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**AN EXAMINATION OF SOLID WASTE COLLECTION AND DISPOSAL
IN MAPUTO CITY, MOZAMBIQUE**

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ABSTRACT

This dissertation was developed from data collected in Maputo City and Cape Town during 2003-2006. It explores the current situation, as well as future solid waste management options for Maputo City, Mozambique. The research seeks to contribute to and enhance understanding of Maputo City solid waste management and be a modest contribution to understanding the social, economical, political and biophysical dimensions of Maputo's solid waste management. The study seeks also to develop a framework of sound practice with respect to both technology and policy that embodies a reasonable balance between feasible, cost-effective, environmentally beneficial and socially sensitive solutions to Maputo's Municipal Solid Waste Management (MSWM) problems.

From an examination of the extent and effectiveness of solid waste management in Maputo City, Mozambique and an analysis of the procedures of the current MSWM system, the study shows that MSW collection and disposal do not differ from the other developing countries of Africa, Asia, South America and the Caribbean, facing similar problems of effectiveness and extensiveness. MSW collection is more effective in central city and some urban neighbourhoods peripheral to the central business district (CBD). It also shows that the current procedures for MSWM in Maputo City need improvement, particularly with respect to organization.

The statistics show that Mozambique and Maputo's economy is growing and that economic conditions will permit an improvement in Maputo's MSWM. It is thus feasible for Maputo to address municipal waste collection and disposal so as to improve public health and the quality of life of the city's inhabitants as well as to improve city aesthetics and reduce poverty.

The study identifies the weaknesses and opportunities of the institutions that deal with solid waste. It concludes that there are weaknesses in the legal controls. These are weak and citizens do not know applicable regulations. There are few private waste companies involved in municipal solid waste collection and none in disposal. There are few personnel trained in waste management and solid waste services need to be managed professionally. Further problems are that the organizational linkages between institutional, executive and operational levels of municipal solid waste management are

not clear, resulting in weakness. There is a lack of organizational capacity to collect fees for waste collection and disposal.

Finally, although the study finds that there is poor municipal coordination of solid waste management in Maputo there are opportunities that can be exploited to improve solid waste management: human resources are available, there is a potential for waste recycling and composting and as Mozambique's capital city there is goodwill and support for improving MSWM. In addition, despite the constraints mentioned there is a good will among all citizens, local and central government, national and international environmental Non Governmental Organizations (NGOs), local and international partners on MSW to see Maputo's solid waste collection and disposal problems solved.

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ABBREVIATIONS AND ACRONYMS

EHC - Environmental Health Centre

GDP – Gross Domestic Product

GNP - Gross National Product

IWMP - Integrated Waste Management Plan

MCC - Maputo City Council

MDHC - Municipal Directorate of Hygiene and Cemeteries

MSW - Municipal Solid Waste

MSWM - Municipal Solid Waste Management

Mt – Metical (Currency of Mozambique. US\$1 = Mt 25000)

NIS - National Institute of Statistic

SWM - Solid Waste Management

UNEP - United Nations Environment Programme

WHO - World Health Organization

Mozal – Mozambique Aluminium

IETC – International Environment Technology Centre

UNDP – United Nations Development Programme

CHAPTER ONE: INTRODUCTION

1.1 General Background

1.1.1 Geography

The Republic of Mozambique is located between 10° 27' and 26° 52' south and between 30° 12' and 40° 51' east, on the south-eastern coast of the African continent. Mozambique has a continental area of 786380 square kilometres (about 2.6 per cent of the African continent) and 13 000 square kilometres of surface water (NIS: 2003). Around 94 per cent of the country is located below 1000 meters altitude. Mozambique is a former Portuguese possession, which gained its independence on 25th June 1975. It is administratively divided into eleven Provinces, one hundred and twenty eight Districts and thirty-three municipalities.

Maputo City, the study area covered by this dissertation, is situated in the south of the country between 25° 49' and 26° 05' south and 32° 26' and 33° 00' east. It covers 316 square kilometres; its population was 966800 at the last Census held in 1997 and is projected to be close to 1.1 million in 2005 (NIS: Statistical Yearbook - Maputo City 2001). Administratively it is the capital of Mozambique, it consists of seven municipal districts, Districts 1, 2, 3, 4, 5, as well as Catembe and Inhaca Island.

