CHARACTERISATION AND MANAGEMENT OF OPEN WASTE DUMPS IN FORDSBURG, JOHANNESBURG, SOUTH AFRICA

FEHMIDA QADDUS RABBANI

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FEHMIDA QADDUS RABBANI

Dissertation submitted for the degree of MSc in Environmental Science& Management

Supervisor: Prof. Tabukeli Musigi Ruhiiga

Date 04/09/17

DECLARATION

I, FEHMIDA QADDUS RABBANI (student number: 24999334), hereby declare that this research is my original work. Unless specifically stated, all the references contained in this study have been duly acknowledged. The work in this dissertation is a record of work that has been done by me and has not been previously accepted for any higher degree or professional qualification at any other educational institution. I further more grant that copyright of the dissertation in the favour of North-West University (Mafikeng Campus).

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FEHMIDA QADDUS

Date .....

Thesis has been submitted with my approval as a university supervisor and I certify that the requirements for the applicable MSc degree rules and regulations have been fulfilled.

Signed.....

PROF. T. M. RUHIIGA

Date .....04/09/17.....

DEDICATION

I dedicate my dissertation to my late mother Hameeda Bibi who always encouraged me to work hard and developed my taste for higher education from an early age. She created the atmosphere where we felt highly educated people like shining stars, she prayed for me to get higher education. Second, I dedicate this work to my beloved husband, Abdul Qaddus Rabbani, who made it possible for me to complete the work. I will not forget his encouragement and moral support. Third, I dedicate my work to my sister, Samina Shabir, for her unending love and support

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ACKNOWLEDGEMENTS

First of all, I am very thankful to my Allah almighty who gave me hope and strength to complete my work. I would like to thank my supervisor, Prof. T.M. Ruhiiga for his support and facilitation of opportunities for me to acquire knowledge and get skills in postgraduate research.

I remember at the time of admission telling my supervisor that I did not have even the basics of research and that I would require extra attention for my work. It is because of the determination, strong criticism and continuous encouragement of my supervisor, that I remain thankful. I admire him like "the Great and very supportive teacher of my life". He has strong grip on his subject he made me understand each and every point with great concern. He has amazing knowledge and flawless way of teaching; I have in the process learned a lot from him.

My special thanks go to my honourable and sweet father, Mr. Nemat Ullah Khan, who always dreamt of my higher education and gave me continuous motivation and encouragement. My special thanks to my honourable father in law Captain Ghulam Rabbani whose continues motivation and encouragement gave me hope and energy to complete my work within time. Special thanks go to the management of *Pikitup* who cooperated with me during the data collection phase of this study. I extend similar appreciation to write in full for their helpful information that was valuable for this research. I found them always very efficient in providing administrative support through valuable documents.

Appreciation goes to North-West University (Mafikeng campus) for financial support that covered my tuition costs. I also thank all the local municipalities included in the study.

ABSTRACT

This study set out to understand salient issues around waste characterisation and its management, using Fordsburg, Johannesburg as the study area. The purpose of the study was to investigate open waste dumps in order to provide baseline information in designing management interventions. To this end, several objectives were specified: measuring the locational attributes of open solid waste dumps and analysing the internal linkages, classify waste across study area, analyse the variations in the profile of waste in the study area and outline current waste management approaches. Following the conducting of fieldwork, primary and secondary data were analysed and results presented. These were then discussed to generate key findings of the study.

Open dumping is a major concern in many South African cities and beyond the borders of the country. Illegal waste dumping in Fordsburg, a residential district in Johannesburg, needs immediate attention from the authorities of the City of Johannesburg (COJ) first; and from all those, whose lives may be adversely affected by such practices. This practice is partly fuelled by rapid urbanisation and the poor handling of waste from generation and through the entire waste chain to final disposal. The key findings of this study are:

- The locational attributes of waste dumps cannot be used to explain variations in the size of waste dumps because both R-square values and correlation coefficients are extremely low;
- The classification of waste and its density across the study area may not necessarily point to the sources of generation;
- The closeness of waste dumps to the roads is an indication of the possible ways in which this waste is illegally dumped;
- The low scores for the mean waste dump size also indicates a higher and regular rate of waste collection; and
- That the outsourcing of the waste collection work to a private contractor could be important in interpreting some of the results.

Waste management practices for Fordsburg have relationships with urban policy, municipal capacity, the state of waste infrastructure, the status of waste information systems, including the need for monitoring, evaluation and training for skills improvement. The study shows that the COJ faces several challenges in trying to deliver a modern waste service. It has also been indicated that some of these challenges are in fact external to the COJ such as: the limited

control over the activities of the contractor and the issue of translating pieces of environmental legislation into standardised measures. The significance of the findings include: some issues around the soundness of current urban planning by COJ with regard to waste delivery.

Recommendations focussed at different stakeholders through whom better practices of waste management could be achieved: the waste directorate of COJ, the provincial department of environment and the national department of environmental affairs.

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DEFINITION OF CONCEPTS

Chemical waste: consisting of, or containing chemical substances: laboratory chemical; film developer; disinfectants expired or no longer needed; solvents, cleaning agents and others

Composting: a method of waste disposal whereby waste is discarded on the ground and can be covered by soil or grass

Domestic waste: waste that is produced by households

Dumps: waste collection sites that are not designated as such but where the public dumps its waste

Heavy metal waste: consisting of both materials and equipment with heavy metals and derivatives, including batteries, thermometers and manometers

Heterogeneous waste: mixed type of waste

Incineration: burning waste and disposing their ashes and may include reusing other resulting compositions

Industrialisation: is the period of social and economic change that transforms a human group from an agrarian society into an industrial one.

Landfill: is a site for disposal of waste materials by burial. Leachates is any liquid that in passing through matter, extracts solutes, suspended solids or any other component of the material through which it has passed

Quantitative Method: a research method where systematic empirical investigation of social phenomena through statistics or mathematical techniques is applied

Random Sampling: a subset of individuals chosen from a larger set

Recycle: goods that can also be regarded as waste by some individuals but can be recycled

Resource recovery: selective extraction of disposed materials for specific next use such as recycling

Scavenging: refers to searching through for salvageable material; such as looking through waste storage bins for food

Solid waste management: controlling the generation, storage, collection, transfer and transport, processing and disposal of solid waste

Urbanisation: the physical growth of urban areas that results in migration and even suburban concentration of people into cities

Waste characterisation: grouping wastes according to their characteristics and compositions

Waste generation: quantity of materials that enter waste stream before composition

Waste management: the collection, transport, processing or disposal, managing and monitoring of waste materials

LIST OF ACRONYMS

COJ:	City of Johannesburg
DEAT:	Department of Environmental Affairs and Tourism
EEA:	European Environment Agency
MSW:	Municipal Solid Waste
MSWM:	Municipal Solid waste Management
MSW:	Municipal Solid Waste
SSA:	Statistics South Africa
SWM:	Solid Waste Management
UNEP:	United Nations Environment Programme
WD:	Waste Dumps

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CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1 Introduction

Solid waste management is an important contributor to many environmental challenges (Webster, 2012), examples include climate change (GHG's), ozone depletion, damage to human health, and resource over-exploitation. The increase in solid waste generation requires effective management systems capable of addressing these environmental problems. In the end, this should facilitate movement towards a more environmentally sustainable society (Laurent *et al.,* 2014). A major cause of a steady increase in waste generation is inadequate participation by household's waste reduction (Bortoleto *et al.*, 2012).

Today, the annual global solid waste generation is about 17 billion tonnes and it is projected to reach 27 billion by 2050 (Karak *et al.*, 2012). Currently, about 1.3 billion tons of the estimated global waste is accounted for by cities which are expected to produce 2.2 billion tons by 2025. This increase will be through population growth, increasing urbanisation and socio-economic changes in developing countries (Hoornweg & Bhada-Tata, 2012).

In South Africa, government regulations require that waste be treated or disposed of in a manner that complies with applicable legislation. This includes waste generated by the mining sector, health services and manufacturing. The implementation of the *Waste Act* (59 of 2008) (RSA, 2009) requires the generation of baseline waste information on the basis of which policy decisions are made The Act makes provision for control mechanisms covering the collection and handling, reducing, recycling, reusing, recovery, treatment and disposal of waste. Furthermore, the Minister must establish a national waste management strategy and may: declare priority waste streams, prescribe measures for the management of identified waste streams, set targets for recycling and minimisation of certain waste streams, and ban certain waste streams from landfill.

The National Waste Management Strategy (DEA, 2011) sets targets to promote the 3R approach with regard to waste. Its implementation has to be monitored and reviewed at least every five years. It is therefore imperative that the state of waste information in the country be recorded as accurately as possible and be made available to decision-makers in government and industry. Section 24 of the Constitution of South Africa (RSA, 1996) provides for the right to a clean environment. Accordingly, everyone has the right to an environment that is not harmful to his or her well-being and that the environment must be

protected for the benefit of present and future generations. In line with this position, there should be a concerted effort on how to deal with hazardous waste generation for purposes of management (LaGrega et al., 2010). However, contemporary literature on waste control recognises that waste can be minimised, re-used, recycled, recovered or disposed of (Arena & Di Gregorio, 2014). Locally in South Africa, the government has developed a strategy to address waste management concerns which include zero waste plans (Ogola, 2012). Du Plessis (2011) also reports on control mechanisms for managing waste.

It is estimated by FAO (2011) that approximately one third of food produced for human consumption is lost through leakages in the food supply chain. These leakages relate to agricultural production post-harvest handling, storage, processing, transportation, distribution and consumption (Gustansson *et al.* 2011). According to a study on food waste in the EU-27, the trade sector account for 5% of the total amount of food waste, the manufacturing sector 39%, households 42%, and food service-catering 14% (EC, 2011a). There is growing evidence that households contribute significantly to the food waste problem (Sharp *et al.*, 2010). In the EU region, this amounts to 42% of the total amount of food waste generated (E.C, 2011a).

In order to address food waste generation in households, several socio-economic factors that could have an impact have been studied (Evans 2012a; Koivupuro *et al.*, 2012; Stefan *et al.*, 2013). From these studies, results show that for Finland, the amount of household food waste generated indicate significant correlation with several factors; the size and the type of household, the gender of the main breadwinner, people's view on the waste prevention potential, food prices, and the household's view on the impact of purchasing different package sizes. Among the different waste prevention initiatives targeting waste stream at household level, food waste show the highest ranks potential (Cox *et al.*, 2010).

The burden of chronic urban waste management in Africa has been reiterated in numerous studies (Oteng-Obabio *et al.*, 2013; Okot-Okumu & Nyenje, 2011; Oteng-Obabio, 2011; or by international development organisations (ADB, 2002), as well as in project reports (UNFCCC, 2011). The consequences of the waste management challenge include avoidable health and environmental disasters. For instance, cholera cases in Ghana and Zimbabwe affected thousands and left hundreds dead (UN-HABITAT, 2010). Harare city had an annual total of 9,785 recorded cholera cases and 330 fatalities with figures of 29,522 and 1,561 respectively at national level (WHO, 2008).

National waste strategies and policies for countries like Kenya, Zambia and Tanzania identify a need to prioritise urban solid waste minimisation and recycling (LCC/ECZ, 2008; NEMA, 2011). It is probably only South Africa that has developed an effective set of policy incentives and penalties that have enabled the growth of a vibrant private sector/commercially driven waste recycling (Mbiba, 2014). A comparison of household behaviour with regard to waste minimisation in East and Southern Africa found similar attitudes. Anthropogenic activities are known to result in the generation of waste, which may cause significant damages to human health, ecosystems and natural resources (Vergara & Tchobanoglous, 2012).

In addition, the general absence of refined waste compositions, data sources used for those that are reported are usually not sufficiently detailed. For example, in some studies, the waste compositions originate from a specific sampling campaign (Gunamantha, 2012; Bernstad *et al.*, 2011), while in others, they are derived from earlier studies, reports or databases (Koroneos & Nanaki, 2012). Only few studies described the uncertainty and variability of the waste composition, while other studies have shown that these uncertainties lead to significant variations in the life cycle assessment (LCA) (Slagstad & Brattebø, 2013). Waste compositions are specific to each case study and are dependent on geographical differences and the type of solid waste management system (SWMS) considered (Turconi *et al.*, 2011). Trace pollutants, such as small quantities of heavy metals, need to be consistently tracked through the SWMS because they may result in important damages, e.g. via thermal treatment and other methods (Fruergaard *et al.*, 2010).

A sense of moral obligation appears to be an important predictor of recycling behaviour among university students in the United States (Largo-Wight *et al.*, 2012). A similar study in São Paulo, Brazil (Bortoleto *et al.*, 2012) found that waste prevention behaviour influenced households perceptions of moral obligation in Brazil. Past behaviour as reported by Somner (2011) may also be an important predictor of intention and behaviour. But few studies have examined the extension of the moral obligation to household waste behaviour (Miafodzyeva *et al.*, 2013). On the other hand, Saner *et al.*, (2012) are of the view that notwithstanding the limitations of LCA, the approach provides valuable inputs in solutions for waste management.

1.2 Research Problem

An increase in urbanisation tends to lead to increasing amounts of municipal waste generation. Fordsburg is a densely populated area where everyone comes with a desire to find a better job and safe environment. This area has a large number of illegal waste dumps, with negative impacts on the environment. Waste-dump services in Fordsburg are very slow; people mostly dump their waste alongside roads and road sites. The Fordsburg area produces annually large quantities of solid waste. The waste volumes are often beyond the management capacity of the existing MSW. Inadequate waste facilities also result in the indiscriminate burning of solid waste. The poor handling of waste is a major cause of environmental pollution and health problems in Fordsburg. It creates a breeding ground for pathogenic organisms with serious implications for the spread of diseases. There is damage to the topsoil structure and water contamination result from open waste dumps. The characterisation of waste is the key point to minimise the waste production at an elementary level. Little is known about the characteristics of waste dumps in urban localities within metropolitan areas. It is therefore necessary that interventions aimed at improving waste management are based on adequate information obtained by ground surveys of dumpsites to capture their particular physical characteristics and the relationships that exist between them. The study will therefore measure the current waste management practices in Fordsburg.

1.3 Research Aim

The main aim of the study is to investigate open waste dumps in order to provide baseline information in designing management interventions.

1.4 Objectives

Several objectives for this study are advanced as follows:

- To measure the locational attributes of open solid waste dumps and analyse the internal linkages in locational attributes.
- To classify waste across the study area.
- To analyse the variations in the profile of waste in the study area.
- To outline current waste management approaches.
- To suggest interventions to improve waste disposal.

1.5 Assumptions

Illegal solid waste dumping in open spaces is a major concern. Dumping is caused by several factors: failure to collect waste on time, poor enforcement of municipal laws, lack of prosecution of offenders and, limited financial capacity. Based on these observations, it is assumed that:

- Fordsburg has systems in place to deal with solid waste handling.
- All households, business units and institutions have access to refuse bins.
- Fordsburg has formal waste collection points that are easily accessible.
- People in the study have limited knowledge about the benefits of a clean environment.

1.6 Rationale

This research has been necessitated by field observations of open waste dumps in the area that showed the absence of consistency in the handling, reduction and disposal of waste in Fordsburg. The need to identify, locate and characterise such dumps becomes necessary, for such an approach provides the requisite primary data for analysing their internal linkages from different locational attributes. The study measured the distance of open waste dumps from the nearest business entities, shopping malls, school, clinics and residential areas, as well as its effect. This type of data is required for long-term waste management plans. The study should also provide city officials and planners with ground evidence and justification for any proposed policy on domestic solid waste management to reduce the level of waste being dumped in open spaces. This study will help to reduce or eliminate open dumps and the bad effect on residential areas like water and soil contamination. This research investigated the management and problems of local municipalities in addressing waste disposal and results are presented in subsequent chapters

1.7 Significance of the Study

A study of this nature should provide information to local municipalities, researchers and residents of this area on problems of managing municipal open waste dumps. This study should contribute to the required information about environmental effects of open waste dumps. We can mostly collect data on legal waste dumps from anywhere, because they are registered. It is very important to collect data about open waste dumps; therefore, this study will contribute to the provision of information for waste management practices and missing

information to minimise water contamination and topsoil damage in Fordsburg. The study should provide some insight into the sources of waste that ends up at waste dumps, a profile of land-uses likely to generate such waste, and how such information can be used to generate appropriate advice and interventions.

1.8 Structure of the Dissertation

The dissertation is structured in six chapters:

Chapter 1 Background

Chapter 1 provides an outline of the study. It contains information on open waste dumps, waste types and international, African and South African laws. Annual waste production includes the challenges and waste management practices at international and national level have been outlined. It further identifies current waste management programmes, tasks, roles and status of open waste dumps at national level. A brief background to the study research problem, the significance of the study, a definition of different concepts, research aims and specific research objectives, assumptions, rationale and structure of dissertation are also given.

Chapter 2 Literature review

Chapter 2 provides an academic and theoretical background to the problem investigated. The literature review covers different aspects of classification of municipal open waste dumps and its management. The chapter enlists current waste management approaches at global, continental and national levels. It enlightens current waste management handling services, disposal and use of new technologies, the health risks of open waste dumps to people, animals, vegetation, water creatures and the environment.

Chapter 3 Materials and methods

This chapter presents a brief description of the study area and methodology of the study. The chapter contains the full detail of materials, methods and different techniques of data collection. It provides an outline of different stages of data collection and instruments used in data collection. A detailed description about municipal waste dumps practices are given. Derived equations are explained in detail to get the required analytical data. How the collected data were analysed, processed and presented is indicated in this chapter.

Chapter 4 Results and analysis

In this chapter, the results of the study are presented in the form of descriptive, quantitative and graphic statistics. The results include expected open waste dumps trends and its sensitivity. All these results are derived according to specific practices and parameters.

Chapter 5 Discussion

This chapter is a discussion of the results.

Chapter 6 Conclusion and recommendations

In this chapter, the conclusions and recommendations of the study are given.

1.9 Summary

This chapter has introduced the scope of the study into open waste dumps. It has described the background, aims and objectives of the study, problem statement, rationale and significance of the study and the structure of the dissertation.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews numerous journal articles concerning waste management approaches all around the world. It covers how waste is addressed in different countries in terms of handling, waste classification, MSW management practices, policies and the amount of waste generated.

2.2 Waste Management Practices

Most waste management systems in place today were developed long before the era of modern civilisation. Since then, innovations in the form of landfills, composting, recycling and mechanical treatment have been incorporated. Movements towards Zero waste (ZW) as a holistic idea of the 21stcentury is understood within the broader sustainability context (Zaman & Lehmann, 2011). With increasing population waste volumes have followed the same trends that are often at alarming rates. This creates management challenges for governments (Magutu *et al.*, 2010). Under these conditions, the need for monitoring and evaluation structures becomes urgent. For South Africa, PGD (2012) suggests that these should be independent of local governments and municipalities as a means of avoiding conflict of interest.

South Africa's constitution provides for the protection of human rights including the right to a safe and healthy environment (UNDP, 2003). Local, district and metropolitan municipalities are responsible for waste management. These structures are also responsible for developing and implementing waste management plans, collecting data for the waste information system, public awareness campaigns and enforcement as per guidelines (DEA, 2011). The relevance of including water use assessment may also be dependent on specific situations, for example, where contaminants from landfill reach groundwater used for human consumption or irrigation. Such cause-and-effect pathways are still not covered consistently in life cycle assessments (LCA), although attempts have been made to use indicators quantifying spoiled groundwater resources (Manfredi *et al.*, 2010). One approach can be the use of transfer coefficients as applied by Fruergaard *et al.* (2010) on different compounds in incinerated waste to assess the composition of the different incineration residues such as flue gas. Applications to other contexts than incineration are also relevant, such as accumulation of hazardous compounds in recycled materials. To help track the different substances,

practitioners should consider the use of material and substance flow analysis MFA/SFA as in Lederer and Rechberger (2010).

Other pressing challenges faced by municipalities is that of illegal dumping, non-formal dump sites, unpermitted landfills, inadequate waste collection services, lack of recycling initiatives, inadequate waste minimisation, and problems of regulation and enforcement (DEA, 2010). Of the 1,203 general waste landfill sites in the country, only about 524 are registered which results in backlogs for landfill sites (DEA, 2011). Waste management system has a shared responsibility approach in which communities work with the government for the sake of efficiency. It requires that waste generators place waste into the containers provided at designated service points and the municipality allocate dustbins to different parts of the city, as well as collect and dispose of the contents (Aremu *et al.*, 2012). Amongst measures that could be used to reduce externalities, Maluleke (2014) suggests full cost accounting, enforcing extended manufacturer responsibility and facilitating changes in household behaviour

GIS can be used to improve the cost effectiveness in waste treatment and recycling centres on the incorporation of spatially dispersed areas in waste collection. Such areas account for a significant percent of the overall cost. To this end, the geography of the service areas should be carefully factored into the planning process. While Zsigraiova et al., (2013) support this approach in route optimisation for waste collection, Chen et al., (2011) and Merrild et al., (2012) suggest the use of the regional scale.

