



THE PROMOTION OF ENVIRONMENTAL SUSTAINABILITY THROUGH WASTE MANAGEMENT IN JOHANNESBURG

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DECLARATION

I declare that this dissertation is my own unaided work. It is being submitted to the Degree of Masters of Science in Engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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.....
(Signature of Candidate)

8th day of January, 2021.
(day) (month) (year)

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DEDICATION

The paper is dedicated to my lovely daughter, my princess,

Jasmine Giavanna Mabanga.

Daddy loves you.

ABSTRACT

The main focus of the GDS 2040 as implemented by the City of Johannesburg is the fulfillment of the 7th point in the Millennium Development Goal, which is to achieve a sustainable environment. Waste management is a direct method of achieving this goal and therefore has been one of the important implementations by the City of Johannesburg. This paper illuminates the waste management practices that would assist Johannesburg in achieving environmental sustainability. A document analysis was carried out in order to understand the different waste management practices used in Johannesburg, and compared them to the waste management practices of four other cities with an outstanding record of waste management practices, namely Kigali, Curitiba, Singapore and Berlin. The analysis identified a number of recommendations which, if applied, would improve the management of waste in Johannesburg and as such increase the chances of achieving a sustainable environment.

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LIST OF ACRONYMS

BSR	Berliner Stadtreinigungsbetriebe
BWB	Berlin Water Utilities
COJ	City of Johannesburg
CONAMA	Chilean National Commission for the Environment
DEA	Department of Environmental Affairs
GDS	Growth and Development Strategy
IDP	Integrated Development Plan
IES	International Enterprise Singapore
IJRC	Interim Johannesburg Reclaimers Committee
ISWM	Integrated Solid Waste Management
MDG	Millennium Development Goals
NEA	National Environmental Agency
NEMA	National Environmental Management Act
NRP	Neighbourhood Renewal Programme
NWMS	National Waste Management Strategy
PIP	Priority implementation Plans
PNRS	National Solid Waste Policy
REMA	Rwanda Environment Management Authority
RURA	Rwanda Utility Regulatory Authority
UNEP	United Nation Environmental Program
SMMEs	Small, Medium and Micro Enterprises

CHAPTER ONE

INTRODUCTION

The implementation of the City of Johannesburg's Growth and Development Strategy (GDS 2040) focuses on ensuring a "resilient, livable, sustainable urban environment" which is supported by establishing sustainable and eco-efficient infrastructural solutions such as housing, eco-mobility, energy, water, waste, sanitation and information and communications technology (COJ, 2017). The GDS 2040 as an initiative is a long-term strategy which was initiated in 2006 as a formulation of the future development path of the City of Johannesburg. Previously, the City of Johannesburg had implemented various initiatives such as the Joburg 2030, the Human Development Strategy, the City Safety Strategy and the Integrated Transport Plan which focused on different parts of the development plan of Johannesburg. The GDS 2040 initiative provided the concept of combining all these previous initiatives into a single cross-city initiative (COJ, 2017). In order to achieve this, Pikitup as a waste management body has strategized their business plan in response to this particular outcome of the GDS 2040 by identifying initiatives which will help in the achievement of this goal (Pikitup, 2018).

This research seeks to investigate whether the initiatives that Pikitup has developed over time are effective as waste management processes in the City of Johannesburg. This research will seek to explore literature and empirical evidence on how specific cities in South Africa, Germany, Rwanda, Brazil and Singapore understand the notion of environmental sustainability and how each city has made efforts in promoting environmental sustainability through waste management methods and practices. The cities chosen will be used as benchmarks to the City of Johannesburg's waste management. This research seeks to clarify the understanding of concepts such as Sustainability, Environmental Sustainability, Waste Management and Sustainable Waste Management. Through this research, understanding of these concepts will be enhanced and most importantly recommendations will be given that can promote environmental sustainability through waste management practices in the City of Johannesburg.

1.1 CORE CONCEPTS

1.1.1 Sustainability

'Sustainability', according to Parker (2017), can be defined as "a socio-ecological process characterized by the pursuit of a common ideal". By its definition, an ideal is unachievable within a specific time or space, but a constant and vigorous approach may lead to a sustainable system (Reda, 2017).

The Oxford Dictionary defines sustainability as "the ability to be maintained at a steady level without exhausting natural resources or causing severe ecological damage". Therefore, the term 'sustainability' should be viewed as humanity's target goal of human-ecosystem equilibrium (homeostasis), while 'sustainable development' according to Parker (2017) refers to the holistic approach and temporal processes that lead us to the end point of sustainability". Even though the use of the term 'sustainability' has been increasing, the chances that people would achieve environmental sustainability continues to depreciate due to continuous environmental degradation, climate change, overconsumption, population growth and societies' pursuit of unlimited economic growth in a closed system (Rull, 2011).

1.1.2 Environmental Sustainability

Healthy ecosystems provide vital goods and services to humans and other organisms (Lu, et al, 2015). There are two major ways of reducing negative human impact and enhancing ecosystem services, the first of which is environmental management. This direct approach is based largely on information gained from earth science, environmental science and conservation biology (Chen, 2016; Parker, 2017). However, this is management at the end of a long series of indirect causal factors that are initiated by human consumption, so a second approach is through demand management of human resource use (Stellenbosch Municipality, 2014).

Management of human consumption of resources is an indirect approach based largely on information gained from economics. Daly (2007) has suggested three broad criteria for ecological sustainability: renewable resources should provide a sustainable yield (the rate of harvest should not exceed the rate of regeneration); for non-renewable resources

there should be equivalent development of renewable substitutes; waste generation should not exceed the assimilative capacity of the environment.

1.1.3 Waste Management

Waste means any substance (whether that substance can be reduced, re-used, recycled or recovered) that is surplus, unwanted, rejected, discarded, abandoned or disposed of, which the generator has no further use for the purposes of production, that must be treated or disposed of (COJ, 2013). Waste management or waste disposal are all the activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things collection, transport, treatment and disposal of waste together with monitoring and regulation (COJ, 2013). It also encompasses the legal and regulatory framework that relates to waste management encompassing guidance on recycling (COJ, 2013). Waste can take any form that is either solid, liquid, or gas and each has different methods of disposal and management. Waste management normally deals with all types of waste, whether it was created in forms that are industrial, biological, household, and exceptional cases where it may pose a threat to human health (Godfrey & Oelofse, 2017). It is produced due to human activity such as when factories extract and process raw materials. Waste management is aimed at reducing and possibly eliminating the effects of waste on health, the environment or aesthetics (Godfrey & Oelofse, 2017).

1.1.4 Sustainable Waste Management

Sustainable Waste Management can be defined as using material resources efficiently to cut down on the amount of waste produced, and, where waste is generated, dealing with it in a way that actively contributes to the economic, social and environmental goals of sustainable development (Pianosi, 2012). Sustainable Waste Management has highlighted the need for a waste management strategy both international and national for various reasons:

- To safely process and dispose of waste within a minimum impact on the environment and health
- To reduce waste directed to landfill
- To extract valuable resources contained within waste that can still be used
- To revise commodity handling to minimize waste

- To identify ownership of waste

There are critical success factors that accompany the effective use of sustainable waste management practices:

- Mandatory recycling and composting legislation
- Integrated community engagement strategy and education program
- Sufficient funding
- Commitment by facilities
- The waste management model must be a closed-loop system
- Plans must be inclusive to all communities including small and rural communities

1.2 PROBLEM STATEMENT

According to statistics from OECD (2008), the total amount of waste produced by the EU in 2006 was about 220 million tonnes which also tallies with the increase in waste produced in China and India due to the increase in population and development (Giusti, 2009). Landfilling in Europe is the major waste management process, disposing more than 60% of the waste (Choi, 2016), followed by recycling and incineration, according to Eurostat (2002). The United Nations encourages countries to implement waste management initiatives on a wide scale such as the Ogoni land clean-up which aims to combat oil waste in the southern lands of Nigeria (UNEP, 2016).

In some Asian countries, landfilling was the major method of waste management in the early 1960s until the waste-to-energy incineration process was introduced in the late 1970s, which reduced the amount of waste produced by 90% and consequently reduces the use of landfilling. Currently in Singapore, there are four incineration plants and a landfill site located offshore of Semakau, where the non-incinerable waste materials and ash are disposed of (Kotwani, 2016).

With regard to environmental management, it is most beneficial to recycle solid waste due to the future exhaustion of landfills, which create the need for the construction of new landfills (Wilson *et al.*, 2009 and Nzeadibe, 2009). Scholars such as Williams (2005) and Seik (1997), have highlighted that the process of informal waste recycling has led to a decrease in environmental damage, and also saved municipal waste collection and

energy, as well as costs of disposal. Regardless of the harmful nature and disadvantages of the landfill process as a waste management method, it is still the main method of waste management in South Africa and has become a primary environmental concern (Sentime, 2014; Samson, 2010 and Ezeah *et al.*, 2013).

The extensive use of landfill as the primary waste management method in South Africa has highlighted the need to look for alternative management approaches. The use of other available waste management processes, requires both help and direction from the government to be effective, which will require the formalisation of the waste sector in South African society and will promote environmental protection and growth as well as sustainable waste management. To better understand the disadvantage of the use of landfill methods, research shows that there are poisonous gas emissions from used landfills, consisting of predominantly methane and carbon dioxide, which is a significant contributing factor to global warming (Williams, 2005). Research on the disadvantages of landfill waste management highlights the issue of landfill leachate on the development space, which has damaging consequence on the environment as a whole (DEA, 2011). With this in mind, all levels of government and civil society in South Africa need to urgently develop more effective and environmentally beneficial ways to move away from the use of landfills.

Within the past decades, the City of Johannesburg has initiated different waste management processes in order to promote environmental sustainability in the City, possibly expanding to the whole province of Gauteng, starting at a micro-level with one suburb at a time to a macro-level of the whole municipality through the organization Pikitup (UNEP, 2016).

1.3 RESEARCH QUESTION

This research explores some of the initiatives put in place in other countries, and compares them to waste management initiatives implemented in Johannesburg. Through an investigation into international best practice, this research informs environmental sustainability in South Africa. Therefore, this research asks the question, *“What waste management practices would assist Johannesburg in achieving their environmental*

sustainability goals?” This research seeks to analyze how increased effectiveness of waste management practices can promote environmental sustainability in the City of Johannesburg. It aims to investigate and extensively assess this promotion of environmental sustainability using the initiative Pikitup set up in 2000 by the City of Johannesburg. This research makes a comparative analysis between Johannesburg, Kigali, Berlin, Curitiba and Singapore, to assess strategies from each city that can be adopted in the City of Johannesburg. This comparative analysis informs the recommendations that are provided at the end of this research.

1.3.1 Aims and Objectives

In carrying out this research, the aim is to analyze how South Africa as a nation has promoted environmental sustainability through the use of waste management, using the City of Johannesburg as a case study. In order to do this, the research:

- a) Analyzes the waste management initiatives implemented in Johannesburg through Pikitup and evaluates how effective they have been since the formation of this unit in 2000;
- b) Analyzes the waste management initiatives used in the cities of Kigali, Curitiba, Singapore and Berlin to determine best practice in solid waste management;
- c) Carries out a comparative study using a matrix table to identify which initiatives can be implemented or improved in the City of Johannesburg.

1.4 STRUCTURE OF THIS REPORT

Chapter one contains the research question that is answered during the course of this dissertation. Chapter two comprises the literature review which focuses on the aspect of waste management practices all around the world and in South Africa. Chapter three of this research explains the methods through which the research was carried out. Chapter four highlights the geographical conditions of the city that forms the core of this research, namely, Johannesburg. It also explores the four study sites which represent best practice in their waste management approaches.

Chapter five explores in detail Johannesburg and its waste management practices in relation to landfilling, recycling, incineration, legislation and other initiatives such as the

use of waste reclaimers and separation at source. The information for this chapter is in the form of documentary sources, such as annual reports and pieces of legislation.

The comparisons with the selected 'best practice' cities are made in chapter six, the discussion chapter. Here a more in-depth analysis of the study site and its waste management practices is carried out and a comparison is made between all four study sites and Johannesburg to identify which initiatives are more advantageous and can be enhanced. Finally, chapter seven comprises the conclusion in which the research question is answered and where a summary of the recommendations for future research is presented.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Waste management is a challenge both at a domestic and a global level. The issues of storage, adequate separation and the processing of waste varies from country to country, but the significance factor is the need for all to be actively involved in waste management (Guerrero et al. 2013). Out of the eight Millennium Development Goals (MDGs) developed by the United Nations, two of the goals are relevant to this study (Liyala, 2011). The first is the promotion of Human Rights and the second is the promotion of environmental sustainability. The lack of adequate waste management can lead to the violation of human rights and dignity, which hinders the process of creating a proper standard of living for those in vulnerable communities. Promoting environmental sustainability through effective waste management will have a direct influence on the promotion and sustaining of human rights and dignity (Liyala, 2011).

There are two major ways of reducing negative human impact and enhancing ecosystem services and the first of these is environmental management (Henry et al. 2006). This direct approach is based largely on information gained from earth science, environmental science and conservation biology (Medina 2011; Chen 2016; Parker, 2017). A second approach is through demand management of human resource use (Medina, 2011). Management of human consumption of resources is an indirect approach based largely on information gained from economics. Daly (1997) has suggested three broad criteria for ecological sustainability: renewable resources should provide a sustainable yield (the rate of harvest should not exceed the rate of regeneration); for non-renewable resources there should be equivalent development of renewable substitutes; and waste generation should not exceed the assimilative capacity of the environment.

Waste management comprises all the activities and actions required to manage waste from its inception to its final disposal. This includes collection, transport, treatment and disposal of waste together with monitoring and regulation (Guerrero et al.,2012). It also encompasses the legal and regulatory framework that relates to waste management, including guidance on recycling (Giusti, 2009). Waste can take any form that is either

solid, liquid, or gas and each has different methods of disposal and management (Jha et al., 2003). Waste management normally deals with all types of waste, whether it was created in forms that are industrial, biological, or household, and special cases where it may pose a threat to human health. It is produced due to human activity such as when factories extract and process raw materials. Waste management is intended to reduce adverse effects of waste on health, the environment or aesthetics (Dong, Rotich & Zhao, 2006)

2.2 WASTE MANAGEMENT GLOBALLY

Being a necessary service, every country strives to provide adequate waste management for its residents. Taking note of the distinct differences between service levels, environmental impacts and costs, solid waste management can be viewed as the most important municipal service and a precondition for other municipal action (Hoornweg and Bhada-Tata, 2012). As the world evolves, the amount of waste produced is increasing faster than the rate of development. As of 2002, about 2.9 billion urban residents generated about 0.6 kg of waste per person per day (0.7 billion tonnes per year). These figures increased as at 2012 to about 3 billion residents generating about 1.2 kg of waste per person per day (1.3 billion tonnes per year) (Hoornweg and Bhada-Tata, 2012). It is estimated that by 2025, the world is likely to see an incline in figures of up to 4.3 billion urban residents to generating about 1.4 kg of waste per person per day (2.2 billion tonnes per year) (Hoornweg and Bhada-Tata, 2012).

Waste management practices are not uniform among countries (developed and developing nations); regions (urban and rural areas), and sectors (residential and industrial). Waste management practices largely deal with municipal solid waste (MSW) which is waste that is created by household, industrial, and commercial activity (Hazra et al. 2009). Every economic activity produces material that can be classified as waste. Some of the larger types of wastes, such as organics and paper are easier to manage, but wastes such as multi-laminates, hazardous and e-waste, present excessively large problems (Hoornweg and Bhada-Tata, 2012). To reduce waste, industry, business and government are now mimicking nature by turning the waste produced by industrial metabolism into resource. Dematerialization is being encouraged through the ideas of

industrial ecology, eco-design and eco-labelling. In addition to the well-established "reduce, reuse and recycle", shoppers are using their purchasing power for ethical consumerism (Cheru, 2002).

Sustainable Waste Management can be defined as using material resources efficiently to cut down on the amount of waste produced, and, where waste is generated, dealing with it in a way that actively contributes to the economic, social and environmental goals of sustainable development (Medina, 2007). Sustainable Waste Management has highlighted the need for a waste management strategy, both international and national, for assorted reasons such as an integrated waste management approach that will ensure multi-stakeholder involvement (Medina, 2007). Implementation of waste management interventions will ensure the implementation of waste hierarchy which firstly aims to safely process and dispose of waste with a minimum impact on the environment and health, secondly, to reduce waste directed to landfill. Thirdly, it allows for the extraction of valuable resources contained within waste that can still be used. Finally, it encourages revised attitudes to commodity handling to minimize waste and identification of ownership of waste (Scheinberg 2011). There are critical success factors that accompany the effective use of sustainable waste management practices such as mandatory recycling and composting legislation, integrated community engagement strategy, education programmes, sufficient funding, and commitment by facilities. The waste management model must be a closed-loop system, which will be regulated by feedback on the evaluation of the process. Plans must be inclusive of all communities (Scheinburg 2011).

Research has shown (Sujauddin et al. 2008; Zhuang et al. 2008; Zurbugg et al. 2012) that individuals in all facets of society have very high interest in effective waste management. Waste management practices have highlighted factors influencing the elements of the waste management systems (Zhuang et al. 2008). Sujauddin et al (2008) express that the generation of waste is influenced by family size, education level and monthly income. Households' attitude to separation of waste is affected by active support and investment, community involvement for public participation (Zhuang et al. 2008), and fee for collection service based on the waste volume or weight (Sheinberg 2011).

Reports show that collection, transfer and transport practices are negatively affected by improper bin collection systems, poor route planning, lack of information about collection schedule, insufficient infrastructure, poor roads and insufficient number of vehicles for waste collection (Hazra and Goel 2009; Moghadam et al. 2009; Henry et al. 2006). Lack of knowledge of treatment systems by authorities is reported as one factor affecting the treatment of waste (Chung and Lo, 2008). The supply of waste facilities significantly influences household waste disposal decision-making, and it affects waste disposal choice. Inadequate supply of waste containers and longer distance to these containers increase the probability of waste dumping in open areas and roadsides. Insufficient financial resources limiting the safe disposal of waste in well-equipped and engineered landfills and absence of legislation are expressed by Pokhrel and Viraraghavan (2005).

For the management of waste in both developed and developing cities, landfilling is still the most commonly used waste disposal system as research shows that of 1.9 billion tonnes of waste generated around the world, 70% is disposed in landfill sites with incineration and recycling covering 11% and 19% respectively (Singh et al., 2014). An example is the city of Ghorahi, in Nepal, which boasts of a well-managed and maintained landfilling facility despite its low income, limited institutional resources and financial capability. The facility incorporates a number of other landfilling processes such as waste sorting for recycling, sanitary landfilling, leachate collection and treatment, and a buffer zone with forests, gardens and a bee farm that shields the site from the surrounding area (Wilson et al., 2012).

In most high income European countries, effort is actually made to collect and analyze waste data based on the established EU framework for the production of community statistics on the generation, recovery and disposal of waste (European Union 2002; (Singh et al., 2014). Nevertheless, these resources are unavailable in low income countries due to their limited financial capability. This therefore creates a gap in the availability of necessary information on waste in these countries which in turn creates problems during waste management planning and implementation. These planning problems combined with other issues such as limited landfill space forces these low income cities to implement waste management systems that are financially unsustainable

thereby giving the waste management system a short lifespan (Bai and Sutanto, 2002; Jin et al., 2006; Singh et al, 2014).

Legislation is also a key process in developing a sustainable waste management system as more often than not, the lack of comprehensive legislation may lead to the city relying on inefficient or unsustainable waste management solutions. Governmental policies, in the realm of waste management, include economic and administrative instruments. Such instruments are imperative to encourage a proficient administration of assets and environmentally friendly treatment of waste (Wilson et al, 2012). Most developing countries lack effective waste management legislation which contributes to the functions of the relevant national agencies not being clearly defined and the lack of coordination among them (Ogawa, 2008). In developing countries, the waste management legislation is usually formulated in fragments in which some of the health Acts and government policies include regulations about waste management. But more often than not, this legislation is not effective due to lack of enforcement (Ogawa, 2008). Therefore, comprehensive legislation, which avoids the duplication of responsibilities, fills in the gaps of important regulatory functions, and is required for the sustainable development of solid waste management systems.

