Waste dumping in Sharpeville (Emfuleni Municipality): An investigation of the characteristics and the potential impacts on air quality

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ABSTRACT

Waste management is of significance as poorly handled waste can have detrimental effects on both the environment, and the public health. Open burning of domestic waste is a common practice in developing countries, particularly in relatively poor areas with minimal or infrequent waste services. The emission contribution of uncontrolled waste burning to air quality issues is known to be immense. Uncontrolled burning of domestic waste is a source of various emissions such as black carbon, particulate matter, volatile organic compounds (VOCs), polychlorinated dibenzodioxins and dibenzofurans (PCDD/F), polycyclic aromatic hydrocarbons (PAHs) and other toxic pollutants. It is important to understand the actual composition of waste that is being burned, since the composition of the waste determines the type of emissions that was formed.

The primary aim of this study was to investigate the extent of waste dumping and burning in Sharpeville, within the context of the fact that waste burning may contribute to air pollution. A pilot study was done to identify the illegal waste dumping sites throughout the township. Thirty-three waste dumping sites were identified during the pilot study. Most of the sites had evidence of historic waste burning, and some of the waste was being burned at the time of the site visits. A second site survey was done where evaluation and cataloguing of the thirty-three illegal waste dumping sites was undertaken. The sites were evaluated based on their location, waste-related activities, size, level of waste burning activity and a visual estimation of the waste composition. One of the thirty-three sites (the largest and most active of the sites) was then selected for further detailed assessment, where waste (composition) characterisation was performed. It was discovered that the waste consisted mainly of organic waste (29%), other wastes such as rock, ceramics, etc. (27%) and paper and cardboard (19%), while other wastes such as plastic film, nappies, polystyrene packaging and burned tyres were also noted. Only small amounts of glass were encountered. The small amount of glass was due to the frequent collection of glass bottles by waste pickers for an incentive. One important factor which determines the composition of emissions is the chemical constitution of the material being burnt. Based on the composition of waste, the formation of greenhouse gases and some persistent organic pollutants, such as dioxins, furans, polychlorinated biphenyls (PCBs) and PAHs are expected. However, a large fraction of the waste that is being dumped is inert (and non-flammable) and minimal emissions are expected during burning activities.

Keywords: *Waste, illegal waste dumping, waste management, waste services, waste burning, waste characterization, pollution, Sharpeville, Vaal Triangle.*

PREFACE

This study attempts to understand the waste composition of the identified illegal dumping sites and the impact of its dominant emission constituents if burned. The primary aim of the study was to investigate the extent of waste dumping and burning in Sharpeville, within the context of the fact that waste burning may contribute to air pollution.

In 2006, the Minister of the Department of Environmental Affairs and Tourism (DEA[1]) declared the Vaal Triangle air-shed as a priority area in terms of Section 18(1) of the National Environmental Management Air Quality Act (39 of 2004). It also addresses the problematic issue of waste burning in Sharpeville. Chapter 1 elaborates on the problem statement and research questions of the study. In Chapter 2, various factors that are contributing towards the frequent occurrence of illegal dumping and waste burning are indicated as a result of its convenience and minimal (or infrequent) service delivery. This chapter also provides a critical analysis of the dynamics of waste burning in relation to the air quality.

A detailed literature review and an empirical investigation were utilised in this regard. The methods of data collection (outlined in Chapter 3) proved to be useful in the provision of insights into the illegal dumping, burning and composition of waste in Sharpeville.

The findings and recommendations of the study, as outlined in Chapter 4, are expected to provide assistance to the community of Sharpeville regarding the importance of proper waste management. It will also be helpful to the Emfuleni Municipality moving forward, particularly with future strategic planning. Based on the findings of the study it is recommended that active and frequent waste service delivery should be implemented, awareness raising on waste management and consequences of poor waste management should be implemented throughout the community and also legal enforcement should be strict and active in order to eradicate waste-related issues that could pose a detrimental hazard to the public community and environment as a whole. The intent of the study was also to provide waste composition information that can serve as a basis for more accurate air emissions modelling, as it relates to the burning of waste.

Chapter 5 provides the final conclusions and recommendations of this study.

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[1] Now the Department of Environmental Affairs (DEA).

LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
CH_4	Methane
CO_2	Carbon dioxide
DEA	Department of Environmental Affairs
DEA	Department of Environmental Affairs and Tourism
DSD	Department of Social Development
EFs	Emission factors
GHGs	Greenhouse gases
HCB	Hexachlorobenzene
H_2S	Hydrogen sulfide
ISWA	International Solid Waste Association
MSA	Municipal Systems Act (2000)
MSW	Municipal solid waste
MWC	Municipal waste combustor
NMOC	Non-methane organic compounds
O_3	Ozone
OC	Organic Carbon
PAH	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzodioxin
PCDF	Polychlorinated dibenzofuran

PM	Particulate matter
POPs	Persistent organic pollutants
PPE	Personal protective equipment
SAWIC	South African Waste Information Centre
TRREE	Training and Resources in Research Ethics Evaluation
SO_2	Sulfur dioxide
SWM	Solid waste management
UNEP	United Nations Environmental Programme
VOCs	Volatile organic compounds

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CHAPTER 1. INTRODUCTION

1.1 Introduction

Bounded by numerous land uses such as industrial-, mining-, commercial-, agricultural- and residential activities, which are situated in close proximity to one another, the Vaal Triangle experiences complex and pressing air pollution issues (Scorgie *et al*., 2003). In 2006, the Minister of the Department of Environmental Affairs and Tourism (DEA[2]) declared the Vaal Triangle air-shed as a priority area in terms of Section 18(1) of the National Environmental Management Air Quality Act (39 of 2004). A variety of assessment studies on air pollution and human health were undertaken for the region between the years 1990 and 2000, with numerous more studies being undertaken thereafter (Scorgie *et al.,* 2003). Air pollution and human health go hand in hand.

Previous research showed the occurrence of aerial particulate matter, Sulfur dioxide (SO_2), ozone (O_3), hydrogen sulfide (H_2S) and benzene concentrations in the Vaal Triangle area and has also identified the existing potential for extensive local exposures of humans to numerous hazardous pollutants of the air (Scorgie *et al*., 2003). Many factors contribute to poor air quality. In the Vaal Triangle area, sources of air pollution may include emissions from industries, motor vehicles, power generation processes, domestic burning of fuels, as well as the mismanagement and uncontrolled burning of waste, to name a few (Afroza *et al*., 2003). This study focused on the investigation of the extent of waste dumping and burning in Sharpeville within the Vaal Triangle area, within the context of the fact that waste burning may contribute to air pollution.

Human activities contribute to the creation of waste, and it is the way in which waste is handled, stored, collected and disposed, which can constitute risks to the environment and to the health of the public (Zurbrügg, 2002). In instances where there are significant human activities concentrated (such as in city centres), safe solid waste management (SWM) is of essence to provide a healthy and safe environment for society (Zurbrügg, 2002). According to World Resources Institute (1996), typically about two thirds of the solid waste that is generated is, not collected for disposal purposes.

According to Bosman *et al*. (2018), the environmental degradation resulting from insufficient waste disposal can be expressed by the contamination of surface and ground water through leachate, soil pollution through direct waste contact or leachate, air pollution by burning of wastes, spreading of diseases by different vectors such as birds, insects and rodents, or unmonitored release of methane by anaerobic decomposition of waste. Service delivery issues in turn lead to illegal dumping and improper waste disposal practices, such as burying the waste or uncontrolled burning of waste.

[2] Now the Department of Environmental Affairs (DEA).

1.2 Problem statement and scope of the study

Waste burning as a waste management method (both controlled and uncontrolled) occurs in almost every country in the world. Controlled waste burning in incinerators is necessary in waste management, particularly to deal with hazardous waste (Cogut, 2016). However, improper incineration of waste materials and uncontrolled waste burning have great potential of being detrimental to the environment (Cogut, 2016). Open burning of waste can take place within residential areas, particularly in rural places where waste services are relatively minimal, or in any public areas which happens to be easily accessible. This particular type of waste burning takes place mostly due to its convenience and unsatisfactory waste collection service, making it hazardous in low income areas and developing countries, which already have difficulties of collecting the municipal solid waste (MSW) that is generated (Cogut, 2016). Waste (particularly organic waste, which comprises of the majority of waste in developing countries) can cause significant odours when not collected in time and open burning can help eliminate these odours (Cogut, 2016).

According to Estrellan and Iino (2010), the burning of anthropogenic materials (such as waste) release relatively higher quantities of polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), organic and inorganic ions, metals and other chemical species per unit mass of material burnt than biomass fuels. Partial combustion takes place often during domestic heating, wherein organic material in the presence of chlorine causes the formation of chlorinated organic by-products, such as PCDDs, PCDFs, polychlorinated biphenyls (PCBs), and hexachlorobenzene (HCB) (Hedman *et al.*, 2005; Maasikmets *et al.*, 2016).

The particular emissions from waste burning vary from case to case depending on the burning conditions (temperature, environment, location etc.) and the composition of the waste that is being burned (Cogut, 2016). Although open burning of waste is not the main, human induced cause of greenhouse gasses (GHGs) throughout the world, due to open waste burning, GHG emissions are of significance (Cogut, 2016). The emissions from the controlled burning of waste are reported in national and global inventories. However, the emissions from the open uncontrolled burning of waste at homes and dumps are more challenging to characterize and are commonly excluded from inventories (Wiedinmyer *et al.*, 2014).

This study focused on the Sharpeville area in the Vaal Triangle, Gauteng Province, which is located between two of the major industrial towns in South Africa, Vanderbijlpark and Vereeniging.

Limited research has been done solely on the burning of waste in Sharpeville and its potential impacts on air quality. However, a number of research studies have been conducted and published for the Vaal Triangle Airshed and Highveld Priority Areas (Lourens *et al.,* 2011). Numerous studies have been undertaken and reported to determine the contribution of open burning of domestic waste to the atmospheric burden of persistent PCDD/Fs, PAHs, and organic carbon (OC) bound into PM (Estrellan & Lino, 2010).

The aim of this study was to provide an assessment of illegal waste dumping sites, where waste is burned (or has the potential of being burned) in the Sharpeville area, and to determine the composition of the dumped waste. The intent is to generate waste composition data that could be used to contribute to more accurate air emissions calculations, which could then be based on actual, verified waste composition data, rather than estimations. Therefore, this research which focused on the dumping and burning of waste in Sharpeville is of importance and will allow for a better and broader understanding of the potential contribution of waste burning to air pollution in the area.

1.3 Research questions and objectives

The aim of this study was to investigate the extent of waste dumping and burning in Sharpeville, within the context of the fact that waste burning may contribute to air pollution.

The research questions included:

1. What are the extent[3] and characteristics of waste dumping and burning in Sharpeville?
2. What is the composition of waste being dumped and burned in Sharpeville?

The final research question (question 3, below) was not the primary focus of this study. The intent of this study was rather to provide waste characterisation and composition data, which could be used in other studies to contribute to more accurate air emissions calculations.

3. Could the burning of waste significantly impact on air quality in the Sharpeville area?

1.4 Limitations of the study

Whilst reading this mini-dissertation, the following limitations of the study should be taken into consideration:

- When determining the extent of the waste dumping sites in Sharpeville, a methodology was used to pre-select randomised routes to represent the Sharpeville area. This meant that although Sharpeville is well represented by the randomised routes, not the entire spatial area of Sharpeville was covered. This could mean that a few dumping sites could have been missed during the investigation phase. The aim of the pilot study was, however, not to do a

[3] As far as the extent of dumping is concerned, the study also aimed to understand the reasons for waste dumping. This was not the main aim of the study and was done by means of literature review and informal engagements with members of the community.

comprehensive analysis of all of the waste dumping sites in Sharpeville, but rather to determine the feasibility of the study, based on the extent of waste dumping in the area.

- The evaluation of the characteristics of the waste dumping sites was done over a period of three days in July 2018 and, therefore, only provides a “snapshot” of the characteristics of the sites. It was evident when the characteristics of the thirty-three sites were compared in July 2017 (pilot study) and July 2018 (second site survey) that differences existed in their characteristics. Five of the thirty-three sites, for instance, were cleaned-up when they were visited in 2018. The study, however, provides a good reference against which the characteristics and extent of dumping may be tracked or compared against in future studies.

- The waste composition analysis was only done at one of the thirty-three sites. The site was selected based on its size, level of dumping and burning activity, as well as the heterogeneous nature of its waste composition (based on visual observation). The waste composition at the site is believed to be representative of what would be found at the majority of the other waste dumping sites.

- The ASTM (American Society for Testing and Materials) method for determining the composition of unprocessed municipal solid waste (ASTM D5231 – 92 (2013) provides for the characterisation of waste composition based on the quantities of waste generated by households. The methodology provides for determining waste fractions that is disposed of in black bags. During this study, the methodology was modified to determine the waste composition in pre-determined quadrants, since the waste was not contained in black bags, but dumped and scattered across bare soil.

- Generally, waste characterisation studies should be undertaken over a period of one week to provide a reasonable representation of the real situation (Dahlen & Lagerkvist, 2008). However, in this study waste characterisation was carried out in one day. Waste characterisation included only waste that was dumped at the site and did not include a full account of the waste that was generated by the population (as more traditional characterisation studies would). This was, however, suitable to the aim of the study, which was to determine the composition of the waste that would potentially be burned at the dumping site.

- A hanging scale was used to weigh the waste fractions during the waste composition analysis. The scale measures in 100 g increments and are therefore only accurate to 0.1 fractions of a kilogram. Considering the weight of the waste fractions measured, the scale accuracy was deemed to be sufficient.

- The data of waste fraction composition are ‘closed’ datasets due to the limited sample space (from 0 to 100 i.e. percentages) (Edjabou *et al.*, 2017). This is referred to as the ‘constant sum constraint’ (Aitchison, 1986), where a waste fraction’s percentage is dependent on the ratio of the other waste fractions included in the sampled waste stream (Edjabou *et al.*, 2017). As a result, the percentages of waste fractions are intertwined intrinsically (Edjabou *et al.*, 2017).

- Although the opportunity for engagement with the community presented itself, engagements with the community were limited, due to the fact that the original study design did not provide for interviews/conversations with the community, and it was not submitted as such to the ethics committee. In future, further research, which includes interviews/questionnaires which involves the community may be used to get a more accurate understanding of the reasons for waste dumping and burning.

CHAPTER 2. LITERATURE REVIEW

2.1 Waste management issues in South Africa

To address historic imbalances in the provision of waste collection services, it is vital that acceptable, affordable and sustainable waste collection services be availed to all South African residents (DEA, 2011). The management of solid waste remains an issue in the cities' authorities in developing countries primarily because of:

- the continuous increase in the generation of waste;
- the burden brought forth to the municipal budget as the consequence of the high costs in association to its management;
- the lack of comprehension over a variety of factors that impact the various phases of waste management; and
- the linkages necessary to ensure that entire handling system functioning is allowed for (Guerrero *et al.*, 2012).

This part of the literature review focuses on the challenges or issues associated with waste management in South Africa.

2.1.1 Increased waste generation rates

According to Oelofse (2015), in 2011 about 108 million tonnes of waste (of which 20 million tonnes were MSW were generated, where 90% of the waste was disposed to landfill. In 2017, approximately 57 million tonnes of waste were reported to be disposed to land (SAWIC, 2017). The persistent increase in the population levels, booming economy, dramatic urbanisation and the rise in community living standards have significantly aggravated the MSW generation rate in developing countries (Minghua *et al.*, 2009).

2.1.1.1 Waste generation as a result of socio-economic activities

The ever increasing socio-economic activities have brought about an increase in the generation of waste in South Africa beyond effective levels of management (Nwokedi, 2011).

According to the Department of Social Development (DSD) (2000), the socio- economic activities proceed to disperse around major city centres in South Africa, thereby bringing about various environmental issues such as air pollution, generation of waste, land pollution and contamination of water regimes among others. An improvement in the socio-economic standards brings about an increase in human population increases due to the migration of people into urban centres for survival purposes (DSD, 2000). The growth in population goes hand-in-hand with the generation of waste. According to Nwokedi (2011), there is a direct relationship between human population and solid waste generation. Generally, an increase in human population brings about or triggers an increase waste generation.

The growth in population and successive innovations have not only brought about a change in consumption patterns across borders but it has also put significant pressure on waste management services (Marshall & Farahbakhsh, 2013). All of this is due to the fact that the world is headed towards a more urbanised and complex future. Continuous technological developments coupled with persistent innovations can only bring forth an increase in waste generation, thus pressurising the management of waste.

2.1.1.2 Waste generation as a result of human activities and factors

Human activities contribute to the creation of waste, and it is the way this waste is handled, stored, collected and disposed, which can constitute risks to the environment and to the health of the public (Zurbrügg, 2002). According to Sujauddin *et al*. (2008) waste generation is influenced by size of families, education levels and monthly income within families. Attitudes of individuals within households, in relation to waste generation and waste management practices (such as sorting of waste) are affected by the continuous support and investment of the municipality, as well as the community residential committees' involvement for public participation (Zhuang *et al*., 2008). Charges for waste collection services on the bases of the volume or weight of waste generated, also plays a role in the attitudes towards recycling (Scheinberg, 2011).

In addition, gender, peer pressure, size of land, location of household and membership of environmental organisation provides a comprehensive explanation for household waste generation, usage and sorting behaviour (Ekere *et al*., 2009).

2.1.2 Municipal waste service provision

In instances where there are significant human activities concentrated (such as in city centres), safe solid waste management (SWM) is of essence to provide a healthy and safe environment for society. The pressure put on waste management services has resulted in the widespread inefficiencies which are primarily because of the lack of financial assistance, inappropriate infrastructure, unsatisfactory waste collection services, uncompliant waste management practices, insufficient waste minimisation and waste legislation not being implemented effectively (Nahman & Godfrey, 2010).