Turning to capacity building, organisations require much more than training. The need to include the elaboration of management structures, processes and procedures, comes into play. This is necessary if municipalities are to manage relationships among public, private and communities (Bryson *et al.*, 2010). Organisational capacity building on waste management issues in municipalities has tended to centre on new technology, improving the financial base and understanding the administration of waste systems (Marshall & Farahbakhsh, 2013). Moreover, adequate organisational capacity building in municipalities should be about delineating strategies for a sustainable waste-management service delivery (Asase *et al.*, 2009). But what is often not widely appreciated in a significant volume of literature on waste management in developing countries, is the assumptions about changing household behaviour. These take time to saturate in the entire population. Reducing waste delivery costs through increasing cost efficiency is a feasible option. Contemporary literature appear to

support the view that improved logistics positively influence efficiency and lowers costs of delivery (Ichinose *et al.*, 2013).

Mismanaging of solid waste could lead to threats to people through public health risks and to the environment through the erosion of habitat integrity. Household solid waste can cause natural resource pollution if not well handled. Open waste dumps are a common feature of cities in the developing world and this poses immediate threats to public health (Agwu, 2012). Another problem in open dumping is open-air burning which led to gaseous emissions into the environment. Open burning of mixed household wastes either in backyards or on landfills results in emissions of greenhouse gases into the air. The inhalation of the resulting aerosols pose a public health risk (Medina, 2010). Guenon *et al.*, (2013) and Leon *et al.*, (2014) found that fire changes soil quality through its effect on the physical and chemical properties. This may lead to degradation and loss of soil productivity.

Poor institutional practice is a major challenge facing municipalities in the provision of effective waste management. Other challenges include poor financial management and equipment management, a shortage of skilled and qualified staff (Godfrey & Nahman 2007). According to Anders & Zenker (2014) the conventional approach tends to focus on the use of courts and commissions to support peace building in Africa. In the case of post-apartheid South Africa, Tshoose (2013) reports that the focus was put on redress in the context of service access and delivery.

The management of solid waste accounts for a significant part of the total budget of municipalities in many countries (Scheinberg *et al.*, 2010). In spite of high costs, local municipalities are expected to provide an adequate waste delivery service for all. Across developing countries, municipalities spend a significant percent of the annual budget on waste services (Memon, 2010). Often challenges in specific financial monitoring and data analysis becomes a barrier to improving service delivery (Parthan *et al.*, 2012). In this section, the review of applicable literature has highlighted consistent challenges facing the WMS. These vary across different geographical areas and demand that place-specific solutions be considered.

2.3 Global Environmental Concerns

With increasing rates of urbanisation across developing countries, it is natural that the MSW has to confront the increasing complexity of the waste stream. This is in addition to

increasing waste volumes (Webster, 2012). Challenges facing the need to keep a clean urban environment are many and diverse. This is even more serious in the cases of the largest cities in developing countries (Dawda, 2010). The increase in urbanisation rates and population leads to higher waste generation (Agamuthu & Fauziah, 2011). The WHO (2007) reports that on the link between proper waste disposal, primary healthcare, illiteracy and poor waste disposal. Under the legislative regime of Malaysia, options for waste disposal are specified (Nagapan *et al.*, 2012). But in spite of the existing state regulations, waste is often simply dumped in with little concern for recovery or recycling (Amin & Go, 2012).

The idea of turning waste into valuable resources (EPA, 2012) has gained increasing attention in conservation circles. This approach offers sustainable opportunities from a socio-economic and ecological perspective (Omran *et al.*, 2009). Malaysia has targeted 22% of total solid waste to be recycled by 2020 but the current recycling rate is only about 5% (Agamuthu & Fauziah, 2011) compared to other developed countries, rates are as high as 30 - 47% (Mahmud & Osman, 2010).

The implication of low levels of waste recycling is that recyclable waste is landfilled. The result is that the rapid utilisation of the landfill space reduces the life span of landfills. This creates environmental problems and the practice is unsustainable from an economic point of view. The traditional consideration of waste as a problem has since changed to a new perspective in which waste is seen as a resource that could support societies to become more sustainable. Likewise, the reuse or recycling of certain waste materials can save the production of virgin materials (UNEP, 2011). Decision-and policy-makers should therefore preferably rely on context-specific life cycle assessment (LCA) studies, and use generalised results or the widely accepted waste hierarchy with caution (Laurent, *et al.,* 2014) .The efficient disposal of waste contributes to the quality of life. Compared to the developed western countries, the Sub-Sahara Africa region still has a long way to go in meeting the basic needs for MSW (UNEP, 1992). The DEA (2012) published guidelines for the protection of the environment and natural resources. But the successful implementation of these guidelines depends on the three tiers of government and on the need to change the behaviour of local communities.

There are improvements in waste law enforcement and public education to ensure that waste is disposed of properly and at designated places. However, some citizens still have reasons to flout waste management and sanitation rules by dumping waste illegally in undesignated

dumpsites. Law enforcement is often a problem because discrepancies exist between job requirements and actual staff deployment (Kanyane *et al.*, 2013). But this problem is not only experienced in waste management agencies; it remains widespread in most public sector operations.

With reference to Malaysia, it is not surprising that advances in living standards have led to increasing amounts of waste generation. Changes in waste generation with population are reported in Jalil (2010) with an indication that a significant present of this waste is made up of recyclables. In general, the increase in waste generation can be traced to changes in consumption behaviour which is driven by per capita income changes. (Jalil, 2010; Zamali *et al.*, 2009). Existing enforcement highlighted several issues. First is that solid waste generators are required to reduce the generation of solid waste. Second, they are expected to use environmentally friendly products. Third, they should minimise waste generation. Fourth, there should be controls on the import, use, discharge or dispose of specified products. Fifth, they should implement recycling coding and labelling (Mahmud & Osman, 2010).

2.3 Waste Management at International Level

The diversity of conditions in WMS across different countries are noted. In Russia, serious cases of environmental degradation due to poor waste management practices are reported (Kravtsova and Volkov, 2015). In the EU, higher generation rates have been reported for OECD countries at 1.39 kg/person/day (OECD, 2010). According to Eurostat, average statistic values for 27 EU countries, 40% of MSW is taken to landfills for final disposal, while for Russia this value is more than 90%. These results are shows that Russia has a long way to go in bridging the gap with other EU countries. The critical challenge here revolves around the slow pace at which Russia is putting in place the requisite policy, legislation and planning to modernise its waste sector.

Waste generation rates across Ghana are sensitive to rates of urbanisation and differences in household income range from 0.2 to 0.8 kg/person/day. Most cities in Sub-Saharan Africa fall into this category (Friedrich & Trois, 2011; UNEP, 2013). Most municipal authorities in Ghana do not comply with existing waste regulations. The result is that people work under very unhygienic conditions at open dumpsites (Mariwah, 2012). Where waste-to-power generation is established, Fujji *et al.*, (2012) report that power generation can be interrupted when there is a mismatch between the steam flow of boiler and the capacity of a steam

turbine. They also note that pre-processing mechanical facilities that can recycle high-quality plastics have lower construction costs. The generation rate of the various fractions showed that the metropolitan councils generated the highest in each fraction of the waste, followed by the municipals and the least from the districts, except for plastics, which had districts generating more compared to municipality (Miezah *et al.,* 2015). At the national level, the main fractions were organic, paper and plastic wastes, though the inert materials and miscellaneous items were also substantial (Miezah *et al.,* 2015). In the case of Ghana, Miezah *et al.,* (2015) found that household waste fractions were dominated by organics, plastics and paper in all areas. For the average waste generation rate from the regional capitals, a daily total amount of 4,270 tons of household waste were generated from the regional capitals based on an estimated national population census for 2014 (Ghana Statistical Service, 2014).

Similar conditions prevail in Latin and South America, where with higher per capita values, greater waste volumes are generated. Paul (2013) presents the zero waste concept as revolutionary; similar sentiments are echoed in SF-Environment (2013). But, from a practical standpoint, zero waste remains an ideal; it is not achievable in realty given the nature of production. However, others in waste management apply the zero waste concept in different ways. For example, a number of studies report improvements towards meeting ZW goals while using waste-to-energy technology and incineration as part of waste treatment (Abbasi *et al.*, 2012; Bjork, 2012; Premalatha *et al.*, 2013). It is noted that the energy content in the municipal solid waste is about 30% of the energy contained in coal and about 67% of energy contained in pure biomass. Waste to energy can be deployed in energy recovery, protection and preservation of the environment (Omari *et al.,* 2014). Waste to energy technologies still produces waste residuals as part of their normal processes, casting doubts as to claims about zero waste.

In Ethiopia, UNEP (2010a) and Oteng-Ababio (2010) reported on Bahir Dar, a city of 220 000 inhabitants which has outsourced urban waste service to the private sector. About 53% of MSW from 9 administrative areas was household waste; 27% commercial waste; 17% institutional waste. What is noted is the effort put into the collection of statistics on the different waste streams (UNEP, 2010a). While this case may represent individual success, it is noted that today very few other Ethiopian cities have opted for this route in waste management.

In Nigeria, a country with the largest population in Africa, waste management remains a nightmare (Agwu, 2012). This is evidenced by the indiscriminate dumping of waste into open drains and highways. Rapid urbanisation, a lack of political will, disastrous urban planning that has failed to cater for water and sanitation has produced the equivalent of an urban jungle. But these conditions are not unique: similar cases exist for Kinshasa in DRC, parts of Nairobi in Kenya and Luanda in Angola (Ruhiiga, 2013a; 2013b). At present, Nigeria's major urban cities, including Port-Harcourt struggle to clear mounting heaps of solid waste from their environment. In Tanzania, Breeze (2012) reports that Dar es Salaam with an annual growth rate of population at 5% faces severe pressure in its waste management service. However, compared to other cities in Eastern Africa, Tukahirwa *et al.*, (2013) found that its waste collection service operated at higher levels. This performance, however, was not matched with respect to the actual disposal of waste at landfills which stood at only 37% (Enezael, 2012).

In India, the range of MSW generated per head varies from 0.2 kg/d in small cities to as high as 0.6 kg/d in metropolitan cities (Chatterjee, 2010; Kaushal *et al.*, 2012). With an increase in per capita income, average waste generation is expected to reach 0.5 kg/d to 1.0 kg/d of MSW per person by the year 2030 (Kaushal *et al.*, 2012). In many metropolitan cities, the use of normal rivers for the discharge of raw sewage, the practice of conducting certain religious rituals in these contaminated rivers and traditional burial sites located along rivers all pose serious health threats. Compaction and levelling of waste and final covering are often not followed at most disposal sites. Some of the low-lying disposal sites have no leachate collection systems or landfill gas monitoring (Kaushal *et al.,* 2012). Government machinery alone does not seem to be capable of handling these situations; hence, the call for community participation in solving these problems (Patel *et al.*, 2014).

Like other developed countries, Japan has an aging population due to the decline in birth rates, good healthcare and higher income level (UN, 2013). Such a decline in growth rates may lead to lower per capita waste generation. This should allow for a higher budget allocation to social welfare programmes. While Japan has been promoting recycling, the municipal waste treatment is still dominated by incinerators (Fujii *et al.*, 2012). As a result, it is important to develop robust and cost-effective waste treatment and recycling systems. Similar conditions apply in several EU countries; Denmark, Norway, Sweden and Switzerland, where high incineration rates of MSW are noted (UNSD, 2011). Also such recycling systems could be adopted by decision-makers in countries such as China where the

building of more incinerators is underway (Song *et al.*, 2013). MOEJ (2013) raises doubts about the power-generation efficiency of incinerators which it reports at no more than 12%. This review indicates that countries show variations in the way they manage their waste and, that the key drivers vary across countries.

2.4 Waste Collection and Disposal

One of the expectations of contemporary waste management is that waste should be disposed of in a manner which is not harmful to people and the environment (LaGrega *et al.*, 2010). The MSW varies widely between different countries, regions and even localities. Most of the management services are provided either through local government authorities or through sub-contracting private companies (Magutu *et al.*, 2010). In line with the requirements of the waste hierarchy management system, certain inherent challenges indicate serious shortfalls in waste delivery services. One such challenge is how to deal with illegal waste dumping (OAG, 2010). Solid waste collection faces many challenges but the difficulties faced by one municipality are different from that experienced by another (Contreras *et al.*, 2008). Work elsewhere has highlighted issues with accounting systems, pollution, service coverage, staff shortages, management of healthcare waste, billing systems and operational inefficiencies (Magutu et al., 2010; Mahasa & Ruhiiga, 2014; Mudau, 2015; Mahamba, 2015). The seriousness of these challenges vary across urban settlements of varying sizes. For example, the use of inappropriate technology undermines the efficiency of waste collection operations and equipment maintenance. The use of inappropriate technology or equipment types undermines the efficiency of waste collection operations and equipment maintenance, especially the use of imported or international donor equipment (Talyan *et al.*, 2008).The failure to consider parameters peculiar to a particular location has led to unreliable waste collection service and sometimes infrequent collection (Coad, 2011). Municipal waste service departments often show evidence of poor institutional practices. Some of these short-comings have been reported in Godfrey and Scott (2010) and in Nahman and Godfrey 2010) for South Africa.

2.5 Waste Classification

In South Africa, the onset of integrated waste management planning (IWMP) highlights issues around the reliability of waste data (DEADP, 2011). Reliable waste management data provide an all-inclusive resource for a comprehensive, critical and informative evaluation of waste

management options in all waste management programmes (Hancs *et al.*, 2011). Where waste characterisation is reported, often the results indicate limited sampling periods, the use of different methods and waste categories making it difficult for comparisons (Wise *et al.*, 2011; SPLM, 2010). There is no reliable source of data on household waste generation rates in South Africa. However, the Waste Information Baseline Report (DEA, 2012) estimates that the average waste generation rates (kg/capita/day) by income level as: very low income 0.3, low 0.46, medium 1.03, high 1.68 and very high 1.85 kg/capita/annum. The State of Environment Report on solid waste in the City of Cape Town specifies 14 different waste categories for which a corresponding percent is indicated. It is not clear whether these percentages represent computations based on mass or volume (DEAT, 1999). Gibb Engineering and Science (2008) reported that food waste makes up 12.5% (by mass) of residential waste collected by the municipality in Cape Town. The waste generated and its composition analysis can help in decision making on which method of energy recovery can be utilised. For waste with a big portion of organic matter, the composting or incineration can be utilised while the presence of large recyclable waste indicates the possibility of material recovery from municipal solid waste. For every kilogram of dry municipal solid-waste, the expected thermal energy recovery is 10.6 MJ/kg (Omari *et al.*, 2014).

Waste can be classified in terms of source, or chemical state or the extent of degradation potential across time (Magutu & Onsongo, 2011). The dominant approach in urban areas in South Africa has been to dump the bulk of the waste at municipal landfills. The increasing use of ICT and related technologies has in recent years given rise to significant e-waste volumes requiring specialised handling and treatment (Mwesigye *et al.*, 2009). The DEA has gazetted waste classification regulations (RSA, 2011) in order to establish standardised reporting procedures. Until 2005, the absence of a waste information system created severe challenges for decision making at the national level. This system of classification is sensitive to the degree of risk inherent in certain waste streams and can be used as a guide in classifying landfills and the suitability thereof for certain classes of waste (DEA, 2012). Unfortunately, these require fundamental statistics which are lacking in many developing countries (Buenrostro *et al.*, 2001) and where they are available, they are inconsistent because they come from many sources which cannot be validated and are sometimes based on assumptions but not scientific measurements (Couth & Trois, 2011; Ranjith, 2012). This tends to put pressure on the municipal budget. Under conditions of a limited municipal budget, the management of waste will not be effective. The result will be that the health of

the people and the environment are at risk. The common practice is for the municipality to inform residents about its waste collection schedule and the location of temporary storage receptacles (Maluleke, 2014).

Municipal wastes come from diverse sources and studies indicate that much of the waste from developing countries is from households (55–80%), commercial or market areas (10–30%), varying quantities from streets, industries, and institutions (Nabegu, 2010; Nagabooshnam, 2011; Okot-Okumu, 2012). Given that waste can be hazardous and can threaten water resources, its management is crucial. Current understanding shows, however, that no single approach is applicable to all waste streams (Mastellone *et al.*, 2009; López, 2010). In addition, in developing countries, waste management receives generally low levels of attention. This may be the result of intense competition for resources in the national budgeting process. The limited resources mean that often waste management does not receive adequate funding (Mudau *et al.*, 2013). But as indicated in earlier sections, policy and planning may in fact be the root cause, rather than inadequate funding. It has been suggested that municipalities could exercise alternative mechanisms for better service delivery (Mihelcic & Zimmerman, 2010; Ruhiiga, 2013). It is noted, however, that the growth of the urban economy and the parallel increase in urbanisation rates directly impact on municipal resource allocation (Beall, 2010). With increasing mean incomes of the urban population, this tends to affect the volumes and complexity of the waste stream.

Pollution of waterways is often associated with problems of leachate leakage from refuse centres which in turn create technical problems in providing clean water. Also, urban floods tend to disrupt drainage systems and the associated storm control infrastructure (Maluleke, 2014). A key characteristics of urban life is the increase in the use of processed foodstuffs and the accompanying packaging which is changing the waste compositing in Egypt (Zayani, 2010). Giugliano *et al.*, (2011) report a study based in Italy in which the make-up of the municipal solid waste used as input data, evaluated and averaged as per waste fractions. Two sizes of integrated waste management system (IWMS) were considered: a metropolitan area, with a gross waste production of 750,000 t/year and a province with a gross waste production of 150,000 t/year. The analysis used the LCA technique covering material and energy recovery activities. Results showed that both large and small IWMS, the energy and environmental benefits are higher than the environmental impacts for all the scenarios analysed. Unfortunately, this problem is aggravated by the diversity of materials in the waste, which is not only food waste and ash, but includes plastic packaging, paper and electronic

waste (Talyan *et al.*, 2008). With reference to waste collection and disposal, a diversity of challenges and solutions have been highlighted. It is noted that many countries face shortage of reliable waste data. Under these conditions, planning for future waste streams has to do with estimation which may not be a true reflection of the actual generation rates.

2.7 Recycling and Waste Minimisation

The analysis of environmental behaviour with respect to recycling, saving energy or other activities based on personal rules and feelings of moral obligation is reported in Thanh *et al.*, (2012). Waste pickers constitute a critical link in the sequence of tasks that go with waste recycling. Those who pick waste are at the bottom of the hierarchy in the sequence of recycling activities (Nzeadibe *et al.*, 2012). It can be argued that such informal waste collection addresses two critical issues: provision of an income for the poor; and sustenance of large scale recycling plants in the cities. PETCO, for example which is South African based, reports collecting 23 000 tons of milk bottles in 2008 (Mamphitha, 2011). This contributes to the reduction of green-house emissions(GHS) (SEWA, 2009).Also at dumpsites in Bahir Dar, Ethiopia, 10–15 informal waste pickers recover reusable and recyclable materials like metal, glass, plastic and textiles and sell it to middlemen or to the private waste company (Worku, 2012).

Even though waste pickers have been involved in collecting recyclables for sale at buy-back centres, their activities have not been documented. This is the scenario taking place in the waste management system of Ghana (Mariwah, 2012). This has serious implications for the waste hierarchy for it shows problems in the way local municipalities understand the totality of the waste chain. Composting is not well practised but as a parallel process to recycling, potentially it would take care of most of the green waste. The environmental and economic impact of recycling technologies and the processing of reclaimed poly-ethylene terephthalate (PET) resins is reported in Frank (2011) and in Chilton *et al.*, (2010). Organic can be recycled through biological composting and digestion processes matter (Al-Salem & Lettieri, 2009). The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes. In South Africa, for example, legislation prohibits the stock-piling of construction and demolition (C&D) waste. Yet, this same type can be re-used directly by the same construction industry at no additional processing costs in landscaping.