Mozambique's municipal solid waste management is facing critical challenges. To understand the current situation with respect to Municipal Solid Waste (MSW) three historical events are relevant to this study: i) Mozambique Independence; ii) The 1976 - 1992 civil war; iii) The World Summit on Environment and Development held in Rio de Janeiro in 1992.

Maputo City gained the status of town, Lourenço Marques, on 10th November 1887 by royal decree of Henrique de Macedo (Arquivo: 1987). It can be assumed that the history of Waste Management in Maputo City is linked to that date. Nevertheless, Waste Management is known from antiquity. Bilitewski et al (1997) in their *Waste Management* state that "as far back as 8,000 to 9,000 B.C., people learned to dispose of their waste out side own settlement". James and Thorpe, in Speight (1996) state that "Environmental management is not new, having been practiced in pre-Christian times".

On gaining independence, the new government put in place political policy that aimed to build a new state. The policy was to dismantle old colonial administrative structures. As part of this the new government nationalized all public and private properties in 1976. One of the results of this was that the expert Portuguese municipal solid waste workers left the country, leaving the MSW system weak. Thus, the institutional capacity in terms of qualified human resources and organization of the solid waste management system was drastically affected. In addition, the former MSW activity plan was ignored interrupting the normal process of MSWM.

Between 1976 and 1992 the country experienced a civil war. One of the consequences was that rural people migrated to towns putting more pressure on the existent weak waste management structures. The increased population in the cities and the reduced institutional capacity placed municipal waste collection and disposal services under stress and not able to cope with the wastes being generated.

In 1992, a Peace Agreement ending the civil war was signed in Rome and the United Nations Conference on Environment and Development took place in Rio de Janeiro. As a consequence of the Rio Conference and the coming of peace Mozambique created a Ministry for Coordination of Environmental Affairs (MICOA) in 1994. This gave new impetus to environmental matters.

In 1997, city and village municipalities were created for the entire country. As a result MSWM gained new dynamism. At that time the central government established the legal basis for waste collection and disposal. It designated local government as responsible for the collection and disposal of waste, accompanied by the threat of legal penalties. Thus, understanding the past, living the present, and planning the future, will permit optimisation of solid waste management, in the hope that the errors of the past will not be repeated.

1.1.2 The Problem

Maputo City has experienced significant population growth, as well as expansion in its business and industrial sectors, subsequent to the ending of civil war and the signing of the Peace Agreement in Rome on October 4, 1992. One of the results of this growth has been a consequential increase in the amount of solid waste generated within the Metropolitan Area. The increase in waste generation in both production and consumption has put greatest demand on waste collection services. An inability to cope

has consequently affected the quality of the environment, city aesthetics and public health. Unsanitary conditions and litter¹, are ubiquitous and affect public health. In 2003-2004, Maputo City experienced outbreaks of cholera, meningitis and dysentery as a consequence of poor sanitation and poor waste management (Table 1.2). Similar situations occurred in many countries of the world in the past. Bilitewski et al (1997) in their *Waste Management* state that, "in the 19th century, nine cholera epidemics claimed 380,000 lives between 1831 and 1873 in Prussia alone; the need for public health measures was dramatically highlighted in 1892 in the city of Hamburg, when about 9,000 people fell victim to a cholera epidemic; in the 6th and 14th centuries epidemics swept through densely populated Europe claiming the lives of one-third of the population (25 million) in a few short years (1347-1352)".

Table 1.2 Occurrence of diseases in Maputo associated with poor sanitation.

Disease	Cases	Deaths	Cases	Deaths
	2003		2004	
Cholera	10626	257	5309	48
Meningitis	20	5	44	5
Dysentery	7044	1	3844	0

Source: Epidemiological Section of Maputo Central Hospital

The direct and indirect relationship between environmental hygiene and life threatening diseases is a reality that can be observed in Maputo City. Sewerage and drains are misused for waste disposal (as a consequence of weak knowledge of waste disposal), there is unsanitary waste disposal, and solid waste treatment is rudimentary. In the near future this will cause serious problems for the city.

¹ Litter is waste that has been misplaced. It must be recovered and brought into the formal waste stream, where it can be managed with the resources that are available for the task (Lombard et al., in Fuggle and Rabie (1994): 509).