The South African Municipal Systems Act (MSA) of 2000 states that municipalities have to provide waste collection, disposal and cleansing services to all its residents (RSA, 2000). According to the South African Constitution, governments at local level or municipalities are appointed by the government at national level to perform certain duties which are inclusive of (RSA 1996):

- Ensuring provision of a democratic and accountable government for local communities;
- Making sure that they provide services to communities in a sustainable manner;
- Promoting social and economic development at all times;
- Promoting a safe and healthy environment; and
- Encouraging community involvement and also involvement of community organisations in the matters of local government.

Although the responsibilities given to local governments and municipalities are clear and comprehensive, the waste management state in South Africa remains uncoordinated and poorly financed (Nahman & Godfrey, 2010).

2.1.2.1 Factors influencing effective waste services provision

Municipalities often encounter problematic situations beyond the ability of the municipal authority to manage (Sujauddin *et al.*, 2008) primarily because of the lack of organisation, financial resources, complexity and system multi dimensionality (Burntley, 2007). Several studies have shown that waste collection, waste transfer and waste transport practices are affected by the rate of waste generation, as well as inappropriate systems of bin collection, inadequate route planning, lack of information regarding schedules for collections (Hazra & Goel, 2009), limited infrastructure (Moghadam *et al.*, 2009), unsatisfactory roads and the quantity of waste collection vehicles (Henry *et al.*, 2006).

South Africa is experiencing serious issues of meeting the high standards in service delivery with a restricted amount of resources (Matete & Trois, 2007). Generally, the organisation and planning of public waste collection services in developing countries are pretty basic (Buenrostro & Bocco, 2003).

In numerous urban areas in developing countries, solid waste management costs consume between 20% and 50% of municipal revenues, though the levels of waste collection service levels remain pretty low, with only between 50% and 70% of residents getting waste services and significant number of the disposal being done in an inappropriate and unsafe manner (Henry *et al.*, 2006).

According to World Resources Institute (1996), typically about two thirds of the solid waste generated is not collected. As an outcome, the waste which is not collected (and which in most cases is also mixed with human and animal faeces) is disposed randomly in the streets and in drainage systems, therefore contributing to floods, reproduction of insect and rodent vectors and the spread of diseases (UNEP-IETC, 1996). Globally, about two billion people lack access to proper MSW collection services and thus dispose their household waste typically by open burning, burial or dumping on open ground or into water courses (UNEP & ISWA, 2015).

2.1.2.2 Redressing past inequities in waste service delivery

The year 2000 was the year when the Local Government Municipal Systems Act (Act 32 of 2000) was put to practice to address the imbalance in service delivery (Matete & Trois, 2007). The Act requires that all municipalities endeavour to make sure that service delivery takes place within local communities in a manner which is financially and environmentally sustainable and that local communities have fair access to these particular services (Matete & Trois, 2007).

According to Miraftab (2004), during the apartheid era, the important tool of the state in its mode of capital accumulation was the construction and stratification of distinct racial categories incorporated with regards to the hierarchy into the labour market. The racialised system of labour exploitation intertwined with the spatial organization of apartheid cities, which divided populations according to their race to maintain social hierarchies by controlling the social movement of black and coloured populations (Lemon, 1991). While the white community suburbs enjoyed high standards for infrastructure and services, the black townships were deprived of even the most basic urban services, therefore, the majority of black townships either had no waste services entirely or were restricted to periodic waste pick-ups from communal skips where residents had to personally collect and dispose their own waste (Miraftab, 2004).

The apartheid era ended prior to 1994, which is the year in which the new Republic of South Africa came into existence. The incoming government - which is currently in power still, faced a significant task of fiscal, political, social and economic transformation, all of which would need a reliable and effective public service capability (Russell & Bvuma, 2001).

Recent research in post-apartheid South Africa shows that despite the redistributive promises of the Constitution of 1994 and the restructuring of local government, not much has changed with respect to the patterns of inequality created during the years of apartheid (Miraftab, 2004). Service delivery remains an issue in numerous parts of the country, particularly in rural and semi-rural areas. Lack of waste service delivery or unreliable waste service delivery contributes largely towards poor waste management, which may give rise to illegal waste management practices such as illegal dumping of waste, uncontrolled burning of waste, or the accumulation of waste which may cause health and safety impacts (Henry *et al.*, 2006).

2.2 Consequences of waste management issues

Consequences of poor waste management range from threats to the environment to threats to public health. The environmental degradation resulting from dumping and insufficient waste disposal can be expressed by the contamination of surface and ground water through leachate, soil pollution through direct waste contact or leachate, air pollution by burning of wastes, spreading of diseases by different vectors such as birds, insects and rodents, or unmonitored release of methane by anaerobic decomposition of waste (Zurbrügg, 2002).

For the purposes of this mini-dissertation, the literature review will focus mainly on domestic waste dumping and waste burning as consequences of waste management issues.

2.2.1 Domestic waste dumping

Illegal dumping of waste refers to an occasion whereby waste is discarded in inappropriate manners in areas such as drainage systems, roads, river sides and on private and public land that is not legally permitted for such a usage (Zurbrügg, 2002). Waste materials dumped are usually inclusive of household waste, old furniture, garden waste, old appliances, construction rubble, and old tyres, among others.

Although the practice of illegal dumping takes place due to various reasons, one of the primary factors inducing illegal dumping is identified as the shortage of proper waste treatment facilities (Ichinose & Yamamoto, 2011). People have a tendency of resorting to illegal dumping in the absence of waste services. When there is a lack of enough proper waste treatment facilities, the cost of proper waste disposal is bound to increase (Ichinose & Yamamoto, 2011). Therefore, people end up disposing their waste illegally to reduce waste disposal costs.

According to Munton (1996), an increase in demand and insufficient disposal capacity leads to an increase in illegal disposal practices, a consequence which would cause a terrible price in terms of environmental degradation and harm to the public health. This logic is quite intuitive, however there is minimal quantitative evidence in support of the argument that a shortage of waste treatment facilities leads to an increase in the frequency of illegal dumping (Ichinose & Yamamoto, 2011).

The root cause for the lack of waste service delivery lies within the government structures (Refer to Section 2.1.2.1.).

2.2.2 Waste burning

People usually resort to the burning of waste when they receive minimal waste services or no services at all, or where collection services are relatively expensive, unavailable, or infrequent (Wiedinmyer *et al.*, 2014). Some burning of waste takes place due to the lack of knowledge of the actual consequences of the burning activities, while other reasons may be inclusive of convenience, habitual purposes, or landfill and cost avoidance (Lemieux, 1998).

Cogut (2016:12) states that dumping can be an eyesore and people may burn waste simply to remove it from the streets or a public place. This can be extremely difficult to prevent and monitor because of its unregulated nature. What aggravates the matter, is the fact that waste dumping and waste burning is dispersed, which increases the public health risk and potential environmental impacts.

2.2.2.1 Controlled versus uncontrolled waste burning

Waste may either be burned in a controlled or uncontrolled manner. The *controlled burning* of waste by means of processes of incineration can be necessary to manage risky waste, for example, health care risk waste and ill-advised cremation of waste. Technologies exist that promote "clean" efficient controlled combustion, that capture energy, and/or mitigate emissions (Wiedinmyer *et al.*, 2014). Modern incinerators have large stacks and specially designed combustion chambers, which have combustion temperatures, elongated residence times, and improved waste agitation while exposing the air to more burning, which reduces harmful emissions.

The focus of this mini-dissertation is, however, on uncontrolled open burning of waste at dumping sites.

Lemieux *et al.* (2004) defines *uncontrolled* open burning as the exposed burning of materials in the atmosphere. The practice of open burning can be inclusive of unplanned fires such as fires in the veld, planned burning activities such as the combustion of grain fields in preparation for the following growing period, arson-initiated combustion of scrap tyres or even explosions of fireworks during celebrations as well as the burning of waste (Lemieux *et al.*, 2004). The practice of uncontrolled open burning of waste is characteristically a form of low temperature combustion coupled with contaminants and sometimes detrimental emissions, which has a significant contribution towards the contamination of the atmosphere (Reyna-Bensusan *et al.*, 2018).

Uncontrolled waste burning, such as residential open burning, occurs outside homes and places where waste is dumped by roadsides and open public spaces. Such open burning of waste is uncontrolled and typically there is no solution to reducing the impacts that uncontrolled burning has on the health and environmental issues.

2.2.2.2 Uncontrolled waste burning and impacts on public health

Uncontrolled burning of waste can be detrimental to the public health as well as to the environment. Kodros *et al.* (2016) incorporated health data into a risk model and predicted that about 270,000 premature adult mortalities was due to the chronic respiratory exposure to uncontrolled burning of domestic waste per year.

Limited comprehensive research has, however, been completed on the impacts of ineffective waste burning and poor waste management in general on public health. Studies mainly focus on the issues related to the waste management system and not the damage that the issues may cause to public health and the environment (Cogut, 2016:9). The studies, generally, ignore issues such as health consequences regarding uncontrolled burning of wastes and “individual by-products of poor waste management rather than those from poor waste management strategies as a whole” (Cogut, 2016:10).

2.2.2.3 Uncontrolled waste burning and impacts on air quality

Uncontrolled burning of MSW remains a significant source of air pollution and is widespread in numerous developing countries. However, only minimal studies quantify the extent of domestic open burning of household waste and its contribution to air pollution (Reyna-Bensusan *et al*., 2018). Christian *et al*. (2010) estimated that about 40 to 50% of the total global MSW generated may be disposed of by uncontrolled burning (which was estimated to have contributed to 5% of the global annual human induced carbon dioxide emissions in 2010).

Uncontrolled burning of domestic waste, may create optimal conditions for the formation and emission various pollutants, such as black carbon, particulate matter, VOCs, dioxins, furans, PAHs and other toxic pollutants. Inventories formulated pursuant to the Stockholm Convention on Persistent Organic Pollutants (POPs) show that open burning of waste materials or biomass as the most significant source of unintentionally generated POPs in developing countries (Fiedler, 2007).

The estimated global open waste burning emissions of long-lived GHGs, such as carbon dioxide (CO_2) is generally small when compared to other human-induced sources (Wiedinmyer *et al.,* 2014).

Emissions from domestic waste burning are released at ground level thus resulting in minimised dilution by dispersion (Lemieux, 1998). In addition, the conditions of low levels of combustion temperatures and low levels of oxygen associated with domestic waste burning may lead to incomplete combustion and extended pollutant emissions (Lemieux, 1998). Due to the diverse composition of waste materials that are usually burned in settings that are unmonitored and the difficulties in obtaining representative environmental samples for the estimation of emission factors (EFs), there is significant unreliability in the estimated emissions from exposed combustion activities (Lemieux *et al.*, 2004).

Figure 2-1 shows measured emissions from open burning of domestic waste against the controlled combustion of municipal waste in a municipal waste combustor (MWC) (Lemieux, 1998). It also compares emissions from waste where recyclables were removed (avid recycler) to waste where no recycling has taken place (non-recycler). The estimated emissions are expressed in micrograms of emissions per kilogram of waste burned.

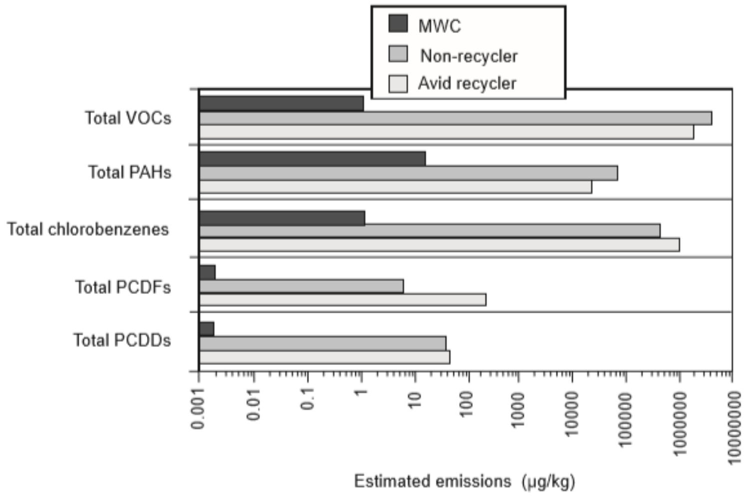

Figure 2-2: Composition of emissions per kilogram of waste burned between open burning (recycler and non-recycler) and controlled combustion (Lemieux, 1998)

Table 2-1: Average results for the various pollutants that were measured, along with the ratio between the avid recycler and the non-recycler (Lemieux, 1998).

Parameter	Average, per mass lost			Average, per household		
	Recycler	Non-Recycler	Ratio	Recycler	Non-Recycler	Ratio
WASTE COMPOSITION						
total daily waste (kg)	1.5	4.9	0.31	1.5	4.9	0.31
PVC in waste (kg)	0.07	0.01	7.00	0.07	0.01	7.00
paper waste (kg)	0.98	3.02	0.32	0.98	3.02	0.32
all plastics (kg)	0.23	0.36	0.64	0.23	0.36	0.64
food (kg)	0	0.28	0.00	0	0.28	0.00
textiles, leather (kg)	0	0.18	0.00	0	0.18	0.00
wood (kg)	0.06	0.05	1.20	0.06	0.05	1.20
glass/ceramics (kg)	0.1	0.5	0.20	0.1	0.5	0.20
metals (kg)	0.14	0.49	0.29	0.14	0.49	0.29
COMBUSTION RESULTS						
max. bed temp (°C)	370	740	0.50	370	740	0.50
fractoin burned (%)	66.7	49.1	1.36	66.7	49.1	1.36
unburned residue (kg)	0.50	2.49	0.20	0.50	2.49	0.20
AIR CONTAMINANT EMISSIONS		(mg/kg burned)			(mg/household·day)	
benzene	725	1240	0.58	725	2983	0.24
acetone	190	940	0.20	190	2262	0.08
styrene	310	740	0.42	310	1780	0.17
total TICs[a]	4000	14400	0.28	4002	34645	0.12
naphthalene[b]	40	48	0.83	40	115	0.35
phenol	85	140	0.61	85	337	0.25
dichlorobenzenes	320	160	2.00	320	385	0.83
trichlorobenzenes	400	110	3.64	400	265	1.51
tetrachlorobenzenes	140	74	1.89	140	178	0.79
pentachlorobenzene	100	53	1.89	100	128	0.78
hexachlorobenzene	48	22	2.18	48	53	0.91
acenaphthylene	3.4	11	0.31	3.4	26	0.13
naphthalene[c]	5.2	18	0.29	5.2	43	0.12
phenanthrene	3.3	7.3	0.45	3.3	18	0.19
aldehydes & ketones	140	2800	0.05	140	6737	0.02
total PCDD	0.047	0.038	1.24	0.047	0.091	0.51
total PCDF	0.22	0.0061	36	0.220	0.015	15
total PCB	0.97	2.86	0.34	0.97	6.87	0.14
PM10	5800	19000	0.31	5803	45712	0.13
PM2.5	5.3	17.4	0.30	5.3	42	0.13
HCl	2400	284	8.47	2401	682	3.52
HCN	200	468	0.43	200	1126	0.18
RESIDUALS IN ASH	µm (or ng) per kg ash					
PCDD, ng/kg	14851	1556	9.54			
PCDF, ng/kg	34040	5800	5.87			
PCB, µg/kg	220	122	1.80			
Cr	300	92	3.26			
Cu	4910	343	14			
Pb	164	32	5.13			
Zn	11500	721	16			

[a]Tentatively identified (VOC) compounds.
[b]Semi-volatile organics analysis.
[c]PAH specific analysis.

Table 2-1 gives a summary of data obtained from the tests that were undertaken by Lemieux, showing the average results for the various pollutants that were measured, along with the ratio between the avid recycler and the non-recycler. It is interesting to note that the estimated emissions varied, not only based on the type of burning (controlled versus uncontrolled), but also based on the composition of the waste. The composition of waste that is being burned is therefore an important factor influencing the emissions that is formed during the burning of waste.

2.2.2.4 The significance of waste composition as it relates to waste burning and air quality issues

Since the composition of waste is a significant factor influencing the level and type of emissions being formed during burning, the intent of this study was to generate waste composition data that could be used to contribute to more accurate air emissions calculations, which could then be based on actual, verified waste composition data, rather than estimations. Information on the composition of waste allows for assessments that will provide information on the impacts of waste burning in the environment and also to the public health.

MSW is inclusive of household waste such as food waste, yard waste, containers and packaging, as well as waste produced from other industrial, commercial, and institutional sources. Paper waste may contain synthetic materials, preservatives and even plastics (The Kerryman, 2018).

Table 2-2 provides an overview of the general waste composition per province (Oelofse, 2015). It can be noted that (by weight) organic waste and paper, typically dominate the waste composition profile.

Table 2-2: Domestic waste composition as % by weight (Oelofse, 2015)

Provinces	Paper	Plastics	Glass	Metal	Organic	Other
	Percentage contribution by weight					
Cape Town	24	15	12	7	32	9
Western Cape	24	22	9	8	22	16
Northern Cape	21	18	10	3	10	39
Free Sate	14	12	8	6	42	19
North West	11	9	6	2	58	14
Gauteng	17	10	5	3	36	30

During this study, the waste composition profile of waste being dumped at one of the largest dumping sites in Sharpeville has been determined. In Chapter 4, the waste composition profile is discussed, relative to the average waste composition of South African provinces.

2.3 An overview of the study area: Sharpeville

This section provides an overview of the study area, Sharpeville, which is located in the Emfuleni Local Municipality in the Vaal Triangle area.