Landfills are generally the most common disposal method for municipal solid waste (Al-Salem & Lettieri, 2009). Landfills were often established in abandoned or unused quarries,

mining voids or borrow pits (Magutu *et al.*, 2010). The degradation of organic matter in landfills can be modelled at different levels of parameterisation. Some inventories of emissions are based on emission rates per ton of waste (Munoz & Navia, 2011), while others rely on more refined properties like the differentiation between carbon structures (cellulose, lignin, etc.) as performed in Koroneos and Nanaki (2012). But recycling alone may not be an adequate approach in minimising greenhouse gas emissions. Instead, the promotion of waste prevention along the waste chain require more emphasis (Barr *et al.*, 2013). In order to fill such a gap, Fujii *et al.*, (2012) proposed the idea of "smart recycling" to evaluate the effect of innovative waste management on carbon dioxide (CO_2) emissions and cost reduction. This entails that waste is used in an alternative, useful manner that will ultimately result in waste minimisation (Phale, 2012). Limitations in the understanding of recycling are noted as some of those involved may not appreciate the benefits (Prestin & Pearce, 2010). It is necessary to caution adherents of waste recycling that, like any other manufacturing concern, it faces both competition and rising costs. There has to be evidence of comparative advantages for a large scale entry of new recycling plants to be set up anywhere. The market as a critical player in business decision making, is often forgotten.

Waste minimisation occurs at two levels; either at the point of generation itself or along the waste chain where some waste recovery occurs. The process links generators with waste recyclers and those companies that provide support services (Vergara & Tchobanoglous, 2012). What does not so far receive widespread support are interventions at source whose long term impact on waste volumes are not well appreciated (Oteng-Obabio, 2011b). But this is a reflection of general environmental education and the concerns with the future of humanity. These concerns vary across countries and the obstacles to changed behaviour towards the sustainability of the environment show similar trends. One way to reduce effects of landfills is to target minimisation efforts at source. Cost-effective approaches can be deployed through the delivery of public education campaigns and the buy-in of communities with regard to design of household recycling processes (De Feo &De Gisi, 2010). Other studies have shown the effectiveness of action planning changing behaviour (Pakpour *et al.*, 2011, Pakpour & Sniehotta, 2012). Iran, for example, has a framework in place for encouraging household waste reduction behaviour but implementation requires public participation (Karim *et al.*, 2013). In other cases, Pearson *et al.*, (2012) and Swami *et al.*, (2011) report that age and gender are significant predictors of waste behaviour.

This section has shown that, there are benefits of waste recycling as it directly feeds into waste minimisation. But it has also shown that there are imbedded challenges facing the waste recycling industry itself. A need to understand and appreciate consumer behaviour and their response to environmental concerns is critical. Investing in changing consumer behaviour to become pro-environment, in the long run could be a worthwhile venture.

2.6 Urbanisation and Waste Crisis

Uncontrolled urbanisation, especially in developing countries of Asia, Africa and Latin America has created challenges for the sustainability of human settlements. One of the outcomes is a waste crisis which is made worse by poor land use and infrastructure planning (Geng *et al.,* 2010). These are problems that have been reported elsewhere in Asia (Chettiparamb *et al.*, 2011; Forouhar & Hristovski, 2012)) and in Africa (UN-HABITAT, 2010).Population growth often when linked to improvements in living standards has very important impacts on the quantity of generated waste (Minghua *et al.*, 2009).

Urban sustainability is concerned about how people make a living in the urban space. Of particular concern are issues around energy efficiency in buildings, the nature of transportation systems, waste disposal and sanitation, the access to recreation, security, air quality, and the quality of life (Pacione, 2009). Access by members of the public to private green spaces is deemed a crucial strategy (Sundaram, 2011). Significant changes are underway in cities across developing countries (Angel *et al.*, 2011). Yet, the direct transfer of first-world models and guidelines to developing countries may often be misguided because the underlying socio-economic dynamics are quite different (Shackleton, 2012; WendeL *et al.*, 2012). The UN has reported that the fastest rate of urbanisation is in the African countries (UN, 2008) and predicts population growth will be concentrated in urban areas over the next 30 years (UN, 2014). This rapid growth is likely to cause backlogs in service provision (Hunter & Posel, 2012).

The majority of case studies on the distribution of green spaces and trees within cities are based on conditions in developed societies (Shackleton, 2012; Wendel *et al.*, 2012), most of which are highly urbanised and with relatively low population growth rates. In contrast, developing societies register high rates of urbanisation forcing planning agencies to struggle to keep up (Angel *et al.*, 2011). The decline of employment in the countryside following changes in the agrarian economy tends to drive increased urbanisation.

The continuing waste crisis persists in developing countries at a time when international donors, central and local governments have made noticeable interventions to improve management through decentralisation, neo-liberal cost-recovery/cost sharing, privatisation and public-private partnership reforms witnessed in diverse cities like Kampala (Okot-Okumu & Nyenje, 2011), Dar es Salaam (Katusiimeh *et al.*, 2013) Enugu in Nigeria, (Nzeadibe, 2009), Lusaka (LCC, 2004; ECZ, 2008) and in Accra (Oteng-Obabio *et al.*, 2013). Yet, Okot-Okumu and Nyenje (2011) argue that some of these initiatives have had limited impact on Kampala and Lusaka. Oteng-Obabio *et al.* (2013) report that the decentralisation programmes from the 'north' are ill fated, since the requisite waste conditions to support them in much of Africa do not exist. The counter-argument here is that it is not decentralisation per se that is problematic; rather, it is the failure to put in place effective structures and mechanisms at local level to ensure its success. It is noted that these interventions ignore the building of expanded partnerships with micro-subsistence and macro-commercial informal actors that are already active across urban Africa (Okot-Okumu & Nyenje, 2011; Oteng Obabio *et al.*, 2013; Scheinberg *et al.*, 2011; Waste, 2014). The role of the informal sector in managing urban solid waste is not fully supported by city authorities even in Latin American countries that are supposedly more accommodative (Fergutz, Dias & Mitlin, 2011). Areas of the city that have been developed recently or are difficult to access may pose a strain on effective waste collection. Illegal dumping and littering pose a serious challenge in Japan for effective waste collection efforts despite improved law enforcement and public education campaigns (Ichinose &Yamamoto, 2011).

In developing countries a major constraint is that of resources required to provide a modern waste delivery system. A basic requirement, for example, the provision of bins to households, remains a challenge. In a study of low-income household's covering- Driftsands, Masipumelela, Greenfield and Tafelsig- in Cape Town, it was found that 68% had no access to bins while another 26% disposed of waste in the street (Govender *et al.*, 2011). Such adverse practices like illegal burning of waste and littering may indicate low levels of environmental education in the general population (Naidoo, 2009). This amounts to a re-statement of the fact that the informal sector is not adequately incorporated in the mainstream economy; a weakness widespread across practically the entire African continent. The potential of the informal sector in contributing solutions to addressing the waste crisis is therefore not widely appreciated.

2.7 Littering Behaviour

A persistent problem across most developing countries is the extent of open littering that is witnessed in urban areas. Keep America Beautiful (2009) argues that litter is caused by human behaviour. EMA (2011) argues that there are numerous causes of littering; understanding these should provide information on options for intervention. Additionally, there has been a perpetual deterioration in the quality of services offered by City Councils, for example in Zimbabwe (Gukurume, 2011). However, informal trading, which is itself a major cause of urban littering, has emerged as a livelihood portfolio for many and is not only confined within the Central Business District (CBD) of Harare and city seams (Dube & Chirisa, 2012) but also along highways.

A possible solution is first acknowledging that littering is part of behaviour and it has place and geographical ramifications. Environmental education is too slow to halt and change human behaviour over a short time span. But prosecution and enforcement do have direct and immediate impact on public responses (Mudau *et al.*,2013). Local governments could, in short pass laws to prohibit littering and make such behaviour a punishable offence. Initially, the public may react with apprehension about the approach but eventually, it will be inculcated in the general public that every form of littering represents an illegal act punishable by law.

2.8 Poverty and Food Waste

The volume of food waste per household is a measure of consumption. In general, urban households produce more food waste than non-urban households. Indeed, in the latter case, so much of the food waste is recycled directly at sites of generation that it is not a major issue. Nahman *et al.,* (2012) reports that the total cost of wasted food at source (R21,195,308,450 per annum or 0.80%) and landfill disposal (R505,080,938 per annum or 0.02%) to the society associated with food-waste problems are estimated at approximately R21.7 billion per annum. This amounts to roughly 0.82% of annual South African Gross Domestic Product (GDP) (Nahman *et al.*, 2012). South Africa's economy is highly dependent on natural resources for food and energy production, and inputs to manufacturing.Most of the food waste that is generated in households include spoiled cooked food, excess cooked food, vegetable and fruit peelings, beverages that went stale, undesirable raw food, meat scraps, fresh fruit and vegetables and salad (Global ideas, 2013; FAO, 2011; DEFRA, 2010). Several studies report that the most perishable

food items account for the highest percentage of food waste. Fresh, fruit and vegetables (FFVs) are usually among the most-wasted items (Parfitt *et al.* 2010).

It is estimated that up to 12 million (24.5%) of the South African population go to bed hungry each day (Hosken, 2013); yet the country has the largest proportion of food wastage in Africa (Allafrica, 2010). In some of the poorest areas around Cape Town and Msunduzi in KwaZulu-Natal, 80% to 87% of the population go hungry every day. Yet, very few poor households in South Africa and specifically in these areas grow their own food (SACN, 2011). Preliminary research has established that in developing countries, food is lost on farms, during transportation and storage (Allafrica, 2012). For developed countries, the greatest losses occur in households and eating establishments. It is estimated that in South Africa only about 4.14% of food waste occurs at post-consumer stages, while the majority of food waste 8.67 million tons per annum is generated during agricultural production (26%), post-harvest handling and storage (26%), processing and packaging (27%) and distribution 17% (Oelofse & Nahman, 2013).

Household food waste is, nevertheless, a small component of the food waste problem in South Africa. According to Oelofse and Nahman (2013), food waste has a triple negative impact. This includes the environmental impact of food waste disposed at landfills and the consequent pollution; socio-economic impacts associated with food insecurity and atmospheric emissions derived during food production, and processing and distribution to consumers contributing to climate change. The accumulated effect of these food wastages from different sources threatens food security of the country. Environmental impacts associated with food waste are caused by the decomposition of food waste that emits the greenhouse gas methane and carbon dioxide; and leachate with the potential to pollute water resources. Methane is a greenhouse gas, which is 25 times more powerful than carbon dioxide (Kevin, 2009) and contributes towards global warming and climate change.

Research work on food waste in the EU found that the retail-wholesale sector accounted for about 5% of the total amount of food waste, the manufacturing - 39%, households- 42%, and food service-catering- 14% (E.C; 2011a). On a global scale, these values change due to a number of control factors. Parfitt *et al.* (2010) report that food losses are higher for developing countries during the post-harvest stages. For industrial economies, these losses occur after the food has been sold to consumers. Unlike in developing countries, the food waste problem traced to households is particularly significant (Sharp *et al.*, 2010; EC, 2011a;

Cox *et al.*, 2010). Beyond the environmental effects of food waste, associated economic implications come into play (Nahman *et al.*, 2012).

Besides the obvious environmental impact of food waste, there are also associated socio-economic impacts, such as business and consumers' savings (Nahman *et al.*, 2012; Koivupuro *et al.*, 2012). At the household level, food waste generation is strongly associated with income indicators as well as with certain attitudes (WRAP 2009; Abeliotis *et al.*, 2012, 2014; Stefan *et al.*, 2013; Quested *et al.*, 2013). However, some results show that food provision parameters are important (Langley *et al.*, 2011, Evans 2012b, Williams *et al.*, 2012). In Ghana, Duku *et al.*, (2011) estimated that organic waste account for 68% of the municipal solid waste. In the same vein, combustion of waste materials is known for emitting dioxins but no experimental evidence has confirmed such pyrolysis of biomass feedstock and the resulting co-products (Verheijen *et al.*, 2010). Beesley *et al.* (2011) present a review of results on the removal of organic and inorganic contaminants. In Sub-Sahara African countries, as a result of the low value of biomass and long haulage distances between sources and potential markets, the majority of organic wastes are left to decay on-site, dumped in open spaces, landfilled or incinerated (McElligott, 2011).

Overall, littering and food waste is a social problem. It is a result of changing behaviour across increasing standards of living and the problem of material accumulation. While poor countries do not in fact appreciate this as a problem, the developed western world has reached such alarming levels of excessive consumption that food waste is a reality (EC,2011a). A differential taxation regime can be put in place to punish culprits and in so doing curb the urge for excessive consumption. This would amount to higher municipal rates for all those households that generate food waste beyond a mean threshold computed for each urban settlement.

2.9 Waste Management in the South African Context

The shortage of space for new landfills in South African cities and towns is reported in IPS (2009). Accordingly, the need for long-term planning to mitigate such a challenge is critical (Remigios *et al.,* 2012). Problems in the management of landfills at local municipality level are widespread as reported in Godfrey *and* Oelofse 2009). But some of these management problems can be traced back to the role of segregation in shaping the history of the country since 1652 (Irvine, 2012). The use of incinerators has both advantages and disadvantages.

Ning et al., (2013) reports that incineration can handle both low-quality waste and high moisture waste to generate energy. The practice of burning waste in the open adversely affects existing pollution levels. Godfrey (2013) calls for the need to educate the public about the benefits of proper waste management. It is under these conditions that issues around extended producer responsibility (DEAT, 2005) and carbon trading have come to the fore. The critical issue is not what countries should do to protect the environment but whether they are capable and willing to implement measures and enforce punitive costs on those who contravene environmental legislation. The state of waste information at the municipal level in South Africa for 2005 showed that 68.9 % kept some data on waste (Godfrey, 2008). However, 62% of those municipalities collecting data believed that they were collecting unreliable data. This sentiment is echoed in DACE (2008) for the PIWMP of the North West province.

South Africa's *Municipal Structures Act* (no. 117 of 1998) allocates to municipalities the responsibility for waste management. To this effect several pieces of legislation (CSIR, 2011; Lincoln, 2011) have been passed. The need for waste information corresponds closely with key waste management challenges currently facing the country (Yohannes *et al.,* 2014). This is despite the fact that South Africa is quite ahead of other African countries in passing applicable environmental legislation (Mangizvo, 2010).

In 2001, the South African government set a target of providing all households with access to refuse removal services by the year 2012, a vision that is yet to materialise (National Treasury 2013). Although it is difficult to obtain reliable waste information in South Africa, data from the Community Survey 2007 indicates that there is a backlog in the provision of waste service delivery to about 2.1 million households (Lehohla, 2007). Data from Statistics South Africa shows that about 892 609 households received no form of waste service at all. In contrast, waste service delivery information indicates that about 4.1 million households out of 12,500,634 households received waste service delivery in 2009 (Stat

SA, 2009). While the lack of access to waste service delivery remains one of the highest challenges in South Africa's rural municipalities, the failure by municipalities to provide waste services in informal settlements and other underserviced areas has resulted in unregulated dumping of household waste (StatSA, 2009).

The low levels of waste service delivery are attributed to inefficient institutional structures (Godfrey & Scott 2011). Some of these institutional challenges include: lack of well-defined

line of authority, ineffective sanitation rules, inadequate organisational capacity, unreliable services and erratic collection schedules among others (Regassa *et al.*, 2011). Many of the municipalities in South Africa do not have clearly defined line of authority that is well established within this institution (Oelofse *et al.*, 2007). Unfortunately, sanitation rules are currently not adequately enforced by South African municipalities because of the increasing population, urbanisation and industrialisation, resulting in a large proportion of mostly rural communities lacking adequate sanitation and waste disposal services (Gemmell & Schmidt, 2012).

2.10 Summary

This chapter has reviewed waste management practices and the classification, collection, transportation, minimisation, reduction, disposal and management practices of solid waste. It has been shown that waste management faces many challenges and these vary across geographical areas. In some of the cases, possible solutions have been suggested. In others, a critique is made of certain populist standpoints. What is not disputed is the extent of challenges facing waste management globally. Having established key features of contemporary literature, the next chapter addresses the methods of investigation.

CHAPTER 3: METHODS OF INVESTIGATION

3.1 Introduction

The methods of investigation for the stated problem are presented. It considers methods used in determining current waste practices. A detailed description of the study area with its coordinates and maps are given. Sources of data, design of collection instrument and research design are briefly described. The population of the study area, sampling techniques, sampling fraction, and a pilot study are provided in this chapter. The techniques used to collect data are explained and their choice justified. Observations and informal interviews are briefly described in this chapter.

3.2 Research Design

A descriptive, non-experimental, field-survey-based quantitative research design was applied. This particular design was chosen based on the numerical nature of the variables of interest and the corresponding measurements. The actual instrument for data collection here was an Observation Schedule (Appendix A). This was reinforced first with secondary statistics from the City of Johannesburg and the Gauteng Provincial Government and secondly, by annual reports of the City of Johannesburg for the period 2002-2014. Thirdly, additional data applicable to municipal waste management were accessed from the Fordsburg local management area.

An informal interview was also conducted with managers at Pikitup, the contractor tasked with waste collection and disposal in Johannesburg. The interview guide was designed on a spread-sheet format allowing for information to be filled in pre-set cells for easy translation into tables. Senior management of the waste directorate at COJ were consulted for detailed additional information (Appendix B). The research design was centred on field surveys with observation schedules. Observation schedules were designed with different variables, which had to be measured in field surveys on 50 samples of waste dumps. These variables were measured according to percentage weight, class and locational attributes. The location by coordinates for each waste dump was measured with a hand-held GPS meter. Then different measurements were taken, like distance from nearest road, building, food retail outlet, business outlet, public building, other waste dump, and official waste dump from each waste dump (Appendix B). The size, width, length and height of waste dumps were measured in metres. The existence or otherwise of official signage and warning boards near waste dumps

were recorded. Next, a data sheet was created with waste classification columns. Waste was classified in terms of glass, paper, metal, construction & demolition, e-waste, garden waste, industrial waste, wood, plastic and rubber.

The use of an observation schedule, secondary statistics and informal interviews is justified by the nature of the objectives and the need to generate data that measures the actual variables of interest in the study. Observations on site during field work allows for the actual taking of measurements. The additional sources of information were used first to fill information gaps where observations could not provide the required data. Secondly, they were used to validate official positions against what was observed in the field.

3.3 Population

The number of open waste dumps was selected on the basis that they were found in Fordsburg. Therefore, only a sample of the population was investigated. The population of interest is the open waste dumps located in the Fordsburg area of Johannesburg. The unit of analysis was "waste dump". In this study, a spot survey was initially carried out to identify, locate and code open dumps. In this area, there are 301 open waste dumps, from which 50 dumps were randomly selected.

3.4 Area and Extent

As a city, Johannesburg is the largest of its kind in South Africa. It is the provincial capital of Gauteng Province, the wealthiest in the country, having the largest economy of any metropolitan region in sub-Saharan Africa. The city is one of the 40 largest metropolitan areas in the world. The City of Johannesburg -Figure 2- had an estimated population of 4.3 million in 2014, while the Greater Johannesburg Metropolitan Area had a population estimated unofficially at 8 million.

Johannesburg has a land area of 334.81 km^2 which is relatively large when compared with other cities, resulting in a moderate population density of 2,900/km^2 in 2014. The city is located on the eastern plateau, known locally as the Highveld, at an elevation of 1,753 metres above sea level..