If waste collection and disposal in Maputo is not addressed these figures will increase, unsanitary conditions will deteriorate, more deaths could occur and environmental conditions will deteriorate. Consideration must be given to planning MSW collection and disposal so as to reduce the incidence of diseases and poverty as well as to improve city aesthetics and life quality of the inhabitants.

1.1.3 Study Objectives

This research seeks to contribute to and enhance understanding of Maputo City solid waste management. It will provide actual information that can be useful to scientists, managers, politicians, planners and legislators. In this dissertation a broad range of municipal solid waste collection and disposal issues will be studied and analysed with a view to suggesting a way forward for the future solid waste management of Maputo City. The completed research will be a modest contribution to understanding the social, economic, political and biophysical dimensions of Maputo's solid waste management. It will suggest a "feasible" option for the future.

The objectives of the study are:

- To examine the extent and effectiveness of current solid waste management practices in Maputo City;
- To analyze the procedures and practices of the current MSWM system;
- To identify the weaknesses and strengths of the institutions that deal with solid waste management;
- Propose feasible options for the future solid waste management in Maputo City;
- To produce a document/framework that can be used in the future planning of Maputo City to ensure that waste collection and disposal are properly considered.

1.1.4 Research Design

This is a case study. It is based on fieldwork conducted in Maputo City during 2004 and 2005. The fieldwork comprised direct personal observations, mapping of the locations of waste disposal bins and instances of informal waste disposal, recorded interactive interviews and administration of questionnaires. The recorded interactive interviews were mainly conducted in Portuguese and where this was not possible in local

languages (Cironga or Cichangane) with the help of a translator. The questionnaires were all compiled and administered in Portuguese. (Annex: 2)

Data on waste management administration in Maputo City were collected using personal observation as well as from interviews with role players and stakeholders: Government officers, municipal staff, Non Governmental Organizations (NGOs), communities and the public. Specifically information was collected on:

- Maputo City Municipal Solid Waste legislation and regulations;
- National and municipal policies and regulations on solid waste management;
- The current situation in Maputo City MSW with respect to human resources, infrastructure, training, finance, education and awareness programs, recycling, composting;
- Community and public participation in MSWM.

Data on actual municipal waste management practices – refuse container placements, collection times and routes, waste transport, disposal and recycling initiatives, incidence of illegal dumping and of litter – was obtained from personal observation. Relevant data was recorded on data sheets and on maps of the city from observations made walking the city streets.

1.1.5 Dissertation structure

The dissertation has seven chapters. The first outlines Mozambique and Maputo City geographical situation, the problem, the study objectives, research design and dissertation structure. It also presents the general conditions that affect sound Municipal Solid Waste (MSW) practices, such as the level of development of Mozambique, the economic structure, natural conditions (climate and hydrology), land use and the many social problems that aggravate Municipal Solid Waste Management. The second chapter is related to literature review and a theoretical background. The third chapter presents the methodology - data collection, instruments and methods used, and analysis of data. The fourth chapter presents the current situation of Maputo Municipal Solid Waste: Maputo's current Municipal Solid Waste Management (MSWM) practices – organizational structure, generation, storage, collection, transfer, transportation and disposal of waste; MSW partners and private operators; legal controls; attitudes to cleanliness, collection and disposal and the current problems. The fifth chapter presents the observations and results – waste production, collected mass per unit area, available

collection volume for areas of the city, final waste disposal procedures and the results. The sixth chapter discusses and compares the situation in Maputo City to other developing countries of Africa, Asia and South America as well as to developed countries in Europe and North America. The last chapter presents the conclusions: Possible keys to successful MSWM in Maputo.

1.2 General Conditions in Mozambique Affecting MSWM.

There are many factors that occur in a huge number of combinations that affect what should be considered sound practice of Municipal Solid Waste Management in Mozambique, particularly in Maputo City. This research seeks to contribute to and enhance understanding of Maputo City solid waste management. The study seeks also to develop a framework of sound practice with respect to both technology and policy that embodies a reasonable balance between feasible, cost-effective, environmentally beneficial, and socially sensitive solutions to Maputo's MSWM problems. This approach to MSWM is used in the Municipal Solid Waste Management Sourcebook of the United Nations Environment Programme (www.unep.or.jp accessed 08/03/2004).