Sedibeng District Municipality is comprised of three local municipalities, one of which is the Emfuleni Local Municipality. The other two local municipalities are Lesedi Local Municipality and Midvaal Local Municipality. The Sedibeng District Municipality is situated in Southern Gauteng Province. The geographical location of the Sedibeng District Municipality is at the edge of three other provinces, namely Free State, North West and Mpumalanga. The local municipality is the only region in the Gauteng Province that is located on the banks of both the Vaal Dam and Vaal River, thus covering what was then referred to the Vaal Triangle. The Emfuleni Local Municipality is situated in the far western portion of the Sedibeng District Municipality and covers an area of 987,45 km^2 (Stats SA). The Local Municipality consists of two main city centres, namely Vereeniging and Vanderbijlpark.

Bounded by numerous land use activities such as industrial, mining, commercial, agricultural and residential which are situated not so far from one another, the Vaal Triangle experiences complex and pressing air pollution issues (Scorgie *et al.,* 2003). Sources of emissions in the Vaal Triangle include industrial and commercial activities, waste treatment and disposal, domestic waste burning, transportation systems, mining industries and miscellaneous activities such as burring of tyres. It is due to above mentioned land use activities and other on-going activities such as poor waste management (which includes the burning of waste) that the air quality of the Vaal Triangle is impacted on.

Studies focusing on open burning as a significant source of hazardous emissions prompted numerous developed countries (where intentional open burning of wastes is strictly controlled and has long been considered as an outdated technology) to impose stringent restrictions on these activities (Estrellan & Iino, 2010). Air pollution and human health go hand in hand. Whether open burning of waste occurs intentionally in residential areas, unintentionally in dumpsites, or due to poorly managed and unregulated incineration, it has detrimental effects on the public health throughout the world (Cogut, 2016). Previous research showed that the occurrence of aerial particulate, Sulfur dioxide (SO_2), ozone (O_3), hydrogen sulfide (H_2S) and benzene concentrations and also identified the existing potential for extensive local exposures to numerous hazardous pollutants of the air (Scorgie *et al.*, 2003). Extensive health related impacts were pointed out for their continuous occurrence in the region due to the high concentrations of airborne particulate matter.

The Vaal Triangle was declared and Air-Shed Priority Area in terms of Section 18(1) by the Minister of Environmental Affairs and Tourism (DEA, 2006). According to DEA (2006), the area referred to as the Vaal Triangle Air-shed Priority Area in terms of section 18(1) of the National Environmental Management: Air Quality Act 2004, (Act No. 39 of 2004) is inclusive of the areas illustrated in Figure 2-3which includes the areas found within the borders of the following:

i. Emfuleni Local Municipality (Sedibeng) in the Gauteng Province,
ii. Midvaal Local Municipality (Sedibeng) in Gauteng Province,
iii. Administrative Regions 6 (Doornkop / Soweto), 10 (Diepkloof / Meadowlands) and 11 (Ennerdale/ Orange Farm) within Johannesburg in the Gauteng Province and,
iv. Metsimaholo Municipality (Northern Free State) in the Free State Province.

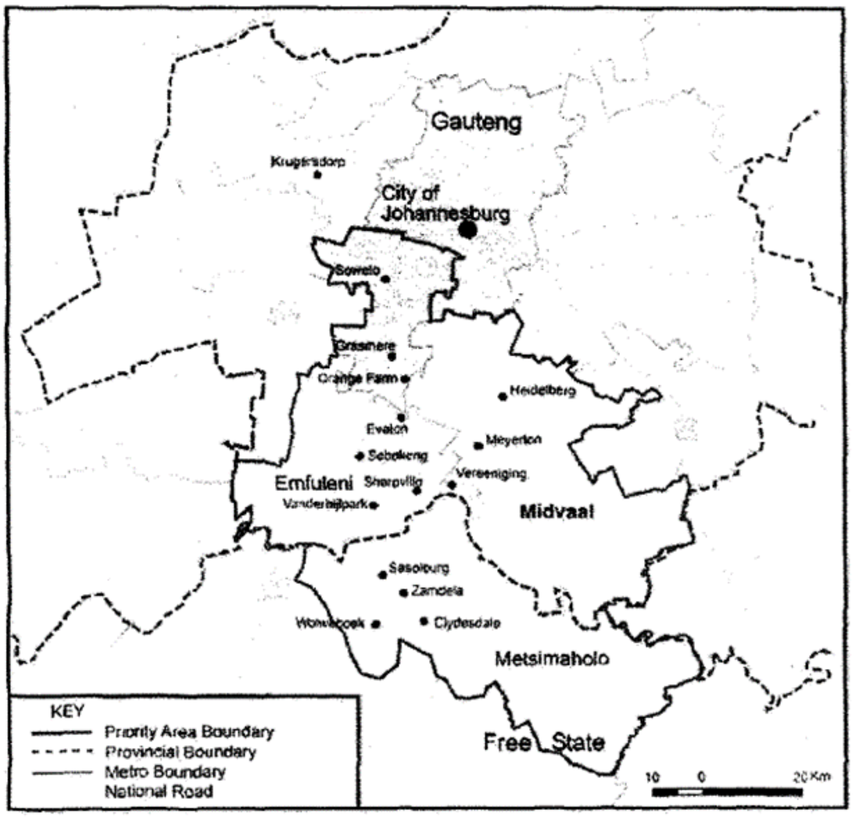

Figure 2-3: The map of the Vaal Triangle Air-shed Priority Areas (DEA, 2006)

The Sharpeville Township, being located within the Vaal Triangle region, already experiences significant pollution from surrounding industries and mines. During a Community Source Survey in 2017 (Nova, 2018), when asked to make a list of sources that pollute the air, indicated that the dumping and burning of waste was seen as the second largest source of air pollution (after dust). The emissions from industries in general is noted as being perceived as the fourth largest contributor to air pollution (Nova, 2018).

CHAPTER 3. METHODOLOGY

This section provides an overview of the processes and methods followed to address the research questions:

1. What are the extent and characteristics of waste dumping and burning in Sharpeville?
2. What is the composition of waste being dumped and burned in Sharpeville?

   The final research question (question 3, below) was not the primary focus of this study. The intent of this study was rather to provide waste characterisation and composition data, which could be used in other studies to contribute to more accurate air emissions calculations.

3. Could the burning of waste significantly impact on air quality in the Sharpeville area?

To aim to answer the research questions, a process was followed which included:

- Conducting a pilot study to identify waste dumping areas, that had the potential to be burned or that were being burned at the time of the study;

- Evaluating and cataloguing the waste dumping areas, according to their size, level of activity, estimated waste composition, etc.;

- Characterising the waste composition at one of the waste dumping sites (to establish the potential impacts of waste composition on air quality, when it is burned); and

- Conducting a literature review to establish the causes for waste dumping and burning, and also the possible impacts of waste burning on air quality.

3.1 Pilot study to identify waste dumping sites

In July 2017, a pilot study was undertaken to identify waste dumping sites. The study focused on identifying sites where waste was being burned or had the potential of being burned. The purpose of the pilot study was to establish baseline information of the extent of waste dumping and burning in Sharpeville. The sites were not evaluated in detail during the pilot study.

3.1.1 Training in preparation for the pilot study

Prior to the pilot study being undertaken, ethics training was done, as well as training to understand the application being used during the study.

3.1.1.1 Research ethics training

Prior to the data collection, the TRREE training programme in research ethics evaluation was undertaken online where the following certificates were obtained: Certificate of Informed Consent, Introduction to Research Ethics, Research Ethics Evaluation and South Africa.

3.1.1.2 Community engagement training

The Nova Institute Training on Conducting Community Source Survey (data collection) took place in Sharpeville prior to the pilot study being conducted. The training was conducted by Mr Pudumo from Nova[4] and mainly focused on how to engage with the community, should they be encountered during the pilot study.

3.1.1.3 Cellular phone application training

To capture data related to actual or potential waste burning sites, a cellular phone application was used (Mobenzi Researcher and Endomonde).

3.1.2 Method of identifying waste dumping sites

The purpose of the pilot study was to identify waste dumping sites, where waste was being burned or had the potential to be burned in future.

3.1.2.1 Determining the routes for waste dumping site identification

Specific routes of about 6 to 10 kilometres were made available and were assigned to designated fieldworkers on a daily basis. The specific routes were planned in such a way to be representative of the entire Sharpeville area. A randomised approach was taken when establishing the routes, where fieldworkers have either had to turn right or left, depending on the pre-determined randomised route. On the given randomised routes, fieldworkers had to identify actual and potential pollution sources, based on the status of waste dumping and/or burning: which are classified into the following categories:

i. Historic - the evidence previous pollution (ash from waste burning);
ii. Active - the current emitting source (waste being burned at the time of the site visit); and

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[4] Nova, a non-profit company founded in 1994 by a multidisciplinary research group (Pudumo, 2017). “Nova” is an Afrikaans acronym for Research and Development for the Prevention of Poverty (Pudumo, 2017). Nova applies a practice research with the sole aim of bettering the quality of life in residences in the Southern Africa (Pudumo, 2017).

iii. Potential - the source is not currently emitting but there are good chances of doing so in the future (waste dumps with the potential of being burned).

3.1.2.2 Capturing of data

Fieldworkers were provided with cell phones with preinstalled research applications – Mobenzi Researcher and Endomonde. Mobenzi Researcher is commonly known as a data collection tool thus generally used for the tracking of the distance followed on a particular route. Once a source was encountered, the GPS coordinates of the source needed to be captured. After capturing the GPS coordinates of the source, the number of sources observed had to be captured in a numeric form.

After observing the source, the fieldworker needed to report the source as either historic, active or potential. If the waste was contained in a skip or a bin, an option of intervention could be chosen and further details on the status of the intervention had to be provided. The status of the intervention could either be empty, half full or full. A photograph of the intervention had to be taken for recordkeeping purposes.

If the identified pollution source was 'active', the fieldworker had to choose which type of active pollution source it was. The types of active pollution sources are as follows: domestic waste burning (in stand), domestic waste burning (public place), tyre burning, cable burning and others. After choosing the type of active pollution source, the fieldworker has to capture the image of the observation. If the fieldworker has chosen 'other' the choice had to be coupled with an explanation of the particular observation. A photograph of the actual observation was taken.

If the identified pollution source was 'historic', the fieldworker had to choose which type of historic pollution source was observed. Historic pollution sources can be evidence of tyre burning, evidence of waste burning or other. After choosing the type of 'historic' pollution source observed, the fieldworker had to take a photograph of the observation.

If the identified pollution source is 'potential', the fieldworker has to choose which type of potential pollution source observed. Potential pollution sources can be domestic waste heap (inside stand), domestic waste heap (public place), old tyres, cables or other. After choosing the type of 'potential' pollution source observed, the fieldworker had to take a photograph of the observation.

After performing the pilot study, the coordinates of the identified sites were logged onto Google Earth and an image showing pins representing waste burning sites within the Sharpeville area was produced (Refer to Chapter 4, Figure 3-1).

3.2 Evaluation and cataloguing of Sharpeville waste burning sites

To expand on the pilot study, a further study was done in July 2018 during which the thirty-three sites identified (during the pilot study) were evaluated in terms of their size, level of activity, waste composition profile, amongst others.

Fieldworkers went back to the exact locations of the thirty-three sites identified in July 2017 to do the further assessment.

Existing literature and methodologies do not specifically recommend the utilisation of any particular method for the examination and evaluation of waste dumping sites for the purposes of the characterisation of waste to allow for the determination of potential air quality impacts. For the evaluation of waste dumping sites, a combination of criteria has been used. The evaluation criteria have been derived from the following documents:

- The Framework for the Management of Contaminated Land (Department of Environmental Affairs, May 2010) (mostly focused on criteria of identifying sites for risk assessment purposes);

- Waste Licence Application Process for Waste Activities in Terms of the National Environmental Management: Waste Act 2008 (No. 59 of 2008) (Department of Environmental Affairs, July 2009) (mostly focused on criteria for the classification of waste sites and fatal flaws);

- Application for Authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), and the Environmental Impact Assessment Regulations, 2014 (Department of Environmental Affairs, April 2016).

The criteria are appended as *Annexure A* of this mini-dissertation in the form of a site assessment sheet. The criteria were used to record the conditions at the waste dumping sites and characteristics, such as the description of the located site (inclusive of potential “fatal flaws” in siting and land use), size and accessibility of the located site, surrounding environmental features and infrastructure, waste disposal and burning practices (active or historical), and an approximate (visual estimation) composition of the waste.

The waste dumping sites were evaluated and an estimated composition was established (where the composition was segmented in percentages of the total waste profile at the dumping site).

Identification and evaluation of waste burning activities and waste disposal activities were also based on a visual assessment. Waste burning activities were either active (when active burning of waste is witnessed) or historic (evidence of waste burning). Observation of waste management activities (informal and/or formal) such as recycling of waste were also noted, where applicable.

The results of the evaluation of the waste dumping sites were used to assess and rank the sites according to size, burning activity, waste composition, location, etc. The aim of the ranking process was to determine which site was the largest and most active, for the purpose of selecting a site to do a more detailed waste composition characterisation.

3.3 Waste characterisation

One site was selected to perform a detailed waste composition characterisation. The purpose of the waste characterisation process was to determine the waste composition profile in order to provide information that could, in the future, be used for more accurate air emissions calculations.

Basically, the fractional composition of waste is determined by undertaking waste fraction composition studies and is commonly given as weight percentages of selected waste materials such as paper, plastic, metal and food waste (Lagerkvist *et al.*, 2011). Numerous international methods exist for domestic waste characterisation. The most commonly utilised method for waste characterisation in South Africa, is referred to as the ASTM (American Society for Testing and Materials) method for determining the composition of unprocessed MSW (ASTM D5231 - 92 (2003).

This method provides the requirements for conducting a waste composition study, including a statistically based method for estimating the number of sorts for waste characterisation. The test method applies to the determination of the mean composition of unprocessed MSW based on the collection and manual sorting of a number of samples of waste over a selected time period covering a minimum of one week. This test method includes procedures for the collection of a representative sorting sample of unprocessed waste, manual sorting of the waste into individual waste components, data reduction, and reporting of the results. The method can be applied to various waste facilities, including landfill sites, waste processing and conversion facilities, and transfer stations. During the study, an adapted version of this methodology was used as a suitable methodology for the characterisation of waste at the waste dumping. A few adjustments to the ASTM methodology was made, for instance: waste was not contained in black bags, but spread across land. Instead of weighing the waste in a closed black bag, grids were determined and sorted, and then weighed.

The waste (composition) characterisation was undertaken at one of the largest disposal sites identified in Sharpeville - which lies along the Andries Potgieter Boulevard (refer to site 16 in Figure 4.46).

The establishment of the average composition of solid waste dumped at the selected site was done according to an adapted version of ASTM D 5231-92 (2003). The waste composition analysis was based on the manual sorting of a number of samples of waste over a spatial grid which covered the entire area of the site where waste was dumped, over a period of one day.

A quadrant sampling technique was used, where different quadrants were determined to be representative of the entire dumping site (only the area where waste was dumped). The site was divided into different segments (or a grid) to allow for multiple samples to be characterised throughout the entire site, to provide for an average, composite profile of the waste. The quadrants were chosen at approximately 50 metre intervals and the sizes of the quadrats were approximately 3 x 3 metres (or 9 m^2) each.

Although the ASTM method for determining the composition of unprocessed MSW (ASTM D5231 - 92; 2016) is inclusive of 'black bags' sampling, in this instance sampling was carried out without bags because waste was already dumped in heaps throughout the site. Some waste was dumped in 'black bags', however, the majority of the bags were badly damaged.

The following materials were used for the waste (composition) characterisation:

iv. Seven plastic containers;
v. Hanging scale;
vi. Measuring tape; and
vii. Data sheet.

Personal Protective Equipment (PPE) in the form of rubber gloves and masks were worn for protection purposes. It is of essence to wear appropriate PPE when handling materials that could pose a health risk to human beings.

Seven samples were taken to cover the dumping area of approximately 400 metres (in length), using the grid/segmented area (as explained above). The waste in the 3 x 3 metre area was sorted into seven categories (as proposed by the ASTM methodology) as follows:

i. Paper and cardboard;
ii. All plastics (dense and plastic film) and polystyrene;
iii. Food waste;
iv. Other organics (not food);
v. Metals;
vi. Glass; and
vii. Other.

Each of the categories were weighed at each of the sampling sites and expressed as a percentage of the total waste sampled at the site, to calculate the percentage composition of each waste type. To calculate an average waste composition for each waste type (to be representative of the entire site), the average composition of each waste type was determined (taking the data of all seven sites into consideration). This average composition data was then used in the results and discussion section to determine the possible implications of the waste composition as far as impacts on air quality is concerned when waste is being.

3.4 Literature review

The collection of secondary data consisted of an extensive literature review to provide context to the research as far as the following is concerned:

- The potential reasons for the dumping and burning of waste in the Sharpeville area;
- The potential impacts of waste burning on air quality;
- The general composition of domestic waste (based on studies done elsewhere in South Africa, as well as international studies);
- How waste composition may influence the type and amount of emissions to air

The purpose of the literature review was to provide context to the current study, when compared to other studies, and to provide background for discussion purposes.

Mainly academic published articles in journals, dissertations and books were utilised for acquiring the secondary data. Databases that were used included the North-West University library database, EBSCO-Host, Google Scholar, Science Direct and the other sources available on the internet.

CHAPTER 4. RESULTS AND DISCUSSION

This chapter contains the results of the study, which focused on:

i. Identifying waste dumping sites, where waste was being burned or had the potential to be burned;

ii. Evaluating and cataloguing the waste dumping sites in terms of their size, waste composition and level of activity, etc.; and

iii. Characterising the waste composition of waste dumped at one of the waste dumping sites (to determine the potential impact that waste composition may have on the formation of emissions, when waste is burned).