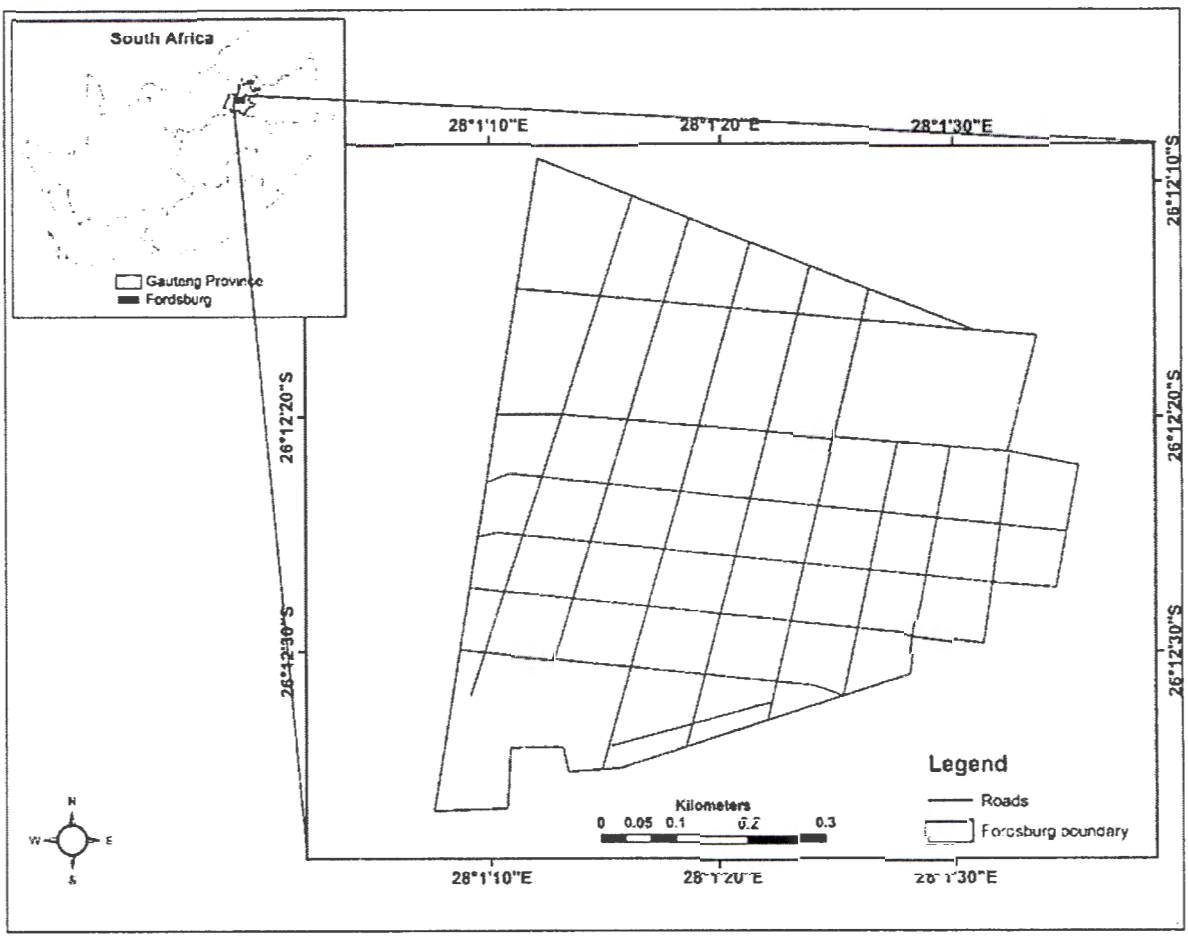

Figure1: South Africa with an insert of Gauteng Province and Fordsburg area

Fordsburg is a suburb in the central region of Johannesburg, South Africa- Figure 2. It is a residential suburb, although housing numerous shops and factories. The area of Fordsburg (Figure 4) was selected as a case study due to several reasons. It is a residential and economic hub of Johannesburg. The composition and development of such area is rapidly changing. Many people of different racial groups are migrating to this residential area for economic reasons. The presence of these different racial groups gives one an idea about settlements and waste management services. This enables one to investigate the current waste management practices.

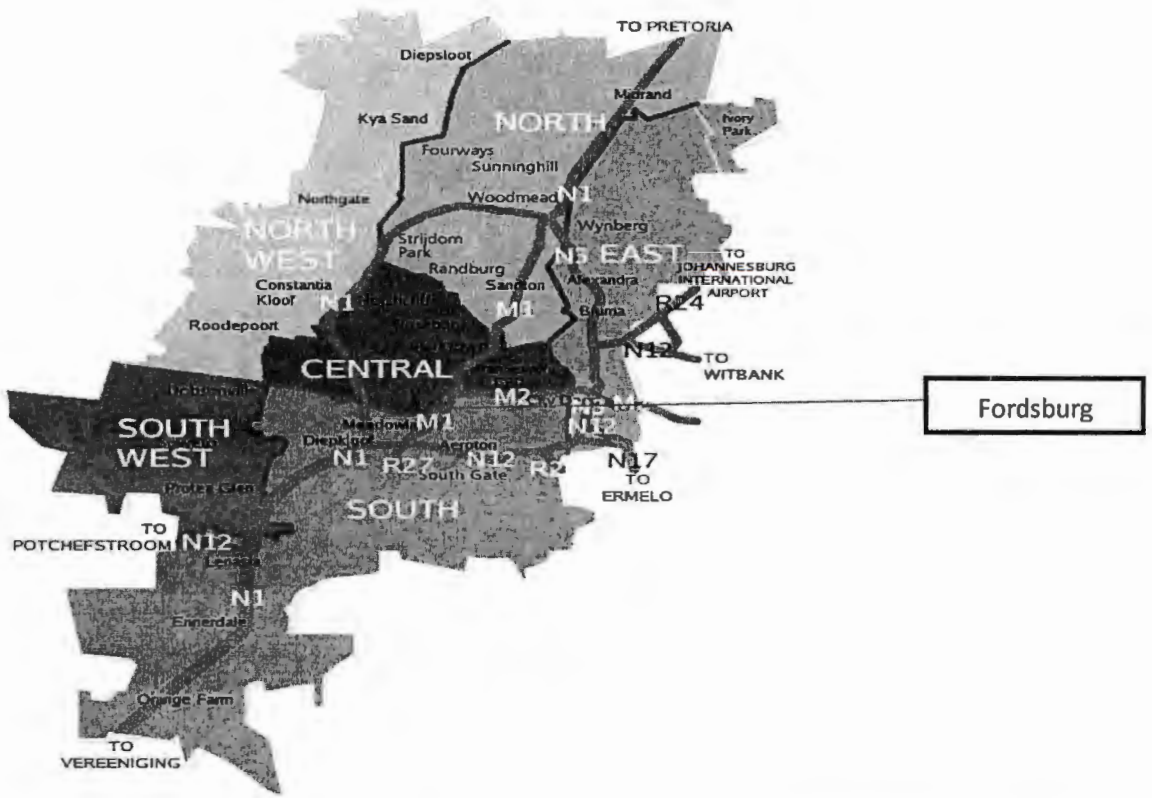

Figure 2: Administrative divisions of City of Johannesburg showing the location of Fordsburg

3.5 Pilot Study

A two stage pilot study of a random sample of five waste dumps was conducted in the Fordsburg area. A team of 5 field assistants was recruited and given on-site training on how to sort waste into classes. In phase 1, waste was physically separated and sorted, then packed into plastic bags and weighed at site using a standard spring balance with a range of 0.5-25Kg. The values were recorded in kilograms. The results were then averaged for each waste class across the five sites to constitute an estimate of waste streams by quantity in Kg. In phase II, a visual estimate was made of the waste dump in terms of the surface area covered by a particular waste class. The estimated surface area was then expressed as a % of the total area of the dump. A set of values recorded gave rise to the generation of means per waste class. The differences between the mean values generated by each of the two phases were studied. It was established that the technique used in phase 1 produced data values of a higher order in accuracy but the technique was not feasible for the entire study area covering 50 waste dumps. It was therefore decided to use the technique in phase II, well aware of its internal limitations with regards to accuracy.

The pilot study was conducted by random sampling of five different open disposal sites in in order to observe the strength and dependability of the instruments. On the basis of the responses, it was established whether distinct items in the observation schedule were appropriate in generating the required measures. Questions and guidelines on the assessment form were checked before going for field surveys in order to reduce errors. In line with the approach of Kitchin and Tate (2000), instruments were adjusted in order to get rid of unclear questions.

3.6 Sampling Techniques

This study dealt with waste dumps, hereafter referred to as WD. An initial field census and mapping exercise provided statistics on the population of WD and on location in the study area. This exercise indicated a population of 301 waste dumps. A street map was used to localise the coded waste dumps in the sample for each dump. A three-digit code was allocated before using a table of random digits to select a sample size of 50 WDs, translating to a sampling fraction of 16.6%. These 50 waste dumps were found to be acceptable in representing the whole population. .

3.7 Sampling Procedure

Random sampling was best fit for the 301 waste dumps. 50 waste dumps represent 16.6% of the total population. These 50 waste dumps were selected by means of a table of random digits using the first three digits from the right and systematically row-by-row. The numbered WDs were then marked on a street map of Fordsburg as 1 to 50.

3.8 Data Collection

3.8.1 Primary data

Primary data were acquired through field surveys, observations and measurements in the study area using an observation schedule (Appendix A). Measurements on this map were done from the centre of the dump and expressed in kilometres and metres using the scale of the map. This was followed by ground visits to individual sites and measurements on the ground using a 50 metre tape as a way of validating earlier measures from map interpretation. Waste was classified in different categories: glass, paper, metal, demolition, and e-waste, garden waste, food waste, industrial, wood, plastic and rubber. A data sheet was created to collect data under these waste classification categories. The percentage weight of each

category was measured by observation. Each waste dump was surveyed with its locational attributes with a GPS hand-held meter. Current waste management practices in this municipality were briefly listed. Secondly, problems encountered in managing solid waste in this municipality were investigated.

3.8.2 Secondary data

For this purpose, the published and unpublished data from various sources were consulted. Secondary data were accessed from the:

- Offices of City of Johannesburg;
- Gauteng Provincial Department of Environmental Affairs and Tourism; and the
- Fordsburg Local Area office.

3.9 Data Collection and Analysis

3.9.1 Observation data

Primary data were collected by two instruments, a structured data sheet and informal interviews. Data collection was done by direct observation at each sample site (Appendix A). Other data on current waste management practices, in particular regarding the handling of municipal waste were obtained from annual official provincial reports of the City of Johannesburg from 2004 to 2014. The information retrieved from these sources was presented in the form of a descriptive profile of municipal waste management system. The main points of this information were later carried forward to the results and discussion section of the study.

After collecting primary data, secondary data were gathered from Annual Reports of Johannesburg. Data analysis was by means of generating descriptive statistics using Excel. This was then followed by the carrying out of Pearson's multiple correlations and then multiple linear regression. These methods made it possible to generate results on individual variables and to establish internal relationships between them.

3.9.2 Informal interview

The informal interview was managed by an appointment with the Chief Operating Officer (COO) of the waste department. The interview was designed to investigate current waste management services and covered the following:

- Policies regarding minimum duration of waste collection on different points, storage, transportation and final disposal.
- Information regarding the capacity to handle, amount of waste, waste policy, legislation, waste management acts, waste management plans, and their application, where applicable.
- Facilities available to the waste management department for disposal of waste, i.e. should waste be divided into different categories, who does this segregation, colour code for disposal for different categories, is infectious waste labelled with basic Bio-hazard symbol? Where do they dispose of hazardous waste?
- Do they maintain a register for waste disposal, and has a waste audit been done in the last three years.
- Training programme, annual education for waste management workers and attitude assessment of the person interviewed.

3.9.3 Data sheets

Site observations were best suited for measurements and estimations of size, number and distribution of the illegal open waste dumps in this area. The land covered by these illegal waste dumpsites were measured and then classified. The influence of these open waste dumps on the direct environment was examined. Observations provide the means for the researcher to carry out on-the spot measurements (Makarati & Chikobvu, 2012).

Table 1: Variables of interest for each dump site:

	List of Variables
X1	Distance from WD to the nearest road
X2	Distance from WD to the nearest building
X3	Distance from the WD to the nearest business outlet
X4	Distance from the WD to the nearest open dump
X5	Distance from the WD to the nearest official bin
X6	Distance from the WD to the nearest food retail outlet
X7	Distance from WD to the nearest public building
Y1	The size of the waste dump measured in square metres

The composition of waste from each waste dump was estimated in percentage value using 10 categories as shown in Table 2.

Table 2: Waste Classifications

	Waste type	Mass	Units
A	Paper	-	Metric ton
B	Metal	-	-
C	Demolition	-	-
D	E-waste	-	-
E	Garden waste	-	-
F	Food waste	-	-
G	Industrial waste	-	-
H	Wood	-	-
I	Plastic & rubber	-	-
J	Others	-	-

3.9.3 Elements of municipal waste chain

The Interview Schedule in Appendix B was used in combination with direct observations (Appendix A) in order to determine the municipal waste chain at each site. An observation schedule was completed, capturing all features of frequency, quantities and movements of waste from base line to final disposal. The rest of the information are presented in the form of tables and descriptive statistics generated by Excel. Plots were generated for each variable of normal distribution. The results of these computations are presented in the results section of this study.

3.9.4 Quantifying standards for handling municipal waste

Quantifications of current action against standards of handling municipal waste were done using data from observations. Descriptive statistics were calculated by way of mean, median, standard deviation and plots showing the extent of clustering and dispersal. To show differences in trends between performance and expected standards, computer-generated graphics were used. Using Excel ™, descriptive statistics were generated and results were applied after getting a 95% confidence level. The results showed the nature, direction and strength of interactions between critical variables and municipal waste handling chain.

3.9.5 Critical technical and managerial limitations

The instruments used in this procedure were Appendices A and B. Descriptive statistics and computer-generated graphics were produced as an initial step in data analysis. Material acquired here led to identification of the critical technical and managerial limitations in the distribution of an efficient municipal waste management plan. Using the results from objectives 1, 2 and 3, a set of limitations were taken out for use in the discussion section of the study. This was done to eliminate potential problems faced by disposal of waste at open dumps.

In the survey, emphasis was placed on waste generation on streets, current waste management practices and disposal practices. However, the actual situation was discussed in detail with officials of the waste management department of the City of Johannesburg (COJ).

The interview was outlined while detailed answers were recorded with the purpose of obtaining knowledge on current waste-management practices of street dumps. Section (a) of Appendix B focused on the personal information of the respondent with regard to qualification, age, sex and rank in the waste management department. Section B describes an inventory of equipment in detail on how many skip bins, refuse trucks, and skip trucks and tractors. Section C focused on the municipal capacity to deal with open waste dumps. Section D measured the extent of awareness of respondents with regard to waste management policy and legislation. This was followed by questions on the waste management plan. Section E dealt with waste management practices in the study area. A detailed discussion was done about the state of hazardous waste and its management. A Section F contained an attitude assessment of the interviewed respondents. Finally, additional information was discussed and captured in detailed.

The interview addressed a wide collection of municipal waste management practices and could briefly be described as follows: (i) any defined procedure for sorting, managing and handling waste; (ii) middle stage of waste between segregation and final disposal; (iii) what type of containers and bags are used in this process; (iv) where is the segregated waste stored while awaiting final disposal; (v) does waste department have their own waste management strategies: do they have their own legislations, and waste management acts; (vi) who handles segregated waste; and (vii) which facilities are available to collect and dispose waste.

3.10 Ethical Considerations

North West University subscribes to a set of ethical principles to guide the conduct of research that has human, environmental and animal implications. To abide by ethics, and for reasons of confidentiality, no names are mentioned anywhere in this dissertation. Nobody was harmed by any means of communication while doing field surveys.

The principle of autonomy (CIOMS, 2002) requires that participants should be treated with respect and be allowed the opportunity to make decisions with regard to their participation in the research project. To this end, there must be special protection for those with diminished or impaired autonomy. The principles of confidentiality require that a participant's right to both privacy and confidentiality be protected. The researcher must ensure that where personal information about research participants or a community is collected, stored, used, or destroyed, this is done in ways that respect the privacy or confidentiality of participants. The principle of justice (HHS, 1979) imposes an ethical obligation to treat each person in accordance with what is right or proper. In research, this is primarily distributive justice whereby there should be equitable distribution of both burdens and benefits of research participation. It is an ethical imperative that the study leaves the participants and/or community better off or not worse off. The selection, recruitment, exclusion and inclusion of research participants must be just and fair, based on sound scientific and ethical principles. The fourth principle did not arise in this research. The safety, rights and dignity of participants were of primary concern and all information gained from them was strictly confidential. Responses to interview were strictly for research purposes. A proposal was presented to the North-West University F.A.S.T Ethics Committee and a formal Ethics Form was duly completed. The accompanying permission documentation is attached and clearance was given.

Ethical issues are indispensable to any form of data collection that deals with animal and or human subjects. Therefore, participants were treated fairly and with dignity. The researcher was always respectful, polite and reliable. This principle helped to build a rapport between the interviewer and respondents.

Usually prior training of field assistants represents an important feature of quality control (Patwary *et al.*, 2012). Researchers have to adhere to the use of standardised protocols that ensure compatibility among different groups. A careful and well organised set of procedures was put in place before the actual collection of data in the field. The researcher signed a

statement indicating that the names and personal particulars of participants would not be divulged to third parties. Furthermore, code names were used in all field notes. At all sites, data collection was very confidential. Possible precautions were taken to minimise risk during surveys. During the interview, a letter of reference from the North-West University was given to the chief operating officer (COO) of the waste department (Appendix B). The reference letter and the researcher's student card were used as a proof of identity.

3.11 Summary

The chapter has illuminated the design of the research, which concentrates on field surveys and measurements followed by the administration of informal interviews plus secondary data from official sources at both provincial and national levels. The research methodology has been explained in detail while creating the atmosphere of experimental research design. The choices of instruments were designed for fieldwork before collecting the primary data. A sampling procedure took place on a street map of Fordsburg before fieldwork. Observation was chosen for fieldwork to characterise open waste dumps in terms of measurement and classification. This chapter explained how instruments were chosen and for what purposes. The chapter also explained how data was collection, sources of data and the pilot study, sampling techniques and data analysis as well as how data were collected, prepared and analysed for specific research objectives and ethical issues were clarified.

CHAPTER 4: RESULTS AND ANALYSIS

4.1 Introduction

The presentation of the results is arranged at two levels. The first level addresses information collected in field surveys and the second level addresses the response from the officials of the waste department. The initial primary data sets on locational attributes and on waste dump characteristics were processed using Excel™ and thereafter subjected first to Pearson's multiple correlation before the use of linear regression.

4.2 Locational Attributes and Analysis

4.2.1 Organisation

In this research, different variables were used to achieve the objectives, namely measuring the locational attributes and analysing the internal linkages. Street names were observed carefully and entered in the first column of the data sheet for each of the 50 waste dumps. Next, the physical address was indicated per street in the second column. The location of each waste dump was measured with a hand-held GPS meter recorded in third column degrees, minutes and seconds.

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4.2.2 Distance from nearest road

The distance of the nearest road from each coded waste dump was measured in kilometres and was indicated with an X (for example, X1). The maximum distance of the nearest road was 8 m from waste dump code 18, namely Lillian Road and the minimum distance was 1 m from the majority of the waste dumps. The majority of waste dumps were not far from road. Results appear in Figure 3.

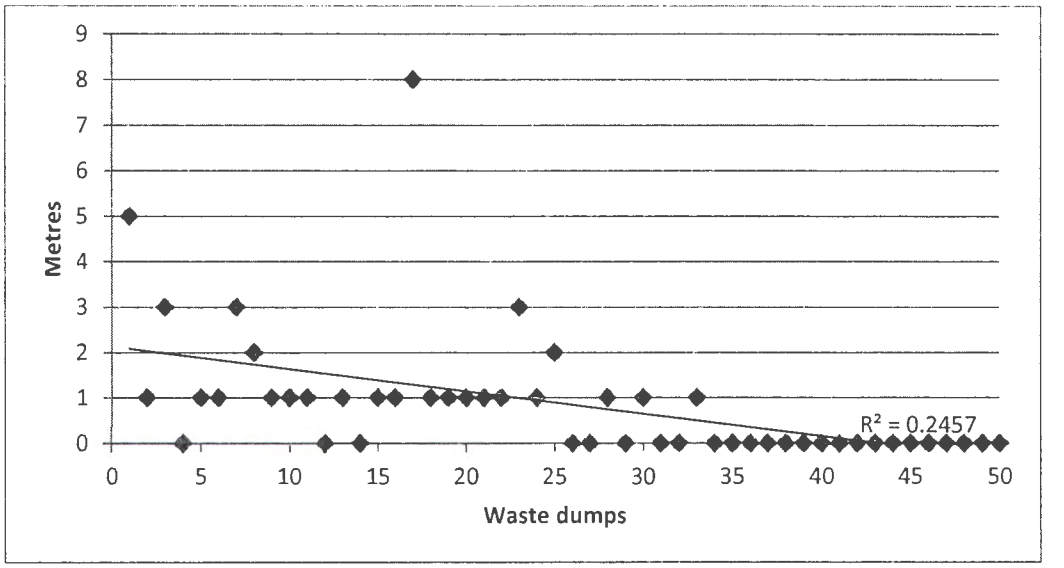

Figure 3: Distance from nearest road

4.2.3 Distance from nearest building

This is a straight-line distance measured from the waste dump to the nearest building (X2). The frequency distribution data showed that the maximum distance was 34 m from a waste dump while the minimum was 1 metre. The results are presented in Figure 4. The R-square value of 0.0245 translates to 2.45% of the variation in y being explained by x_1.

