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CHALLENGES AND OPPORTUNITIES IN SOLID WASTE MANAGEMENT IN ZIMBABWE'S URBAN COUNCILS

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DECLARATION

I, **Aleck Muchandiona**, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Water Resources Engineering and Management (WREM) of the University of Zimbabwe. It has not been submitted before for examination for any degree in any other University.

Signature: ____________________

Date: _____________________

The findings, interpretations and conclusions expressed in this study do neither reflect the views of the University of Zimbabwe, Department of Civil Engineering nor of the individual members of the MSc Examination Committee, nor of their respective employers.

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LIST OF SYMBOLS AND ABBREVIATIONS

AfDB	African Development Bank
EMA	Environmental Management Agency
FGD	Focus Group Discussions
GOZ	Government of Zimbabwe
IBP	International Best Practise
ISWM	Integrated Solid Waste Management
MDGs	Millennium Development Goals
MHCW	Ministry of Health and Child Welfare
MLGRUD	Ministry of Local Government Rural and Urban Development
MSW	Municipal Solid Waste
MUDGI	Ministry of Urban Development Government of India
NGOs	Non Governmental Organisations
O&M	Operation and Maintenance
SW	Solid Waste
SWM	Solid Waste Management
UCAZ	Urban Councils Association of Zimbabwe
WSP	Water and Sanitation Programme
WSS	Water Supply and Sanitation

DEDICATION

This thesis is dedicated to my precious sister Plaxides and to my unforgettable late mother for their encouragement, teachings, motherly love, words of wisdom and financial support.

This thesis is also dedicated to my lovely wife Tendai and to my daughter Mary for their sacrifice towards my education.

To Mary, I expect you to go beyond your father's achievements

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ABSTRACT

Modern trends demand the sustainable management of solid waste through waste minimization, material recovery, full collection and sanitary disposal of waste. Poor solid waste management in Zimbabwean urban councils has been worsened by a decade of economic challenges which culminated in cholera and other related diseases which killed about 4, 000 people countrywide in 2008 and 2009. While more emphasis has been placed on the traditional collection of waste, the principles of integrated solid waste management have not been fully followed. The poor performance of urban councils on solid waste management has a great impact on the quality of scarce surface and groundwater resources, human health and the environment in Zimbabwe.

A research study was carried out between October 2012 and June 2013 for 32 urban councils of Zimbabwe. The objectives of the study were to assess the extent and challenges of solid waste collection, transportation, sanitary disposal and financial sustainability in Zimbabwe's urban councils. The methods used to collect data were an urban council survey for the 32 urban councils in Zimbabwe and a questionnaire which was administered in person to the town engineer, health officer, town clerk, health inspector and other junior staff of each of the 32 urban councils. Field visits and observations were done on residential areas, landfills and open dumpsites. Data verification was done using audited urban council financial reports, management reports, rapid assessment reports and weighbridges receipts from Central Mechanical Department. Focus Group Discussions with health officers, town treasurers and town engineers were also done to validate the collected data. The data was analysed using the bivariate Pearson two tailed correlations test to test the relationship between indictors and performance level.

The results revealed that 64.3 ± 27.6% of the properties in Zimbabwean urban councils are covered by municipal solid waste management services. The collection efficiency of solid waste was 63.9 ± 27%. The performance was below the international best practices of proper solid waste management. The challenges in poor refuse collection were attributed to serious shortage of refuse equipment, landfill equipment, human resources and shortage of proper receptacles. Recycling strategies seemed to be nonexistent as revealed by low receptacle coverage of 44 ± 27%, the extent of recovery of municipal solid waste of 2% by informal waste pickers and unsorted waste at the landfills. The results suggest that 99% of the urban council landfills were not sanitary.

It was concluded that poor coverage and collection of solid waste were caused by serious shortages of refuse equipment, human resources and proper receptacles. Poor sanitary disposal of solid waste could be attributed to shortage of landfill equipment and failure by urban councils to invest in landfills as revenues were just sufficient for the traditional collection of waste. It was recommended that the councils should extend coverage to all areas, increase their refuse equipment, provide receptacles to customers, increase human resources, construct engineered landfills and seek other financing mechanisms besides user charges.

Key words *solid waste management, urban councils, performance level*

1. INTRODUCTION

1.1 Background

Agenda 21 states that the air, water, land and even dwellings of people around the world, are so badly polluted to the extent that the health of about 100 million people are affected (UNSD, 1992). Solid waste is one of biggest challenges of the urban areas of all sizes, from mega-cities to the small towns and large villages, which are home to the majority of humankind. It is almost always in the top five of the most challenging problems for municipal managers (Rodic *et al.*, 2010; UNEP, 2011). Cities spend a substantial proportion of their recurrent budget on solid waste management, yet waste collection rates for many cities in low- and middle-income countries remain as low as ten percent in peri-urban areas (UN Habitat, 2010). In addition, the non-industrialised countries have low levels of refuse collection rates of 30 to 60% in low income countries and 50 to 80% in middle income countries (UNEP, 2009; UN Habitat, 2010).

The low levels of refuse collection have been attributed to several factors, among which are; declining economies, insufficient funds and lack of adequate equipment (Senkoro, 2003). However, countries are expected to progress in the sound management of chemicals and waste by 2020; through the sharing of knowledge, experience and best practices (UNSD, 2012). Moreover, all countries, consumers and stakeholders are encouraged to take all possible measures to prevent unsound management or illegal dumping of waste particularly hazardous waste.

In pursuit of these objectives the United Nations Conference on Sustainable Development held in Rio de Janeiro Brazil 2012 put more focus on the disposal of hazardous waste such as health waste, radioactive waste, electronic waste and plastics (UNSD, 2012), whereas Agenda 21 highlighted the need to reduce waste at source and pollution at the disposal site. Agenda 21 also specified that appropriate solid waste technologies on the basis of health risk assessment should be developed and all large cities should have appropriate solid waste disposal capacities. The Agenda also highlighted that adequate infrastructure to handle waste and programs for protecting environmental injury should have been established by year the 2000 (UNSD, 1992). However, it seems that not even one of these targets have been achieved, particularly in developing countries.

Mangizvo (2010) suggested that open dumping will continue to be the way of disposing waste by municipalities in Africa due to financial constrains. Similar studies by Masocha (2004) revealed that solid waste disposal systems in Zimbabwe were open dumpsites and the few landfills available were not sanitary. For example, the study by Love *et al.*(2006) for Golden Quarry landfill in Harare the largest city in Zimbabwe, showed that coliforms, cadmium, iron, lead, and nitrates in ground water were above the water quality guidelines. Ground water in the suburb was also not suitable for domestic use. Similar studies by Mangizvo (2008) for the management practices at Mucheke municipal dumpsite in Masvingo showed that soils within a 50 metres radius had been contaminated by trace amounts of lead, iron, copper, zinc, and phosphorus. Another study found out that high concentration of zinc, lead, and copper were found in surface soil samples up to 75 metres from Kariba disposal site (Chifamba, 2007).

Protecting water resources from the negative impacts of waste requires good policies, strategies and guidelines in line with international trends (Idris *et al.*, 2004; Oelofse, 2008). There is need to call for the development and enforcement of comprehensive national and local waste management policies, strategies, laws and regulations. Countries which do have adequate solid waste management systems must prevent illegal dumping of hazardous wastes through the use of relevant international instruments, rules and regulations (UNSD, 2012). Urban areas in developing countries, in particular Sub-Saharan Africa where a multiplicity of factors, notably institutional weakness, administrative incapacity, poor supervision and enforcement of existing environmental legislation, have made sanitary disposal of solid waste one of the most serious environmental and health challenges facing municipalities (Senkoro, 2003).

1.2 Problem Statement

The growing piles of illegally dumped solid waste near houses and open spaces in urban areas of Zimbabwe provide overwhelming evidence that solid waste management systems are failing to copy with increasing volumes of solid waste being generated (Masocha, 2004; Chifamba, 2007). It has been said that the refuse collection efficiency by urban councils in Zimbabwe has dropped from 80% in the mid 1990s to as low as 30% in 2006 (Practical Action, 2007). In addition, poor solid waste management has been worsened by a decade of economic decline which culminated in the 2008 to 2009 Cholera outbreak which led to the death of about 4 000 people countrywide (Government of Zimbabwe, 2013b). Moreover, the UN Habitat (2010) revealed that the rates of diarrhoea and acute respiratory infections are significantly higher for children living in households where refuse is dumped or burnt in the yard compared to municipalities that receive adequate collection services.

Globally, there are ongoing campaigns encouraging the use of the environment in a sustainable manner; which implies that the negative impacts of waste on the environment and climate change must be taken into consideration (UNEP, 2011). The performance assessment of solid waste management services thus provides comparable data that would be used to inform investigation into waste policy, technology, financing, governance, good and bad practice focusing on sustainability (Rodic *et al.*, 2010). The performance assessment of urban councils for comparative and benchmarking purposes has seldom been done in Zimbabwe. However, studies on the assessments of the impacts and inefficiencies of solid waste management practices for a few urban councils have been done (Masocha, 2004; Chifamba, 2007; Mangizvo, 2010a).

1.3 Research Objectives

1.3.1. General Objective

To assess the extent and challenges in storage, collection, transportation, disposal and financing of solid waste management in the urban areas of Zimbabwe in 2012

1.3.2. Specific Objectives

1 To assess the extent and challenges in storage, collection and transportation of municipal solid waste in urban areas of Zimbabwe in 2012.

2 To assess the extent and challenges in the disposal of municipal solid waste in urban areas of Zimbabwe in 2012.

3 To assess the financial sustainability of the solid waste management function in urban areas of Zimbabwe in 2012.

1.4 Justification

The research should help the policy makers in formulating policies that should govern solid waste management efficiently. The assessment of the challenges and weakness of the existing solid waste management should help policy makers in addressing gaps and weakness in the existing laws and policies. In addition the performance assessment of urban councils should help urban local authorities in identifying the local authorities that were performing better than others. The councils would then analyse the management practices which exist in that particular local authority. Other local authorities would then copy the best practices. This study moves in the direction of providing data for comparing urban councils in terms of solid waste management.

Moreover, the study provides information for benchmarking. For councils to properly set targets or benchmarks they have to know first their level of performance. The goals will then be set based on the available resources and analysing the activities that make other local authorities better performing. Furthermore, the performance level of the urban council could be used to rate staff competence. Training needs should be identified through a comparative analysis with different local authorities.

The study encourages urban councils to be well coordinated and share experiences. Exploring the opportunities helps urban councils to realise the financial, social and environmental benefits and opportunities in material recovery and moving towards the direction of archiving the Millennium Development Goals (MDGs). The potential for improving the life styles of informal waste pickers would be realised by exploring the challenges and weakness of recycling waste at source and at disposal sites and how to address them.

1.5 Scope and Limitations

The scope of this study included the performance assessment of the Zimbabwean solid waste management function. The indicators that have been used by Government of India, Environmental Management Agency of Zimbabwe (EMA) and Government of America have been used in this study to assess the extent and challenges in Solid waste management (United States Army, 1994; Government of Zimbabwe, 2007; MUDGI, 2008). The indicators below have been used

1. Coverage of kerbside collection of solid waste.
2. Efficiency in collection of solid waste
3. Extend of recycling and sanitary disposal of waste.
4. Financial performance of the urban councils
5. Adequacy of machinery and human resources

The study was carried out on all the 32 urban councils as a large sample gives a true reflection of the performance of Zimbabwe in the regional and global world.

1.6 Structure of the Thesis

This thesis consists of five chapters. Chapter 1 gives the background of the problems and challenges of solid waste management in the world, Africa and Zimbabwe. The need for the performance assessment in a bid to ascertain the challenges and the causes of poor solid waste management is the basis upon which this study was undertaken, hence the objectives and justification of carrying out this study. Chapter 2 gives relevant literature on the challenges of solid waste management in different parts of the world. Drivers that have lead to sound solid waste management in other countries was also reviewed. The role of sustainable solid waste management and contributions in the attainment of MDGs is also given. Chapter 3 gives the summary of the study area in terms of its location, population and the administration of the town. Materials and methods used to collect and analyse data in order to fulfil the objectives. Results and findings were presented and discussed in Chapter 4. The results are outlined in Chapter 4 compared with the findings from other countries. Chapter 5 gives conclusions and recommendations.

2. LITERATURE REVIEW

2.1. Introduction

This chapter reviews the works and findings of various researchers on solid waste management. Approaches that lead to sustainable environment in relation to solid waste management are explained and international best practices for which the urban councils of Zimbabwe must aim for are also given. The current scenario and challenges faced by urban councils, internationally, regionally and locally with respect to solid waste management are described. The global view of solid waste management especially towards the environmental and health issues is also discussed. The policies, laws and regulations that govern SWM are also explained. The definition of the parameters that are used to assess the performance and benchmarking of urban councils in terms of Solid Waste Management (SWM) are also given. The environmental aspects of solid waste management on water quality are also reviewed.

2.2. Solid Waste Management Practices

Municipal Solid Waste (MSW) is generally defined as waste generated from homes, street sweeping, industries, institutions and commercial areas which needs to be collected by or on behalf of local authorities (Hester and Harrison, 2002). Proper solid waste management involves waste characterization, waste minimization, sorting, recycling, reuse, collection and disposal of non recyclable waste in engineered landfills. Waste management has been grouped into waste management hierarchy in which source waste reduction and reuse is most preferred, followed by recycling or composting, energy recovery and finally treatment and disposal of solid waste in engineered landfills as shown in Fig 2.1.

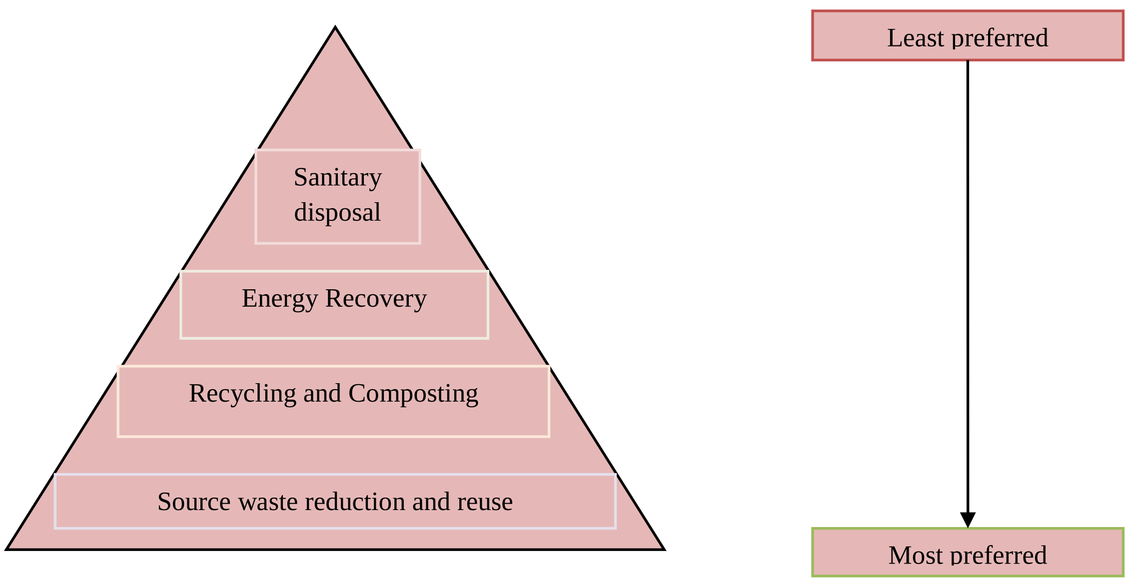

Figure 2.1: Waste management hierarchy. Source: Hester and Harrison (2002).

Waste characterization involves classifying the waste into different categories such as organic waste, plastics, paper, metallic, hazardous and non hazardous waste. This is important for planning purposes, especially in formulating a recycling strategy and in the design of landfills. For example, when the composition of solid waste in the landfill constitutes more of the organic component, it might be necessary to make provision for the collection of gas which would be emitted from the organic component. However when the overall objective of solid waste management is to deposit waste in landfills then knowing the composition of waste might not be necessary (Vesilind *et al.*, 2002).

Waste minimization involves reducing the generation of waste in homes and industries. For example, cooking just enough food so as to minimise food that would be thrown in bins. The generation of waste in industries could be reduced by using less material to manufacture goods, use of few packaging material, durable products and efficient use of resources. Waste minimization could also be achieved through reuse of goods in homes and industries. Waste minimization is very important in that it reduces the quantum of waste that needs to be collected, therefore reduces the collection and disposal costs. Composting is very important since more than half of municipal waste constitutes organic waste. In addition, composting helps in material recovery through production of organic fertilizers which plays an important role in agricultural production. Composting should be done in a composting plant or in a properly managed composter in the backyard (Hester and Harrison, 2002). Reducing the volume of the organic waste helps in reducing the quantity of waste that enters the landfill, hence increasing the lifespan of the landfill.

The storage of waste in proper receptacles or bins is very important in the management of waste. The receptacle must be large enough to store waste until the council came to collect waste, so that residents do not dump overflowing waste. The choice of receptacles depends on the generation rate per capita and the method of lifting and empting the receptacle in the refuse collection vehicle. Since recycling starts at household level, many receptacles must be in place to cater for different types of waste. local municipalities must provide residents with receptacles (CSIR, 2011). This is important as it caters for the poor.

Sorting influences the waste management option. Sorting influences recycling, recovery of materials and energy recovery. Solid waste must be sorted at household level into recyclable and inert materials. Most treatment methods needs some form of sorting waste into different fractions. Traditionally waste has been collected as mixed, but the modern trend requires waste to be collected in sorted form using different or same vehicle with different compartments. Some systems involve collecting waste as mixed and then sorting the waste at the central point. Residents collect waste in receptacles to the gate alongside the road and this is referred as kerbside collection. The type of collection equipment depends on the nature of the roads, the distance from the collection centre to the landfills and the population. Compactor vehicles, cage trucks combination of the tractor and trailer are some of the equipment that could be used to transport waste. The local authorities should maintain their vehicles regularly and should have a dedicated mechanic to service and repair the equipment (CSIR, 2011).

Disposing waste in the landfills is regarded as the last resort in proper solid waste management. All the waste that cannot be composted, recycled or reused should be deposited in the landfill. Thus landfills should be able to hold waste until they are stable and inert to prevent harm to public health and the environment. There must be different types of landfills for disposing non hazardous waste and the one for disposing hazardous waste. An engineered landfill is defined as any lined landfill that is operated using good practices such as covering and compacting refuse on daily basis, monitoring ground water, collecting and treating leachate (United States Army, 1994). Compaction is usually carried out by bulldozers.

Waste management policies are very crucial for the management of waste and there must be political stability and support from Government for effective management of waste. Policies available encourage recovery, reuse and waste prevention through user and provider participation. Europe and United States introduced the Zero Waste policy which seek to enforce the waste minimization strategy and encourage the use of compostable packaging materials (UN Habitat, 2010). According to their policy, movement and disposal of hazardous waste should be restricted. For proper solid waste management, the above policies must be enforced. Good solid waste management includes among others good institutional set up. Local authorities should have adequate staff, good financial management and involve stakeholders in planning and management of waste. The waste management authority should have customer care services, public education and campaign services (CSIR, 2011).

