research participation were strictly adhered to during the survey. To ensure the security and confidentiality of the participants, they were informed at the outset that their anonymity would be safeguarded. Each participant voluntarily completed the questionnaire as he/she signed a permission form which also stated that they could withdraw at any time during the survey process. All the data are currently secured in a safe location and no persons, except the researcher, her supervisor and editing personnel, may gain access to the data under any circumstances.

3.7.5.1 Residents

The researcher was a full-time student and had received funding from Central University of Technology (CUT) to conduct the study on the scale that had been envisioned. To assist in the field work phase of the study, maps were obtained from the local municipalities. Houses were numbered on the maps and random numbers were selected by computer for the initial visits. The researcher thus conducted the field study by walking from house to house and knocking on the doors of the randomly selected houses. When a member of the household declined to participate in the survey, the next house was approached until the target of 50 houses per town were reached. Log sheets were completed to record each successful visit.

Some respondents were hesitant to participate in the study as they had signed forms and were afraid that they could lose their houses through a hoax. However, as the researcher carefully explained the purpose of the survey and the research process to them in their local language, many agreed to complete the questionnaire. If they did not want to participate, the house next door was approached. Nobody was coerced in any manner to complete the questionnaire. In some instances, the researcher went back to a house after working hours and on weekends to ensure that 50 respondents per town were included in the survey.

3.7.5.2 Municipal official

Upon visiting the municipal offices in Welkom, the researcher and her supervisor discussed the ethical rules and conduct and requested approval for the study by the relevant gatekeepers. A municipal official responsible for waste management services was approached and recruited for participation in the study at the municipal offices in Welkom. Information pertaining to each town was supplied by the authorised official on separate forms for each of the selected towns. This official was responsible for the entire district and agreed to cooperate after the nature and purpose of the study had been explained to him and gatekeepers' letters had been submitted.

It is reiterated that ethical considerations for the participation of all the respondents were adhered to in every respect. Letters requesting access from the local municipality to the different areas are included in the Appendixes.

3.7.6 Language barriers

As was mentioned before, language barriers were overcome as the researcher, who personally conducted the field work phase of the study, is proficient in English, Afrikaans and the indigenous language used by the local communities. All queries pertaining to the nature and purpose of the survey as well as the questions in the questionnaires could therefore be clarified to ensure frank and unambiguous responses.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The data collection methodology was discussed in the previous chapter. In this chapter the results of the processed data are tabulated, interpreted and evaluated.

A total number of 300 community participants (N = 300) (50 for each of the six towns) participated in the study, whereas information of the six towns that resort under the authority of this official was obtained from this person.

The analysis of the socio-demographic profile of respondents plays a very importance role in research. Such an analysis gives clear indications of diverse factors such as family structure, education, and the economic status of a specific family which may affect the value system of the respondents. The way people act, feel and think is directly or indirectly influenced by their background. Information in this regard this helped the researcher to understand the social structure and social relations of the respondents under study.

4.2 Demographic data: community respondents

4.2.1 Gender

The gender of the community respondents is presented in Table 4.1. Statistics South Africa estimated the total population of South Africa at 56.5 million in 2017. About 29% of the population is aged younger than 15 years and 8% is about 60 years. The life expectancy at birth for 2017 was estimated at 61% for males and 66% for females and the black population is in the majority at 81% of the total South African population. Western Cape has the highest number of life expectancy at birth for both male and females while the Free State has the lowest life expectancy (Statistics South Africa, 2017).

Table 4.1: Gender distribution of respondents

Towns	Females Total	Females %	Male Total	Male %	TOTAL (n)
Allanridge	34	68	16	32	50
Hennenman	32	64	18	36	50
Odendaalsrus	39	78	11	22	50
Ventersburg	34	68	16	32	50
Virginia	39	78	11	22	50
Welkom	35	70	15	30	50
TOTAL	**213**	**71**	**87**	**29**	**N=300**

*n = 50; N=300

Responses relating to the gender of respondents indicated in (Table 4.1) that the majority of respondents were female. The research indicates that in most societies women are responsible for domestic work and are taking care of their households. (South African Civil Society Information Service [SACSIS], 2014). A similar trend was observed by Lutui (2001) where the majority of respondents was female. and this study done in the Matjhabeng population indicated that there are also more females respondents than males (Matjhabeng Local Municipality, 2012). The South African Census reported that there are approximately 51% females and 49% males in the population (Statistics South Africa, 2017). Contrary to the current study, Gumbi (2015) reported that the sample distribution in the Ekurhuleni Metropolitan Municipality was 80% males and 20% females. Although Gumbi (2015) does not account for this discrepancy in the population figures, it may be argued that more men than women were available in the urban setting during the day for a research survey, as more men may have been employed than women. This is only conjecture however, and other variables may have accounted for this finding.

4.2.2 Population distribution

The population of South Africa was estimated around 56 million in 2017. Gauteng was the province with the largest population at 14 million followed by KwaZulu-Natal at 11

million. The Northern Cape had the lowest population figure at just over a million whereas the Free State had just over 2 million people (Statistics SA, 2017).

4.2.3 Ethnicity

In terms of ethnicity, statistics have shown that 80% of the Matjhabeng population is African (Statistics SA, 2016). The current study was conducted among residents in township areas and hence 100% of the resident respondents was African (Matjhabeng Local Municipality, 2012).

4.2.4 Marital status

Marriage is an important social institution in most South African societies and thus the perceptions and attitudes of people may vary according to their marital status. For example, marriage might make a person behave more responsibly and maturely and this may impact the views of respondents in a survey. In terms of marital status, diverse data were recorded for the participants (Table 4.2). Note that the first figure in each column in all tables refers to the percentage of respondents, whereas the second figure in parenthesis refers to the sub-total of the participants for each variable.

Table 4.2: Marital status of respondents

Towns	**Married**		**Single**		**Divorced**		**Widowed**		**Living together**		**Total (n)**
	n	%	n	%	n	%	n	%	N	%	
Allanridge	17	34	11	22	8	16	3	6	11	22	50
Hennenman	10	20	14	28	9	18	4	8	13	26	50
Odendaalsrus	20	40	12	24	4	8	2	4	12	24	50
Ventersburg	14	28	14	28	8	16	4	8	10	20	50
Virginia	16	32	12	24	6	12	2	4	14	28	50
Welkom	14	28	14	28	8	16	4	8	10	20	50
TOTAL	**91**	**30**	**77**	**26**	**43**	**14**	**19**	**6**	**70**	**23**	**N=300**

*n = 50; N=300

The majority of the married respondents (20 or 40%) hailed from Odendaalsrus whereas only 20% (10) from Hennenman were married. Overall most of these respondents were married (91%) followed by those single (79%) while the lowest was windowed (38%). The fact that the majority of the heads of the households were working resulted in the questionnaires being answered by relatives or persons living in the house at the time of the survey. Conversely, a study undertaken in Ekurhuleni Metropolitan Municipality regarding waste management responses indicated that about 69% were married while 31% of them were unmarried (Gumbi, 2015). (Table 4.3) indicates which of the respondents providing the information of the owners of each house.

4.2.5 Home ownership

About 80% of South Africans have formal dwellings, 14% informal dwellings and 6% traditional dwellings.

Table 4.3: Ownership of the houses by respondents

Towns	Yes Total	Yes %	No Total	No %	TOTAL (n)
Allanridge	21	42	29	58	50
Hennenman	18	36	32	64	50
Odendaalsrus	15	30	35	70	50
Ventersburg	24	48	26	52	50
Virginia	19	38	31	62	50
Welkom	20	40	30	60	50
TOTAL	**117**	**39**	**183**	**61**	**N=300**

*n = 50; N=300

The provinces with higher percentages of households living in formal dwelling is Limpopo (92%), Mpumalanga with (87%) and Northern Cape (86%) (GHS, 2017).

Table 4.3 and Table 4.4 indicated the respondents who were present in the house in the absence of the owner.

The survey was done during the day when most of the heads were at work. This resulted in the finding that, in all the towns under survey, a large percentage of respondents was not the owners of the houses they were residing in .

Table 4.4: Position or role in the household

Towns	Child of the owner Total	Child of the owner %	Renting Total	Renting %	TOTAL (n)
Allanridge	2	4	27	54	29
Hennenman	5	10	27	54	32
Odendaalsrus	6	12	29	58	35
Ventersburg	4	8	22	44	26
Virginia	9	18	22	44	31
Welkom	6	12	24	48	30
TOTAL	**32**	**17**	**151**	**83**	**N=183**

*n = 50; N= 300

The results may have been impacted by the ownership status of the respondents at the time of the survey, as most respondents were either renting, were not related to the owner, or were domestic workers. This suggests that the commitment to and knowledge of domestic waste management could have been limited among some respondents, yet all residents of a dwelling are part of the waste generation chain and should thus be cognizant of basic waste management practices in the domestic sphere.

4.2.6 Period of residential occupation

Table 4.5 indicates the period of time the respondents had been staying in the various surveyed dwellings. This period ranged from a year to more than five years. In each of the six towns, more than 70% (35) of the respondents had been living in the area for more than five years (Table 4.5).

Table 4.5: Period of time that respondents resided in the surveyed homes

Towns	Less than one year		One to five years		More than five years		Total
	n	%	n	%	n	%	
Allanridge	0	0	10	20	40	80	50
Hennenman	0	0	9	18	41	82	50
Odendaalsrus	0	0	11	22	39	78	50
Ventersburg	0	0	12	24	38	76	50
Virginia	0	0	15	30	35	70	50
Welkom	0	0	13	26	37	74	50
Total	**0**	**0**	**70**	**23**	**230**	**77**	**N=300**

*n = 50; N= 300

When the data pertaining to the length of stay and the burning and illegal dumping in Table 4.17 (of waste were integrated, it appeared that there was a relationship between length of stay and the tendency to burn or illegally dump waste. This is suggested by the fact that the highest rates of burning and illegally dumping waste were found among residents who had been living in the area for more than five years. Dawnaraina (2004) recorded a similar result by indicating that the length of stay in the study area showed a strong association with residents who illegally dumped waste.

4.2.7 Number of residents per household

It is inconclusive whether the quantity of waste that is generated per household is influenced by the number of residents living on a property. Table 4.6 reflects the number of people per household in each surveyed town.

Table 4.6: Number of people living on the premises

Towns	One to two		Three to four		Five to six		Seven to eight		Total
	n	%	n	%	N	%	n	%	
Allanridge	20	40	22	44	8	16	0	0	50
Hennenman	27	54	12	24	11	22	0	0	50
Odendaalsrus	29	58	18	36	3	6	0	0	50
Ventersburg	32	64	14	28	4	8	0	0	50
Virginia	27	54	15	30	8	16	0	0	50
Welkom	20	40	17	34	10	20	3	6	50
Total	**155**	**52**	**98**	**33**	**44**	**15**	**3**	**1**	**N=300**

*n = 50; N= 300

Table 4.6 indicates that more than 50% from all six the towns under study lived in medium sized households that accommodated one to four members. Only three households reportedly accommodated seven to eight residents.

According to Sivakumar and Sugirtharan (2010), the quantity of waste generated by families can differ from household to household. This suggests that there is no blueprint for the manner in which affluent and poor families produce waste. For example, a family of two people may generate as much waste as a family of four, as there is evidence that income levels affect waste production. For example, high-income households of more than four members may manage waste well as they may be adequately facilitated, but

they may also be more wasteful as replacing food and clothing items may be affordable. Left-over food may therefore not be consumed as readily as in low- or medium income households. Medium income households may also produce less waste although there may be more people living in the home as such families are thrifty in the manner in which they utilise consumables. Thus middle income residents may produce less unnecessary waste as they know that they can ill afford wasting food, leftovers and worn-out clothes.

4.2.8 Educational level

Financial circumstances are linked to educational standards which in turn enable some people to live in high income areas (GHS, 2017). A study that was undertaken in Gaborone in Botswana regarding waste management revealed that educational levels impacted household size, and it was suggested that high educational levels were associated with smaller (4 to 6) family sizes (Gabairiti et al., 2012). The educational levels of the respondents in the current study are presented in Table 4.7, which illustrates a range of educational levels from primary to tertiary education.

Table 4.7: Educational level of respondents in selected Free State towns

Towns	Primary		Secondary		Tertiary		Total
	n	%	n	%	n	%	
Allanridge	7	14	43	86	0	0	50
Hennenman	12	24	25	50	13	26	50
Odendaalsrus	5	10	40	80	5	10	50
Ventersburg	10	20	33	66	7	14	50
Virginia	7	14	33	66	10	20	50
Welkom	15	30	22	44	13	26	50
Total	**56**	**19**	**196**	**65**	**48**	**16**	**N=300**

*n= 50; N= 300

Table 4.7 presents the education demographics of the response group. The data are divided into three categories namely primary (grades 1 – 7), secondary (grades 9 – 12) and tertiary (post-grade 12) education. All the respondents had received some form of schooling ranging from primary to tertiary level. In South Africa, secondary schooling is concluded after 12 years of basic education before a learner voluntarily enters tertiary education to obtain a university degree or a diploma. According to Statistics South Africa (2016), approximately 86% of the total population of the Free State had completed school at the time of the 2016 survey, but only 4.6% of the population had obtained higher education qualifications.

The findings of the current study reflected similar secondary school rates but slightly higher rates for tertiary education than the national average. The majority of the respondents in this study held a secondary (high) school qualification. Allanridge and Odendaalsrus had the highest rates of secondary school qualified respondents at 86% (43) and 80% (40) respectively, while 26% of the Welkom and Henneman respondents held tertiary qualifications. Dawnaraina's (2004) study showed fairly similar results, as "the overall education levels averaged 19% for tertiary and 63% for secondary level education in an area with low to middle socio-economic status when compared to high income areas". Etengeneng (2012) states that people with a higher education status tend to have a more positive attitude and participate in waste management practices because of their knowledge of waste issues. Poswa (2000) concurs, and argues that, with regards to domestic waste management, less educated people do not regard cleanliness and waste related issues as a priority. Moreover, the Statistics (2016) recorded under the general household survey that an improvement in waste handling by individuals with tertiary qualifications (i.e., an increase from 9.3% to 14%). It is thus argued that people with higher levels of education should have a sound understanding of the impact of waste on the environment (Statistics South Africa, 2016). Gumbi's (2015) study also found that improved educational qualifications influenced employment opportunities (Figure 4.1).

In light of the foregoing findings, the researcher presents the argument that education is vital for sustaining waste management programmes because people can only be

convinced of the necessity for effective waste management strategies if they understand the negative effects of poor waste handling and management.

4.2.9 Employment

Improved educational qualifications influence employment opportunities positively. Figure 4.1presents the data reflecting the employment status of the participants in the current study (*n= 50; N=300).

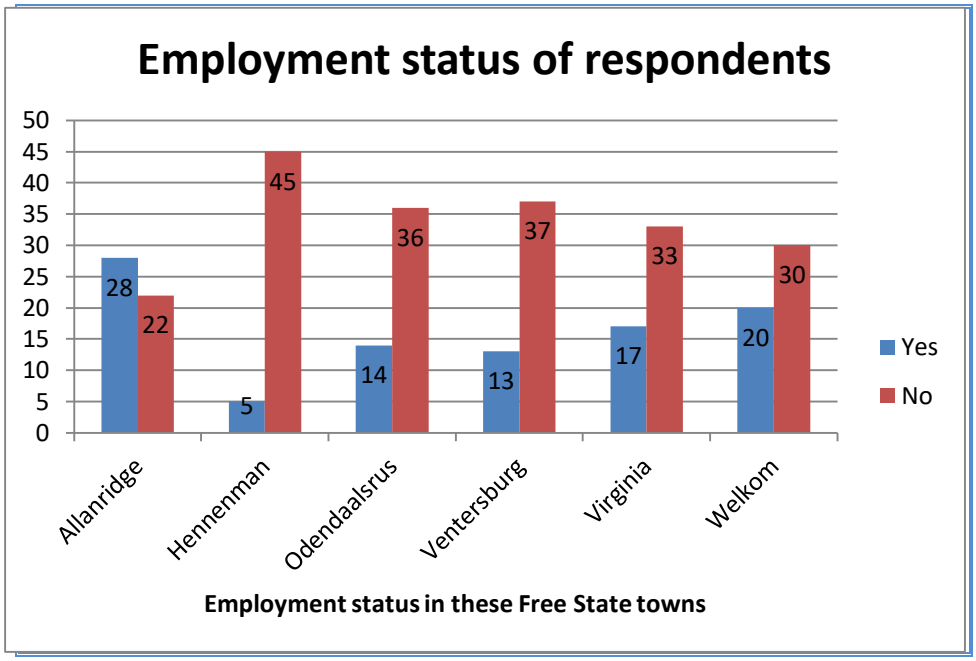

Figure 4.1: Employment status of respondents

A large majority of the participants was unemployed. This finding should be viewed in context as the survey questionnaire was completed by a resident who was present in each home at the time of the visit. It was assumed that many household heads and home owners were at work at the time. However, as literate members of the household (see Table 4.7) who had resided there for a year or more (see Table 4.5), the participants were cognisant of domestic waste management strategies and for this reason the data may be deemed valid.