4.1 Results of waste dumping site identification

During the pilot study in July 2017, thirty-three waste dumping sites within the Sharpeville area were identified (Figure 4-1). The coordinates of the identified sites were logged into Google Earth and a Google map, indicating the position of the thirty-three waste dumping sites within the Sharpeville area was produced (Figure 4-1).

The sites were mainly located in the vicinity of houses in open fields or vacant pieces of land, across from houses, next to roads and even in trenches. The level of burning activity differed at the sites, with some being highly active and others with evidence of historic burning.

The objective of the pilot study was not to evaluate the dumping sites in detail, but rather to gain an understanding of the extent of waste dumping and burning in the Sharpeville area, to determine whether it warrants further study. The pilot study revealed that waste dumping and burning were extensive and warranted further study. The follow-up study was done a year later, in July 2018, where the thirty-three sites were further assessed in terms of their size, level of burning activity, waste composition, location etc.

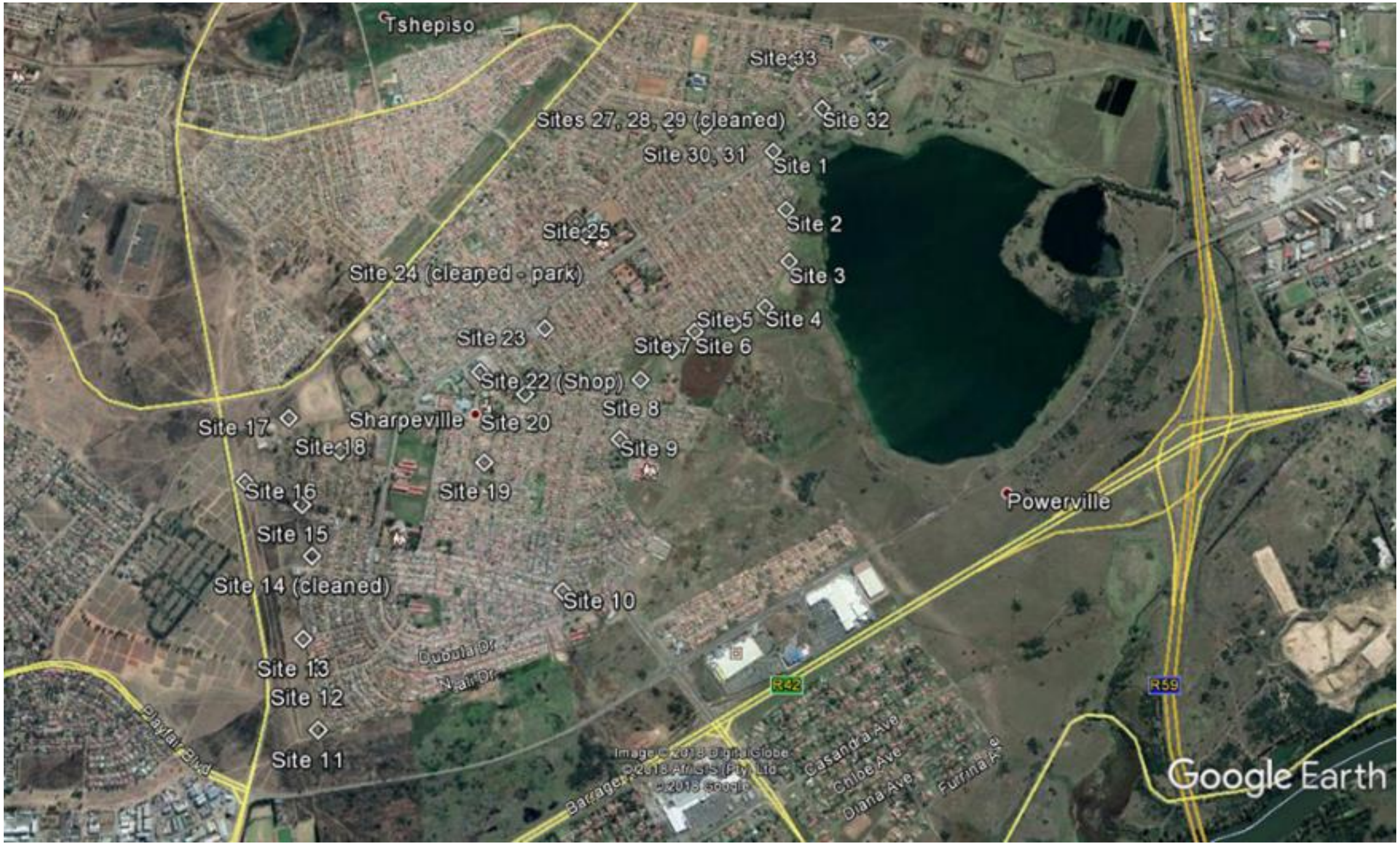


Figure 4-1: **Google Earth Image of the sites located in Sharpeville that were evaluated and assessed during the study.**

4.2 Results of evaluation and cataloguing of Sharpeville waste dumping sites

The thirty-three sites that were identified during the pilot study (in July 2018) were assessed based on their location, size, level of burning activities and waste composition, among other aspects. A full description of each site was provided to allow for the evaluation and trending the sites in the future.

The full description of the sites is provided in tables, which also provides imagery of the waste dumping sites.

4.2.1 Site 1 S26°40’ 46.05”; E027°53’ 10.48”

Site location: Site 1 is located on the corner of Seeiso Street and Seilhatole Avenue in Sharpeville. It is surrounded by a main road towards the north, an open field towards the south and east, and residential dwellings towards the west. The site is situated roughly 250 metres north-west of the edge of the Leeukuil Dam.

Figure 4-2: Location of site 1 in south-westerly view parallel to Seeiso Street

Figure 4-3: South-easterly view of site 1 with the Leeukuil Dam visible

Site description: Waste is dumped in an area of approximately 400 m^2 directly adjacent to Seeiso Street. At the time of the site visit, it was observed that the open field was being used for recreational activities (children playing soccer) and as a grazing area for cattle. The site has a gentle slope towards the Leeukuil Dam and its vegetation cover is best described as natural veld with scattered alien species. The site is easily accessible from both Seeiso Street and Seilhatole Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

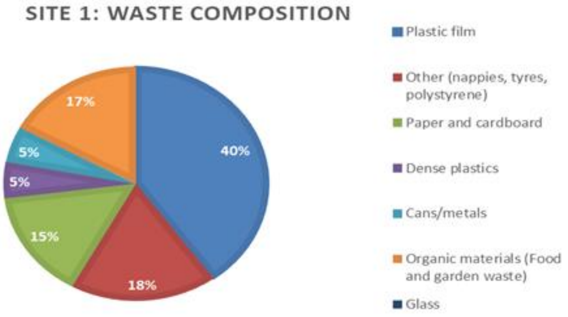


Figure 4-4: Composition of waste dumped at site 1

Visual observation indicated that the waste consisted mainly of plastic film (40%), followed by other wastes, such as tyres, polystyrene and nappies (18%); and roughly 15% paper and cardboard, 5% dense plastics, 5% cans and metals and no glass.

A pedestrian indicated that waste was being recycled from the dump.

Although no active waste burning was observed at the time of the site visit, evidence existed of waste being burned at multiple locations within the site.

4.2.2 Site 2 S26°40' 55.15"; E027°53' 11.10"

Site location: Site 2 is located on the corner of Khabasheane Street and Kupeka Avenue in Sharpeville. It is surrounded by residential dwellings towards the north and an open field towards the south. The site is situated roughly 200 metres west of the edge of the Leeukuil Dam.

Figure 4-5: Location of site 2

Figure 4-6: Evidence of burnt tyres in site 2

Site description: Waste is dumped in an area of approximately 500 m^2 directly adjacent to the Leeukuil Dam and parallel to Kupeka Avenue. At the time of the site visit, a lady was seen collecting bottles. The open field next to the dumping site was used for recreational activities. The site has a gentle slope towards the Leeukuil Dam and its vegetation cover is best described as natural veld with scattered alien species (mostly covered in grass).

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

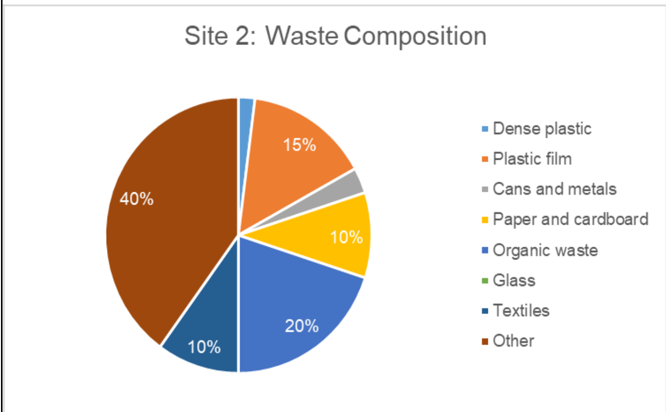


Figure 4-7: Composition of waste dumped at site 2

Visual observation indicated that the waste consisted mainly of other wastes, such as tyres, building rubble, polystyrene and nappies (approximately 40%), followed by 20% organic materials and roughly 15% plastic film, 10% paper and cardboard, 10% textiles, 2% dense plastics, 3% cans and metals and no glass.

Although no active waste burning was observed at the time of the site visit, evidence existed of historical burning.

4.2.3 Site 3 S 26°4'2. 93; E 27°53' 10.32"

Site location: Site 3 is located on open field across from the corner of Dubula Dr and Matlaku in Sharpeville. It is surrounded by residential areas, an open field towards the south and east, and residential dwellings towards the west. The site is situated roughly 200 metres west of the edge of the Leeukuil Dam.

Figure 4-8: Location of site 3

Figure 4-9: Evidence of waste burning in Site 3

Site description: Waste is dumped in an area of approximately 500 m^2 with multiple patches of burning scattered around directly parallel to Dubula Dr Street. At the time of the site visit, domestic animals were observed. The site has a gentle slope towards the Leeukuil Dam and its vegetation cover is best described as natural veld with scattered alien species. The site is easily accessible from both Dubula Dr Street and Matlaku Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

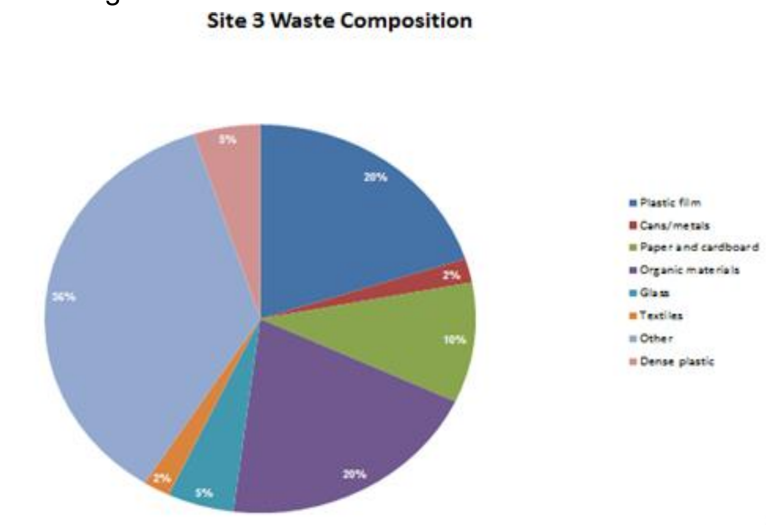


Figure 4-10: Composition of waste dumped at site 3

Visual observation indicated that the waste consisted mainly of plastic films (approximately 20%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 36%); and roughly 10% paper and cardboard, 5% dense plastics, 2% cans and metals and 5% glass.

4.2.4 Site 4 S 26°41’9.24 93; E 27°53’ 5.31”

Site location: Site 4 is located across the intersection of Dubula Dr and Motshentone Avenue in Sharpeville. It is surrounded by very close proximity from residential areas, an open field next to the road. The site is situated roughly 350 metres away from the edge of the Leeukuil Dam.

Figure 4-11: Location of site 4

Figure 4-12: Site 4

Site description: Waste is dumped in an area of approximately 500 m^2 with multiple patches of burning scattered around directly parallel to Dubula Dr Street. At the time of the site visit, domestic animals were observed. The site has a gentle slope towards the Leeukuil Dam and its vegetation cover is best described as natural veld with scattered alien species. The site is easily accessible from both Dubula Dr and Motshentone Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

Visual observation indicated that the waste consisted mainly of plastic films (approximately 20%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 36%); and roughly 10% paper and cardboard, 5% dense plastics, 2% cans and metals and 5% glass.

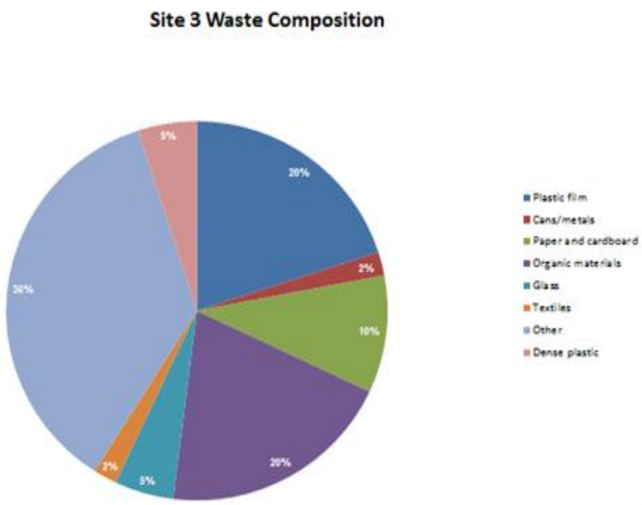


Figure 4-13: Composition of waste dumped at site 4

4.2.5 Site 5 S26°41’ 11.14”; E027°52’ 60.00”

Site location: Site 5 is located at the junction of Molefe Avenue and Mofolo Avenue in Sharpeville. It is surrounded by residential dwellings (formal and informal), an open field and two roads (Molefe Avenue and Mofolo Avenue). The site is situated roughly 400 metres away from the edge of the Leeukuil Dam.

Figure 4-14: Evidence of historic burning at site 5

Figure 4-15: Site 5 with piles of waste being dumped

Site description: Waste is dumped in an area of approximately 400 m^2 at the junction of Molefe Avenue and Mofolo Avenue. The site has a gentle slope towards the Leeukuil Dam and its vegetation cover is best described as natural veld with scattered alien species. There is a canal on site separating the site from what looked like an old rehabilitated waste site. The site is easily accessible from both Molefe Avenue and Mofolo Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

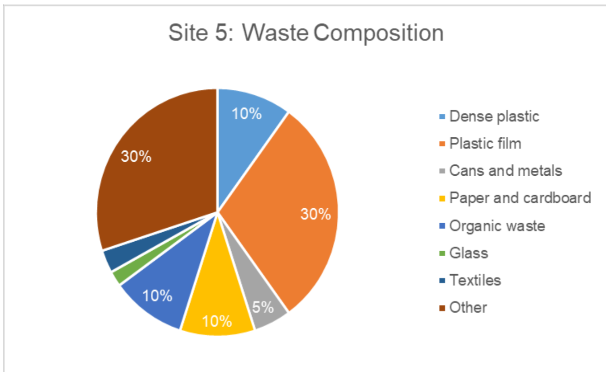


Figure 4-16: Composition of waste dumped at site 5

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 30%); and roughly 10% paper and cardboard, 10% organic materials, 10% dense plastics, 5% cans and metals and 2% glass. Although no active waste burning was observed at the time of the site visit, evidence of historic burning existed.

4.2.6 Site 6 S26°41' 11.47"; E27°52' 53.45"

Site location: Site 6 is located on Mbata Avenue (1841 Mbata Avenue) in Sharpeville. It is parallel to residential dwellings and adjacent to a retail area (shops). It is also surrounded by an open space.

Figure 4-17: Evidence of waste burning in Site 6.

Figure 4-18: South-easterly view of Site 6 with the Leeukuil Dam visible.

Site description: Waste is dumped in an area of approximately 500 m^2 on Mbata Avenue. At the time of the site visit, it was observed that the local residents were burning waste for warmth. The site is flat and is situated about 600m from the Leeukuil Dam. The site is easily accessible from on Mbata Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

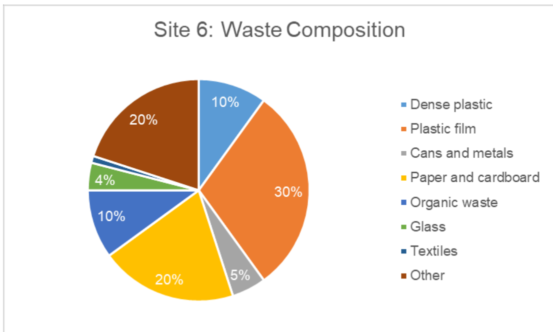


Figure 4-19: Composition of waste dumped at site 6.

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by other wastes, such as building rubble (approximately 20%); and roughly 20% paper and cardboard, 10% dense plastics, 10% organic materials, 5% cans and metals and 4% glass.

4.2.7 Site 7 S26°41’ 13.13”; E27°52’ 49.40”

Site location: Site 7 is located on the corner of Hulwana Street and Mbata Avenue in Sharpeville, adjacent to a school (Lebowa Primary School). It is surrounded by a residential dwellings and a school. There is a ditch running through the dumping site. The site is situated roughly 600 metres from the edge of the Leeukuil Dam.

Figure 4-20: Active burning in site 7

Figure 4-21: Waste dumping at site 7

Site description: Waste is dumped in an area directly adjacent to Lebowa Primary School. At the time of the site visit, a lady was seen collecting plastic bottles and glasses. The lady mentioned that the plastic bottles and glasses were being taken to a nearby recycling place. Another individual was seen burning waste in a black plastic bag on site.

The site is flat and its vegetation cover is best described as veld dominated by alien species.