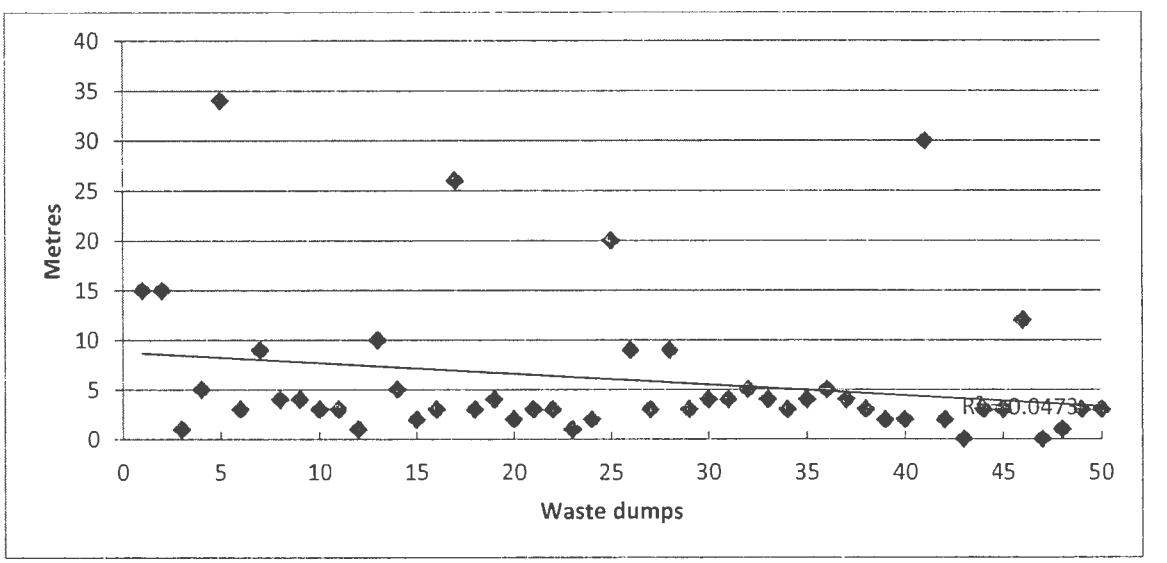

Figure 4: Distance from nearest building

4.2.4 Distance from nearest business outlet

Open waste dumps were then observed in relation to another locational attribute: closeness to a business outlet. The results show a distance ranges of 1 to 75 m. Measurements are presented in Figure 5. The R-square value of 0.019 translates to 1.9% of the variation in y being explained by a change in $x_2$which is insignificant.

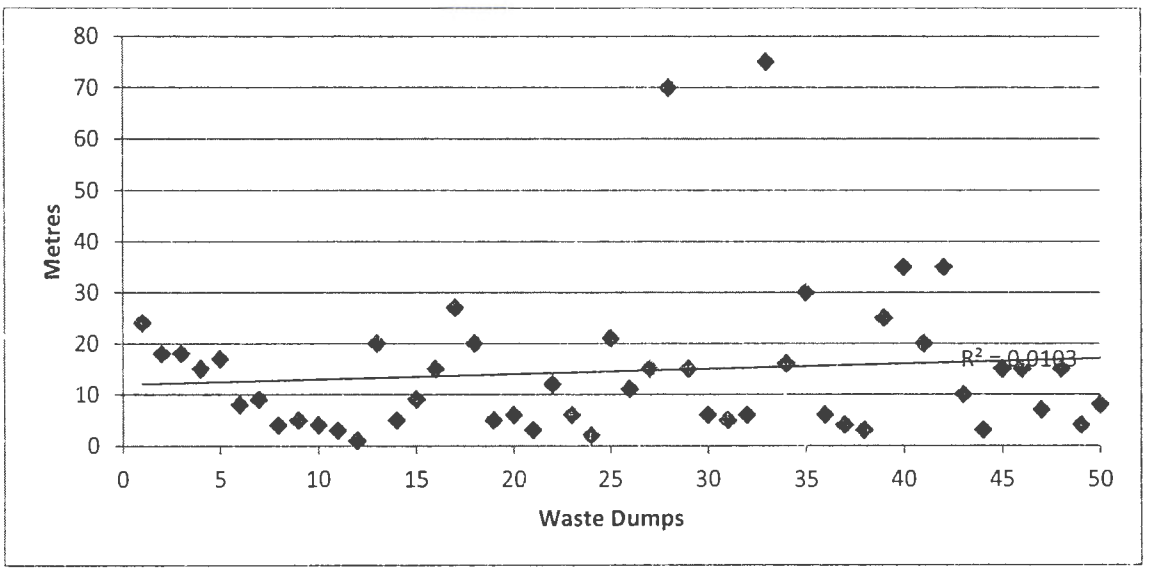

Figure 5: Distance from nearest business outlet

4.2.5 Distance from other open dumps

To establish the proximity of waste dumps in the study area, the distances between waste dumps within the sampled waste dumps were measured. A range of 2 to 36 m was obtained. The results appear in Figure 6 and show an R^2=0.003 value, translating into 0.3% of the variation in the *y*.

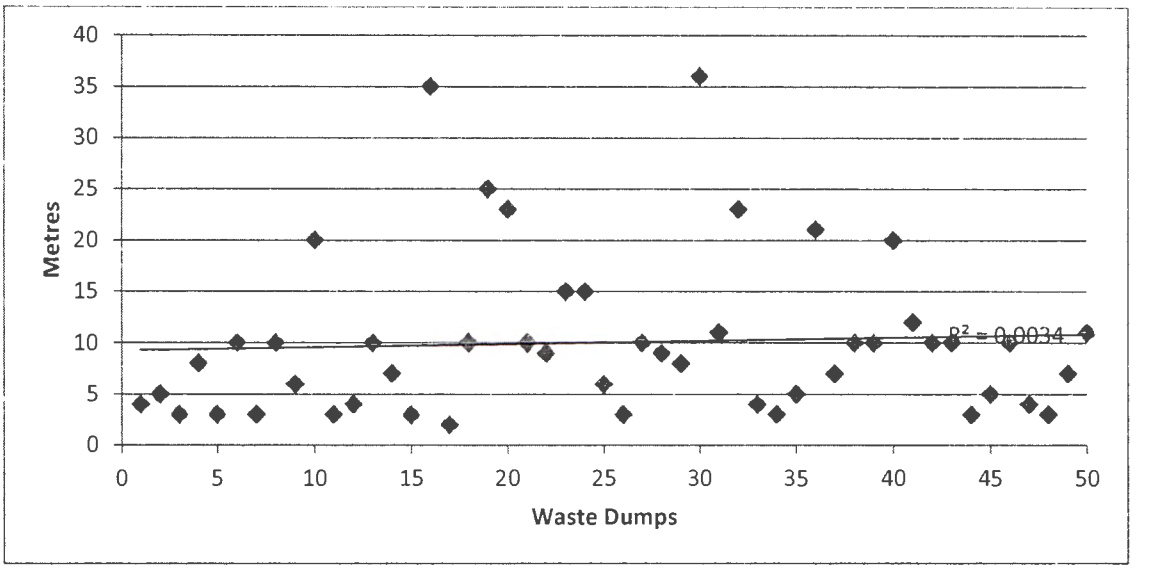

Figure 6: Distance from nearest open dump

4.2.6 Distance from nearest official bin

The distance from open waste dumps to formal waste bins was measured for each waste dump (X_5).The results are presented in Figure 7. The high concentration of so many scores close to or on the 0-metre line suggests that even where a bin is provided on site by the municipality, waste is not deposited in such bins. The coefficient of determination R^2 score of 0.094 was obtained translating to 9.4% variation in y explained by the role of X_5.

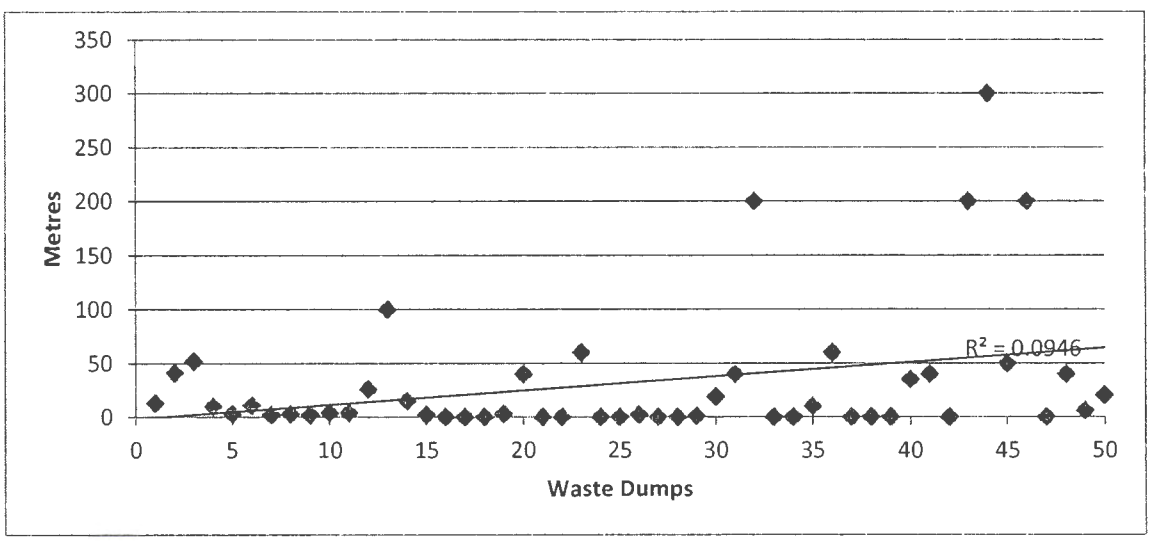

Figure 7: Distance from nearest official bin

4.2.7 Distance from food outlet

Food outlets in the form of takeaways, restaurants and hotels often dump food waste in close proximity to their premises. The scores showed a range of 3 to 300 m. The distribution of scores is captured in Figure 10. The R-square value of 0.076 translates to a 7.6% of the variation in y being dependent on x_6.

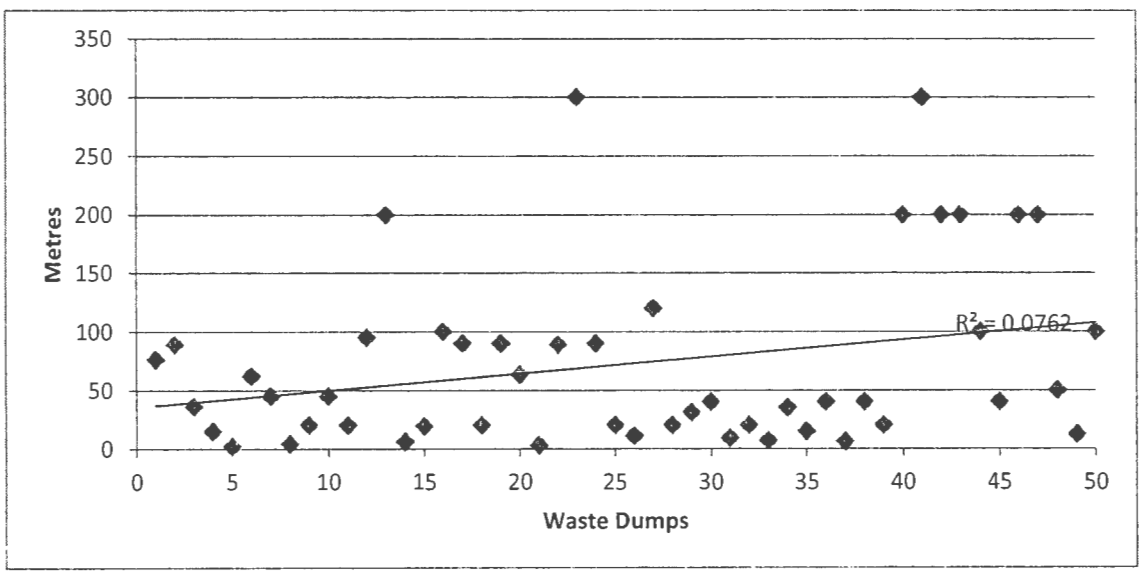

Figure 8: Distance from nearest food retail outlet

4.2.8 Distance from nearest public building

The distance from the nearest building (X_7) was measured for each waste dump. The results appear in Figure 9. Only eight dumps fall beyond the 10 m radius of each dump in the study area. This is equivalent to only 16% of the sampled waste dumps, with the remaining 84% falling within this radius. This result shows that, given the nature of the residential area with its high density of streets and private residences, the few spaces available for illegal dumps will still be located close to a public structure. The choice of waste dumps close to residential and public buildings could indicate that those responsible for illegal dumping are not apprehensive about dumping next to people's homes.

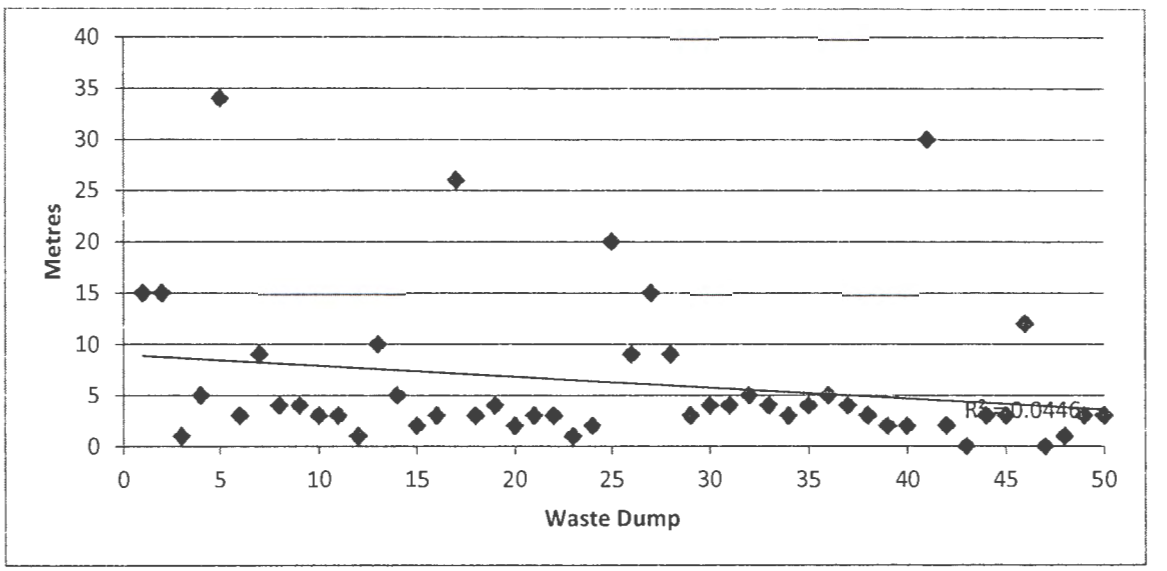

Figure 9: Distance from nearest public building

The coefficient of determination R-square value of 0.044 translates to a 4.4% variation being explained by the effect of x_7 on change in y.

Table 3: Summary of mean distance scores

Variables	Mean distance in metres
X1 Distance from nearest road	0.88
X2 Distance from nearest building	6.04
X3 Distance from nearest business	14.6
X4 Distance from nearest open dump	10.08
X5 Distance from nearest official bin	50
X6 Distance from food retail outlet	72.3
X7 Distance from nearest public building	7.42

From Table 3, mean scores indicate that *distance to the nearest road (X_1)* is the lowest value implying that most waste dumps are indeed close to roads. This suggests that people who actually do the dumping at these sites come with vehicles, on foot and or use wheelbarrows. The highest mean value reported for *distance from the nearest food outlet (X_6)* is 72.3 m. The mean value for formal bins at 50 m appears to show that all waste dumps in the study area are at some significant distance from the nearest formal waste bin. This result has implications when considering possible interventions to counter illegal waste dumping.

4.3 Multiple correlation and regression

Using SPSS™ programme, data was input from Excel spread-sheet in order to run multiple correlations using Pearson's product moment technique. Table 4 shows the initial descriptive statistics for mean and standard deviation. It was noted that X1(*distance to the nearest road*) scored the lowest mean at 0.84 while X6 (*distance from WD to the nearest other waste dump*) registered the highest at 67.65. These scores are significant because they describe critical distance attributes in the study.

Table 4: Descriptive statistics for correlation analysis

Descriptive Statistics

	Mean	Std. Deviation	N
X1	.84	1.434	49
X2	6.14	7.374	49
X3	14.80	14.818	49
X4	9.98	7.918	49
X5	31.71	63.095	49
X6	67.65	69.735	49
X7	6.14	7.374	49
Y	11.61	16.078	49

In Table 5, the results of correlation analysis are presented at two levels of significance; 0.01 and 0.05. It is noted that the highest positive correlation values are for these variables: X1 and X2, X2 and X7 both at 0.434 at 0.01 significant level while X5 and X6, X5 and Y are important at 0.05.

Table 5: Pearson's correlation

Correlations

		X1	X2	X3	X4	X5	X6	X7	Y
X1	Pearson Correlation	1	.434**	.155	-.160	-.193	-.084	.434**	-.122
	Sig. (2-tailed)		.002	.287	.272	.184	.566	.002	.403
X2	Pearson Correlation	.434**	1	.201	-.191	-.036	.162	1.000**	.022
	Sig. (2-tailed)	.002		.167	.189	.806	.267	.000	.878
X3	Pearson Correlation	.155	.201	1	-.154	-.147	.064	.201	.006
	Sig. (2-tailed)	.287	.167		.290	.313	.662	.167	.969
X4	Pearson Correlation	-.160	-.191	-.154	1	.051	.140	-.191	-.088
	Sig. (2-tailed)	.272	.189	.290		.730	.336	.189	.546
X5	Pearson Correlation	-.193	-.036	-.147	.051	1	.335*	-.036	.293*
	Sig. (2-tailed)	.184	.806	.313	.730		.019	.806	.041
X6	Pearson Correlation	-.084	.162	.064	.140	.335*	1	.162	.191
	Sig. (2-tailed)	.566	.267	.662	.336	.019		.267	.189
X7	Pearson Correlation	.434**	1.000**	.201	-.191	-.036	.162	1	.022
	Sig. (2-tailed)	.002	.000	.167	.189	.806	.267		.878
Y	Pearson Correlation	-.122	.022	.006	-.088	.293*	.191	.022	1

Sig. (2-tailed)	.403	.878	.969	.546	.041	.189	.878	

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

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

c. Listwise N=49

From Table 6, it was noted that a significant number of coefficients are negative indicating dispersion away from the mean.

For regression analysis, Table 6 shows the basic descriptive statistics in terms of mean and standard deviation. The mean size of the waste dumps in the study area stand at 11.61 square metres. This shows that on average, the sizes of the waste dumps in the study area are relatively small.

Table 6: Descriptive statistics for regression analysis

Descriptive Statistics

	Mean	Std. Deviation	N
Y	11.61	16.078	49
X1	.84	1.434	49
X2	6.14	7.374	49
X3	14.80	14.818	49
X4	9.98	7.918	49
X5	31.71	63.095	49
X6	67.65	69.735	49
X7	6.14	7.374	49

In Table 7 only X1 (distance from WD to nearest road) is removed leaving the rest of the 6 predictor variables.

Table 7: Multiple regression results

Correlations

	Y	X1	X2	X3	X4	X5	X6	X7
Pearson Correlation	1.000	-.122	.022	.006	-.088	.293	.191	.022
	-.122	1.000	.434	.155	-.160	-.193	-.084	.434
	.022	.434	1.000	.201	-.191	-.036	.162	1.000
	.006	.155	.201	1.000	-.154	-.147	.064	.201
	-.088	-.160	-.191	-.154	1.000	.051	.140	-.191
	.293	-.193	-.036	-.147	.051	1.000	.335	-.036
	.191	-.084	.162	.064	.140	.335	1.000	.162
	.022	.434	1.000	.201	-.191	-.036	.162	1.000
Sig. (1-tailed)	.	.202	.439	.485	.273	.021	.095	.439
	.202	.	.001	.143	.136	.092	.283	.001
	.439	.001	.	.083	.094	.403	.134	.000
	.485	.143	.083	.	.145	.156	.331	.083

	.273	.136	.094	.145	.	.365	.168	.094
	.021	.092	.403	.156	.365	.	.009	.403
	.095	.283	.134	.331	.168	.009	.	.134
	.439	.001	.000	.083	.094	.403	.134	.
N	49	49	49	49	49	49	49	49
	49	49	49	49	49	49	49	49
	49	49	49	49	49	49	49	49
	49	49	49	49	49	49	49	49
	49	49	49	49	49	49	49	49
	49	49	49	49	49	49	49	49
	49	49	49	49	49	49	49	49
	49	49	49	49	49	49	49	49

Table 8: Regression analysis

Variables Entered

Model	Variables Entered	Variables Removed	Method
1	X7, X5, X4, X3, X6, X1[b]	X2,.	Enter

a. Dependent Variable: Y

b. Tolerance = .000 limit reached.

The multiple correlations at 0.343 represent the relationship between the set of seven predictors X variables and the y-dependent variable. In Table 9, the R-square value of 0.118 translates to 11.8% of the variation in y being dependent on the predictor variables. The Adjusted R-square at -0.008 shows the effects of cancelling out for errors producing-0.8% score for variability.