The majority of the respondents were secondary school children and state pensioners, of which both groups were unemployed. The participants' employment status was determined. Reference is also made to the number of pensioners that resided in the homes (Table 4.8).

Table 4.8: Nature of employment of respondents

Towns	**Permanent**		**Temporary**		**Occasional**		**Pensioner**		**Total**
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
Allanridge	3	6	13	26	12	24	10	20	38
Hennenman	0	0	2	4	3	6	7	14	12
Odendaalsrus	4	8	4	8	6	12	8	16	22
Ventersburg	1	2	9	18	3	6	5	10	18
Virginia	6	12	7	14	4	8	10	20	27
Welkom	7	14	5	10	8	16	8	16	28
Total	**21**	**15**	**40**	**28**	**36**	**25**	**48**	**33**	**N=145**

***n= 50 ; N=300**

Overall, the employment rate (97 people had some form of employment) was lower that the pensioner rate and the learner/never employed rate (203 participants) combined. Combined, only 145 respondents (48.3% = permanent, temporary, occasional and pensioner) had some form of income. The data thus suggest cause for concern as more than 50% (155 participants) had no income at all. It is also noteworthy that the permanent employment rate was significantly lower (21 participants) compared to the part-time employment rate (76 participants combined) and an income by means of a pension (48 participants).

These findings have various implications for domestic waste management practices. First, as the income per household may be limited, efforts may be made to waste as little as possible in terms of consumables.

4.2.10 Income

The respondents were requested to state their monthly income category. It may only be assumed that this information was provided correctly, as monthly income is a very personal matter and people are notoriously loath to reveal this information accurately.

Table 4.9 indicates the monthly income of the working respondents per month. Gumbi (2015) found that about 25% of the respondents was permanently employment, 28% was self-employed, 17% earned a living through other means, and 30% was not employed. The current study did not include self-employment as a category (Table 4.8), but it was assumed that this employment status would be included under either the temporary or occasional employment categories.

Table 4.9: Income of the respondents

Towns	No income		R1 to R800 per month		R801 to R3200 per month		R3200 to R12800 per month		Total
	n	%	n	%	n	%	n	%	
Allanridge	12	24	22	44	8	16	8	16	50
Hennenman	38	76	5	10	3	6	4	8	50
Odendaalsrus	28	56	6	12	5	10	11	22	50
Ventersburg	32	64	7	14	2	4	9	18	50
Virginia	23	46	6	12	6	12	15	30	50
Welkom	22	44	13	26	5	10	10	20	50
Total	**155**	**52**	**59**	**20**	**29**	**10**	**57**	**19**	**N=300**

*n = 50; N= 300

Of the 300 respondents, 155 recorded no income at all, which tallies with the unemployment data in Table 4.8. This suggests that the respondents answered these questions frankly, which adds to the validity of the data.

Table 4.9 indicates that more than 50% of the respondents from Henneman, Odendaalsrus and Ventersburg, with the rate for Henneman as high as 76% (38 of the 50 participants), had no income. In Virginia, 30% (15) of the respondents earned more than R3 200 per month.

The above data may not be conclusive in terms of income per household, as more than one person per household may earn an income. South African Statistics reported that in 2011 about 16% of households earned no income at all, while between 2001 and 2011 the percentage of people earning between R3 500 to about R12 801 per month increased by over 9% in the Matjhabeng area (Matjhabeng Local Municipality, 2012). Gumbi's (2015) study conducted in the Erkuhuleni Metropolitan Municipality found that the monthly income that was earned either through permanent or other forms of employment by 70% of the respondents was about R1 000 per month, whereas 42% of the respondents indicated that they earned above R1 000 per month, 16% earned between R5 000 and R6 000 per month, and 12% earned between R4 000 and R5 000 per month.

Households' main sources of income differ and more than one source may ensure an income for a specific household by means of salaries, pensions, or income through self-employment and business enterprises. Nationally, in 2017 58% of households received salaries as a main source of income whereas 20% of households received a pension or grant. The Western Cape (79%) and Gauteng (73%) were the provinces with the largest percentage of households that earned salaries and in the Eastern Cape and Limpopo grants were more prevalent than salaries as a source of income. In the Free State where the study was conducted, 60% of households' income was earned by means of salaries and 50% received grants (Statistics South Africa, 2017).

4.2.11 Access to media resources

This variable was included in the questionnaire as it was deemed appropriate as a measure to determine whether waste management information and motivational directives could be transmitted to the various communities under study. The findings were encouraging as it was illuminated that 100% of the respondents had access to radio broadcasts, which will render this source vital in municipalities' efforts to educate people about domestic waste management strategies.

Table 4.10: Residents' access to the media

Towns	Television % (n)	Radio % (n)	Daily newspaper % (n)	Weekly newspaper % (n)
Allanridge	40 (20)	100 (50)	0	0
Henneman	38 (19)	100 (50)	0	0
Odendaalsrus	56 (28)	100 (50)	0	0
Ventersburg	70 (35)	100 (50)	0	0
Virginia	80 (40)	100 (50)	0	0
Welkom	88 (44)	100 (50)	0	0
TOTAL (N)	**186**	**300**	**0**	**0**

***n= 50; N= 300

Table 4.10 indicates that all the respondents (100%) had access to a radio and more than 60% had a television in their homes. The latter figure may even be higher if it is considered that people – and especially children − often tend to watch television with neighbours. The highest rate of access to television was in Welkom (88%) followed by Ventersburg (70%), whereas the lowest rate was in Henneman (38%), which was relatively low for a rural area. None of the respondents read either daily or weekly newspapers regardless of the fact that the weekly *Vista* newspaper is readily available at libraries every Thursday (Matjhabeng Local Municipality, 2016). Neither radio

programmes nor television broadcasts focus on specific residential areas, thus the fact that residents did not have access to local information regarding littering, poor environmental practices or incorrect waste handling strategies could have contributed to a negative or an indifferent attitude towards domestic waste management. However, if residents are sensitised in the future to information regarding indiscriminate littering and poor waste management and how these practices impact the environment negatively, steps may be taken in the right direction towards proper domestic waste management. For example, if residents see photos of their neglected and poorly maintained environment compared with others where citizens take responsibility for the cleanliness of their living conditions, they may be motivated to actively participate in keeping their environment clean. But as long as the attitude persists that the government or the local municipality is solely responsible for maintaining the environment and disposing of waste, little will happen to improve the situation in the domestic waste management sphere.

The assets that residents have – such as owning a home, appliances, a motorcar or furniture − influence the extent to which they can and will diversify their livelihoods. According to GHS (2017), households in urban and metropolitan areas are much more likely to procure assets than households in rural areas due to financial constraints in the latter areas. The current study found that about 62% of the households under survey owned television sets, whereas the national average is about 70% for rural areas (Ibid).

4.3 Demographic data of the Municipal Official

Waste management officer at Matjhabeng local municipality is currently working for all six towns that resort under Matjhabeng local municipality. The authorization to conduct the field study in Matjhabeng Local Municipality was verbally given by the waste management officer. The maps of the different areas were provided to the researcher.

4.4 Residents' attitudes towards waste management

It is important to involve residents in proper waste management practices, yet this will only occur if they are regularly exposed to information regarding littering and prevention of littering; how they could contribute to reduce air, water and land pollution; and how diseases that are caused by incorrect waste disposal practices and treatment can be prevented.

4.4.1 Reaction to indiscriminate discarding of waste and littering

To address objective three, the respondents were requested to comment on their reactions and actions when confronted with waste that is indiscriminately discarded in their respective neighbourhoods (Table 4.11).

Table 4.11: Reaction of respondents of MLM area when waste is thrown around

Towns	Ignore it		Pick it up yourself		Ask them why		Tell them not to		
	n	%	n	%	n	%	n	%	
Allanridge	24	48	6	12	0	0	20	40	50
Hennenman	33	66	7	14	0	0	10	20	50
Odendaalsrus	29	58	8	16	0	0	13	26	50
Ventersburg	17	34	4	8	4	8	25	50	50
Virginia	23	46	8	16	3	6	16	32	50
Welkom	30	60	5	10	0	0	15	30	50
TOTAL	**156**	**52**	**38**	**13**	**7**	**2**	**99**	**33**	**N=300**

*n= 50; N= 300

What is disturbing about the results is that the majority of the respondents would simply ignore indiscriminate littering or waste disposal. The respondents from Henneman (66%) and Odendaalsrus (58%) in particular tended to ignore littering. Conversely, 50% (25) of the Ventersburg respondents would take a more assertive stance by accosting the culprit and telling him/her not to litter or discard waste inappropriately. A very few respondents from only two areas (Virginia [6%] and Ventersburg [8%]) indicated that they would ask the culprit why they littered or discarded waste inappropriately. Overall, a very small number of respondents 38 0f 300 stated that they would take action and pick the litter up themselves in order to discard it appropriately. Overall, the data suggest that the residents had not been sensitised to the issue of littering and poor waste disposal strategies, although some responses indicated that certain households were aware of high pollution levels and might take action if the situation required it. Therefore, one can assume that the residents may be receptive to information and will practise measures to reduce environmental pollution for their health and safety.

Based on the above findings, it may be argued that the local municipalities have either been ineffective in or are in denial of their mandate to sensitise and educate citizens about the threats associated with waste and appropriate waste management strategies. In either case, the mandate is clear that more concerted efforts should be put in place to inform and educate the citizenry about their waste management responsibilities. In this context, Barr (2007) explains that environmental values and people's understanding of environmental issues influence the way in which they produce and manage waste. Thus local authorities have a clear responsibility to take action in order to address the issue of poor waste management strategies in their areas of responsibility.

Dawnaraina (2004) states this responsibility succinctly:

> "Community involvement in waste management issues is important; e.g., participation in setting own community standards. This process must be governed by rules that set standards of acceptable behaviour and time frames for a process that must be binding on all the stakeholders and participants."

4.4.2 Sharing waste management concerns

It was important to discover whether waste management concerns affected the residents and whether they would be prepared to discuss these concerns with other citizens.

Table 4.12: Would you share waste management concerns with other residents?

Towns	Yes		No		Total
	n	%	n	%	
Allanridge	15	30	35	70	50
Hennenman	15	30	35	70	50
Odendaalsrus	19	38	31	62	50
Ventersburg	5	10	45	90	50
Virginia	12	24	38	76	50
Welkom	9	18	41	82	50
Total	**75**	**25**	**225**	**75**	**N=300**

*n= 50; N=300

The majority of the respondents indicated that they did not discuss domestic waste concerns with other community members. It was only in Odendaalsrus, Henneman and Allanridge that 30% or more of the participants stated that they discussed waste concerns with other community members. Overall, a mere 25% of the participants would share their waste management concerns with fellow residents.

Although citizen participation in service delivery is one of the goals of Local Agenda 21 which originated at the Rio summit on Environment and Development in 1992, this seems to be a pipe dream among many communities. For example, Dawnaraina (2004) also found that a limited number of residents was really concerned about waste management

issues. According to Etengeneng (2012), this problem is primarily associated with a lack of education regarding domestic waste management practices.

4.4.3 The importance of keeping the environment clean

Regardless of their unwillingness to take action in order to ensure that the environment was kept clean of waste, all the respondents (100%) indicated that they deemed it important to keep the environment clean and neat. However, their lack of willingness to act in this regard suggests that they expected the local municipality to take sole responsibility for this task.

Holistic and responsible environmental management and practices can only be achieved if all role players, which include all residents, accept their responsibilities in this regard and act accordingly. Educating communities and motivating them to change their mind set and attitude towards domestic waste management have therefore become crucial. The starting point will be that local municipalities accept this mandate and start creating effective communication channels between the municipality (i.e., the service provider) and residents. Utilising local radio stations, distributing flyers, and engaging in school and community organisation visits can be effective points of departure.

4.5 Collection and transportation of MSW

The respondents were aware that waste was collected by service providers contracted by the municipality and that the waste was transported to landfill sites.

4.5.1 Waste collection days

Waste is collected on specified days and Table 4.14 indicates if they know when their waste is scheduled for collection.

Table 4.13: Knowledge of waste collection days

Towns	Yes		No		Total
	n	%	n	%	
Allanridge	25	50	25	50	50
Hennenman	25	50	25	50	50
Odendaalsrus	20	40	30	60	50
Ventersburg	28	56	22	44	50
Virginia	20	40	30	60	50
Welkom	30	60	20	40	50
Total	**148**	**49**	**152**	**51**	**N=300**

*n= 50; N= 300

Table 4.13 illustrates that there was an almost equal division between those participants who knew when the waste collection week day in their area was (49.3%) and those who did not (50.7%). This lack of information about an important health service might have been due to the fact that almost 50% of the respondents was not home owners and may have been owners' relatives, children or pensioners residing on the premises. However, even pensioners and tenants should know when waste is collected, so this high rate of uncertainty about waste collection schedules was a disconcerting finding. However, it supports the lethargic and disinterested attitude towards waste management issues that was illuminated in previous sections and thus serves to validate these findings.

4.5.2 Frequency of waste collection

The collection and transportation of domestic solid waste is generally the most costly phase of the MSW management process. The participants' awareness of the frequency of waste collection was therefore explored (Table 4.14).

Table 4.14: Frequency of waste collection from domestic dwellings

Towns	Once a week		Every two weeks		Once a month		Once every two months		
	n	%	n	%	n	%	n	%	
Allanridge	18	36	12	24	10	20	10	20	50
Hennenman	10	20	20	40	10	20	10	20	50
Odendaalsrus	16	32	16	32	10	20	8	16	50
Ventersburg	15	30	24	48	6	12	5	10	50
Virginia	20	40	20	40	5	10	5	10	50
Welkom	10	20	11	22	15	30	14	28	50
TOTAL	**89**	**30**	**103**	**34**	**56**	**19**	**52**	**17**	**N=300**

* n= 50; N= 300

About 40% (20) of the responses from Virginia stated that there was a regular collection of waste every week whereas the other 40% (20) stated that collection of waste took place every two weeks. In Ventersburg, the largest percentage of the respondents (48% or 24 respondents) stated that waste was collected every two weeks whereas, combined, the majority of the respondents (more than 50%) in Welkom indicated that waste was collected once a month or once every two months. The responses of respondents of the towns differ from the waste management department which indicated that waste was collected once a week.

There was thus a disconcerting lack of agreement among residents of each respective town regarding the frequency of waste collection in their areas. Overall, the majority (103 of the 300 participants) agreed that waste was collected every two weeks in their respective areas, but this constituted a mere 34%. These findings again support the

impression of residents' lack of knowledge and concern about waste management practices.

A possible explanation for this lack of consensus regarding waste collection frequencies is that collection may indeed have occurred intermittently and not regularly according to a waste collection schedule per area, and that the respondents were baffled by this irregular service.

Compared to the findings in Maluleke's (2014) study, the collection ratios recorded in this study were poor. Maluleke (2014) found that 98% of Limpopo residents stated that waste was collected regularly in their area.

According to General Household Survey (2017), refuse is removed at least once a week for about 90% of all households in metropolitan areas. It is most common in Mangaung and Bloemfontein in the Free State (96%) and the City of Johannesburg (95%), and least common Tshwane (85%). However, as the data for the current study were obtained in township areas, there is clear evidence that these areas are marginalised and that consistent waste removal scheduling, with unambiguous information being disseminated to all households, is an issue that needs urgent attention.