The site is easily accessible from both Hulwana Street and Mbata Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

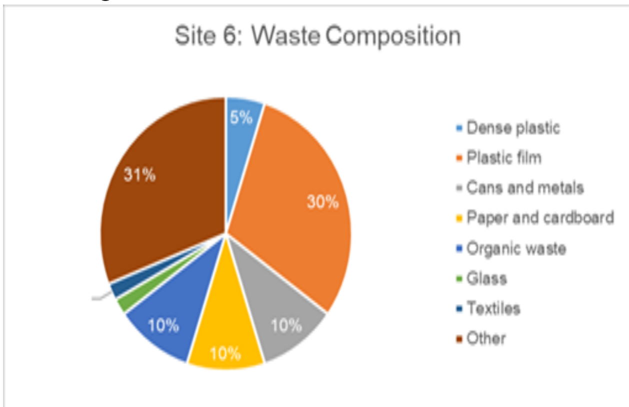


Figure 4-22: Composition of waste dumped at site 7

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 31%); and roughly 10% paper and cardboard, 10% cans and metals,10% organic materials, 5% dense plastics, 2% textiles and 2% glass.

4.2.8 Site 8 S26°41’ 47.17.41”; E27°52’ 43.76”

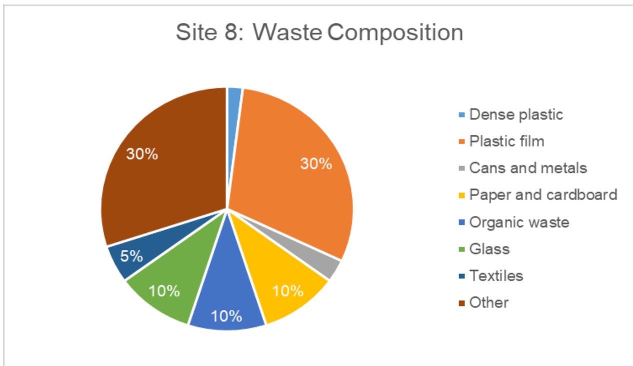
Site location: Site 8 is located on Sakala Street in Sharpeville. It is adjacent to Hulwana Avenue. It is surrounded by an open field, residential dwellings and a school (Lebona Primary School).

Figure 4-23: Pile of waste in site 8

Figure 4-24: Close-up of waste composition at site 8

Site description: Waste is dumped throughout a large area (of approximately 200 m^2) in piles covering areas of about 30 m^2. The open field is partially fenced (only on Sakala Street). At the time of the site visit, an individual was seen dumping waste and also children were seen playing on the road next to the illegal dumping site. The site is easily accessible from Hulwana Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.



Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 30%); and roughly 10% paper and cardboard, 10% organic materials, 10% glass, 5% textiles, 2% dense plastics and 3% cans and metals.

Figure 4-25: Composition of waste dumped at site 8.

Although no active waste burning was observed at the time of the site visit, evidence existed of waste being burned at multiple locations within the site.

4.2.9 Site 9 S26°41' 25.51"; E27°52' 39.26"

Site location: Site 9 is located on the corner of Zwane Street and Nhlapo Street, directly adjacent to a school (Titima Primary School), in Sharpeville. It is surrounded by residential dwellings and a road.

Figure 4-26: Evidence of past waste burning at site 9

Figure 4-27: Extent of waste dumping at site 9

Site description: Waste is dumped in an area of approximately 1.6 km^2 directly parallel to Zwane Street. At the time of the site visit, an individual was seen collecting dense plastics (plastic bottles etc.). A small portion of waste was seen burning. The site' s vegetation cover is best described as natural veld with scattered alien species. The site is easily accessible from both Zwane Street and Nhlapo Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

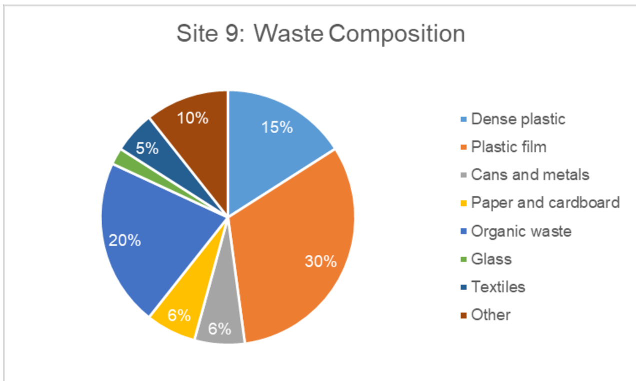


Figure 4-28: Composition of waste dumped at site 9.

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by organic materials (approximately 20%), 15% dense plastics, 10% other wastes, such as tyres, polystyrene and nappies and roughly 6% paper and cardboard, 5% textiles, 6% cans and metals and 2% glass.

4.2.10 Site 10 S26°41’ 45.57”; E27°52’ 27.42”

Site location: Site 10 is located on the corner of Teatea Street and Dlamini Street in Sharpeville. It is situated within a residential area, next to Dlamini Street and also about 20m from a retail area.

Figure 4-29: Waste profile and location of site 10

Figure 4-30: Piles of waste dumped at site 10

Site description: Waste is dumped in an area of approximately 500 m^2 directly parallel to Dlamini Street. Waste piles occupying areas of approximately 30 m^2 are scattered throughout the larger area. The vegetation cover of the rea is best described as natural veld which is in good condition. The site is easily accessible from both Dlamini Street and Teatea Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

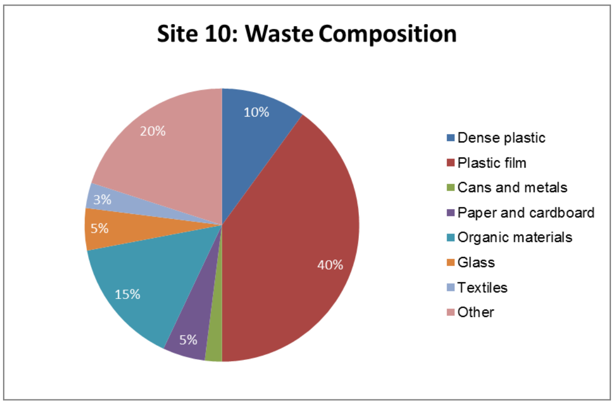


Figure 4-31: Composition of waste dumped at site 10

Visual observation indicated that the waste consisted mainly of plastic films (approximately 40%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 20%); and roughly 15% of organic materials, 5% paper and cardboard, 5% glass and 2% cans and metals.

At the time of the visit an individual was seen collecting cans. One pile of waste was burning and also evidence existed of waste being burned at multiple locations within the site.

4.2.11 Site 11 S26°41' 59.60"; E27°51' 47.89"

Site location: Site 11 is located on Oliphant Street in Sharpeville. It is surrounded by an open area and informal and formal residential dwellings. The illegal dumping site is situated opposite the Vuka Cemetery.

Figure 4-32: Waste dumping at site 11

Figure 4-33: Compositional waste of site 11

Site description: Waste is dumped in an area forming an L-shape, of approximately 0.6 m^2 on Oliphant Street. Waste is also dumped on the edge of the cemetery. At the time of the site visit, it was observed that pedestrians use that area for walking and also for recreational activities (children playing soccer). The site has a vegetation cover which is best described as veld dominated by alien species. The site is easily accessible from Oliphant Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

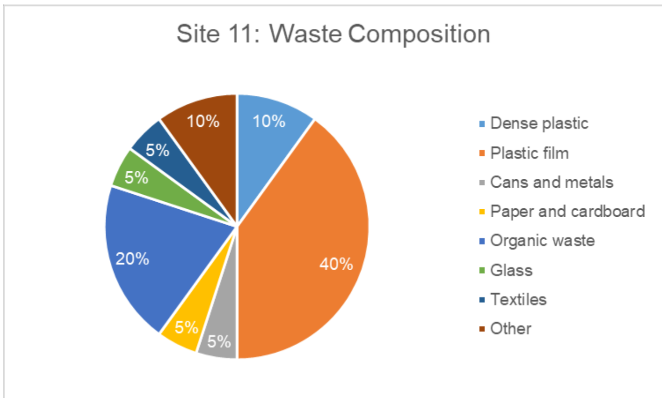


Figure 4-34: Composition of waste dumped at site 11

Visual observation indicated that the waste consisted mainly of plastic films (40%), followed by organic materials (20%), wastes, such as tyres, polystyrene and nappies (approximately 10%); 10% of dense plastic and roughly 5% paper and cardboard, 5% cans and metals, 5% glass and 5% textiles.

4.2.12 Site12 S26°41’ 51.24”; E27°51’ 48.47”

Site location: Site 12 is located alongside Sanuku Street in Sharpeville. It is situated next to a church and open field next to a cemetery. There is no fencing next to the road that is opposite houses. The site is situated in close proximity to the O.L Sherman A.M.E Church.

Figure 4-35: Location of site 12

Figure 4-36: Composition waste of site 12.

Site description: Waste is dumped in an area of approximately 400 m^2 directly adjacent to Sanuku Street with waste piles scattered around the site. At the time of the site visit, evidence of waste burning was observed. The site has informal and formal settlements, church and a cemetery. Children were seen playing near the dump. The site is dominated by natural veld with scattered alien species. The site is easily accessible from Sanuku Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

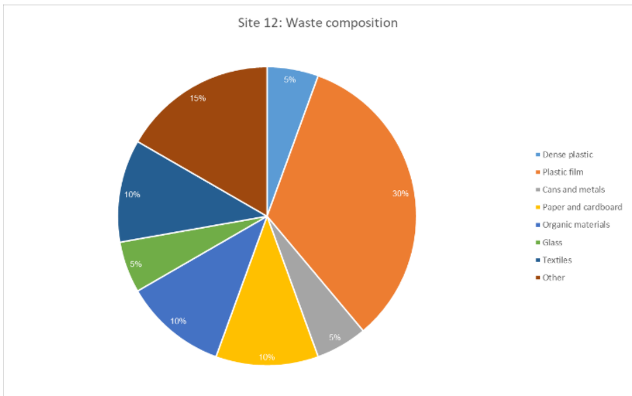


Figure 4-37: Composition of waste dumped at site 12

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 15%); and roughly 10% paper and cardboard, textiles 10%, Organic materials 10%, 5% dense plastics, 5% cans and metals, and glass 5%.

4.2.13 Site 13 S26°41' 47.12"; E27°51' 46.84"

Site location: Site 13 is located on the corner of Lepheahe Street and Molefe Street in Sharpeville. It is surrounded by Lehlasedi High School, a cemetery, and residential dwellings.

Figure 4-38: Waste dumping at site 13

Figure 4-39: Waste composition at site 13

Site description: Waste is dumped in an area of approximately 500 m^2 at the corner of Lepheahe Street and Molefe Street. At the time of the site visit, it was observed that the local residents of Sharpeville used that open space for walking and also for recreational activities. Its vegetation cover is best described as natural veld with scattered alien species. The site is easily accessible from both Lepheahe Street and Molefe Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

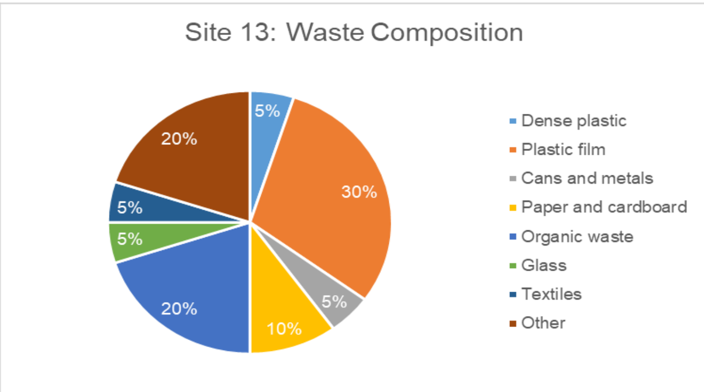


Figure 4-40: Composition of waste dumped at site 13

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 20%); and roughly 20% organic materials, 10% paper and cardboard, 5% dense plastics, 5% cans and metals and 5% glass.

A pedestrian indicated that waste was being recycled from the dump. Although no active waste burning was observed at the time of the site visit, evidence existed of waste being burned at multiple locations within the site.

4.2.14 Site 14 S26°41’ 35.95”; E27°51’ 49.34”

Site location: Site 14 is located on the corner of Lepheahe Street and Manyokolo Street in Sharpeville. It is situated next to a cemetery, within a residential area.

Figure 4-41: Evidence of burning at site 14

Figure 4-42: Cleaned out site 14

Site description: At the time of the site visit, evidence of historic burning was observed and there was no active dumping. It seemed as if the site was cleaned up between July 2017 and July 2018. The site is easily accessible from Lepheahe Street and Manyokolo Street.

4.2.15 Site 15 S26°41’ 28.67”; E27°51’ 48.56”

Site location: Site 15 is located alongside Sekese Street in Sharpeville. It is situated at the edge of the cemetery. The site is surrounded by informal settlements and is located adjacent to the cemetery.

Figure 4-43: Location of site 15

Figure 4-44: Composition of waste site 15.

Site description: Waste is dumped in an area of approximately 500 m^2 directly adjacent to Sekese Street. At the time of the site visit, it was observed that there were informal settlements and formal settlements. During the site visit children were seen playing near the dump. The site was dominated by natural veld with scattered alien species. The site is easily accessible from Sekese Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

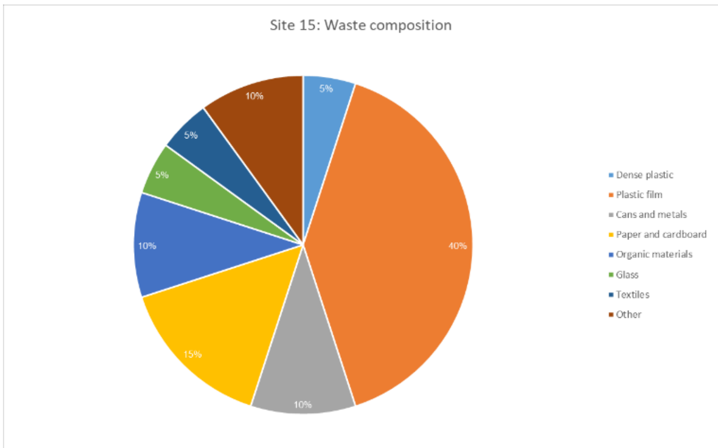


Figure 4-45: Composition of waste dumped at site 15

Visual observation indicated that the waste consisted mainly of plastic films (approximately 40%), 15% paper and cardboard followed by other wastes, such as tyres, polystyrene and nappies (10%); and roughly, textiles 5%, Organic materials 10%, 5% dense plastics, 10% cans and metals, and glass 5%.

4.2.16 Site 16 S26°41’ 59.60”; E27°51’ 47.89”

Site location: Site 16 is located on the corner of Andries Potgieter Boulevard and Sekese Street in Sharpeville. It is surrounded by a main road (Andries Potgieter Boulevard), an open field and two cemeteries. The site is situated next to a water tower. The site is approximately 1,2 km^2 of which most of the surface area is covered by waste.

Figure 4-46: Location of site 16

Figure 4-47: Composition of waste site 16

Site description: Waste is dumped in a large area next to a main road (approximately 1,2 km^2). At the time of the site visit, it was observed that people were using the open field for walking. The site is not fenced and is extremely large in size. At the time of the visit waste was being burnt.

The site is easily accessible from both Andries Potgieter Boulevard and Sekese Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

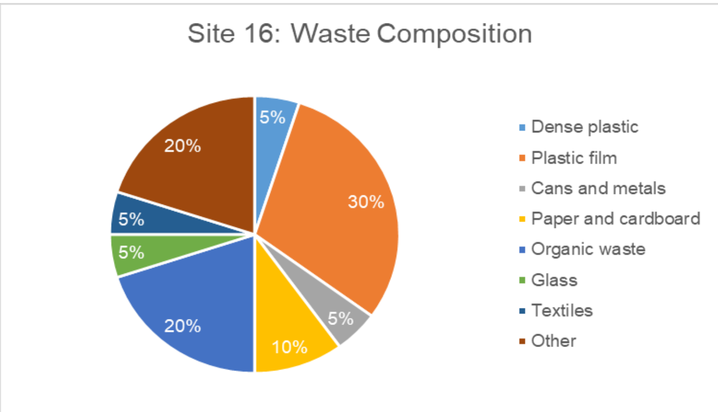


Figure 4-48: Composition of waste dumped at site 16

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 20%); and roughly 20% organic materials, 10% paper and cardboard, 5% dense plastics, 5% cans and metals and 5% glass.

This was the biggest of the thirty-three sites observed. Active burning of waste was taking place at the time of the site visit.

4.2.17 Site 17 S26°41’ 16.12”; E027°51’ 47.68”

Site location: Site 17 is located off Moraka Street, between the reservoir and the George Thabe Stadium in Sharpeville. It is surrounded by informal residential dwellings, a reservoir and a stadium (George Thabe Stadium). The site looked like it has been cleaned prior to the site visit.

Figure 4-49: Waste dumping at site 17

Figure 4-50: Composition of waste site 17

Site description: Waste is dumped in a small area, directly adjacent to the reservoir, parallel to the stadium (George Thabe Stadium). At the time of the site visit, it looked as though the site has been cleaned. The open field was being used for walking, and as a grazing area for cattle. The site’s vegetation cover is best described as veld dominated by alien species. The site is easily accessible from Moraka Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

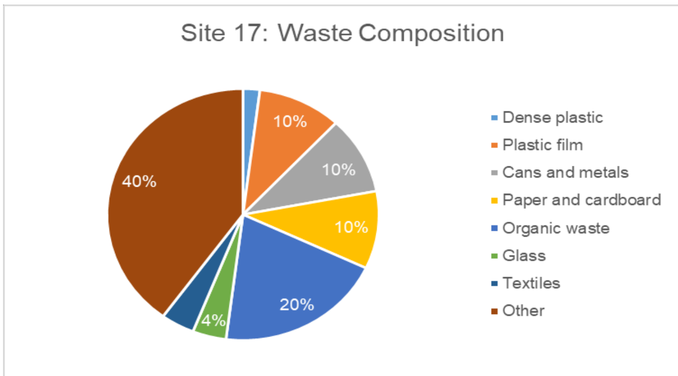


Figure 4-51: Composition of waste dumped at site 17

Visual observation indicated that the waste consisted mainly of other wastes, such as building rubble, polystyrene and nappies (approximately 40%); followed by organic materials (approximately 20%), and roughly 10% plastic films, 10% paper and cardboard, 10% cans and metals, 2% dense plastics and 4% glass.