Table 9: Model summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.343[a]	.118	-.008	16.145

a. Predictors: (Constant), X7, X5, X4, X3, X6, X1

b. Dependent Variable: Y

In Table 10, the values relevant to the least squares regression line coefficients are presented. The regression value of 1459.280 in the first row represents the cumulative effect of the x's on y while the residual at 10948.352 accounts for that portion of the impact that falls outside the role of predictor variables. The F-ratio at 0.933 indicates that the overall regression model is a good fit for the data. The results show that the predictor variables are statistically significant at .482

Table 10: Analysis of Variance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1459.280	6	243.213	.933	.482[b]
	Residual	10948.352	42	260.675		
	Total	12407.633	48			

a. Dependent Variable. Y

b. Predictors: (Constant), X7, X5, X4, X3, X6, X1

The constant in Table 11, column B is 10353 which is the (a) in the regression equation of the form y=a+x2+x3+x4+x5+x6 +x7. Translated, this becomes:

Y=10.535-(-1.135 Road) +(.028 Business) –(-.250 Retail) + (.063 Institution) + (.025 Dump) + (.063 Formal bin)

Table 11: Standardized Coefficients

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	10.535	5.489		1.919	.062		
	X1	-1.135	1.858	-.101	-.611	.545	.765	1.307
	X3	.028	.165	.026	.172	.864	.914	1.095
	X4	-.250	.308	-.123	-.812	.421	.914	1.094
	X5	.063	.040	.248	1.564	.125	.838	1.194
	X6	.025	.037	.110	.684	.497	.812	1.231
	X7	.063	.367	.029	.171	.865	.740	1.351

a. Dependent Variable: Y

Unstandardized coefficients are used to show how much the y varies with an X independent variable when all other X variables are held constant. Testing for the statistical significance of each of the predictor variables is possible. This tests whether the unstandardized and or standardized coefficients are equal to 0 (zero) in the population. If $p< .05$, the conclusion is that the coefficients are statistically not significant and, different to 0 (zero). The *t*-value and corresponding *p*-value are located in the **t** and **Sig** columns, respectively. From Table 12, under "t" and "Sig" none of the coefficients fall within the ($p< .05$) range. This indicates that the coefficients are individually not statistically significantly different to zero. Overall, these results on correlation and regression shows that:

(i)the predictor variables X1, X2, X3, X4, X5, X6 and X7 are statistically significant in relation to the Y- the size of waste dumps in square metres.

(ii) The regression model developed here provides a good fit for the data.

(iii) the low value of R-Square and Adjusted R-Square, and the coefficient of determination, indicates that other variables, not included in this study may explain better the variations in Y

(iv) this is confirmed by the ANOVA which indicates that the regression portion accountable by the 7 predictor variables is insignificant

4.4 Site Characteristics

4.4.1 Variables of interest

The variables of interest used in characterising the different waste sites appear in Table 12. The generation of descriptive statistics for each of the variables in Table 13 was carried out using the programme XLStat™.

Table 12: Variables and units of observation

	Code	Name of variable	Units
1	SZE	Size of site	square metres
2	LGT	* Total length	metres
3	WDT	* Total width	metres
4	DPT	* Estimate of depth	mms
5	LTT	* Extent of littering at site	% of tract
6	SAC	* Evidence of scavenging by people?	number of people on site
7	ANM	* Evidence of scavenging by animals?	count data

8	BRD	* Evidence of scavenger birds?	count data
9	DUR	* Estimate of waste duration before collection	Count data -days
10	DGR	* Extent of ground degradation	% of tract
11	WAC	*Evidence of stagnant water [% estimate of water cover]	square metres as a %
12	SOC	* Evidence of soil contamination [% estimate of visually contaminated soil surface]	square metres in %
13	EMS	* Detected any odours and or stench at site?	Yes/No

Table 13: Summary of descriptive statistics

	SZE	WDT	LGT	DPT	LTT	SAC	BRD	ANM	DGR	WAC	SOC	DUR
OB*	50	50	50	50	50	50	50	50	50	50	50	50
Min	1.00	1.00	1.00	1.00	1.00	.00	.00	.00	.00	.00	.00	2.00
Max	90	9	10	88	20	4	30	4	30	70	30	3
Ran	89	8	9	87	19	4	30	4	30	70	30	1
Mea	11.4	2.5	3.5	36.28	5.8	1.98	3.52	2.02	7.144	11.82	13.44	2.26
StaD	15.983	1.529	2.112	16.992	3.446	1.204	4.011	.979	7.904	11.355	7.796	.443

Where OB= observations, StaD= standard deviation, Ra= range, Mea= mean, min=minimum, max=maximum

4.4.2 Size of waste dump site (SZE)

The size of the waste site was established through measurement using a rectangle as a base shape for configuration. The length and width were recorded in metres and fractions thereof. From the results, the range came to 89 square metres with a mean value of 11.4 square metres. The significance of the value for the mean is that most of the waste sites are small in physical size which points to the volume of waste at a site at the time of observation (Figure 13). The measured value for range indicates the significant diversity in the size of waste sites in the study area. The standard deviation values indicate the spread of the data points relative to the mean. In this case, the standard deviation value is relatively small showing the clustering of points close to the mean as confirmed in Figure 10.

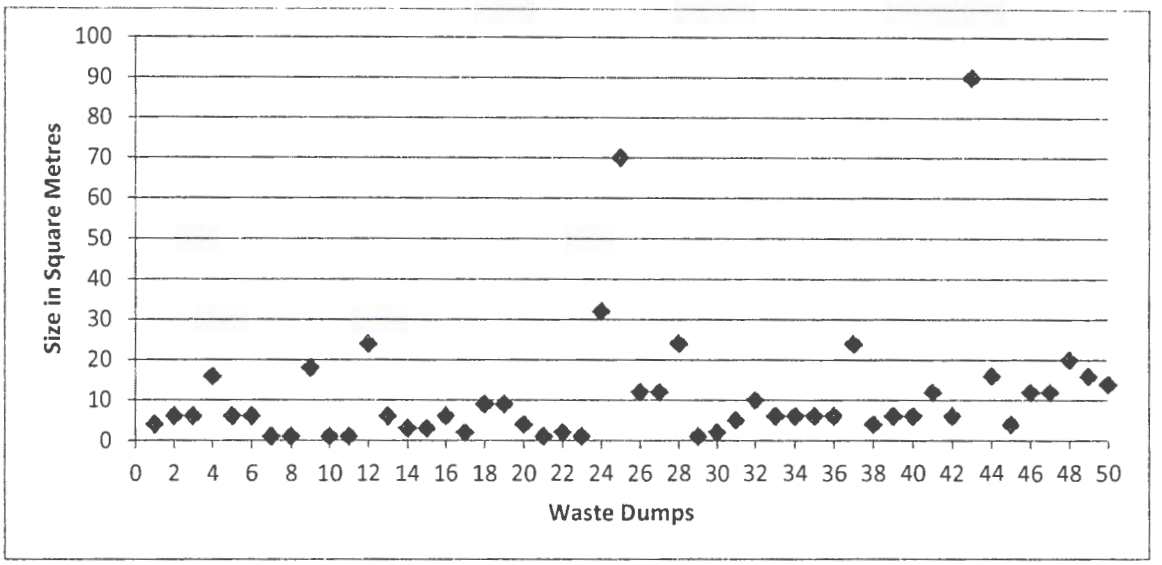

Figure 10: Scatter plot for size of waste dumps

It should be noted from the scatter plot that only two values are in the region of 40^{+} square metres, indicating that in general most of the dumps are small. This result is confirmed by Figure 11 in which the highest frequency of 33 is for those dumps of sizes 0 to10 m^2.

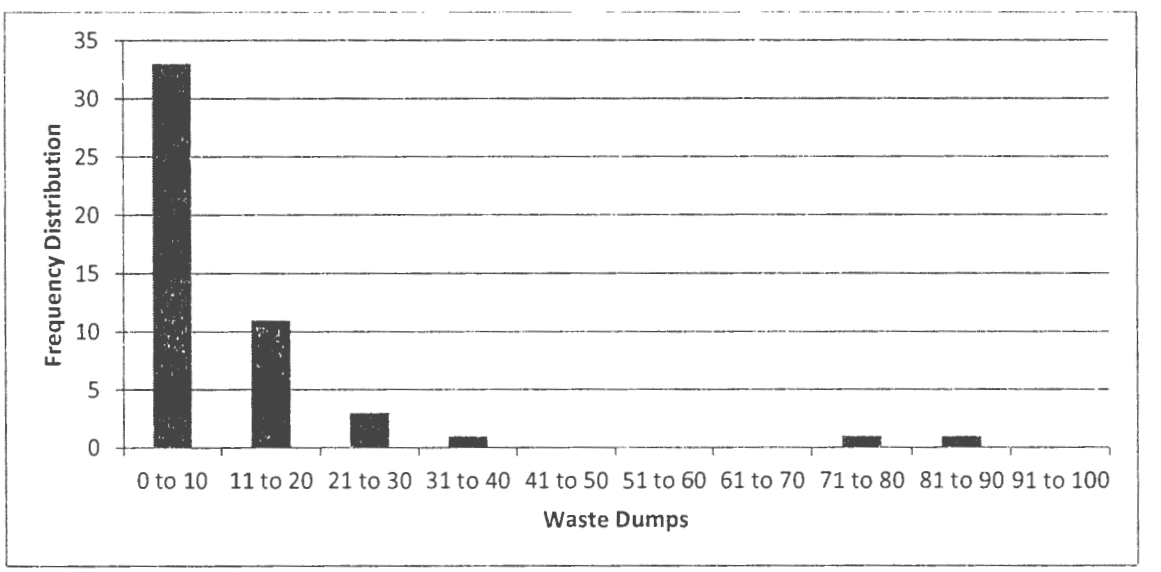

Figure 11: Frequency distribution for size of dumps

4.4.3 Extent of littering (LTT)

The extent of littering at the site was established through estimation and the resulting values expressed in percentages. The length and width were recorded in metres and fractions thereof. From the results, the range came to 19, the mean was 5.8 while the standard deviation was 3.446. The significance of the value for the mean is that most of the waste sites are small in physical size which points to the volume of waste at a site at the time of observation. The range indicates the difference between the lowest and highest scores. The standard deviation value indicates the departures of individual points from the mean of the data. In this case, the SD value is relatively small showing the clustering of points close to the mean.

4.4.4 Scavengers on site (SCA)

The number of people who were observed scavenging through the waste at the site was recorded as count data. From the results, the range came to 4, the mean was 1.98 while standard deviation scored was 1.204. The significance of the value for the mean is that this translates to 2 people per site. The overall low numbers of scavengers may be related to the small size of the waste dumps and the high frequency at which such waste is collected. This would appear to leave limited waste volumes that can only attract few people. The SD value is relatively small showing the clustering of points close to the mean implying that the differences between individual values in the data distribution are limited.

4.4.5 Scavenger birds on site (BRD)

The number of scavenger birds at the site was established through observation and recorded as count data. From the results, the range came to 30, the mean was 3.52, while the standard deviation scored was 4.011. The significance of the value for the mean is that at most of the waste sites, there were between three and four scavenger birds. But the maximum value of 30 indicates that at the larger sites, scavenger birds were a dominant element. The SD value is relatively small showing the clustering of points close to the mean.

4.4.6 Animals on site (ANM)

The presence of domestic animals like cows, goats, dogs, sheep, cats and donkeys was established following observation and enumeration at site. Of these animals, only stray cats and dogs were seen; no other animals were observed at the sites. This may be partly because larger animals associated with township households are not allowed in the inner city. From the results, the range came to 4, the mean was 2.02, while standard deviation score was 0.979.

The significance of the value for the mean is that most of the waste sites either had no animals at all or very few given that the value for maximum came to only 4. The SD value is relatively small at less than 1.00 showing the clustering of points below this level.

4.4.7 Estimate of waste duration in days before collection (DUR)

The number of days a given quantity of waste has stayed at a site before collection was estimated during observation. From the results, the range came to 1, the mean was 2.26, and the standard deviation came to 0.443. The significance of the value for the range at 1 is that the values in the distribution are spread across a narrow band. The maximum value at 3 days and minimum value at 2 days accounts for the mean falling in between these values. The value for the mean is low and the value for standard deviation at 0.443 is very small. This would appear to indicate an absence of significant differences in the period waste remains at a site. Overall, waste is cleared within two to three days at each site.

4.4.8 Estimate of surface water cover (WAC)

The size of the waste patch covered in stagnant water was established by estimation during observation. From the results, the range came to 70%, the mean was 11.82 while the standard deviation came to 11.355. The significance of the value for the range shows that some of the sites were water-logged but the mean value appears to indicate that water has no significant presence at most sites. The standard deviation value is close to the mean value indicating a clustering characteristic earlier reported for other variables.

4.4.9 Estimate of % soil contamination (SOC)

The extent of soil contamination was established through observation of the topsoil immediately below the waste. Visual observation indicated advanced levels of decomposition of vegetable matter mixed with other non-vegetable waste products. This was taken as evidence of contamination and expressed as a % of total surface area of the site. From the results, the range came to 30%, the mean was 13.44, while standard deviation came to 7.796. The low scores indicates that waste does not remain uncollected long enough for decomposition to occur. This once again confirms an earlier finding that waste is collected at least within 2-3 days of being dumped at a site.

4.4. 10 Gas emissions at site (EMS)

Odours were detected at only 4 sites suggesting significant gas emissions arising out of decomposing waste. The low level of EMS may indicate the fast rate at which waste is collected at these sites before the process of decomposition becomes effective. It may also indicate the limitations of detecting smell given that no digital metres for air quality measurements were deployed.

4.5 Extent of Signage

Observations at sites showed that out of 50 sites, signage appeared at only 17 sites translating to 34% of the sampled waste dumps. It was, however noticed that at some of the sites, the signage existed sometime in the past but has since been vandalised and looted leaving behind simply a metal frame. The positioning of illegally dumped waste next to clearly marked bill boards with warning signs against dumping shows that these warning signs are ignored by members of the public.

4.6 Waste Classification

Waste composition was visually estimated in terms of relative contribution in percentage to total waste at a dump (z) from each sample waste dump. Unlike the pilot study that measured waste by volume, in this study, an estimate of surface area covered as actual waste sorting for the 50 sites was used. This was then expressed as a percentage value for each type of waste. Waste was classified in the categories glass, paper, metal, demolition & construction, e-waste, garden waste, food waste, industrial, wood, rubber and plastics. Excel was then used to generate simple descriptive statistics covering frequency distribution, mean, sum and standard deviation. An applicable bar diagram, Figure 14, is used to show this distribution.

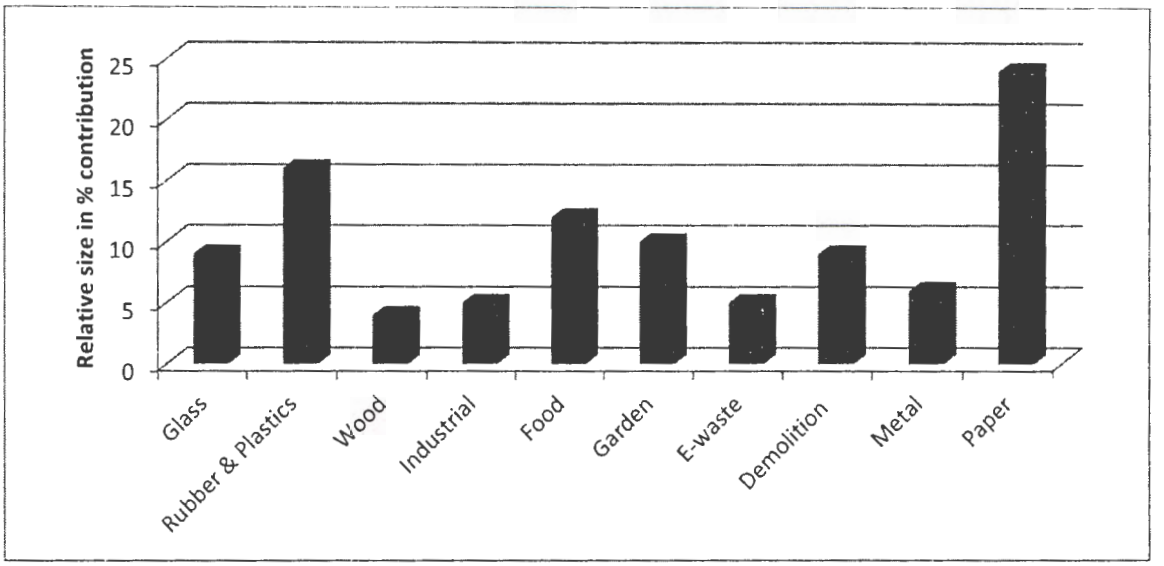

Figure 12: Waste profile in the study area

From figure 12, it is noted that paper, rubber and plastics constitute the most dominant waste streams.

4.7 Variations in the Profile of Waste

The aim here was to establish, based on waste types, the differences in the composition of waste between the 50 sites in the sample. Data for analysis were carried forward from Objective 3. Descriptive statistics using Excel was applied to generate relative composition percentages for the various waste classes. A consolidated distribution table in percentages was generated for comparison. The results appear in Figure 14. From the figure, it will be noted that paper, rubber and plastics, and food are the four leading classes of waste. Given that the study area is a residential district in an urban setting, this is to be expected. The high score for food waste would point to relatively above-average incomes of households in the source regions. But given that the dominant role of paper and plastics in ranking is based on surface area computations, actual volume data values could be different as reported in DACE (2008) and in DEAT (2012).

4.8 Current Waste Management Practices

4.8.1 Policy

A senior manager responsible for waste management was interviewed to represent the position of COJ. Responses from the COJ on the implementation of waste legislation from the national and provincial tiers of government showed that the city was aware of its mandate. The city had already developed an integrated waste management plan (IWMP) in line with guidelines from DEAT (2000), the waste management act (RSA, 2008) and the National Waste Management Strategy. It was reported that additional sets of legislation specific to waste issues were incorporated in the plan. While the COJ remained responsible for the overall management of waste in the city, it had outsourced the day-to-day tasks of waste collection, transport and disposal to a private contractor in order to achieve greater technical and financial efficiency. The Fordsburg area is within this arrangement and the actual collection and disposal of waste in the study area is handled by this contractor. The findings here are contrary to Mudau (2015) who found that most local municipalities in Limpopo did not have the requisite legislation in place.

4.8.2 Capacity

According to information provided by the operations manager of the contractor, waste at illegal dumps is collected twice a week. It was admitted that the frequency of collection could be increased, given the fast rate at which waste is piled up at these sites. However, increasing collection rates to daily or twice a week would entail additional cost and overheads that the contractor would not be able to shoulder.

4.8.3 Infrastructure

With reference to the basic infrastructure for waste collection, the operations manager at Pickitup revealed that they used skip bins for temporary collection of waste at different street sites as well as refuse trucks, skip trucks and tractors. The responses did not indicate that they had problems with waste collection due to a shortage of vehicles. But it was admitted that preference during collection was for formal waste sites.

Field observations on the streets of Fordsburg showed that cement bins are fixed and have plastic bags but they are not sufficient to contain all the waste generated in this area. Waste spill-over at these bins was noted. In some areas, these waste bins were broken and people throw waste in the street or dump it next to the roads. In some streets, these waste bins were 200 metres away from the open waste dump, evidencing that a lack of temporary storage facilities was another reason for open dumping. People dump their household and industrial

waste at communal sites on a daily basis. However, there were delays in collection, sometimes of up to two weeks. Metal bins are big and strong to use for temporary waste storage in streets. The bins are user friendly and last a long time. Once again, observations indicated littering around such bins probably because people may not be able to throw the waste inside the skip bins.

4.8.4 Operations

With reference to operations, the COJ reported that waste was not sorted at collection points, but instead it was forwarded as general waste either to transfer/treatment stations or directly to landfill sites. It was reported that for medical waste, the main hospitals run their own on-site incineration. It was also reported that smaller medical facilities, including clinics had contractual arrangements with specialised waste collection companies, which handled the collection and conveyance of such waste to regional centres for treatment and safe disposal. The COJ admitted that as a modern city, they were aware that an inadequate infrastructure for waste collection, handling, transportation and disposal constrained their operations.

The operations manager of Pickitup indicated that some waste segregation did in fact take place at some designated waste sites. The use of coloured bags: transparent bags for paper and segregated waste; red bags for medical waste; black bags for garden waste and blue bags for street litter did not appear to be effective in curbing illegal waste dumping. It was reported that illegal waste dumps were far more expensive to service compared to formal dumps. It was reported that these illegal dumps were often not at one place; they moved from one place to another. In addition, even when households receive plastic bags with a volume capacity of at least two weeks, littering remain a serious problem. This would appear to point to imbedded problems in the way waste generators respond to available waste service.