1.2.1 Level of Development of Mozambique

According to the World Bank Atlas classification system, low-income countries are those with a GNP per capita of equal or less than \$695 dollars (in 1993). Lower-middle income countries have GNP per capita between \$696 - \$2,785, Upper-middle income countries: \$2,786 - \$8,625 and High-income countries have a GNP per capita of equal to or more than \$8,626.

In their consideration of *Environmental Assessment in Developing and Transitional Countries: Principles, Methods, and Practice*, Lee and George (2000) categorise countries according to their per capita national income. The lowest category (annual income per capita of less than 766 US\$) includes 49 countries: their per capita incomes range between 80 (Mozambique) and 730 US\$ (Armenia). It is thus evident that Mozambique falls at the bottom of the lowest category. In my mother tongue we say: "the last goat suffers from the shepherd's stick thus maintaining the flock dynamic". So, as the "last goat" Mozambique requires an incentive to improve the dynamic of its Solid Waste Management. Opportunities for Maputo MSW improvement are however severely constrained by low levels of: human resource development, infrastructure development and lack of access to capital. On the other hand Mozambique offers many

diverse natural resources that can be exploited and as it is starting from a very low base, opportunities to make substantial rapid improvements in MSWM exist, provided these are matched to local realities.

1.2.2 Economic structure

The main Mozambique economic sectors comprise:

- **Agriculture and forestry:** Mozambique has around 15 million hectares of arable land and 4,6 million hectares of forest. This sector generates about a third of the country's GDP, secures more than 80% of total employment, supplies food to the population and raw materials to industry. It contributes about half of the country's exports. (Mozambique Directory of Exporters: 2002)
- **Fishery:** With an area of 1,3 million hectares of inland water and a 2500 km coastline, Mozambique has significant fishery resources in its rivers, lakes, ponds and in the sea. The fishery involves industrial, semi-industrial, artisanal fisheries and sport fishing sectors. The Ministry of Fishery (2006) in their *General Report of Activities 2005* refer the contribution of the main fishing resources in 2004 and 2005 as follows: "industrial and semi-industrial commercial production: 30210 and 26248 tonnes of diverse fishery representing US\$97 and 98 million respectively; artisanal fisheries estimated catch: 60 and 58 million tonnes. Production of other fishing resources in tonnes: 610 (2004) and 1170 (2005). The total volume of export was 16590 tonnes (US\$ 89 million) in 2004 and 16580 (US\$ 97 million) in 2005, a 9% increase".
- **Mineral Resources:** Mozambique has several mineral deposits. These include coal, natural gas, illmenite, grafite, fluorine, gold, marble, granite, precious and semi-precious stones, asbestos, bentonite, diamond, apatite and barite. Bentonite, diamond, apatite and barite are not exploited yet. (Mozambique Directory of Exporters: 2002)
- **Energy resources:** A considerable hydroelectric potential exists, estimated at 11,755 MW. The Cahora Bassa Dam, the second largest dam in Africa and the Chicamba Dam ensure part of the country's needs, as well as exporting energy to the neighbouring countries South Africa, Malawi and Zimbabwe. Apart from this natural gas reserves are estimated at 32 billions cubic meters. (Mozambique Directory of Exporters: 2002)

- **Manufacturing Industry:** The manufacturing sector includes a large number of industries such as chemistry, metallurgy, manufacturing of vehicles tires and tubes, textile and clothes making, hardware, water and electricity matters, soap, batteries, glassware, household utensils, wagons, shaving blades. (Mozambique Directory of Exporters: 2002)
- **Transport:** Mozambique has three international seaports with facilities appropriate for loading and unloading containers. These are located at the coastal cities of Maputo, Beira and Nacala at the south, centre and north respectively. From these ports railways link to the inland countries of Swaziland, South Africa and Zimbabwe (from Maputo); Malawi and Zimbabwe (from Beira) and Malawi (from Nacala). (Mozambique Directory of Exporters: 2002)
- **Tourism:** With an almost endless seafront, an attractive rustic landscape and a variety of wildlife, islands, museums, and beaches the country has many tourist attractions. (Mozambique Directory of Exporters: 2002)

All these sectors were severely and negatively affected during the civil war (1976-1992) as all economic efforts were concentrated on the war. Thus, the economy at that time was called a “war economy”. As a result of the General Peace Agreement (AGP-Acordo Geral de Paz) ending the civil war in 1992, the former centralized economy become a liberal economy. As a consequence the economic growth post war, as well as the growth of population, business and industrial sectors, has been great. The waste generated as a consequence of this growth had become a “headache” for the scarce waste managers faced with the question of how to deal with the problem of waste volume fed by the increases in both sector production and private consumption.