The General Household Survey (2017) states that 95% of waste is removed at least once a week in Free State metropolitan municipalities, 87% is removed in other urban areas, and 1.9% is removed in rural household areas at least once a week. It is therefore reiterated that the dichotomy in waste removal frequencies between urban and rural areas is disconcerting. In the Western Cape, weekly household waste removal is 89% in metropolitan municipalities, 97% in urban areas, and 56.2% in rural areas. The latter rate is considerably better in rural areas in the Western Cape than in the Free State. Overall, these statistics make it evident that rural areas are marginalised in terms of weekly waste removal schedules, which may not only explain the confusion that existed among the participants in the current study, but also raises deep concerns about sustainable health and environmental issues in these rural areas. Maluleke (2014) expresses this concern in no uncertain terms:

> "Failure to take attention to solid waste management will lead to various diseases and serious pollution [and] it is therefore important that solid waste [removal services] be rendered effectively and efficiently to promote a healthy community. This benefit will be directed to the community and the public sector on a mutual understanding of protection of the environment and the people."

Local municipal authorities should take note that if waste is not collected by service providers on a regular basis, residents take various measures to dispose of their uncollected waste, which may often exacerbate health risks (figure 4.2).

4.6 Community waste disposal practices

4.6.1 Types of waste generated in the area of study

Waste comes in different forms or types and may be classified differently according to their sources. Municipal waste is generated at domestic dwellings, and in offices, schools, and businesses.

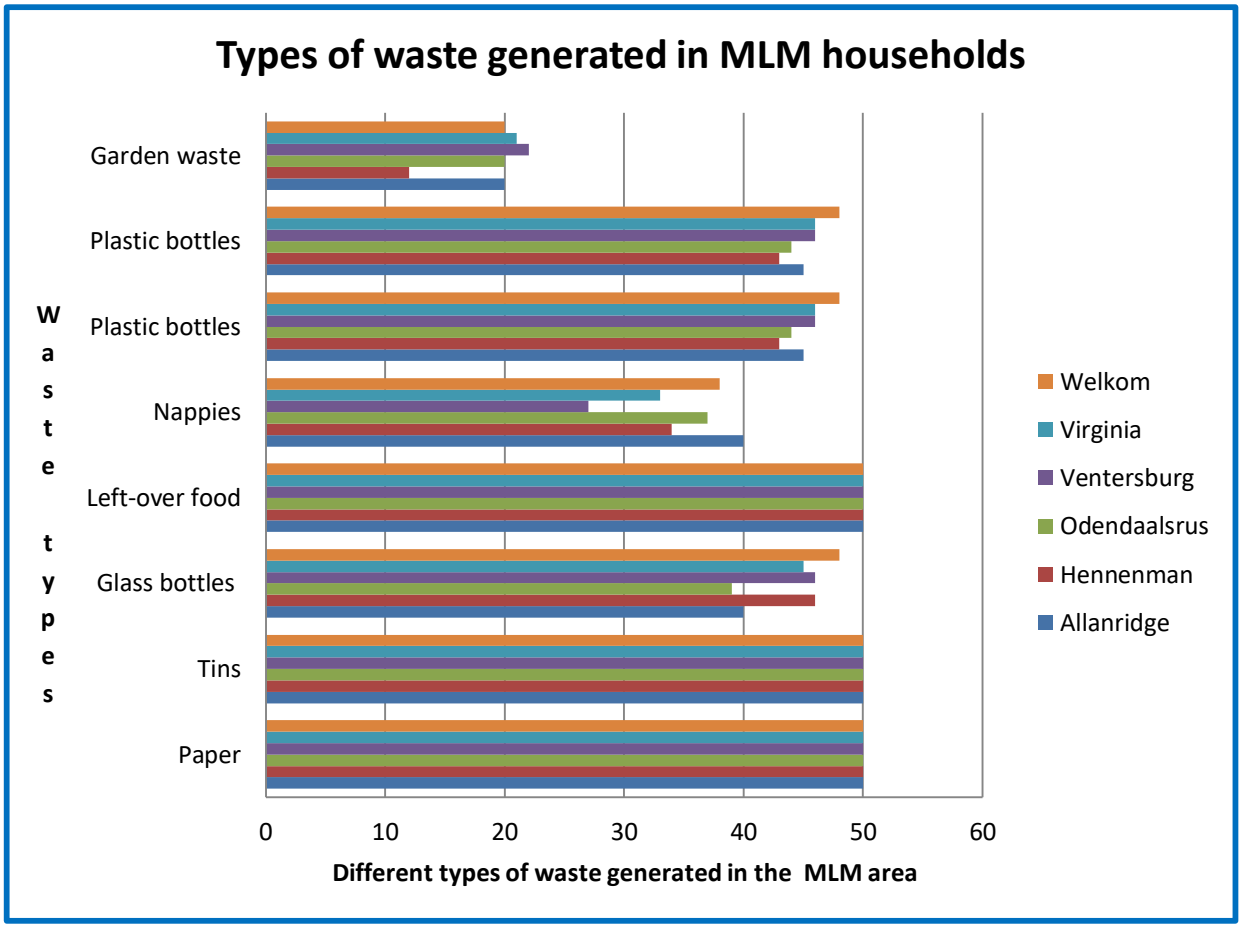

Figure 4.2: Types of waste generated in the MLM area

The types of waste generated by residents in the Matjhabeng municipal area are listed in Figure 4. 2. Note that no combined total was recorded for the participants' responses as more than one category could be indicated.

The data reveal that every type of waste material, including those that could have been recycled, were disposed of. The respondents also indicated that they all put paper, tins and leftover food in disposal bins on a regular basis; however, the combined data showed that relatively few (less than 44%) of the respondents placed garden waste in their bins for collection. In 2013, paper, tins, glass, plastics and tyres contributed 25% to MSW in Gauteng and 22% in Cape Town (CSIR, 2013). Globally, almost 50% of MSW is organic waste, of which 17% is paper (Hoornweg & Bhada-Tata, 2012). Poswa (2000) found that in Umtata and in the Durban area, the types of waste generated in low income

areas were mainly organic (food) waste. Most of the waste generated at household level is related to product packaging from manufacturing companies and food leftovers. The types of waste listed by Gumbi (2015) are cardboard (36%), food waste (18%), plastics (14%), glass (8%), organic waste (7%), tins (4%), scrap metal (4%), and other (5%).

4.6.2 Uncollected waste

Environmental pollution is a major problem associated with the rapid rise in human standards of living. It is therefore vital that solid waste is treated appropriately to reduce the volume of waste and to eradicate environmental pollution. The current study recorded the measures residents took to deal with waste that was not collected (Figure 4.3). Burning uncollected waste was a common practice among 30-40% of the respondents from Allanridge, Odendaalsrus and Henneman because, if they did not, uncollected waste would attract rodents to their yards and houses. In Ventersburg, 90% (45) of the respondents indicated that they did not burn waste near their houses but took it back to their yards or to central points away from the dwellings where residents lived.

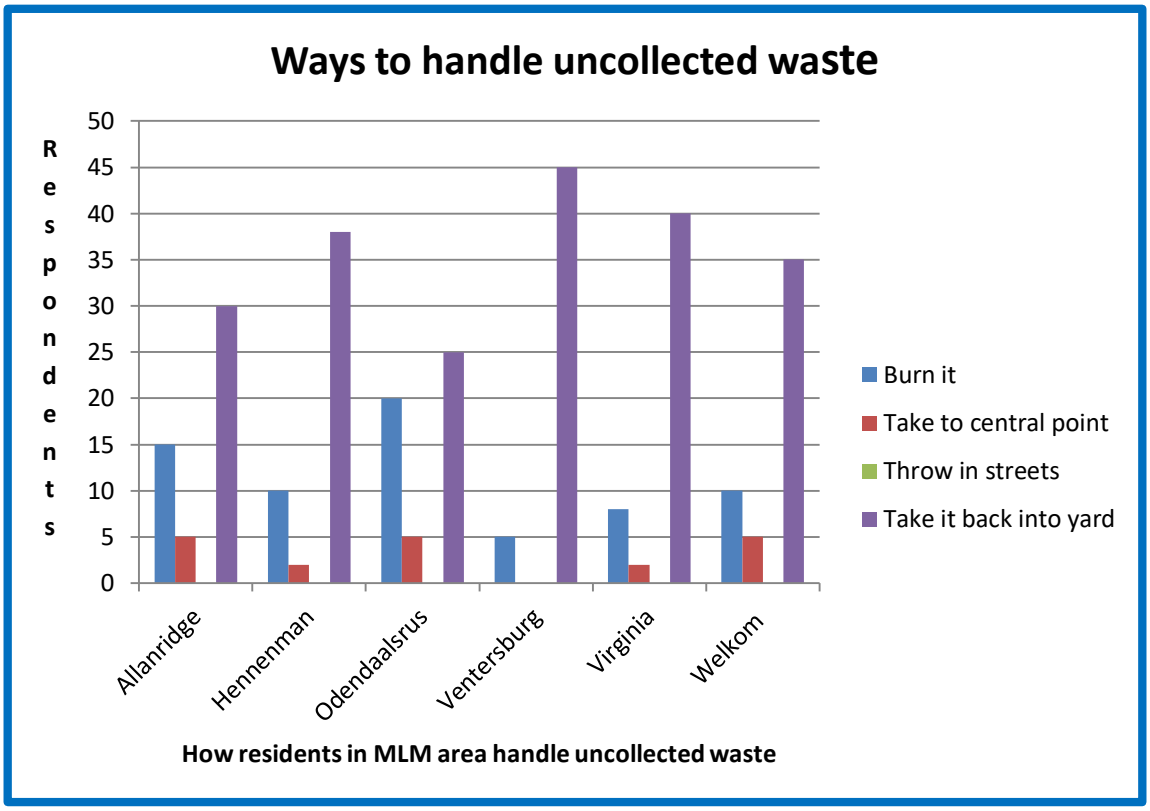

Figure 4.3: Ways in which uncollected waste was treated

(*n = 50; N= 300)

Overall, only 19 (6%) of the households where the respondents lived tended to take uncollected waste to a central disposal point. This low figure may indicate a lack of interest in getting rid of unwanted waste or it may reflect on the poor circumstances of residents who may not have access to transport to these central disposal sites. On a more positive note, it was noted that a large percentage of households did not put the environment further at risk by burning uncollected waste as they might have been aware of the damage burning of waste can cause to the environment. It was also heartening to note that none of the households would leave the waste in the streets.

However, the large overall number of households (213) that tended to take uncollected waste back to their yards was a worrying finding, as waste that is left untreated holds various health and environmental risks. For example, it may attract stray dogs and rodents, cause unpleasant odours in the neighbourhood, and it may release toxins if not

properly treated. Such waste is also unsightly if material that is not biodegradable is strewn across yards and the environment may be contaminated.

The burning of household waste in a drum in a backyard releases more dioxins than a municipal incinerator which is responsible for burning thousands of tons of MSW daily (Halden, 2008). Inadequate waste collection practices and a lack of local institutional capacity to provide efficient waste collection and transportation of waste could be responsible for frustration and self-practice methods used by residents who resort to dumping and burning waste indiscriminately. This inadvertently leads to questions regarding the implementation of national waste management policies. Moreover, it becomes questionable whether policies and monitoring mechanisms exist at local government level as the results suggest that waste collection and transportation services were not adequately and appropriately provided in the surveyed areas at the time of the study.

4.6.3 Sorting and compacting waste

Table 4.15 indicates whether waste was sorted before it was collected by the local authority or service provider.

Table 4.15: Sorting of waste before collection by community members

Towns	YES n	YES %	NO n	NO %	Total
Allanridge	32	64	18	32	50
Hennenman	30	60	20	40	50
Odendaalsrus	35	70	15	30	50
Ventersburg	34	68	16	32	50
Virginia	30	60	20	40	50
Welkom	30	60	20	40	50
Total	**191**	**64**	**109**	**36**	**N=300**

*n= 50; N = 300

The respondents were asked whether the households where they resided sorted their waste before collection by the local authority or a service provider. The results (Table 4.15) indicate that the majority (63%) of the households sorted/separated waste before collection. However, apart from composting, the manners in which waste was separated were not explored, which was a limitation of the study. This is disputed by the Waste Manager who indicated that the waste is not sorted before collection in any of the six towns.

Based on the findings of earlier studies, it was important to determine whether the practice of sorting waste was associated with residents' levels of education (see Tables 4.7 and 4.16).

Table 4.16: Summary of educational levels of the respondents

	Primary n(%)	**Secondary n(%)**	**Tertiary n(%)**
TOTAL	**59(19)**	**196(65)**	**48(16)**

N=300

When the data were integrated, it was found that the results were inconclusive. The educational level of the participants was relatively high, with 64% of the participants holding a secondary and 16% holding a tertiary level education. These percentages translated into a combined secondary and tertiary education level of close to 80% of the sample. However, overall the community's willingness to sort waste was 63%. This discrepancy might have been due to various cultural norms or pressures among the residents that were not explored in the study. Another factor that could have impacted this finding is that the number of home owners was limited among the respondents and that the respondents were not aware of the true state of affairs in this context. Another suggestion is that residents, regardless of their educational level, have become used to the idea that local municipalities are solely responsible for waste management, and this attitude may have impacted this finding significantly.

Domestic waste sorting improves the recycling of re-usable materials, which in turn reduces environmental problems (Dyson & Chang, 2005). The latter study found that households that fell in higher income brackets tended to sort or separate waste before collection more readily than households in the medium or low income brackets. It was also revealed that 90% of the people from high income areas had tertiary levels of education, which means that higher levels of education were associated with knowledge regarding the importance of and the need for sorting and separating waste (Dyson & Chang, 2005). However, this relationship was inconclusive in the current study. A low level of public awareness of the importance of waste sorting may also have a direct impact on people's willingness to participate in effective waste management strategies. If low levels of awareness are found, it may be indicative of a strong need to increase awareness raising efforts, because it may have important implications for public participation in waste management (Dyson & Chang, 2005).

It was for the above reasons that Gumbi (2015) also explored waste separation measures, and it was found that, because of the failure of the municipality to collect waste regularly, the methods of disposal ranged from placing waste in bins (39%) to some form of recycling (25%). In the latter study, sorting occurred as one of the disposal methods of waste. In the current study, 63% of the respondents was aware of the importance of sorting waste at source whereas 36% was unaware of this practice. In Dawnaraina's (2004) study, the majority of the respondents from the Chatsworth area was willing to separate their household waste because they were provided with plastic bags to sort the waste for recycling. This latter fact is noteworthy, as the provision of receptacles for waste disposal is a vital function of local municipalities, particularly in low-income areas where residents lack the funds to provide suitable receptacles for waste.

In light of the above, it may be argued that local municipalities should consider offering incentives such as sufficient waste receptacles, achievement awards or a rebate in rates to promote recycling at household level, particularly in township and low income areas. Financial losses from the collection of rates can be offset by the monetary gain from recycling as it is easier to handle and dispose of waste that has been separated at

household level, and this will result in considerable savings in terms of time and labour costs (Zhang et al., 2012).

4.6.4 Composting practices

Should municipalities encourage and promote composting practices by the community, this initiative will reduce volumes of garden waste and will result in environmental benefits as the soil quality will be improved which, in turn, will lead to the growing of vegetables in home gardens.

Compost is the result of a biological process, but it requires human intervention to convert vegetation waste into compost through the natural process of decomposition as well as treatment technologies that involve the process of recycling waste products to produce soil conditioner (Global Composting Solution, 2018). The annual organic waste generation in South Africa was 3 023 600 tons whereas it was 160 353 tons in the Free State in 2012 (SAWIC, 2012). Fertilizer consumption in South Africa between 2005 to 2015 of the three major fertilizer components (nitrogen [N], phosphorus [P] and potassium [K]) was very high 450 000 tons and remained 10 000 tons in 2015/2016 (FERTASA, 2016). Because waste may contain a variety of organic materials, it is ideal for composting purposes under certain conditions. Table 4.17 reflects the composting practices in the study area.

Organic food waste is divided at source to separate domestic, industrial and commercial waste streams and can be used for on-site composting or it can be directed to landfills. Organic food waste used as feedstock for an anaerobic digester has the potential to generate electricity and/or heat, while the digested sludge could be applied as fertiliser. Similar to abattoirs, commercial beverage and food production enterprises such as cheese factories, breweries and fruit and vegetable processing facilities could use their organic waste to produce their own heat and electricity on site (SAGEN & SABIA, 2016).