The waste management directorate is responsible for a hygienic and clean environment for households, institutions, industries and business in the City of Johannesburg. Pickitup collects and disposes 1.4 million tons of domestic waste, which is generated by 3.2 million citizens per annum. The company has its own waste management strategies in meeting its mandate and its approach may not necessarily be aligned to what COJ would normally do.

4.8.5 Waste data

The COJ keeps detailed statistics on components of the waste chain for the geographical area under its jurisdiction. Part of this data is regularly provided by a private company contracted

to handle urban waste. From the interview, the COJ indicated that with reference to illegal waste dumps, existing data on waste volume were essentially estimates. The COJ reported that they maintained an up-to-date register on waste volumes delivered to landfill sites for disposal, but conceded that there were problems with generating a reliable statistics on waste generation. This position concurs with DACE (2008) and DEA (2012) on the status of waste data in South Africa.

4.8.6 Monitoring and evaluation

The COJ reported that a waste management audit is carried out at three-year intervals. However, it was admitted that such an audit was not adequate in tracking changes in waste generation and collection. It was also acknowledged that waste generation volumes were rising faster than originally planned. This tended to put pressure on financial resource allocation for waste management. Ideally, auditing could be done every year to alert the COJ early enough about bottlenecks in the waste chain and to trigger prompt corrective responses.

The municipality has authorisation to provide arrangements for landfills and equipment for waste management. The residents of Fordsburg, on the other hand, are required to ensure that waste is deposited at proper places. Whenever they witness illegal dumping, they are required to report this through a toll-free number to COJ for appropriate action. The fact that Pickitup is sub-contracted to handle waste collection and disposal means that COJ cannot directly exercise its mandate of monitoring and evaluation. This has to be indirect through the management structures of Pickitup.

4.8.7 Skills training

The COJ reported that significant financial resources are made available every year for short training courses for lower, middle and senior managers in the waste management directorate. Such training, it was reported, was meant to update personnel on relevant skills as a way of improving their performance. Responses from Pickitup, on the other hand, implied that they found the cost of training employees rather a burden on their finances. This result highlights an earlier finding in Mahasa and Ruhiiga (2014) on medical waste handling practices in the Free State where a similar sentiment was expressed with regard to the cost of training.

4.9 Summary

Chapter 4 has presented the results and analysis thereof. Results were reported with reference to the objectives of the study. The results show that the size of the waste dumps cannot be explained adequately by locational attributes. These attributes consistently record low and/or insignificant coefficients. The impact of the x's in explaining the variation in y – change in the size of a waste dump – is tested by using R^2, ANOVA and multiple linear regression. Overall, it has been established from the results that there are other drivers outside this study that could provide better explanations for the size and presence of illegal waste dumps. The results from interviews with the COJ and Pickitup have been summarised and key features highlighted. It has been shown that servicing illegal dumps in the Fordsburg area remains both expensive and problematic. The implications of these results are discussed in the next chapter.

CHAPTER 5: DISCUSSION

5.1 Introduction

In this chapter, a discussion of key findings is made to establish a link with the overall research problem.

5.2 Site Characteristics

Results on site characteristics consistently showed low scores for mean, range and standard deviation. These results indicate the limited variation in the data distribution for each of the observed variables. The extent of variability across the different waste dumps in the study area is therefore limited.

5.3 EXTENT OF SIGNAGE

The results indicated the existence of warning signage against illegal waste dumping. But the existence of freshly dumped waste next to these warning signs seems to indicate a lack of community awareness about the need for a clean environment.

5.4 Classification of Waste

Waste classification was done by direct observation at individual waste dumps across the study area in terms of waste type. This made it possible for the researcher to determine waste classes against locational attributes. It is necessary to classify waste to determine recyclable, biodegradable and hazardous waste, so that waste can be handled according to its type. The classification of waste was done at 50 dumpsites to generate primary data sheets. The types of waste determine how to transport and dispose of waste, and which risks and precautions are involved in this procedure. Rubbish waste, paper, food waste, wood, e-waste, demolition waste, metal, glass, plastic and rubber were the main categories found at different waste dumps. The main waste class was paper (24%), which was the main by-product of manufacturing factories. These waste dumps result from households, educational institutions and business entities. Food waste (12%) at open waste dumps also results from nearby restaurants and food retail outlets.

Demolition waste was also found at some waste dumps, but this waste is spread infrequently throughout Fordsburg. Some open waste dumps comprised bulk waste made up of discarded

vehicles, broken household effects, wood and electrical devices. Littering was widespread along most streets. It comprised of dirt, leaves and animal waste. These wastes come from streets, parks, nearby hotels, sidewalks and vacant heaps.

Paper mostly comes from restaurants, households and goods packaging, comprising 24% of the total. Plastic comprised of 16% and food 12%; because this area is dominated by food retail outlets. Fordsburg is a middle class district that generates significant food waste However, it is a bitter truth that in spite of moderate standards of living there is a lack of knowledge on how to keep the city neat and clean. They throw waste along the sides of the road, with no concern for residents' health and the city's beauty.

These results are important in respect of Objective 1, which covers classification. Paper, plastics and food waste are the dominant types in the study area. The results do not allow for the identification of the supply areas of these waste classes relative to the current position of illegal waste dumps. The presence of a particular type of waste at an illegal site does not necessarily point to the proximity of potential culprits of illegal dumping. This is confirmed by the results in Chapter 4, where it was established that the characteristics of illegal waste dumps seemed to indicate that some of the people responsible for dumping might not even be residents of Fordsburg. The probability that people dump waste at sites that are convenient to them is high in theory. But the high levels of private car ownership at household level increases the supply sources of such waste. Moreover, the private contractor confirmed that certain high-income residential districts were meticulously clean. It was not clear whether this was not at the expense of low-income and poor neighbourhoods. Under these conditions, ideas about zero waste (Matete & Trois, 2008) may take long before becoming a reality on the ground.

5.5 Waste Profile in Fordsburg

The waste profile in Table 13 represents the properties across the physical, biological and chemical makeup (UNEP, 2010b). It is concerned with mainly what exists in open waste dumps. A waste profile helps to determine which process is applicable in that area in terms of disposal, recycling, transport or minimisation of waste. Waste profiles are primary data in this research. In a waste profile, the main classifications are glass, food, demolition waste, wood, paper, metal, e-waste, garden waste and others.

Table 14: Waste profile

Class	Profile Characteristics
Food	Food waste totalled 52% at road waste dumpsite number 21 and 12% of the total waste profile. Minimum percentage of waste was food waste amounting to 2% from some sites, and some dumps had no food waste. High-income residents buy food and throw away leftovers. It was proved by their packaging boxes and wrapping papers. Rotten vegetables and fruit were found near places where there was a food retail outlet.
Paper	The mean for paper waste in Fordsburg was 24%, with the maximum at 70 % from Mint Road waste dumpsite number 27, and the minimum (2%) from waste dump number 21- Terrace Road. Nine waste dumpsites contained more than 40% of the total waste paper.
Glass	The maximum percentage of glass (45%) was at waste dump site number 16 along Clare Road, while the minimum (2%) was at five waste dumps. At two waste dumps there was no glass.
Metal	The maximum percentage (20%) of metal came from three waste dumpsites, and the minimum (2%) from five waste dumps, while six waste dumpsites contained no metal.
C&D	There was no demolition waste from 23 waste dumps out of a total of 50 dumps.
Garden	The maximum garden waste (60%) was found at waste dumpsite number 5 on Barney Simon Road, minimum was 2% from three waste dumps. There was no garden waste from five waste dumps. The maximum wood (35%) came from waste dumpsite number 50 along Central Road and the minimum (2%) from four waste dumpsites.
Plastics & rubber	The maximum percentage of plastic and rubber (40%) came from three waste dumps sites, and the minimum (2%) came from waste dump 25 along High Street Road. One waste dump, number 24 along Main Reef Road, had zero plastic and rubber waste.

E-waste	Maximum e-waste was 20% from two waste dumpsites, minimum was 2% from six waste dumpsites. No e-waste came from 12 waste dumps
Industrial	This scored the second lowest value at less than 5% of all the waste dumps in the study area.
Bio-waste	Human and animal waste was dominant at most dumpsites during the surveys, but it is not mentioned in this research. At some waste dumps, it was very difficult to analyse waste because of bad odours. Other bio-waste originated from Food waste which mainly came from hotels and restaurants.

The total waste profile in Fordsburg comprised of: metal (6%), wood (4%), e-waste (5%), industrial waste (5%), plastic (16%), food (12%), demolition waste (9%), garden waste (10%) and glass (9%). Glass, metal, wood, e-waste, industrial waste and demolition waste accounts for low percentages of waste in this profile because they do not arise from daily activities. They are occasional and therefore account for very little in the total percentage of waste. Industrial waste plays a very small role in the residential areas. At some waste dumps, useless pieces of clothes were found, and old clothes were seen at one dumping site, but as it was not a direct part of the waste classification, this was ignored. The waste profile of Fordsburg was dominated with paper 24%, plastic 16%, and food waste 12%. These types of waste account for 52% of the total waste profile of Fordsburg. Metal (6%), wood (4%), e-waste (5%), industrial waste (5%), demolition waste (9%), garden waste (10%) and glass (9%) comprise 48% of the total waste profile in Fordsburg.

From these results, the most consistent characteristic of illegal waste dumps in the Fordsburg area is their variability. This variability is with reference to physical size in terms of volume estimates, surface area, the actual classes and density of waste at each site. The graphs in Chapter 4 on the results clearly indicate this. What is the importance of this variability with respect to Objective 3, as stated in Chapter 1 of this report?

If the study had included time series data corrected through repeat measurements at intervals across significant periods, then the *seasonality* and imbedded *instability* of these dumps would have been highlighted. In the absence of such data, which fell outside the original research design, the analysis presented in Chapter 4 gives the impression that the results are

generally stable. During observations, it was established that the actual number of waste dumps deviated from the results of ground enumeration as reported in Chapter 3. This would appear to point to three possible explanations. First, the prompt removal of such waste at some of the sites discourages would-be culprits from dumping fresh waste. Secondly, every fresh waste dump attracts additional dumping, such that a waste dump can appear at a site that did not have one before. Thirdly, some of the sites are essentially temporary and seasonal; meaning that at the time of the ground census, they could have been "skipped" as they did not exist.

Overall, the waste profile is what would be expected of a middle-to high -income area that is both residential and commercial. The high number of sites in the Fordsburg area points to the possibility that a significant percentage of this waste may be coming from other areas, both residential and commercial, other than from Fordsburg itself.

5.6 Locational Attributes and Internal Linkages

Several characteristics were measured: distance from nearest road, business entities, building, public building, informal dump, formal dump and food retail outlet. The size of waste dumps in terms of length and width of the waste dump was measured. This study showed most of the waste dumps were situated close to public buildings. It can thus be said that most residents were not likely to walk long distances and tended to dump waste at the corners of their buildings. The distribution of open waste dumps indicated a spread across various land-use types: residential, commercial, recreation and open spaces.

Waste dumps were mostly located far away from formal waste bins while few were located closer to formal waste bins. It shows that at some sites, there was an abundance of waste, compared to the number of formal waste bin. Waste management practices in the study area were briefly observed in terms of waste collection and segregation. Significant volumes of waste ended up in running water along the streets washed into the streams.

The sizes of 50 waste dumps were each demarcated and their dimensions recorded. This generated a measure of size which was then related to distance to the nearest road. The relationship between locations of waste dump is dependent on distance from nearest business or food retail outlet. There was no visible design for the distribution of waste dumpsites in locational attributes. Size of waste depends on accumulation of waste from its surroundings, its type and space for dumping.

The results on locational attributes of waste dumps in the Fordsburg area were presented in Chapter 4. Certain key features stand out:

- Correlation analysis of distance from particular features and the size of waste dumps generated were consistently low scores.
- The coefficient of determination as expressed by the R-square and Adjusted R-square also showed consistently low and insignificant scores.
- Results from ANOVA indicated the minimal explanatory powers of predictor variables for the y-dependent variable.
- The multiple regression output indicated a good fit for the data.

What is the significance of these results in relation to objective one that covered locational attributes of waste dumps? First, distance measures were used as explanatory variable, numbered as $x_1, x_2 \ldots\ldots x_7$, while the size of the waste dump was (y), the dependent variable. Analysis aimed at establishing whether distance attributes could explain the size variations in waste dumps. It has already been indicated that the outputs indicated a low and insignificant correlation, which was confirmed by the computation of R-square as a base for ANOVA. Overall, the results indicate that the size of illegal waste dumps in the area has little to do with the potential sources of waste generation. This shows that there are variables other than those linked to the location of the waste dumps relative to socio-economic nodes in the urban space that could provide better correlations. These other variables were not part of this study, but the findings are very significant for waste management.

The low scores for distance measures point to the diversity of generation sources, a finding that does not feature much in local literature about waste generation and characterisation. Recall that earlier it has been mentioned that those responsible for illegal dumping have a diversity of movement options, which minimises the constraint distance would otherwise impose on the decision to dump waste. If this is so, it has been established that some of the waste dumped in the Fordsburg area may in fact be coming from outside and be dumped by people in cars and other types of vehicles. If this was not the case, the income status of the Fordsburg area would not make it possible for households to generate the waste volumes witnessed during fieldwork on its own, even allowing for collection once a week.

Characterising waste by class and matching such classes to potential generation sources is a common technique in waste management studies. The understanding is that if food waste, for example, is found at a dumping site close to a food outlet, then such an outlet is most

probably responsible for illegal dumping at the site. However, the results of this study cast doubt on the scientific basis of such a simplistic logic. The results in this study raises doubts about the suitability of such an application because location attributes score poorly against variations in the size of waste dumps. Once again, this emphasises the diversity, highlighted earlier, in the source regions of waste at illegal dumps. These findings, as will be seen later, have direct implications for municipal waste management, especially for programmes aimed at eliminating illegal waste dumping in the urban space.

5.7 Current Waste Management Practices

The results of waste management practices represent interview responses of officials of the COJ and the private contractor. The results that covered policy, capacity, infrastructure status, waste data, monitoring and evaluation, and skills training for employees were presented in Chapter 4. In this section, the focus is on the significance of the responses and differences between the positions of the COJ and the contractor. These differences are important, for they inform what actions the COJ could institute to address the problem of illegal waste dumping.

Both the COJ and the contractor indicated that servicing illegal waste dumps was a serious financial burden, but both did not convey any impression that alternative approaches to managing these dumps were planned or were underway. From the waste management directorate of the COJ, it was established that the city operates its waste mandate as per existing municipal, provincial and national legislation applicable to issues of waste management. The COJ for example, did not indicate problems in implementing waste legislation at local level. Neither did it indicate that it faced financial constraints that undermined its capacity to provide a modern waste delivery service.

Responses of the COJ on the question of illegal waste dumps were mixed. Having outsourced the services of waste collection and disposal to a private contractor, the COJ did not feel directly responsible for the day-to-day operations in respect of waste collection, transportation, treatment and final disposal. While the COJ claimed that they provided overall leadership and took responsibility for waste management, the actual work on the ground was entrusted to the contractor. There was no indication therefore that the COJ sees the problem of illegal waste dumping in Fordsburg and in the rest of the city as requiring different management interventions. Although the outsourcing of waste collection, treatment and

disposal services to a contractor improves technical efficiency of the service, it reduces the ability of the COJ to intervene in addressing shortcomings in the waste system. For example, the contractor indicated that the costs of providing on-the-job training for its workers were rather prohibitive. This is in spite of an existing incentive scheme through which participating companies can recover part of their costs through the national skills training levy. The COJ, on its part, was not forthcoming about its participation in the skills training programmes. However, it indicated that short courses were provided for officials of the waste directorate targeted at different levels of personnel and the acquisition of specific requisite skills. Secondly, the COJ was silent about the role of its monitoring and evaluation team, given that employees of the contractor were not directly under its control.

With reference to waste data, the contractor did provide some basic data on waste collected, waste treated and waste landfilled to the COJ, but the COJ admitted that such data fell far short of requirements as per legislation on waste information (DEAT, 2006; Godfrey, 2008). Note that the problem of developing reliable waste datasets at municipal level remains a persistent challenge (Mudau *et al*, 2013; Godfrey, 2008). The use of estimation models based on assumed household per capita waste generation, into which industrial waste, institutional waste and commercial waste are factored to generate an overall waste volume for a specific period, is unsatisfactory.

However, this constraint cannot be blamed squarely on capacity issues at municipal level. Other studies (Mudau *et al.*, 2013; Mahamba, 2015; Mahasa & Ruhiiga, 2014) point to the inherent problem of generating standard measures from the existing diversity of guidelines, minimum standards, norms and requirements on waste management. The official source documents are beset by the lack of standardised quantitative measures that local municipalities can apply across board (DWAF, 1998a). For example, the minimum requirements for the disposal at landfill (DWAF, 1998b), minimum requirements for the handling, classification and disposal of hazardous waste (DEAT, 1999) are essentially qualitative descriptions but do not specify measurement units for use by local municipalities.

5.8 Summary

This chapter has presented and discussed the internal links in the dynamics of waste dumps. Waste management practices in Fordsburg have been presented and interpreted in relation to the research problem of the study. The results of the state of waste delivery services have been provided. Suggestions were made for new trends and for sound waste management

services, keeping in mind Objective 1, 2, 3 and 4, Objective 5 was achieved. Discussions of the findings have been provided in this chapter.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This study set out to understand salient issues around waste characterisation and its management, using Fordsburg, Johannesburg as the study area. The purpose of the study was to investigate open waste dumps in order to provide baseline information in designing management interventions. To this end, several objectives were specified: measuring the characteristics of location, and analysing the internal links, waste classification, analysis of variations in the waste stream, and outline current waste practices. Following the fieldwork survey, primary and secondary data were analysed and results presented. These were then discussed to generate key findings of the study. In this chapter, conclusions based on the findings are presented, followed by recommendations aimed at improving the performance of the waste delivery service.

6.2 Conclusion

Open dumping is a major concern in many South African cities and beyond the borders of the country. Illegal waste dumping in Fordsburg, a residential district in Johannesburg, needs immediate attention from the COJ first and from all those, whose lives may be adversely affected by such practices. These practices are partly fuelled by rapid urbanisation and the poor handling of waste from generation and along the entire waste chain to final disposal.

6.3 Study Limitations

The study did not involve the gathering of information from households in the Fordsburg area. Such an exercise could have generated household data for consideration in understanding the problem of illegal waste dumps. The decision not to include household interviews and or questionnaires was informed by the fact that such an approach in studies of waste management is already locally oversaturated (Mudau *et al.*, 2013; Mudau, 2015; Mahamba, 2015). Hence, the focus was put on understanding locational attributes instead, for this area does not feature much in local research on urban areas.

6.4 Solutions to Findings

The key findings of this study are that:

- The locational attributes of waste dumps are weak in explaining variations in the size of waste dumps .*The solution for this state of affairs lies in the recognition that illegal dumping is a far more complex behavioural attribute than is currently understood. Further research in this respect is called for.* However, COJ could intervene to force a change in public responses to illegal waste dumping. Such intervention could be built around a series of integrated programmes:

  (i) Carry out aggressive and periodic public education campaigns across schools, colleges and institutional settings that deal with large numbers of people. The aim would be to increase environmental awareness and in the process to make people know that all forms of illegal waste dumping pose health hazards to all.

  (ii) COJ should ask for help and participation of its law enforcement agencies in order to increase the intensity of prosecution. Penalties for illegal waste dumping should be made clear through the mass media, local radio stations and prominent signage so that the general public is sensitised about the practice as a punishable offense.

  (iii) A system for reporting offenders should be put in place through, for example, a toll-free telephone link. But care should be taken to safeguard the identity of those who report offenders.

  (iii) The entire Fordsburg area can be sub-divided into area blocks and volunteers, who are residents of these blocks hired to be on the look-out for offenders. COJ should not find this a financial challenge to its current budget outlay for waste management.

- The classification of waste and its density across the study area may not necessarily point to the sources of generation. *The implications of this finding is that relating the siting of residential areas to the distribution of illegal waste dumps may in fact place blame on the wrong areas. The need to understand illegal dumping as a particular behavioural plane which is variable across time, space and social class calls for further research in this regard. For example, little research has been conducted on the way urban residents respond to open unsecured spaces in their search behaviour for potential sites for waste dumping.*

- The closeness of waste dumps to roads points to the possible ways in which this waste is illegally dumped. *Waste dumping culprits are not confined to people on foot or*

pushing wheelbarrows. Motorists, in the urban space have become increasingly a source of such behaviour.