2.3. Urban Councils Solid Waste Management and Practises

The management of solid waste in most parts of the eastern and southern Africa consists of seven stages which are refuse generation, storage, transfer, collection, transportation, processing and disposal (Tevera *et al.*, 2003). The author did not include recycling, reuse and composting of waste in his definition which are also vital in sound solid waste management. The stages of waste management vary from country to country depending on the existing technology, level of participation of stakeholders and institutions and policies

2.3.1. Solid Waste Generation Rates

It is expected that developed countries should produce more waste than developing countries because they have more to spend in buying packaged goods and food stuffs. Most of the industries in developing countries are primary industry hence their industrial waste generation rates are also very high as compared to those in developed countries. (UNEP, 2011). UNEP (2011) also pointed out that the municipal waste generation rates in many developing countries have now crossed the one kilogram per capita per day mark and the total waste generation is higher in developing countries than in developed countries (UNEP, 2011). A study by Musademba *et al* (2011) on the management challenges of Chinhoyi municipality of Zimbabwe, found out that the waste generation rate was 0.34kg/capita/day which was by far below the one estimated by UNEP (2011) for developng countries. The per capita waste generation rate of 0.33kg/day in Kenya seemed to show that there are no significant difference across African countries which is by far below the 1kg/capita/day as suggested by UNEP (Mwai *et al*., 2008).

When a country is growing economically, the tendency is that there would be high waste generation rates. For example, the generation of waste in Ireland has increased greatly since the mid 1990's in line with a period of extremely rapid economic growth (Desmond, 2006). In addition, the waste generation rates for Asian countries are very high due to economic growth, for example the waste generation rates for Malaysia changed from 0.88 to 1.4kg in 2011. In China the average waste generation rate per capita was found to be 1.65kg/day. On the other hand, per capita waste generation rates in India, one of the middle income countries varies from 0.2 kg to 0.6 kg per day in cities (Chaurasia, 2011) which is lower than the generation rates for developed countries. Therefore it could be hypothesised that high income countries generate more waste than low to middle income countries due to the fact that they cannot afford to buy luxurious packaged food stuffs.

According to EPA (2005) figures, municipal waste generation rate per capita per day has risen from 0.59kg in 2001 to 0.68kg in 2004 in European countries. The international benchmark target of 0.3kg/capita/day has not been achieved by European countries (EEA, 2005). For example, the generation of municipal waste in Ireland is 0.7kg/capita/day which is more than twice the benchmark target of 0.3kg/capita/day and is clearly unsustainable. Overall municipal waste generation and resource use are growing at unsustainable levels (EPA, 2005), that is waste generation rate and economic growth has not been decoupled.

2.3.2. Waste Composition

It is expected that an urban area which has many industries is likely to produce more metallic waste. For example, the composition of waste in Bulawayo the second largest city in Zimbabwe was 50% plastics, 40% food waste and biomass, 10% paper, 5% metallic waste (Mudzengerere, 2012). The composition of waste in Chinhoyi, one of the municipalities in Zimbabwe was 45% food and biomass waste, 23% plastics, 12.5% metallic waste and 7% paper waste (Musademba *et al*, 2011). The low metal waste composition in Bulawayo was due to the fact that industries were non functional over a decade of economic decline. This could be a result of little waste coming from industries as most industries were not operating and for the two urban councils there were equal consumption patterns of food stuffs.

2.3.3. Storage of Waste and Coverage of Receptacles

A receptacle is any container that could be used to store waste temporally. A proper receptacle must be durable, closed on top and not easily damaged by dogs and rodents. In Zimbabwe both urban councils and owners of the properties are responsible for ensuring that receptacles are available for each property (Government of Zimbabwe, 2002). For example, Bulawayo City Council used to supply metal bins to its residents. However, high costs of bins have caused residents to use plastics bags as temporary waste storage facility. Muzengerere (2012) found out that 48% of the residents were using plastic bags as receptacles in Bulawayo. The author estimated the coverage of proper receptacles (metallic bins) to be 44%. The author also suggested that bins should be charged at a nominal fee so that members of the community could afford them (Mudzengerere, 2012). Mangizo (2007) also highlighted the same challenges in Gweru the provincial town of Midlands Province in Zimbabwe and recommended that the city councils should ensure that refuse bins are readily available to residents for sustainable waste management. Providing receptacles to the residents by urban councils is very important as it caters for the poor who usually don't afford to buy receptacles.

The economic challenges in Zimbabwe have greatly reduced the coverage of receptacles. The storage of waste before collection and transportation to the dump site involved the use of various receptacles (Musademba *et al.*, 2011). The receptacles in Chinhoyi included polythene bags, propylene sacks, metal bins, and disposing waste into pits dug at the back of the house. In Chinhoyi 22% of households were using bins, which used to be provided by the municipal council, 26% were using sacks, 19% were using plastic bags, 25% were disposing of waste into pits, and 8% were using other alternative receptacles, such as boxes and plastic buckets (Musademba *et al*., 2011). Serious shortage of receptacles in Chinhoyi, Gweru and Bulawayo provide enough evidence that there are no recycling strategies across Zimbabwe as recycling requires more than one receptacle per property for sorting and separation of different types of waste. The shortage of receptacles would also mean that residents would dump waste as residents do not have receptacles to store waste.

In a study by Manyanhaire (2012), the coverage of proper receptacles in Sakubva high density suburb in Mutare, Zimbabwe was 64%. Residents of Sakubva were using other unacceptable receptacles such as card boxes and sacks which constitute 26% (Manyanhaire, 2009). Manyanhaire (2012) also pointed out that the proper receptacle would take seven days to fill, the time usually between one collection to the next collection. Sacks and cardboard boxes fill up easily resulting in overspills and this would attract flies, rodents and mosquitoes (Manyanhaire, 2009). The residents with sacks usually dump solid waste illegally so as to create more space for other waste and to prevent the accumulation of flies.

2.3.4. Source Sorting and Separation of Waste

Sorting involves separating waste into different components such as biodegradable waste, plastics, metals, bottles and paper. Sorting makes subsequent solid waste management stages such as waste recovery easier and promotes recycling. A study by TARSC and CFH (2010) on assessing solid waste management in Chitungwiza, Epworth and Mutare revealed that 26% of the households are separating waste at source. The author did not give the driver for separation of waste at source in these 3 urban areas. The possible reason could be that residents separate biodegradable waste for composting purposes in the backyard. In Mutare high density suburb about 41% were doing source sorting and separation (TARSC and CFH, 2010). This seemed not to agree with the findings by Manyanhaire (2009) in the same area on the analysis of domestic waste in Sakubva high density area of Mutare. The author estimated that 11% of the households were doing source separation of waste which was lower than that found out by TARSC and CFH (2009). This seemed to be the true picture of waste separation because the author managed to support his argument through giving data of coverage of receptacles of 60%, one receptacle per household and the lack of knowledge by residents to know the benefits of sorting and recycling.

2.3.5. Collection Efficiency and Transportation

In developing countries, 30 to 60 percent of all the urban solid wastes remain uncollected and less than 50 percent of the population is served (UNEP, 2009). In low-income countries, collection alone drains up to 80 to 90 percent of municipal solid waste management budget. This is partly due to the fact that developing countries have poor financing mechanisms and available funds are not enough to invest in other subsystems of solid waste management. In high-income countries, collection accounts for only less than 10% of the budget, which allows large funds to be allocated to waste treatment facilities. Upfront community participation in these advanced countries reduces the collection cost and facilitates waste recycling and recovery (UNEP, 2009).

Major issues to deal with refuse collection remain unresolved for major cities in Asian developing cities. For example, lack of equipment had led to reduced collection efficiency of 70% of households wastes in Asian countries (Magalang, 2003). In addition Padungsirikul (2003) estimated the collection efficiency of Bangkok in Thailand to be between 60 to 80%. Findings by Chaurasia (2011) agreed that waste collection efficiency ranges from 50% to 90% but treatment and disposal is not more than 5%. Urban Local Bodies (ULBs) spend 60% to 70% of money on collection and less than 5% on treatment and disposal costs in developing countries (Chaurasia, 2011). This is partly due to the fact that developing countries have poor financing mechanisms to fund solid waste management fully.

African countries still face challenges in the collection of municipal waste. For example, Blight and Mbande (1996) pointed out the issue of lack of equipment, the use of aging and inappropriate machinery being attributed to inefficiency in the management of waste in many cities in developing countries. Studies by Mwai *et al.* (2008) estimated the coverage of solid waste management services as 58% in Kenya because of lack of equipment and aging machinery.

Zimbabwe has also not been spared by the challenges which are affecting other African countries in the collection of solid waste. For instance, studies by Mudzengerere (2012) in Bulawayo showed that there was an acute shortage of equipment and the city council was striving to make sure refuse is collected. The reason was that the city council had only ten functional compactor trucks against an ideal of 25, two tipper trucks, two front end loaders and one dozer with no landfill compactor (Mudzengerere, 2012). Bulawayo city council was collecting refuse once per month for all the residential areas except for food outlets, shops, hospitals, schools and colleges where collection was three times per week (Mudzengerere, 2012). Therefore refuse collection was inconsistent and waste was being generated daily regardless of the current situation of the city.

Gweru city council has been experiencing the same challenges which Bulawayo city council has experienced. Mangizvo (2010a) showed that the collection efficiency was poor in Gweru because the city council had only one functional refuse truck for the whole city in 2008 to 2009 (Mangizvo, 2010a). The author recommends that the Gweru City Council should remove all solid wastes in the town centre on a daily basis. Moreover, the author suggested that the whole solid waste management process should be improved, that is non functional vehicles should be repaired. Furthermore, the author also gave an option of waste collection schedule which would help in the monitoring and evaluation of the waste management program.

Chinhoyi urban council also has been experiencing problems in the collection of waste. The coverage of collection of solid waste at a frequency of once a week was 48%. This was alluded to serious shortage of equipment as the urban council only had one seven-tonne open truck and two tractors and trailers combinations to collect waste (Musademba *et al*, 2011). In another study by Masocha (2004) the collection efficiency in Victoria falls was 60%. Poor collection efficiency across Zimbabwean urban areas implies that the users might burn the uncollected waste, illegally dumping waste in open spaces and composting waste in the backyard.

2.3.6. Recycling and Recovery of Solid Waste

Recycling and recovery of waste includes various types of activities such as reuse (e.g., plastic and glass containers), recycling of materials for industrial production (e.g., paper and iron), converting waste into energy (e.g. burning tyres in cement kiln to produce heat), and converting waste into a resource (e.g., composting and landfill gas). Hence technology can determine the level and sophistication of recycling and recovery activities (UNEP, 2009). In general, recycling involves collecting directly from houses and businesses, discarded items that can be sold for reuse and reprocessing into raw materials that can be used by others, or manufacturing new products (Gonzenbach and Coad, 2007).

The average solid waste recycling rate in the world cities is 29% (UN Habitat, 2010). For most developing countries recycling is not formally done by the council or landfill operators but it is done by informal recyclers or pickers and scavengers (Idris *et al.*, 2004). It has been suggested by UN Habitat (2010) that recycling sector could save a city of its municipal solid waste management budget by 20% or more. Recycling can be taken as a business where organizations extract valuable assets through refuse processing. In addition, waste is considered a source of income for scavengers. Recently, waste is considered an important replacement source for other sources of energy and material (UNEP, 2011).

Recyclable and residual solid waste must be separated at source for easy recycling thus reducing the waste that will reach the landfill. Residual waste is waste that could not be reused, recycled and any other form of processing. Recycling requires that specific materials be sorted. Recycling can reduce by 30% the waste stream that could be collected and deposited in landfills (United States Army, 1994). Organic waste must be removed from the waste that enters landfills and must be composted (Wang and Nie, 2001; Rada *et al.*, 2009).

2.3.7. Solid Waste Disposal

The status of solid waste management in most developing countries is a threat to both the environment and human life (Mwai *et al*., 2008). Major issues to deal with, disposal and dumpsites remain unsolved in major cities (Magalang, 2003). Though sanitary landfill or an engineered landfill is the most common technology around the world, the conventional and environmentally unfriendly methods, including open-burning, open-dumping and non-sanitary landfill are still evidenced. However, in most countries these are officially banned allowing only sanitary landfill for final disposal. The technologies may also vary in accordance with the type of final disposable waste, for example, some landfills may be used for co-disposal of special wastes. The landfills for hazardous wastes could be more complicated and are known as "secure landfill." The location of landfill, is also an important factor considering the transportation costs and its impacts on the urban environment (UNEP, 2009).

The collected waste should be processed and deposited in sanitary landfills and incinerators. It is a requirement for many governments to deposit waste in sanitary landfills or incinerators. The minimum requirements for a sanitary landfill are that it should not pollute underground and surface water and any landfill that pollutes surface and ground water is considered as an open dump site (United States Army, 1994). The landfill should also reduce odors and blowing of refuse. When designing landfills it is required to know the characteristics of waste. Different types of waste might require different landfills such as hazardous and non hazardous landfills. The equipment required for construction and operation of landfills is front end loader, track loader and dragline. Steel wheeled compactor with a landfill blade is more preferred to spread and compact the landfills whereas the loaders, dozers and compactors are best suited for preparing the landfill base and drainage layers (United States Army, 1994).

In Zimbabwe, the Environmental Management Agency (EMA) regulates the sanitary disposal of waste using the criterion in Table 2.1. The criterion rate the extent of sanitary disposal of waste using colours.

Table 2.1: Criteria for classifying landfills in Zimbabwe. Source: Government of Zimbabwe (2007).

Classification	*Risk*	*Criteria*
Blue	Safe	Impermeable substrate, leachate controlled and treated and surface sealed
Green	Low environmental risk	Low risk contamination, remote site with limited effects
Yellow	Medium environmental risk	Base permeable, open dump, leachate meets yellow standards. The conditions for Green not meet
Red	High environmental risk	No protection, permeable substrate, leachate not controlled, hazardous solid waste, ground water contaminated. Landfills that fail to meet the Yellow criterion

The ideal sanitary landfill is rated as blue. Here the sanitary or engineered landfill is measured on the basis of impermeable substrate underneath the refuse. The refuse should be compacted and covered, leachate controlled and treated. The criterion in Table 2.1 does not specify the frequency of compacting and covering the landfill as was done on the minimum requirements of the sanitary landfill in United States which specify the frequency of one day. The criterion does not have anything about underground wells which are important for ground water monitoring around the landfill.

Residents usually use unsustainable practices as a way of disposing waste when the council failed to collect waste; 60% of the residents resort to illegal dumping and 20% of the residents resorted to burning of refuse when the council failed to collect refuse (Masocha, 2004). Burning is not allowed as it causes further environmental pollution. Burying and composting is practiced but to a lesser extend as they both constitute a total of 20% (Masocha, 2004). These are however more environmental friendly measures of waste management. Bartone (2000) argued that to improve solid waste management, there is need to enforce laws against illegal dumping and most urban areas in the developing world use the crude dumping system to dispose of their solid waste. This is whereby waste is tipped into a dump, which has very little on-site management.

Musademba *et al* (2011) argued that failure by the town councils to collect waste has resulted in the community adopting some practices which are not environmentally friendly. In Chinhoyi, Musademba *et al.* (2011) survey reports that 31.5 % of the households resort to burning, 31.9% resort to burying or open pit, 30.1% resort to illegal dumping and 6.5% of the community resort to composting. Open waste dumps are prime breeding sites for houseflies, rodents, mosquitoes, and other vectors of communicable diseases, such as fever, dysentery, diarrhoea, cholera and malaria (Musademba *et al*., 2011). Illegal dumping is a criminal offence which can attract a fine from the Environmental Management Authority but residents dump their refuse at night.

The increase of refuse dumps in Gweru city in Zimbabwe is due to non-collection of waste by the urban council. Factors such as lack of financial resources, human resources, refuse equipment and poor environmental awareness among members of the public have contributed a lot to poor solid waste management (Mangizvo, 2010a). Members of the public have worsened the situation by having very little concern for the environment and dumping their solid waste indiscriminately. Mangizvo (2010a) suggested that the situation in Gweru city centre is a potential health hazard if no action was taken to address it. He also concluded that stakeholders in Gweru city council need to play their part in an integrated approach to solid waste management so that the city could be a pleasing place with clean and functional water ways (Mangizvo, 2010a).

2.3.8. Ground Water Pollution

Studies have shown that solid waste disposal on land can negatively impact on both surface and ground water resources. Leachate from dump sites and unlined landfills is the main potential source of pollution from solid waste disposal that needs to be managed (Oelofse, 2008). Since ground water is an alternative source to augment water supply in Zimbabwe, it is good to preserve it through sound solid waste management. Studies have revealed that soil is contaminated by being in contact with solid waste and leachate. For instance, a study of the dumpsite in Kariba in Zimbabwe, metal concentrations were determined in soil samples collected from the area during 1996 and 1997. Accumulation of copper (Cu), lead (Pb), iron (Fe), and zinc (Zn) were found within the disposal site. The concentration of Zn, Pb, and Cu were found in surface soil samples up to 75 meters away from the disposal site (Chifamba, 2007). The author also showed that water samples taken from the vicinity of the dumpsite had a high concentration of mercury (Hg) and lead (Pb)

2.4. Institutions Involved in Solid Waste Management in Zimbabwe

2.4.1. Responsibility of Solid Waste Management Service Providers

Solid waste is managed by urban councils in Zimbabwe. The urban councils have the sole purpose of managing waste recycling, minimization, collection, disposal and planning. The responsibility of Zimbabwean urban councils is the same as those in South Africa. Urban councils in South Africa has the duty to clean the streets, waste minimization, waste collection, transportation, disposal and planning (DEAT, 2007). Urban councils in Zimbabwe may contract individuals to collect waste and perform landfill operations. Environmental Management Agency and Ministry of Health is there to monitor and regulate urban councils in terms of SWM.

2.5. Legislation Governing Solid Waste

The state of solid wastes in most of the developing countries is a major threat to both human and environmental resources. One of the reasons why there is little progress being made is a lack of clear objectives, coupled with a lack of information and of a strong analytical base in which various policies and strategies can be formulated or aligned during the decision making processes (Mwai *et al*., 2008). Therefore, protecting the water resources from the negative impacts of solid waste requires more than just good policies, strategies and guidelines but sound solid waste management in line with international trends (Oelofse, 2008).

2.5.1. Environmental Management Act (EMA) of 2002 in Zimbabwe

Section 69 of the Environmental Management Act (2002) states that no person or group of individuals is allowed to dispose waste that will pollute the environment or affect the health of people (Government of Zimbabwe, 2002). In addition, this law on Section 36 also states that every user would take necessary measures to reduce waste through waste minimization, reuse and deposit inert waste in engineered landfills. Although, the issue of recycling and reuse was mentioned, section 36 did not specify things that need to be carried out to recycle waste and specific programs that need to be taken. It seems that waste minimization is not followed in Zimbabwe as witnessed by few public campaigns on waste minimisation, strategies for separation of waste and involving users in the management of waste.