The study also found that the implementation of anaerobic digestion at operations such as these could reduce transport costs to landfill sites and costs incurred for heat and

electricity generation. On a larger scale, it would significantly reduce the amount of waste that is generally redirected to landfills (SAGEN & SABIA, 2016).

Table 4.17: Frequency of composting practices in the Matjhabeng area

Towns	YES TOTAL	YES %	NO TOTAL	NO %	
Allanridge	5	10	45	90	50
Hennenman	4	8	46	92	50
Odendaalsrus	8	16	42	84	50
Ventersburg	4	8	46	92	50
Virginia	5	10	45	90	50
Welkom	8	16	42	84	50
Total	**34**	**11**	**266**	**87**	**N=300**

*n = 50; N = 300

Table 4.17 indicates that a high rate (87%) of the respondents was not aware of any composting practices in the households where they resided and that a mere 11% of the households practised composting. According to Poswa (2000), normal waste composting ranges between 20-50% in developing countries, which means that the rate of composting in the area under study was far below the norm. Increased composting could reduce the volumes of waste that are deposited at landfill sites which would reduce waste disposal costs. Naidoo (2009) suggests that households should be encouraged to compost their vegetable waste by means of actual “practice and showcase” demonstrations to illustrate the ease of composting and to show the resultant healthy crops that can be produced in home (and even school and community structure) gardens. Some waste that cannot be composted due to its non-biodegradable nature can be recycled.

4.7 Recycling practices in the area of study

Recycling has environmental benefits if the life cycle of a product is extended and it reduces air and water pollution through the creation/manufacturing of new products. Thus residents must ensure that they minimise waste by recycling. Two types of waste are particularly recyclable, namely glass and plastic (Table 4.18).

Table 4.18: Frequency of glass and plastic recycling

Towns	Glass bottles		Plastic bottles		Total
	n	%	n	%	
Allanridge	10	20	10	20	20
Hennenman	4	8	4	8	8
Odendaalsrus	11	22	11	22	22
Ventersburg	4	8	4	8	8
Virginia	5	10	5	10	10
Welkom	2	4	2	4	4
Total	**36**	**12**	**36**	**12**	**N=300**

*n= 50; N = 300

Because the distribution of the recycling frequency of glass and plastic was the same in each town, it may be assumed that the same respondents recycled both glass and plastic. This number was 36 of 300 residents in total, which means that a mere 12% of the participants recycled glass and plastic. This implies that 88% of the glass and plastic waste that had been generated in the study area would go to waste on landfill sites. Thus, because these materials are not biodegradable, the consequences for the environment may be severe in the near future.

In the study that was conducted by Dawnaraina (2004), a maximum of 29% of the respondents stated that they were recycling paper, plastic, tin and scrap metals. The low rates of recycling that were uncovered in the latter and current studies suggest that it has become important to educate residents about recycling to improve waste management efforts (Etengeneng, 2012). Although about 1.9 million tons of waste had been collected for recycling by 2016 (Packages SA, 2016), much more should be done to increase this figure in efforts to conserve the environment and to reduce the costs of waste.

The participants were requested to comment on whether they were prepared to engage in recycling activities, but the results were a resounding failure for recycling endeavours among the surveyed communities (Figure 4.4).

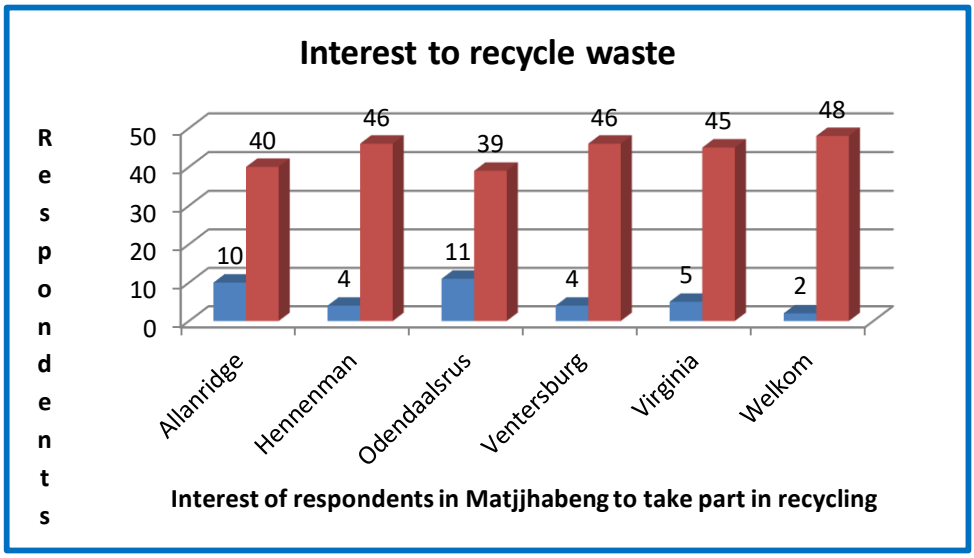

Figure 4.4: Attitude towards the recycling of waste (*n= 50; N = 300)

The results that are presented in Figure 4.4, are consistent with the results found for glass and plastic recycling, in the sense that the same rate of respondents (88%) was not only disinterested in recycling glass and plastic, but they were also disinterested in engaging in any recycling at all. This finding may suggest that, as residents, the respondents felt that it was the responsibility of the local municipality to remove and recycle waste products. Therefore, regardless of the relatively high levels of school education of the majority of the respondents, they were not willing to recycle anything

and did not intend to do so in the near future. This may suggest that they were not aware of the environmental benefits of proper domestic waste disposal and recycling, or that they simply did not care, deeming it their local authorities' responsibility to manage waste once they discarded it.

Dawnaraina (2004) encountered relatively similar attitudes, as it was found that 35% of the respondents in Chatsworth in Durban was of the view that recycling projects were successful, whereas 65% was not interested in recycling. No interest in recycling was observed in the Xhariep District Council (Free State Province), while the attitude of the residents in the Motheo and Thabo Mofutsanyane District was different as limited interest in recycling was recorded at only 25% and 44% of the landfill sites respectively. In contrast with these other three districts, recycling took place at landfill sites in Lejweleputswa and Fezile Dabi District (67%; 79%) respectively (Roberts, 2013). This is a clear indication that the attitudes regarding recycling differs from one area to another.

Various authors have argued that the training and education of people have been taken for granted Maluleke (2014) and Sentime (2014) yet these are the most important elements that drive waste management initiatives. Residents must be informed of the differences between good and bad waste management, and this can only occur by means of education and awareness campaigns (Dawnaraina, 2004; Barr, 2004; Etengeneng, 2012). If waste management is a collaborative enterprise, then the time has come for local municipalities, through various campaigns and awareness initiatives, to provide information and incentives to their residents to ensure that domestic solid waste is managed in an effective and sustainable manner.

4.8 Community members' views on the quality of service delivery by their MLM

According to the South African Constitution (South Africa, 1996a), municipalities are mandated to provide basic services to citizens, and these services are the fundamental building blocks of an improved quality of life. One such service is the removal of solid domestic waste from households. The accessibility of basic services is closely related

to social capital and the failure of municipalities to deliver services can have a detrimental impact on social and economic development. Figure 4.5 records the positive ("yes") and the negative ("no") attitudes of the respondents in terms of service delivery in their respective areas.

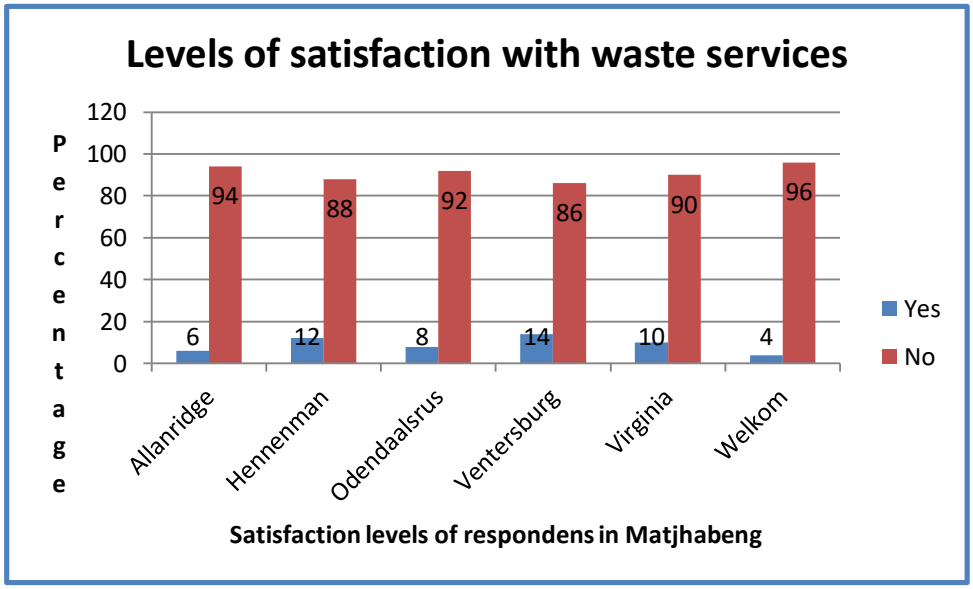

Figure 4.5: Respondents satisfaction with current waste service delivery in Matjhabeng (*n = 50; N= 300)

The responses recorded in Figure 4.5 indicate a resounding rate of dissatisfaction (91%, 273 of 300) with the services provided by the respective local municipalities in the study area. One of the reasons why the respondents were not dissatisfied was because they felt that the frequency of collection is insufficient. The respondents were not only dissatisfied with solid waste management services, but they also accused their respective municipalities of corruption, complaining that they were not doing their work. Some respondents demanded that their municipalities be placed under administration even though none of the responses were recorded on the questionnaires.

The respondents were requested to indicate whether they were satisfied with the waste collection service in their respective areas. They were also requested for suggestions of how they thought this service can be improved.

Corrective measures/opinions of the respondents included the following:

- Communication with the residents if the truck that collects municipal solid waste will not be available to collect waste.
- Communication with regards the schedule for collecting municipal solid waste
- Communication via radio or pamphlets.
- Issuing of plastic bags or bins to store their waste at home.
- Where the roads are not built properly, central point for collection of waste must be available.
- Municipality must not collect waste at night without making residents aware and
- Meeting should be held to discuss municipal solid waste issues.

In contrast to the mere 10% satisfied residents in the current study, Dawnaraina's (2004) study in Chatsworth in the eThekwini Metropolitan Municipality found that more than 50% of the respondents was content that the service delivery in that area was good and they expressed their satisfaction with it. Naidoo (2009) also investigated the need for increased refuse removal in low-income suburbs in Pietermaritzburg because not all households had received regular refuse removal services due to security issues, and private contractors often replaced municipal workers. In conclusion, Naidoo argued that various factors that could increase the frequency of waste collection were most likely not possible due to a lack of human capacity, financial constraints, and the limited number of functional vehicles at the time of the study.

The problems illuminated by the above findings appear endemic to the South African society, as the Auditor General (South Africa, 2018) revealed that a mere 13% of local municipalities in South Africa received a clean financial audit for the 2017 budget year. In 2015/2016, only 49 of 263 municipalities received clean audits, which was about 19%. This figure was similar to the figures recorded in a 2011/2012 report from Auditor

General (2012) which suggests that very little happened in terms of municipal service improvement over a three-year period.

4.9 Sources of energy used by residents

Most South Africans households use a mixture of energy sources such as electricity, coal and paraffin for cooking and heating purposes. Table 4.19 and Table 4.20 indicate which sources of energy were used at the time of the study by Matjhabeng Local Municipal residents.

Table 4.19: Source of energy for cooking

Towns	Electricity		Paraffin		Total
	n	%	n	%	
Allanridge	40	80	29	58	50
Hennenman	30	60	34	68	50
Odendaalsrus	35	70	20	40	50
Ventersburg	30	60	35	70	50
Virginia	34	68	25	50	50
Welkom	50	100	15	30	50
Total (N)	**219**	**73**	**158**	**52**	**300**

* n=50; N=300 (*Note that totals are not provided as the respondents could list one or both options)

The participants indicated that electricity and/or paraffin were/was the preferred sources of energy for cooking in preference to other sources such as coal, gas and firewood. It is assumed that once households have gained access to electricity as a main source of energy, they will shift away from using any other energy source. Electricity is considered a safe and clean energy source because it does not produce emissions (Western Cape Government, 2017). South African households that were connected to mains electricity supply increased from 76% in 2002 to 84% in 2017. According to the General Household

Survey (StatsSA, 2017), electricity usage is most commonly used in the Northern Cape (92%), Limpopo (91%) and Free State (90%) provinces. Electricity is used as a source of energy for cooking by 75% of households in South Africa (StatsSA, 2017).

Table 4.20: Source of energy for heating

Towns	Electricity		Paraffin		Firewood		Coal		Gas		Total
	n	%	N	%	n	%	n	%	n	%	
Allanridge	40	80	41	82	11	22	14	28	5	10	50
Hennenman	40	80	35	70	11	20	15	30	8	16	50
Odendaalsrus	32	64	43	86	5	10	8	16	17	34	50
Ventersburg	38	76	34	68	8	16	5	10	10	20	50
Virginia	39	78	34	68	9	18	5	10	20	40	50
Welkom	44	88	40	80	20	40	10	20	15	30	50
Total (N)	**233**	**78**	**227**	**76**	**64**	**21**	**129**	**43**	**75**	**25**	**300**

* n=50; N=300 (*Note that more than one source could be listed by the respondents)

Overall, more than 75% of the households used electricity and paraffin as sources for heating, whereas 25% used gas for this purpose. Almost all the households had access to electricity, either through formal or informal connections. It is surmised that electricity was the preferred source of energy due to the fact that it is viewed as safer and more accessible than other energy sources (Albertyn et al., 2012). Lloyd (2014) suggests that low-income households in South Africa resort to using energy sources such as paraffin and candles only when they do not have money to afford electricity.

4.10 The role of the Local Municipality in MSW management

The section presents the data that were obtained from a municipal official who was solely responsible for the coordination of waste management services in the Matjhabeng Municipal area. In this capacity he was overall responsible for MSW management in the six towns under study. A questionnaire that had been designed with reference to best waste management practices as elicited in the literature was administered to him at the municipal waste management offices in Welkom. The questionnaire comprised various sections to obtain data regarding demographic details, areas and services, collection methods, and details of workers and equipment. The demographic data that had been obtained were presented in the demographic data section (Chapter 4.2).

4.10.1 Areas and service

Waste management services have been provided to all six towns in the Matjhabeng area since before 1990. The head office is based in Welkom. At the time of the study, only one official was responsible for cooperating waste management operations in all six towns. The official confirmed that waste collection occurred in residential, business and industrial areas. The services that were referred to included environmental management, litter picking at public and open spaces, street cleaning, and illegal dumping management. Gumbi's (2015) study found that the Ekurhuleni Metropolitan Municipality collected about 80% of municipal solid waste whereas the other 20% was collected by contractors. In the Matjhabeng area, 100% of waste was collected by municipal workers.

4.10.2 Collection methods and frequency of collections

Kerb collection was the only waste collection method used in the study area. No plastic bags were handed out to residents but it was mentioned that 240 litre bins had been distributed in the area.

The official stated that waste was collected once a week from each allocated section in each town on different days of the week (Mondays to Fridays). Big trucks towing trailers

were used as the mode of transport for collection of waste in all six towns. Some days, due to maintenance of the trucks, the municipality did not collect waste from residential and other areas. It was stated that the municipality maintained communication with residents through radio broadcasts and the distribution of pamphlets.

4.10.3 Workers and equipment

Severe challenges that were experienced in effectively providing waste management services to the surveyed communities were the poor condition and maintenance of the trucks, budget limitations, and the ignorance of the residents who dumped waste in open spaces. The official mentioned that the residents did not sort the waste before they discarded it which made their work more difficult. It was stated that the workers who collected waste received appropriate training and that these courses were ongoing. Workers received training in safety, health and the operation of mechanical equipment. Protective gear was worn by workers such as overalls, gloves, safety boots/shoes, face masks, goggles and respirators.

4.11 Delimitations of the study

The study area was delimited to one of five municipal districts in the Free State. The data and findings could therefore not be generalised to municipal waste practices across the Free State Province.

Moreover, the study was delimited to one municipal official compared to 300 residents who completed the residents' questionnaire, which limited the comparative value of the data.

4.12 Limitations of the study

When the data were integrated, it was clear that some limitations in the questionnaire design limited the interpretative value of the data.