Between 1996 and 1999 Mozambique registered very positive macroeconomic performance. Inflation fell to single digit figures and the annual growth rate of real GDP was above ten per cent, while investment reached an average of around 27 per cent of GDP. The growth was broadly based, including nine per cent growth in agriculture and animal husbandry and 18 per cent in industry (excluding mega-projects). The annual average growth in private consumption was around seven per cent.

(www.govmoz.gov.mz/parpa/source/cap3, accessed 18.08.05)

Two mega-projects, the Mozal aluminium and the Sasol gas pipeline, have transformed Mozambique's balance-of-payments position. In 2000, before the first phase of Mozal came on stream, the country's exports were dominated by prawns, cashew nuts and were

worth less than US\$150m. By 2003 Mozal was contributing half of Mozambican export earnings. In 2005, when Mozal phase II and the Sasol gas pipeline came on stream, the two mega-projects accounted for three-quarters of total export earnings. (www.viewswire.com accessed 18.08.05)

Nevertheless, one of the characteristics of Mozambique is the economic and social inequality between Maputo City and the rest of the country.

Data for Maputo City shows that:

- There is a high concentration of economic activity – 60 per cent of Mozambique's industry is concentrated in Maputo City;
- The city generates 40 per cent of GDP from only ten per cent of the population;
- The GDP per capita of Maputo is higher than in other parts of the country;
- 68.1 per cent Mozambique's service industries – commerce, finance, transport, communications, administrative – are in the city;
- Maputo harbour, as the export port of the Maputo-Witbank Development Corridor, makes a significant contribution to the city economy. (NIS:2001)

These statistics show that there are economic and social differences between Maputo City and other parts of the country, but also that Mozambique and Maputo's economy is growing. The positive macroeconomic performance, the mega-project contributions to total export earnings, the good level of economic development in Maputo City – which is more healthy than other parts of the country – suggests that economic conditions will permit an improvement in Maputo's MSWM. It is thus feasible for Maputo to address municipal waste collection and disposal so as to improve public health and the quality of life of the city's inhabitants as well as to improve city aesthetics.

1.2.2.1 Budget for Maputo Municipal Solid Waste

The 2004 activity report of the Directorate of Hygiene and Cemeteries shows that the budget for Maputo's MSW was: Metical 3000 – 4000 million (between US\$130 000 and US\$170 000) per month distributed as follows: (figure 1.2.1.)