Section 83 of the EMA (2002) also states that illegal dumping in roads, water, streets, land or at any place is not allowed, but to dispose in designated places or containers that are provided for that purpose. In addition, the same Section clearly states that the owner of the vehicle, ship or an airplane is required to make sure that no passengers are allowed to throw waste to the environment. Furthermore, Section 83 also states that all people or local authorities responsible for a certain area or premise must provide receptacles or designated sites for waste storage (Government of Zimbabwe, 2007).When analysing this law in line with the prevailing situation of waste on roads and pathways, it is enough evidence that these laws, though good are not implemented or not enforced. It is also not clear on who is responsible for providing receptacles as the law gave the responsibility for both the local authority and customers.

Section 180 of EMA (2002) Chapter 20:27 assigns the Agency to set regulations and standards regarding the activities which have influence on the environment. Thus the Environmental Management (Effluent and Solid Waste Disposal) Statutory Instrument Number 6 of the year 2007 enforces every generator of waste except households to develop a waste management plan by the end of each year and it is an offense for the waste generator to fail to produce the plan. Likewise, Statutory Instrument 10 of 2007 enforces that each year the generator of hazardous waste should also develop a waste management plan which should include an inventory of hazardous (quantity and composition), goals for reducing waste and its adverse effects on the environment. This act is very important in the management of solid waste as it provides data on waste inventory and the plan for sound solid waste management. However, the regulation did not emphasise the involvement of stakeholders in the formulation of the waste management plan.

Section 14 of Statutory Instrument 6 states that every local authority shall designate suitable sites as waste disposal sites and waste shall be collected at a collection frequency that do not favour decomposition of waste (Mangizvo, 2010a). The same regulation also states that the local authority or the owner of the premises shall ensure that there are adequate receptacles to receive litter or refuse until the collection time elapsed (Government of Zimbabwe, 2007; Mangizvo, 2010a). Environmental Management

(Plastic Packaging and Plastic bottles Regulation) Statutory Instrument 98 of 2010 highlighted the need to reduce plastic by encouraging the use of biodegradable plastic and sets the minimum requirements of plastics. The above regulations helps to maintain a town in a clean environment as the waste generators would be having enough receptacles to store waste. In addition the local authorities are regulated to collect waste at an ideal frequency which was left to be determined by local authorities and health inspectors. The regulation on plastics is very important in the reduction of waste as plastics constitute a significant amount of municipal solid waste.

2.5.2. Public Health Act of 1996.

Section 83 of the Public Health Act of Zimbabwe (1996) states that it shall be the duty of every local authority to take all lawful, necessary, and reasonably practical measures for maintaining its district, in a clean and sanitary condition by preventing the accumulation of waste, which may be injurious or dangerous to health (Government of Zimbabwe, 1996). This law is also in line with the EMA Act of 2002 although the Act did not give the details of how the council, waste generators and residents must do to achieve a heathy environment. For local authorities to achieve a healthy environment it should provide receptacles, collect refuse and dispose it in engineered landfills.

2.5.3. Bye Laws for Urban Councils

Most urban councils in Zimbabwe have bye laws that govern sold waste in their area of jurisdiction, for example the bye laws of the Gweru City of 1982 govern the collection and disposal of wastes in the city. It states that it is the responsibility of the owner to maintain the premise free from solid wastes, such as debris, disused motor vehicles, filth, glass, paper, rags, rubbish, rubble, and anything regarded as a nuisance (Gweru City Council, 1982). The premises should be kept clean to prevent the breeding of bed bugs, cockroaches, flies, rodents, or any other germ (Mangizvo, 2010a). However, urban councils do not have management regulations to support the minimization, recycling and involving stakeholders in managing waste.

2.5.4. Staffing or Human Resources

Adequate staff is essential in the day to day management of waste. The number of required staff is determined by the number of households. The optimum number of staff required for proper management of solid waste, expressed as the Household to Total Refuse staff ratio should be between 150 to 200 (Henderson, 2005; DEAT, 2007). Similar studies in South Africa urban councils by DEAT (2007) revealed that the average Household to Staff ratio is 273. Henderson (2005) also suggested that the level of qualified personnel plays an important role in the success of the solid waste management system. The same author suggested that the international staff break down is 10% for top management, 25% for middle management and 75% for labourers. Due to economic meltdown in Zimbabwe the employment rate has gone down across Zimbabwe and this could have affected the human resources that work in solid waste management.

Management of solid waste requires health officers who plan, schedule and supervise the collection of solid waste. Engineers are necessary in the design of engineered landfills, selection of landfill equipment and refuse collection vehicles. Health officers and engineers are important in supervising collection and treatment of leachate. Dump attendant is important in keeping records of waste that enters the landfill. Health supervisors play a key role in supervising refuse collectors, street sweepers and drivers. Health supervisors may also monitor the cleanliness of the living and working areas Accountants and accounts clerks are important in doing the accounts of solid waste management. A human resources officer is required for solid waste management personnel.

2.6. Performance Assessment and Benchmarking of Solid Waste Management

Several authors have pointed out that the performance assessment of local authorities and public organizations service delivery is becoming an issue of increasing importance in many countries as a first step towards benchmarking (Coe, 1999; Karagiannidis *et al*., 2004). When assessing the performance of the collection systems, it is important to integrate effectiveness and efficiency of the system as was done in many recent projects in the USA and in Europe (Worthington and Dollery, 2000; Accounts Commission, 2000). This is also in agreement with Karagiannidis *et al* (2004) who suggested that best service performance, economically, technically, operationally, etc would result in an environmentally friendly management by satisfying various legislative and sound solid waste management practices such as recycling, composting, reuse and recovery.

Private and public organizations are increasingly adopting the benchmarking process so as to measure their own performance, evaluate their investments and to rate themselves on the local or global market (Ammons, 1999; Coe, 1999; Karagiannidis *et al.*, 2004). The effectiveness and efficiency of waste services depend on a variety of parameters such as coverage of household with kerbside collection and sanitary disposal of municipal solid waste. Benchmarking seek to quantify the above parameters in order to determine their necessary combination for optimum results and also to identify whether urban councils are making progress or not in solid waste management. Therefore, benchmarking is a means of optimizing waste services operation and administration by encouraging local authorities to set targets and to employ efficient and best practices (Karagiannidis *et al*., 2004). It is upon this basis that Zimbabwean local authorities must be assessed, so that poor performing urban councils could learn from better performing ones. Ammons (1999) opined that benchmarking is a point of reference where local authorities can measure the performance gap between where they are now and where they want to be in future, and could be used to track their progress in closing that gap.

Some authors agreed that there are two types of benchmarking, that is metric and process benchmarking (Kingdom *et al*., 1996; Marques *et al.*, 2010). Metric benchmarking is a process in which organizations assess their own performance progressively or continuously over the years and compare their performance with other organizations offering the same services, generally through the use of performance indicators. Process benchmarking is a process in which an organization identifies the activities and operations that need to be improved sequentially, that leads to a superior level. In summary, metric benchmarking mainly involves what needs to be improved whereas process benchmarking seek to answer the question of how to improve it (Kingdom *et al*., 1996; Marques *et al*., 2010). Given the Zimbabwean scenario, it would be appropriate to implement benchmarking in stages. The first stage would be to start with metric benchmarking before taking process benchmarking because the processes that need to be improved would only be identified after comparing local authorities.

The performance monitoring of waste services, exchanging experiences of all sorts and using performance indicators in assessment was first stressed by the Aalborg Charter of 1994 (Bolli and Emtairah, 2001). The Aalborg Charter was signed in Aalborg Denmark by European participants in the conference on sustainable cities and towns. In Zimbabwe the measurement of performance could be used to rate the performance of members of staff, efficient use of resources and for comparison with different peers so as to copy best practices. There are many important benefits of the performance assessment of urban councils both for the community and the waste service provider. Some of these important benefits among other things include; effective monitoring of operations, better cooperation between municipalities and enhanced elaboration of alternative solutions (European Environmental Bureau, 2002). Several authors have pointed out that the purpose of benchmarking is to provide essential tools for tracking environmental progress, supporting policy evaluation and informing the public (OECD, 2003; EEA, 2005; Desmond, 2006). In addition, service providers and users need to know their level of performance in order to aim for a higher level using best practices.

2.6.1. Performance Indicators

Indicators are key statistics that summarize a particular issue (EPA, 2002). A study by Mwai *et al.* (2008) for integrating Millennium Development Goals (MDGs) in the formulation of strategies for Solid Waste Management (SWM) concludes that there is need to protect human life, reduce cost, reduce poverty and enhance environmental protection. Due to the multiplicity and complex nature of the above objectives, Mwai *et al.* (2008) used performance indicators to model possible SWM options that could be used to meet the above objectives. The same author quantified indicators through a life cycle analytical procedure which covered the environmental, the economic and the social aspects of solid wastes. It is also recognized internationally that for waste management to be sustainable, there is need to set objectives or benchmarks and the measurement of progress towards them might be determined through the use of performance indicators (OECD, 2003; UNSED, 2005; Desmond, 2006; EEA, 2003).

The main function of performance indicators is to reflect trends in the state of solid waste management at both local and regional level. Assessment indicators can also be used to monitor progress made in realizing set policy targets and to enable managers in municipal councils to evaluate their work, investments and the effects of their policies (Karagiannidis *et al*., 2004). In addition, assessment indicators are also used to simplify the complexity in solid waste management into data that is understood locally and globally when measuring efficiency and effectiveness of the system (Smeets and Wetering, 1999; United Nations' Division for Sustainable Development, 1999).

According to Jerie (2006) there are many indicators used to measure efficiency and effectiveness of the solid waste management system such as number of households covered in the service area, frequency of collection of solid waste, efficiency in collection of solid waste and amount of time spend in collecting the waste. Jerie (2006) should have included some other vital indicators such as extent of waste recovery and extent of disposal of waste in sanitary landfill which are equally important when evaluating the SWM system. The author might have assumed that the waste service companies were disposing waste in engineered landfills and recycling waste efficiently.

Frequency of collection of solid waste is the amount of time between the collection intervals or time spends by the refuse truck when collecting refuse in the service area to come back to the same point and is usually expressed in days. The frequency of collection is an important indicator in the analysis of the solid waste management system in that a high time interval between collections would result in consumers dumping illegally or burning the refuse. Solid waste must be collected at a rate that does not favour the decomposition of waste. The decomposition of waste depends on the temperature and the types of waste generated and varies from country to country (Jerie, 2006).The time interval of collection might also result in the health implications, such as breeding of flies, mosquitoes etc. Health experts agreed that a collection frequency of at least once a week is ideal for good health reasons (Jerie, 2006). Karagiannidis *et al.* (2004) suggested that refuse collection heavily depends on the frequency of collection. It is therefore important that roads be in good shape and that the distance from the service area to the landfill be minimal so as to reduce the transportation time hence the number of properties covered per unit time.

Solid waste collection efficiency is the quantity of solid waste collected over the solid waste generated. This is a very important indicator in the assessment of the solid waste management system. This indicator seeks to answer the question of whether urban councils are collecting all the refuse which is generated (Jerie, 2006; MUDGI, 2008; Chaurasia, 2011). All the waste generated should be collected for the purposes of recycling, composting, energy recovery and disposal so as to maintain a health free and safe environment. For health reasons all the waste should be collected that is the collection efficiency should be 100%. The average solid waste collection efficiency of the 17 world cities is 89% as shown in Fig 2.2 (UN Habitat, 2010).

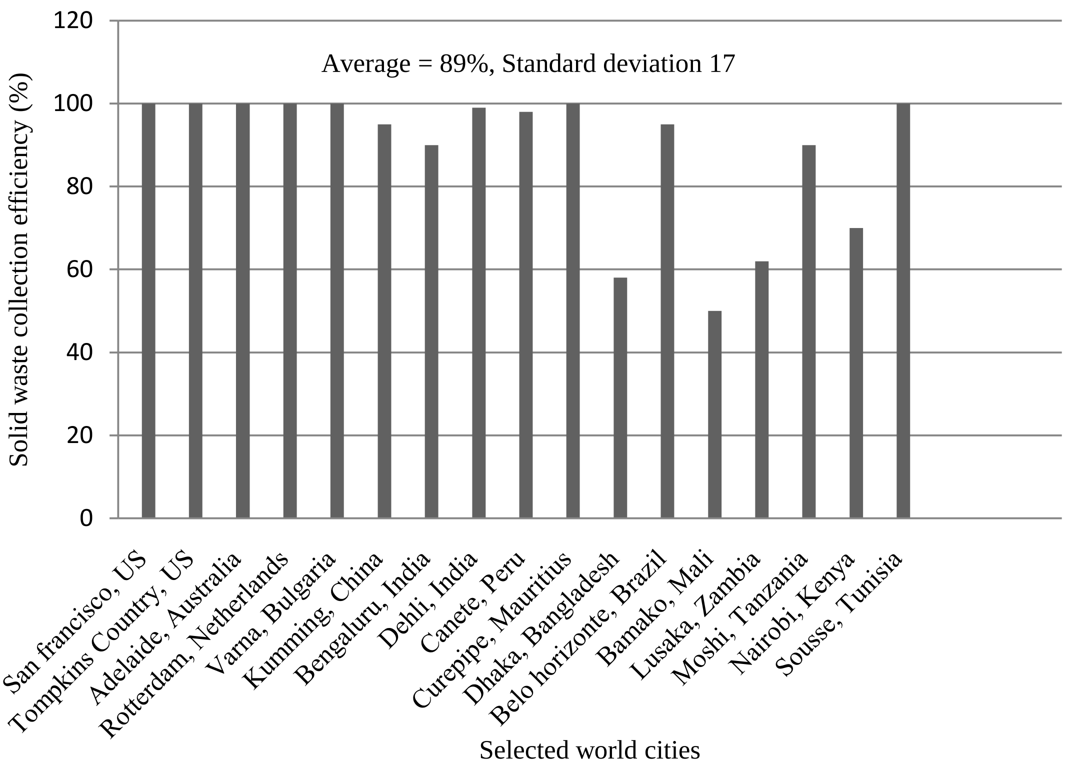

Figure 2.2: Refuse collection efficiency for 20 selected world cities. Source: UN Habitat (2010)

When evaluating the performance of the SWM system it is important to measure the financial sustainability of the system. Efficiency in cost recovery is used to measure the financial sustainability of the SWM system and is defined as the ability of the organization to recover its cost from user charges. The charges should be set on the basis of full cost recovery (UN Habitat, 2010). The tariff structure should also cater for the poor through cross subsidies. When running any business, it is very important to know the costs and to prepare the budgets before carrying out the business (UN Habitat, 2010). The table below shows the tariff structure of the selected world cities.

Table 2.2: Tariff structure of 11 selected world cities in US$ for SWM. Source: UN Habitat (2010)

City	*Adelaide, Australia*	*Belo Horizonte, Brazil*	*Rotterdam, Netherlands*	*San Francisco, US*	*Tompkins, US*	*Varna, Bulgaria*	*Delhi, India*	*Dhaka, India*	*Lusaka, Zambia*	*Moshi, Tanzania*	*Nairobi, Kenya*	*Average*
Monthly fee (US$)	8	6	33	22	15	8	0.8	1	18.80	1	0.20	8

The mean of the world cities is US$ 8.00 per month and ranges from US$ 0.25 to US$ 33. The tariffs are very high for developed countries and low for developing countries.

The high figure of the refuse charge for Lusaka does not tally with refuse collection efficiency as is the case with developed countries. The low tariffs for the developing countries might be that developing countries are not operating on full cost recovery and investing in other subsystems of solid waste management such as landfills, recycling and processing.

The cost of refuse collection, increased transportation costs for the amount of refuse collected and high cost recovery indicates that a council might not be using best practices in the service area (Karagiannidis *et al.*, 2004). However, this definition does not specify how to deal with debts as most users in developing countries face challenges in paying refuse charges. Therefore, the SWM system might have a good cost recovery but a poor collection in collecting revenues. Thus, integrating revenue collection efficiency with the efficiency in cost recovery would be more appropriate in developing countries (MUDGI, 2008; Chaurasia, 2011).

The viability of any business enterprise depends on the collection efficiency of solid waste related charges. Collection efficiency of solid waste related charges can be defined as the amount of money collected during a given year over the charges or the amount billed during that year. The international benchmark is 100% which implies that the organization is expected to receive the entire amount it has billed (MUDGI, 2008; Chaurasia, 2011). However, a lower value reflects that either the charges are too high and consumers do not afford to pay or unwillingness to pay by customers.

2.6.2. Performance Assessment of Solid Waste Worldwide

The performance of world cities was measured using performance indicators which are waste collection coverage, extent of recovery of solid waste, user inclusivity and financial sustainability. Extent of recovery of MSW is defined as the quantity of solid waste recovered or recycled over the total solid waste generated, User inclusivity is defined as the number of households who are involved in the planning and management of waste over the total number of households in the city, Financial sustainability is defined as the number of households who receive and pay for solid waste collection services over the total number of households in the city (UN Habitat, 2010).

Table 2.3 below shows the table of the performance assessment of the world cities. The study was carried out by UN Habitat (2010) using four indicators in order to fill the gap of information for comparative purposes. Table 2.3 shows that developed countries are advanced in the management of waste, where as developing countries still manage solid waste unsustainably. In addition developing countries are still performing badly in recycling waste.

Table 2.3: The performance in terms of solid waste management of 11 selected world cities (%). Source: UN Habitat (2010)

Indicator\City	*Adelaide, South Australia*	*Rotterdam Netherlands*	*Minas Gerais, Brazil*	*Canete, Peru*	*Bengaluru, India*	*Kunming, China*	*Bamako, Mali, Africa*	*Caperipipe Coast Africa*	*Lusaka, Zambia*	*Moshi, Tanzania*	*Nairibi, Kenya*	*Average values*
Collection and sweeping coverage (%)	100	100	95	75	70	100	58	100	45	61	65	86
Extent of recovery of waste (%)	50	30	11	12	29	0	0	0	6	19	23	16
User inclusivity (%)	80	100	80	60	20	60	60	60	40	40	60	60
Financial sustainability (%)	100	100	85	40	40	50	90	50	100	30	18	64

Generally, developing countries are still far in achieving the MDGs. The average of performance of the cities worldwide is as follows; refuse collection and sweeping coverage is 86%, extent of recovery of waste is 16%, user inclusivity is 60% and financial sustainability is 64%. In addition most developing countries where falling below the average of refuse collection coverage and financial sustainability.

2.6.3. Benchmarks for Solid Waste Management

The process of performance assessment of solid waste management services brought about benchmarks. For example Table 2.4 shows the indicators that are used by 12 selected world cities. The benchmarks have clear objectives and resources of how to achieve them. This is good in that it sets any solid waste management system in the direction of meeting targets and thus sustainability.