These limitations were:

- Visual observations of the residential areas that were visited by the researcher were not recorded as part of the field study. Thus residents' claim that they did not discard waste in the streets could not be verified.
- The residents' questionnaire did not elicit information regarding the protective clothing worn by waste collection workers that they observed. Thus the official's claim of protective clothing could not be verified.
- Because no waste disposal workers at landfill sites participated in the study, the claim of the use of protective clothing − particularly gloves, goggles and respirators − could not be verified.
- Only one municipal official was included in the data collection process. Although the data he provided were based on his training, knowledge and experiences as a municipal manager, no data were obtained from other waste management officials or waste workers to support or refute the findings.

4.13 Conclusion

The data analysis and the main findings were presented in this chapter. The demographic features of the resident respondents, waste handling practices by residents, residents' experiences of waste collection, and communication gaps between the community and the municipality were discussed. The residents were aware that waste management services were provided by the MLM, which predominantly comprised collection of waste from the pavements. However, the residents mentioned that there were challenges preventing them from minimising their waste and managing it properly. These challenges included lack of waste bins that facilitated the separation of waste at household level, erratic collection schedules (there were times when waste was not collected on scheduled days and residents had limited knowledge of which days were scheduled for waste collection), illegal and haphazard dumping of waste, and a lack of communication between the municipality and the residents with regards to waste management issues. However, very few residents practised waste separation and composting and a limited number was prepared to recycle waste.

The municipal official who participated in the study indicated that the constraints that prevented the desired provision of effective waste management services were an insufficient budget and vehicles that were not enough or maintained properly.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study investigated waste management practices by residents and municipalities in six towns in the Matjhabeng municipal district in the Free State Province, South Africa. The data collection instruments were two questionnaires: one was directed at residents and the other one was administered to a waste management official. The main purpose was to obtain information with regards to MSW management practices by both residents and the municipality and to determine if the residents were satisfied with the service they received. The study sample comprised 50 residents from each of six towns (i.e., 300 houses were visited and 300 questionnaires were completed by residents). Conversely, only one municipal official completed an appropriate questionnaire. The results obtained from an analysis of the questionnaire data were recorded in Chapter 4 of this study report.

In general, the respondents expressed disinterest in and an apathetic attitude towards waste management practices in the study area, whereas the municipal official blamed the challenges experienced in waste management services on a limited budget, poorly maintained vehicles, and ignorant residents.

5.2 Integration of data provided by residents with those provided by the waste management official

Various discrepancies between the views and experiences of the residents and the claims made by the waste management official suggest that waste management services in the area under investigation were in crisis at the time of the study, and that this situation may be exacerbated if drastic measures to improve waste management services and educate residents are not taken as a matter of urgency.

- The municipal official claimed that waste collection occurred regularly in all areas in the Matjhabeng municipal area except when trucks had to be serviced, yet

residents were baffled by this question as few could determine either the scheduled days or the frequency of waste collection in their respective areas. This finding suggests that waste collection is erratic and infrequent, which poses a real threat to the health of both people and the environment. A matter of grave concern is that the residents stated that they predominantly dumped uncollected waste in the yards of the properties where they lived, whereas the official stated that illegal dumping by "ignorant" residents occurred predominantly on open spaces. In either case, the health and well-being of residents and the sustainability of the environment are at stake if these practices continue unabated.

- The municipal official claimed that communication with residents through radio broadcasts and the distribution of pamphlets was maintained. However, this claim is questionable as a large majority of the residents was unaware of information regarding waste management practices in their area. It was evident that they had not been informed of or sensitised to the benefits of recycling or composting as these practices were not considered at all.

- The lack of information regarding the benefits of collaborative waste management by residents and municipal workers spiralled into an apathetic attitude among the majority of the resident respondents. It may be argued that this apathetic attitude was mirrored by the municipal official and the municipal structure he represented, as very little was apparently done to support residents in their waste disposal endeavours on days that trucks were 'maintained' and thus out of commission. Residents were unable to transport waste to communal collection points and one can only surmise the extent and volumes of uncollected waste rotting away in yards and on open properties.

- The residents and the municipal official agreed on one point, which was that the municipal budget was insufficient in supporting efficient waste management practices. Not only were plastic bags or other waste receptacles not issued to residents, but the fact that 240 litre bins were made available in some residential

areas is questionable as most of the residents did not mentioned that they discarded waste in such bins.

More than 70% (35) of respondents of the Matjhabeng area indicated that the frequency of collection is insufficient.

- Communication with the residents if the truck that collects municipal solid waste will not be available to collect waste.
- Communication with regards the schedule for collecting municipal solid waste
- Communication via radio or pamphlets.
- Issuing of plastic bags or bins to store their waste at home.
- Where the roads are not built properly, central point for collection of waste must be available.
- Municipality must not collect waste at night without making residents aware.
- Meeting should be held to discuss municipal solid waste issues.

5.3 Conclusion

During the investigation, many underlying factors were revealed that significantly contributed to improper management of MSW in the Matjhabeng municipal area. It was found that the frequency of waste collection in Matjhabeng was inadequate and that there was no collaboration between the residents and the municipality with regards to waste management. Despite the municipal official's claim that communication channels were open between the municipality and the residents, limited evidence of waste management knowledge or incentives in terms of recycling, composting or waste separation strategies could be traced among the respondents in all six towns. It is acknowledged that the respondents were not all home owners, but as they were all residents of households where waste was generated, it is reasonable to expect that they should have had some knowledge of waste management practices other than discarding waste in bags and leaving it on pavements, in yards or on open sites.

Improper solid waste management has negative effects on residents' health when diseases strike or when the environment is damaged. Positive change in the Matjhabeng Local Municipality area will not happen overnight, but this study has demonstrated that the entire community needs to take a stand about their surroundings and immediate environment in collaboration with the municipality, because everyone has the right to live in a clean and healthy environment.

The literature review revealed that South Africa has some of the best and most advanced environmental policies in the developing world, but what is needed currently is the effective implementation of these policies. Moreover, education about the environment at local level will be a step forward in ensuring a sustainable and healthy environment. To achieve this goal, strong societal concerns for a clean environment and access to waste management information by all role players are vital. To this end, awareness campaigns and the protection of community concerns should be a priority, and the community should be allowed access to decisions concerning planning, operations and the management of waste disposal facilities.

A lot of gaps still exist in MSW management in South African due to challenges caused by the economic climate and barriers to technological development, particularly in rural areas. But there are many channels to explore that could be useful in developing effective and appropriate waste management practices for the situation we are faced with.

5.4 Recommendations

Public participation is very important when it comes to improving the status of waste management practices in this country. One vital component that should never be overlooked is residents' views and ideas that should be included in the initial planning stages of managing solid waste. Discussions with residents or their representatives is a way of showing them that their opinions matter and, in turn, residents will show respect for and contribute towards strategies that were formerly regarded as the exclusive mandate of municipalities. Changing residents' apathetic attitude towards waste

management is important because, regardless of their age, resident position or their educational or financial status, they are responsible for handling waste from point of generation to collection or recycling. Any change in waste management should therefore be preceded by collaborative and consultative processes if successful and sustainable waste management is the objective.

Communication between residents and waste management officers will also help in taking this relationship to the level of mutual understanding and it will open doors for discussions on issues of solid waste management in a frank and open manner.

It is acknowledged that, in the current economic climate, most local municipalities operate within the constraints of insufficient financial resources. As a result, waste management is marginalised and maintained as a low budget 'priority' with minimal effort to set things straight, which is a fact that was illuminated by this study. Solid waste management should therefore receive high priority and sufficient budgetary allocations because it impacts the environment and the health of residents.

Educating the populace with regards to improving solid waste practices in the Matjhabeng municipal area should also be a priority. The study found that all residents have access to radio broadcasts, and local radio stations should be utilised to convey positive messages about waste management to residents.

Pamphlet distribution is an easy means of conveying messages to society, and incentives in the form of rebates for efficient communal and private waste management initiatives should be considered.

Waste collection schedules should be widely disseminated. Media facilities such as "Whatsapp" and SMS messages are widely applicable and should be used for regular updates on waste collection schedules and frequencies.

Skips in which residents can discard waste should be strategically placed in areas where solid waste cannot be collected on scheduled days. In this way illegal dumping will be reduced.

In conclusion, this researcher agrees with WASTECON (2000) that the lack of waste awareness, together with the invisible priority given to waste management as a municipality service, is a core societal problem that should be eradicated as a matter of urgency.

REFERENCES

ABEL, A. 2007. An analysis of solid waste generation in a traditional African city: The example of Ogbomosho, Nigeria. *Environment and Urbanization*, 19, 527-537.

ACHANKENG, E. 2003. Globalization, urbanization and municipal solid waste management in Africa. African Studies Association of Australasia and the Pacific 2003 Conference Proceedings, Africa on a Global Stage, Adelaide, 1-3 October.

ADENIYI, S., AREMU, A., SULE, B., DOWNS, J. & MIHELCIC, J. 2012. Framework to determine the optimal location and number of municipal solid waste bins in a developing world urban neighbourhood. *Journal of Environmental Engineering, 138*(6):645−653.

AGBESOLA, Y. 2013. Sustainability of municipal solid waste management in Nigeria: A case study of Lagos. Water and Environmental Studies Department of Thematic Studies, Linköping University. [Online] no. 009. Available at: hhtps://pdfs.semanticsscholar.org/c0aa/8c2013eced1c847cc60cc6cb08db547433d5b4.pdf (Accessed 28 November 2017).

AHMED, S. & ALI, S. 2006. People as partners: Facilitating people's participation in public-private partnerships for solid waste management. *Habitat International,* 30(4):781−796.

AL ANSARI, M.S. 2012. Improving solid waste management in Gulf Co-operation Council states: Developing integrated plans to achieve reduction in greenhouse gases. *Modern Applied Science*, 6:60-68.

ALBERTYN, R., RODE, H, MILLAR, A.J.W. & PECK, M.D. 2012. The domestication of fire: The relationship between biomass fuel, fossil fuel and burns. *Burns Journal* 38(6):760-795.

ALLEN, A.R., DILLON, A.M. & O'BRIEN, M. 1997. Approaches to landfill site selection in Ireland. In: P.G. Marinos, G.C. Koukis, G.C. Tsiambaos & G.C. Stournaras (Eds.). *Engineering Geology and the Environment*, pp. 1569-1574.

ANNEPU, R.K. 2012. Sustainable solid waste management in India. Waste-to-Energy Research and Technology Council (WTERT). City of New York: Columbia University. Available at http://www.seas.columbia.edu/earth/wtert/sofos/Sustainable%20Solid%20Waste%20Management%20in%20in%20India_Final.pdf (Accessed 30 September 2018).

ARMITAGE, N. 2007. The reduction of urban litter in the storm water drains of South Africa. Department of Civil Engineering, University of Cape Town. *Urban Water Journal*, 4(3):151-172.

ATKIN, E. 2018. *The global crisis of plastic pollution. The New Republic.* April 16. Available at: https://newrepublic.com/article/147988/global-crisis-plastic-pollution. (Accessed on 30 September 2018).

AUDITOR GENERAL SOUTH AFRICA (AGSA). 2012. Consolidated general report on the audit outcomes of local government 2012. Available from: http:/www.agsa.co.za/Document/Auditreports.aspx. Accessed: 13 September 2017.

AUDITOR GENERAL SOUTH AFRICA (AGSA). 2018. Consolidated general report on the audit outcomes of local government 2018. Available from: http:/www.agsa.co.za/Document/Auditreports.aspx. Accessed: 19 November 2018.

BARNARD, A. 2013. The role of socio-demographic variables and their interaction effect on sense of coherence. SA Journal of Industrial Psychology | Vol 39, No 1

BARR, S. 2004. What we buy, what we throw away and how we use our voice. Sustainable Household waste management in UK. *Sustainable Development,* 12**:**32-44. URL:http://www3.interscience.wiley.com/cgi-bin/fulltext/107062301/PDFSTART

BELLO, I.A., ISMAIL, M.N.B., & KABBASHI, N.A. 2016. Solid waste management in Africa: A review. *International Journal of Waste Resources*, 6:216.

BERSI-KATHIMERINI. 2005. Landfills a thing of the past in Germany where advanced management rules. Available at: www.seas.columbia.edu/earth/wtext/sofos/Evridiki_Bersi_Kathimerini.pdf. (Assessed on 29 September 2018).

BOGNER, J.M., ABDELRAFIE AHMED, C., DIAZ, A., FAAIJ, Q., GAO, S., HASHIMOTO, K., MARECKOVA, R., PIPATTI, T., & ZHANG, 2007. Mitigation of global greenhouse gas emissions from waste : conclusions and strategies from the intergovernmental panel on climate change fourth assessment report. Waste management and Research.

BOSWELL, J.E.S. 1997. The life Cycle costing of landfills. Presented at a seminar of the landfill special interest group in Cape Town. Institute of Waste Management of South Africa.

BOTSWANA GOVERNMENT. 2011. Retrieved April 2011, from Botswana Environmental System: http://www1.eis.gov.bw/EIS/Policies/Environmental%20Policies/Botswana's%20Strategy%20for%20Waste%20Managment.pdf

BRANCHINI, L. 2015. *Waste to energy.* Switzerland: Springer.

BRUNNER, P. & FELLNER, J. 2007. Setting priorities for waste management strategies in developing countries. *Waste Management & Research, 25*(1):234−240.

CALIFORNIA DEPARTMENT OF RESOURCES, RECYCLING AND RECOVERY (CALRECYCLE). 2010. California Compost Quality Council. Available at: http://www.ciwmb.ca.gov/lglibrary/innovations/organics/Summary.htm (Accessed 21 May 2016).

CANADA. 2016. Population and dwelling counts for Canada: Provinces and territories and census subdivisions for 2016 and 2011 censuses. Available at: http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Table.cfm?Lang=Eng&T=302&SR=1&S=86&O=A&RPP=100 (Accessed in May 2017).

CHIMUKA, L. & OGOLA, J. 2015. Leading the way: Directions of municipal solid waste management in South Africa. In: T. Simelane & R. Mohee (Eds.). *Future directions of municipal solid waste management in Africa,* pp. 176-199*.* South Africa: Africa Institute of South Africa.

CHISADZA, C. A . 2015. Solid waste management (SWM) in Johannesburg: Alternative futures. Unpublished dissertation for the Degree of Master of Development Finance, Stellenbosch University, Stellenbosch.

COINTREAU, S. 2006. Occupational and environmental health issues of solid waste management with special emphasis on middle and lower income countries. Washington D.C: The World Bank for Reconstruction and Development/the World Bank. Available at: www.worldbank.org/urban (Accessed on 11 July 2017).

COLLINS, J. & MANEVELDT, G. 2001. Compost. Available at: http://www.botany.uwc.ac.za/Envfacts/facts/compost.htm (Accessed on 16 June 2007).

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR). 2012. *Municipal waste management: Good practices*. Pretoria, RSA: CSIR.

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR). 2013. The current waste generation and management trends in South Africa. Pretoria, RSA: CSIR.

COUTH, R. & TROIS, C. 2012. Sustainable waste management in Africa through CDM projects. *Waste Management*, 32:2115−2125.

DAWNARAINA, R.B. 2004. An Investigation of solid waste management practices: The case of the Chatsworth Township in Metropolitan Durban. Manuscript submitted to the University of KwaZulu-Natal, Durban. Masters Degree.

DEPARTMENT OF ENERGY (DoE). 2015. Energy Advocacy. South African Energy situation. http://www.energy.gov.za/files/media/Pub/Energy-Advocacy-May2015-Issue-1-newsletter.pdf www.energy.gov.za: Pretoria: DoE.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). 2010. National policy on provision of basic refuse removal services to indigent households. Pretoria: DEA.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). 2011. National Waste Management Strategy. Government Gazette 35306. Government Notice 344 of 4. Pretoria: DEA.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). 2012. National Waste Baseline Report. Department of Environmental Affairs. Pretoria: DEA.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). 2013. National Waste Baseline Report. Department of Environmental Affairs. Pretoria: DEA.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS (DEA). 2018. South Africa's state of waste. A report on the state of the waste. Second draft report. Pretoria: DEA.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM (DEAT). 2007. South Africa's environmental outlook: A report on the state of the environment. Pretoria: DEA.