In both developed and developing countries, there are social or cultural norms that affect designs of solid waste management systems. Where the society allows only a certain social class or group to deal with solid waste, the availability of workforce for solid waste collection and disposal becomes constrained by this rule. In some countries, directly handling human waste is a traditional taboo, which then prohibits co-composting refuse and human waste. The lack of understanding of local cultures and ways of life by the external support agency, is often a cause of failure of a collaborative project (Ogawa, 2008). Taking into consideration the social aspects at a municipal level is also essential when formulating sustainable legislation and policies as it ensures a higher efficiency and effectiveness towards a sustainable path (Mofid-Nakhaee, et al.,2020). Also, the environmental consciousness of a society can be an important aspect of a sustainable waste management as the participation of the people in the society increase the success rate of the waste management system (Vieira et al, 2018). An example is inadequate

waste sorting among people having an effect on the recycling process. Recyclable materials mixed with other kinds of wastes results in economically as well as environmentally inefficient recycling operations, consequently making other treatment options, such as incineration or landfill, more attractive.

According to Mbeng (2009) and Vieira (2018), people are drawn towards a clean and healthy environment and the ideology of learning, information and awareness campaigns are key triggers for behavioural change. Conversely, it does not give a guarantee that people will participate in recycling or separation initiatives. In high income countries such as the US, the disposal of waste is seen as an environmental concern although it is not an issue that is perceived to have any sense of urgency. The failure to identify the relationship between waste management issues and how it may contribute to climate change can prove to be of grave concern in high income countries (Vieira, 2018). Research done by Mofid-Nakhaee, et al (2020) on the effectiveness of public awareness and education shows that there is a reduction of 40% in the total cost and an increase of 17% in the social impacts when education campaigns and public awareness are implemented. Therefore, there is a positive effect of educating the public with regard to waste management - costs are reduced and beneficial social impacts are increased.

In relation to recycling, reports have shown social influences, altruistic and regulatory factors are some of the reasons why certain communities develop strong recycling habits. People who frequently go to the bins to dispose of general refuse are more likely to recycle at home, and in most cases, as the distance to the recycling bins decreases, the percentage of citizens who separate and collect at home increases (Gonzalez-Torre and Adenso-Diaz, 2005). To increase recycling rates, governments should encourage markets for recycled materials and increase professionalism in recycling companies. Other factors reported are: financial support for project recycling projects and infrastructures; number of recycling companies; presence of drop-off and buy-back centers; and organization of the informal sector (Minghua et al. 2009; Matete and Trois 2008; Sharholly et al. 2008; Henry et al. 2006; Nissim et al. 2005). In Europe and North America most municipal recycling programs were initiated with the recycling markets located close to waste management plants. Currently, marketing of recycling materials

has evolved into a global business. The price paid per tonne of waste paper in New York City is usually based on the purchase price in China. The majority of waste recycled in Buenos Aires, as another example, is shipped to China (Hoorweg and Bhada-Tata, 2012).

Waste management is also affected by enabling factors that facilitate the performance of the system. They are: technical; environmental; financial; socio-cultural; institutional; and legal. Research suggest that technical factors influencing the system are related to skills among personnel within municipalities and government authorities (Harza and Goel 2009). Socio-cultural aspects include people participating in decision making, community awareness and societal attitudes for contributing to solutions (Sharholy et al. 2009; Moghadam et al. 2009).

Factors negatively affecting the environmental aspect of solid waste management in developing countries are the lack of environmental control systems and evaluation of real impacts (Matete and Trois 2008). Municipalities have failed to manage solid waste due to financial factors. The huge expenditure needed to provide the service, the absence of financial support, limited resources, the unwillingness of the users to pay for the service and lack of proper use of economic instruments have hampered the delivery of proper waste management (Sharholy et al. 2007; Sujaddin et al. 2008). Waste management is the sole duty and responsibility of local authorities, for which the public is often not expected to contribute (Vidanaarachchi et al. 2006). The operational efficiency of waste management depends upon the active participation of both the municipal agency and the citizens (Sharholy et al. 2009).

Local waste management authorities lack organizational capacities, leadership and professional knowledge (Chung and Lo 2008). If the information is not complete or is scattered around various agencies concerned, it is extremely difficult to gain an insight into the complex problem of municipal waste management (Seng et al. 2010). Those employed as waste workers usually have very low social status, which results in low level of motivation (WIEGO, 2018). Municipalities tend to offer limited training and skills to those who are employed as waste workers. There is a need for municipalities to redefine

and restructure the role of waste workers, by providing more training for those employed, and creating more effective monitoring and evaluation systems to better encourage waste management (Vidanaarachchi et al 2006; Zurbugg et al 2005; Asase et al 2009).

When citizens in a society are provided with information about the advantages of recycling, how to sort waste and participating in programs aimed at better educating communities about recycling, they will tend to be more environmentally conscious (Guerrero et al. 2013). When political leaders give credence to waste management issues, this allows for the various support programs and strategies to be a more efficient collection system, better infrastructure and low-cost recycling technologies. An effective waste management process not only depends on participation from all sectors of society, but most importantly from the efficiency of the infrastructure and equipment (Guerrero et al. 2013).

2.3 WASTE MANAGEMENT IN SOUTH AFRICA

The analysis of waste management in South Africa, needs to reflect on the policy and regulatory environment. The story of waste and recycling in South Africa starts with the Environmental Conservation Act of 1973 (COJ 2013). It set out the requirements for the management of waste and provided the first legal definition of waste. It was largely focused on the permitting, control and management of waste disposal sites. The intention was to reduce the environmental impacts associated with poorly operated landfills, many of which were in fact unmanaged dumpsites (COJ 2013).

South Africa's emphasis on sustainable development is a primary objective at ensuring a much-needed balance in social and economic challenges and protecting environmental resources (Chimuka et al. 2015). For the waste management sector in South Africa, this means more attention, care and protection of waste management processes is required. However, rapid urbanization and a growing population has increased the generation of waste, which has promoted the need for more effective waste management processes and policies (Mohee & Bundhoo 2015). However, with the awareness to develop and establish a more effective waste management processes, various issues continue to be a challenge, such as ineffective systems of data collection, lack of adequate enforcement

capacity, and lack of necessary awareness and education amongst various sectors of stakeholders within and outside of the waste sector (Chimuka et al. 2015).

According to the National Waste Management Strategy (NWMS) (COJ 2013), the problem that South Africa faces regarding the waste sector is firstly, an increased volume of waste generation which puts pressure on waste management facilities to deal with the growing population and economy (COJ 2013). According to the National Waste Information Baseline (NWIB), South Africa generated approximately 108 million tonnes of waste in 2011, which consisted of 59 million tonnes of general waste at a rate of 0.2 to 1.3 kg/capita/day (Dlamini, Simatele & Kubanza, 2019)

Secondly, due to rapid urbanization and industrialization, there has been an increase in the level of complexity of the waste stream which directly affects waste management and develops a critical problem when general waste is mixed with hazardous waste (COJ 2013). Thirdly, although there has been major improvement made since the end of apartheid to ensure that most South African households have access to curbside domestic waste collection services, statistics showed that in 2007 only 61% of South African households has access to this service, and there is still an imbalance skewed towards the more urban and affluent areas of cities. A fourth challenge the waste sector faces in South Africa is lack of adequate data collection: there is no obligation for the submission of waste data regarding waste flows and balances in communities (COJ 2013; Matete & Trois 2008). This has created a shortage of necessary data and the information that is available is often contradictory and unreliable. The insufficient promotion of the waste hierarchy has resulted in limited economic potential of the waste management sector.

The fifth challenge is the lack of infrastructure for recycling purposes that will enable the separation of waste at source and the distribution of waste to either buy-back facilities or to material recovery (COJ 2013; Matete & Trois 2008). The lack of necessary improvement of infrastructure has led to decreasing levels of maintenance and investment. A last challenge is the underpricing of facilities and services offered by the

waste management sector in South Africa. The costs put on the facilities and services are not appreciated by consumers nor producers (Matete & Trois 2008).

The management of waste in South Africa has been based primarily on the principles of waste management hierarchy from early waste policy to the most recent waste legislation. The use of the waste hierarchy (“reduce, reuse, recycle”) has been policy since 2009, but the management of waste has not necessarily followed the hierarchal approach. It is only since the promulgation of the National Waste Management Act (2008) and finalization of the National Waste Management Strategy (2009) that the implementation of the hierarchy approach was prioritized (COJ 2013). Management of waste through the hierarchal approach is a recognized international model for the prioritization of waste management options (COJ 2013). It offers a holistic approach to the management of waste materials and provides a systematic method for waste management during the waste lifecycle addressing in turn: waste avoidance, reduction, re-use, recycling, recovery, treatment, and safe disposal as a last resort. This aims to eventually reduce the reliance of South Africa’s waste disposal on landfills (Godfrey & Oelofse 2017).

Landfilling of general waste remains the dominant technological solution in South Africa, with an estimated 90% of all waste generated in South Africa disposed of to landfill (Samson 2008). This is typical of waste management in developing countries, where disposal of waste, often to uncontrolled dumpsites, dominates (Gumbo & Simelane 2015). Several environmental and human concerns associated with landfills, prompted Government to develop policy and regulations aimed at improving the way in which landfills are designed and operated. Historically, South Africa has operated many landfill sites, most of which were unlicensed. Landfilling is driven by the unwillingness of municipalities to find alternative solutions, and (until recently) the plentitude of space in South Africa (Godfrey & Oelofse 2017).

Recycling has been taking place in South Africa for many decades, driven mostly by social needs and to a limited extent, the demand for certain resources (Samson 2008). Various options have been made available for the treatment of either general waste or of materials separated from it for recovery or recycling or pretreatment prior to disposal (Zurbugg et

al 2012). The growth of consumption goods in South Africa has resulted in the increase of discarded goods and packaging material. Recycling diverts components of the waste stream of reuse. The success of recycling is largely dependent on the market availability for both the raw and re-manufactured products (Nkosi et al, 2013). Integrated Solid Waste Management (ISWM) is an approach that has been developed to manage and recycle solid waste in effective ways and promote the protection of environment and human health (Zurbugg et al 2012). This involves an appraisal of both local needs and the required conditions to effectively facilitate the selection of the most appropriate waste management activities for possible implementation (Zurbugg et al 2012). The enabling environment is a significant factor in the process of sustainable waste management, which can be described as the set of interrelated conditions that bring about sustained and effective change. This is most effective if identified at early stages of waste management processes, in that a proposed project is adaptable, flexible and operational in all ways that meet all aspects of a society (Zurbugg et al 2012).

2.3.1 Waste management in the City of Johannesburg

Waste management in Johannesburg can be traced back to the apartheid era, during which waste service resources was distributed unevenly. Swilling and Hutt (1999) highlight the difference in services between the black and white communities due to the political state of affairs. In 1995 GJTMC was in charge of providing waste management services in accordance with the local government transition act (Swilling and Hutt 1999). According to Swilling and Hutt (1999), the most common method of collection was the use of refuse bags issued by the municipality every week when door to door collection of waste was conducted. However, due to dense population in certain areas and inadequate infrastructure, collection of waste was limited (Kubanza, 2012).

According to an article by Landie (2010), to maintain the cleanliness of a city, there has to be a partnership between the municipality and the community which it serves. The clean city campaign, which was one of the early initiatives implemented by the City of Johannesburg post-apartheid, was implemented in 2009 in preparation for the 2010 FIFA World Cup. This initiative aimed at engaging Johannesburg residents and businesses so as to change their attitude towards illegal dumping and waste. This initiative formed a part of the City of Johannesburg integrated waste management strategy which is an integral

part of Johannesburg's waste management system (Landie, 2010). Johannesburg uses landfilling as its most common waste disposal practice which accommodates all the different kinds of waste generated due to lack of waste separation thereby generating greenhouse gases which are detrimental to the environment. An example is the Robinson Deep landfill site where the tonnes of organic waste disposed generates a large amount of green gases and untreated leachate which contaminate the surrounding soil and ground water (Meyers et al, 2006).

The waste to energy initiative is a private partnered process with only private companies venturing into this method and municipalities as stakeholders (Ringwood, 2015). The first waste to energy initiative in the City of Johannesburg (CoJ) was initiated in 2007, when a contract was signed with EnerG Systems Joburg over 20 years to implement the waste to energy project at no cost to the City. This was meant to reduce the traffic of waste into Robinson Deep and Marie Louise landfill sites as well as provide job opportunities for the residents and generate revenue for the city (Baker and Letsoela 2016). More recently, other private companies like PlasWEn are partnering with municipalities in Cape Town, Tshwane and Johannesburg to resurrect the initiative of waste to energy. Although it is still at the early stages, there are plans to initiate the plant in Tshwane as a test run (Ringwood, 2015). The promotion of composting, waste-to-energy and other reuse and recycling initiatives supported by the introduction of separation at source programmes have also been implemented (Kadyamadare, 2017). "Waste-to-energy" technologies have been introduced to the society as one of the opportunities to improve the management of solid waste at the same time promoting a clean and healthy environment through the recovery of waste and the generation of energy, hence becoming a potential contributor to the City of Johannesburg's socioeconomic development (Dlamini, Simatele & Kubanza, 2019).

According to Taiwo (2009), research conducted in low, middle and high income areas, showed that 82%, 83% and 70% of participants respectively were keen on separating their waste based on recyclability. The research highlighted the possibility for separate at source which aimed at substantially minimizing the amount of landfill disposed waste. The City of Johannesburg's waste management practices comprises mainly of waste collection, recycling and most of all, landfilling which are guided by the NEMA Waste Act

and the Johannesburg Waste By-laws (Friedrich and Trois 2010; Mohee and Simelane 2015). These legislations are put in place by the state government to ensure that residents and private companies take proper care of the waste generated (Ringwood, 2015). Dlamini, Simatele and Kubanza (2019) estimate that the landfill airspace in Johannesburg will be totally exhausted by 2023.

Studies by Landie (2010) highlight separation at source as an initiative which most commonly promotes recycling so as to increase the amount of waste diverted from landfill sites. Waste reclaimers can technically be viewed as the originators of recycling as they were separating reusable waste and giving them value long before recycling was implemented as a means of waste management (Samson, 2018). The incorporation of waste reclaimers as an initiative to promote recycling in Johannesburg is also a recent and ongoing programme by the City of Johannesburg. It is also used as another way to improve the waste processing scheme so as to regulate the price of recyclable materials at buy-back centres which increases the rate of recyclable material (Dlamini, 2017) and also contribute towards the elevation of the quality of life of the people within the city by ensuring them a clean environment and by identifying, promoting and supporting potential job opportunities within the sector (Memela, 2018). The separate at source initiative was only implemented after the 2009 business year and so before the implementation, the waste reclaimers had to create their own “separate outside source” initiative where they would separate different valuable wastes which could be resold, thereby transforming the city’s landfill into a resource area (Samson, 2018).

Over the last two to three years, reclaimers across the City have started organising through the Interim Johannesburg Reclaimers Committee (IJRC) to challenge Pikitup’s separation at source and integration projects. Reclaimers are demanding that all programmes and policies related to recycling should be grounded in recognition that reclaimers are the founders of the city’s recycling system and economy. Pikitup and the City formed a task team with reclaimers to develop a framework on integrating reclaimers after a protest by the Interim Johannesburg Reclaimers Committee (IJRC) in July 2017 (Samson, 2018). The task team has made great progress in collectively designing and implementing a new registration process for reclaimers.

The City of Johannesburg has come up with a new initiative, the general scope of which is to provide CoJ with a waste treatment technology facility that will accept 500 000 tonnes of municipal solid waste per annum through a “design-build-finance-maintain-operate-transfer” public-private partnership (PPP) model to provide a sustainable solution to reducing waste to landfill (COJ 2013; Matete & Trois 2008). PPP secures the substantial initial capital funding required for the project. The City of Johannesburg believes that the new proposed project will bring a variety of benefits such as renewable energy, revenue from sale of by-products, the potential to earn carbon credits, private party expertise, raising capital, and many more benefits (COJ 2013; Samson 2008).

2.4 CONCLUSION

Since waste management is a significant component of ensuring sound environmental health and sustainability both domestically and internationally, developing effective waste management methods from the international to national, and even down to close-knit communities, will develop societies that are more environmentally aware.

Looking into how environmental sustainability has been promoted through waste management practices in South Africa, Germany, Brazil, Rwanda and Singapore will also present a perspective on waste management in other countries. This research will analyze each country’s understanding of environmental sustainability and how waste management is perceived in ensuring environmental sustainability as a means of establishing the best practice.

CHAPTER THREE

RESEARCH METHODS

This research seeks to investigate how environmental sustainability can be promoted through effective waste management practices. Waste management is a significant component in ensuring sound environmental health and sustainability both domestically and internationally which helps to develop societies into more environmentally aware and stable communities (Zurbugg et al. 2012).

This research looks into how environmental sustainability can be promoted through waste management processes practiced in Johannesburg, with reference to the processes used in Berlin, Kigali, Curitiba and Singapore. This research analyses each city's understanding of environmental sustainability and how waste management is perceived in ensuring environmental sustainability. This study explores the narratives around the notion of environmental sustainability and how this can be promoted through effective waste management.

3.1 RESEARCH METHOD

This research utilizes multimethod, which is a combination of two or more qualitative methods. Qualitative research methods generate information that is rich and has a well-grounded description of processes that clearly identifies local contexts. It preserves chronological flow which helps with deriving sound explanations (Amaratunga et al, 2002). The qualitative method for this research is a desktop study as mentioned in chapter one. A desktop study focus on the collection of information without fieldwork. It incorporates the use of internal sources, reports and statistics documents amongst others such as library sources and the internet (B2B International, 2019).

For information gathering, the tool most suitable for this research which was applied to the desktop study was document analysis, which is a systematic process used in reviewing or evaluating documents, both printed and electronic material (Bowen, 2009). The desktop research approach in this study allows for other sources of information such as documentation, reports, published articles, formal and informal discussions (Amaratunga et al, 2002). Document analysis deals with examination and interpretation

of information in order to depict the meaning or understanding, and develop first-hand information (Corbin & Strauss, 2008).

The second research method is a comparative analysis where a matrix table was used to compare the effectiveness of the waste management initiatives implemented in the selected cities. Matrix tables are often used to cross-classify a multi-dimensional concept of a topic of interest (Verdinelli & Scagnoli, 2013). In this research, the matrix table allowed for the information retrieved to be expressed in column and row groups as expressed in table 1. When the information regions and report are combined, the display grows horizontally and vertically as information is added. A matrix is also defined as a grid used to display information in a structured manner (Tannas, 2012). Matrix analysis has been known over the past century to effectively summarise the complex nature of generating knowledge. A matrix can consist of verbal information, and it explains various aspects of the research that requires an overview of the data related to certain information (Klopper, Lubbe & Rugbeer 2007). This matrix table consists of the study cities as the row headings against the different waste management initiatives considered, as the column headings. These waste management practices were determined using the waste hierarchy and the waste management practices common in all cities hence producing the five common waste management processes discovered in this research.

Table 1: Sample of Matrix table

	Landfilling	Legislation	Recycling	Incineration	Initiatives
Johannesburg					
Singapore					
Curitiba					
Kigali					
Berlin					

3.2 LIMITATIONS

During the course of this research, a number of limitations were encountered which hindered the direct process of the research. Firstly, due to the specific method selected for this research, validation was limited as the research was based solely on document analysis. In order to get information on the waste management processes in Johannesburg, Pikitup and City of Johannesburg were contacted on numerous occasions. Unfortunately, it was impossible to arrange an interview with any Pikitup or City of Johannesburg personnel. Therefore, all the information from Pikitup was accessed from the Pikitup annual reports which are available on their website. Although no interview could be arranged for COJ personnel, an internal document with limited information was received directly from the City of Johannesburg. This was limited due to confidentiality considerations. Most of the information obtained from the City of Johannesburg was also accessed from their website. There was also the issue of limited updates in the reports from COJ and Pikitup websites which made it difficult to gather relevant and up-to-date information. Finally, obtaining information on the waste management practices of each study site was limited by the amount of accessible information online and the number of research works that have been carried out on these particular cities.

3.3 INFORMATION RETRIEVAL PROCESS

For the purpose of this study, the information was accessed mainly from annual reports from Pikitup and City of Johannesburg, websites of government platforms such as Department of Environmental Affairs, as well as various media coverage and waste management newspapers. The information extracted from these sources was considered to be the primary sources for this study as they reveal commitments the CoJ made with the intention to establish effectiveness in waste management process. By using these sources, the research focused on a number of specific criteria – landfilling, recycling, legislation, mayoral strategy goals and other initiatives implemented, or yet to be implemented in the waste management process in Johannesburg. These initiatives can be considered to form the basis of Johannesburg waste management practice and hence were also considered when evaluating waste management practices from the other cities so as to provide a direct comparison. Due to limited access, the information on waste

management for the four study cities was derived from the respective legislative body reports as well as supporting online documents and other academic journals which highlight the waste management processes of the cities. Documents such as the Berlin Senate Department for Urban Development and the Environment Communication and the National Environmental Agency, were used in retrieving information concerning waste management legislation for Berlin and Singapore. Other online documents and journals were consulted to provide in-depth information.