Table 2.4: Benchmarks and Indicators of the 12 selected World Cities as a percentage. Source: GUDGI (2008); UN Habitat (2010)

Town, Country	*Waste collection coverage (%)*	*Scientific disposal of waste(%)*	*Extent of recycling (%)*
Adelaide, South Australia, Australia	100	NA	54
Belo Horizonte, Brazil, South America	95	100	NA
Canete, Peru, South America	90	80	NA
Kunming, China, Asia	100	100	NA
India, Asia	100	100	80
San Francisco, US, North America	100	100	NA
Varna, Bulgaria, Europe	100	NA	27
Tompkins, US, North America	100	100	61
Rotterdam, Netherlands, Europe	100	100	28
Moshi, Tanzania, East Africa	100	100	NA
Sousse, Tunisia, North Africa	100	100	2
Bamako, Mali, West Africa	NA	NA	25
Average	98	100	40

Note NA = Not Applicable

The average set benchmarks for the 12 world cities was; collection coverage 98%, scientific disposal of wastes 100% and extent of recycling 40%. Although the average benchmark for collection coverage was 98%, it should be 100%, that is, all people must receive basic refuse collection services. In addition most developed countries were able to reach 100% as shown in Table 2.4.

2.7. Solid Waste on the United Nations Agenda

Agenda 21 of the United nations states the need for reducing health risks from environmental pollution and hazards under the section on protecting and promoting human health (UNSD, 1992). The main objective of Agenda 21 was to encourage development to proceed without harming or endangering the health of the people and the environment. The specific objectives were that each country should develop national programs for dealing with waste minimization at source and disposal by the year 2000 (UNSD, 1992). The above objectives are yet to be achieved in most developing countries and this is because the ability of countries to tackle pollution and health problems is greatly restrained because of lack of resources among other factors (UNSD, 1992 ; Mangizvo, 2010b). In addition countries should develop appropriate solid waste disposal technologies on the basis of health risk assessment. This implies that environmental impact assessment should be carried out before a landfill is constructed. The ideal site should not be too close to the water course and the land must be impermeable to reduce the flow of leachate. This can be thus addressed through developing appropriate solid waste disposal capacities in towns and large cities (UNSD, 1992).

2.8. Millennium Development Goals and Solid Waste Management

The Millennium declaration was ratified by 189 heads of state in 2000 at the United Nations Millennium Summit. At this summit MDGs were agreed to reduce poverty, improve health and lives. The targets in the goals were set for 2015 using 1990 as a base year. Although the MDGs did not specify solid waste directly, sound solid waste management can produce significant progress towards the attainment of the MDGs (Gonzenbach and Coad, 2007).

Solid waste management plays a vital role in attainment of the MDG 1 of reducing poverty and eradication of poverty. Many employment opportunities are found in solid waste collection, recycling and processing SWM systems. In many areas refuse work is labour intensive because of a deliberate policy to favour employment creation (Gonzenbach and Coad, 2007). Recycling by informal waste pickers is a good move in improving the lives of the urban poor, thus moving towards achieving MDG 1 of eradicating extreme poverty and hunger (Rodic *et al.*, 2010). In addition Solid waste management provides many opportunities for employment in street sweeping. In low to middle income countries, significant proportions of the urban populations are involved in recycling, reuse and material recovery (UN Habitat, 2010). The production of compost from organic waste is a particular example. If excluded from such work, tens of thousands in many of the world's largest cities would have no income and no means of supporting their families (Gonzenbach and Coad, 2007). Therefore solid waste management has a vital role in fulfilling Target 1 under MDG 1 of halving the proportion of people whose income is less than a dollar by 2015 and Target 2 under MDG 1 of reducing by half the people who suffer from hunger. This is also in agreement with UNEP (2011) who pointed out that municipalities have realized that waste contains valuable resources, which can be recovered as materials for recycling, as a resource to generate energy and as an alternative for fossil fuels (UNEP, 2011).

Cholera and diarrhoea related diseases are some of the major killers of children under five years in developing countries (Gonzenbach and Coad, 2007; UN Habitat, 2010). Rotting garbage is implicated in the spread of diarrhoea because houseflies breed in improperly managed solid waste and if the piles of refuse are so close to the houses, houseflies carry microbes from waste to food. Burning solid waste causes the emission of toxic substances to the air such as dioxins and furars which cause respiratory diseases (UN Habitat, 2010). Sound solid waste management involves the storage of refuse in acceptable bins and collecting the refuse at a frequency of at least once a week. The collected refuse must be disposed of in an engineered landfill and thereby minimizing the number of house flies which in turn reduces the spread of diarrhoea to young children who live near disposal landfills (Gonzenbach and Coad, 2007). Hence solid waste management plays an important role of fulfilling Target 5 of MDG 4 which seeks to reduce child mortality. However Target 5 of MDG 4 is yet to be achieved as most developing countries are still facing serious challenges in the management of waste.

Without sound SWM, it is difficult to achieve Target 5 of MDG 4 which seeks to reduce two thirds of under five mortality rate by 2015. Solid waste, if improperly managed can pollute the water in drains which might then endanger the lives of children who swim in the shallow ditches. Reuse the containers from the dumps by children and indiscriminate waste dumping are other ways in which gastro-intestinal related diseases are transmitted. The municipalities must move from open dump sites into proper engineered landfills. (Gonzenbach and Coad, 2007).

Sound solid waste management prevents the spread of malaria and bilhazia (Mangizvo, 2010a). Malaria is transmitted by the *Anopheles* mosquito and *Aedes aegypti* mosquito (Gonzenbach and Coad, 2007). These mosquitoes breed in stagnant rainwater that collects in discarded containers, tyres, shells etc on the refuse piles. If these items are disposed of around houses or on waste disposal sites they should be covered so that they don't harvest rainwater. *Filariasis* is spread by another type of mosquito which breeds in polluted stagnant water. Dumping wastes in drains and sweeping waste into drains cause blockages which resulted in stagnant water which is an ideal breeding ground for mosquitoes. The best way to reduce breeding or breaking the life cycle of mosquitoes is to prevent rainwater from collecting in the shells, containers and blocked drains. That is all conditions that favour the accumulation of stagnant water must be eradicated through good solid waste management (Gonzenbach and Coad, 2007). Therefore, sound solid waste management is vital in achieving target 7 of MDG 6 which seeks to reduce the spread of HIV or Aids, Malaria and other diseases by 2015 and reverse the incidence of malaria and other major diseases.

2.9. An Integrated Approach to Solid Waste Management

The Rio Declaration on Sustainable Development UNCED (1992) defined sustainable waste management as the implementation of the integrated life cycle management concept in waste management. Tammemagi (1999) suggested that sustainable waste management must not only consider scientific disposal of solid waste and leachate but must include protecting health, environment and reducing the burden on natural recourses and the lives of future generations. Chung and Lo (2003)) argued that for sustainable waste management, economic considerations needed to achieve sustainability must be factored in. This was later elaborated by the United Nations (2005) that environmentally friendly waste management must not only consider scientific disposal or recycling of wastes that are generated but should address the cause of high waste generation rates by attempting to manage unsustainable ways of production and consumption. Integrated Solid Waste Management based on the "Reduce, Reuse and Recycle" (3R) approach aims at the efficient management of solid waste from all waste generating sectors (municipal, demolition, industrial, urban agriculture and healthcare facilities) and involving all stakeholders (waste generators, service providers, regulators, government and community) (UNEP, 2011).

In many developing countries, the approach to refuse management has been rather convectional, concentrating on certain aspects of waste management, such as collection, transportation and disposal (UNEP, 2011). Conventional systems are failing to cope with increased waste generation rates and new waste streams. Many solid waste management systems in developing countries are not practicing the 3R principles and awareness for potential resource recovery in solid waste and use of waste as a resource has been very low. Therefore, there is a need to adopt the 3R principle, in such a way that they can effectively and efficiently manage high waste generation rates with diversified waste streams. A strategy for Integrated Solid Waste Management should have the 3R principles that encourage resource efficiency and toxic free materials cycle (DEAT, 2007; UNEP, 2011).

2.9.1. Public Campaigns and Stake Holder Participation

Municipal solid waste issues have an impact on millions of families, and hence, public participation and support are of vital importance to solid waste management (Wang and Nie, 2001). The authors also suggested that televisions, radios, newspapers and other public media must be used for public campaigns and advertising solid waste management programs. Public campaigns and stakeholder participation important if followed. It seems that the campaigns on the radios and at community level on solid waste management are not well known in Zimbabwe.

Stakeholder participation is becoming an essential part of SWM. Major stakeholders include waste generators, regulators, service providers such as organizations involved in waste collection and disposal, and organizations involved in recycling and recovery. Each stakeholder has a specific, clear and active role to improve the efficacy and efficiency of SWM by active participation and continuous interaction. Waste generators, traditionally considered as passive partners have a major responsibility to reduce, segregate, and properly discard the waste as per the regulations (Mwai *et al.,* 2008; UNEP, 2009; UN

Habitat, 2010). If there are no regulations companies would dispose waste illegally and not separate waste as there are expenditures involved in such operations.

A close cooperation would be required between waste generators and waste collectors to increase the coverage and effectiveness of the waste collection system, proper disposal of waste, recycling and recovery of materials. Furthermore, with rapid changes in the quantity and composition of solid waste, regulatory organizations or governments have to be in continuous dialogue with the stakeholders to introduce appropriate regulations which can help bring the required improvements in the SWM system (UNEP, 2009). For example Mangizvo (2010) suggested that there should be public awareness, educational campaigns and tmass media to improve the situation of solid waste management in Gweru, Zimbabwe. In addition, the author concluded that the society must recognize and accept the fact that littering is unacceptable. Littering should be forbidden through public education.

2.9.2. Waste Inventory

Waste inventory is a principle of integrated SWM. Whereby a complete waste inventory all waste streams in a given municipal area should be assessed. This exercise must include the source of generation, quantification and classification of different types of wastes for household, commercial, industrial, agricultural, and hazardous wastes. The hazardous wastes will include medical wastes and e-wastes. It is expected that different stakeholders should develop their waste inventories so that a database might be readily available (UNEP, 2011). It is important that each local authority in Zimbabwe has its own database of the quantity and types of waste streams for easy planning and management of solid waste.

3. MATERIALS AND METHODS

3.1. Description of Study Area

3.1.1. Location and Climate of Zimbabwe

Zimbabwe is a landlocked country located in the Southern Africa region, lying between latitude*s* 15° and 23° South, and Longitudes 25° and 34° East. The climate is tropical and consists of high temperatures in summer and low temperature in winter as shown in Table 3.2. The rain season normally starts from early November to late March. High temperatures in the rainy season have a bearing on the rate of decomposition of the solid waste. Table 3.2 shows the mean lowest and highest annual temperature range and the mean annual rainfall for Zimbabwe.

Table 3.1: Mean temperature and mean annual rainfall of Zimbabwe. Source: Mazvimavi (1998); Nhapi *et al.*(2010)

Season	*Altitude (m)*	*Temperature (ºc)*	*Mean annual rainfall (mm/yr)*
Low veld	162 to 600	9.4 to 33.7	344 to 600
Middle veld	600 to 1200	5.5 to 30.7	600 to 700
High veld	1200 to 1800	5.0 to 27.5	700 to 1200
Eastern Highlands	1800>	5.0 to 22.	1200 to 2000

3.1.2. Classification of Urban Councils in Zimbabwe

There are 32 urban areas in Zimbabwe and their locations on the map of Zimbabwe are as shown in Figure 3.1. There are ten provinces and the province in which each urban area is located is also provided. Section 29 of the Urban Council Act of 2013 was used to classify urban councils into cities, municipalities, urban councils and local boards. The Urban Councils Act establishes municipalities, town councils, local government areas, and local boards in Zimbabwe. The Act provides for the powers and functions of all urban councils as well as the establishment and functions of the Local Government Board. The urban councils were grouped into seven cities, eight municipalities, 11 urban councils and five local boards using a combination of population size and the level of economic development (Government of Zimbabwe, 2013a).

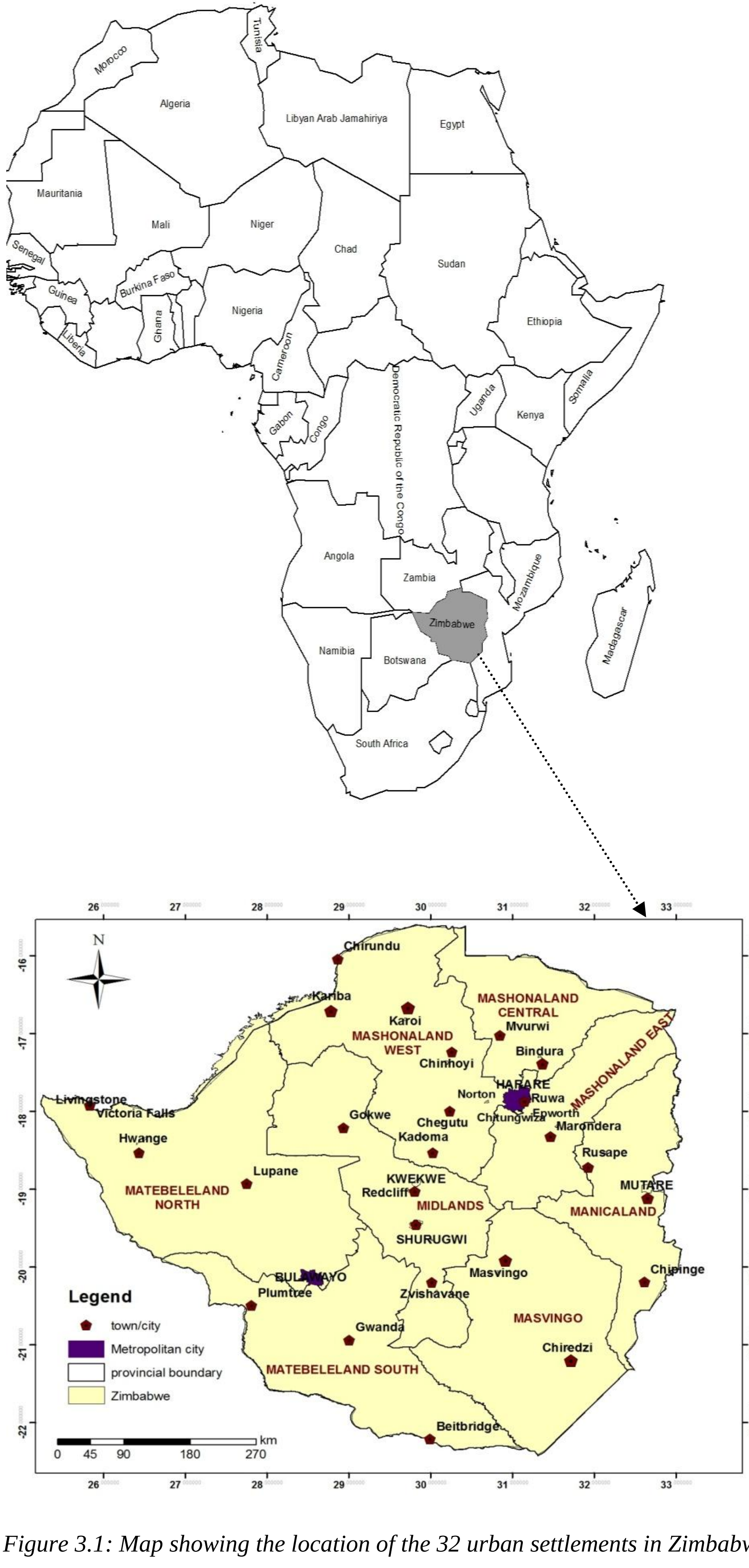

Figure 3.1: Map showing the location of the 32 urban settlements in Zimbabwe

In this study the size of the urban council was based on population only because the quantity of solid waste generated depends on the population of the town. Therefore, the urban councils were arranged according to the population size as shown in Fig 3.2.

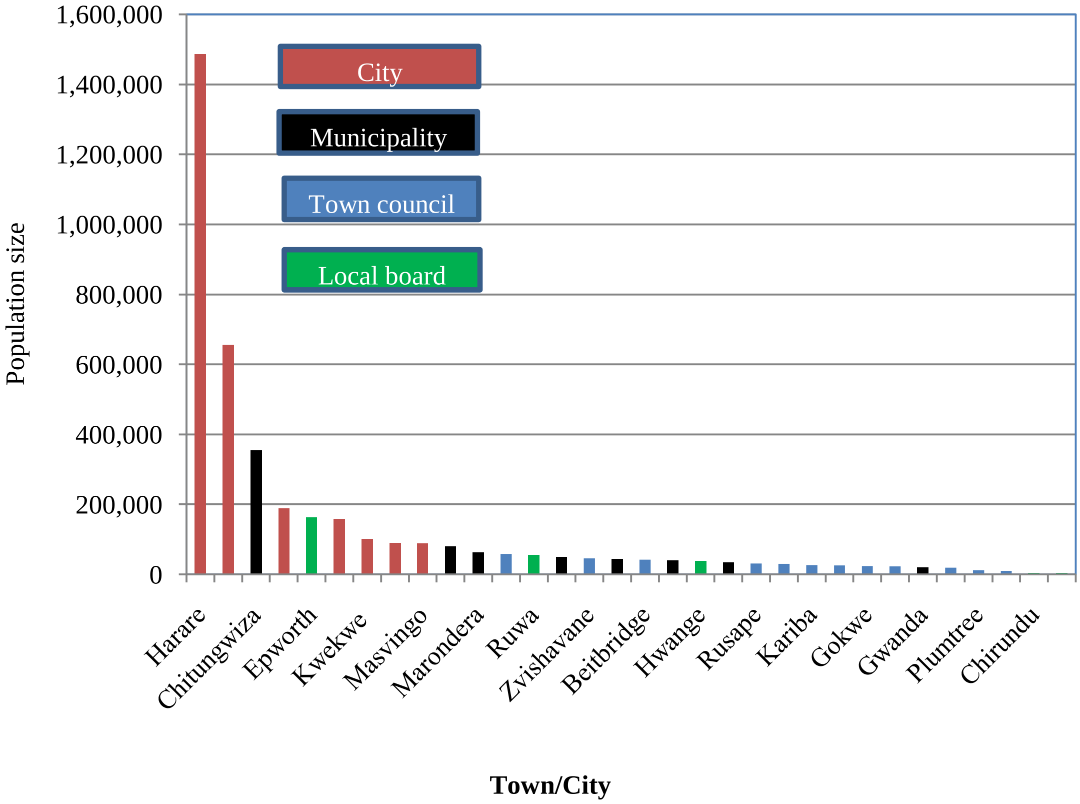

Figure 3.2: Population of 32 Zimbabwean urban areas. Source: Zimbabwe National statistics Agency (2012)

The average household size in Zimbabwean urban area was 5 and the population growth rate was 1.2% (Zimbabwe National Statistics Agency, 2012). Harare is the largest city of Zimbabwe with the largest population and Lupane being the least.