DIAZ, L.F., BERTOLDIDE, M., BIDLINGMAIER, W. & STENTIFORD, E. 2007. Compost science and technology. *Waste Management Series,* 8. Amsterdam: Elsevier.

DOUTI, N.B., ABANYIE, S.K. & AMPOFO, S. 2017. Solid waste management challenges in urban areas of Ghana: A case study of Bawku Municipality. *International Journal of Geosciences,* 8(4). Full-Text HTML XML Pub. Date: April 18, 2017.

DUBOIS, M., GONZALEZ, A.M.M. and KNADEL, M. 2004. Municipal solid waste treatment in the EU. Centre for Environmental Studies, Aarhus University, Denmark.

DU PLESSIS, A. 2008. Public participation, good environmental governance and fulfilment of environmental rights. Available at: http://www.saflii.org/za/journals/PER/2008/12.html (Accessed on 8 January 2017).

DYSON, B. & CHANG, N.B. 2005. Forecasting municipal solid waste generation in the fast growing urban region with systems dynamics modelling. *Waste Management,* 25(7):669-679.

EARTH LINK AND ADVANCED RESOURCES DEVELOPMENT (ELARD) (Earth Link and Advanced Resources Development in association with Golder Associates Africa). 2009. *Environmental and social impact assessment of construction and operation of Syria Cement and Captive power plant and associated quarrying activities, Syria.* Damascus, Syria: Syrian Cement Company (SCC).

EBERHARD, A. and NAUDE, R. 2014. The South African Renewable Energy Independent Power Producer Procurement Programme: A review and lessons learned. *Journal of Energy South Africa, Vol. 27 no. 4 .*

EL-MABROUK, F.A. 2014. Integrated Solid Waste Management in the Arab Countries, PhD. Faculty of Engineering, Benghazi, Libya.

El-SHERBINY, R., GABER, A. & RIAD, M. 2011. Waste management. In: H. Abaza, N. AAB & B. Zeitoon. *Arab environment 4 green economy: Sustainable transition in a changing Arab World*. Report of the Arab Forum for Environment and Development (AFED). Lebanon, pp. 205-234.

ENERGY AND RESOURCE INSTITUTE. 2012. *Waste*. Available at: https://books.google.co.za/books?isbn=8179935442A (Accessed on 12 November 2016).

ENVIRONMENTAL PROTECTION AGENCY (EPA). 1998. Illegal dumping prevention guidebook. Chicago, USA.

ENVIRONMENTAL PROTECTION AGENCY (EPA). 2013. *National waste report*. Wexfort, Ireland: Johnstown Castle.

ENVIRONMENTAL PROTECTION AGENCY (EPA). 2015. Advancing sustainable materials management: 2013 fact sheet. Available at:

https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf (Accessed on 12 November 2016).

ENVIRONMENTAL PROTECTION AGENCY (EPA). 2017. Waste reduction. Available at: http//.www.wastereduction.gov.hk/en/assistancewizard/waste_red_sat. (Accessed on 12 November 2017).

ENVIRONMENTAL PROTECTION DEPARTMENT (EPD). 2017. Waste reduction. Available at: http//.www.wastereduction.gov.hk/en/assistancewizard/waste_red_sat. (Accessed on 12 November 2017).

ETENGENENG, D. 2012. Municipal solid waste management in Grahamstown, Republic of South Africa. *Novia,* 1-41.

ETHEKWINI MUNICIPAL COMMUNICATIONS DEPARTMENT. 2008. Refuse services. Available at: http://www.durban.gov.za/durban/services/services/dsw/refuse_sites/new_landfills/landfill7 (Accessed on 20 August 2017).

EUROPEAN COMPOSTING NETWORK (ECN). 2006. ECN: About the network. Available at: http://www.compostnetwork.info/ (Accessed on 10 September 2016).

EUROPEAN ENVIRONMENT AGENCY (EEA). 2009. *Diverting waste from landfill: Effectiveness of waste-management policies in the European Union*. Copenhagen: EEA.

EUROPEAN ENVIRONMENT AGENCY (EEA). 2010. *The European environment state and outlook 2010: Synthesis*. Copenhagen: EEA.

EUROPEAN ENVIRONMENT AGENCY (EEA). 2013a. ETC/SCP. In A. Reichel. *Municipal waste management in Germany.* Working paper for the EEA. Available at: www.eea.europa.eu/...municipal-solid-waste/germany-municipal-waste-management (Accessed on 29 September 2018).

EUROPEAN ENVIRONMENT AGENCY (EEA). 2013b. Managing municipal solid waste: A review of achievements in 32 European countries. EEA Report No. 2/ 2013. European Environment Agency. Available at: www.eea.europa.eu/...municipal-solid-waste/germany-municipal-waste-management (Accessed on 29 September 2018).

ENVIRONMENTAL PROTECTION AGENCY (EPA). 1997. Innovatiive Uses of Compost. Composting of soil contaminated by Explosives. United States.

ENVIRONMENTAL PROTECTION AGENCY (EPA). 2013. *National waste report*. Wexfort, Ireland: Johnstown Castle.

ENVIRONMENTAL PROTECTION AGENCY (EPA). 2015. Advancing sustainable materials management: 2013 fact sheet. Available at: https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf(Accessed on 12 November 2016).

ENVIRONMENTAL PROTECTION AGENCY (EPA). 2015. Advancing sustainable materials management: 2013 fact sheet. Available at: https://www.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf(Accessed on 12 November 2016).

EUROPEAN UNION. 1999. *Waste Policy.* Available at: www.ec.europa.eu (Accessed 27 October 2016).

EUROPEAN UNION. 2011. *Waste Policy.* Available at www.ec.europa.eu (Accessed 27 October 2016).

EUROSTAT. 2016. Waste statistics: Municipal waste. Available at: www.ec.europa.eu (Accessed on 8 June 2018).

EZEAH, C., FAZAKERLEY, J.A. & ROBERTS, C.L. 2013. Emerging trends in informal sector recycling in developing and transition countries. *Waste Management*, 33, 25092519.

EZEAH, C. & ROBERTS, C.L. 2012. Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Nigeria. *Environmental Management*, 103:9−14.

FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY. 2006. https://www.bmu.de/en/ Accesssed 18 November 2017.

FEDERAL STATISTICAL OFFICE. 2017. Germany – New heads of the federal statistics. Available from https://www.destatis.de/EN/Homepage.html. Accessed 18 Novemeber 2018.

FERTILIZER ASSOCIATION OF SOUTH AFRICA (FERTASA). 2016. South African fertilizers Market Report, Department of Agriculture, Forestry and Fisheries. www.fertasa.co.za Accessed 19 October 2018.

FISCHER, C. 2013. *Municipal waste management in Germany*. Copenhagen: EEA.

FRED, M. 2008. Municipal solid waste: EIA renewable energy – Municipal solid waste (MSW) date and information website. Available at:

http://www.eia.doe.gov/cneaf/solar.renewables/page/mswaste/msw.html (Accessed 27 February 2016).

FURTER, L. 2004. Green waste should not end up in large holes in land. Available at: http://search.sabinet.co.za/images/ejour/resource/resource_v6_n1_a17.pdf (Accessed on 03 May 2017).

GABAIRITI L, SHANGODOYIN DK, SETLHARE K & SEDIAKGOTLA K 2012: Estimation of Household Waste Generated in Gaborone City Council.

GARCIA-GARCIA, G. 2017. Development of a Framework for Sustainable Management of Industrial Food Waste. PhD, Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, England.

GAUTENG PROVINCIAL GOVERNMENT. 2006. *Provincial Integrated Waste Management Policy.* Johannesburg: Gauteng Provincial Government.

GENERAL HOUSEHOLD SURVEY (GHS). 2017. Statistical South Africa 2017 Census. Pretoria: Statistics South Africa.

GEYER, R., JAMBECK, J.R. & LAW, K.L. 2017. Production, use, and fate of all plastics ever made. *Science Advances, 3,* 5 July. DOI:10.1126/SCIADV.1700782

GODFREY, L. 2007. Facilitating the improved management of waste in South Africa through a national waste information system. *Waste Management, 28*(1):1660−1671.

GOODSTEIN, E.S., 2005. Economics and Environmental (4th edition), 359-400. Wiley and Sons Incorporated. United States.

GLOBAL COMPOSTING SOLUTIONS. 2018. Commercial Composting Solutions for a wide range of organic waste. Hotrot Solution. https://www.globalcomposting.solutions/hotrot-solutions. Accessed 12 November 2018.

GROUNDWORK. 2017. Statistics. http://www.groundwork.org.za/ Accessed 18 November 2018

GRIMSHAW, J., THOMAS, R., MACLENNAN, G., FRASER, C., RAMSAY, C.R., VALE, I., WHITTY, P., ECCLES, M.P., MATOWE, L., WENSING, M.J.P., DIJKSTRA, R.F. & DONALDSON, C. 2004. Effectiveness and efficiency of guideline dissemination and implementation strategies. *Health Technology Assessment*, *6*:1−72.

GUMBI, S.E. 2015. Current waste and minimisation patterns and practices: An exploratory study on the Ekurhuleni Metropolitan Municipality in South Africa. Dissertation submitted for the degree of Master of Science, University of South Africa, Pretoria.

HALDEN, R. 2008. In the spotlight: Cancer research initiative of South Africa http://www.carisa.org.za/spotlight_dioxins.html (Accessed on 18 April 2008).

HARDOY, J., MITLIN, D. & SATTERTHWAITE, D. 1992. *Environmental problems in third world countries*. London: Earth Scan.

HAWARD, M. 2018. Plastic pollution of the world's seas and oceans as a contemporary challenge in ocean governance. *Nat Community,* 9:667. DOI:10.1038/s41467-018-03104-3.

HOORNWEG, D. & BHADA-TATA, P. 2012. What a waste: A global review of solid waste management. *Urban Development*, 15:22-32.

HUDGINS, M., LAW, J., ROSS, D. and SU, J. 2011. The “sustainable landfill” becomes a reality. *Waste Management World* 11(3).

KÖRNER , K. L. 2003-2006. Municipal solid Waste Generation in Asia. In R. S. I. Körner , & D. l. Dr. D. Aslan (Ed.), Solid Waste Management in Asia (p. 220). TUHH, hamburg University of Technology, Germany.

INSTITUTE OF WASTE MANAGEMENT (IWM), KZN. 1999. Waste management notes, p. 51. Certificate in Waste Technology course.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC). 2006. IPCC good practice guidance and uncertainty management in national greenhouse gas inventories. Electronic publication URL. Available at: www. Ipccnggip.iges.or.jp/public/gp/English (Accessed on 05 December 2017).

IPSEN, K.I. 2005. Triple helix innovation model for developing sustainable waste incineration solutions. Rio de Janeiro: International Energy Conference.

JOWIT, J. 2010. Recycling still the most effective waste disposal method? *The Guardian,* 16 March.

KARAGIANNIDIS, A. 2012. *Waste to energy opportunities and challenges for developing and transition economies: Green energy and technology*. London: Springer-Verlag.

KATZENELLENBOGEN, J.M., JOUBERT, G. & ABDOOL KARIM, S.S. 1997. Epidemiology: A Manual for South Africa. Cape Town: Oxford University Press.

KESSELMAN, M., KRIEGER, J. & JOSEPH, W. 2012. Democracy in comparative perspective: German, Russia and South Africa. Available at:

www.sps.ed.ac.uk/__data/assets/pdf_file/0019/102529/DCP_Handbook12-13FINAL.pdf (Accessed on 18 February 2016).

KJAER, B. & REICHEL, A. 2013. *Municipal waste management in Denmark*. CITY: European Environmental Agency.

KOJIMA, M. & MICHIDA, T. 2011. Economic integration and recycling in Asia: An interim report. Chosakenkyu Hokokusho: Institute of Developing Economies.

KREITH, F. 1994. Handbook of Solid Waste Management. McGrawHill, USA.

KUBANZA, N.S. AND SIMATELE, D., 2015. Social and environmental injustices in solid waste management in sub-Saharan Africa: a study of Kinshasa, the Democratic Republic of Congo, Local Environment: The International Journal of Justice and Sustainability, 20, 1-20.

KUMAR, S. & KHANNA, M. 2009. Measurement of environmental efficiency and productivity. *Environmental and Development Economics, 14*(4):475–495.

KUNIYAL, J. C. 2010. Solid Waste Management in the Sensitive Hills of the North-western Himalayas. In J. Singh, R. AL, J. Singh, & R. AL (Eds.), *Solid Waste Management - Present and Future Challenges* (p. 260). kullu-Manali: I.K International Publishing House Pvt Ltd.

KURIAN, J., NAGENDRAN, K., PALANIVELU, K., THANASEKARAN C. and VISVANATHAN, C. 2004. Dumpsite Rehabilitation and Landfill Mining, CES, Anna University, Chennai, 600 025.

LANDCARE RESEARCH. 2007. Fact Files. Landcare Research. http://www.landcareresearch.co.nz/research/globalchange/fact_file.asp (Accessed February 24, 2017).

LANSINK, A.D. 1979. Waste hierarchy of waste management. Dutch Parliament. Available at: www.recycling.com/downloads/waste-hierarchy-lansinks-ladder/ (Accessed on 12 November 2016).

LLOYD, P. 2014. The energy profile of a low-income urban community. *Journal of Energy*. Cape Peninsula University of Technology, Cape Town, South Africa.

LUTUI, V. 2001. *Waste management practices, perceptions and attitudes in Tonga*. Manuscript submitted for a Master's degree, School of Geosciences, University of Wollongong.

MALULEKE, P.H. 2014. A review of solid waste management practices in Polokwane City. Master's Dissertation, University of South Africa, Pretoria.

MARSHALL, R.E. and FARAHBAKHSH, K. 2013. Systems Approach to Integrated Solid Waste Management in Developing Countries, 33,988-1003.

MATJHABENG LOCAL MUNICIPALITY (MLM). 2012. Municipal profile. Available at: http://www.matjhabeng.fs.gov.za (Accessed on 18 August 2015).

MBULIGWE, S.E. & KASSENGA, G.R. 2004. Feasibility and strategies for anaerobic digestion of solid waste for energy production in Dar es Salaam city, Tanzania. *Resources, Conversation and Recycling*, 42:183-203.

MEDINA, M. 2011. Municipal solid waste management in Third World Cities: Lessons learned and a proposal for improvement, Human Settlement Development, p3.

MENON, M.A. 2010. Integrated solid waste management based on the 3R Approach. *Journal of Materials Cycles and Waste Management,* 12:30-40.

McCARTHY, J. E. 1994. The municipal solid waste problem in the main industrialized countries', in Alberto Quadrio Curzio, Luigi Prosperetti and Roberto Zoboli (ed) "The management of municipal solid waste in Europe: Economic, Technological and Environmental perspective', Elsevier Science, 15-25.

MCDOUGAL, F.R. 2001. Life cycle inventory tools: Supporting the development of sustainable solid waste management systems. *Corporate Environmental Strategy*, 8(2):142-147.

MacRobert Attorneys. 2014. News blog on National Environmental Management Air Quality Amendment Act (Act 20 of 2014). Available at: www.macrobert.co.za/News-blog/blog/Air-Quality Amendment-Act-2014. 19 May 2014.

MENON, M.A. 2010. Intergraded solid waste management based on the 3R Approach. *Journal of Materials Cycles and Waste Management*, 12:30-40.

MOHEE, R. and BUNDHOO, M.A. 2015. A Comparative Analysis of Solid Waste Management in Developed and Developing Countries, in Simelane, T and Mohee, R (Eds.), Future Directions of Municipal Solid Waste Management in Africa, Africa Institute of South Africa, South Africa, p6-29.

MUDHOO, A., MOHEE, R. and SIMELANE, T. 2015. Future Directions of Municipal Solid Waste Management in Africa, Pretoria: Africa Institute of South Africa.

MUSEE, N. and WITI, J. 2014. Chapter 6: Waste. In: Witi, J an Stevens, L (Eds.) GHG National Inventory Report: South Africa, Pretoria: Department of Environmental Affairs, pp. 236-239.

NAIDOO, K. 2009. *Analysis of municipal solid waste management in South Africa: Msunduzi Municipality as a case study*. Dissertation submitted to the School of Geography, Faculty of Science and Agriculture, University of Natal, Durban.