Although no active waste burning was observed at the time of the site visit, evidence existed of waste being burned at multiple locations within the site.

4.2.18 Site 18 S26°41’ 21.86”; E27°51’ 55.27”

Site location: Site 18 is located on the corner of George Thabe Street and Andries Potgieter Boulevard in Sharpeville. It is surrounded by a sports field and located within an informal settlement.	
 **Figure 4-52: Site 18 with bags of waste being stored on bare soil**	 **Figure 4-53: Composition of waste site 18.**
Site description: Waste is dumped in an area of approximately 0.5 km^2 directly adjacent to George Thabe Street and Andries Potgieter Boulevard. At the time of the site visit, a storage area for recycling without access control was observed. The site is easily accessible from both George Thabe Street and Andries Potgieter Boulevard.	
Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste. No active burning was taking place at the time of the site visit. The waste was stored in 1 tonne bags and a visual estimation of the waste composition could not be done.	

4.2.19 Site 19 S26°41’ 26.20”; E27°52’ 17.59”

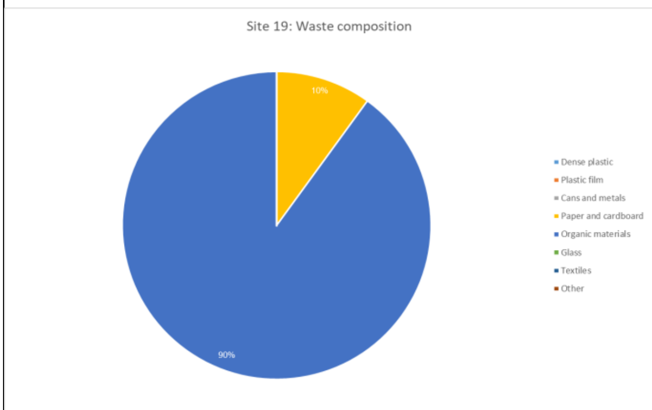
Site location: Site 19 is located along Safatso Street in Sharpeville. It is surrounded by some residential dwellings.

Figure 4-54: Signs of historic dumping and waste burning at site 19

Figure 4-55: Composition of waste at site 19. Most of the waste has been cleaned up

Site description: Waste is dumped in an area of approximately 400 m^2 directly adjacent to Safatsa Street, with two piles of waste on the site. At the time of the site visit, it was observed that the area looks like it was cleaned out. The site was located within an open field, which was being used for recreational activities (children playing soccer). The site has informal and formal settlements and its vegetation cover is best described as natural veld with scattered alien species.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.



Visual observation indicated that the waste consisted mainly of organic material (approximately 90%) and paper and cardboard (approximately 10%).

There was no evidence of recent burning or dumping of waste.

4.2.20 Site 20 S26°41’ 17.25”; E27°52’ 25.23”

Site location: Site 20 is located on the corner of Khabasheane Street and Khantsi Street in Sharpeville. It is surrounded by an open field, residential dwellings and a church.

Figure 4-57: Evidence of waste burning at site 20

Figure 4-58: Composition of waste site 20

Site description: Waste is dumped in an area of approximately 400 m^2 next to the corner of Khabasheane Street and Khantsi Street. At the time of the site visit, it was observed that the open field was being used for recreational activities. The site’s vegetation cover is best described as natural veld with scattered alien species. The site is easily accessible from both Khabsheane Street and Khantsi Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

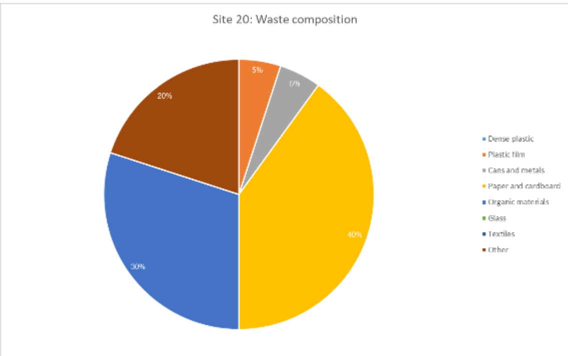


Figure 4-59: Composition of waste dumped at site 20

Visual observation indicated that the waste consisted mainly about 40% paper and cardboard, approximately 30% organic material, approximately 5% of Other material such as tyres, polystyrene and nappies, plastic films and approximately 5% of cans and metals.

Although no active waste burning was observed at the time of the site visit, there was evidence of waste burning. There was no access control on site, the area is not fenced thus anyone can access the site at any time.

4.2.21 Site 21 S26°41’ 15.15”; E27°52’ 26.72”

Site location: Site 21 is located within the roundabout of Khabasheane Street and Khantsi Street in Sharpeville. It is opposite a church, within a residential area.

Figure 4-60: Dumping of mostly garden and organic waste at site 21

Figure 4-61: Composition of waste site 21

Site description: Waste is dumped in an area of approximately 600 m^2 directly adjacent to Khabasheane Street and Khantsi Street. At the time of the site visit, evidence of historical burnin was observed. The site was being used for recreational activities (children playing soccer). The site consisted mostly of patches of bare soil.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

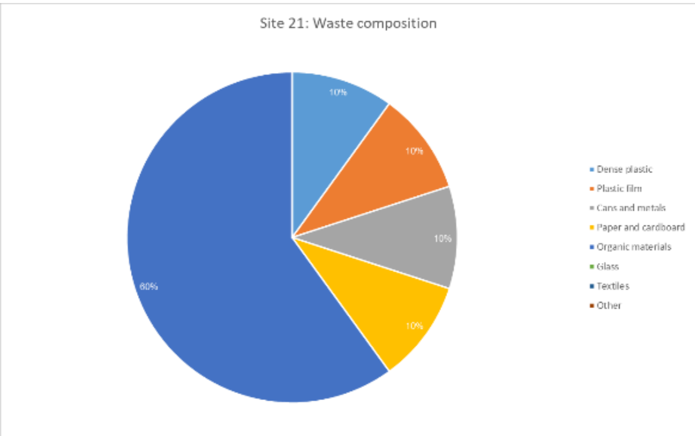


Figure 4-62: Composition of waste dumped at site 21

Visual observation indicated that the waste consisted mainly of organic material 60%, plastic films (approximately 10%), followed by other wastes, such as tyres, polystyrene and nappies (approximately 10%); and roughly 10% paper and cardboard, 10% dense plastics, 10% cans and metals, textiles 0%, other 0% and 0% glass.

Although no active waste burning was observed at the time of the site visit, evidence shows there is no access of control and any pone can access the area.

4.2.22 Site 22 S26°41’ 13.18”; E27°52’ 18.53”

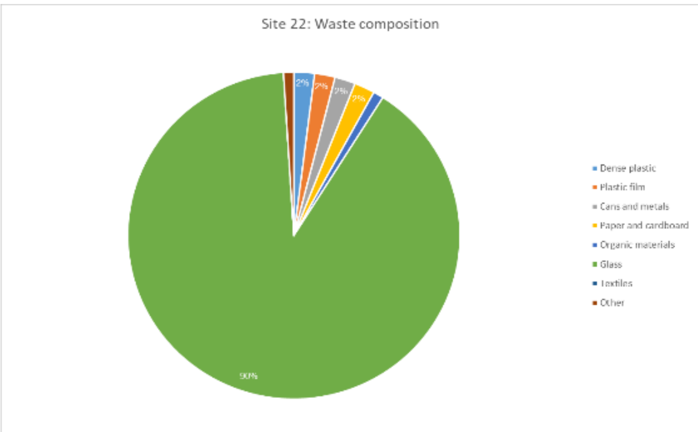
Site location: Site 22 is located at Seiso Street in Sharpeville. It is within a commercial complex across Sharpeville Exhibition Centre within a residential area.

Figure 4-63: Site 22, a waste dump/storage area located next to a commercial complex

Figure 4-64: Composition of waste site 22

Site description: Waste is dumped in an area of approximately 10 m^2 directly adjacent to Seiso Street. Waste from Ndombi’s Pub and Restaurant was being stored in a dedicated area.

Waste-related activities: The site seemed like a temporary storage site at the commercial complex. Waste could have been stored for collection for disposal purposes, for or recycling. Visual observation indicated that the waste consisted mainly of glass 90% and, plastic films (approximately 2%), followed by other wastes, such as tyres, polystyrene (approximately 2%); and roughly 2% paper and cardboard, 2% dense plastics, 2% cans and metals, organic material 1%, other 1% and textiles 0%.



4.2.23 Site 23 S26°41’ 8.13”; E27°52’ 29.66”

Site location: Site 23 is located on the unnamed street parallel to Seiso Street in Sharpeville. It is behind a commercial complex (Shoprite) close to Sharpeville Exhibition Centre.

Figure 4-66: Location of site 23

Figure 4-67: Waste composition of waste site 23

Site description: Waste is dumped in an area of approximately 250 m^2 directly parallel to Seiso Street. No evidence of waste burning was observed. Three bags filled up with glass bottles were stored at the site. Its vegetation cover is best described as natural veld with scattered alien species.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste. No active waste burning was observed at the time of the site visit. An individual was seen collecting plastic bottles.

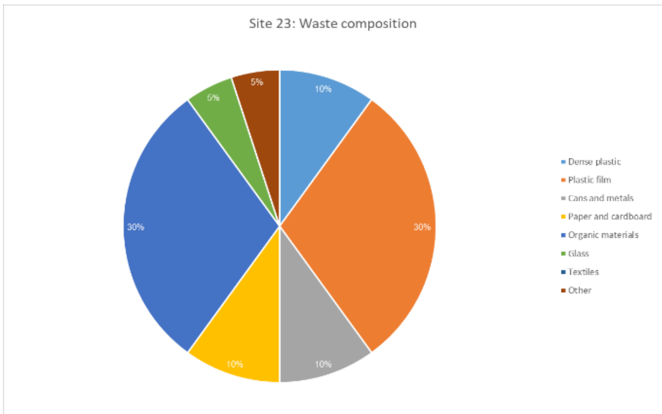


Figure 4-68: Composition of waste dumped at site 23

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by organic materials 30%, other wastes, and roughly 10% paper and cardboard, 10% dense plastics, 10% cans and metals, such as tyres, polystyrene and nappies (approximately 5%) and glass 5%.

4.2.24 Site 24 S26°40' 59.30"; E27°52' 19.59"

Site location: Site 24 is located on Sobuza Street in Sharpeville. It is surrounded by a residential area in Meadowdale Park.

Figure 4-69: Site 24 has been totally cleaned by residents

Figure 4-70: Cleaned t site 24

Site description: At the time of the site visit, it was observed that an illegal dumping site (observed during the first site visit in 2017) was turned into a recreational park. The cleaning started in November 2017. The site is easily accessible from Sobuza Street.

Waste-related activities: The illegal dumping site (observed in 2017) was cleaned up and turned into a recreational park by the residents of the area. No dumping of waste took place at the time of the site visit (July 2018).

4.2.25 Site 25 S26°40’ 55.24”; E027°52’ 38.08”

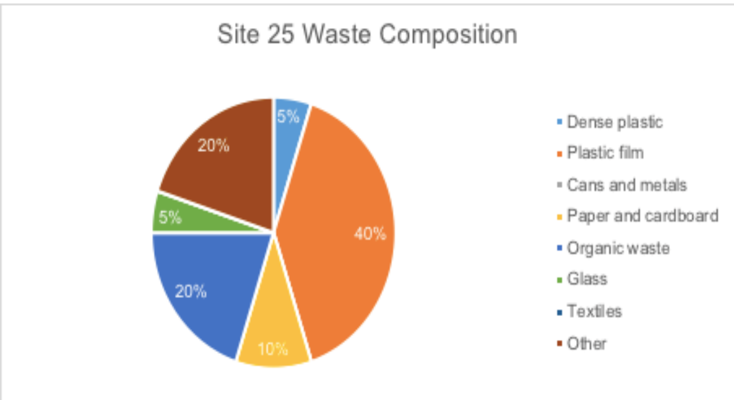
Site location: Site 25 is located on Hulwana Avenue in Sharpeville. It is surrounded by a road (Hulwana Avenue), a school (Kopanong Primary School) and residential dwellings.

Figure 4-71: Waste profile at site 25

Figure 4-72: Dumping of waste at site 25

Site description: Waste is dumped in an area of approximately 100 m^2 Hulwana Avenue. The dumping site consists of multiple portions of burnt waste scattered around. The site is flat and consists of bare soil. The site is easily accessible from Hulwana Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.



Visual observation indicated that the waste consisted mainly of plastic films (approximately 40%), followed by other wastes, such as building rubble, polystyrene, hair and nappies (approximately 20%); and roughly 20 % of organic materials, 10% paper and cardboard, 5% dense plastics, 5% no glass and no cans and metals.

Figure 4-73: Composition of waste dumped at site 25

Although no active waste burning was observed at the time of the site visit. Evidence existed of waste being burned, historically, at multiple locations within the site.

4.2.26 Site 26 S26°40’ 52.87”; E27°52’ 36.77”

Site location: Site 26 is located on the corner of Hulnena Street and Sobhuza Street in Sharpeville. It is situated next to the Sharpeville Police Station.

Figure 4-74: Site 26 with dumped waste that has been cleaned up

Figure 4-75: Cleaned out site 26

Site description: At the time of the site visit, it was discovered that the site (originally observed in 2017) has been cleaned up and building rubble was used to cover up the area where waste was historically dumped.

4.2.27 Site 27, 28, 29 S26°40’ 39.84”; E27°52’ 54.27”

Site location: The site is inclusive of Site 27, 28 and 29. The large site is situated opposite the Sharpeville Assembly of God Church.

Figure 4-76: Cleaned out site 27, 28, 29

Figure 4-77: Cleaned out site 27, 28, 29

Site description: At the time of the site visit, it was discovered that the site (originally used for dumping during the first visit in 2017) has been cleaned up and building rubble was used to cover up the historical dumping sites. No waste was being dumped at the site at the time of the site visit in July 2018.

4.2.28 Site 30, 31 S26°40’ 40.95”; E27°52’ 59.86”

Site location: Site 30 and 31 are located on the corner of Sobhuza Street and Raporoko Street in Sharpeville.

Figure 4-78: Composition of waste 30 and 31

Figure 4-79: Evidence of waste burning in Site 30 and 31

Site description: Waste is dumped in an area of approximately 60 m^2 along Sobhuza Street. The dumping site consists of multiple piles of burnt waste, scattered around the site. The site is flat and consists of natural veld with scattered alien vegetation. The site is easily accessible from Hulwana Avenue.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

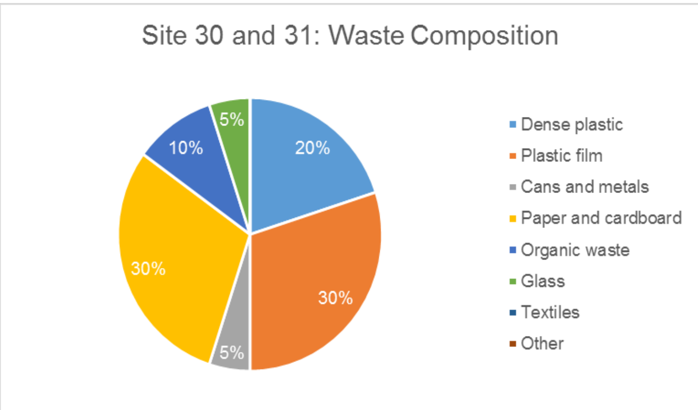


Figure 4-80: Composition of waste dumped at site 31

Visual observation indicated that the waste consisted mainly of plastic films (approximately 30%), followed by paper and cardboard (approximately 30%) and roughly 20% dense plastic, 10 % of organic materials, 5% glass.

4.2.29 Site 32 S26°40’ 40.47”; E27°53’ 19.65”

Site location: Site 32 is located on the corner of Seiso Street and Rafube Street in Sharpeville. It is situated approximately 300 m from Leeukuil Dam. The site is within a residential area.

Figure 4-81: Site 32

Figure 4-82: Composition of waste site 32

Site description: Waste is dumped in an area of approximately 200 m^2 directly adjacent to Seiso Street and Rafube Street. A petrol station is located near the site. The site has informal and formal settlements. At the time of the site visit, children were seen playing near the dump. The site is covered in natural veld with scattered alien vegetation species.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

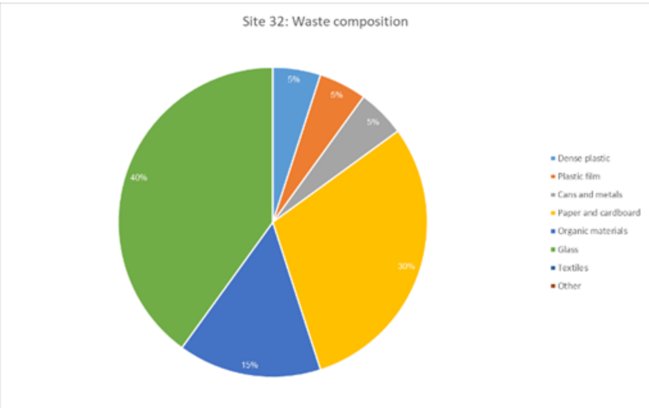


Figure 4-83: Composition of waste dumped at site 32

Visual observation indicated that the waste consisted mainly of glass 40%, and roughly 30% paper and cardboard followed by organic materials 15%, 5% dense plastics, 5% cans and metals and plastic films (approximately 5%).