3.1.3. Departments in Urban Councils of Zimbabwe that Manage Solid Waste

The urban councils are responsible for management of solid waste and there are few private actors in the management of solid waste. Harare is the only urban council which has a standalone department which deals with solid waste management. Cities and Municipalities have SWM under the department of Health and Social Services. Towns and local boards have SWM under the department of works and estates . The managers of solid waste in cities and municipalities are health officers where as in town councils and local boards engineers are managers of solid waste. In addition, engineers in town councils and local boards have also other duties such as being managers in water supply, wastewater management, roads and infrastructure development.

3.2. Data Collection

This study was carried out from 1st October 2012 to 1st September 2013. The following type of data was collected; number of properties in the given area, number of properties with solid waste kerbside collection, solid waste generation rate, number and types of receptacles, monthly quantum of waste collected, monthly quantum of waste recycled, landfill ratings, organogram of staff, operation expenses and revenues from SWM. The technical and financial data from the urban councils and the 2012 preliminary population census data were used. The reason was that data for the year 2012 was available during the time of the study.

3.2.1. Questionnaire

A questionnaire in Appendix A was designed through participation with local authorities' senior management staff such as town engineers, town clerks and town treasures from 1st October to 31st December 2012.

3.2.2. Key Informant Interviews

Interviews were done with the town engineers, treasurers, health officers and junior personnel who directly handle waste. All the 32 urban council were well informed in advance to gather and retrieve data from the records. The interviews were carried out when data was already gathered and the purposes of interviews were mainly to depict how the data was collected, the methods used and to score the reliability of the data collected. The interviews were conducted from 7th January to 19th February 2013 for all the urban councils. Two days were spent on cities and one day on towns. In most of the interviews conducted the urban council staff seemed prepared and ready for the meeting and about 95% of the interviewees attended. Some questionnaires were left with some gaps during the time the interviews were conducted as some data needed to be recalculated and verified.

3.2.3. Field Visits and Observations

Field visits and observations were made, with a day spent on cities and half a day on towns. Field visits were made also in the residential areas to observe the general status or cleanliness of the town. Field visits on landfills were done to assess the status of the landfills.

Criteria in Table 3.2 for minimum requirements for landfills was used to evaluate whether the landfill was meeting the requirements of the engineered landfill.

Table 3.2: Criteria for evaluating the sanitary status of landfills. Source: United States Army (1994); Government of Zimbabwe (2007)

Minimum requirements for the compliant landfill	*Total rating weight (%)*
Sitting	10
Environmental impact assessment	10
Lined landfill	25
Control and treatment of leachate	25
Covering of the landfill	20
Ground water monitoring around the landfill	10

The criteria was developed using the EMA criteria for evaluating landfills and the minimum requirements for engineered landfills in United States of America. Ground water monitoring around the well and environmental impact assessment were added to the existing EMA criteria. Colour codes were replaced with numbers for the purposes of quantitative data analysis.

Landfills were rated based on the criterion in Table 3.2. A rating of 10, for example was given when the environmental impact assessment was carried out before the construction of the landfill. A landfill that was constructed prior to the environmental impact assessment was given zero percent rating. A landfill that was properly lined was given 25% and a land fill that was not lined was given zero percent rating and so on.

3.2.4. Focus Group Discussions

Focus group discussions were done so as to formulate indicators to measure performance and validate the collected data. Separate focus group discussion involving health officers, town treasures and engineers were made. Mixed Focus Group Discussion which includes a mixture of engineers, health officers and treasures were made during the formulation of indicators and development of the questionnaire through participatory approach. Focus Group Discussions were also done for data validation.

3.2.5. Data Cleaning

The questionable data (data which were on the extremes) was noted after comparing urban councils with similar characteristics on graphs both demographically and administratively. The questionable data was then followed up 2 weeks after the day of interviews. Rapid assessment reports of some urban councils were used to verify the data collected. Financial records of urban councils were also used to verify the data collected. Meetings were also done with NGO who undertook rapid assessment reports mainly to verify the figures which were not agreeing. Validation of the data was then done in Kadoma with town engineers, town treasures and health officers through focused group discussions.

3.2.6. Reliability of the Data

Data was considered most reliable when the urban councils have been using methods such as weighbridges to estimate the quantity of refuse collected in towns, an updated record of waste generation study, keeping an updated database of properties, receptacles, quantity of waste disposed at landfills and arrears free financial data. Data was considered least reliable when the waste generation rate of a certain urban council have been estimated from generations of other urban area, waste collected have not been based on records from landfills but estimations of trips by drivers, financial data includes arrears from previous years, number of properties have been estimated. The reliability index was used during data collection to rate the quality of the data collected. A score of 1 was used to rate the most reliable data. The least reliable data was assigned a score of 4.

The colour codes instead of numbers would be used to represent the reliability of the data on the graphs. The reliability index with colour codes is shown in Fig 3.3

Table 3.3: Reliability scoring with colour codes

Colour	Reliability score
1 Blue	1
2 Green	2
3 Yellow	3
4 Red	4

3.2.7. Data Processing

The collected and verified data was then substituted in the following equations for computation of indicators of measuring the performance of the 32 urban councils in terms of solid waste management;

Coverage of receptacles was defined as the percentage of occupied properties and establishments that have receptacles

$$\textbf{\textit{Coverage of receptacles}} = \left(\frac{a}{b}\right) \times 100 \ldots\ldots \textbf{\textit{Equation 1}}$$

a = Total number of occupied properties and establishments in the service area
b=Total number of occupied properties and establishments using acceptable receptacles

Coverage of solid waste collection services was defined as the percentage of occupied properties with kerbside collection of refuse once or more per week.

$$\textbf{\textit{Coverage of solid waste collection services}} = \left(\frac{b}{a}\right) \times 100\ \% \ldots\ldots \textbf{\textit{Equation 2}}$$

Where a = total number of properties in the service area or urban council boundary
b =Total number of properties with kerbside collection of refuse once or more per week

Efficiency of collection of municipal solid waste was defined as the total waste collected by the council versus the total waste generated within the council area, excluding recycling or processing at the generation point.

$$\textbf{\textit{Solid waste collection efficiency}} = \left(\frac{b}{a}\right) \times 100\% \ldots\ldots \textbf{\textit{Equation 3}}$$

Where a = Total waste that is generated and which needs to be collected (tones/month)
b= Total quantum of waste that is collected by the council (tones/month)

Extent of recovery of municipal solid waste collected was defined as the quantum of waste collected, which is either recycled or processed.

Extent of solid waste recovery $= \left(\frac{a}{b}\right) \times \mathbf{100}\%$**..*Equation 4***

Where a = total amount of waste that is processed or recycled
b = Total quantum of waste that is collected by council or authorized service providers

Extent of sanitary disposal of waste in engineered landfills was defined as the degree of meeting the minimum requirements (Table 3.2) of disposing waste in engineered landfills.

Maintenance coverage ratio was defined as current year maintenance expenses, expressed as a percentage of the total annual SWM expenses

Maintenance coverage ratio $= \left(\frac{a}{b}\right) \times \mathbf{100}\%$ **...*Equation 5***

Where a =Maintenance expenses in the given year
b = Total SWM expenses within a given year

Efficiency of cost recovery in SWM services was defined as the extent to which the council is able to recover all operating expenses relating to SWM services from operating revenues of sources related exclusively to SWM.

Efficiency of cost recovery in SWM $= \left(\frac{b}{a}\right) \times \mathbf{100}$**...*Equation 6***

Where a = Total annual operating expenses
b = Total annual operating revenues

Efficiency in collection of SWM charges was defined as current year revenues collected, expressed as a percentage of the billed total revenues, for the corresponding time period

Collection efficiency of solid waste management charges $= \left(\frac{a}{b}\right) \times \mathbf{100}$**.........*Equation 7***

Where a = Current revenues collected in the given year
b = Total operating revenues billed during the given year

Financial sustainability *was defined as collected revenues in a given year over the SWM related expenses incurred during that year*

Financial sustainability $= \left(\frac{a}{b}\right) \times \mathbf{100}$**..*Equation 8***

Where a = Current revenues collected in the given year
b = Total operating expenses incurred during the given year

Ideal equipment was used to estimate the adequacy of equipment. The refuse equipment which was in running order or economically viable to repair was counted as the existing machinery. The ideal number of required equipment depends on urban councils' local conditions. The ideal number of equipment was made based on population size and the amount of waste the council was generating.

3.2.8. Data Analysis and Presentation

The Statistical Package for Social Sciences (SPSS) version 16 was used for cleaning the data and correlation analysis. Pearson correlation tests were done between the indicators and performance variables so as to establish the relationship between the two variables. SPSS was also used for computing the means and variances. International best practices values from literature review were used to compare with the local indicators. The data was then presented in tables and bar graphs.

4. RESULTS AND DISCUSSIONS

4.1. Presentation Approach

This chapter presents the results and discussion of the extent and challenges in solid waste management in Zimbabwean urban councils. Findings from this study are presented in subsequent sections of this chapter with the aid of tables and graphs as per each objective. In addition, findings of this study were compared with literature on the performance of other countries in the region and international standards in terms of solid waste management. Recommendations and conclusions are given at the end of each discussion of results for each objective.

4.2. The Extent and Challenges in Collecting Municipal Solid Waste

4.2.1. Solid Waste Generation

A survey was carried out for all the 32 urban councils in Zimbabwe. A questionnaire was administered in person to the town engineers, health officers, town clerks and health inspectors on solid waste generation. It has to be noted that respondents for Gweru and Victoria Falls were not able to participate in this study due to administrative issues. In addition, interview results showed that Chirundu and Lupane were not providing basic SWM services to their residents because they did not own any refuse equipment. The total municipal waste generation rate results for the 26 urban councils in Zimbabwe are shown in Fig 4.1. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

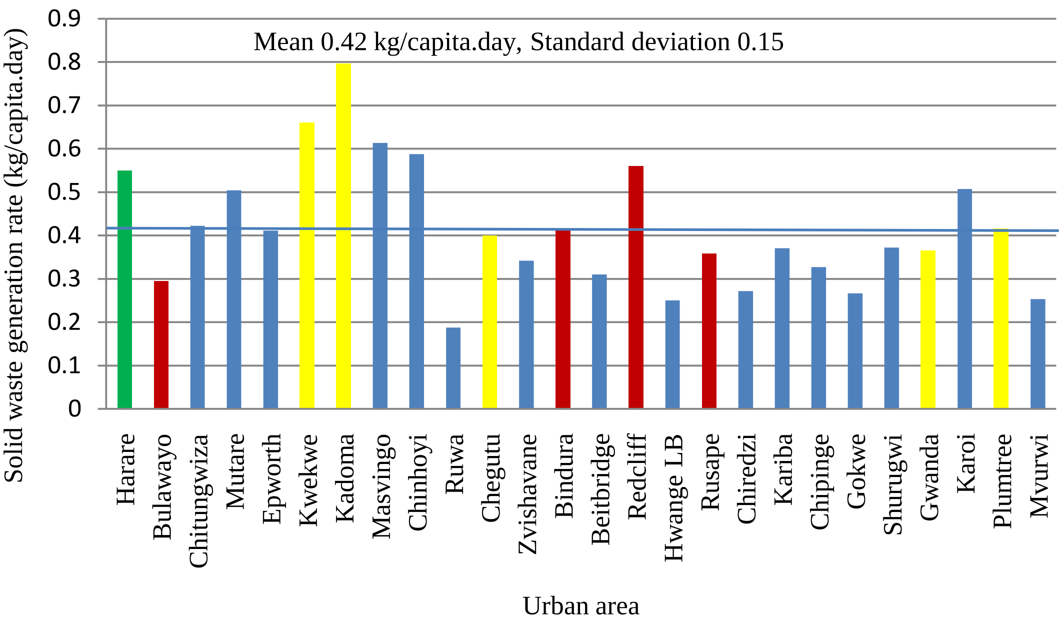

Figure 4.1: Solid waste generation rates for Zimbabwean Urban areas for the year 2012

From Fig. 4.1, the average municipal solid waste generation rate was found to be 0.42 ± 0.15 kg/capita/day, ranging from 0.2kg/capita/day for Ruwa to 0.8kg/capita/day for Kadoma. The mean for the 26 urban councils was above the generation rate for Chinhoyi of 0.34 kg/capita/day (Musademba *et al.,* 2011). This could be attributed to a slight economic growth as the country was on the recovery phase. The average for the 26 urban councils was also above the average waste generation rate for Kenya (0.33kg/capita/day) (Mwai *et al*., 2008). The results also show that cities and municipalities generally have a high per capita solid waste generation rate in comparison to local boards and towns. This could be explained by the availability of high disposable incomes in cities and municipalities.

4.2.2. Storage of Waste

Proper receptacles include plastic and metallic bins or plastic bags provided by urban councils to residents to store waste. Cardboard boxes, paper bags, plastic bags made of very thin plastic were used in most urban councils but were not proper receptacles. Fig 4.2 shows the level of proper receptacles in Zimbabwean urban councils. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

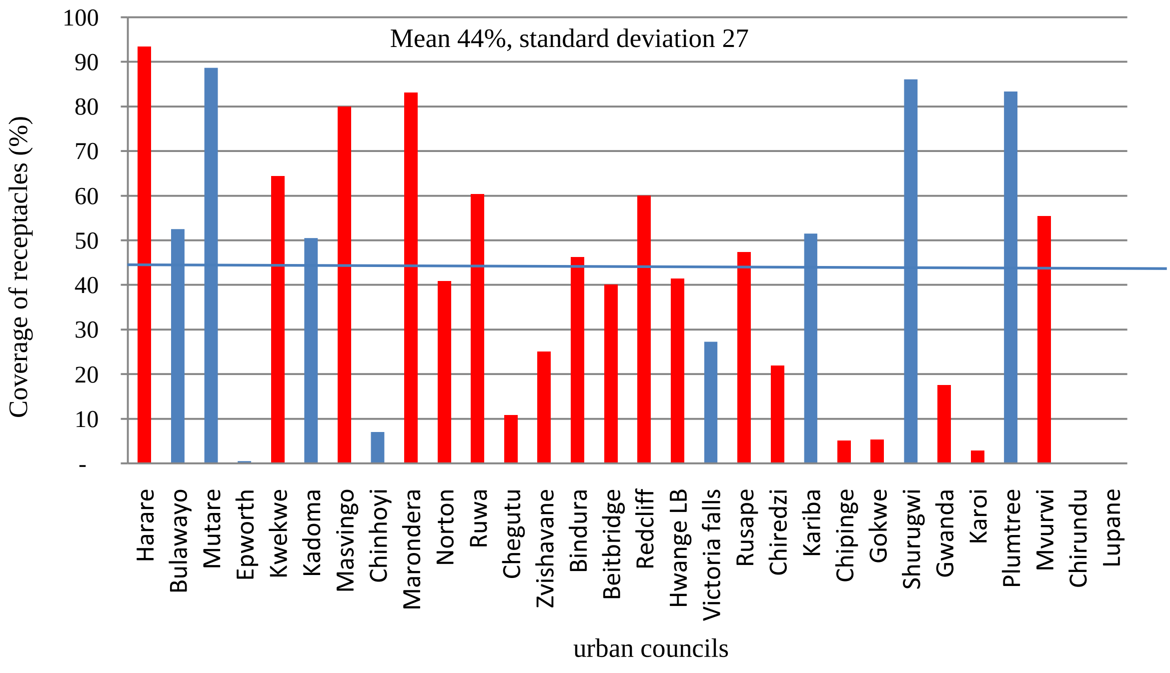

Figure 4.2: Coverage of receptacles of the 28 urban councils of Zimbabwe

The mean for the 28 urban councils surveyed on coverage of receptacles was 44 ± 27% as shown in Fig 4.2. The graph shows that local boards and towns experience serious shortage of receptacles. However, all the cities had a coverage of receptacles which was above 50%. Receptacles are important for successful recycling programs because they enable separation and sorting of different types of waste. The available receptacles were not even enough for storing unsorted waste and different types of solid waste.

Fig 4.2 showed that the coverage of proper receptacles was 52% for Bulawayo. Mudzengerere (2012) also estimated the coverage of proper receptacles in Bulawayo to be 46% which was close to the mean of 44% determined in this study. With these shortages, there is need for the council to provide receptacles to residents at a fee that can be paid over a certain period of time.

The coverage of receptacles for Mutare urban was 89%, which is higher than 64% found by Manyanhaire (2009). The difference could be attributed to the economic recovery of the city from a decade of economic decline. Moreover, the difference in figures could be due to the fact that the average found by Manyanhaire (2009) was not for the whole city but for a single suburb. This is so because the sample size used has a bearing on the average obtained. In this study the average was taken for all sectors unlike Manyanhaire (2009)'s study.

4.2.3. Coverage of Solid Waste Through Kerbside Collection

The questionnaire was administered to 32 urban councils and 73% of the urban councils responded to the questionnaire. Gweru, Marondera, Victoria Falls, Chitungwiza and Kwekwe did not respond due to administrative issues. Chirundu and Lupane were not providing basic SWM services to their residents because they did not own any refuse equipment and as such were not considered in the quantitative analysis. The coverage of solid waste management services in these two urban areas was therefore 0%. Fig 4.3 shows the coverage of SWM services for the 22 urban councils who were providing SWM services to their urban areas. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

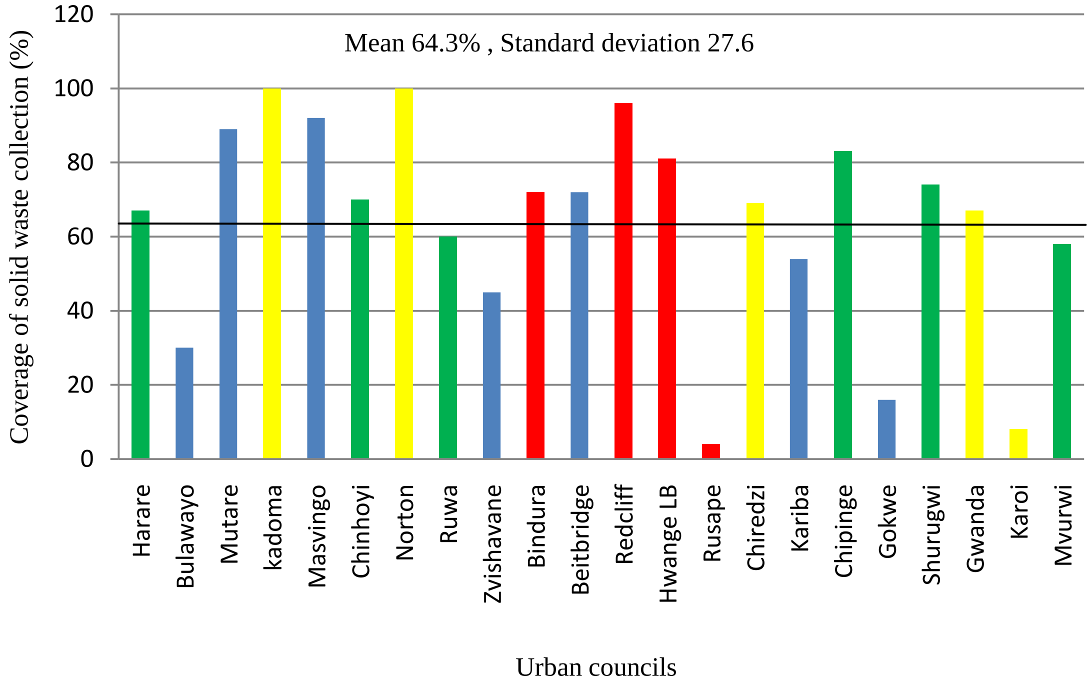

Figure 4.3: Coverage of kerbside solid waste collection

The average kerbside solid waste collection coverage was 64.3 ± 27.6%. The collection schedule for all urban centres was once a week in the residential areas and at least twice a week in commercial, institutional and industrial areas. Low figures of SW collection coverage for Gokwe, Karoi and Rusape were as a result of these three urban councils failing to collect refuse in their residential areas. The average collection coverage by Zimbabwean urban councils of 64.3% was below the world cities average of 86% (UN Habitat, 2010). This means that Zimbabwean urban councils were operating below the performance of the world cities. In addition, the average coverage of kerbside collection of waste (64.3%) was below the international benchmark average of 98% (UN Habitat, 2010). The ideal coverage of solid waste collection services should be 100%. This means that all residents must be covered by basic solid waste collection services.