NASSOUR, A., Al-AHMAD, M., ELNAAS, A. & NELLES, M. 2011. Practice of waste management in the Arab region. In: M. Kule-Weidemeier (Ed.). *Water-to-Energy resources,* 2011-4. International conference MBT and sorting systems, conference proceedings, 24-26 May 2011, pp. 81-91.

NATIONAL SOLID WASTE MANAGEMENT COMMISSION (NSWMC). 2015. Draft national solid waste management status report (2008-2014). Philippines: National Solid Waste Management Commission.

NAVARRO, A.R. 2003. A systems approach on solid waste in Metro Manila. Philippines. Lund University International Master's Programme in Environmental Science, Lund University. Sweden.

NEW YORK DEPARTMENT OF ENVIRONMENTAL CONSERVATION (NYDEC). 2015. Solid waste management facilities. New York: NYDEC. Available at: http//www.dec.ny.gov/chemical/8495.html (Accessed on 18 July 2017).

NIDONI, P. 2017. Incineration process for solid waste management and effective utilization of by product. *International Research Journal of Engineering and Technology* (IRJET). Vol. 4, Issue 12 Dec 2017.

NKOSI, N., MUZENDA, E., ZVIMBA, J. & PILUSA, J. 2013. Current waste generation and management trends in South Africa: A review. International Conference on Integrated Waste Management and Green Energy Engineering, April 2013.

NKWACHUKWU, O.I., CHIDI, N.I. & CHARLES, K.O. 2010. Issues of roadside disposal habit of municipal solid waste, environmental impacts and implementation of sound

management practices in developing country "Nigeria". International Journal of Environmental Science and Development, 1(5): 409-418.

NZEADIBE, T.C. & ANYADIKE, R.N.C. 2012. Social participation in city governance and urban livelihoods: Constraints to the informal recycling economy in Aba, Nigeria. *Culture and Society*, 3:313-325.

OELOFSE, S.H.H. & GODFREY, L. 2008. Defining waste in South Africa: Moving beyond the age of waste. *South African Journal of Science, 104*:242−246.

OKIBO, B.W. & KAMAU, C.G. 2012. A study to explore internal auditors' compliance with quality assurance standards: A case study of state owned cooperatives in Kenya. *International Journal of Research Studies and Management*, *1*:190−126.

OKOT-OKUMU, J. 2012. Solid waste management in African cities – East Africa, Waste Management – An Integrated Vision, ISBN: 978-953-51-0795-8, InTech, http://dx.doi.org/10.5772/50241. http://www.intechopen.com/books/wastemanagement-an-integrated-vision/solid-waste-management-in-african-citieseast-africa

OKYERE, A.E. 2014. Characterization and composting of solid waste generated in the Aburi Township. Kwame Nkrumah University of science and technology Kumasi , Ghana. Master of Science degree in Environment.

OMRAM, A. & READ, A.D. 2008. "Waste not, want not". A study of household attitudes towards recycling of solid wastes. *Environmental Engineering and Management Journal*, 7:1-8.

ORESANYA, O. 2014. Waste management in Lagos State. Available at: http://www.lawma.gov.ng/md%20presentation/2013/SWM%20in%20Lagos%20Journey%20So%20Far.pdf (Accessed on 20 October 2017).

PALMER DEVELOPMENT GROUP. 1996. Report on the evaluation of solid waste practices in developing urban areas of South Africa. Unpublished report to the Water Research Commission. WRC report no. 629/2/96.

PETERSEN, C. & KIELLAND, M. 2003. Statistik for hjemmekompostering 2001. Miljøprojekt nr. 855, 2003 (Statistics for home composting 2001, in Danish). Data generated by the Danish EPA.

PIIPO, S. 2013. *Municipal solid waste management in Finland*. Finland: Green Settle Publications.

POERBO, H. 1991. Urban solid waste management in Bandung: Towards an integrated resource recovery system. *Environment and Urbanization, 3*(1):60−69.

POSWA, T.T. 2000. A comparison of attitudes towards and practices of waste management. Dissertation for the degree of Master of Health in Technology, Department of Environmental Health, Technikon Natal, Durban.

PUOPIEL, F. 2010. Solid waste management in Ghana: The case of Tamale Metropolitan area. Master's thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

QU, X.Z., LI, X.X., SUI, Y., YANG, L. & CHEN, Y. 2009. Survey of composition and generation rate of household wastes in Beijing, China. *Waste Management,* 29:2618-2624.

QUODEN, J. 2004. The dual system in Germany: 13 years' of experience. International Centre for Research on Environmental Issues. December 2004. Available at:

http://www.environnementpropriete.org/english/2004/2004download_pdf/Quoden2004.pdf (Accessed on 25 May 2017).

RAMPHELE, M. 1990. Restoring the land: Environment and change in post-apartheid South Africa. London: Panos.

RATHI, S. 2006. Alternative approaches for better municipal solid waste management in Mumbai, India. *Journal of Waste Management,* 26(10):1192–1200.

ROBERTS, H.A. 2013. Status of landfill sites in the Free State Province. *Interim: Interdisciplinary Journal*, 12(10):32-41. Available at: http://reference.sabinet.co.za/sa_epublication_article/interim_v12_n1_a5 (Accessed: 30 April 2015).

ROTTER, S. 2011. Incineration: RDF and SRF - Solid waste from fuels. 2002. In: G. Tchobanoglous & F. Kreith. *Solid waste technology & management: Handbook of solid waste management* (2nd ed.). New York City McGraw-Hill.

SAGEN AND SABIA. 2016. Biogas Industry in South Africa. An assessment of the skills need and estimation of the job potential. Published by the South African-German Energy Programme (SAGEN), in cooperation with Southern African Biogas Industry Association (SABIA), Pretoria.

SALMINEN, A.E. & RINTALA, J.A. 2002. Semi-continuous anaerobic digestion of solid poultry slaughterhouse waste: Effect of hydraulic retention time and loading. *Water Research,* 36(13):3175-3182.

SENTIME, K. 2014. Impact of legislative framework governing waste management and collection in South Africa. *African Geographic Review*, 33:81-93.

SHARHOLY, M., AHMAD, K., MAHMOOD, G. & TRIVEDI, C.R. 2008. Municipal solid waste management in Indian cities: A review. *Waste Management,* 28(2):459-467.

SIEFERT, H. 2010. Thermische Verfahren. In: M. Kranert, & K. Cord-Landwehe, (Hrsg.). *Einführung in die Abfallwirtschaft: Vollständig aktualisierte und erweiterte Auflage*. Wiesbaden: Vieweg & Teubner Verlag.

SIMATELE, D. & ETAMBAKONGA, C.L. 2015. Scavenging for solid waste in Kinshasa: A livelihood strategy for urban poor in the Democratic Republic of Congo. *Habitat International*, 49:266-274.

SIMATELE, D., BINNS, T. & SIMATELE, M. 2012. Urban livelihoods under a changing climate: Perspectives on urban agriculture and planning in Lusaka, Zambia. *Journal of Human Development and Capabilities*, 13:269-293.

SIMATELE, D. & SIMATELE, M. 2014. Climate variability and urban food security in sub-Saharan Africa: Lessons from Zambia using an asset-based adaptation framework. *South African Geographical Journal,* pp. 1-21.

SIMELANE, T. & GUMBO, T. 2015. Innovations in municipal solid waste management: Experiences from eThekwini Municipality, South Africa. In T. Simelane & R. Mohee (Eds.). *Future directions in municipal solid waste management in Africa*. South Africa: African Institute of South Africa, pp. 202-217.

SIMELANE, T. & MOHEE, R.R 2012. *Future directions of municipal solid waste management in Africa*. Pretoria: Africa Institute of South Africa.

SINGH, P. 2013. Impact of solid waste on human health: A case study of Varanasi City. *International Journal of Scientific & Engineering Research,* 4(11), November.

SIVAKUMAR, K. & SUGIRTHARAN, M. 2010. Impact of family income and size on per capita solid waste generation: A case study in Manmunai North Divisional Secretariat Division of Batticaloa. *Journal of Science of the University of Kelaniya, Sri Lanka*, 5:13-23.

SNYMAN, N.J. 2007. Waste stream analysis for the City of Tshwane Metropolitan Municipality. Unpublished raw data. Pretoria: Tshwane: Metropolitan Municipality.

SOKKA, L., ANTIKAINEN, R. & KAUPPI, P. 2007. Municipal solid waste production and composition in Finland: Changes in the period 1960–2002 and prospects until 2020. *Resources, Conservation and Recycling,* 50:475–488.

SOUTH AFRICA. 1973. *Hazardous Substances Act No. 15 of 1973*. Pretoria: Government Printer.

SOUTH AFRICA. 1977. Health Act No. 63 of 1977. *Government Gazette* (No. 63 of 1977). Pretoria: Government Printers.

SOUTH AFRICA. 1989. Environmental Conservation Act No. 73 of 1989. *Government Gazette (*No. 73 of 1989). Pretoria: Government Printer.

SOUTH AFRICA. 1993. Occupational and Safety Act No. 85 of 1993. *Government Gazette (*No. 85 of 1993). Pretoria: Government Printer.

SOUTH AFRICA. 1996a. Constitution of the Republic of South Africa, Act No. 108 of 1996. *Government Gazette (*No. 85 of 1993). Pretoria: Government Printer.

SOUTH AFRICA. 1996b. National Road Traffic Act No. 93 of 1996. *Government Gazette (*No. 93 of 1996). Pretoria: Government Printer.

SOUTH AFRICA. 1998a. National Environmental Management Act No. 73 of 1998. *Government Gazette (*No. 73 of 1998). Pretoria: Government Printer.

SOUTH AFRICA. 1998b. Local Government Municipal Structure Act No. 117 of 1998. Government Gazette (No 117 of 1998). Pretoria: Government Printer.

SOUTH AFRICA. 1998c. National Water Act No. 36 of 1998. *Government Printer (*No.36 of 1998). Pretoria: Government Printer.

SOUTH AFRICA. 2003. The Waste and Emissions Trading Act 2003 (Amendment) Regulations 2011 (S.I. No. 2499 of 2011). Pretoria: Government Printer.

SOUTH AFRICA. 2004. *National Environmental Management: Air Quality Act No. 39 of 2004* (NEMAQA). Pretoria: Government Printer.

SOUTH AFRICA. 2008. *National Environmental Management Act (NEM:WA): Waste Act, 2008 (Act No. 59 of 2008). Government Gazette.* Pretoria: Government Printer.

SOUTH AFRICA. 2010. *National Environmental Management Act: Environmental Impact Assessment (EIA) Regulations of 2010. Government Gazette.* Pretoria: Government Printer.

SOUTH AFRICA. 2013. National Energy Act No. 34 of 2008. *Government Gazette No*. 34 of 2008. Pretoria: Government Printer.

SOUTH AFRICA. 2014. National Environmental Management: Waste Amendment Act No. 26 of 2014. *Government Gazette* (No. 37714) 2 June. Pretoria: Government Printer.

SOUTH AFRICA. DEPARTMENT OF ENVIRONMENT AND CONSERVATION. 2007. Environment and Conservation Act 2007 *Government Gazette*. Pretoria: Government Printer.

SOUTH AFRICA. DEPARTMENT OF ENVIRONMENTAL AFFAIRS. 2012. National Environmental Management: Waste Act No. 59 of 2008. *Government Gazette*. Pretoria: DEA

SOUTH AFRICA. DEPARTMENT OF ENVIRONMENTAL AFFAIRS. 2017. State of waste report (SoWR). A report on the state of waste. First draft report. Pretoria: SoWR .

SOUTH AFRICA. DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM (DEAT). 1999. National waste management strategies and action plans South Africa: Action plans for integrated waste management planning version A. *Government Gazette*. Pretoria. DEAT.

SOUTH AFRICA. DEPARTMENT OF WATER AFFAIRS. 1998. National Water Act No. 36 of 1998. *Government Gazette*, Pretoria.

SOUTH AFRICA. DEPARTMENT OF WATER AFFAIRS AND FORESTRY (DWAF). 1997. Minimum requirements for waste disposal by landfill (2nd ed.). *Waste Management Series*. Pretoria: DWAF.

SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE (SANBI). 2015. Annual Report. Available at: https://www.sanbi.org/biodiversity-science (Accessed 14 November 2016).

SOUTH AFRICAN CIVIL SOCIETY INFORMATION SERVICE [SACSIS], 2014. A non-profit news agency promoting social justice. Seeking answers to the question:

How do we make democracy work for the poor? Available from https://sacsis.org.za/site/article/2423.

SOUTH AFRICAN NATIONAL STANDARDS (SANS). 2007. Electricity distribution: Guidelines for the provision of electricity distribution networks in residential areas. Pretoria: Standards South Africa. (SANS 507-1:2007).e.1.00.

SOUTH AFRICAN WASTE INFORMATION CENTER (SAWIC). 2012. Department of Environmental Affairs. *Government Gazette*. Pretoria: SAWIC.

SOUTH AFRICA. 2013. National Energy Act No. 34 of 2008. Government Gazette No. 34 of 2008. Pretoria: Government Printer.

SOUTH AFRICAN WASTE INFORMATION CENTER (SAWIC). 2014. Department of Environmental Affairs. *Government Gazette*. Pretoria: SAWIC. Available at: sawic.environment.gov.za/?menu=65 (Accessed on 1 October 2018).

SOUTH AFRICAN WASTE INFORMATION CENTER (SAWIC). 2015. Department of Environmental Affairs. *Government Gazette*. Pretoria. Available at: sawic.environment.gov.za/?menu=65 (Accessed on 1 October 2018).

SOUTH AFRICAN WASTE INFORMATION CENTER (SAWIC). 2018. Department of Environmental Affairs. *Government Gazette*. Pretoria. Available at: sawic.environment.gov.za/? menu=65 (Accessed 3 November 2018).

SOUTH AFRICAN-GERMAN ENERGY PROGRAMME (SAGEN) & SOUTHERN AFRICA BIOGAS INDUSTRY ASSOCIATION (SABIA).2016. Biogas industry in South Africa: An assessment of the skills need and estimation of the job potential. Pretoria: SAGEN & SABIA

STATISTICAL SOLUTIONS. 2018. Complete Dissertation. Expect Guidance every step of the way. https://www.statisticalsolutions.co.za.

STATISTICS SOUTH AFRICA. 2012. *Census*. Pretoria: Statistics South Africa.

STATISTICS SOUTH AFRICA. 2016. *Census*. Pretoria: Statistics South Africa.

STATISTICS SOUTH AFRICA. 2017. *Census*. Pretoria: Statistics South Africa.

STRIVASTAVA, S. 2012. Plastic waste management by substituting natural fibres. *Journal of Surface Engineered Materials and Advanced Technology*, 2:292-294.

TCHOBANOGLOUS, G., THEISEN, H. & VIGIL, S. 1993. *Integrated solid waste management: Engineering principles and management issues*. USA: McGraw-Hill.

TROIS, C. & POLSTER, A. 2007. Effective pine bark composting with the dome aeration technology. *Waste Management*, 1(27):96-105.

UNITED NATIONS. 2012. *World economic situation and prospects: Global economic outlook*. New York: United Nations Press Release.

UNITED NATIONS. DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS (UNDESA). 2014. World population prospects: 2013 revision. Available at: http://esa.un.org/wpp/ (Accessed on 03 November 2017).

UNITED NATIONS ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND PACIFIC (UNESCAP). 2009. Economic and social survey of Asia and the Pacific: Addressing triple threats to development. Available at: http://archive.epa.gov/epawaste/nonhaz/municipal/web/html/. Accessed 03 November 2017).

UNITED NATIONS ENVIRONMENTAL PROGRAMME (UNEP). 1996. International source book on environmentally sound technologies for municipal solid waste management. Hyperlink: [www.unep.fr/scp/cp/understanding/concept]. Accessed on 6 November 2017.

UNITED NATIONS ENVIRONMENTAL PROGRAMME (UNEP). 2000. Environmentally sound management of solid wastes and sewage-related issues. United Nations: UNEP.

UNITED NATIONS ENVIRONMENTAL PROGRAM (UNEP). 2009. Developing an integrated solid waste management plan. Available at: http://www.unep.or.jp.ietc/publications/sp/ISWMPlanVol2.pdf (Accessed on 11 September 2015).