CHAPTER FOUR

OVERVIEW OF STUDY AREAS

An interpretation of the information was provided using the qualitative explanation building strategy, which involves the analysing of documents by building an explanation about the situation regarding how environmental sustainability has been promoted through waste management processes practiced in Johannesburg, with reference to the processes used in Berlin, Kigali, Curitiba and Singapore. These cities were chosen as the preferred study sites using two criteria namely geographical location – each city is found in a different continent of the world thereby expanding the research to a world-wide range. The other criteria were their various waste management specializations. Each city is mainly known for a specific waste management practice in which its success rate is high. Aside from Berlin, which was used as the benchmark for this research due its general success rate across all waste management practice, Singapore thrives most in the use of incineration as its main waste management practice while Curitiba is known world-wide for its environmentally sustainable initiatives including waste recycling and recovery schemes. Kigali, although it lacks in infrastructural development, still uses some successful waste disposal and cleanliness initiative which South Africa has taken notice of and has implemented.

This qualitative explanation was carried out by stipulating causal links between the cities, leading bodies and the awareness of environmental sustainability in the general societal structures of the countries (Amaratunga et al, 2002). Using the same criteria used in retrieving information on the waste management practices in Johannesburg, information was derived for the four study sites covering the waste management practices of landfilling, recycling, incineration, legislation and other waste management initiatives. At the end of the document analysis, recommendations were provided as this study's aim is to identify the effectiveness of waste management in specifically the City of Johannesburg and recommend possible rectification procedures if ineffectiveness is discovered during the course of the study. The study was concluded by drawing on the information analysed, and the recommendations provided.

4.1 OVERVIEW OF JOHANNESBURG

The City of Johannesburg is a Metropolitan Municipality which comprises an area of approximately 1 645 km², with a population of approximately 5.8 million according to Stats SA (2020) which shows a 2.6% increase from 2019. Johannesburg is the commercial and economic hub of South Africa and the African continent, and it contributes to about 47% to the provincial and 17% towards national economic growth. Municipal waste is serviced through Pikitup, a municipal owned entity with over 700 000 service points per week. It also has 119 informal settlements serviced daily through community based private contractors. It also holds four permitted landfill sites and 150 compactors (COJ 2013). In order to explore waste management in Johannesburg, one must also explore Pikitup as an entity as it is the sole waste management company for the City of Johannesburg. Hence, this research focuses on Pikitup and their waste management practices with reference to the above mentioned criteria.

Pikitup is a utility organisation set in place by the City of Johannesburg in 2001 as a means of providing waste management services to residents of Johannesburg. This was set in place in accordance with the National Environmental Management Act 107 of 1998 (Pikitup, 2018). Pikitup, which is also a service provider of the City of Johannesburg and specializes in the integrated waste management of Johannesburg, was started in 2000 to provide waste management services to the City of Johannesburg (Pikitup, 2013). Since its establishment, Pikitup has strived to achieve a number of goals by implementing numerous waste management initiatives. The organization has done this through promoting its aims such as preventing and minimizing the production of waste, and creating value from waste by ensuring the establishment of a recycling economy, whereby the community can benefit from recycling activities and also provide an effective delivery service of waste in Johannesburg to promote a clean and health community thereby increasing investor confidence (Pikitup, 2018).

In line with the organization's core purpose to promote resource security, environmental sustainability and good governance in the City of Johannesburg as envisaged in the Johannesburg Growth Development Strategy (GDS 2040), a number of initiatives have been developed and implemented over the years. These initiatives aim to minimize the

production of waste, increase reuse and recycling activities and also manage the disposal of waste in the community thereby providing a more sustainable environment (Oelofse and Godfrey, 2008). The City of Johannesburg aims to implement sustainable waste minimisation, reuse, recycling and recovery programmes through strategic interventions including the promotion of composting, waste-to-energy and other reuse and recycling initiatives supported by the introduction of waste separation at source programmes. These programmes should contribute towards the elevation of the quality of life of the people within the city by ensuring them a clean environment and by identifying, promoting and supporting potential job opportunities within the sector (Memela, 2018).

According to Pikitup (2018) about 6 000 tonnes of waste is collected and disposed of daily. Although there is a lack of information on how much waste was produced yearly before or in the early years after the introduction of Pikitup, current information according to the City of Johannesburg (2011) show that about 1 492 000 tonnes of waste was produced in 2008 which was a 4.4% increase from the amount of waste produced in 2003 (COJ, 2003). Nevertheless, with the introduction of Pikitup, reports still show an increase in production of waste in Johannesburg from 2008 projected to 2023. It recorded that the production of waste in 2013 rose to above 1.5 million tonnes a year and almost 1.7 million tonnes in 2017 (Pikitup, 2014; 2016). This trend is foreseen to increase slightly by 2023 (fig 1).

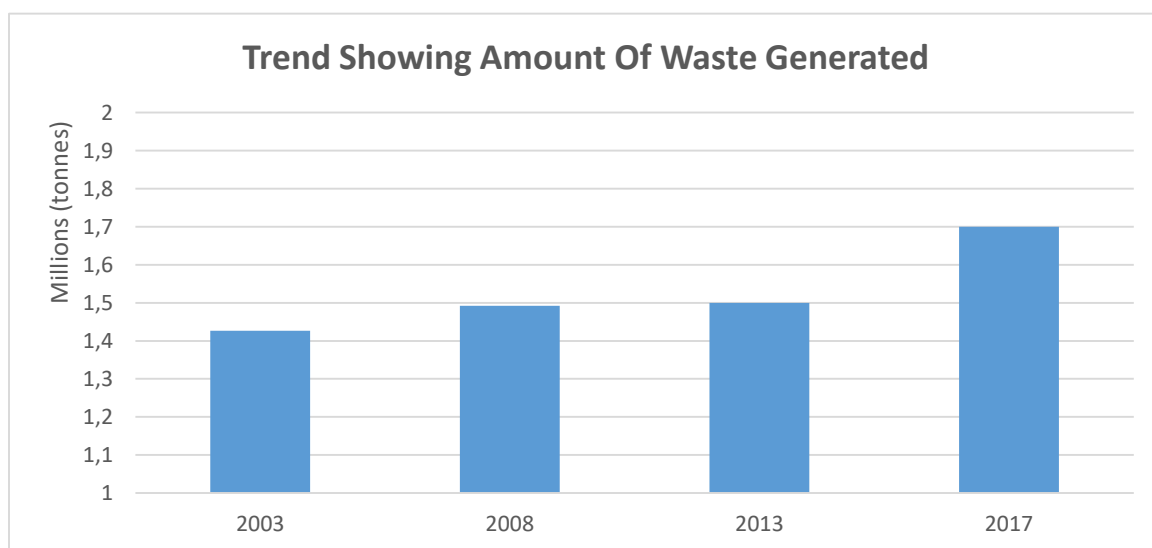


Figure 1: Amount of waste generated (in tonnes) in the City of Johannesburg from 2003

A number of successful initiatives have been carried out by Pikitup, for example, the separation at source, which aims to improve recycling and reduce landfill waste in Johannesburg (Mbiba, 2014; Pikitup, 2018), implementing the Jozi@work initiative with the strategy of appointing community based contractors who will be responsible for the collection and management of waste, street cleaning and removal of illegal dumpsites (Pikitup, 2018). The Bulky Waste Service initiative, which was implemented in 2015, is another successful initiative developed by Pikitup. It was established as a means to remove large amounts of household waste on a monthly basis and divert the recyclable wastes from landfill sites so as to increase the lifespan of landfill sites (Pikitup, 2017). Initiatives to fight illegal dumping of refuse have also been implemented by the organization in collaboration with the City of Johannesburg's Environmental Health Department and the Metropolitan Police Department, due to the fact that illegal dumping is one of the biggest issues in waste management in the City of Johannesburg (COJ, 2012; Pikitup, 2018). Another successful initiative implemented by Pikitup is the introduction of buy-back centers as a way to minimize waste. This consists of buy-back establishments where waste materials which have some sort of economic value are bought from the community and sold to outside markets for some profit (Blaauw Schenck & Viljoen, 2012; Pikitup, 2017).

4.2 OVERVIEW OF BERLIN

Berlin's success in its waste management practice has been inspiring within the past 20 years. The amount of waste generated has been on a constant decrease and waste recovery and recycling is on an increase (Zhang et al, 2010). As the largest and second most populated city in Germany, Berlin has a land area of 892 km² and carries a population of about 3.7 million inhabitants within its borders (World Population Review, 2019). There have been reports of declining levels of municipal waste in Berlin, which show that the amount of waste has reduced from 2 594 000 tonnes in 1992 to 1 481 000 tonnes which is about 43% in 2012. Some 79% of municipal waste comes from households, and the remaining is from the commercial sector. However, reports show that 57% of the waste is disposed in accordance with regulations, and 43% is recycled or processed in waste-to-energy recovery. The reduction rate of waste in Berlin since 2000 has been quite dramatic, especially the amount of waste disposed to landfill and

incineration which reduced to less than 1 million tonnes in 2007, a 60% reduction rate since the early 1990s (Schulze, 2009). Furthermore, since recyclable waste comprises about 80% of the total commercial waste (Schwilling et al., 2004), there has been a lot more work done to promote separation and recycling of waste which has helped reduce the amount of commercial waste on a major scale between the early 1990s till 2007.

The decline in municipal waste is attributed to the falling amounts of commercial waste and the separation techniques of municipal recyclables (Berlin Senate Department for Urban Development and the Environment Communication 2013). This was a by-product of the series of waste management Acts and legislations in which has guided and promoted the minimum waste policy of Berlin. An important legislation which was approved in 2011 by the Berlin House of Representatives was the Land Berlin. This created conditions for the prevention of waste and the disposal of all waste generated in Berlin for a planning period through until 2020. The strategy specified the key steps needed for the development of waste management in Berlin in a modern, closed-loop system in the coming years (Berlin Senate Department for Urban Development and the Environment Communication 2013). The main objective of the Land Berlin Act is to promote low volumes of waste, which also ensures environmentally-compatible and economic waste disposal. The Berlin Closed Substance Cycle and Waste Management Act, also known as Land Berlin, is responsible for the disposal of the waste generated within city. The duties relating to the collection and disposal of waste from private households and of disposable waste from other sources are entrusted to the BSR (*Berliner Stadtreinigungsbetriebe*) as a statutory body of Land Berlin (Berlin Senate Department for Urban Development and the Environment Communication 2013).

There has been a decline in the need for landfills in Germany over the last years and this is mainly due to the increase in the amount of recycled and recovered waste. Most of the remaining solid waste (construction waste, bio-waste) that is not recycled is incinerated, for co-incineration. There are innovative methods for solid waste treatment in an environmentally responsible manner, such as mechanical-physical stabilisation and mechanical-biological treatments. These treatments include sorting and separating the waste into combustible fraction which could be used for waste to energy recovery. However, it could be sorted and separated into biodegradable fraction that is subjected

to biological treatment and then composted under aerobic conditions. There are two compost plants that are currently operating in Berlin - Pankow (capacity of 160 000 tonnes per year) and Reinickendorf (capacity of 180 000 tonnes per year) totalling a capacity of 340 000 tonnes per year. This amounts to almost 36% of the total amount of waste disposal in 2008. Berlin's incineration plant which is the Ruhleben incineration plant is currently the only incineration plant in the country, holding a total capacity of approximately 520 000 tonnes per year (Thürmer, 2007). In the case of by-products, metals are separated out for recycling, the slag may be reused after reprocessing and the energy output can be used as heat and electric power.

4.3 OVERVIEW OF SINGAPORE

Singapore is a small but highly urbanized and industrialized island city-state in Asia, having a large and growing population of 5.7 million people (Statista, 2019), warm climate and high humidity due to its location of about 137 km north of the Equator. Singapore has a very high population density of 7 088 person/km² and a land area of 682.7km² (Yearbook of Statistics Singapore, 2008). Singapore is considered a land-scarce country, and almost 83% of the residents live in multi-story high-rise public housing buildings (Kalaian et al., 2009). With the rapid economic and population growth, higher standard of living and changing lifestyles, the refuse output in Singapore has been increasing steadily.

Singapore has experienced close to seven-fold increase in the amount solid waste disposed of from about 1 260 tonnes a day in the 1990s to 8 443 in 2017 due to growth in the country's population and economy (NEA 2018). As stated by Eng (2012), the amount of waste produced annually increased from 0.7 million tonnes in 1972 to 2.8 million tonnes in 2000 and to 7.8 million tonnes in 2011. As the growth is expected to continue, the main challenge that Singapore is experiencing is finding adequate land space for waste disposal as the country has limited land. To provide a more sustainable form of waste management, the country adopted some strategies, which were categorized into minimization or prevention, recycling, waste-to-energy, volume reduction and landfill. The hierarchy of solid waste management in respect to the strategies is waste minimization (reduce, reuse and recycle), followed by incineration and then landfill.

A committee called the National Environment Agency (NEA) developed plans towards the country's waste management system. The government ensured that sustainable waste management involved the people, both public and private sectors (NEA 2018). Also, various Singapore-based companies continue to sponsor new waste management techniques and are constantly collaborating with both regional and global partners to deliver best solutions (IES 2008). Although waste minimization is top priority, the most preferred waste management practice is incineration due to the low land space and the availability of only one offshore landfill site in Singapore (Bai & Sutanto, 2002). The government has ensured that at least 92% of waste produced is incinerated, while the remaining 8% is disposed of at landfills at a unique offshore waste facility (IES 2008). Singapore has four incineration plants that serve as a land-efficient waste management method and provides about 3% of the island's electricity needs (IES 2008).

Singapore's integrated waste management system focuses on three main areas: the first is collection; the second, recovery; and the third, treatment. The core strategies for the sustainability of Singapore's waste management include the minimization of waste through reducing, reusing and recycling; a push towards the zero use of landfill; and developing an effective waste management industry to position Singapore at the center of effective waste management technology in the region (IES 2008). There has been an increase in the recycling rates in Singapore as there has been an increase in waste generation as a result of economic and population growth. Landfilling plays a minor role in Singapore due to geographic and legislative prohibition. Moreover, the waste generated in Singapore is used as a valuable resource and action has been taken to develop incineration technology, for energy recovery and to protect the environment. The only offshore landfill site, which is the Semakau Island, strictly accepts only inert, inorganic solid waste. Hence, a large bulk of food waste is directed to incinerators while a small percentage of the remaining waste is recycled using anaerobic digestion and compositing of the digested material (Zhang et al, 2010).

4.4 OVERVIEW OF CURITIBA

Curitiba, which is the capital of the Brazilian state Parana, is well known for its innovative initiatives, ranging from their public transport systems to their waste management initiatives, environmental education and social programmes (Rabinovitch, 1992). The city occupies 431km² with a population above 1.9 million (World Population Review, 2019) and is one of the fastest growing cities in Brazil in terms of economy and demography (Rabinovitch, 1992). The amount of waste generated by the city of Curitiba has increased from around 800 tonnes per day in 1992 (Rabinovitch, 1992), to about 1 600 tonnes per day in 2017 due to the increase in population and industrialization. For collection, the most common method of waste disposal in Curitiba is with the use of plastic containers, metal baskets or in plastic bags which is separated into recyclables and non-recyclables and placed on the streets' sidewalks. This resulted in Curitiba's ground-breaking recycling campaigns and systems of waste collection, sorting, and commercialisation (Calafate-Faria, 2013). Some of these initiatives were the integration of social programmes and environmental education which involved the implementation of the 'garbage that is not garbage' initiative and the garbage exchange programme.

One of the most common waste recycling programmes in place is the *Lixo que nao è Lixo* (or waste that is not waste) which is based on the exchange of recyclable waste for food; an example is the *Câmbio Verde* initiative, which was initiated in the year 1991 and it was targeted for the low income districts of the city where there was no easy access for waste truck. The Waste that is not Waste initiative promotes the implementation of separation at source of organic and inorganic waste for easy recycling (Rabinovitch, 1992). Another initiative implemented was the Green Exchange municipal programme which was initiated in 1991. The programme targets poor districts of the city due to the lack of infrastructure i.e. Waste trucks were not able pass to collect waste on a hill or riverbank. The collection happens once a week in low income neighbourhoods, with the exchange of recyclable waste with food.

The "purchase of garbage program" (also known as the "green exchange") which was initiated by the mayor of Curitiba, Jaime Lerner, focuses mainly on social and environmental aid for the rural areas of the city. Most rural areas lack accessible routes

for the garbage trucks due to their location and so improper dumping of refuse in public places which may increase the chances of disease spread. In order to reduce this, centres have been set up where residents deliver their collected garbage in exchange for bus tickets and groceries which in turn has had a relative decrease in diseases caused by improper waste disposal and also a provision of job opportunities for the residents (Soltani & Sharifi, 2012; Rabinovitch, 1992).

The purchase of garbage initiative also focuses on the squatter settlements as the waste collection services do not operate within the squatter camps, mostly due to lack of access into the settlements. Due to the lack of access and also lack of basic knowledge about waste management and hygiene, there is quite a large number of illegal dumping sites which promotes diseases. Moreover, in these areas there is a high prevalence of malnourishment. Therefore, in order to eradicate this situation, the purchase of garbage initiative was implemented, which allows residents of the squatter settlements sell their sorted waste in exchange for bus tickets, groceries, or school supplies for the children. This has helped to reduce the amount of illegal dumping dramatically, thereby improving healthy living conditions (Rabinovitch, 1992). There is also a program for the children of these rural and squatter areas where they gather up recyclable waste from around the communities as an incentive for school supplies, snacks and tickets for plays. This initiative promotes educational and environmental responsibility for the children and also improves the ecosystem of the community by ensuring an increase in waste control (Thomas, 1992).

4.5 OVERVIEW OF KIGALI

Rwanda is a land-locked country, located at an altitude of 1 250m (Seburanga, 2015). According to Population Stat (2020), the population of Kigali has increased to 1 132 686 with a growth rate of 2.6% per annum since 2002 (National Institute of Statistics of Rwanda, 2012). Although Rwanda's population density is the highest within the East African region at 460 people/km², Kigali's population represents only a tenth of the country's population. With its size of about 730km², it serves as the economic hub of the country (Kabera Et al, 2019). According to Isugi and Niu (2016), due to the rate of growth in population, and the improvement of living standards, there is a growing concern

associated with waste generation in Kigali city. All the waste generated by the city is collected and disposed of at the only landfill site in Kigali of which 68% of the waste composition is organic waste (Isugi & Niu, 2016).

According to Kabera, Wilson and Nishimwe (2019), the total waste generated in Kigali not calculated due to the fact that households and businesses are usually compelled to look after their own disposal of waste, usually through illegal dumping. Isugi and Niu (2016) estimate the total amount of waste generated to be between 1 800 tonnes to 2 000 tonnes per day, of which only 400 tonnes are accounted for in the Nduba landfill while the remaining are illegally dumped. Rajashekar, Bowers and Gatoni (2019) agree with this data as they estimate the amount of waste generated to be between 500 to 800 tonnes per day and also estimating a 63% increase in the waste generation to about 1 300 tonnes by 2030.

The government has implemented some initiatives to tackle the waste management problem but they still face issues relating to waste disposal and its facilities. One of the issues present in Kigali City is the implementation of composting as a majority of the solid waste generated is organic waste (Rajashekar, Bowers & Gatoni, 2019). In many cities, instead of incineration, dumping and burning are the preferred disposal methods. For example, about 84% of the solid waste produced is burnt openly in Kigali. The issues of waste management as seen in Kigali are mainly attributed to inadequate equipment and staff as well as the inefficiencies associated with central government agencies (Aryeetey-Attoh, 2003; Benedine et al., 2011).

The major disposal process in the Kigali waste management system is landfilling, although in recent years the city has been working on ways to successfully implement recycling and waste-to-energy initiatives. However, the government has also put in place land use management plans which are to be adhered by all citizens in the county. This is due to the unavailability of land in Kigali and the subsequent increase in the generation of waste due to the increase in population of the city. Plans have been developed to install incinerators that will be used to burn wastes instead of dumping them but the implementation is still at the processing stage due to financial limitations, yet the solid wastes are increasing daily (Nshimiyimana, 2015). According to Nshimiyimana (2015),

recycling is still a very young and unknown process in Kigali such that only a few are aware of it while others remain ignorant to its importance. From his research, he deduced that although landfilling is the main process of waste disposal, the technology used in landfilling is quite outdated as the method is quite similar to that of open dumping and has no proper coverage or treatment. Nshimiyimana (2015) also highlighted that the main challenges of waste management in Kigali can be directly associated with inadequate infrastructural facilities such as insufficient expertise and lack of financial resources, legal and administrative enforcement. A successful initiative implemented by the government has been the Umuganda model set in place to improve the cleanliness standard of the city. Various significant features were discovered about the Umuganda, in which every Saturday of the month all citizens commit time to projects aimed at improving public spaces (Malofha 2017).