4.2.4. Correlation of Coverage of SWM Services with Coverage of Receptacles

Table 4.1 shows the results of the Pearson paired correlation test between coverage of solid waste collection services with coverage of receptacles.

Table 4.1: Correlation of Coverage of SWM services with Coverage of receptacles

Variables	*Coverage of solid waste management*	*Coverage of receptacles*
Observations	23	23
Mean	64.3	44.2
Pearson Correlation coefficient	0.36	
P(T<=t) two-tail (p<0.05)	0.005	

Table 4.1 shows that there is a weak relationship between coverage of solid waste collection services with coverage of receptacles. This relationship is low in the sense that some residents do not have receptacles in areas that receive basic solid waste collection services. Residents who do not receive basic solid waste collection services had few or did not have receptacles. The low figures of coverage of kerbside collection of waste have resulted in the increase of illegal dumping of waste in the urban areas. It was also found out that areas that did not have the basic collection services dispose waste in open spaces and along the roadside. The accumulated waste poses health risk to children who normally play or pick discarded items. For example the photo in Fig 4.4 shows an illegal dump site in Chitungwiza in an area that was not covered by kerbside collection of waste.

Figure 4.4: Photo of an illegal dumpsite in an open space near a road in Chitungwiza

4.2.5. Collection Efficiency of Municipal Solid Waste

The questionnaire was administered to 32 urban councils and 88% of the urban councils responded on the section of solid waste collection efficiency. Fig 4.5 shows the collection efficiency of the 26 urban councils of Zimbabwe. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

The range of solid waste collection efficiency for the 26 Zimbabwean urban councils was from 6% to 100% and the mean was 63.9 ± 27%. This was an improvement in solid waste collection efficiency over the one which was established by Practical Action (2007) of 30%. The increase in solid waste collection could have been due to the economy of Zimbabwe which seemed to be recovering during the period of the study. Epworth, Gokwe and Karoi had the lowest collection efficiency because they were collecting waste only in commercial, institutional and industrial areas. In residential areas of Gokwe and Epworth the residents were disposing solid waste in pits at the back yard where as in Karoi burning and open dumping was common.

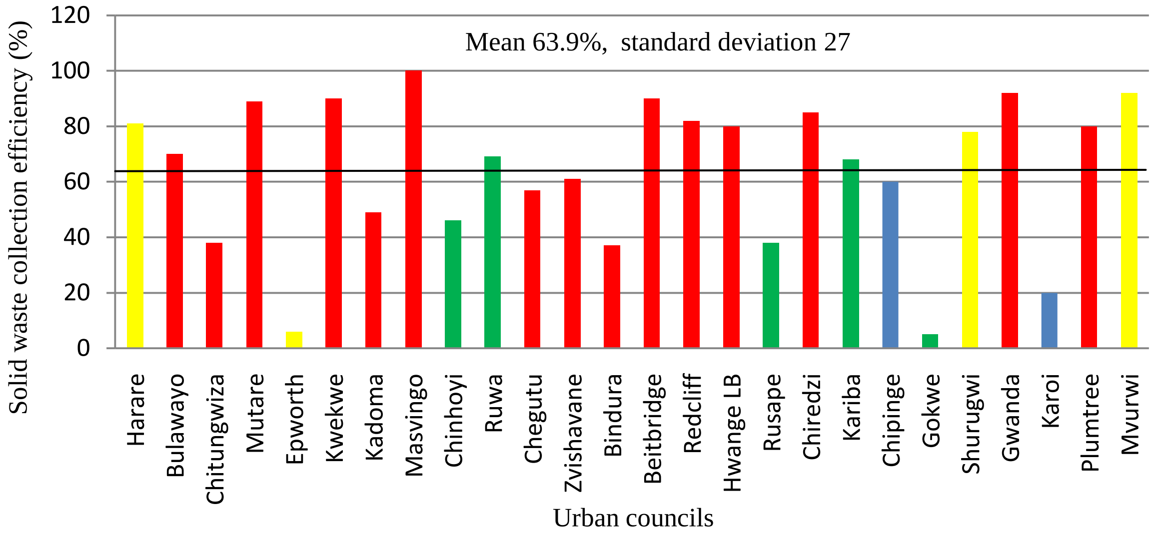

Figure 4.5: Collection efficiency of municipal solid waste of the 26 urban councils

The results in Fig. 4.5 show that the collection efficiency of SW for Chinhoyi was 44%, which is almost equal to 48% estimated by Musademba (2011). The mean for the Zimbabwean urban councils of 63.9%, was low when compared to the mean for the world cities of 89% (UN Habitat, 2010). This shows that Zimbabwean urban councils were operating below the performance of international cities.

4.2.6. Correlation of Collection Efficiency with Coverage of Receptacles

Table 4.2 shows the results of the Pearson paired correlation tests between SW collection efficiency and the coverage of proper receptacles. Table 4.2 shows that there is a strong relationship between SW collection efficiency and coverage of proper receptacles. Residents need proper receptacles that store waste up to a period of one week, which was a collection schedule for the council in residential areas. Therefore receptacles would not spill up until that period and odours would be minimised. Residents who were using improper receptacles were illegally dumping their solid waste as their receptacles fill up before the one week period. The uncollected illegally dumped waste reduced the solid waste collection efficiency. Thus proper receptacles influence the collection efficiency of solid waste.

Table 4.2: Correlation of Collection efficiency of SWM services with Coverage of receptacles

Variables	*Collection efficiency of solid waste*	*Coverage of receptacles*
Observations	22	22
Mean	62.7	43.2
Pearson Correlation	0.67	
P(T<=t) two-tail (p<0.05)	0.0009	

4.2.7. Reuse/Recycling of Municipal Solid Waste

Recycling was mainly done by informal waste pickers. The amount of waste recycled is presented in Fig 4.6. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

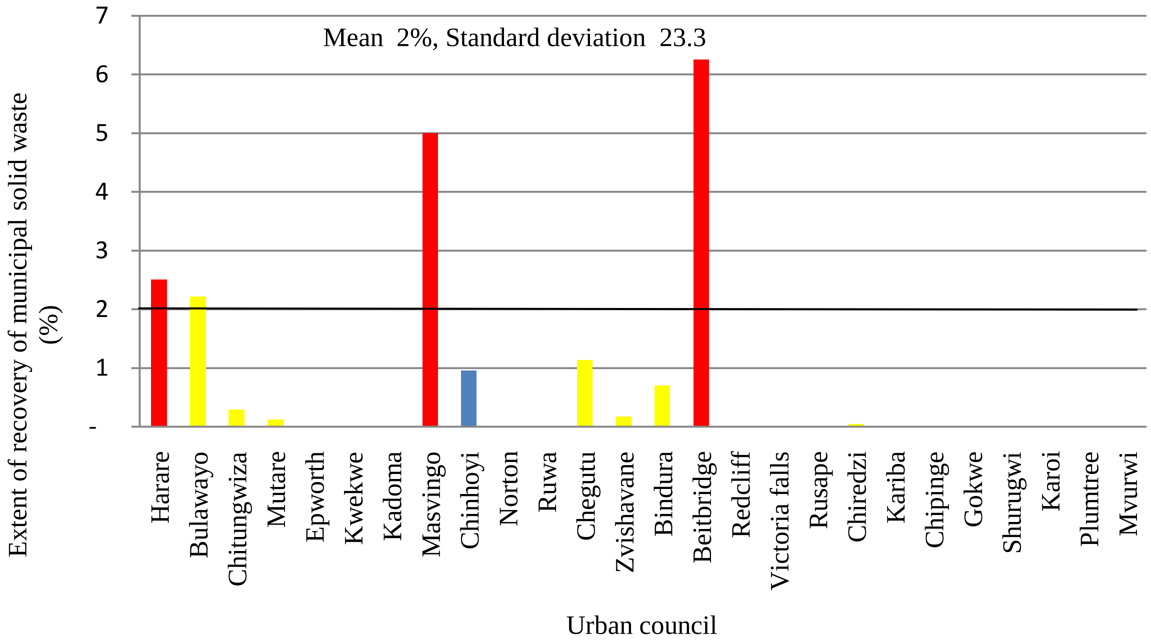

Figure 4.6: Extent of solid waste recovery

Solid waste recovery ranged from 0 to 23.3%. Waste pickers were more common in cities and municipalities as shown in Fig 4.6 because cities and municipalities have more to spend on packaging food stuffs such as plastics and bottles. According to UN Habitat (2010), recovery of waste by informal recyclers reached a maximum of 20 to 30% and had improved the lives of the poor in developing countries. Moreover, this study is in line with what has been suggested by Idris *et al.* (2004) who suggested that in most developing countries recycling was not formally done by the council or landfill operators but it was done by informal recyclers or pickers and scavengers. Therefore, informal waste pickers should be promoted as this would assist in reducing poverty for urban poor and reaching MDG 1 of halving the people who suffer from hunger and poverty.The waste was not sorted at all dumpsites which made recycling of waste difficult. In addition, domestic and industrial waste was mixed which could be a health threat to waste pickers.

Fig 4.7 shows waste pickers sorting waste at landfills in Mutare (A) and Gweru (B). Wastes picked at the landfills include scrape metals, sacks, card board boxes, plastics and plastic bottles. The councils or government should provide residents with recycling facilities such as storage receptacles for storing different types of waste so that waste pickers recycle waste at the points of generation rather than at the disposal sites.

Figure 4.7: Sorting of waste at Mutare dumpsite (A) and Gweru dumpsite (B)

In addition, although it is a requirement of all users and stakeholders to be involved in waste minimisation as stated by the EMA Act of 2002 of Zimbabwe, stakeholders were not involved in the management of waste as witnessed by no public campaigns through media on waste separation and minimization. This implies that there was lack of enforcement of the legislation by EMA. In addition, during the time of this study there were no composting institutions who convert organic municipal waste into organic fertilizers. UN Habitat (2010) suggested that organic waste should not be deposited in landfills but should be composted and the nutrients must be recovered. The organic waste constitutes 42% of the waste in most Zimbabwean urban areas (Musademba *et al.*, 2011; Mudzengerere, 2012). Composting this organic waste into organic fertilizers has a possibility of minimizing the quantum of waste that enters landfills there by increasing the life of the landfill. Recycling by informal waste pickers could save the local authorities collection budget by 20% from collection costs, if informal waste pickers pick waste at point of generation (Rodic *et al*, 2010). This implies that if recycling strategies are fully followed they have a possibility of reducing 70% of the waste that enters landfills (UN Habitat, 2010).

4.2.8. Extent of Sanitary Disposal of MSW

The disposal of solid waste in Zimbabwe was not environmentally sustainable as 98% of landfills were not sanitary. The extent of sanitary disposal of waste was 50% for Bulawayo and 20% for Shurugwi. Bulawayo was rated; 10% for selecting a proper site, 10% for carrying out Environmental impact assessment prior to the construction of the landfill, 25% for the lined landfill, 10% out of 25% for control and treatment of leachate, 0% for burying waste in the landfill and 0% on ground water monitoring around the landfill. Shurugwi was rated; 20% for covering the landfill and 0% for the rest of the parameters. The reason why Shurungwi was performing better was that it was supported by a private mining company to construct, bury and compact the landfill. In addition, the landfill in Shurugwi was located right in the middle of the residential area and therefore the council and the mining company could not afford to keep flies away and odours reach the residents.

Odours and blowing papers were observed in all the uncovered landfills except for Shurugwi. This is in line with Mangizvo (2010) who concluded that open dumping will continue to be the way of disposing waste by municipalities in Africa due to financial constrains. Fig 4.9 shows some of the typical dumpsites (landfills) that were in Zimbabwe which were not sanitary. Photo A is of Chitungwiza landfill and B is a photo of a landfill in Karoi.

Figure 4.9: Dumpsites in Chitungwiza (A) and Karoi (B)

Karoi landfill was located in the wetland and threatened both ground and surface water resources. The landfill was not properly sited as landfills are not supposed to be constructed in wetlands or slope areas. Chitungwiza landfill was unfenced and residents were practicing urban agriculture in it. However, residents put their life at risk to diseases.

4.3. Adequacy of Collection and Landfill Equipment

A survey was conducted on randomly selected 16 urban councils on adequacy of collection and landfill equipment. Table 4.3 presents the results of the refuse equipment. Serious shortage of landfill equipment against the ideal number of landfill equipment is also leading to poor sanitary disposal of waste. The reason why the councils use open dumpsites and fail to bury refuse on daily basis in open dumpsites could be attributed to lack of landfill equipment.

Table 4.3: Refuse collection and landfill equipment of the 16 urban councils of Zimbabwe

equipment	*Refuse compactor*		*Front end loader*		*Tractor and Trailer*		*Dozer*		*Landfill Compactor*		*Skip bin*		*Skip truck*		*Weigh bridge*		*Skip bin And tractor*		*incinerator*		*Fumigation equipment*	
	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired	Existing	Desired
Harare	47	46	2	2	11	11	1	2	1	2	100	150	7	10	0	1	2	3	1	2	3	6
Bulawayo	15	25	0	1	0	0	0	1	0	2	0	20	0	2	0	1	0	0	0	1	0	2
Kwekwe	2	4	0	1	2	2	0	1	0	1	0	7	0	1	0	1	0	0	0	1	2	2
Kadoma	3	4	0	1	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Masvingo	2	8	0	1	1	6	0	1	0	1	0	1	0	1	0	2	0	3	1	3	0	1
Norton	0	2	0	1	2	3	0	1	0	1	0	8	0	1	0	1	0	1	0	1	0	2
Zvishavane	0	2	0	1	2	2	0	1	0	1	0	3	0	0	0	1	0	1	0	1	0	1
Redcliff	0	2	0	1	1	2	0	1	0	1	0	10	0	0	0	1	0	1	1	2	0	1
Hwange LB	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	1
Rusape	0	2	1	2	3	3	0	1	0	1	0	5	0	1	0	1	3	0	0	0	0	0
Chiredzi	1	2	0	1	0	1	0	1	0	1	0	9	0	0	0	1	0	1	0	1	0	0
Chipinge	0	2	0	1	2	2	0	1	0	1	0	2	0	0	0	1	0	1	0	0	0	0
Gokwe	0	1	0	1	1	1	0	1	0	3	0	1	0	1	0	1	0	1	0	1	0	1
Gwanda	0	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0
Karoi	0	1	1	0	1	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Mvurwi	0	1	0	0	1	1	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	0

Harare, Kadoma and Masvingo were using both refuse compactors and tractors. Bulawayo was using only refuse vehicles because of large distance from the collection points to the landfill. Mudzengerere (2012) found out that Bulawayo city council has 10 functional compactor trucks against an ideal of 25. The difference in the number of compactor trucks with that found by Mudzengerere (2012) could be that five non functional refuse compactors could have been repaired during the time this study was conducted. Urban towns and local boards showed serious problems of having one tractor and trailer as the only refuse equipment to manage waste. Local boards and urban towns did not afford to buy expensive refuse trucks without the assistance of the government or NGOs. Table 4.3 shows that the councils do not have adequate machinery to manage waste except Harare which has adequate machinery.

4.4. Adequacy of Manpower

The managers of solid waste management for cities and municipalities were health officers. For urban towns and local boards, engineers were the managers of the four departments which were solid waste, water supply, wastewater, roads and infrastructure development. Table 4.4 presents four parameters; Households to Staff Ratio, Top management to Total staff Ratio, Middle management to Total staff Ratio and Labourers to Total staff Ratio.

Table 4.4: Household to Staff ratio and staff break down proportions for urban councils

Urban council	*Household /Refuse staff ratio*	*Top management / Refuse staff ratio (%)*	*Middle management / refuse staff ratio (%)*	*Labourers /Refuse staff ratio (%)*
Harare	393	0.7	3.5	95
Bulawayo	903	1.6	3.8	94
Mutare	275	0.6	1.1	98
Epworth	7690	17.2	0	82.8
Kwekwe	362	2	3	95
Kadoma	584	4	8.6	87
Masvingo	399	3	0	96
Chinhoyi	1215	3	6.5	90
Ruwa	920	6.6	0	93.3
Chegutu	584	2	5.6	92.5
Zvishavane	862	7	7	86
Bindura	908	2.4	0	97.6
Beitbridge	330	6	2.8	91
Redcliff	425	5.6	4.5	90
Rusape	488	0	5.9	94
Kariba	405	5.9	0	94
Chipinge	779	10	10	80
Gokwe	888	5	0	95
Shurugwi	468	2.4	8.1	89.4
Gwanda	471	25	8	66.7
Karoi	496	10	10	80
Mvurwi	208	15	0	84.6
Mean	**911**	**6**	**4**	**90**

The mean Households to Staff ratio for the 22 urban councils was 911 and ranged from 208 to 7,690 as shown in Table 4.2. The wide range was due to Epworth which had only 6 workers to deal with solid waste management. The reason why Epworth had few workers was that it was not collecting refuse in residential areas. According to (Henderson, 2005) the international standard for Household to Staff ratio is between 150 to 200. Comparing the international standards with the Zimbabwean performance range of 208 to 7690, it showed that Zimbabwe had a serious shortage of refuse manpower. Similar studies in South Africa by DEAT (2007) revealed that the average Household to Staff ratio was 273. Comparing the South African average with the Zimbabwean average of 911, it showed that South Africa has a higher number of manpower than Zimbabwe. Shortage of manpower in Zimbabwe was as a result financial constrains.

Table 4.2 also shows that the mean ratio of Top management/ Total refuse staff is 6% and ranged from 0 to 25%. Cities and municipalities had low top management to staffing ratio in the range of 0.3 to 3%. High Top management to Total staff ratio was common for urban towns. According to (Henderson, 2005) the optimum refuse staff break down is 10% Top management to Total staff ratio. Comparing the international best practice with the Zimbabwean Top management to Total refuse ratio of 6% it shows that Zimbabwean urban councils did not have adequate top management man power.