- The low scores for the mean waste dump size does point to a higher and regular rate of waste collection. *This points to the relative success of COJ in quickly removing illegally dumped waste.*

- The outsourcing of the waste collection work to a private contractor could be important in interpreting some of the results. *The debate as to whether waste collection and disposal should be outsourced remains a lively topic. What, however is not questioned is the relative success in service delivery when such a service is privatised. It is possible for local municipalities to successfully deliver a waste collection and disposal service. It is also possible for private contractors to do the same. The distinction lies in the way the public sector is committed to service delivery compared to the private sector. The overriding principle for the latter is the profit motive at any cost. In the process, the service offered to the urban community may become compromised.*

Waste management practices were discussed, paying attention to urban policy, municipal capacity, the state of waste infrastructure, the status of waste information systems, monitoring, evaluation and the role of skills training. The study shows that the COJ faces several challenges in trying to deliver a modern waste service. It has also been indicated that some of these challenges are in fact external to the COJ: the limited control over the activities of Pickitup (the contractor) and the issue of translating pieces of environmental legislation into standardised measures. The significance of the findings has been addressed in the discussion chapter of this document and issues around the soundness of current planning by the COJ with regard to waste delivery were raised. To this end, the original four objectives of this study as set out in Chapter 1 have been addressed successfully.

6.5 Recommendations

6.5.1 Waste Management Directorate

- The COJ should initiate campaigns through mass media channels to increase the awareness of the people about the need for a clean environment. These campaigns should also be used to encourage waste sorting at source.
- For households, the COJ could consider introducing an incentive scheme where participating households are given rebates on their services levy.
- Public education should be sponsored by the COJ to increase environmental awareness and to alert the urban population about the dangers of waste.
- A more stringent set of penalties for illegal waste dumping offenses should be enforced

6.5.2 Provincial and national departments of environment

This study has highlighted internal problems in the translation of the high number of existing waste legislation into workable measures at municipal level. It is recommended that all such legislation be consolidated per service level to facilitate easier implementation and to create opportunities for standardisation of compliance measurements and the carrying out of monitoring and evaluation assessments.

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APPENDIX A: OBSERVATION SCHEDULE FOR FIELD SURVEY

Observation will be carried out on waste disposal sites to check the following: Interval and ration scales will be used for numerical values of these measurements.

- Location of dumpsites
- Site characteristics
- Waste classification
- Presence of municipal signage discouraging and warning residents against littering

Site No.....

(a)Location of dump sites

	Variable Identity	Measure
1	Street	*
2	Physical address	*
3	Locality	*
4	Distance from nearest road	Metres
5	Distancefrom nearest public building	Metres
6	Distancefrom the nearest business outlet	Metres
7	Distancefrom nearestbuilding	Metres
8	Distance from the nearest official dumpsite	Metres
9	Distance from nearest food retail outlet	Metres
10	Distance from nearest open waste dump	Metres

(b) Site characteristics

1	Size of site	square metres
2	* Total length	Metres
3	* Total width	Metres
4	* Main height of waste	Metres
5	* Extent of littering at site	% of tract
6	* Evidence of scavenging by people?	number of people on site
7	* Evidence of scavenging by animals?	count data
8	* Evidence of scavenger birds?	count data

9	* Estimate of waste duration before collection	Days
10	* Estimate of last date of collection (time span since last collection)	days from date of observation
11	* Type of ground vegetation degradation	% of tract
12	*Evidence of stagnant water contamination? [% estimate of water cover	square metres as a %
13	* Evidence of soil contamination? [% estimate of visually contaminated soil surface]	square metres in %
14	* Total amount of land covered by waste	square metres
15	* Detected any odours and or stench at site?	*

(c) Waste classification

	Type	% by volume	Rank by % volume
16	Glass		
17	Paper		
18	Metal		
19	Demolition		
20	E-waste		
21	Garden		
22	Food		
23	Industrial		
24	Plastic and Rubber		
25	Wood		
Total estimated volume of waste at site			

(d): **Municipal signage**

	Description of state	Tick as applicable
27	Formal signage is in place at the site	
28	No formal signage exists at the site	
29	Formal signage exists but cannot be read easily	
30	Signage exists but has been vandalised	

APPENDIX B: INFORMAL INTERVIEW SCHEDULED FOR WASTE MANAGEMENT DIRECTORS

RESEARCH: TITLE: CHARACTERISATION AND MANAGEMENT OF OPEN WASTE DUMPS IN FORDSBURG, JOHANNESBURG SOUTH AFRICA
(INFORMAL INTERVIEW WITH DIRECTORATE OF WASTE MANAGEMENT)

My name is Fehmida Qaddus Rabbani. I am an MSc student in Environmental Science at the North-West University, Mafikeng Campus, Mmabatho, South Africa. I am conducting research on the "*Characterization and Management of open waste dumps in Fordsburg, Johannesburg*".

Could you kindly assist me in collecting information, by accepting this participation in this informal interview? Information generated will only be for academic purposes and will be treated with confidentiality. Your cooperation will be highly appreciated.

SECTION A: MUNICIPAL CAPACITY TO DEAL WITH SOLID WASTE LEVEL OF EDUCATION OF WASTE MANAGEMENT PERSON

HIGHEST EDUCATIONAL QUALIFICATION	NUMBER	PERSON INTERVIEWED COO
Post Graduate		
Graduate		

Age	40
Sex	Male

SECTION B: INVENTORY OF EQUIPMENT

Equipment	Total available	Old	New	Desired Number
Skip bins				
Refuse trucks				
Skip trucks				
Tractors				

SECTION C: MUNICIPAL CAPACITY TO DEAL WITH WASTE:

How frequently is garbage collected by waste management department from open dumps?

Twice a week	Twice a week
Once a week	
Fortnightly	
Monthly	
Rarely	

What is the amount of waste generated every day in your municipal waste collection setting?

Two trucks daily

SECTION D: WASTE MANAGEMENT POLICY:

1. Are you aware of any legislation applicable to the Municipal solid waste management?

   If yes, please list the legislative Act

Yes, NEMWA

2. Does your municipality have a waste management plan?

YES

3. Are you aware of authorization?

   If yes, when is it required?

SECTION E: WASTE MANAGEMENT PRACTICES:

4. Tick the facilities available for waste management

Segregation	Containment	Ordinary Burial	Deep burial	Burning	Autoclave	Incineration
YES	YES	YES				

5. Should waste be segregated into different categories?

YES

If yes, who does the segregation?

WORKERS

6. Do you colour code the waste for disposal?

YES

If yes, then please tell colours for waste Categories

Transparent	PAPER & SEGREGATED WASTE
Red	MEDICAL WASTE
Black	GARDEN WASTE
Blue	STREET LITTER

7. Is the infectious waste labelled with the basic biohazard symbol?

We do not handle hazardous waste

8. Where do you dispose hazardous waste?

NO

9. Do you maintain a register for waste disposal?

YES

10. Have your services done a waste audit in the last three years?

YES

Employee education:

11. Have you undergone any training programme on municipal waste management?

YES

12. Does your municipality annually provide education on waste management to its employees?

YES

13. Would you like to attend a programme on waste management?

YES

SECTION F: ATTITUDE ASSESSMENT:

14. Please circle whichever is applicable

a) Safe management of municipal waste is not an issue at all

Agree ◯ Disagree ☐ No comment ☐

b) Safe management of municipal waste is the responsibility of the government

Agree ☐ Disagree ◯ No comment ☐

c) Waste management is teamwork/no single class of people is responsible for safe management

Agree ◯ Disagree ☐ No comment ☐

d) Safe management efforts by department increase financial burden on management

Agree ☐ Disagree ◯ No comment ☐

e) Safe management of municipal waste is an extra burden on work

Agree ☐ Disagree ◯ No comment ☐

Additional information retrieved from the responses of COO

- Open waste dumps are very expensive to manage
- Waste bags are enough to contain waste for two weeks but people still litter
- This year the total amount of waste was 50 million
- Last year this amount was 60 million
- Mostly open waste dumps are in residential area
- Open waste dumps have no specific place, therefore, it is very difficult to manage them
- Once a week all open waste dumps are collected completely
- Suburbs are relatively clean areas regarding littering and open waste dumps

Thank you for your cooperation

Name of student: Fehmida Qaddus Rabbani

Student Number: 24999334

APPENDIX C: REFERENCE LETTER FROM NORTH-WEST UNIVERSITY

NORTH WEST UNIVERSITY
YUNIBESITI YA BOKONE BOPHIRIMA
NOORDWES UNIVERSITEIT
MAFIKENG CAMPUS

Department of Geography & Environmental Sciences

To: **WHOM IT MAY CONCERN**

From: Prof. TM Ruhiiga

School of Environmental & Health Sciences

North West University

Mmabatho 2735

Date: 17th April 2015

Ref: REQUEST FOR FORMAL AUTHORISATION FOR A RESEARCH PROJECT

This is to introduce Mrs. Fehmida Qaddus Rabbani, student Number [24999334] who is currently registered with the ***Department of Geography & Environmental Sciences*** for an ***MSc- Environmental Science*** degree. She is pursuing a research masters degree under my supervision and her topic of the research is on:

Characterisation and management of open waste dumps in Fordsburg, Johannesburg

17/04/2015

Her research involves the conduct of fieldwork in the Fordisburg area in which she will have to enumerate open waste dumps, code them, select a sample, visit and make measurements of the state of each site in the sample. Her work will also involve reference to secondary data from official annual reports of the ***Gauteng Provincial Department of Environmental Affairs*** and ***City of Johannesburg*** that talk to issues of waste management for the period 2000-2014 Following the statistical analysis of primary and secondary data sets so collected, the study aims to generate advice on how best to manage urban waste.

It will therefore be appreciated if you could provide her the necessary formal permission letter to facilitate her conduct of fieldwork in the Fordsburg area and access to official annual reports.

Should you require additional information on this request, please free to let me know and such information will be provided.

Thank you

Sign.....Date.17/04/2015

TM Rubinga

Professor: Human Geography & Environmental Science &
Chair: School of Environmental & Health Sciences Research Committee
Faculty of Agriculture, Science & Technology
North West University
Mafikeng Campus
Private Bag X2046
Mmabatho 2735
Tel: 018 389 2310
Cell: 073 669 7983
Fax: 018 389 2637
E-mail: [redacted]

APPENDIX D: LETTER OF INDEMNITY FROM CONTRACTOR COMPANY

INDEMNITY

1. Pikitup Johannesburg (SOC) Limited (hereinafter referred to as "Pikitup" and including its directors, employees, contractors shareholder, agents and assigns) has at the undersigned Student's request agreed to allow the Student access to certain of Pikitup's operational waste management sites (e.g. landfills, depots, recycling / garden centres, sorting facilities and/or integrated waste management facilities, hereinafter referred to as "premises) to conduct academic research.

   The Student hereby–

   1.1. acknowledges that,

      1.1.1. Pikitup's premises are active waste management facilities involving heavy machinery, vehicle and materials logistics and other operations usually conducted at waste management facilities;

      1.1.2. notwithstanding the entire scope of precautionary measures taken, premises such as those operated by Pikitup poses inherent risks to the physical and medical health and wellbeing of persons entering those premises;

      1.1.3. entry to and research activities at Pikitup's premises are undertaken at the Student's voluntary acceptance of the risks present in such an environment; and

      1.1.4. the described risks, should they materialise, could result in personal injury, permanent disablement, death, legal costs and/or the loss of or damage to property and associated claims for direct and consequential loss including but not limited to loss of profits, loss of income etc. and accordingly,

   1.2. indemnifies and agrees to keep indemnified and hold Pikitup harmless against any loss or claim:

      1.2.1. including loss or claims for damage to equipment or property, personal injury, resultant disability, loss of profit, income or opportunity, howsoever caused and whether general or special, direct or consequential, incurred either on or about the premises of Pikitup which the Student or his/her dependents might suffer; and/or

      1.2.2. any third party or Pikitup may suffer arising out of the wilful or negligent acts or omissions of the Student in connection to carrying out the intended research at Pikitup premises or in relation to the Student's access to Pikitup's premises.

THIS INDEMNITY THUS GIVEN AND SIGNED AS SET OUT BELOW

Fehmida Qaddus
Student signature

Name: FEHMIDA QADDUS
ID number: 24999334
Address: 46 CROWAN ROAD
FORDSBURGH
JOHANNESBURGH

APPENDIX E: WASTE CLASSIFICATION ^ (PRIMARY DATA)

Site	GLASS	PAPER	METAL	DEMOLITION	E-WASTE	GARDEN	FOOD	INDUSTRIAL	WOOD	PLASTIC RUBBER
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
1	2	10	2	50	2	18	2	2	2	10
2	5	40	5	0	5	15	5	0	5	20
3	5	50	5	0	5	5	10	5	6	9
4	15	35	6	0	4	5	20	0	5	10
5	0	5	0	5	0	60	20	0	5	5
6	40	15	5	5	0	20	5	0	5	5
7	5	50	5	0	2	2	16	4	6	10
8	5	45	10	0	0	5	15	0	0	20
9	14	46	15	0	0	5	10	0	0	10
10	0	60	0	10	0	0	5	5	0	20
11	10	20	8	2	5	15	16	0	2	22
12	20	10	3	10	5	5	2	5	15	25
13	5	50	5	2	2	2	10	2	2	20
14	5	5	5	5	0	10	10	18	2	40
15	3	15	2	20	10	5	25	2	3	15
16	45	5	5	15	0	10	5	0	5	10
17	15	5	0	50	0	5	5	10	5	5
18	5	25	5	5	6	6	8	5	5	30
19	2	18	20	5	5	15	10	14	5	16
20	20	10	5	20	5	5	5	12	8	10
21	20	2	2	6	0	10	52	0	0	8
22	10	15	5	20	5	10	5	10	12	8
23	0	5	0	10	0	55	5	5	5	15
24	5	15	5	70	5	0	0	0	0	0
25	5	10	5	50	5	0	5	15	3	2
26	10	30	10	0	5	5	15	0	10	15
27	5	70	2	3	2	10	2	0	0	6
28	2	30	3	2	3	20	20	15	0	5
29	2	36	3	2	2	10	20	0	0	25

30	3	22	5	30	5	10	20	0	0	5
31	12	30	2	0	2	4	4	30	10	6
32	20	20	5	0	7	2	20	10	0	16
33	5	30	0	0	5	5	20	0	5	30
34	10	20	5	0	0	5	20	0	0	40
35	5	30	5	0	5	10	30	5	0	10
36	15	20	15	0	10	5	0	0	15	20
37	5	15	0	0	10	0	20	10	10	30
38	5	10	10	0	5	0	20	0	10	40
39	10	40	10	0	10	0	20	0	0	10
40	5	20	10	0	10	20	5	0	5	25
41	5	30	20	0	5	10	10	0	0	20
42	10	20	15	0	5	10	20	0	0	20
43	20	10	20	10	10	0	5	15	0	10
44	10	20	10	30	5	5	5	0	0	15
45	5	30	5	0	20	20	0	0	0	20
46	10	30	20	0	5	15	10	0	0	10
47	5	15	5	0	5	5	5	40	0	20
48	2	2	6	5	20	20	5	0	30	10
49	5	30	10	5	10	20	10	0	0	10
50	5	10	5	0	0	5	10	10	35	20

APPENDIX F: ETHICS CLEARANCE CERTIFICATE

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Private Bag X6001, Potchefstroom
South Africa 2520

Tel: (018) 299-4900
Faks: (018) 299-4910
Web: http://www.nwu.ac.za

Institutional Research Ethics Regulatory Committee
Tel +27 18 299 4849
Email Ethics@nwu.ac.za

ETHICS APPROVAL CERTIFICATE OF PROJECT

Based on approval by the **Health Science Ethics Committee (FAST)**, the North-West University Institutional Research Ethics Regulatory Committee (NWU-IRERC) hereby approves your project as indicated below. This implies that the NWU-IRERC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: **Characterisation and management of open waste dumps in Fordsburg, Johannesburg.**

Project Leader: **Prof TH Ruhliga**
Student: **FQ Rabbani**

Ethics number: NWU-00455-15-A9

Approval date: 2014-08-18 **Expiry date:** 2016-04-16 **Category** N/A

Special conditions of the approval (if any):

- All queries regarding this application received from the Health Sciences Ethics Committee (FAST) must be addressed and clarified.

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- *The project leader (principle investigator) must report in the prescribed format to the NWU-IRERC:*
  - *annually (or as otherwise requested) on the progress of the project,*
  - *without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.*
- *The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-RERC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.*
- *The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-IRERC and new approval received before or on the expiry date.*
- *In the interest of ethical responsibility the NWU-IRERC retains the right to:*
  - *request access to any information or data at any time during the course or after completion of the project;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the project are revealed or suspected,*
    - *it becomes apparent that any relevant information was withheld from the NWU-IRERC or that information has been false or misrepresented,*
    - *the required annual report and reporting of adverse events was not done timely and accurately,*
    - *new institutional rules, national legislation or international conventions deem it necessary.*

The IRERC would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the IRERC for any further enquiries or requests for assistance.

Yours sincerely

Prof LA Du Plessis

Digitally signed by Prof LA Du Plessis
DN: cn=Prof LA Du Plessis, o=North West University, ou=Campus Rector, email=Linda.DuPlessis@nwu.ac.za, c=ZA
Date: 2016.02.24 08:13:49 +02'00'

Prof Linda du Plessis
Chair NWU Institutional Research Ethics Regulatory Committee (IRERC)

APPENDIX G: AUTHORIZATION FROM ENVIRONMENTAL AFFAIRS, SOUTH AFRICA

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Private Bag X447, Pretoria, 0001. Environment House, 473 Steve Biko Road Pretoria, 0002. Tel: +27 12 399 9000, Fax +27 86 625 1042
Ref: Referral to Pikitup (Hard Copy)
Enquiries: J vd Merwe
Tel: (012) 399-9765 **Fax:** (086) 697-1343 **E-mail:** jvdmerwe@environment.gov.za

Prof. TM Ruhiiga
Chair: School of Environmental & Health Sciences Research Committee
North West University (Mafikeng Campus)
Private Bag X2046
MMABATHO
2735

Fax no: 018 389 2637
E-mail: tabukeli.ruhiiga@nwu.ac.za

Dear Prof Ruhiiga

REQUEST FOR FORMAL AUTHORISATION FOR A RESEARCH PROJECT (MRS FEHMIDA QADDUS RABBANI, STUDENT NO 24999334)

On behalf of Mr Mark Gordon, Deputy Director-General: Chemicals and Waste Management, National Department of Environmental Affairs, I wish to acknowledge receipt of your letter dated 17 April 2015, with thanks. Kindly accept our apology for the delayed response.

Line mangers responsible for General Waste Management and Hazardous Waste Management and Licencing have been consulted and they have advised that Mrs Rabbani would not require permission from the National Department of Environmental Affairs as the mandate to grant this concent does not fall with the DEA but rather with the City of Johannesburg, and in this case it would be the Metropolitan Municipality. The facility in question namely Fordsburg falls under the Waterval Depot, no 2 Alberts Street, Albertsville. The Depot callcentre no is 087 357 1487.

It is recommended that permission be sought from The Municipal Manager, City of Johannesburg Metropolitan Municipality, Mr Trevor Fowler who can be contacted on (011) 407 7300 or by email on citymanager@joburg.org.za, and Pickitup respectively.

Yours sincerely

Ms Nosipho Ngcaba
Director-General
Department of Environmental Affairs
Letter signed by: Ms Judith vd Merwe
Designation: Acting Director: Administrative Support
Office of the Deputy Director-General: Chemicals and Waste Management
Date: 22/05/2015

Batho pele- putting people first

APPENDIX H: LETTER OF EDITORSHIP

CORRIE GELDENHUYS
POSBUS 28537
DANHOF 9310

✆ 083 2877088
☎ +27 51 4367975
corrieg@mweb.co.za

25 July 2016

TO WHOM IT MAY CONCERN

Herewith I, **Cornelia Geldenhuys (ID 521114 0083 088)** declare that I am a qualified, accredited language practitioner and I have edited the dissertation submitted by **Fehmida Qaddus Rabbani (Student number 24999334)** for submission for examination:

Characterisation and management of open waste dumps in Fordsburg, Johannesburg

All changes were indicated by track changes and comments, to be addressed by the researcher.

.....
C GELDENHUYS
MA (LIN – *cum laude*), MA(Mus), HED, Postgraduate Dipl, Library Science, UTLM

ACCREDITED MEMBER OF SATI – Membership number: 1001474 (APTrans)
GEAKKREDITEERDE LID VAN SAVI – Lidmaatskapnommer: 1001474 (APVert)
Member of/Lid van PEG (The Professional Editors Group)