CHAPTER FIVE

WASTE MANAGEMENT PRACTICES IN THE CITY OF JOHANNESBURG

5.1 INTRODUCTION

This chapter focuses on the analysis of the waste management processes used in the City of Johannesburg, concentrating specifically on landfilling, incineration, recycling, legislation and other initiatives. In order to analyse these processes, relevant information was acquired from both Pikitup and City of Johannesburg annual reports, dating back to 2010 and taken to 2019, including the Pikitup business plan report and strategic imperatives report. Internal sources, such as staff presentations and reports, were used to validate other internet sources which were used in providing the necessary information for this study.

5.2 JOHANNESBURG WASTE MANAGEMENT PROCESSES

The most commonly used waste management process in South Africa to date is the use of landfill sites. Research showed that in 2011 as much as 90% of the total waste generated country-wide was disposed of in landfill sites (Stats SA, 2018). In Johannesburg, Pikitup currently has four active landfill sites along with 11 waste management depots located at strategic points of the city, 42 garden refuse sites, one composting plant and one incinerator (Pikitup, 2018). Based on the exponential increase of solid waste generated in South Africa, it has been observed that there is a lack of available land space for waste disposal, should new landfill sites be needed. According to information on the Pikitup website, as the amount of waste disposed in the landfill site increases per annum, while the amount of airspace in the landfill site reduces. It is estimated that the landfill sites will be overrun by 2025 (Pikitup, 2018). This therefore has increased the importance of other waste management methods like recycling, in which a very low percentage of South African households participate (Afrika et al, 2016).

The importance of recycling as a means to reduce the negative impact of waste on the environment has caught recent attention, hence the introduction of the National Waste Management Strategy by the municipality which aims to divert at least 25% of recyclable

waste from landfill sites and to initiate the separation at source initiative on a municipal scale in response to the National Environmental Management Act of 1998 (NEMA, 2008). Hence the City of Johannesburg has implemented processes with the aim of reaching a target of up to 60% of waste which was to be diverted from landfill sites by 2018. Nevertheless, only a little above 34 000 tonnes was diverted in 2017, which was less than 3% of the total waste generated and less than the previous year which recorded 49 000 tonnes diverted (Memela, 2018). The separation at source initiative was targeted to be implemented in at least 30% of household within the municipality although the amount of households involved in this initiative seems to be reducing as the percentage dropped from 17.5% in 2017 to 12% of active households in 2018.

Another important aim of this strategy was to achieve an 80% municipal implementation of local awareness programmes by 2016 (Stats SA, 2018). According to the annual reports, Pikitup has also implemented a “multiyear waste minimization programme and public education awareness” which is in response to the GDS 2040 waste to landfill target of diverting at least 2.5 million tonnes of recyclable waste from the landfill sites (Annual Report, 2016). This would help to inform the use of recycling as another means of waste management rather than just landfilling. Currently, even as the importance of recycling gains more awareness, still a very low percentage of households participate in this process with research showing only about 12.7% in the Gauteng region actually recycling their waste (Stats SA, 2018). Koushki et al (2004) highlight a number of factors which affect the collection and transportation cost of waste from household or pickup sites to the landfills. Such factors are population size and density, the area size, the quantity of household generated solid waste, the collection distance, the configuration of streets and roadways, and the level of area traffic congestion.

Due to the difficulty in placing disposal facilities in highly populated areas, the cost of transporting waste tends to increase, which triggers the idea of providing transfer stations which would substantially reduce the cost of waste transportation. According to Pikitup, the introduction of the separation at source initiative in 2011 was a means to assist with the awareness and participation of recycling amongst households in Johannesburg. Since the initiative to divert solid waste from landfill site in order to economize on the use of

landfill airspace, research has highlighted that one of the major advantages of active recycling in Johannesburg would be the profit as it is said to generate up to R36 billion which would have a major impact on the financial status (Savides, 2016).

5.3 MAYORAL STRATEGIES

As a municipally owned entity, the core strategies of Pikitup are informed by the mayoral priorities of the city as well as the GDS 2040 principals. The priorities include the Priority Implementation Plans (PIPs) which are developed for each priority and are included in the Integrated Development Plan (IDP) for the City of Johannesburg. From these priorities, Pikitup identified a number of goals which are to be achieved through the implementation of the strategies. In the 2012/13 business year, three goals were focused on to identify the initiatives to be implemented. These goals were re-evaluated in the 2013/14 business year and a new goal was added, bringing them to four. By the 2015/2016 business year a fifth goal was incorporated. An additional two goals were introduced in 2013/14 and 2014/15, but these were omitted in subsequent years. Table 2 shows the goals that were to be achieved using the implemented initiatives. The goals are explored in more detail below.

Table 2: Strategic Goals of Pikitup (Pikitup, 2013; 2014; 2015; 2016)

GOAL	OBJECTIVE	EXPLANATION
Goal 1: Shift towards Integrated Waste Management and Waste Minimisation	Objective 1.1: To ensure that waste to landfills is minimised	Various projects are to be implemented to minimise waste to landfill. The ultimate aim is to reduce greenhouse gas emissions as well as increase airspace.
	Objective 1.2: To ensure Appropriate infrastructure is developed to dispose of	The new model of operations requires different infrastructure needs such as buy-back

	waste in a sustainable manner	centres, composting facilities and others. The necessary infrastructure needs to be developed. In addition, there may be new technologies to be implemented such as Waste-to-Energy and Landfill Gas Extraction. Additional technologies may be identified related to the various waste streams.
Goal 2: Promoting and Ensuring the Effective Delivery of Waste Services	Objective 2.1: To ensure effective and efficient waste services	These services include domestic waste removal, street cleaning, informal settlements as well as some public owned facilities. The objective is to ensure that these services are rendered in an efficient manner and that the highest cleanliness levels are achieved.
Goal 3: Realization of value throughout the Waste Value Chain	Objective 3.1: To use waste as a resource for poverty alleviation and create job creation opportunities	CoJ has high levels of unemployment, poverty and inequality. Waste minimisation provides opportunities to use

		waste as a resource and these should assist communities to address poverty. Consideration is given to the implementation of coproduction to address these challenges.
Goal 4: Partnerships and Involving Stakeholders	Objective 4.1: Increasing partnerships to deliver and ensure active stakeholder engagement	Key to the successful achievement of waste prevention and minimisation is the change of citizen behaviour. The intention is to mobilise communities in partnership with labour, business and civil society to enable changed behaviour. This will result in a cleaner city with less littering and illegal dumping, as well as increased volumes of waste diverted from landfills.
Goal 5: Build an Effective and Efficient Waste Management Company	Objective 5.1: To optimise financial management and sustainability	The entity currently has a deficit. In order to be a leading company the financial position of the

		company needs to be addressed.
	Objective 5.2: To improve customer satisfaction and change behaviour	The behaviour of residents impacts on the success of the initiatives related to waste minimisation. In addition, the services rendered impact on residents and therefore a specific focus is placed on the management of interfaces with the community.
	Objective 5.3: To provide safe and secure environment to all employees	Safety is a key priority of the company to ensure that staff are safe and that the working environment is created to reduce incidents and deaths.
Goal 6: Promoting and Implementing Developmental Service Delivery to ensure Economic and Social Development	Objective 6.1: To use waste as a resource for poverty alleviation and create job creation opportunities	CoJ has high levels of unemployment, poverty and inequality. Waste minimisation provides opportunities to use waste as a resource and these should assist communities to address

		poverty. Consideration is given to the implementation of coproduction to address these challenges.
Goal 7: Grow the contribution of the waste sector in the green economy	Objective 7.1: To use waste as resource for poverty alleviation and create job creation opportunities	CoJ has high levels of unemployment, poverty and inequality. Waste minimisation provides opportunities to use waste as a resource and these should assist communities to address poverty.

Table 3: Table showing the change in strategic goals per year

Goals Year	1	2	3	4	5	6	7
2010/11							
2011/12							
2012/13	X	X			X		
2013/14	X	X			X	X	
2014/15	X	X			X		X
2015/16	X	X	X	X	X		
2016/17	X	X	X	X	X		
2017/18	X	X	X	X	X		
2018/19	X	X	X	X	X		

1 - Shift towards Integrated Waste Management and Waste Minimisation

2 - Promoting and Ensuring the Effective Delivery of Waste Services

3 - Realization of value throughout the Waste Value Chain

4 - Partnerships and Involving Stakeholders

5 - Build an Effective and Efficient Waste Management Company

6 - Promoting and Implementing Developmental Service Delivery to ensure Economic and Social Development

7 - Grow the contribution of the waste sector in the green economy

Between 2010 and 2012, Pikitup strategic goals mainly focused on the GDS 2040 principals and the COJ priorities. By the 2012/13 financial year, Pikitup introduced three strategic goals which have been carried on until the present (goals 1, 2 and 5 of table 3). The 2013/14 financial year saw the addition of a new strategic goal (goal 6 of table 3) which was discontinued after that financial year. Reasons for the discontinuation were not addressed by Pikitup, however this goal was replaced by goal 7 of table 3 above which was also incorporated for only the 2014 financial year. Pikitup annual reports for 2015 through to 2018 highlight the addition of two strategic goals which are still being carried out presently (goals 3 and 4 of table 3). Since the annual reports do not provide any follow up for these strategic goals so far, it is difficult to understand the reasons for the change in strategic goals over the years. It is possible that the goals were achieved and so were discontinued or it could be that Pikitup were faced with challenges which might have forced the City to hold off on the goals indefinitely and focus more on more practically achievable goals. The strategic goals are discussed below.

Goal 1: Shift towards Integrated Waste Management and Waste Minimisation

According to Pikitup (2013), integrated waste management is the culmination of waste prevention, minimization and waste management processes. These activities relate to ensuring that the necessary projects are implemented to ensure waste is diverted from landfills and that re-use and recycle activities are encouraged. In addition, the necessary infrastructure to support these initiatives has to be addressed. The projects included are separation at source roll out and extension to additional areas, building buy-back centres and garden refuse sites, developing a business case for dealing with green waste and composting as well as addressing the operations and viability of the incinerator. According to the Pikitup reports (2012 and 2013), up to 10 garden sites were upgraded to receive recyclable waste in 2016 and another five were upgraded into integrated waste facilities in 2017 and five new garden sites were completed in 2018 (Memela, 2018). The programme also recognises the roles of waste reclaimers in the process and relevant interventions are included to formalise and structure this community (Pikitup 2012; 2013). Pikitup documents have very little information on the waste to energy initiative in Johannesburg. However, a feasibility study was completed on six different sites and five

were found to have enough gas to generate electricity. These sites were Robinson Deep, Marie Louise, Goudkoppies, Linbro Park, and Ennerdale (COJ 2013). This was considered the largest project in South Africa in which renewable energy was generated from the project to be fed into the municipal grid, off-setting largely coal derived electricity. This project brought about social benefits through reduced odor in the Robinson Deep and Marie Louise area. It also created employment opportunities and generated revenue for the city as well as introducing 'green' electricity which contributed to electricity stability (COJ 2013).

Goal 2: Promoting and Ensuring the Effective Delivery of Waste Services

Whilst investigating and implementing projects to enhance waste minimisation, it is necessary to ensure that current services are provided in an efficient manner and that service levels are improved. Various initiatives, introduced in the 2013/14 financial year, are aimed at improved general cleanliness levels of the environment in the inner city, outer city, hostels and informal settlements (fig 2). Specific attention is also paid to measures to address illegal dumping in the city. In order for the operation to improve and become more efficient, particular attention is given to the management of the fleet as it contributes to poor service delivery as well as high costs. Education and awareness creation in the community is critical to address matters of illegal dumping, as well as more effective law enforcement. It is acknowledged that Pikitup cannot achieve these goals by itself and therefore requires partnerships and participation from various stakeholders (Pikitup, 2012; 2013).

Table 4 shows the progress and challenges of some of the activities Pikitup has implemented to achieve this strategic goal. This table highlights limited street furniture such as bins and limited access to the rural areas as some of the recurring challenges hindering the goal from being achieved. In reference to the progress made, it highlights that the cleanliness standard of the City of Johannesburg has remained on a stationary level over the last three financial years (Malema, 2018). This is also illustrated in figure 2 below as it shows the unchanged level of cleanliness of the City of Johannesburg from 2014 to 2017. However, tracing the cleanliness level back to 2010 with the implementation of the clean city initiative (Landie, 2010), the graph shows that there has

been a huge decline in the cleanliness level of the city thereby showing a lack of participation of the residents compared to the initial implementation of the initiative.

Table 4: Successful initiatives for effective service delivery by CoJ (Memela, 2018)

Activity	Progress	Challenges
Adhere to Provincial Waste Cleanliness standard	Street Cleaning Level 2 cleanliness Province use Photographic Evidence Over 3 FYs, the level has not changed.	Insufficient street furniture – number of bins as well as inability to recycle street waste Very labour intensive and not very productive Lack of mechanized units for street cleaning In areas like Inner City – traffic congestion and informal traders impact accessibility of areas to clean streets as well as continuous littering
Adhere to Provincial Waste Collection standard	Currently 98% RCR rounds completed on time i.e. 15:30 – 16:30 . The depots has pushed the time to 17h00. Collection at Formal households have weekly service (240l bins) servicing 864 185 units	Fleet availability used to impact on ability to complete time but additional new vehicles and proactive maintenance of vehicles improved availability
Provide waste services to low income/informal settlements	Pikitup covers : 164 informal settlements Informal = 183 895 Units Informal settlements issued with refuse bags collected 3-5 times a week depending on area.	Availability of bins to new areas sometimes a challenge. Access and road conditions in informal areas a challenge for vehicles – Jozi@Work implemented in these areas Only 1 bag per stand, but due to backyard shacks this is not sufficient Refuse bags are used for other purposes leading to illegal dumping

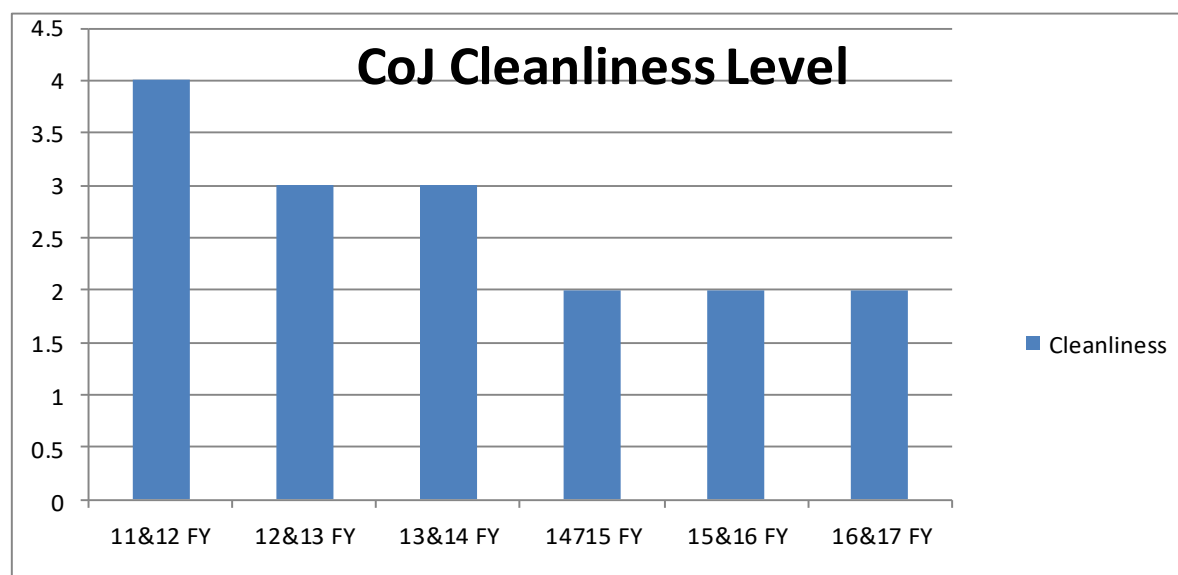


Figure 2: Trend of cleanliness level in COJ

Goal 3: Realization of value throughout the Waste Value Chain Objective

The main aim of this goal was to use waste as a resource for poverty alleviation and create job creation opportunities. The City of Johannesburg has a high level of unemployment, poverty and inequality. Waste minimisation provides opportunities to use waste as a resource and these should assist communities to address poverty. Consideration is given to the implementation of coproduction to address these challenges (Pikitup, 2016).

Goal 4: Partnerships and Involving Stakeholders Objective

This goal focuses on Increasing partnerships to deliver and ensure active stakeholder engagement. The key to successful achievement of waste prevention and minimisation is the change of citizen behaviour. The intention is to mobilise communities in partnership with labour, business and civil society to enable changed behaviour. This will result in a cleaner city with less littering and illegal dumping, as well as increased volumes of waste diverted from landfills (Pikitup, 2016).

Goal 5: Promoting and Implementing Developmental Service Delivery to ensure Economic and Social Development

At the centre of the concept is co-production: citizens are active participants with the state in shaping the future of their own outcomes. The concept values empowerment as a central force in democratic societies and has been used in similar forms in many countries. Another central feature is that citizens become part of the service delivery process of the state and are therefore not just passive recipients of state planning and resource allocation. The characteristics of the developmental state and the developmental service delivery approach is in line with the characteristic that the strategic capability and the involvement of the people is part of the process of development.

Co-production has the potential to transform public services so that they are better positioned to address these problems and to meet urgent challenges such as public spending cuts, an ageing society, the increasing numbers of those with long-term health conditions and rising public expectations for personalised high quality services. Pikitup

aims to make a contribution by ensuring that a recycling economy is established in the City of Johannesburg where communities and entrepreneurs will be able to manage and benefit from recycling activities and waste may be used as a resource to produce various products. At the centre of this intervention is the establishment and facilitation of various cooperatives to participate in recycling activities, cleaning of informal areas as well as addressing illegal dumping in various communities (Pikitup, 2013).

Goal 6: Building an Efficient and Effective Waste Management Company

Various enabling services and processes are required to drive a highly efficient and effective organisation. In order to achieve this goal various supporting processes, systems and structures should be in place (Pikitup 2013). These relate to:

- Review and implementation of appropriate policies;
- Effective Management of risks;
- Financial management;
- Achieving a clean audit;
- Building a skilled workforce aligned to the needs of the organisation;
- Performance Management;
- Communication and Stakeholder management initiatives to increase education and awareness;
- Improved productivity measures; and
- Customer Centric Approach

Goal 7: Grow the Contribution of the Waste Sector in the Green Economy

The main objective of this goal was to use waste as a resource for poverty alleviation and create job opportunities, using the skills and willingness of the community to participate in waste management services as well as the establishment of cooperatives and SMMEs in the recycle economy of Johannesburg, in order to create jobs, and to ensure poverty alleviation and inclusive economic growth.

The City of Johannesburg has high levels of unemployment, poverty and inequality. Waste minimisation provides opportunities to use waste as a resource and these should

assist communities to address poverty. Consideration is given to the implementation of co-production to address these challenges. Co-operatives were to be appointed through the Jozi@Work framework to take responsibility for cleaning in areas. This approach was to be implemented in an incremental manner, starting with Soweto in the first half of the financial year and then to be implemented in additional areas within the City of Johannesburg (Pikitup, 2014).

The availability of the Pikitup and City of Johannesburg annual reports identify the re-evaluation of strategies as a yearly method, which is informed by the yearly changes in Mayoral strategic priorities and the GDS 2040. From the annual reports, the changes resulting from re-evaluation carried out by the municipality over a numbers of years are minimal to none in respect to the strategies placed in the previous years, as very insignificant changes are made in the annual reports concerning the strategies and implementation processes (Pikitup 2015). However, this can be explained either through the stagnant model of the mayoral strategic priorities and the goals of the GDS 2040 which are specific and non-changing in the goal of minimizing waste and the eradication of landfill as a methods of waste disposal. Another way of analysing it would be that the mayoral strategies are robust, hence causing a slow implementation resulting in the strategies needing to be repeated in later years.