Table 4.2 also showed that the average Middle management to Total staff ratio is 4% and Labourers to Total refuse staff is 90%. According to Henderson (2005) the optimum staff breakdown is 25% for Middle management and 65% for Labourers. All the urban councils failed to reach the optimum international best practice of 25% for Middle management to Total refuse staff. The Labourers to Total refuse staff have an average of 90% for Zimbabwean urban councils which were above the international best practice. This implied that the composition of manpower in Zimbabwe had a bias towards labourers than the managerial level.

4.4.1. Correlation of Collection Efficiency of Solid Waste with Household to Staff Ratio

Correlating Collection efficiency of SW with Households to Staff ratio shows that there is a strong relationship between collection efficiency and Households to Staff ratio as shown in Table 4.5. This means that adequacy of man power has a major role to play in proper solid waste management.

Table 4.5: Correlation of Collection efficiency of solid waste with Household to Staff Ratio

Variables	*Collection efficiency of solid waste*	*household to staff ratio*
Observations	23	23
Mean	63.6	904
Pearson Correlation	-0.53	
P(T<=t) two-tail (p<0.05)	0.014	

4.5. Financial Sustainability of the Solid Waste Management Function

4.5.1. Levels and Types of Tariffs

Table 4.6 shows the solid waste management tariff structure for 15 urban councils in Zimbabwe.

Table 4.6: The solid waste management tariff structure for Zimbabwean urban councils in US $ per month

Area\urban council	*Harare*	*Bulawayo*	*Chitungwiza*	*Kwekwe*	*Masvingo*	*Chinhoyi*	*Chegutu*	*Norton*	*Zvishavane*	*Bindura*	*Beitbridge*	*Redcliff*	*Rusape*	*Chiredzi*	*Chipinge*	*Gokwe*	*Karoi*	*Mvurwi*	***Mean***
Low density	9.50	6.35	3.50	4.00	4.00	3.00	2.00	2.30	2.00	3.00	8.00	3.00	4.00	6.00	5,00	1.00	6.00	5.00	**4.56**
Medium density	9.50	6.35	3.36	-	4.00	3.00	2.00	2.30	2.00	2.00	7.00	3.00	3.00	-	5.00	1.00	5.00	3.00	**4.19**
High density	6.5	4.56	3.50	2.30	4.00	3.00	2.00	2.30	2.00	1.50	5.00	3.00	2.00	2.00	2.00	-	2.50	3.00	**3.06**
Institutional	9.50	14.00	15.00	10.00	38.00	-	-	11.50	6.00	7.00	13.00	5.00	5.00	30.00	5.00	5.00	20.00	10.00	**13.33**
Commercial	15.00	14.00	30.00	15.00	38.00	-	-	11.50	12.00	9.00	17.00	5.00	5	20.00	6.00	5.00	20.00	10.00	**15.16**
Industrial	15.00	14.00	30.00	15.00	38.00	-	-	11.50	12.00	9.00	33.00	10.00	10.00	45.00	6.00	-	20.00	10.00	**20.80**

The mean tariff structure for domestic areas in the high density was US$ 3.06, medium density was US$ 4.19 and low density was US$4.56 per property per month. The tariffs were high for cities and low for urban towns and local boards. However, Zimbabwean domestic tariffs were lower than the average tariffs for the world cities of US$8.00 (UN Habitat, 2010).The domestic tariff structure also was based upon the affordability of the residents to pay rather than on cost recovery. The basis upon which the domestic tariff structure was based is good as it takes into consideration, the ability and affordability of customers to pay. However, the SWM tariff structure did not factor in the money to invest in the construction and operation of landfills. The tariff structure for refuse collection was catering for the poor and the ability of residents to pay for services.

The average tariff structure for institutional areas was US$13.33 per institution per month as shown in Table 4.6. The average refuse charge for commercial areas was US$15.16 per property and the average refuse collection charge for industrial areas was US$20.80 per stand. The tariffs for institutional, commercial and industrial areas were below the United States domestic tariff of US$27.00. Very high tariff structures for institutional and commercial areas were as a result of increased collection frequency which was done on daily basis. Again the overall tariff structure factored in only the collection costs of refuse rather than the cost of investing in landfills.

4.5.2. Efficiency in Cost Recovery of SWM charges

The urban councils who responded on financial issues were 30 out of 32. Gweru and Victoria Falls were not able to respond due to administrative issues. Results showed that Chirundu and Lupane were not providing basic SWM services to their residents and were therefore not collecting money from the residents. Fig 4.8 shows the efficiency in cost recovery of SWM services for the 26 urban councils of Zimbabwe. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

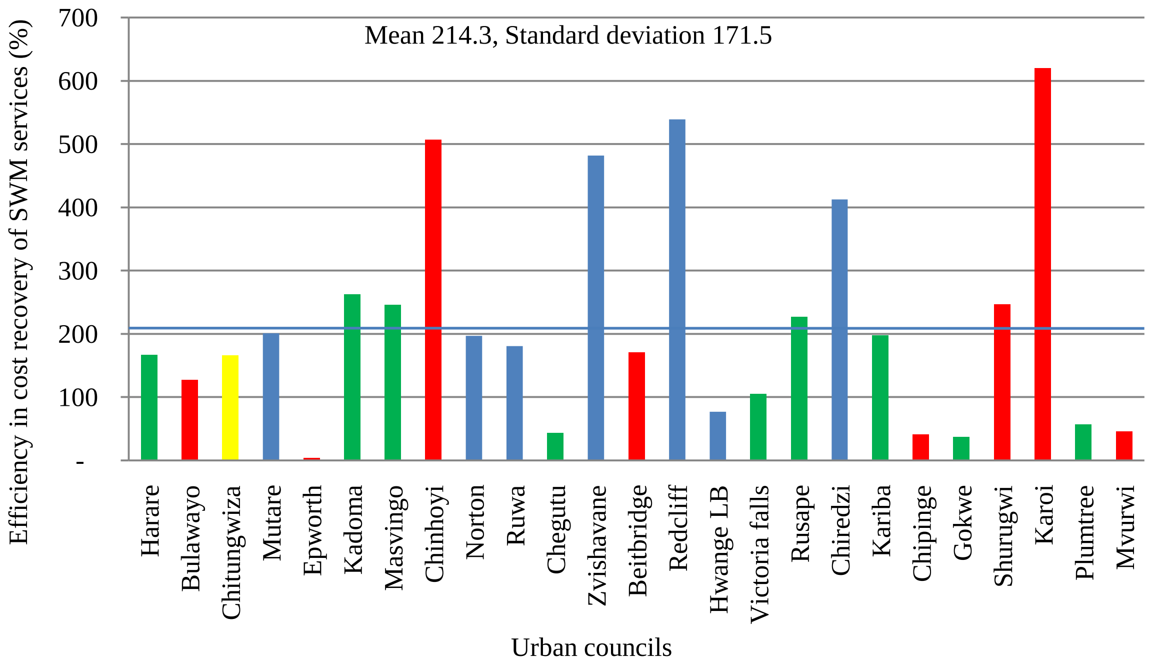

Figure 4.10: Efficiency in SWM for the Zimbabwean urban councils

Efficiency in cost recovery was calculated using Equation 6 in the Methods. The cost recovery was very high above average for Zvishavane, Redcliff, Chiredzi because these urban councils have functional industries. The efficiency in cost recovery was also very high for Karoi as they service institutional, industrial and commercial areas which were charged high tariffs. The efficiency in cost recovery was very high with an average of 217 ± 168.9% for the 26 urban councils of Zimbabwe. Figures of more than 100% mean that income was more than expenditure. However, Chegutu, Bindura, Chipinge, Gokwe, Plumtree and Mvurwi were not able to recover their cost because income was less than expenditure. The reason could be that they have not charged a fee that included all the incurred costs.

The efficiency in cost recovery of Zimbabwean towns is above the Indian urban council benchmark of 100% (MUDGI, 2008). The reason could be that Zimbabwean urban councils were not spending on the sanitary disposal of waste. The expenditure of solid waste includes the cost incurred from storage to the disposal of waste in engineered landfills. Therefore, the expenditure was lower for Zimbabwean urban councils since costs of sanitary disposal of waste were not included.

4.5.3. Correlation of Cost recovery of SWM services with Tariffs

The correlation analysis shows that there is a very weak negative relationship between the tariff structures and efficiency in cost recovery as shown in Table 4.7. This mean that the effects of tariffs contribute to a smaller extent to the attainment of cost recovery of SWM services

Table 4.7: Correlation of Cost recovery of SWM services with Tariffs

Variables	*Cost recovery of solid waste*	*Tariffs*
Observations	16	16
Mean	251	3.8
Pearson Correlation	-0.05	
P(T<=t) two-tail (p<0.05)	0.00014	

4.5.4. Efficiency in Collection of Solid Waste Management Charges

The efficiency in collection of SWM charges was calculated using Equation 7 in methods and was presented in Fig 4.9. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

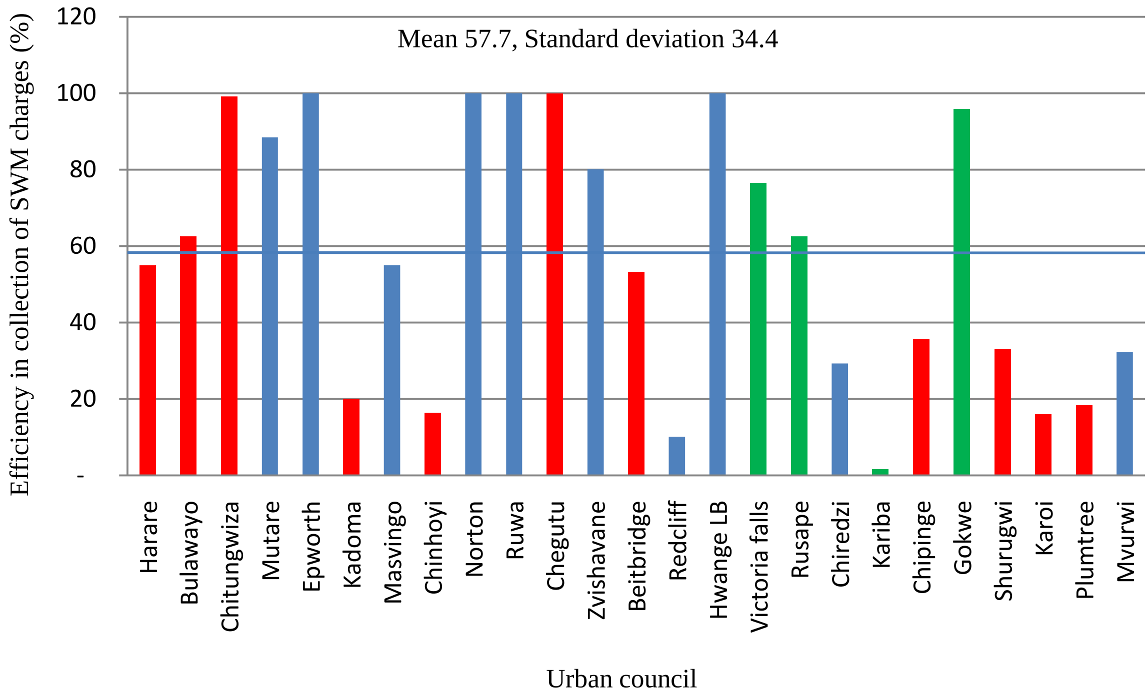

Figure 4.11: Efficiency in collection of SWM charges

The mean collection efficiency of solid waste management charges was 57.7± 34.4%. Kadoma, Chinhoyi, Redcliff, Kariba, Karoi and Plumtree had the lowest collection efficiency which was below 20%. The collection efficiency of solid waste management charges was above average for most cities as shown in Figure 4.11. The reason was that the disposable income in cities is high as compared to municipalities, towns and local boards. High collection efficiency of SWM charges for Gokwe, Rusape and Epworth were due to the fact that disposable income was high in commercial areas, the only areas they were collecting refuse.

4.5.5. Correlation of Efficiency of Collection with Cost Recovery and Tariff Charges

Table 4.8 shows the results for correlation analysis at $p<0.05$.

Table 4.8: Correlation of Cost recovery with Efficiency of collection and SWM tariff charges

		efficiency in cost recovery of SWM services	*SWM tariffs for residential areas*
efficiency in collection of SWM charges	Correlation Coefficient	-0.47	-0.33
	Sig. (2-tailed) (p<0.05)	0.0004	0.00001
	Observations N	25	15

There is a weak negative relationship between efficiency in cost recovery and efficiency in collection of SWM charges. This shows that urban councils which are performing well in cost recovery have a low efficiency in collection of SWM charges as shown in Table 4.8. Table 4.8 also shows that there is a weak relationship between collection efficiency of solid waste management charges with domestic tariffs. The increase in Tariff levels will result in some residents failing to pay as the tariffs might not be affordable.

4.5.6. Financial Sustainability

Financial sustainability was used to measure the ability of the urban council to cover annual costs from annual collected revenues. More focus on financing solid waste were given only to the collection and transportation of refuse, without investing in landfills, recycling and processing, the other subsystems of the solid waste management. Financial sustainability was calculated using equation 8 from the methods and the results are then presented in Fig 4.12. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

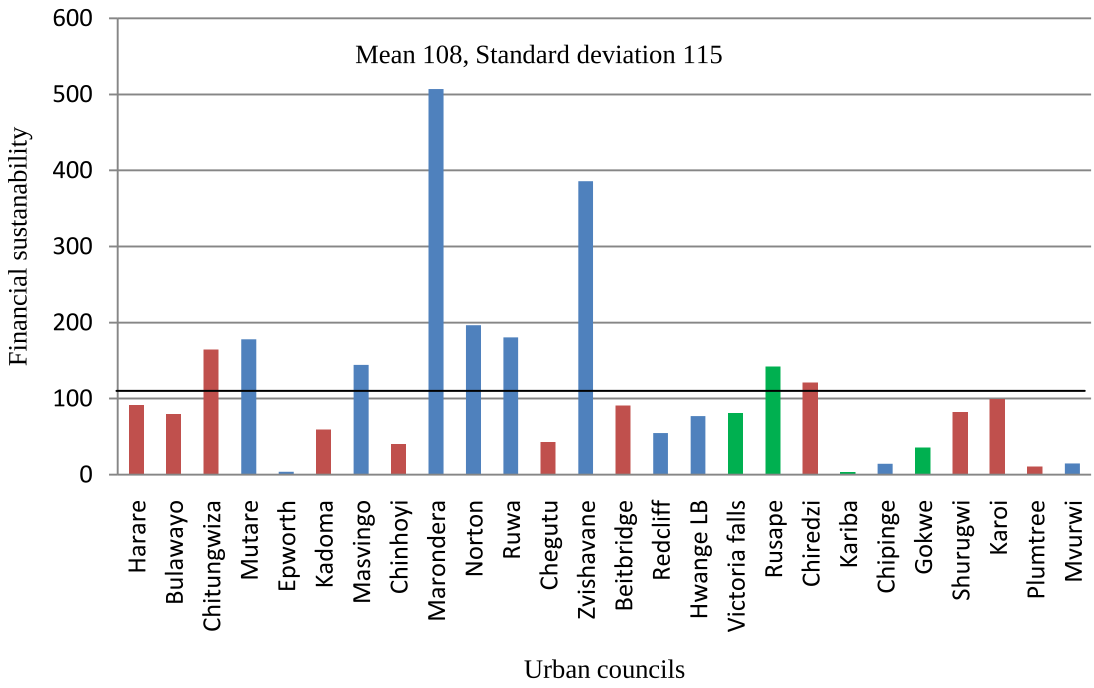

Figure 4.12: Financial sustainability of the Zimbabwean urban councils

The financial sustainability of the solid waste management system was 108%. For the system to be sustainable the annual cost incurred should equal or balance the revenues collected from service charges, that is the ratio must be 100% and above. Figure 4.5 suggest that the available funds were just enough to support the collection of waste. This would also mean that the urban councils did not have surplus to invest in other subsystems such as building engineered landfills, recycling and composting of the solid waste management system. This is in line with studies by UNEP (2009) which estimated that collection alone drains up to 80 to 90% of municipal solid waste management budget in low-income countries. Chitungwiza, Zvishavane and Rusape seemed to have high annual financial sustainability. The annual cost was low for these three urban councils because they were not channelling funds to the collection of refuse which resulted in the high annual cost recovery. This was reflected by the refuse collection efficiency which was not satisfactory as shown in Figure 4.1.

4.5.7. Maintenance Budgets

Urban councils use trailed tractors and refuse compactors for the collection and transportation of refuse. Harare city council has additional equipment such as front end loaders and skip trucks for collection of refuse. This equipment needs to be maintained to reduce break downs and down times. Fig 4.6 shows the ratio of maintenance costs to total operating costs which were calculated using equation 5. The reliability of the presented data was differentiated by making use of four colour codes as previously explained in the methodology in section 3.2.6.

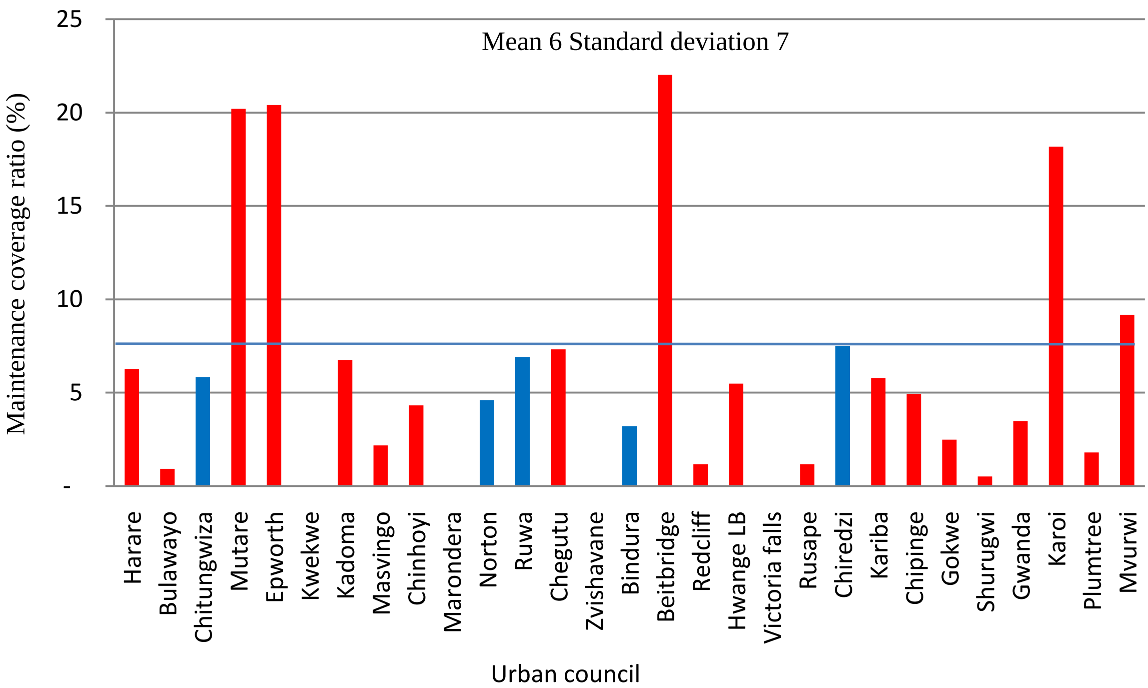

Figure 4.13: Maintenance coverage ratio for Zimbabwean urban councils

The mean ratio of maintenance costs to total operating costs was 5%. The high value for Karoi was due to the fact that the town had been collecting refuse only in towns, without collecting in residential areas and this has resulted in low total operating costs. Most urban councils were not budgeting money to cater for maintenance. Therefore, urban councils only reacted to breakdowns (repairs).