UNITED NATIONS ENVIRONMENTAL PROGRAMME (UNEP). 2010. *Developing integrated solid waste management plan training manual: Assessment of current waste management systems and gaps therein.* Vol. 2. Japan: Osaka/Shiga.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA). 2010. State and local solutions to solid waste management problems. Available at: http://www.epa.gov (Accessed on 11 July 2016).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA). 2013. Clean energy and climate change — waste management: How waste management impacts greenhouse gas emissions. Available at: http://www.epa.gov/region9/climate change/waste.html (Accessed on 12 November 2017).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA). 2016. Municipal solid waste generation recycling and disposal. http://archive.epa.gov/epawaste/nonhaz/municipal/web/html/.

VAN BEUKERING, P., SEHKER, M., GERLAGH, R., KUMAR, V. 1999. Analysing urban solid waste in developing countries: A perspective of Bangalore, India. *Working Paper No. 24*.

WALLACE, T. 2017. Global plastic waste totals 4.9 billion tonnes. Cosmos the science of everything. *Cosmos*. Available at: https://cosmosmagazine.com/society/global-plastic-waste-totals-4-9-billion-tonnes (Accessed on 29 September 2018).

WASTECON. 2000. Biennial Conference and Exhibition, 5-7 September, 2000, Somerset West, Cape Town, South Africa: proceedings. http://www.energy.gov.za/files/media/Pub/Energy-Advocacy-May2015-Isue-1-newsletter.pdf

WASTE CRISIS LOOMS. 2013. *Infrastructure News*. Available at: http:www.infrastructurene.ws/2013/01/24/local-waste-crisis-looms/. (Accessed on 15 August 2016).

WEI, Y., Fan, Y., WANG, M. & WANG, J. 2000. Composting and compost application in China. *Resources, Conservation & Recycling*, 30(4):277-300.

WESTERN CAPE GOVERNMENT. 2017. Department of Environmental Affairs and Development Planning Services: Waste Management. URL:http://www.westerncape.gov.za/eng/your_gov/406/services/27683/202219. (Accessed 6 June 2018).

WILLIAMS, P.T. 2005. *Waste treatment and disposal* (2nd ed.). West Sussex, England: John Wiley and Sons.

WORLD BANK. 1999a. *What a waste: Solid waste management in Asia*. Washington, D.C. 20433, U.S.A. World Bank.

WORLD BANK. 1999b. Decision Makers' Guide to Municipal Solid Waste Incineration. Washington, D.C. 20433, U.S.A. World Bank.

WORLD BANK. 2014. The economic impact of the 2014 Ebola epidemic: short and medium term estimates for West Africa. Washington, DC: World Bank; doi:10.1596/978-1-4648-0438-0. Available from: http://documents.worldbank.org/curated/en/524521468141287875/The-economic-impact-of-the-2014-Ebola-epi-demic-short-and-medium-term-estimates-for-West-Africa

WORLD ENERGY COUNCIL. 2013. Chapter 7b: Waste to Energy. In: Lo Re, L, Plamonti, G and Tarhini, M. (Eds.) World Energy Resources, s.l: World Energy Council, pp. 7b.2 – 7b.14 .

WORLD HEALTH ORGANISATION (WHO). 2008. Health and sustainable development. https://www.who.int/sustainable-development/cities/health-risks/water-sanitation/en/

WRIGHT, C. & GODFREY, L. 2010. The impact of an unhealthy environment on human health in South Africa. *CSIR Briefing Note No. 2009/04*, June. Available from .www.ehrn.co.za/lowerolifants/download/briefingnote_2009_04.pdf. (Accessed 17 August 2016).

ZERBOCK, O. 2003. *Urban solid waste management: Waste reduction in developing nations.* Houghton: Michigan Technological University.

ZHANG, W.Q., CHE, Y., YANG, K., REN, X.Y. & TAI, J. 2012. Public opinion about the source separation of municipal solid waste in Shanghai, China. *Waste Management Res., 30: (12)61–1271.*

ZHANG, C., LIA, X. & ZHIA, Q. 2016. The Status of Municipal Solid Waste Incineration (MSWI) in China and its Clean Development. Available at www.sciencedirect.com Accessed 18 October 2017.

ZHAO, Y. 2017. *Municipal solid waste management and waste-to-energy possibilities in the Philippines*. Unpublished Master's thesis, LUT School of Energy Systems, Lappeenranta University of Technology, Finland.

ZHENG, Y., DONG, Z.Y., LOU, F.J., MENG, K. & QUI, J. 2014. Optimal allocation for energy storage systems for risk mitigation of DISCOs with high renewable penetrations. IEEE Transactions on Power systems. Volume: 29 Issue: 1.

ZURBRUGG, C. 2002. Urban solid waste management in low-income countries of Asia: How to cope with the garbage crisis. Paper presented at the Scientific Committee on Problems of the Environment. Urban Solid Waste Management Review Session, Durban, South Africa. Available at: http://www.recycling.com/downloads/waste-hierarchy-lansinks-ladder/ (Accessed on August 2016).

ANNEXURE A:

SOLID WASTE MANAGEMENT PRACTICES QUESTIONNAIRE: RESIDENTS

The purpose of this questionnaire is to get a better understanding of the solid waste management practices in Matjhabeng Local Municipality.

Since waste collectors play an important role in the management of waste, this questionnaires was compiled to gain information on the effectiveness and possible problems of domestic waste collection.

- The questionnaire to be completed is not a test but contains questions to determine the perceptions, behaviour and knowledge of residents about waste collection methods and the perceptions/knowledge of residents regarding waste management in their respective towns.
- There are no right or wrong answers.
- To ensure the best results, please answer the questions truthfully.
- All the results will be handled in the strictest confidence and no names of persons/managers/respondents or residents of the different municipalities will be published.

Contact details:

Fax No. ……... Cell No. ……

E-mail address: ……. Telephone no. ……..

Name: ……. Date: ……

Signature ……

QUESTIONNAIRE

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

1. SECTION A: **Office use**

In which area do you reside?

AREA

Allanridge		1
Hennenman		2
Odendaalsrus		3
Ventersburg		4
Virginia		5
Welkom		6

2. SECTION B: HOUSEHOLD INFORMATION

1. Indicate your gender

Male		1
Female		2

2. Population group

African		3
White		4
Coloured		5
Indian		6

3. Marital status

Married		7
Single		8
Divorced		9
Widowed		10
Living together		11

4. Are you the owner of the yard or house?

Yes		12
No		13

If you answered "no" to question 4, please answer question 5.

5. What is your position/role in the household?

Child of the owner		14
Renting		15
Babysitter or maid		16
Relative		17
Boyfriend or girlfriend of the owner		18

6. For how many years have you stayed in the house or in the yard?

Less than 1 year		19
More than 1 year but less than 5 years		20
More than 5 years		21

7. How many houses are situated in your yard?

1		22
2		23
3		24
If more than 3 - Specify……..		25

8. How many people are staying on the premises?

1-2		26
3-4		27
5-6		28
7-8		29
9-10		30
10 or more (specify number) ……		31

9. Are you staying in the main house on the premises?

Yes		32
No		33

10. How many people are staying with you in your house?

1-2		34
3-4		35
5-6		36
7-8		37
9-10		38
10 or more (specify the number)……		39

11. Indicate your educational level

Primary school		40
Secondary school		41
Tertiary		42
none		43

12. Do you work?

Yes		44
No		45

If you answered "yes" to question 12, please answer question 13.

13. What type of work do you do?

Permanent		46
Contract or Temporary		47
Occasional		48
Pensioner		49
Other: specify		50

14. Indicate how much you earn:

Income	**Per week**	**Per month**	**Other … specify**	
No Income				51
R1 to R800				52
R801 to R3 200				53
R3 201 to R12 800				54
More than R12 800				55
				56

15. Do you have access to the following sources?

Television		57
Radio		58
Daily newspaper		59
Weekly newspaper		60
Other: Specify ……		61

16. Which source of energy do you use for cooking?

Electricity		62
Paraffin		63
Firewood		64
Coal		65
Gas		66
Other - specify……..		67

17. Which source of energy do you use for heating?

Electricity		68
Paraffin		69
Firewood		70
Coal		71
Gas		72
Other - specify……..		73

18. Indicate how you handle/treat your waste:

Burn in yard		74
Put out for collection on pavement		75
Take to collection point		76
Other method: specify		77

19. Is waste collected from your household?

Yes		78
No		79

20. If your waste is collected from your house, who is responsible for the collection?

Municipality		80
Private contractors		81
Other: specify:		82

21. Indicate the date from which waste has been collected in your area:

Before 1990		83
1991 - 2000		84
2001 – 2010		85
2011 – 2015		86
Do not know		87

COLLECTION METHODS

22. Indicate which type of collection method is used in your area:

Kerb/pavement collection (from households)		88
Central collection point in area		89
Other: Specify…		90

23. If waste is collected at a central point, do you have challenges transporting your waste?

Yes		91
No		92

If you answered "yes" to question 23, please answer question 24.

24. Indicate how you get your waste to the central collection point:

Walk and carry it		93
Car		94
Bakkie		95
Neighbours take it		96
Other: specify: ……..		97

25. Do you receive plastic bags from the municipality?

Yes		98
No		99

26. How often does the municipality collect waste from your area?

Once a week		100
Every two weeks		101
Once a month		102
Once every two months		103
Other (specify) …….		104

27. Indicate on which day you have to put out your waste:

Monday		105
Tuesday		106
Wednesday		107
Thursday		108
Friday		109
Do not know		110

28. Indicate which type of vehicle is used to remove/collect your waste:

Big truck		111
Small bakkie		112
Do not know		113
Other (specify)……		114

29. Was there any period of time when the municipality did not collect waste from your area?

Yes		115
No		116

If you answered "yes" to question 29, please answer question 30.

30. What do you do with your waste if it is not collected?

Burn it		117
Take it to the central point		118
Throw it in the street		119
Other: Specify……		120

31. Do you sort the waste before collection?

Yes		121
No		122
Do not know		123

32. Do you recycle any waste?

Yes		124
No		125

33. If you recycle waste, please indicate what types of waste you recycle:

Paper		126
Tins		127
Glass/Bottles		128
Leftover food and vegetable peels		129
Nappies		130
Plastic bottles		131
Garden waste (leaves, branches etc.)		132
Other (specify)…….		133

34. Indicate what types of waste you put in waste bags/bins:

Paper		134
Tins		135
Glass/Bottles		136
Leftover food and vegetable peels		137
Nappies		138
Plastic bottles		139
Garden waste (leaves, branches etc)		140
Other: Specify…		141

35. Please indicate if you use waste to make compost:

Yes		142
No		143

36. If you make compost, please indicate what waste products you put into your compost:

…… …… …… ……		144

37. Do you attend meetings for members of the community?

Yes		145
No		146

If you answered "yes" to question 37, please answer questions 38 and 39.

38. When do you have meetings?

Daily		147

Weekly		148
Every two weeks		149
Monthly		150
Every two months		151
When necessary		152
Do not know		153
Other: Specify…		154

39. Do you discuss domestic solid waste management with other members of the community?

Yes		155
No		156

RESIDENTS' ATTITUDE TOWARDS WASTE

40. Does it worry you when you see people throwing waste around?

Yes		157
No		158

41. If you see people throwing waste in the streets/in a neighboring area, what do you usually do?

Ignore it		159
Pick it up myself		160
Ask them why		161
Tell them not to		162
Other (specify) …		163

42. Is it important for you that your environment is kept clean/that no waste is lying around?

Yes		164
No		165

43. Indicate if you are satisfied with the waste collection service in your area:

Yes		166
No		167

44. If you are not satisfied with the waste collection service in your area, please Indicate how the service can be improved:

…… …… …… ……	168

45. If the municipality has to communicate information to you, indicate which communication method you prefer:

Radio		169
E mail		170
Published in newspaper		171

Pamphlet		172
Notification at community centres		173
Other method (specify) …….. ……..		174

THANK YOU FOR YOUR CO-OPERATION IN COMPLETING THE QUESTIONNAIRE

ANNEXURE B:

Central University of Technology, Free State

SOLID WASTE MANAGEMENT PRACTICES QUESTIONNAIRE: MANAGEMENT

The purpose of this questionnaire is to get a better understanding of solid waste management practices in Matjhabeng Local Municipality.

Since waste collectors play an important role in the management of waste, this questionnaires was compiled to gain information on the efficiency and possible problems of domestic waste collection.

- The questionnaire to be completed is not a test but contains questions to determine the perceptions, behavior and knowledge of workers and residents towards waste collection methods and the perceptions/knowledge of residents regarding waste management in their respective towns.
- There are no right or wrong answers.
- To ensure the best results, please answer the questions truthfully.
- All the results will be handled in the strictest confidence and no names of persons/managers/respondents or residents of the different municipalities will be published.

Contact details:

Fax No. ……... Cell No. ……

E-mail address: ……. Telephone no……..

Position: ……

Name: …… Date: ……

Signature ……

QUESTIONNAIRE

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

AREAS AND SERVICES

1. Indicate in which areas your municipality collects waste.

Office use

Matjhabeng (Allanridge)		1
Matjhabeng (Henneman)		2
Matjhabeng (Odendaalrus)		3
Matjhabeng (Ventersburg)		4
Matjhabeng (Virginia)		5
Matjhabeng (Welkom)		6

2. Indicate from which of the following areas the municipality collects waste:

Residential area		7
Businesses		8
Industrial areas		9

3. Indicate since when the municipality has been collecting waste:

Before 1990		10
1991 - 2000		11
2001 – 2010		12
2011 – 2014		13

4. Indicate which other services, except collection of waste, take place in your area

……	14
……..	15
……	16
……	17

COLLECTION METHODS

5. Indicate which type of collection method is used:

Kerb collection from households		18
Central collection point in area		19
Do not know		20
Other:Specify: ……		21

6. How often is waste collected in your area?

Once a week		22
Every two weeks		23
Once a month		24
Once every two months		25
Other: specify ……		26

7. Do the residents sort the waste before collection?

Yes		27
No		28
Do not know		29

WORKERS AND EQUIPMENT

. 8. Indicate what type of transport is used to collect waste from households:

Tractor		30
Vehicle with trailer		31
Trucks		32
Other (specify) ……		33

9. Indicate what type of transport is used to transport waste from the households to the landfill site

Tractor		34
Vehicle with trailer		35
Trucks		36
Other (specify) ……		37

10. Do the workers who load the waste collection vehicles receive training?

Yes		38
No		39

11. If you answered "yes" to question 10, please answer question 11. Identify the type of training received

Safety training		40
Health training		41
Other (specify)		42
Indicate the number of days per course:		43

12. Are the workers provided with personal protective equipment?

Yes		44
No		45

13. If you answered "yes" to question 12, please answer question 13. Indicate which types of PPE are provided to workers:

Overalls		46
Gloves		47
Safety boots/shoes		48
Face masks		49
Other (specify)		50
1.		51
2.		52
3.		53

THANK YOU FOR YOUR CO-OPERATION IN COMPLETING THE QUESTIONNAIRE

ANNEXURE C: Letter requesting permission to collect data

Central University of Technology, Free State

CENTRAL UNIVERSITY OF TECHNOLOGY, FREE STATE
SENTRALE UNIVERSITEIT VIR TEGNOLOGIE, VRYSTAAT
YUNIVESITHI E BOHAREBG YA THEKENOLOJI, FOREISTATA

FACULTY OF HEALTH AND ENVIRONMENTAL SCIENCES
DEPARTMENT OF LIFE SCIENCES

26 August 2015

RESEARCH PROJECT: MS KA MOLEKO

This letter seves to confirm that Ms KA Moleko, is registered at the Department of Life Sciences, at the Central University of Technology, Free State as a MTech: Environmental Health student. To obtain her qualification she has to undertake research in a waste related field.

The aim of her research is to assess the solid waste practices which takes place in the Matjhabeng Local Municipality and will include the following towns, namely:

Welkom
Virginia
Ventersburg
Hennenman
Odendalsrus and
Allanridge.

As part of the research process she will request residents of the respective towns and municipal staff members working in the solid waste sections to complete a questionnaire. No names of individuals (respondents) will be published.

Your co-operation will be greatly appreciated. If you have any enquiries regarding the study please feel free to contact me, Dr H Roberts, Ms Moleko's supervisor, at robertsh@cut.ac.za or phone at 051-5073122 or 0845500621.

Kind regards

Dr H Roberts
Senior Lecturer: Environmental Health

58 President Brand Street , Bloemfontein
Private Bag X20539, Bloemfontein, 9300
Telephone: 051-5073122