According to local dwellers in the township areas, the most common method of waste removal within their society is the use of waste trucks to collect from their door step once a week. The initiative of separate at source or any form of recycling is rarely heard of within these societies thereby increasing the amount of garbage produced and set aside for landfill disposal. Areas where illegal dwellings have been erected do not experience the luxury of the municipality arranging for their waste to be picked up once in a week as these illegal communities are not part of the municipal plan (Pikitup, 2016). There is also the problem of narrow lanes in these areas that prevent access by Pikitup collection vehicles (Silverman & Zack, 2007). The Pikitup annual reports fail to mention what is being organised for these communities, meanwhile dwellers in such places have to live with the consequences of illegal dump sites and mini landfill sites designated by the community members for dumping of their refuse (Pikitup 2016).

5.4 SOUTH AFRICAN WASTE MANAGEMENT LEGISLATION

There has been a number of pieces of legislation and policies created in order to tackle the waste management issues which have plagued South Africa and also to improve the living conditions of its residents. All waste management processes practiced in South Africa are governed by these legislations to ensure they are carried out properly and are abided by.

5.4.1 South African Constitution Act (Act No. 108 of 1996)

The South African Constitution Act (1996) is the supreme law of the country, which includes numerous parts that affect the sustainability of human living. Section 24 of the Constitution states that everyone has a right to the environment that is not harmful to their health and wellbeing and to have that environment protected for the benefit of the present and future generation through reasonable legislative and other measures that prevent environmental pollution and degradation, promote conservation and secure ecologically sustainable development and the use of natural resources while promoting justifiable economic and social development (South African Constitution, 1996).

5.4.2 National Environmental Management Act (Act No. 107 of 1998)

This Act highlights environmental ideologies that should be implemented by the various municipalities and organs of the state in order to prevent any negative environmental effects. The main principle of sustainable development in the context of the present study focuses on avoidance of waste, and where it cannot be avoided, it should be minimised and reused or recycled where possible with disposal being the last option. Section 16 of the Act states that the municipalities need to adhere to the environmental principles. Section 28 of the Act emphasises the duty of care towards the environment, where anyone who has or is likely to cause harm to the environment must take reasonable measures to protect, minimise and mitigate harm done to the environment. The mismanagement of municipal waste has a potential to result in detrimental environmental impacts, hence, municipalities are required to formulate waste by-laws and management plans to amend waste issues in the environment within their jurisdiction through proper collection, treatment and disposal (NEMA, 1998). Pikitup waste management strategies are thereby formulated in accordance with the City of Johannesburg waste by-laws and

the NEMA Act so as to follow the required standards of waste management and protect the environment and its residents.

5.4.3 Johannesburg Waste By-Laws

The City of Johannesburg Metropolitan municipality has published the Waste Management By-Laws in terms of section 13a of the Local Government Municipal System Act, 2000. The Waste Management By-Laws act as a guide in order for the municipality to achieve certain environmental goals. The By-Laws contain definitions of a number of terms of which correspond with, or are taken from the definition chapter in the NEMA Waste Act. The definition of terms like “waste” and “generators of waste” were seen to have been directly extracted from the NEMA waste act legislation. Other similar common terms have similarly related definitions (COJ, 2013; NEMA, 2008).

As seen in the objectives of both pieces of legislation, they both have similar goals and objectives but approach them from different perspectives. According to the City of Johannesburg Waste By-laws, their main objective is to avoid waste, and where it cannot be avoided, they look into the minimization, recycling, reuse, recovery and disposal of waste in an environmentally sound manner (COJ, 2013). Another objective of the waste by-laws is to promote sustainable development and environmental justice through proper measures of waste management. The By-laws also seek to regulate the collection, delivery, storage and treatment of waste within the municipality through the accreditation of service providers.

5.4.4 National Environmental Management Waste Act (Act No. 59 of 2008)

According to the South African National Environmental Management Waste Act (No. 59 of 2008) as amended in June 2014, waste refers to:

- (a) any substance, material or object that is unwanted, rejected, abandoned, discarded or disposed of or that is intended or required to be discarded or disposed of by the holder of that substance material or object whether or not that substance can be reused, recycled or recovered and includes all waste as defined in Schedule 3 of this Act.
- (b) any other substances, materials or object that is not included in Schedule 3 that may be defined as waste by the Minister by notice in the Gazette (NEMA, 2008)

The NEMA Waste Act objective focuses more on the protection of health, well-being and the environment, although it follows similar steps to the City of Johannesburg waste By-Laws in achieving this by aiming to avoid and minimize the consumption of natural resources and production of general waste. The Act encourages reducing, recycling and reusing of waste, and the treatment and safe disposal of waste as a last resort to prevent pollution and environmental degradation (NEMA, 2008). Unlike the By-Laws, the NEMA Waste Act of 2008 aims to promote ecologically sustainable development while promoting at the same time, economic and social development. In order to achieve this, the legislation highlights the promotion and assurance of effective waste delivery and the remediation contaminated or possibly contaminated land to reduce the risk of health and environmental harm (NEMA 2008). One of the major issues with these pieces of legislation is the level of compliance in the municipality. Without compliance, these Acts remain ineffective, hence the difficulty in achieving a sustainable environment. The municipality is focused on achieving 80% compliance in terms of all waste management activities in the By-Laws through effective enforcement including prosecution in cases of non-compliance (Memela, 2018). Unfortunately, this goal has not yet been achieved due to challenges as shown in table 4.

5.4.5 National Waste Information Regulation 2012

This legislation was published by the Department of Environmental Affairs in August 2012 and was implemented on the 1st of January, 2013. The aim of this legislation is to regulate the collection of data and information to fulfil the objectives of the national waste information system provided for in Section 61 of National Environmental Management Waste Act (No 59 of 2008). Municipalities are mandated to report the quantities of municipal waste generated within the municipality in accordance to the procedures stated in the National Waste Information Regulation. The reporting of waste information is to assist the municipalities to identify the trend in improvement in the management of waste and also enable them to identify challenges in order to formulate and develop effective solutions (Gumbi, 2015). The annual reports generated by Pikitup and COJ are partly in accordance with this legislation to submit current data and finding on the waste management processes of the municipality. This information is stored by the South

African Waste Information System to keep track of the waste management progress of the municipality and also to aid in establishing more improved strategies.

5.4.6 National Waste Management Strategy 2011

The National Waste Management Strategy (NWMS) is a legislative requirement of the National Environmental Management Waste Act (No. 59 of 2008). The aim of the NWMS is to achieve the objectives of the Waste Act. It is the responsibility of the municipalities to implement the waste hierarchy, conduct waste awareness campaigns among local communities and finally, provide effective and efficient waste management services. The NWMS emphasises that integrated waste management plans formulated by the municipalities need to be practical and easily implementable; they need to be focused and must include priorities, objectives and targets; and they must make provision for financial arrangements.

The NWMS is structured around a framework of eight goals which are targeted to be met in 2016 and they are: the promotion of waste minimisation through reuse, recycle and recovery of waste; ensuring the effective and efficient delivery of waste services; growing the waste sector to the green economy; ensuring that people are aware of the impact of waste on their health, well-being and environment; achieving integrated waste management planning; ensuring sound budgeting and financial management of waste for waste services; providing measures to remediate contaminated land; and establishing effective compliance with and enforcement of waste legislation. These objectives are required to be implemented by local municipalities as authorities mandated to provide waste services (NEMA, 2008; (Gumbi, 2015). In order to achieve the requirement of the NWMS, Pikitup, under the supervision of the municipality has initiated a number of strategies ranging from door to door waste collection, to the mandatory implementation of separation at source. Pikitup has also organized a number of campaigns to educate the masses on waste minimization and recycling. The provision of buy back centres in the rural areas are also initiatives following the requirement of NWMS so as to abide by the Waste Act and by-laws.

5.4.7 South African Action Plan for Waste Minimisation and Recycling 1999

This legislation focuses on addressing the major issues, needs and problems presently being experienced with waste minimisation and recycling in South Africa. This document represents the ideal method of implementing activities of the Action Plan in terms of resource allocation, time schedule and responsibilities. Limited resources may hinder full implementation of the Action Plan to correspond with the required time frame, hence, the continuous monitoring and editing of the legislation. As resources increase, additional initiatives can be implemented. Municipal solid waste has a potential to result in negative environmental impacts when controlled inappropriately, thus the implementation of this action plan by municipalities is of vital importance in minimising the environmental impacts (Gumbi, 2015). The City of Johannesburg, as stated by the annual business report, develops action plans in accordance with this document. These action plans highlight budgets, responsibility and schedules as assigned by the municipality in reference to the mayoral goals to be achieved (COJ, 2016). This aids the appropriate and effective carrying out of strategies.

5.4.8 Plastic Bag Regulation R 543

The plastic bag regulation was enacted by the Department of Environmental Affairs and Tourism in 2002, in accordance with section 24d of the Environmental Conservation Act (Act No. 73 of 1989). The main aim of the regulation is to disallow the manufacturing and commercial distribution of plastic bags with a thickness that is less than 80 micrometres and the painting marks embedded in the plastic to be approved by the Minister. The Regulation was implemented due to the circulation of inferior plastic bags which were not recyclable and therefore affecting the environment. Currently, plastic bags which meet the standards of the regulation are now sold at retail stores at a cost of approximately 60c. This is implemented as one of the initiatives to reduce waste and promote reuse of plastic bags as they can be used several times before they tear and need to be disposed of (Gumbi, 2015). In Johannesburg, all the commercial and retail outlets are required to comply with this regulation. However, Pikitup has no information on the extent to which they are complying.

5.5 WASTE RECLAIMERS

More recently, the municipalities have begun to focus more on recycling so as to improve environmental sustainability by putting initiatives in place to minimize the production of waste and improve the collection and processing of recyclable waste (Brakpan Herald, 2018). Since the mandatory implementation of waste repurposing and recycling, it seems like waste reclaimers have been given a huge advantage as this has presented them with more jobs and means to fend for themselves and families.

According to the nationwide survey on recycling, only 10% of waste generated in 2011 was being recycled, with Johannesburg and Ekurhuleni recording the lowest rate of recycling (NDEA, 2012), although the City of Johannesburg municipality recorded significant improvement due to an educational campaign introduced in communities to expose them to the benefits of recycling. Another way used to improve this was the incorporation of waste reclaimers in the waste processing scheme so as to regulate the price of recyclable materials at buy-back centres which increases the rate of recyclable material and also gives the waste reclaimers a proper income. In the process of reducing waste to landfill, the City of Johannesburg has resorted to empowerment of waste reclaimers which also creates jobs while making Johannesburg a better city. Due to the vast number of waste reclaimers in the city, waste reclaimers account for almost 7% of the waste diverted from landfill sites in Gauteng province as a whole. According to Pikitup, the number of waste reclaimers in Johannesburg is nearly 6 000 and in order for the municipality to work properly with them, the waste reclaimers would need to formally organize themselves in groups so as to be integrated into the waste management program (Randburg Sun, 2018).

The advantage of the waste reclaimers becoming a cooperative is that it enhances the sustainability of living by granting access to shared logistics, infrastructure, information and collective bargaining power which ensures a better and steady income for its members. With the waste reclaimers formalizing themselves, the City of Johannesburg has partnered with PETCO, the Department of Economic Development and Pikitup in a waste reclaimers empowerment project which was launched in 2014 (Greentime, 2014). This has enabled waste reclaimers to get more equipment like the 50 trolleys donated by

PETCO and the training of 300 waste reclaimers. Pikitup has also provided safety gear for the reclaimers (Greentime, 2014).

On the flip side, the initiative to incorporate waste reclaimers into the waste management program can be seen as a form of dispossession according to the Johannesburg engineering news forum (Arnoldi, 2018). According to an interview with Dr Melanie Samson, the initiatives rather depreciate the source of revenue of the waste reclaimers as private waste collection companies are more frequently occupying the roles previously played by waste pickers. All this is due to the demeaning of the importance of waste reclaimers (Arnoldi, 2018). Before the establishment of the Waste Act in 2008, everything in a disposable bin and in landfill sites was considered as waste and had no value and so was buried. At this time, the idea of recycling was nothing but an abstract concept, only understood by reclaimers who had a more in-depth understanding of what the community defined as waste (Arnoldi, 2018). In Dr. Samson's interview, she noted that recycling became a top priority in Pikitup's business plans and policy documents between the year 2012 and 2015. This was evident in the adoption of a business model dedicated to establishing a recycling economy in the city that prioritises 'separation at source' as a flagship programme. By 2015, Pikitup's corporate goal was to ensure the realisation of value throughout the waste value chain, which resulted in Pikitup's repositioning to focus on establishing a recycling economy (Arnoldi, 2018).

The integration of waste reclaimers into the waste management system has caused some confusion due to the narrow definition of reclaimer integration according to the separation at source strategy as "the incorporation of reclaimers into the value chain of separation at source". According to Dr. Samson, the definition ignores the fact that reclaimers are already integrated into global value chains. It excludes the political and social aspects of integration, dictates the form recycling should take, and grants primary separation at source as a distinct policy objective over reclaimer integration (Arnoldi, 2018). Pikitup has integrated reclaimers by providing them with training and equipment that the City and Pikitup believe should assist them in their work. However, the Johannesburg reclaimers claim that the training does not recognise them as people who are already well informed

and who have already established an effective manner of going about recycling (Greentime, 2014).



Figure 3: Waste recycling by local waste pickers at the landfill site in Polokwane city. An estimated amount of 28,000m³ was disposed monthly bringing it to a total of 336,000m³ of waste annually (Chimuka, 2011).

Nevertheless, other projects by Pikitup to form cooperatives with reclaimers to handle separation at source have failed. This is due to the reclaimers earning less than they were before the cooperative was established and, consequently, leaving the project. Presently, Pikitup has determined that the only way for reclaimers to be integrated is to form cooperatives and bid for contracts in low-income areas. In addition, registering as individuals and trying to seek employment with formal private companies that are involved in separation at source activities could be another solution. However, Dr. Samson indicated that most reclaimers have not been aware of these options (Arnoldi, 2018). This is because the collection of recyclables is contracted to private companies and cooperatives of community members. It could also be that reclaimers have no access to the materials that their livelihoods depend on, or have been forced to start working earlier in the day to prevent private companies from collecting recyclables from residences before them.

In an interview with some of the reclaimers, they stated that they were not included in Pikitup's stakeholder engagement plans until the 2015/16 business plan. Additionally,

they are the only group that is placed in the lowest category of minimal engagement in the document. The representative of the Johannesburg waste reclaimers also stated that they are not integrating into Pikitup's system, but Pikitup is integrating into their system (Arnoldi, 2018). Unfortunately, the feud between waste pickers and the municipality seems to be unending as waste reclaimers proposed a protest in the early months of 2019 due to the accusation that the municipality had defaulted in their agreement with the reclaimers organisation since submitting their October 2018 request in to compensate or credit the reclaimers for the additional work done in waste disposal (Pijoos, 2019). The Department of Environmental Affairs estimates that there are about 62 000 waste reclaimers in the entire country with above 25 000 operating as trolley pushers and the rest at landfill sites. According to Pikitup, only about 1 200 have been registered under the waste reclaimers' initiative. The City of Johannesburg explains that the aim of registering under the initiative is to identify waste reclaimers currently in the system so as to integrate them into the waste management system and thereby provide them with protective clothes, tools and relevant training (Pijoos, 2019)

According to the Council for Scientific and Industrial Research (CSIR) (2018), it has been recorded that waste reclaimers collect an estimated 90% of disposed packages and papers in the entire country which in return saves the city a lot of landfill space but unfortunately earn very little from the recycled waste they sell. Hence, the Department of Environmental Affairs is creating a guideline to assist municipalities in involving waste reclaimers into the waste management system. According to Samson in an interview with *GroundUp* magazine, the aim of the guideline was to recognise the importance of waste reclaimers in the recycling economy and to ensure their conditions, revenue and most importantly, position in the value chain are improved as the recycling environment develops (GroundUp, 2019). Part of the guidelines created by the Department of Environmental Affairs is to register all waste reclaimers in the country and train enforcement agencies so as to understand the rights of waste reclaimers. Also the Department of Environmental Affairs aims to convert closed landfill sites with buy-back centres for waste reclaimers but all these are being held on a thin thread of mistrust as most waste reclaimers are still sceptical about the implementation of the guidelines in the near future or even at all (Postman, 2019; GroundUp, 2019).

5.6 CONCLUSION

The City of Johannesburg has identified that the era of landfilling as a primary waste management process is at its end and therefore is focused on exploring other more sustainable waste management processes. With the evolution of the strategic goals over the years, Pikitup has arrived at the knowledge that sustainable waste management begins with the waste hierarchy. Not entirely shifting from the original goals as stated in the early annual reports, Pikitup is still implementing initiatives with the aim of achieving those goals which focus on waste avoidance, minimization and recycling. Although no concrete statistics was produced on waste to energy, the information shows that Pikitup is still looking into this initiative as a potential method of diverting waste from landfill sites.

The implementation of initiatives such as 'separate at source' need to be enforced more effectively so as to improve its participation thereby increasing the rate of recycling. In addition, the incorporation of waste reclaimers into the waste management systems is another initiative which has proven to improve the rate of recycling in Johannesburg and should be further invested in. More initiatives should still be formed in accordance with the legislation of the City of Johannesburg in order to promote a sustainable environment, as will be discussed in the comparison with the other four cities selected for this study.

CHAPTER SIX

DISCUSSION

6.1 INTRODUCTION

This research seeks to identify the effectiveness of waste management practices in Johannesburg, and how they can be enhanced to further promote environmental sustainability. This chapter compares the practices used by the City of Johannesburg as identified in chapter five, to waste management practices used in other more environmentally advanced cities such as Berlin, Curitiba, Singapore and Kigali. From the initiatives implemented by the City of Johannesburg, it shows that the main challenges faced by the City of Johannesburg in relation to its waste management are waste avoidance and waste minimization, implementation of recycling processes, incineration and the implementation of waste-to-energy, and the reduction of landfill usage as the landfill spaces are deteriorating drastically. The City of Johannesburg shares similarities with a number of challenges found in some of the selected study cities and so this chapter discusses the waste management processes used in tackling the challenges faced in these various cities.

The City of Johannesburg also worked closely with Kigali in 2017 to study some of their waste management initiatives with the aim of emulating those which proved beneficial to the City of Johannesburg (SAWIC, 2018). One of the initiatives researched on with high prospects was the Rwanda Umuganda Model which includes the introduction of a monthly clean-up campaign targeting all the regions of the City (Malofha 2017). Also, the City is revising the waste management by-laws so as to make the separation at source mandatory in every community (Malofha 2017). The third intervention in Johannesburg that has a parallel with Kigali is through education and awareness of waste campaigns and stakeholder involvement programmes. The fourth is through developing partnership guidelines to involve mission-critical stakeholders as active participants in implementation of a new approach to waste management (Malofha 2017).

Another city which was used as a comparison is the city of Curitiba in Parana, Brazil. This city is well known for its advanced waste management initiatives put in place, as described below (Rabinovitch, 1992). The City of Johannesburg can integrate a number

of these initiative as the city of Curitiba shares many similarities with Johannesburg. An example is the “garbage that is not garbage” initiative which promotes recycling in the city and also provides more jobs for individuals. Another initiative which may work in Johannesburg is the “purchase of garbage program” which encourages separation at source and delivery of individual waste to specific depots located around the community in exchange for bus tickets, groceries and educational materials for the children (Soltani & Sharifi, 2012). This could help reduce illegal dumping of waste in communities, increase recycling on a household level and provide aid at the same time for the community. It is an initiative that specifically targets informal settlements where there is difficulty of access for conventional garbage removal.

For this research, the city of Berlin will be used as the benchmark city for best practice in waste management practices. Berlin is seen as one of the leaders in waste management and environmental sustainability. Statistics show a 43% reduction in waste production between 1990 and 2012 and this city is projected to reduce even further in coming years (Berlin Senate Department for Urban Development and the Environment Communication 2013). The Berlin waste management initiatives focus on zero waste and waste minimization, and includes economic waste disposal with attention paid to protecting the climate and conservation of resources.

This chapter further highlights the five main problems in the waste management processes of the City of Johannesburg and delivers an in-depth discussion of how these processes are implemented in the other cities and what can be incorporated in to the city of Johannesburg waste management system in order to improve the sustainability of our environment.