4.5.8. Correlation of Maintenance Budgets with Efficiency in Collection of Solid Waste

There is no significant relationship between collection efficiency and maintenance budgets as shown in Table 4.9. The reason could be that the equipment has not yet exceeded its economic life and 75% of the refuse equipment consist of tractors which required only the minimum maintenance.

Table 4.9: Correlation of Maintenance budgets with Efficiency in collection of solid waste

Variables	*Maintenance coverage ratio*	*Efficiency in collection of solid waste*
Observations	23	23
Mean	6	63.6
Pearson Correlation	-0.53	
P(T<=t) two-tail (p<0.05)	0.89	

4.6. Culture and Mindset in Solid Waste Management

The duty of urban councils and EMA was to ensure that papers and waste are not thrown everywhere, but in receptacles. The general public people had been throwing solid waste everywhere. It was then the role of street sweepers to pick and collect discarded waste. Failure by urban councils to collect waste had caused residents to illegally dump waste on roadsides and open spaces. Residents had been reluctant to pay for the poor services of collection of waste. Burning waste was also common, if the council failed to collect waste.

4.7. Summary and Discussions

This section summarizes the extent and challenges of solid waste management in Zimbabwean urban councils. This section also gives a summary of the discussion of results on the extent and challenges in solid waste management in Zimbabwean urban councils

4.7.1. Summary and Discussions on the Extent of Solid Waste Management

The coverage of solid waste management in urban councils of Zimbabwe was 64.3% at a collection frequency of once a week. Failure by urban councils to follow their collection schedules has resulted in the residents illegally dumping solid waste in open spaces and near roads. The solid waste collection efficiency was 63.9% with some urban councils such as Epworth, Karoi and Gokwe not collecting refuse at all in the residential areas.

Bulawayo and Shurugwi were partially meeting the sanitary disposal of solid waste by 50 and 20% respectively, the rest of the urban councils were using open dumps which could potentially pollute both surface and underground water resources. Recycling at the dumpsite was done by informal waste pickers. The extent of recycling or reuse of waste at the dumpsite was ranging from 0 to 23.3%.

Solid waste management in Zimbabwean urban councils was not financially sustainable as revealed by a mean of 108% which were not enough to invest in subsystems of solid waste management such as recycling and landfills. Poor financial sustainability has been caused by very poor collection efficiency of service charges from residents of 57.7 ± 34.4%.

4.7.2. Summary and Discussions on Challenges of Solid Waste Management

Poor collection efficiency seemed to be caused by shortage of refuse collection equipment as the existing equipment was far from the existing refuse fleet. All local boards and urban towns had a range of one to two tractors with a trailer combination, reserved for refuse collection.

Poor refuse collection was caused by serious shortage of staff which had been below the international standards and good practises in the region. The house hold to staff ratio was in the range of 208 to 903 against the ideal of 150 to 200. In addition, the staff break down ratio in terms of top management, middle management and labours revealed that there is critical shortage of the top management and middle management as revealed by the Top management to Total refuse staff, Middle management to Total refuse staff Ratio of 0.2 to 9%, 0.3 to 8% against the ideal of 5% and 25% respectively. The top management are very important in the day to day management of waste. They are the ones who project future waste generation rates, formulate policies, plan, design and construct solid waste management facilities. The middle management are important for the success of any solid waste management system as they supervise, inspect and ensure that quality services are provided to customers.

Critical shortage of proper receptacles has caused poor collection efficiency of municipal solid waste. Proper receptacles hold and store waste between the collections where as improper receptacles filled up easy, spills and do not minimise odours, hence residents with improper receptacles were illegally dumping waste which end up reducing the collection efficiency.

Shortage of landfill equipment has also contributed to the poor sanitary disposal of waste. All the urban councils except for Harare which had one front end loader and a landfill compactor, the urban councils do not have landfill equipment to deal with the sanitary disposal of waste. The waste in the landfill was not sorted and this reduced the recycling efficiency at landfills by informal waste pickers. In addition very low coverage of receptacles of 40% had also contributed to low recycling of waste since receptacles enable the easy recycling of waste. Poor collection efficiency also was caused by poor recycling efficiency as recycling reduces the waste stream to be collected and transported to the landfills.

5. CONCLUSIONS AND RECOMMENDATIONS

The study which was carried out in Zimbabwe on the extent and challenges of the urban councils on solid waste management systems came up with the following conclusions and recommendations:

Table 5.1 Conclusions and recommendations per each objective

Objectives	Conclusions	Recommendations
1) To assess the extent and challenges in collecting municipal solid waste in urban areas of Zimbabwe in 2012	Poor refuse coverage and collection in Zimbabwe was caused by inadequate equipment as the existing equipment was far from reaching the optimum levels. Inadequate human resources in the management of waste is also a major contributor of poor refuse collection services, as the figures were far from international best practices Poor refuse coverage and Collection efficiency was also poor because of lack of proper receptacles	The councils should increase equipment to meet the capacity Councils should increase refuse human resources to optimum levels. Councils should Increase the number of proper receptacles to cover all areas
2) To assess the extent and challenges in the disposal of municipal solid waste in urban areas of Zimbabwe in 2012	The disposal of solid waste was far from being environmentally sustainable and all urban councils were using open dumps with the exception of Bulawayo and Shurugwi. All the urban councils do not have landfill equipment such as Landfill compactors, Dozers and front-end loaders except Harare Challenges in recycling were as a result of no separation of waste at source as evidenced by a critical shortage of receptacles, recycling	Councils should Construct engineered landfills Councils should Acquire landfill equipment Encourage recycling, through supplying customers with adequate receptacles, public campaigns and involving users in the planning and

	reduces the waste that enters landfills.	collection of waste
3) To assess the financial sustainability of the solid waste management function in urban areas of Zimbabwe in 2012	Urban councils seemed to be financially sustainable as the money collected from service charges was just enough to meet the incurred costs, however the collected money was not enough to invest in other subsystems of solid waste management	The councils should seek other financing mechanisms from government and NGOs

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APPENDICES

APPENDIX A: URBAN COUNCIL SURVEY QUESTIONNAIRE

Table 6.1 shows the questionnaire used to collect data for the performance evaluation of the 12 urban councils.

Table 6.1: Questionnaire, designed through a participatory approach with Zimbabwean urban councils and modifying the MUDGI questionnaire

				Name of urban council	
Ref	**Data Item**	**Comment**	**Unit**	**Response**	**Reliability Score**
3.1	**Coverage of SWM services through door to door collection of waste.**		**%**		
	Definition: Percentage of occupied properties and establishments that are covered by kerbside collection system at least **once** a week.				
3.1.1	a. Total number of occupied properties and establishments in the service area	The service area refers to either the ward or the council boundary	#		
3.1.2	b. Total number of properties with kerbside collection at least once a week	Include kerbside collection by the council itself or council-approved service providers or vendors.	#		

	Coverage = [(b/a)*100]		%		
	Additional information				
3.1.3	Properties with collection daily		#		
3.1.4	Properties with collection once a week		#		
3.1.5	Properties with collection twice a week		#		
3.1.6	Properties with collection once in more than a week		#		
3.1.7	**Total** number of properties with some form of collection				
3.1.8	Properties with no collection at all				
3.2	**Efficiency of collection of municipal solid waste**		%		
	Definition: The total waste collected by the council and authorized service providers versus the total waste generated within the council area, excluding recycling or processing at the generation point.				

3.2.1	a. Total waste that is generated and which needs to be collected	The total waste generated excluding waste processed or recycled at the generation point. This would depend on the population of the city, and the composition of economic activities. This should be calculated using the waste generation per capita (0.2-0.4 kg/cap.d) multiplied by the population of the town, plus the waste actually collected from industry, commerce and institutions as reflected by the number of loads and their weight.	tonnes/month		
3.2.2	b. Total quantum of waste that is collected by the council or authorized service providers	The total waste collected from properties, establishments and common collection points. This should be based on actual weighing of the collected waste. Daily generation should be aggregated to calculate the total monthly quantum.	tonnes/month		
	Collection efficiency = [(b/a)*100]		**%**		
	Additional information				
3.2.3	Waste generation per capita for the city or town		kg/cap.d		
3.2.4	Weight of loads collected from domestic areas		tonnes/month		
3.2.5	Weight of loads collected from industrial areas		tonnes/month		
3.2.6	Weight of loads collected from commercial areas		tonnes/month		
3.2.7	Weight of loads collected from institutional areas		tonnes/month		

3.2.8	Weight of loads collected from other areas		tonnes/month		
3.2.9	Total weight of loads collected by the council	Checking figure should be same as figure given in 2.2.2	tonnes/month		
3.3	**Extent of recovery of municipal solid waste collected**		%		
	Definition: The ratio of recycled or processed waste to the quantum of collected waste.				
3.3.1	a. Amount of waste that is processed or recycled	The total quantum of waste intake by waste processing/recycling facilities operated by the council or operator at a city/ward/locality level. Inert matter, and other material refused by the processing/recycling facilities, which will go back to the dumping sites/landfills, should be deducted from the intake quantities. Waste collected at intermediate points by informal mechanisms (rag pickers, etc.) and fed back into the recycling chain should be included in this quantity.	tonnes/month		
3.3.2	b. Total quantum of waste that is collected by the council or authorized service providers	(This corresponds to the quantity of (b), as measured for the indicator on collection efficiency). Should be same as 3.2.2	tonnes/month		
	Extent of segregation = [(a/b)*100		**%**		
3.4	**Extent of sanitary disposal of waste at landfill sites**		%		

	Definition: Sanitary disposal is the amount of waste that is disposed in landfills that have been designed, built, operated and maintained as per standards laid down by EMA/SAZ/US Army. The extent of sanitary disposal should be rated as a percentage of waste that has been deposited in sanitary landfills as laid down in the table for minimum requirements for sanitary landfills.				
3.4.1	a. Total waste disposed in controlled landfills and dumpsites every month.	A daily record of all waste being disposed at controlled landfill sites should be kept. The monthly total should be the sum of daily totals in a month.	tonnes/month		
3.4.2	b. Total waste deposited in all landfills, dumpsites and illegal dumps every month.	The total waste disposed after collection and recovery (if any) at landfills (including compliant landfills, open dumpsites and undesignated sites).	tonnes/month		
2.4.3	c. Sanitary landfill rating	Lined landfill, treatment and control of leachate and covering the refuse, environmental impact assessment and siting			
	Extent of recovery = [a/b]*c*100		**%**		
3.6	**<u>Efficiency of cost recovery in SWM services</u>**		**%**		
	Definition: This indicator is defined as the total annual operating revenues from SWM as a percentage of the total annual operating expenses on SWM. This indicates the extent by which the council is able to recover its operating expenses from the revenues.				

3.6.1	a. Total annual operating expenses	Include all operating expenses incurred by the council towards SWM services that is salaries, payments to contractors for activities outsourced by the council. To be supported by computer printout of monthly exception reports for 2012. The figure here should agree with the breakdown figure given in 3.10.8	USD		
3.6.2	b. Total annual operating revenues	Include all charges for SWM and income from recycling and processing. This should exclude income earned by contractors, or the informal sector, that is not passed onto the council. To be supported by computer printout of exception report for 2012.	USD		
	Cost recovery = [(b/a)*100]		**%**		
3.7	**<u>Efficiency in collection of SWM charges</u>**		**%**		
	Definition: Efficiency in collection is defined as current year revenues collected, expressed as a percentage of the total operating revenues, for the corresponding time period.				
3.7.1	a. Current revenues collected in the given year	Revenues collected for bills raised during the year. This should exclude collection of arrears as inclusion of arrears will skew the performance reflected. Collection efficiency is in fact an indicator of how many arrears are being built up, and therefore only current revenues should be considered.	USD/Annum		

3.7.2	b. Total operating revenues billed during the given year	The total quantum of revenues related to SWM services that are billed during the year. This should include revenues from all sources related to SWM charges, surcharges, etc.	USD/Annum		
	Collection efficiency = [(a/b)*100]		**%**		
3.8	**<u>Maintenance coverage ratio</u>**		**%**		
	Definition: Maintenance coverage ratio is defined as current year maintenance expenses, expressed as a percentage of the total annual SWM expenses.				
3.8.1	a. Maintenance expenses in the given year	Maintenance-related expenses recorded in a particular year, excluding salaries, running costs and capital repayments	USD/annum		
3.8.2	b. Total SWM expenses within a given year	The total costs of running the SWM function. This should include costs for all functions related to solid waste management such as VAT, electricity charges, purchase of chemicals, etc.	USD/annum		
	Maintenance coverage ratio = [(a/b)*100]		**%**		
3.9	**<u>Coverage of receptacles</u>**		**%**		
	Definition: Percentage of occupied properties and establishments that have receptacles.				
3.9.1	a. Total number of occupied properties and establishments in the service area	The total number of occupied properties in the service area should be established. The service area refers to either the ward or the council boundary	#		

3.9.2	b. Total number of occupied properties and establishments using acceptable receptacles	The total number of occupied properties or establishments where refuse in an acceptable receptacle or bin is collected by municipal collectors or anyone authorized by the council to do so	#		
	Coverage of receptacles = [(b/a)*100]		**%**		
3.10	**Additional Information not related to indicators**				
	Financial Information - Operating Expenses				
3.10.1	Regular Staff and administration		USD		
3.10.2	Outsourced/Contract Staff Costs		USD		
3.10.3	Electricity Charges/Fuel Costs		USD		
3.10.4	Chemicals and cleaning materials		USD		
3.10.5	Repairs/Maintenance Costs		USD		
3.10.6	Cost of receptacles		USD		
3.10.7	Other Costs		USD		
3.10.8	Total Operating Expenditure	The total here should be same as the figure in 3.6.1 which is also given here in red as a checking figure	USD		
3.10.9	**Financial Information - Operating Revenues**				
3.10.10	Arrears at the beginning of previous year (2011)	As at 1 Jan 2011	USD		
3.10.11	Revenue demand from user charges	Revenue solid waste collection in 2011	USD		

3.10.12	Revenue demand from tax - Water Service only	2011	USD		
3.10.13	Revenue demand from other revenues (eg. connection costs/Donations etc)	2011	USD		
3.10.14	Total Revenue Demand for previous year	2011	USD		
3.10.15	Total Revenue Demand for **previous** year (from user charges, taxes, etc)	2011	USD		
3.10.16	Collection against arrears (2011)	Of the arrears at the beginning of 2011, how much was collected?	USD		
3.10.17	Collection against the current demand of previous year (2011)	Of the billed amount in 2011, how much was collected?	USD		
	Refuse Collection Tariff Structure				
3.10.18	Residential - Low density		USD/month		
3.10.19	Residential - Medium density		USD/month		
3.10.20	Residential - High density		USD/month		
3.10.21	Institutional		USD/month		
3.10.22	Commercial		USD/month		
3.10.23	Industrial		USD/month		
	Staff Information				
3.10.24	Senior Management-Health Officer (Sanctioned)		#		
3.10.25	Senior Management-Health Officer (Working)		#		

3.10.26	Sanitary Inspector (Sanctioned)		#		
3.10.27	Sanitary Inspector (Working)		#		
3.10.28	Sanitary Supervisor (Sanctioned)		#		
3.10.29	Sanitary Supervisor (Working)		#		
3.10.30	Cleaners/Drivers (Sanctioned)		#		
3.10.31	Cleaners/Drivers (Working)		#		
3.10.32	General (Sanctioned)		#		
3.10.33	General (Working)		#		
3.10.34	Others Specify		#		
3.10.35	Total (Sanctioned)		#		
3.10.36	Total (Working)		#		
3.10.37	Are daily records of waste received at compliant landfill maintained?		Yes/No		
3.10.38	Is weighbridge available at landfill site?		Yes/No		
3.10.39	Are daily records of waste received at open dumpsites maintained?		Yes/No		
3.10.40	Is weighbridge available at dumpsite?		Yes/No		
	Functional refuse collection equipment				
	Equipment			Existing	Desirable
3.10.41	Refuse compactor		#		
3.10.38	Front-end-loader		#		
3.10.39	Tractor and trailer		#		

3.10.40	Dozer		#		
3.10.41	Landfill compactor		#		
3.10.42	Skip bin		#		
3.10.43	Skip truck		#		
3.10.44	Weighbridge		#		
3.10.45	Skip bin and tractor		#		
3.10.46	Incinerator		#		
3.10.47	Landfill fumigation equipment		#		
3.10.48	Other (specify)		#		

Source MUDGI, 2008

APPENDIX B: REFUSE COLLECTION TARIFF STRUCTURE

Table 6.2 Shows the tariff structure for the residential high density, low density, institutional, commercial and industrial areas

Table 6.2: The tariff structure for Zimbabwean urban councils in US $

Area\urban council	*Harare*	*Bulawayo*	*Chitungwiza*	*Masvingo*	*Zvishavane*	*Redcliff*	*Rusape*	*Chipinge*	*Gokwe*	*Karoi*	*Mvurwi*
Low density	9.5	6.35	3.5	4	2	3	3	5	-	6	5
High density	6.5	4.56	3.5	4	2	3	3	2	1	5	3
institutional	9.5	14	15	38	6	5	5	5	5	20	10
commercial	15	14	30	38	12	5	5	6	5	20	10
Industrial	15	14	30	38	12	10	10	6	-	20	10

APPENDIX C: CRITERIA FOR EVALUATING LANDFILLS

Field visits were done to evaluate landfills based on the criteria in Table 4.2. The land fill that meets all the minimum requirements was rated 100%. The rating was then multiplied by the extent of scientific disposal to get the actual percentage.

Table 6.3: Criteria for evaluating the compliance of the landfill. Source: US army (1994) , Government of Zimbabwe (2007)

Minimum requirements for the compliant landfill	*Rating (%)*
Lined landfill	25
Treatment of leachate	25
Covering of the landfill	20
Environmental impact assessment	10
Ground Water monitoring around the landfill	10
Sitting	10

APPENDIX D: PHOTOS: URBAN COUNCIL'S SOLID WASTE MANAGEMENT SURVEY

Figure 6.1: Photo of waste sorting at landfills

Figure 6.2: Photos of burning landfills

Figure 6.3: Photos of interviews with council staff