During the site visit, large bags full of glass bottles and cardboard were observed. It seemed as if the waste was being stored for recycling purposes.

4.2.30 Site 33 S26°40' 32.80"; E27°53' 15.96"

Site location: Site 33 is located off Rafube Street in Sharpeville. It is situated next to a church within a residential area.

Figure 4-84: Location of site 33

Figure 4-85: Composition of waste at site 33

Site description: Waste is dumped in an area of approximately 200 m^2 directly adjacent to Rafube Street. At the time of the site visit, it was observed that there were multiple portions of burned waste scattered amongst the waste piles. The site is situated approximately 400m from the Leeukuil Dam. The site is covered in natural veld with scattered alien vegetation species.. The site is easily accessible from Rafube Street.

Waste-related activities: Waste is illegally dumped on the surface of soil with no compaction or covering of the waste.

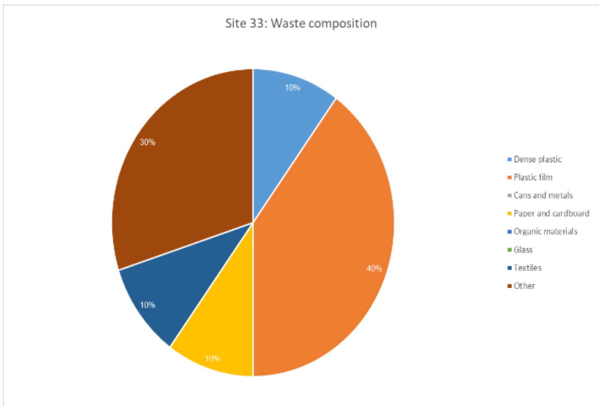


Figure 4-86: Composition of waste dumped at site 33

Visual observation indicated that the waste consisted mainly of plastic films (approximately 40%) and, polystyrene and nappies (approximately 30%); 10% dense plastics, and textiles 10%, roughly 10% paper and cardboard followed by other wastes, such as tyres 0% cans and metals, organic materials 0%, and glass 0%

4.2.31 Summary of the evaluated waste dumping sites

The following trends were noted at the thirty-three sites that were evaluated:

4.2.31.1 Waste composition

Except for three sites where glass was found in significant quantities, glass was typically absent at most of the dumping sites. At the three sites where glass was found, it seemed that it was stored or stockpiled for recycling purposes (based on the bags in which it was stored and its location). It was learned that the waste pickers typically targeted waste such as glass bottles, dense plastics and metal and cans.

Twenty of the thirty-three sites evaluated had between 20% and 40% plastics, consisting of mostly plastic film and small quantities of dense plastic. This indicates that plastic film is rarely collected for recycling and thus ends up occupying numerous dumping sites. It was established that the waste pickers never opted to collect plastic film because the local scrap yards (recycling companies) do not provide for any collection of plastic film waste, and therefore no incentives existed for the recycling of plastic film. Taking to consideration that this particular waste type is generated on a daily basis, it becomes very problematic due to the large quantities generated, and the fact that it ends up being dumped and/or burned. The large quantities of plastic film, mostly consisting of plastic shopping bags, also shows that disincentive schemes, such as the plastic bag regulations, are not always effective in the avoidance of waste generation.

Apart from glass being recycled, it was also evident, from the waste composition, that cans and dense plastics (such as milk and cold drink bottles) were removed from the dumped waste stream for recycling purposes. An individual was seen collecting cans at Site 10, while another person was seen collecting plastic bottles from Site 23. All of them, when asked regarding the collection of these particular waste types, indicated that a local scrap yard (recycling facility) gave financial incentives in return for these waste types.

Most of the sites were characterised by a significant amount of used nappies, polystyrene packaging and evidence of burned tyres. Fourteen out of thirty-three sites had between 20% and 40% of “other” waste types such as tyres, polystyrene and nappies. The used nappies were not covered, and posed a potential hazard to public health, since the majority of these sites are located within residential areas.

4.2.31.2 Burning of waste

Three active waste burning sites were observed (site 6, site 7 and site 16) at the time of the site visit. At site 6, a group of teenagers were seen gathered around a waste-related fire. These young individuals were burning waste materials for warmth next to what seemed like an old commercial building. At site 7, waste was seen burning in a black plastic bag (Figure 4-20). The fire was initiated by a person who transported waste with a wheel-barrow, dumped the load of waste and set it alight. The person was not approached during the site visit to enquire about the reasons for the waste being dumped and burned.

Sixteen sites had evidence of waste burning with multiple black patches containing ash and smoke being observed at the time of the site visit. Apart from the five sites which had been cleaned up, all of the sites had the potential of waste being burned, because of the fact that there was waste, which was easily accessible to the public.

4.2.31.3 Cleaned-up waste dumping sites

It was discovered that five of the waste dumping sites, which were identified during the pilot study in July 2017, were cleaned up and dumping was no longer taking place at the time of the second site visit (July 2018). One site was cleaned up and turned into a recreational park (Site 24) as part of a community initiative. Waste materials such as old tires, wood, plastic bags and building rubble were utilised in the development of this recreational park (Figure 4-70). Building rubble was used to cover up the area and also to create foot paths (Figure 4-74). Four other sites were cleared from waste, also as part of community initiatives, where the community initiated and funded the clean-up projects.

The thirty-three sites showed variation in waste composition, size and waste burning activities. However, the reasons for dumping (at sites where residents provided information) was generally the same at all of the sites, being the fact that the municipality did not render frequent and consistent waste collection services.

4.3 Results of the waste composition characterisation study

Understanding the composition of waste forms the basis of planning and developing any waste management system (Christensen, 2011). Results from the evaluation of the thirty-three sites (refer to Section 4.2 of this mini-dissertation) were used to select one site, which could then be subjected to an in-depth waste characterisation, to provide information on the composition of waste.

Site 16 was selected for waste characterisation purposes, due to the fact that it was the largest site, which had the largest extent of dumping taking place. The site was also the most active in terms of waste being dumped and waste being burned, at the time of the site visit. The final factor which contributed to the site being selected, was the composition of the waste, which was largely heterogeneous, consisting of different types of waste.

As explained in Chapter 3 of this mini-dissertation, a grid was drawn over the active dumping part of the site to cover most of the site surface area. Waste samples were taken from seven areas of approximately (3m x 3m) 9 m^2 each. Waste was categorised into seven categories or groups, as explained in Chapter 3 of this mini-dissertation. Table 4-1 shows the seven waste categories and their descriptions.

Table 4-1: Descriptions of waste component categories

Waste Type	Description
Paper and cardboard	Office paper, computer paper, magazine, glossy paper, waxed paper, newsprint, corrugated and cardboard
All plastics and polystyrene	Dense and plastic film
Food waste	All food waste except bones
Other organics (not food)	Yard waste (Branches, twigs, leaves, grass and other plant material), wood, textiles, rubber, leather and other primarily combustible materials not included in the above component category
Metals	Ferrous (Iron, steel, tin cans and bi-metal cans), aluminium and non-ferrous non-aluminium metals (copper, brass, etc)
Glass	All glass materials
Other	Rock, sand, dirt, ceramics, plasterboard, bricks, cement, concrete, building rubble and bones

Table 4-2 shows the composition of waste types in percentages and weight of the seven sampled areas. The average weights of all the waste types and standard deviation of all the waste types are presented (Table 4-2).

Reflecting on the average waste composition of the seven sampled areas, organic waste (excluding food, which consists of yard waste, wood, textiles, rubber, leather etc.) dominated the waste composition profile with an average of 29% of waste (by weight) consisting of organic waste. "Other" wastes (consisting of rocks, sand, dirt, ceramics, plasterboard and bone) were the second most dominant waste type, with 27% on average (by weight) of the waste profile consisting of *"other"* waste.

Organic waste (excluding food) dominated the waste composition of 3 sampled areas (Sample 3, Sample 4 and Sample 7), followed by *other* dominating the composition of 3 sampled areas (Sample

1, Sample 2 and Sample 5). Organic waste (not food) weighed 3.5 kg (30%) out of 11.8 kg in Sample 3, 6.6 kg (38%) out of 17.5 kg and 12.8 kg (52%) out of 24.5kg in Sample 7 (Table 4-2). *Other* wastes comprised 10 kg (42%) out of a total of 28.5 kg in Sample 1, 7 kg (38%) out of 18.6 kg in Sample 2 and 8 kg (46%) out of 17.5 kg in Sample 5. (Table 4-2). The standard deviation was calculated and is shown on Table 4-2. The standard deviations for the *organic waste* and *other waste* are 4.14 kg and 3.94 kg, respectively and they are the highest among those of the rest of the waste categories, due to the variability of these wastes found at the seven sampled areas (Table 4-2).

Paper and cardboard constituted 19% (on average) of the entire site waste composition. All three of these waste types (organic waste, other waste and paper and cardboard) are not targeted by waste pickers due to the lack of financial incentives for their recycling in Sharpeville. Although most of the components of organic waste and other wastes are non-recyclable, they may have value for composting purposes.

Glass and metals were minimal across all of the sampled areas (Table 4-2). This was expected (based on the visual observations done during the first site observations) and consistent with what was seen at most of the dumping sites, since glass and metal wastes are most frequently collected by waste pickers. *Metals* and *glass* both contributed relatively little towards the waste composition with 4% each (on average).

On several occasions, waste pickers were seen collecting dense plastic (milk or cold drink containers), cans and glass wastes. The percentage for plastics was higher than anticipated (9% of the total composition), probably because all plastics (dense and plastic film) as well as polystyrene were grouped together for the waste characterisation study.

Food waste comprised approximately 7% of the total waste profile and consisted mostly of leftover food.

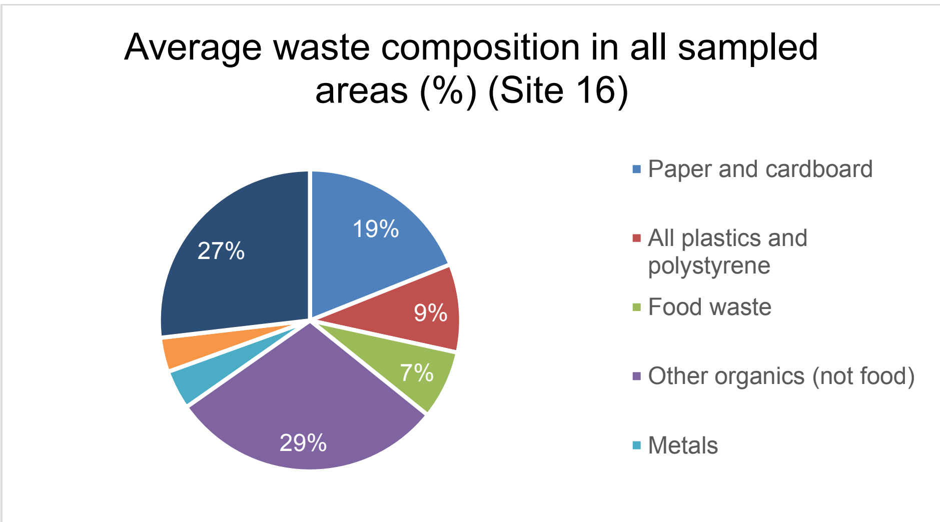


Figure 4-87: Average Waste Composition in all sampled sites in percentage (%)

Table 4-2: Composition of waste in percentage and weight of the seven sampled areas (Site 16)

Waste Type	Sample 1 (Weight)	Sample 2 (Weight)	Sample 3 (Weight)	Sample 4 (Weight)	Sample 5 (Weight)	Sample 6 (Weight)	Sample 7 (Weight)	Average Weight	Standard Deviation
Paper and cardboard	3.4	2.4	2	4	4.3	6.2	3	3.6	1.30
	12%	13%	17%	23%	25%	42%	12%	19%	
All plastics and polystyrene	2.2	1.2	1.6	3.1	1.8	1.2	1.2	1.8	0.65
	8%	6%	14%	18%	10%	8%	5%	9%	
Food waste	0.2	3.2	3	1	0.2	2	0.5	1.4	1.20
	1%	17%	25%	6%	1%	14%	2%	7%	
Organic waste (not food)	10	4	3.5	6.6	2.5	0	12.8	5.6	4.14
	35%	22%	30%	38%	14%	0%	52%	29%	
Metals	0.6	0.8	0.8	1	0.4	0.8	1	0.8	0.20
	2%	4%	7%	6%	2%	5%	4%	4%	
Glass	0.1	0	0.1	1.8	0.3	1.6	1	0.7	0.71
	0%	0%	1%	10%	2%	11%	4%	4%	
Other	12	7	0.8	0	8	3	5	5.1	3.94
	42%	38%	7%	0%	46%	20%	20%	27%	
Total	**28.5**	**18.6**	**11.8**	**17.5**	**17.5**	**14.8**	**24.5**	**19**	**5.27**
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	

4.3.1 Comparison of Sharpeville waste composition to the rest of South Africa

In 2017, South Africa generated about 42 million tonnes of general waste of which 11% (4.9 million tonnes) was recycled (DEA, 2018). In South Africa, the mainstream recyclables include paper, plastic, glass and metal waste (DEA, 2018). The minimal percentage of waste recycling, on a larger scale, can only mean that large amounts of waste will be landfilled. In areas where waste services are minimal or infrequent some of the waste may be illegally dumped and eventually burned.

4.3.1.1 Glass waste

According to Oelofse (2015), the percentage contribution by weight of glass waste in the Gauteng province is relatively lower than the other provinces, with 5%. Glass waste contributed 4% towards the composition of the actual site samples (Figure 4-87). This therefore shows that there is a similarity in human behaviour regarding glass waste. In contrast, the percentage contribution by weight of glass waste in Cape Town is relatively higher than of any other province (Table 2-2). The percentage contribution by weight of metal waste (3%) in Gauteng is also low compared that of other provinces such as Western Cape (8%) and Free State (6%).

4.3.1.2 Paper and packaging waste

South Africa, as a developing country, has experienced a growth in paper and packaging recycling rates from 47.3% in 2010 to 52.6% in 2014 (PackagingSA, 2015). However, large amounts of paper waste remain in numerous illegal dumping sites throughout the Sharpeville area. This is due to lack of infrastructure and relevant facilities for paper recycling within the township. The local scrap yards do not cater for the collection of paper and cardboard. The paper and plastics component of the Sharpeville site was 19% and 9%, respectively. This compares well with what Oelofse (2015) has found for the rest of South Africa, with paper ranging between 11% and 24%, and plastics between 9 and 22% (Table 2-2).

4.3.1.3 Organic waste

Waste in developing countries primarily consists of organic waste, which constitutes 64% of waste in low-income countries (Hoornweg & Bhada-Tata, 2012). According to Figure 4-87, organic waste (not food) constitutes 29% of the waste composition of the sampled sites in Sharpeville. Developed, industrialised countries, in contrast, have much higher percentages of paper waste and much lower concentrations of organic waste (Cogut, 2016). The organic waste profile in South Africa varies greatly between the different provinces, with as much as 58% of waste in the North-West province consisting of organic waste and only 10% of the waste in the Northern Cape consisting of organic waste.

In China, organic waste also constitutes a relatively high percentage (in this regard, 40% in rural areas, 48% in semi-urban areas and 50% in urban areas) (Table 4.3). This therefore shows that the frequent generation of organic waste occurs not only in South Africa but even in developed countries such as China.

4.3.2 Understanding the potential contribution of waste burning to air pollution

Solid anthropogenic fuels such as domestic wastes and industrial wastes when subjected to open burning can form toxic pollutants particularly with the presence of polymeric materials (Estrellan & Iino, 2010). Anthropogenic materials burning release a relatively higher quantity of PAHs, VOCs, PCDD/Fs, organic and inorganic ions, metals and other chemical species per unit mass of material burnt, than any other natural fuels (Estrellan & Lino, 2010). Domestic waste has a very complex waste composition, and it is therefore important to understand its actual waste composition prior to determining the constituents of the emissions produced when burned.

Emissions from open burning of plastics, tyres, and more recently electronic wastes, along with household scraps such as paper products and yard trimmings have become an issue as localized exposures of residents to these pollutants are prevalent (Estrellan & Lino, 2010). Usually, metallic elements found in anthropogenic fuels functioned as catalysts producing emissions numerous times higher than biomass fuels, most notably for PCDD/Fs (Estrellan & Lino, 2010).

The contribution of open burning of waste to other pollutant emissions is rather substantial (Wiedinmyer *et al.*, 2014). In comparison with the global emission inventories recently prepared for the Task Force on Hemispheric Transport of Air Pollution, the open burning of waste emissions of non-methane organic compounds (NMOC) and carbon monoxide are each equivalent to 7 and 5% of the global total estimated anthropogenic emissions, respectively (Wiedinmyer *et al.*, 2014). According to Wiedinmyer *et al.* (2014), the global emissions of particulate matter (PM) from the open combustion of waste are very significant in comparison to the global human induced emissions approximated for the HTAP inventory. The open waste combustion $PM_{2.5}$ emissions are equivalent to 29% of the total global anthropogenic $PM_{2.5}$ emissions, and the particulate organic carbon emissions approximated are equivalent to 43% of the total global anthropogenic OC emissions (Wiedinmyer *et al.*, 2014). $PM_{2.5}$ refers to the atmospheric particulate matter (PM) that have a diameter of less than 2.5 micrometres. Worldwide emissions of CO_2 resulting from the open burning of waste are relatively small compared to total anthropogenic CO_2, however, the regional CO_2 emissions, specifically in numerous developing countries in Asia and Africa, are significant (Wiedinmyer *et al.*, 2014). A research study in the Gauteng province provided confirmation that ambient concentrations of fine particulate matter in townships are 51% higher than in urban residential areas and 78% higher than fine PM concentrations in industrial areas (Hersey *et al.*,2014).