6.2 LANDFILLING

As mentioned in the previous chapter, landfilling is South Africa’s most common waste management process with about 90% of the total waste produced being disposed of in landfill sites (Stats SA, 2018). With currently only four active landfill sites in Johannesburg as reported by Pikitup, Johannesburg is quickly running out of landfill airspace due to the exponential increase in the generation of waste. Due to the geographical location of Johannesburg, being situated on the Highveld and its central business district on the

Witwatersrand (Joburg, 2018), it is the most populated city in South Africa with an estimate of 5.7 million residents. Therefore, there is a lack of suitable land space for landfill sites with the prediction that the current landfill sites will be filled by 2025 (Pikitup, 2018). In comparison to Berlin, which is the second most populous city in Germany, the reduction rate of waste in Berlin since 2000 has been quite dramatic, especially the amount of waste disposed to landfill and incineration which reduced to less than 1 million tonnes in 2007, a 60% reduction rate since the early 1990s (Schulze, 2009). Currently there are only around 160 landfill sites in operation across Germany with only three landfill sites in Berlin (Schulze, 2009; Zhang et al, 2010). This can be attributed to the Waste Disposal Act in 1972 which focused on terminating uncontrolled refuse dumps and replacing them with supervised landfill sites, managed by the local government (Schnurer, 2002) and also the Waste Avoidance and Management Act of 1986 which was implemented to steer away from the idea of new and more landfill sites and incineration plants and focused more on waste avoidance, recovery and recycling.

In Johannesburg, information from numerous news outlets such as The Guardian and Eye Witness News state the government enforcing new measures for residents to compulsorily separate their waste at the source or waste will have to be transported to other landfill sites outside Johannesburg which will increase the waste tax rate for residents (Lindeque, 2018). Currently, the City of Johannesburg is steering away from landfilling and implementing more initiatives to drive its resident into more recycling. This is in accordance with the Waste By-laws and the NEMA Waste Act which promote the avoidance and minimization of waste and encourages the diversion of waste from landfill sites.

By comparison, Singapore has only one offshore landfill site available (Bai & Sutanto, 2002). The growth of solid waste generation has imposed a considerable demand on waste disposal, which has raised a concern as Singapore has limited land space (NEA, 2008). Singapore initially had three landfill sites outside the city limits which were mainly reserved for untreated waste or waste that could not be disposed of any other way. Two of the main landfill sites, Lim Chu Kang and Lorong Halus, reached their capacity in 1992 and 1999 respectively (Bai & Sutanto, 2002), leaving Semaku landfill site which collects 9% of Singapore's waste consisting solely of incinerated ash (NEA, 2006; MEWR, 2006).

With Singapore also facing waste increment due to their development and population increase, landfilling has been placed on the lowest rung in the waste management hierarchy and more focus has been put on other waste management processes.



Figure 4: Robinson Deep landfill site in Johannesburg. The site has a maximum of 3 years left until it reaches capacity (Lindeque, 2018).



Figure 5: Semakau Landfill (started operations in 1999) (Eng, 2012)

Curitiba, being a smaller and less populous city than the previously mentioned examples, is least similar to the City of Johannesburg with regards to landfilling, as it is not known for its landfilling practice but for recycling and the numerous initiatives to improve recycling. According to waste management journals, only about 30% of waste generated is disposed of in *Fazenda Rio Grande* waste Sanitary Landfill which was opened in 1989 for organic and non-recyclable material landfill (Mertanen, 2011). There has not been any

current investment in another landfill site due to Curitiba's stringent geology, access, topography and land use (Cristina, Braga, & Bonetto, 1993).

In comparison with landfilling in Johannesburg, Kigali may be behind in the waste management race due to lack of equipment, facilities and financing. There are close similarities between both cities and their waste management practices as both use landfill sites as their primary waste disposal system. While Johannesburg currently has four active landfill sites, Kigali currently has one functioning landfill site – Nduba, which is located in Gasabo district and has been operational since 2012. Apart from Nduba, there are two small private compost facilities in Kigali, and facilities at the three major hospitals for the simple combustion of hazardous clinical waste without any emission controls (Wilson et al., 2015). Also both cities generate a substantial amount of organic waste amidst the total waste generated. In Kigali, all the waste generated by the city is collected and disposed of at the only landfill site of which 68% of the waste composition is organic waste, which ideally would use more of a composting method or incineration but the lack of incineration plant hinders such process. According to Nshimiyimana (2015), in as much as landfilling is the main process of waste disposal in Kigali, the technology used in landfilling is quite outdated as the method is quite similar to that of open dumping and has no proper coverage or treatment. He also highlighted that the main challenges of waste management in Kigali can be directly associated with inadequate infrastructural facilities such as insufficient expertise and lack of financial resources, legal and administrative enforcement.

6.3 INCINERATION

Unlike cities such as Singapore, whose main waste disposal process is via incineration, this is a process yet to be fully embodied by the City of Johannesburg. According to Pikitup Integrated Waste Management Plan (2015), the City of Johannesburg has one incinerator amongst its waste disposal infrastructure. Currently there is no substantial information covering incineration as a waste management process in Johannesburg except the future plan to adopt it during the implementation of waste to energy as part of the process of producing usable energy (Dlamini, Simatele & Kubanza, 2019). This may

be due to the understanding that incineration may pose negative environmental effects, hence does not thoroughly support the idea of a sustainable environment (Dlamini, 2017). By comparison, 91% of waste collected in Singapore is incinerated and only 9% (consisting of incinerated ash) is disposed at Semaku landfill site (NEA, 2006; MEWR, 2006). Four incinerators exist in Singapore i.e. Taus managing 2 000 tonnes per day, Ulu Padan, 1700 tonnes per day, Senoko, 2 400 tonnes per day and Taus South incinerator, 3 000 tonnes per day (Ng et al, 2017). The capacity for incineration of all solid waste was sufficient until 2007 at 8 200 tonnes per day. In Singapore, incineration has been implemented nation-wide to generate energy from waste materials, as well as to reduce the volume of waste substantially. Due to the scarcity of land, Singapore adopted the policy of incinerating all 'incinerable' solid waste, including food waste (NEA, 2009). With the closure of Lorong Halus Dumping Ground in 1999, most disposed solid waste has been diverted to incineration plants, making incineration the main disposal method in Singapore. The volume reduction of waste after incineration is almost 100%, hence making this method popular in countries with limited territory for landfills (Khoo et al, 2010). After 30 years of experience in incineration, Singapore has gained more benefit due to the pressure of land scarcity. Nevertheless, building more incineration plants may not be economically and environmentally sustainable. A typical incinerator requires the energy input of 70 kWh/tonne waste and generates around 20% ash (Tan and Khoo, 2006).



Figure 6: Tuas and Senoko Incineration Plants. Built in 1986 and 1992 respectively (Eng, 2012).



Figure 7: Tuas south, which is the largest. built in 2000 and Keppel-Seghers, built in 2009 (Eng, 2012)

Incineration is a successful initiative used in Singapore, which the City of Johannesburg could emulate as one of a suite of waste management strategies. The City of Johannesburg currently has only one incineration plant which, according to recent articles and reports from Pikitup and CoJ, has no information on its size and capacity. Nevertheless, there is a need for a functional incineration plant, so that more can be achieved in the management of non-recyclable waste and could involve a waste-to-energy initiative. The technology for waste-to-energy is not lacking and would also benefit the country especially by assisting with the provision of energy to complement the power supply of the country.

In Berlin, after most of the waste generated has been recycled and recovered, most of the remaining solid waste (construction waste, bio-waste) is incinerated for co-incineration, mechanical–physical stabilization and for mechanical and biological treatment. Mechanical–physical stabilization and mechanical–biological treatment are environmentally sustainable methods that depend on incineration to produce either combustible fraction which is used for waste-to-energy recovery, or biodegradable fraction that is subjected to biological treatment and then composted under aerobic conditions. The total amount of disposed waste summed to 934,499 tonnes. About 505,400 tonnes of this waste was incinerated and accounted for 54% of the total amount of disposed waste in 2008 (Zhang et al, 2010). This occurs in the Ruhleben incineration plant which is currently the only incineration plant in the country and has a total capacity of approximately 520,000 tonnes per year (Thürmer,2007).

The idea of incineration in Curitiba has not yet been considered as waste to energy technologies in Brazil in general are relatively new and largely unregulated (International

Finance Corporation, 2015). Just like Johannesburg, incineration is yet to be implemented but mainly because it is seen as a viable option for the disposal of waste by some people, but as an environmental hazard by others. Currently, there have been no laws dealing with waste to energy at Federal, State or Municipal levels. There are various draft laws at each level of government, most of which are against the use of incineration, with the exception of two laws at the federal level. There have been various public protests against the use of incineration across Brazil, as well as specifically in the State of Paraná, in which Curitiba is located. There have also been official statements of the Public Defender's Office against the use of incineration technologies (International Finance Corporation, 2015). Nevertheless, it is known that the government of Paraná is in support of the idea of incinerators but there have yet to be any plans to build one. Meanwhile, other municipalities in Parana have been going forward with agreements to build incinerators (Global Alliance of Waste Pickers, 2019).

In looking at Kigali, the municipal waste composition is highly organic, thereby making composting and incineration a highly suitable method for waste disposal. Kigali's minimal infrastructural development prevents the city from implementing sophisticated waste management strategies such as building of incineration plants or recycling facilities, although plans are being made by the government to install incinerators. According to Nshimiyimana (2015), these initiatives are still in the processing stage due to financial limitations, yet the solid waste is increasing daily. With regard to hazardous waste, the government has constructed an incinerator with installed capacity of 100 kg per hour at the landfill site. While reports note that a small portion of hazardous and infectious waste is burnt by the incinerator, interviews suggest that the incinerator is not currently in operation and that the majority of hazardous waste is disposed of in a pond and covered on a monthly basis (Rajashekar, Bowers & Gatoni, 2019).

6.4 RECYCLING

As stated by Samson (2008), recycling has superficially been taking place for a number of years based on the social needs and demand for certain resources. It has proven to be an adequate substitution for landfilling in terms of waste management and environmental sustainability although it is only practiced by a minority of households

(Pikitup, 2018). The City of Johannesburg has publicly announced recycling as mandatory from 2018, with the aim of reducing the amount of generated household waste which is disposed in landfill sites. In order to achieve this, the City of Johannesburg implemented processes to assist in diverting up to 60% of waste from landfill sites by end of 2018. Pikitup statistics show that less than 3% was diverted from landfill sites in 2017 which was even less than the recorded 49 000 tonnes of the previous year (Memela, 2018). Currently, even with the improved awareness of recycling, a very low percentage of households are interested in recycling with Johannesburg recording a miniscule 12.7% according to Stats SA (2018).

In correspondence with the goals of the mayoral strategies, the City of Johannesburg not only implements initiatives to promote recycling, but also promotes the improvement of buy-back centres, and also the regulation of the prices of which the recycled resources are being sold. This on its own increases the importance of recycling based on the demand of both the raw and re-manufactured products (Nkosi et al, 2013). Also there have been improvements in the preparation of recyclables as a number of garden sites were upgraded to receive recyclable waste (Memela, 2018). All these show preparations being made to fully integrate recycling into Johannesburg waste management processes but it is safe to say that recycling is still has a long way to go before it is fully incorporated.

In comparing recycling as a waste management process in Berlin to Johannesburg, Berlin's waste management practice is far more advanced. The city is more developed, more experienced and better equipped in the aspect of sustainable environmental management and so there can barely be any comparisons made to Johannesburg. Recycling has been an active process in Berlin since the early 1990s as the city's waste management focus mainly on waste reduction and recycling. Therefore, it is no surprise that recycling and recovery of waste is on an increase in Berlin (Zhang et al, 2010). Furthermore, since recyclable waste comprises about 80% of the total commercial waste (Schwilling et al., 2004), there has been a lot more work done to promote separation and recycling of waste which has helped reduce the amount of commercial waste on a major scale between the early 1990s till 2007 as illustrated in figure 8 below. There has been a decline in the need for landfills in Germany over the past years and this is mainly due to the increase in the amount of recycled and recovered waste. Most of the remaining solid

waste (construction waste, bio-waste) that is not recycled is incinerated, for co-incineration.

Development of waste management in Berlin has been to the level of resource management which consists of two main bio-degradable municipal waste fractions - paper waste and waste from municipalities and households. The financial aspect of recovering, reuse and recycling of waste is balanced out by Germany's high material, energy, labour and waste disposal costs.

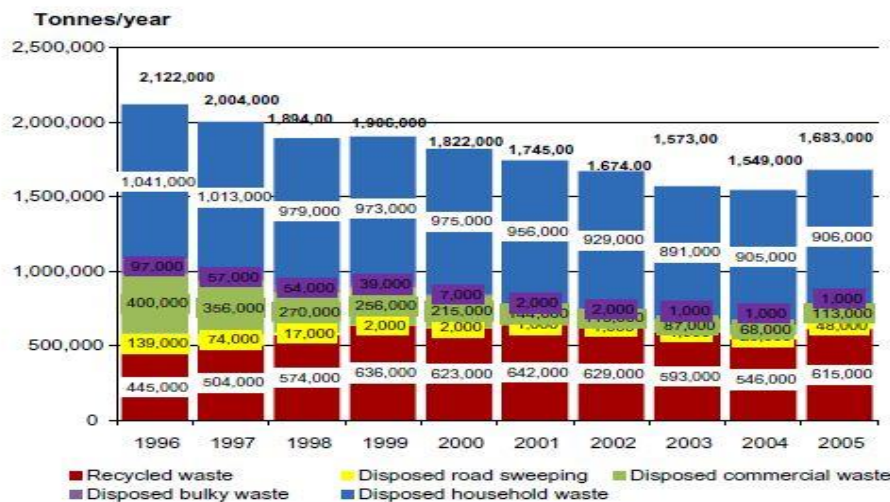


Figure 8: Decline of Generated Waste in Berlin from 1996 – 2007 (Zhang, 2010)

The disposal of waste has declined while recycled waste has been, and is still increasing due to some of these strategies:

- Separating bio-waste collection and treatment thereby reducing biodegradable waste disposed of at the landfills.
- Increasing material recycling of paper, glass, plastic and metal.
- Increase waste-to-energy activities and climate protection.

Figure 9 shows the decline in disposed waste and increase in recycled waste. While 269 000 tonnes were recovered in 1992, an increase of 650 000 tonnes (40%) was seen in 2007 (Schulze, 2009; Zhang et al 2010). Separation of waste into the different recyclable materials such as glass, paper, and cardboard, lightweight packing and organic waste guaranteed a high recovery rate. Total amount of waste generated in 2007 was 168 000 tonnes, in which the amount of disposed and amount recycled accounted for 59.8% and 40.2% respectively (Zhang et al, 2010). Domestic waste amounted to 65% and 35% of

disposed and recycled respectively. Complete recycling occurred in domestic bulky waste and road sweeping, while trade and commercial waste were totally disposed of by incineration.

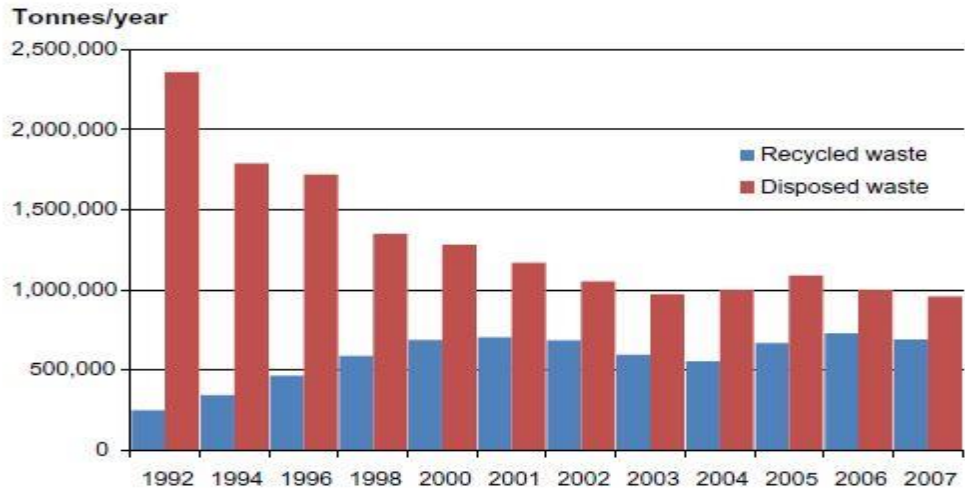


Figure 9: Reduction and Increase for disposed and recycled waste in Berlin (Zhang, 2010)

Curitiba is mostly known for their innovative waste management initiatives, which mainly support recycling. The city has over the years implemented a number of successful initiatives of which have improved the recycling process even further. Due to the topography of the city, landfilling is not a viable option and so their waste management practice needs to focus more on waste recovery. According to Keuhn (2007) and Johnson (2001), about 70% of generated waste in Curitiba is recycled with over 90% of the city's population participating in recycling programs (Meadows, 1995). Due to these achievements, Curitiba earned the highest environmental prize in 1990 from the United Nations Environment Programme (UNEP). Ever since the recycling programs were implemented in 1989, over 419,000 tonnes of recyclable waste has been separated instead of being disposed in landfill sites (Making the Modern World, 2004) thereby increasing the lifespan of the existing landfill sites. Most of the recycling in Curitiba is carried out by informal agents and the recovered materials sold to local industries for reuse.

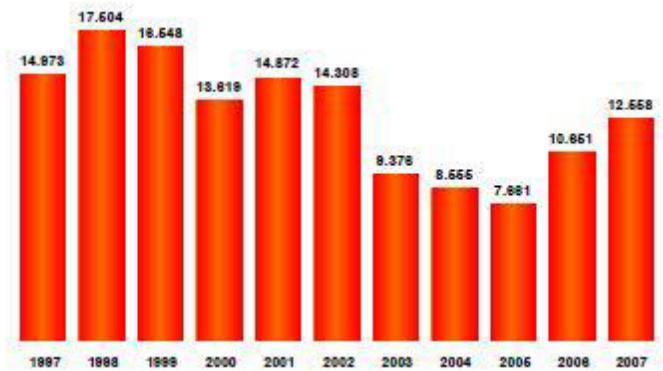


Figure 10: Amount of recyclable waste (tonnes/yr.) collected in Curitiba (IPPUC, 2008)

As much as Singapore is years ahead in the recycling industry in comparison with Johannesburg, both cities need to set up their own waste recycling industry in order to sustain the waste separation and recycling programmes. Bai and Sutanto (2002), stated that there is only one active recycling plant in Singapore that produces compost and soil fertilizer, while in Johannesburg, Pikitup most recently upgraded some garden sites to be able to collect recyclable materials but there is no major active recycling plant as recycling is still trying to be implemented through the various initiatives. A common perception in both Johannesburg and Singapore is the belief that recycling activities are the responsibility of waste collection companies or other relevant authorities but not themselves and so enforcement of recycling initiatives is an issue. In Singapore there has been an increase in the recycling rates as there has been an increase in waste generation as a result of economic and population growth. Still, only a small percentage of the remaining waste is recycled using anaerobic digestion and compositing of the digested material (Zhang et al, 2010).

Due to Singapore's highly industrialized economy and strong focus on manufacturing, the city incorporates a two-step approach to recycling: firstly, resource conservation through a more intensive and coordinated effort at developing the recycling industry; and second, waste reduction and elimination at source through product and process innovations as well as developing green technologies for industry through private-public collaborations (Lang, 2007). Moving upstream to deal with waste, Singapore has noted that their main issue is the growing waste quantities as it seems that the threat to public health has been resolved. In order to combat this, waste minimisation and recycling measures were adopted in addition to the NRP, to increase awareness.

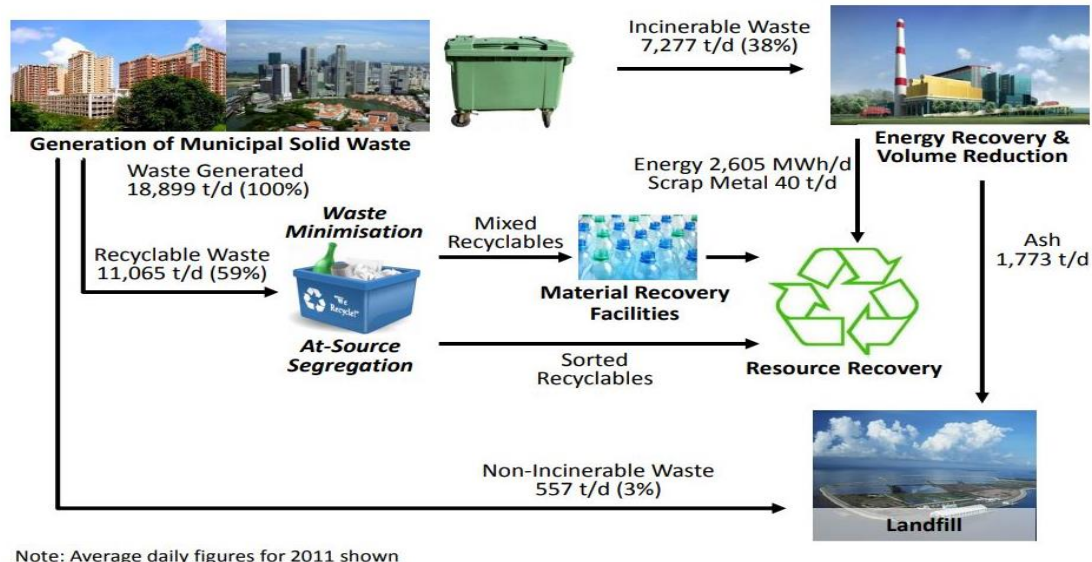


Figure 11: Singapore's Waste Management Flow system (Eng, 2012)

In comparison with waste management practices in South Africa, Kigali may be behind in the waste management race due to lack of equipment, facilities and financing. The waste management in Kigali is a public–private partnership which is tendered every three years. Households pay an affordable fee depending on their ability to pay (the service is free to the poorest category), and 95% fee collection rates are achieved, partly through co-collection with charges for local security patrols, which is a service people value highly given the recent history of the country (Kabera et al., 2019). The major disposal process in the Kigali waste management system is landfilling, although in recent years the city has been working on ways to successfully implement recycling and waste-to-energy initiatives. According to Nshimiyimana (2015), recycling is still a very young and unknown process in Kigali such that only a few are aware of it while others remain ignorant to its importance. The government is still trying to implement recycling and other forms of waste management processes into the system but the major setback is the lack of facilities and financial assistance to build these needed facilities. Nevertheless, there have been a number of strategies, mostly unsuccessful, which have been implemented in order to promote recycling and waste recovery.

Overall, waste recycling rates are low in Kigali. According to a report done by REMA (2017), only about 2% of waste generated is recycled although more recent studies suggest that the recycling rate is closer to 10 - 12% (Kebera et al., 2019). Nevertheless,

these figures are still lower than the government's aim of 30% by 2020 and 40% by 2030. Kigali's recycling process can be interpreted as a public-private partnership as the government works with other private stakeholders in order to achieve a successful recycling process (REMA, 2017). Currently, only a few private companies recycle of which they focus mainly on paper and plastic. Also, there is no domestic recycling facility for PET bottles, therefore most of the bottles are crushed and sold to recyclers in Uganda, Kenya, Tanzania and, until recently, China (REMA, 2017). Plastic and paper recycling companies receive plastics from other smaller companies who source these materials mainly from household waste, separate and clean them and are mixed with other materials to create new products for sale. On the other hand, due to various policy documents, informal waste reclaimers are actively discouraged and landfill operators indicated that this practice is highly regulated as a result of tight security (Rajashekar, Bowers & Gatoni, 2019).

According to previous research, in 2012, the government of Rwanda had made attempts to implement separation at household level but the initiative was unsuccessful due to a lack of any downstream sorting. As part of this campaign, households were trained to separate waste and waste collection companies were asked to collect organic and inorganic waste separately (Rajashekar, Bowers & Gatoni, 2019). In 2017, Rwanda opened an electronics recycling facility in Bugesera worth approximately USD 1.5 million.

6.5 LEGISLATION

Waste management legislation in South Africa is in accordance with Section 24 of the South African Constitution which gives the right to a safe and clean environment. The legislation therefor follows the waste management hierarchy, prioritizing waste avoidance and then minimization and then recycling before landfill disposal. In the midst of all other legislation, the city of Johannesburg as a municipality implements the Johannesburg waste management by-laws along with the NEMA Waste Act to govern its waste management process.

In comparison to Johannesburg, Berlin's waste management legislation and the practices that flow from it is far more advanced. The city is more developed, more experienced and better equipped in the aspect of sustainable environmental management and so there

can barely be any comparisons made to Johannesburg. The COJ waste by-laws are the closest comparison to the legislation put in place in Berlin as they both focus mainly on waste avoidance and then subsequently waste minimization and recovery. The legislation governing both cities also encourages the diversion of waste from landfill in order to extend the lifespan of landfill sites in use. The mayoral strategies of the City of Johannesburg are aligned with the waste management By-laws and the NEMA Waste Act. The importance of recycling as a means to reduce the negative impact of waste on the environment has caught recent attention, hence the introduction of the National Waste Management Strategy (NWMS) by the municipality which aims to divert at least 25% of recyclable waste from landfill sites and to initiate the separation at source initiative on a municipal scale in response to the National Environmental Management Act of 1998. However, there is still an issue of enforcement and applicability in society, which Berlin has successfully carried out by implementing it into their educational system, and also imposing strict penalties and governing board for defaulters. Also, CoJ is not active in large scale composting and only a very low percentage (less than 5%) of households and establishments actually compost or have a compost maker (Ekwelibe, 2017). Evidence from Berlin shows the advantages of composting on a national scale and how it can be connected to an energy source.

The early 1970s showed the progressive evolution of waste management in Germany as a country, especially by the implementation of the independent Waste Disposal Act in 1972 which focused on terminating uncontrolled refuse dumps and replacing them with supervised landfill sites, managed by the local government (Schnurer, 2002). In 1986 the Waste Avoidance and Management Act was implemented which steered away from the idea of new and more landfill sites and incineration plants and focused more on waste avoidance, recovery and recycling. Currently in Germany, there have been a number of legislations, ordinances, administrative provisions and voluntary commitments put in place in order to enhance their waste management practices (BMU, 2009) such as the German Packaging Ordinance of 1991, the Technical Instructions on the Storage, Chemical, Physical and Biological Treatment, Incineration and Storage of Waste Requiring Particular Supervision (1991) and also the Technical Instructions on Waste from Human Settlement (1993).

In Berlin, the Act for Promoting Closed Substance Cycle and Waste Management and Ensuring Environmentally Compatible Waste Disposal was implemented in 1999 (Schulze, 2009; BSDUDE, 2013). The Berlin Closed Substance Cycle and Waste Management Act focuses mainly on promoting closed cycles of substance management and low volumes of waste, while also ensuring environmentally-compatible and economic waste disposal (BSDUDE, 2013). It is Berlin's responsibility to manage all waste generated within the city according to Section 5.1 of the Berlin Closed Substance Cycle and Waste Management Act. The collection and disposal of household waste and private waste sources are generally delegated to the Berliner Stadtreinigungsbetriebe (BSR). Construction, health and industrial waste is disposed of by the Berlin Department for Health, the Environment and Consumer Protection (Zhang et al, 2010; BSDUDE, 2013). Even more recently, Berlin is looking into the acquisition of environmentally compatible services and products about which the city released a policy statement that implements the Berlin Public Procurement Act which was enforced on the 23rd July 2010. This new Act obliges all public purchasing offices in Berlin to take environmental criteria into consideration for their procurements, including the lifecycle costs (BSDUDE, 2013).

In relation to Curitiba, the National Solid Waste Policy (PNRS) governs the guidelines for solid waste management in Brazil which was published in 2010 and revised 2012. The national policy identifies a priority list of actions for waste management, with zero waste being the preferred option, followed by reduction, reuse, recycling, treatment and environmentally adequate final disposal (International financial Corporation, 2015). The policy is based on the co-responsibility for post-consumer waste management between government bodies and companies that are involved manufacturing, transporting and distributing products. It emphasizes the inclusion of waste pickers in the waste management system that is put in place, including prioritizing contracts with associations and cooperatives over private companies. The National Environmental Policy is considered an important regulatory benchmark due to the formalization of environmental concerns and definitions in an overarching national law. It encourages the requirement for environmental licensing and institutes the polluter pays principle (International financial Corporation, 2015).

Specific Legislation in Relation to Waste Pickers (sometimes referred to as scavengers) are an important part of the waste management operations in Curitiba. However, not all of the waste pickers operate within the formal legal framework. Therefore, Mott MacDonald critically reviewed the legislation and guidance relating to waste pickers in order to understand the current legal context regarding this aspect of waste management (International financial Corporation, 2015). In Johannesburg, there are no regulations governing waste pickers as they are yet to be incorporated in to the waste management system of the City of Johannesburg. It may be a lot easier for waste pickers and the City of Johannesburg to reach an agreement if there is legislation implemented to guide the activities of waste pickers.

The use of waste to energy technologies in Brazil is relatively new and extremely unregulated, paralleling the situation in South Africa. CONAMA resolution 316/2002 mainly focuses on thermal technologies. It highlights the criteria and procedures for thermal waste treatment functioning, including the specifics of urban waste. It highlights the need to implement a segregation programme in order to prioritize recycling and reuse before thermal treatment. Monitoring of emissions and burn tests are also included (International financial Corporation, 2015).

CONAMA resolution 264/1999 stipulates the permitting obligations of co-processing waste to be used in cement industries. There were no laws identified that deal with waste to energy at Federal, State or Municipal levels. At Federal level, an inter-ministerial act has been proposed to be developed for the purpose of regulating incineration technologies, however it is believed that this has not yet progressed. There are various draft laws at each level of the government of which most of them rule against the use of incineration (International financial Corporation, 2015). There have been various public protests against the use of incineration in Brazil, more specifically in the State of Paraná. These included official statements of the Public Defender's Office against the use of incineration technologies (International financial Corporation, 2015).

Recycling Legislation CONAMA resolution 275/2001 indicates a collection color-code system for all government locations and suggests that this color code system should be utilized in all recyclable waste collection. The color code divides the collection into various

types of waste, namely: paper, plastic, metal, glass, food waste and non-recyclable. At municipal level, Curitiba shopping centers are required to separate their waste in accordance with these regulations, dividing at least: paper, plastic, metal, glass and non-recyclable waste (International financial Corporation, 2015). These regulations are understood to be enforced mainly for large companies but possibly less so for smaller organizations. This inclusion of detailed separation at source is in contrast with legislation applicable to CoJ, where the separation at source policies are much broader.

In Singapore, waste management regulations govern the initiatives and policies in which waste management process are carried out. The National Environment Agency (NEA) plans, develops and administers Singapore's solid and hazardous waste management systems. This includes licensing and regulatory functions to ensure that waste is properly collected, treated and disposed of (NEA, 2018). The management of solid and hazardous wastes is governed by the Environmental Public Health Act, Environmental Public Health (General Waste Collection) Regulations, Environmental Public Health (General Waste Disposal Facilities) Regulations and Environmental Public Health (Toxic Industrial Waste) Regulations. In accordance with the Environmental Public Health regulation, the NEA implemented the waste management disposal strategies which display the hierarchy of disposal processes followed in Singapore as illustrated in figure 12 below to produce a more sustainable waste management system (NEA, 2018). Similar to Singapore, the waste management initiatives used in Johannesburg are also in accordance with the Waste By-laws and the NEMA Waste Act which follow the waste hierarchy shown in Figure 12.

To assist with the recycling initiative, the National Environment Agency implemented the National Recycling Programme (NRP), launched in April 2001 (Claudio, 2004), which placed recycling bins around public areas and are responsible for recycling collections in both public and private areas registered under the public waste collection scheme (NEA, 2018). A similar policy could be implemented in Johannesburg alongside the separation at source initiative to improve its enforcement and compliance by the residents.



Figure 12: The Hierarchy of waste management as used in Singapore (NEA, 2018)

Before 2010, the Kigali city management of waste had no national policy or system indicating a legislative framework that handles solid waste management, with households, communities, NGOs, the private sector, community associations as well as district authorities dealing with Solid Waste Management activities. These activities generally have limited financial and technical resources, however, there has been growth with the city's waste management in the past ten years (Rajashekar, Bowers & Gatoni, 2019).

The governing body of most waste management in Rwanda is the Organic Law which decides on the mode of preservation, conservation and promotion of the environment in Rwanda. Moreover, Kigali's waste management is guided by values that are focused on environmental protection, sustainability as well as sanitation. The overall principles that lead the environmental sector as a whole, such as the protection principle and the polluter-pays principle, are embodied in the Organic Law which serves as a legal guide and delegates responsibilities to various competent authorities, including the Rwanda Environment Management Authority (REMA) as well as the national Fund for Environment in Rwanda (FONERWA) (REMA, 2017). There are three more levels to the legal ranking governing waste management and they get most of their power from the extensive Organic Law. Of the three levels, the second level is governed by the 2018 law of the environment: specifically, this law has definitions of the terms found in the waste management sector, including the sanctions and fines for unauthorized activities.

The law of the environment also establishes environmental protection committees at district, sector as well as cell levels in Kigali city. Finally, the third level of legal acts involving household waste is embraced by the National sanitation policy. This provides the vision for the entire sector and points out precise interventions necessary to achieve a warrantable and impartial access to solid waste management and sanitation (Rajashekar, Bowers & Gatoni, 2019). The policy aims to improve the efficiency of Solid Waste Management at a national level while highlighting principles of full cost recovery and financial stability of waste operators. It ensures that the principles of hierarchy are implemented.

There are legal directives around waste management which are determined by RURA, REMA and the city of Kigali. These are regulations and guidelines on solid waste collection, transportation and recycling and they are:

1. guidelines on Solid Waste and Transportation (2014) drafted by RURA, which regulates the mode and frequency of waste collection specifically the amount and deadline fees which are payable to RURA and it determines household tariffs;
2. regulation of Solid Waste Recycling in Rwanda (2015) drafted by RURA, which provides standards for a recycling site and recycling facility permitting process and requirements and;
3. guidelines on practical tools involving Solid Waste Management (2010) by REMA, which provides detailed technical guidelines on the landfill and compost operation that includes site slope requirements, soil and clay liners standard, landfill gas management techniques, land closure and lastly compost chemical composition.

In the socio-economic arena, the city makes little or no effort in implementing processes such as recycling, reuse, reduction or separation at source due to the lack of a robust ideology on waste management. Hence they have put in place long term strategies that will be implemented to achieve long term solutions, and these include delegation of waste management to Water and Sanitation Corporation (WASAC) which was established and will work together with the Rwanda Environmental Management Authority (REMA), all of these under the Ministry of Infrastructure (MININFRA) to design and harmonize policies and programs regarding waste management and sanitation issues (Nshimiyimana, 2015).

Unlike Kigali, Johannesburg is fully invested in the implementation of waste avoidance, minimization and recycling initiatives. Kigali's legislation revolves around policies that aid cleanliness in the transportation and disposal of waste mainly due to unavailability of infrastructure and finance which would aid in more advance waste management methods. However, with the availability of infrastructure and finance to develop infrastructure, Johannesburg has legislations which put more focus on recycling and waste to energy.

6.6 INITIATIVES

In accordance with the Mayoral strategies, Pikitup has strived to implement a number of strategies of which are aimed to assist with waste minimization as required by the Integrated Waste Management Policy and the National Waste Management Strategy. Some of these initiatives are the Separation at Source household recycling programme, for which plastic bags are provided to households and collected weekly or dropped off at designated garden sites. This also acts as a means to provide jobs, businesses and income for the unemployed residents within the City. Also Pikitup is collaborating with other private stakeholders to recycle lubricating materials. Another initiative the City of Johannesburg is trying to implement is the Waste to Energy initiative which aims to produce electricity from the gases extracted from waste. Landfill gas is mainly made up of methane, carbon dioxide and oxygen, of which methane is the most harmful to the ozone layer. The landfill gas-to-energy projects minimise environmental damage by reducing methane emissions. Producing energy from the City's landfill sites will alleviate pressure on the national grid.

In 2015, the new Bulky Waste Service was initiated in order to remove bulky household waste once a month. This strategy aimed to expand the lifespan of the landfill sites by diverting recyclable waste away from landfill. Another successful waste minimization strategy implemented by the City of Johannesburg is the establishment of buy-back centres where waste materials that are seen to have economic value are bought from the community at these waste sorting facilities and resold to markets outside for a small profit. This is also another means to create jobs for the unemployed. Currently, numerous clean up campaigns are being set up which focus on maintaining the general environment. Communities and City Departments have participated actively in these campaigns,

removing many thousands of tonnes of excess waste from neighbourhoods. Apart from cleaning problem areas, these campaigns have also managed to create awareness among communities.

Curitiba can be used as an excellent example of successful implementation of sustainable environment initiatives (Kruljac, 2012). Concepts such as operation strategies, monitoring, and institutional controls are considered in this city when implementing waste management strategies. With strategies that aim to integrate public-private partnerships and calculated democratic approaches, the presence of political commitment, organizational capabilities and policy consistency at the local level have helped to gain sustainability within the waste sector (Kruljac, 2012). Curitiba has developed innovative solutions, such as a prioritized recycling campaign and refuse collection program, for the sustainability of their waste management systems (McAllister, 2015). One of them is the integration of social programmes and environmental education which involved the implementation of the 'garbage that is not garbage' initiative and the garbage exchange programme.

Curitiba is famous for its recycling programme *Lixo que nao è Lixo* (or Waste that is not Waste) and its social programmes which involve low income people. This is based on the exchange of recyclable waste for food; an example is the *Câmbio Verde* initiative, which was initiated in the year 1991 and it was targeted for the low income districts of the city where there was no easy access for waste trucks. The Waste that is not Waste initiative promotes the implementation of separation at source of organic and inorganic waste for easy recycling (Rabinovitch, 1992). The initiative with regard to recyclable household waste has been active since 1989 in Curitiba.

Another initiative implemented was the Waste Purchase (*Compra do lixo*) initiative which focused on the squatter areas where the waste trucks have no access. The main aim of this initiative was to motivate the eradication of illegal and improper dumping of waste. The waste purchase initiative placed a 2000kg waste container (equivalent to 200 bags) in the middle of the community. The residents' solid waste was then separated into recyclable and non-recyclable and packed in specific bags which are taken to the waste container by the residents and deposited there in exchange for groceries, depending on

the amount of waste bags delivered. Usually, the equivalent rate stands at five bags of waste to one bag of groceries (10kg), or a bag of waste for a crate of eggs. Fewer communities participated in this initiatives as the waste trucks began to gain access into these communities due to the development of road infrastructure. Active communities reduced from 75 in 1989 to only 11 communities in 2010 until the initiative was finally shut down in 2010. Normally, where a point of *Compra do Lixo* is closed, they start a point of *Câmbio Verde* to stimulate the people to separate waste (Mertanen, 2011).

The Green Exchange municipal programme was initiated in 1991 was implemented at 89 points. The programme targets poor districts of the city due to the lack of infrastructure i.e. waste trucks were not able to collect waste on a hill or riverbank. The collection happens once a week in low income neighbourhoods, with the exchange of recyclable waste with food. The waste collection involves 4kg of waste per 1kg of food or used kitchen oil which are collected by the Ambiental Santos organization, who commercializes the oil by extracting impurities and cleaning the product (fig 13).



Figure 13: A point of *Cambio Verde*

In comparison with the City of Johannesburg, taking into consideration the similarities in the level of development of both cities, emulating some of the initiatives used in Curitiba such as the green exchange and the *Lixo que nao è Lixo* and implementing them alongside already existing initiatives such as the separation at source and buy back centres could not only improve the rate of recycling in the city of Johannesburg but also promote participation and compliance as it will be providing the residents with living essentials. This will be most advantageous in the rural areas that are not registered as Pikitup street collection sites and where Pikitup is having difficulty covering and accessing properties, such as in informal settlements.

As much as Singapore's main waste management strategy focuses on waste volume reduction by incineration which relieves pressure on landfilling, it is not suitable to depend completely on incineration and landfilling to solve the solid waste problem due to rising costs and environmental concerns. Therefore, NEA adopted a multi-pronged approach focusing on recycling as it saves energy and conserves resources. The initiative focused on the minimization of waste generated at source, waste recycling to reduce the amount of waste that needs to be disposed of, volume reduction of combustible waste through waste-to-energy incineration, and reduction of waste to landfilling in order to extend the life of the Semakau Landfill. Zhang (2010) discusses a more in-depth implementation on environmental education and how it is being carried out in schools or conveyed to the public when promoting recycling behaviour. More recently, initiatives are being implemented to help improve the minimization of waste such as the Singapore Packaging Agreement which is a voluntary industry-government platform that helps in promoting packaging of waste for recycling and reuse. It also aims to promote reduced packaging for products which helps with minimising waste and is to become a mandatory initiative by 2021. There is also the Mandatory Waste Reporting of which large hotels and malls are obliged by law to submit waste disposal and recycling information, waste reduction plans and targets dating from 2015. It encourages the government to work with hotels and malls to improve their waste management practices. The government has also disallowed the use of disposables for dine-in at new hawker centres and are continuously working with stakeholders to encourage the use of reusable dishes (NEA, 2018).

Other initiatives which aim to improve recycling of domestic wastes are also being implemented the National Recycling Programme (NRP) implemented by the NEA, which is aimed at encouraging mandatory recycling repositories for all condominiums, by providing a recycling bin for every block and landed unit and ensuring that all schools incorporate a recycling programme. There is also the provision of dual chutes for general waste and recyclables on all new public housing launched from 2014. This policy was expanded in 2018 to accommodate all new non-landed private residential developments taller than four storeys (NEA, 2018). Then there are the Community outreach initiatives which aim to educate consumers by using posters, fridge magnets, online media to

demonstrate how easily recycling reuse and recovery can be incorporated into daily lives thereby increasing domestic recycling (NEA, 2018).