The largest fraction of waste determined at the Sharpeville site was organic waste, which contributed to 29% of the total waste composition. Although the uncontrolled burning of organic wastes has the potential to produce greenhouse gases, mostly in the form of CO_2. Brockway (2012) argues that the burning of organic waste may in some instances be less harmful to the environment than landfill disposal. During burning processes, the organic waste (which would have had the potential to form methane when decomposed during landfilling) is converted to by-products, ash and CO_2, which reduces the GHG equivalent (compared to landfilling). The fact that uncontrolled burning usually goes hand in hand with the co-disposal and co-burning of organic waste with potentially harmful wastes, makes the burning of organic waste a potential risk to air quality. The most preferable disposal/treatment option for organic waste is composting, in most cases (Oelofse, 2015).

The second largest fraction was “other wastes” (27% of the total waste composition profile), which mostly contained inert (non-flammable) material such as rock, sand, dirt, ceramics, plasterboard and bones. The burning of this waste fraction will most probably not have a significant impact on air quality since it is mostly inert and will not produce emissions.

Usually, the MSW containing approximately 12% of plastic waste is burnt, releasing toxic and detrimental gases like dioxins, furans, mercury and PCBs into the atmosphere (Verma *et al.*, 2016). The burning of PVC releases halogens which have the potential of polluting the air. For instance, any plastic burnt in open will produce dioxins or toxic substances (Verma *et al.*, 2016). A number of studies have shown that soot and solid residue ash possess a high potential of causing health and environmental concerns, particularly VOCs, semi-VOCs, smoke (particulate matter), particulate bound heavy metals, PAHS and PCDD/Fs (Valavanidid *et al.*, 2008). The combined plastics composition of the waste in Sharpeville is approximately 9%. Although the emission of toxic pollutants is expected when plastic-containing waste is being burned, it is expected that the contribution of plastic wastes to air pollution in Sharpeville should be relatively low.

CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

The state of waste in South Africa is being influenced by a numerous driving forces and pressures such as population growth, economic growth, level of income, increased urbanisation, and the globalisation of recycling market (DEA, 2018). These forces contribute to the increase in the quantity and complexity of waste generated, and the pressure on existing infrastructure top manage these wastes (DEA, 2018). Illegal dumping is driven by factors such as infrequent or lack of waste services, thus the waste ends up being dumped in public spaces. The waste is then eventually burned for eradication purposes. This the then leads to the emission of detrimental pollutants into the atmosphere. The pollutants are not only detrimental to the environment, however also to the public health.

In more severe cases (at higher concentrations or long term exposure), CO_2 exposure can cause difficulties in breathing, respiratory diseases, asthma, inhibition of the central nervous system, loss of consciousness and eventual cardiorespiratory failure and even death (Cogut, 2016). The impacts of GHGs on the environment is detrimental and well-researched. Persistent organic pollutants such as dioxins, furans, PCBs and PAHs are toxic to the environment and to people and persist in the environment for long periods of time.

With waste service delivery being a significant issue and also the occurrence of illegal waste dumping and waste burning, it is of essence that the South African government intervenes to ensure frequent and reliable waste services the people of South Africa. The legal enforcement of legislations related to waste management is also important in this regard. It is important for the relevant officials make sure that strict enforcement is implemented. This will assist with minimising the frequent occurrence of illegal practices.

5.1 Conclusions

This section aims to conclude on the three research questions:

1. What are the extent[5] and characteristics of waste dumping and burning in Sharpeville?
2. What is the composition of waste being dumped and burned in Sharpeville?

The final research question (question 3, below) was not the primary focus of this study. The intent of this study was rather to provide waste characterisation and composition data, which could be used in other studies to contribute to more accurate air emissions calculations.

[5] As far as the extent of dumping is concerned, the study also aimed to understand the reasons for waste dumping. This was not the main aim of the study and was done by means of literature review and informal engagements with members of the community.

3. Could the burning of waste significantly impact on air quality in the Sharpeville area?

5.1.1 Extent and characteristics of waste dumping sites in Sharpeville

During the pilot study, thirty-three illegal waste dumping sites were identified. The dumping sites were scattered throughout Sharpeville and most of them were within close proximity to residential areas, therefore in a convenient location to "dispose" (or dump) waste. After the visual evaluation of the thirty-three sites, it was discovered that twenty out of the thirty-three sites had between 20% and 40% of film plastics within their waste composition (and also Site 17 had about 90% of film plastic within its waste composition). A significant amount of used nappies, polystyrene packaging and evidence of burned tyres were occupying most of the sites, where they constituted between 20 and 40% of the waste composition of fourteen sites. Three sites had piles of 1 ton bags filled up with glass bottles (Site 18: Figure 4-53, Site 22: Figure 4-74 and Site 32: Figure 4-82). Twenty-nine sites had minimal amounts of glass, plastic bottles and cans, possibly because waste pickers typically target them more than the others for recycling purposes. Five of the thirty-three sites (originally identified in 2017) had been cleaned up when the sites were re-visited in 2018.

As mentioned in Section 1.4 of this mini-dissertation, the utilised routes were pre-determined, therefore the thirty-three sites are not inclusive of every site in Sharpeville. However, they provide a comprehensive representation of the rest of the township.

5.1.2 Composition of waste being dumped in Sharpeville

One of the thirty-three sites was comprehensively evaluated in terms of its waste composition. The site was selected based on its size, level of dumping and burning activity, as well as the heterogeneous nature of the waste composition (based on visual observation). The selection of the site was also based on the premise that it would be a good representation of the waste dumping sites in Sharpeville and also based on the fact that it would represent the most probable case scenario for waste burning.

The waste of the sampled site was constituted primarily of organic waste (29%), followed by *other waste* such as rock, sand, dirt, ceramics, plasterboard and bones (27%) and paper and cardboard (19%). The frequently collected (for the purposes of recycling) waste types such as glass and metal wastes constituted less of the waste profile. A significant amount of these end up in local scrap yards which provide incentives in return. Most of the waste pickers do it because they need money and also because they are unemployed.

This was a true reflection of what was seen at most of the dumping sites in Sharpeville. The percentage for plastic wastes were higher than anticipated (9% of the total composition), probably because all plastic wastes (dense and plastic film) as well as polystyrene were categorised together for the waste characterisation study. In Sharpeville, it was usually only the dense plastic (milk bottles and cold drink bottles) that was collected by reclaimers for recycling purposes. Taking in to consideration that plastic film is generated on a daily basis, it becomes very problematic due to the fact that it ends up being burned. The large quantities of plastic film, mostly consisting of plastic shopping bags, also shows that disincentive schemes, such as the plastic bag regulations, are not always effective in the avoidance of waste generation.

5.1.3 Impacts of waste burning on air quality

Waste burning, which is commonly practised throughout the world, particularly in developing countries, produced numerous detrimental air pollutants which may cause harm to the environment and public health. The open burning of plastic waste burning is one significant source of air pollution (Verma *et al*., 2016). The by-products of plastic burning are airborne particulate emission (soot) and solid residue ash (black carbonaceous colour) (Verma *et al*., 2016). The detrimental particulates end up occupying the air, thus posing harm to the public health and environment. A large quantity of pollutants of environmental and health concern inclusive of carcinogens such as PAHs, nitro-PAHs and dioxins have been identified in the airborne particulate emission (Verma *et al*., 2016). The burning of plastics at various operating conditions detected VOCs and semi VOCs, especially olefins, paraffin, aldehydes and light hydrocarbons (Valavanidid *et al*., 2008). Among other VOCs, such as benzene is known as a carcinogen and released during plastic combustion (Verma *et al*., 2016).

The largest fraction of waste determined at the Sharpeville site was organic waste, which contributed to 29% of the total waste composition. Although the uncontrolled burning of organic wastes has the potential to produce greenhouse gases, mostly in the form of CO_2,. During burning processes, methane is converted to CO_2, which reduces the GHG equivalent. The fact that uncontrolled burning usually goes hand in hand with the co-disposal and co-burning of organic waste with potentially harmful wastes, makes the burning of organic waste a potential risk to air quality. The most preferable disposal/treatment option for organic waste is composting, in most cases (Oelofse, 2015).

The second largest fraction was “other wastes” (27% of the total waste composition profile), which mostly contained inert (non-flammable) material such as rock, sand, dirt, ceramics, plasterboard and bones. The burning of this waste fraction will most probably not have a significant impact on air quality since it is mostly inert and will not produce emissions.

Usually, the MSW containing approximately 12% of plastic waste is burnt, releasing toxic and detrimental gases like dioxins, furans, mercury and PCBs into the atmosphere (Verma *et al*., 2016). The burning of PVC releases halogens which have the potential of polluting the air. For instance, any plastic burnt in open will produce dioxins or toxic substances (Verma *et al*., 2016). A number of studies have shown that soot and solid residue ash possess a high potential of causing health and environmental concerns, particularly VOCs, semi- VOCs, smoke (particulate matter), particulate bound heavy metals, polycyclic aromatic hydrocarbons (PAHs) and PCDD/Fs (Valavanidid *et al.*, 2008). The combined plastics composition of the waste in Sharpeville is approximately 9%. Although the emission of toxic pollutants is expected when plastic-containing waste is being burned, it is expected that the contribution of plastic wastes to air pollution in Sharpeville should be relatively low.

5.2 Recommendations

The outcomes of the study have several relevant implications for the strategic planning and execution of waste management programmes in the Sharpeville area (particularly), Emfuleni Municipality or throughout the country at large and therefore lead to the following recommendations:

1. It is recommended that further studies (for the expansion of knowledge) be conducted and thus the interviews that were not conducted, be conducted;
2. It is recommended that there is assurance by the relevant parties for frequent and reliable waste services;
3. It is recommended that the reuse, reduce or recycling of waste materials take place where feasible;
4. Environmental education is also of essence. It should therefore be considered moving forward; and
5. It is recommended that the emissions calculations (based on estimated waste composition profiles) be updated using the more accurate waste characterisation results, such as the results produced by this study. To increase the accuracy of emissions calculations, it is recommended that the waste samples of known waste composition be burned and the emissions monitored. The outcomes should be then compared to the calculated emission factor values (determined by the application of the actual waste composition data) to improve the accuracy of the emission factor calculations in future.

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ANNEXURES

ANNEXURE A. CATALOGING OF SHARPEVILLE WASTE BURNING SITES

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

Private Bag X6001, Potchefstroom
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Web: http://www.nwu.ac.za

Geography and Environmental Management
Tel: +2718 299 1477
Email: claudine.roos@nwu.ac.za

CATALOGING OF SHARPEVILLE WASTE BURNING SITES – JULY 2018

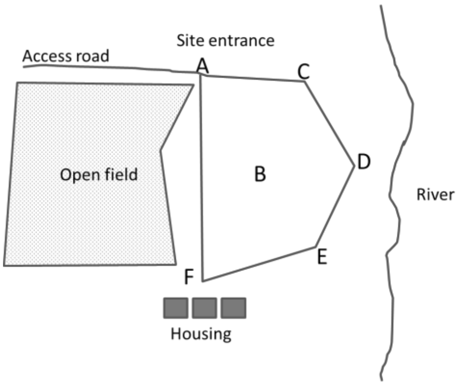
Please complete the following sections per waste burning site visited.

Date and time of site visit:	Information gathered by:

1. Name/number of site	
2. Description of location including the adjacent land and land uses.	

<table>
<tr><td>3. Please make a rough drawing of the waste burning site and indicate the position of coordinates and where photographs were taken below.

Example:


</td><td></td></tr>
<tr><td colspan="2">4. Verification of site coordinates

<u>Instruction</u>: Use the references (e.g. A or B) given in the drawing to distinguish the positions where coordinates were taken.</td></tr>
<tr><td>Site entrance ref.

S:

E:

Elevation:</td><td>Centre of site ref.

S:

E:

Elevation:</td></tr>
<tr><td>Site boundary ref

S:

E:

Elevation:</td><td>Site boundary ref

S:

E:

Elevation:</td></tr>
</table>

Area of the entire site in m^2:   **Length:** **Width:**
Area of the portion of the site where burning activity is evident in m^2:   **Length:** **Width:**
Notes: ....
5. Site photographs Instruction: Colour (date stamped) photographs must be taken from the centre of the site in at least the eight major compass directions. Indicate the photograph number – i.e. the number which is displayed on the camera when the photograph is taken.

From centre of the site towards NORTH Photograph number: Description (if any):	**From centre of the site towards NORTH-EAST** Photograph number: Description (if any): ....

From centre of the site towards EAST Photograph number: Description (if any):	**From centre of the site towards SOUTH-EAST** Photograph number: Description (if any): ....
From centre of the site towards SOUTH Photograph number: Description (if any):	**From centre of the site towards SOUTH-WEST** Photograph number: Description (if any): ....
From centre of the site towards WEST Photograph number: Description (if any):	**From centre of the site towards NORTH-WEST** Photograph number: 395 Description (if any): ....

<table>
<tr><td colspan="5">6. Site description

<u>Instruction</u>: Please tick the most appropriate boxes for the sections below.</td></tr>
<tr><td rowspan="3">Description of the gradient of the site</td><td></td><td colspan="3">Flat</td></tr>
<tr><td></td><td colspan="3">Slight gradient</td></tr>
<tr><td></td><td colspan="3">Steep</td></tr>
<tr><td>What sensitive environmental features are observed on site or close to the site (i.e. wetland/river)?</td><td colspan="4">Description:</td></tr>
<tr><td>Prevailing wind direction?</td><td colspan="4"></td></tr>
<tr><td>Give a description of the socio-economic environment (i.e. settlements, informal recyclers, children playing in are) which may be affected?</td><td colspan="4">Description:</td></tr>
<tr><td rowspan="4">Indicate the landform(s) which best describes the site</td><td></td><td>Ridgeline</td><td></td><td>Open valley</td></tr>
<tr><td></td><td>Plateau</td><td></td><td>Plain</td></tr>
<tr><td></td><td>Side slope of hill/mountain</td><td></td><td>Undulating plain/low hills</td></tr>
<tr><td></td><td>Closed valley</td><td></td><td>Dune</td></tr>
<tr><td rowspan="2">Indicate the types of groundcover present on the site</td><td></td><td>Natural veld – good condition</td><td></td><td>Natural veld with scattered aliens</td></tr>
<tr><td></td><td>Natural veld with heavy aliens</td><td></td><td>Veld dominated by alien species</td></tr>
</table>

		Gardens		Sport field
		Cultivated land		Paved surface
		Building or other structure		Bare soil
According to your observation, give a brief description of land uses and/or prominent features that does currently occur within the surrounding area (a <u>500 m</u> radius of the site).	**Description:**			
Are there any specific odours present?				
Fatal flaws at the site (if possible to answer)				
Within a 3000m radius of the end of an airport landing strip		Yes		No
Within the 1 in 50 year flood line of any watercourse		Yes		No
Within an unstable area(fault zone, seismic zone, dolomitic area, sinkholes)		Yes		No
Within the drainage area or within 5 km of water source		Yes		No
Within an area with shallow and/or visible water table		Yes		No
Within an area adjacent to or above an aquifer		Yes		No
Within 100 m of the source of surface water		Yes		No
Within 1km from the wetland		Yes		No

7. Site access and infrastructure Instruction: Please tick the most appropriate boxes for the sections below.				
Is there an access road to the site?		Yes		No
Is the site fenced?		Yes		No
Are there any access control arrangements in place?		Yes		No
Notes:				

8. Waste disposal and burning practices at the site Instruction: Please tick the most appropriate boxes for the sections below.				
What best describes the site? **(Tick all of the appropriate boxes)**		Waste dumped on surface of soil.		Waste disposed in trenches/holes.
		Waste dumped in a quarry		Waste disposed of in designed cells
		Landfilling (waste is buried and the site is at the same elevation as the surrounding area)		Land building (waste is not being buried. Waste is disposed on the surface of land and covered. The site is at a much higher elevation than its surroundings)

		Regular compaction and covering of waste		Irregular compaction and covering of waste
		No compaction or covering of waste		
	Notes/description:			
What is the approximate (visual estimation) composition of the waste currently at the "dumping" site?	%	**Dense plastics** *(i.e. Beverage And Other Bottles, Toys, Food Tray)*	%	**Plastic film** *(i.e. Food Wrapping, Carrier Bags, Refuse Sacks)*
	%	**Cans/metals** *(i.e. Beverage And Food Cans, Batteries)*	%	**Paper and cardboard** *(i.e. Newsprint, Cardboard, Tissue)*
	%	**Organic materials** *(i.e. food waste)*	%	**Glass** *(i.e. jars, bottles)*
	%	**Textiles** *(i.e. clothing, cloth)*	%	**Other*** *(give a description of other wastes composition below)*
Composition of "*other" wastes				
Is any waste being recycled from the landfill site?		Yes		No

If yes, which types of waste are being recycled?				
Method of recycling (i.e. informal salvaging, recycling by contractor)?				
Is waste being burned at the site?		Yes		No
Why is waste being burned?				
How regularly is waste being burned?				
Which source of energy/ ignition is used to light the fire?				
Is there a specific day/time that waste is being burned? And why?				
Give a description of the waste burning practices (i.e. who lights the fire, how, etc.)				

What site specific environmental and social impacts can be observed at the site during operations?	**Environmental**: **Social**:

9. Contact details of any persons interviewed during the site visit.					
Name	**Surname**	**Cell number**	**Telephone number**	**E-mail address**	**Postal address**

10. Any other relevant information or notes

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