In comparison with the initiatives used in Singapore, the City of Johannesburg needs to put more effort towards educating people about proper household waste recycling behaviour in order to see progress in the recycling rate. Johannesburg also has certain educational awareness programmes in place but needs to find methods to get individuals, households and businesses involved so as to increase the awareness of the importance of a sustainable environment. As both cities are currently struggling with land scarcity, a major strategy which could be implemented is introducing extended producer responsibility in order to tackle the issue of high generation of waste.

For companies and industries, Singapore initiated the Pay-as-you-throw fee, whose structure encourages waste generators to reduce their waste disposal. Also, the provision of recycling services at every industrial estate was implemented for easy access. One of the most popular initiatives is the implementation of Recycling Programmes in schools which helps build awareness, educates and promotes action from the young ones as they are encouraged to volunteer as Green Ambassadors (Eng, 2012).

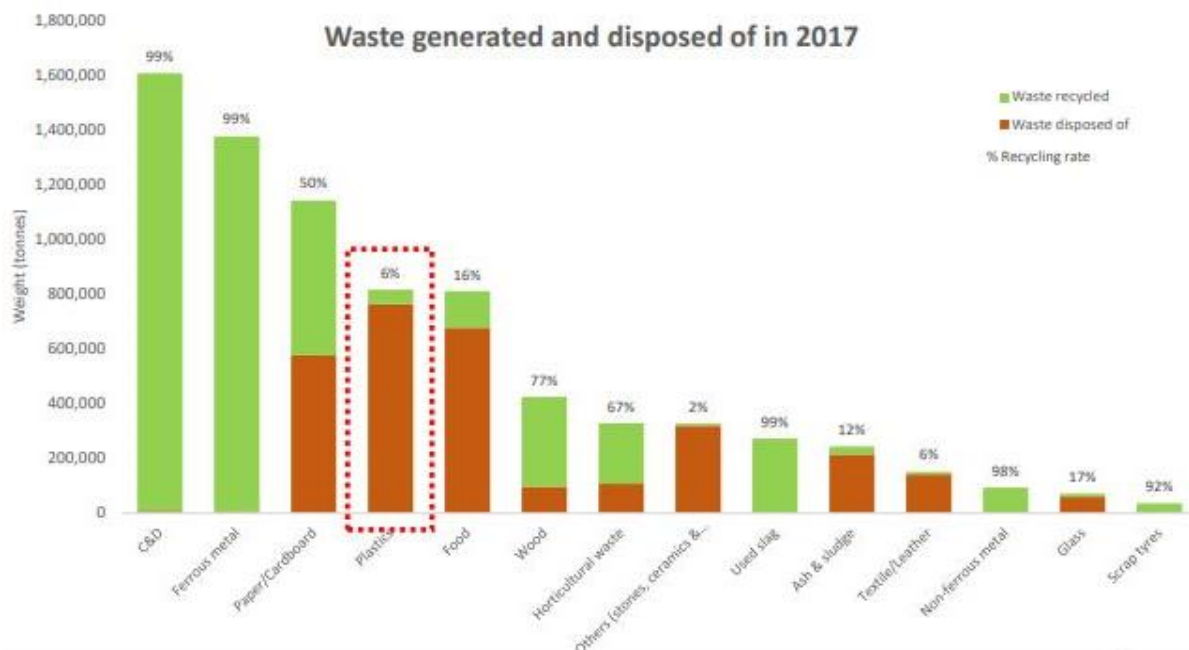


Figure 14: Graph showing percentage of recycled materials in 2017 (NEA, 2018)

In order to improve the development of the recycling industry in Singapore, the Sarimbun Recycling Park initiative was created to promote the setting up of recycling facilities with low cost rental. Twenty recycling plants have currently been initiated and focus on the recovery of higher value-added secondary construction material. Also, there is the creation of Eco-park, which is situated beside the Tuas incinerator, which is used for sorting recyclable household refuse such plastics, glass and metals.

These strategies have improved solid waste management in Singapore with an increase in recycling rates, from 40% to 54% between the year 2000 and 2007. The progress made in waste minimization and recycling has reduced the need for waste to end up in the landfill. As a result, the Semakau landfill's lifespan has increased from 20-30 to 35-40 years and there is a decline in the need for additional incineration plants (from one in every 5-7 years to one in every 7-10 years). In addition, 5.97 million tonnes of municipal waste was generated in 2008, 56% of which was recycled, 41% incinerated and 3% land filled. Furthermore, the Singapore green plan 2012 proposed to increase the rate of recycling to 60% by 2012 and 0% landfill. The NEA and MEWR (2006) reported that approximately 22,800 tonnes of scrap is recovered per year using magnetic separation from incinerated ash. Additionally, 980 million KWh of electricity is generated per year, which could source 2-3% of the demand for electricity in Singapore. As both Singapore and Johannesburg lack landfill space, initiatives such as waste to energy and recycling should be on the forefront of the waste management practices. Nevertheless, initiatives such as the pay-as-you-throw fee may not be effective in the City of Johannesburg due to the difficulty to monitor and enforce it. Nevertheless, such initiatives could be explored so as to discover what initiatives would promote cleanliness effectively in the City of Johannesburg.

Berlin, being years ahead in waste management, can boast of numerous successful initiatives of which have been put in place to ensure a sustainable waste management system. The state of Berlin has worked on various campaigns and model projects for ensuring that their residual waste is reduced significantly. The actions and pilot projects are based on bio-waste. The pilot project ranges from Biomass project, which is a concept introduced in 2010. The purpose was to determine the amount of CO₂ savings that must be achieved through sustainable material and energy use of biogenic waste from Berlin.

The phosphorus potential in the state of Berlin project, is a concept which is meant to run from 2010 till 2020. It was based on a phosphorus recycling of sewage sludge and sewage sludge ash as its waste management goal. The RC Concrete (Recycled Concrete) project is a plan to use RC concrete in all public building projects to promote environmental and resource conservation. There is also a recycling gypsum initiative, which establishes a network of acceptance points for gypsum plasterboard which enables the recycling of gypsum in Berlin specifically (Senate Department for the Environment, Transport and Climate Protection, 2020).

The Recycling cup-to-go was launched by the Senate Department and the BSR as a joint initiative and it was launched as 'Better World Cup' with Berlin's business and environmental associations. The purpose was to increase the use of reusable cups. In November 2018, Zero Waste project in schools was introduced. This was a modular structure for Berlin's schools which was based on zero waste subject. Another project aimed at zero waste is the Re-use Berlin which promotes reuse instead of discarding. This was an initiative by the Senate Department for the Environment, Transport and Climate Protection. In finding solutions for reducing waste, Berlin initiated the resources protection strategy which aims to achieve this through the treatment of hazardous mineral waste (Senate Department for the Environment, Transport and Climate Protection, 2020). These very comprehensive and advanced initiatives can provide inspiration and guidance for CoJ in recycling and reusing of waste and also implementing Zero Waste to minimize waste generation. The waste recycling initiative in CoJ is still rudimentary with a very low percentage of waste being recycled and an even lower percentage being reused. Implementation of these initiatives used in Berlin may help increase the amount of recycled waste in COJ and also reduce the amount of waste being produced.

The government in Kigali has attempted to implement a community awareness to encourage the members of the public to get involved in matters regarding waste management such as separation of waste according to their categories of organic and inorganic, so as to improve waste recycling, home composting, waste minimization and adherence to environmental and waste management laws. According to this research, the failure of this initiative is due to lack of education on environmental benefits and also lack of legal enforcement from the education system to the political administration.

In comparison with waste management practices in South Africa, Kigali may be behind in the waste management race due to lack of equipment, facilities and financing. There are close similarities between both cities and their waste management practices, for example, both use landfill sites as the primary waste disposal system, although Johannesburg currently has four active landfill sites while Kigali has only one active site. This is approximately proportional to the population of each city. Also both cities generate a substantial amount of organic waste amidst the total waste generated which ideally would require more of a composting method or incineration but the lack of functioning incineration plant in both cities would hinder such processes. Kigali's minimal infrastructural development prevents the city from implementing other waste management strategies such as building of incineration plants or recycling facilities. On the other hand, Johannesburg is more developed, and has less financial limitations in respect to implementing the other waste management strategies.

Therefore, it is much easier to implement strategies due to the availability of proper recycling facilities and initiatives which assist in enforcing these initiatives. Nevertheless, the awareness initiative in recent years has improved considerably with the Umuganda initiative in which citizen get together to clean up their locality every Sunday. This initiative encourages cleanliness of the city but has no impact on the disposal practices. The Umuganda initiative also helps with more awareness and education of the importance of a waste free environment in the city. Johannesburg has already adopted a version of the Umuganda initiative into its list of already existing strategies to assist with community cleanliness in the less developed communities. The City of Johannesburg has implemented a number of initiatives to improve and encourage other forms of waste management such as the separate at source, the use of buy-back centres and other awareness programs to encourage waste minimization and recycling. It can be safely assumed that in the near future with an increased GDP, Kigali waste management practice will improve as the city is investing in the waste-to-energy initiative which would also help with the economy of the country (Malofha 2017).

6.7 CONCLUSION

After an in-depth look at the study sites and their respective waste management practices, it is appropriate to use Berlin as the benchmark for this research on the basis of its extensive development in waste avoidance, recovery and recycling. Berlin also holds the most effective legislation on waste management amongst the study sites, thereby being able to implement effective strategies in order to reduce their waste production. Cities such as Kigali are still inexperienced in dealing with waste management issues as viewed in this paper. Kigali still focuses on landfilling with poor strategies on recycling or waste avoidance. The city also is not yet equipped to implement an incineration strategy and so, only focuses on the community cleaning initiative. However, Johannesburg has learned from this initiative in devising similar community clean-up drives. Singapore, due to the lack of land space, focuses more on incineration. This city still faces major issues in dealing with the reduction of waste generated and recycling of waste which has been implemented but accounts for low percentages of waste. Johannesburg can, however, use Singapore as precedent for implementing a waste-to-energy programme, using its existing incinerator and potentially bringing more on board. Finally, Curitiba is quite advanced in waste management as they minimise their waste production and are quite successful with implementing initiatives which assist in promoting recycling and recovery of waste. However, the city still needs to improve on the use of waste reclaimers and implementing proper legislation that will govern and hold accountable the management of waste in the city. The socio-economic and land settlement similarities with Johannesburg make Curitiba an important sourcebook for recycling initiatives. Figure 3 is a matrix table showing the different cities and the waste management processes in which they are actively successful in.

Table 5: Matrix table showing the waste management activities of each city.

	LANDFILL	INCINERATION	RECYCLE	LEGISLATION	INITIATIVES
BERLIN					
CURITIBA					
SINGAPORE					
KIGALI					
JOHANNESBURG					

VERY POOR	POOR	AVERAGE	GOOD	VERY GOOD
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CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1 SUMMARY OF FINDINGS

From the matrix table in the previous chapter, it can be seen that Johannesburg is active in landfilling as its primary waste disposal method but with the issue of limited landfill space, Johannesburg may be facing some major waste issues in the near future. Johannesburg also has fairly effective waste management legislation and implemented initiatives which help improve the waste management practice of the city as is seen in the waste by-laws, the NEMA Waste Act, separation at source and the use of waste reclaimer initiatives which complement waste recycling and recovery (as shown in Chapter Five). Nevertheless, these processes still fall below expectation due to the lack of enforcement in the city. Therefore, the laws and strategies are available but generally are not being practiced. Johannesburg is still underperforming in relation to the use of incineration, and waste recycling and recovery. This is due to the fact that the city has only one incinerator about which there is very little information on its functionality, and recycling is still an emerging practice with only a very low percentage of waste being recycled. This research would therefore recommend a number of practices that should be considered in order to improve the waste management practice in Johannesburg.

Firstly, the adoption of legislation that focuses more on waste avoidance should be considered. Though the NEMA Act focuses mainly on the waste management hierarchy and the NWMS is obliged to meet the objectives of the NEMA Act, it can be argued that the strategies implemented focus more on waste recycling and minimization rather than waste avoidance and zero waste. This research recommends that the City of Johannesburg acquire perspective from Berlin as it shows that it is easier to implement other waste management practices when the amount of waste generated is at a minimum. Also, taking into consideration the population density and the metropolitan nature of both cities, it is clear that the enforcement strategies used in Berlin are most effective. It can be argued that the waste management legislation in Johannesburg is sufficient in addressing the waste management issues, nevertheless, the enforcement of this legislation should be looked into; Johannesburg has legislation guiding the disposal of

waste and encouraging recycling but this is not sternly enforced and so is mainly overlooked. Therefore, methods that would encourage the inhabitants to get involved should be established.

Secondly, the City of Johannesburg already has effective initiatives that promote waste minimization and recycling, but not necessarily waste avoidance which should be prioritized. This research suggests that Johannesburg will be able to improve on this process by adopting some of Curitiba's initiatives and ideology as they focus more on the avoidance of waste. It has also been taken into consideration the fact that the population of Johannesburg is four times that of Curitiba and thereby produces more waste. Nevertheless, there are a number of initiatives that could still be effective, especially given the socio-economic similarities between these two cities. For example, both cities unofficially make use of the services of waste reclaimers and also both cities tend to overlook the importance of these people. With the large number of waste reclaimers in Johannesburg, incorporating them into the waste management system can only be advantageous to the city as that will improve the process of recycling noticeably and protect their interests. This research recommends the implementation of incentives, mainly for households in less developed communities whereby the waste is separated into recyclable and non-recyclables and delivered to specific nearby depots in return for some sort of payment, as is found in Curitiba. This would also help motivate waste reclaimers who are not yet under the organisation of the municipality to organise themselves so as to benefit both themselves and the municipality. Again this should help improve the implementation of recycling and waste recovery down to the household level.

Finally, with regard to incineration, it is understood that basic incineration, although it is quite effective in the disposal of waste, is also harmful to the environment as it produces harmful gasses from the incineration plants. Therefore, this research recommends the further look into the implementation of waste-to energy. Cities such as Berlin and Singapore are quite advanced in this practice and so can be emulated. These cities, most especially Singapore, are similar in size and population to Johannesburg therefore it can be assumed that consumption of the national grid is also similar. This is to highlight the use of waste to energy in Singapore as this produce 3% of the electricity used in the city. Currently, South Africa's national grid has been experiencing frequent load shedding

which has had to be implemented from time to time due to the excess load on the national grid. Needless to say, the waste to energy initiative would not only be effective with the reduction of waste, but also would be a relief process on the national grid, thereby providing a better environment and better living conditions for the residents. South Africa has the technology with which 'waste to energy' can be introduced. The use of organic and biodegradable waste to create power and electricity is a field that should be explored in order to help Johannesburg especially in this current period whereby the power consumption is rising. For this to occur, CoJ would need to recheck the functionality and activity of its incineration plant.

7.2 CONCLUSION

This research has aimed at discovering what waste management practices would help assist Johannesburg to achieve their environmental sustainability goal. This would be the point at which the environment in which we live in is maintained on a steady level continuously, without negatively affecting its natural resources or ecosystem. One major way to achieve this is by sustainable waste management which is basically ensuring the use of resources properly in order to reduce the production of waste and then, when waste is produced, it is being dealt with properly so as to contribute to the economic, social and environmental goals of sustainable development (Pianosi, 2012).

The research focused on analyzing how effective waste management practices implemented in the City of Johannesburg may promote its environmental sustainability. The research analyzed the current waste management practices in Johannesburg and deduced that the use of landfill sites is one of the main waste management practices in Johannesburg. Only within the past decade has the implementation of widespread recycling and recovery been introduced by the initiation of the separation at source initiative and the introduction of buy-back centers in order to promote waste minimization within the city, which was carried out only in a limited number of suburbs. A document analysis was carried out to understand the waste management practices which are being used by the City of Johannesburg in order to promote a sustainable environment. The information was derived from numerous sources such as articles, websites, news

mediums and annual reports from the city of Johannesburg and Pikitup which elaborate on the different practices used in waste management.

These sources enabled the research to explore all the waste management practices currently being practiced in Johannesburg. It highlights the reliance on the use of landfill space and the need to involve other waste management methods such as incineration, recycling and recovering of waste. This is linked to the implementation of the 'separate at source' and buy-back centers initiatives implemented by the City of Johannesburg and other initiatives governed by the mayoral strategies of the City of Johannesburg. Also the research shed light on the legislation governing waste management in Johannesburg such as the waste by-laws, the focus of which lies on the avoidance of waste and then the minimization of waste, and the NEMA Act focusing on the protection of health, wellbeing and the environment, and the protection of the ecosystem. Finally, the research looked at the waste reclaimers initiative which the City of Johannesburg is working on and incorporating into their system as an organization to work with for the improvement of sorting out recyclable waste and keeping the city clean.

Comparison was made between the waste management practices used in Johannesburg and waste management practices in Kigali, Singapore and Curitiba, while Berlin was used as a benchmark for waste management due to their high success in waste avoidance and minimization. Berlin also showed to have active and functioning landfilling disposal system having only a small amount of waste disposal at the landfill site and a majority of waste generated either compost or was turned to energy for the city, incinerated in any of the active incineration plants or recycled if recyclable. Most of all, Berlin introduced a series of successful pieces of legislation to promote waste avoidance more specifically and a number of initiatives to ensure proper enforcement of the legislation from education to penalties and incentives. This could be adoptable quite easily in the City of Johannesburg as Johannesburg has adequate legislation and initiatives but lacks in the aspect of enforcing this legislation hence leading to a low level of success in its waste management initiatives. From the research, Kigali was seen to rank the lowest with the use of landfill site as their main waste management method and little or no involvement in other methods due to lack of funding and infrastructure.

However, this city is noteworthy for its inclusion of the entire population in its city cleansing initiative. Singapore, due to lack of land space, is successful in the use of incineration and the implementation of waste-to-energy which is derived from the by-product of the incinerated waste. This can be a strategy adopted by the City of Johannesburg as Johannesburg has an incineration plant but there is no information which shows its activity or functionality. Curitiba is well known for its initiative which promotes environmental sustainability. This city has a very stable landfilling disposal system and recycling system with initiatives such as the Waste That is Not Waste initiative and the Green Exchange (Cambio Verde) initiative which have been very successful in the minimization of waste. The city is also known for its involvement of waste reclaimers which help keep the city clean and also with the collection and separation of recyclable waste from non-recyclable waste. The research showed the similarities between the city of Curitiba and Johannesburg and how some of the initiatives used in Curitiba could have some success if implemented properly in Johannesburg. Also both cities make use of waste reclaimers and are having difficulties incorporating them into the system. The research shows that this could be an advantageous process and more consideration should be given to the development of the waste reclaimers initiative.

In conclusion, after taking into consideration the difference between the case study cities and Johannesburg in terms of land mass, population, socioeconomic and financial status, a few recommendations were made which may help improve the waste management practice in order to promote environmental sustainability in Johannesburg. First was the implementation of initiatives which would ensure the enforcement of the legislation put in place in Johannesburg to guide the waste management system. Secondly was the adoption of initiatives such as those used in Curitiba. The population is most likely to react positively towards an incentive based initiative or an initiative that is practically beneficial to individuals. This would ensure the improvement of already standing initiatives put in place to promote recycling and recovery of waste. Finally, is the initiation of waste-to-energy in Johannesburg. South Africa is not new to the technology as it was initially implemented in 2007 using the gasses emitted from four of the landfill sites (Pikitup, 2013). The use of biodegradables is a technology that can be harnessed by the City of Johannesburg by putting in the finance and effort to ensure the incineration plant

becomes functional. This then produces the by-products needed to harness energy which would be beneficial especially to the city of Johannesburg power grid.

7.3 RECOMMENDATIONS FOR FUTURE RESEARCH

During this research, some limitations were met which hindered verification of the documentary sources. One major limitation was the acquiring of information from Pikitup and CoJ personnel. In the process of acquiring the information for this research, the author attempted to request for interviews with certain Pikitup and CoJ personnel. However, it was extremely difficult getting in touch with the individuals who were never available hence the use of questionnaires and interviews to confirm the analysis could not be used.

Secondly, acquiring detailed records on the types and quantity of waste was also an issue as this information was not available to the author. This can be problematic to both the City of Johannesburg and other researchers as this study is important in the process of strategy formulation. Availability of this study to researchers will definitely improve the City of Johannesburg's policy, strategy and implementation as quantitative research can be carried out to improve the waste management process of the city.

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