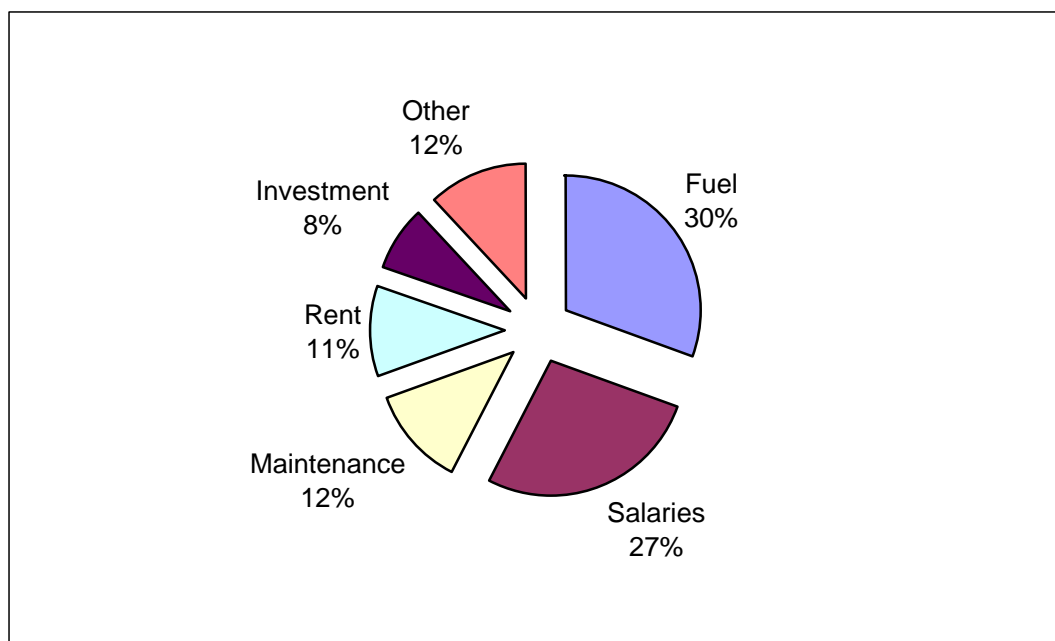


Figure 1.2.1 Maputo Solid Waste Management Budget – 2004

In 2006, the councillor responsible for Maputo’s MSW stated: “The monthly costs for cleaning operations and solid waste collection is budgeted at Mt 3.500 million without including investments. To maintain a clean city will cost 50 per cent more than the current fees collected by Mozambique Electricity Enterprise, which is Mt 1.500 – 1.700 million per month. There is therefore a need to review the criterion of the actual collection fee, introducing a proportional fee system (polluter pays) could be one of the solutions” (Manguana, 2006). (The willingness of Maputo’s citizens to pay a higher fee for waste collection is discussed in chapter 5).

The breakdown of categories of expenditure in the above table shows that fuel and salaries absorb 58 per cent of the MSWM budget. The interviews with both drivers and municipal officials revealed common accord that a primary factor contributing to the low rate of solid waste collection in the city is the high down time of collection vehicles. It can be deduced from the high expenditure on fuel that the high down time of collection vehicles is not due to a lack of fuel. However, expenditure on maintenance seems to be low, suggesting that this may be the reason for many collection vehicles being out of operation at any time. It is not clear precisely what budget categories “investment” and “other” actually cover, as there is little evidence of expenditure on new collection vehicles, sites, buildings or other items of a capital nature.

1.2.3 Natural conditions

In summer the high temperatures (28 – 30° C) decompose municipal waste quickly. A consequence is that unpleasant odours, flies, cockroaches, mice and other vermin are frequent nuisances in some of Maputo's neighbourhoods.

In the rainy season (October - April) the topography of the area causes municipal solid waste that has not been placed in containers to be washed from high lying zones to lower lying areas of the city. The Central B and C neighbourhoods are most affected.

The sea and the prevailing winds from the sea, serve to both aggravate and ameliorate waste management problems. The winds do disperse odours but they also cause waste, not in covered containers, to be blown around the city, creating a nuisance and an environment that is not conducive to public health.

Natural climatic variations also affect the amount and composition of waste during the year. In the rainy season there is a marked increase in vegetable waste because of the fruit harvest (mangos, pineapple, litchis and peaches become plentiful) and availability of vegetables. At this time fruit and vegetables are sold widely by street vendors and from markets: fruit skins and pips and non-edible portions of vegetables are found littering most city streets. From September to April waste on beaches increases due to increased tourism in these months. Waste on beaches consists also of food waste, but includes food packaging, wrapping and beverage containers.

Thus, in planning future waste collection and disposal the seasonal aspect of type and volume of MSW must be considered and allowed for. A MSWM plan that does not allow for seasonal and natural variations will be under resourced for parts of the year and over resourced at others.

1.2.4 Land use

Land use in the city is controlled by zoning and through licensing by the legal authorities. As a result, there is a mosaic of land uses in Maputo City, namely residential, commercial, industrial, agricultural, tourist, harbour, services, railway and green field areas. (Annex Av-5)

The commercial area (formal and informal) includes wholesale and retail trading, markets, informal small trading as well as a recreational park. It includes Alto Maé A

(South), Central A, B and C, and Polana A and B neighbourhoods. The informal commercial areas have a state of cleanliness lower than that seen in the formal commercial areas. Nevertheless, the general state of cleanliness in the city's commercial areas leaves much to be desired.

In the industrial area diverse products are processed and manufactured. Animal, fish and agricultural products are processed. Ironmongers, metal workers and mechanics are found. There are also construction, printing and hardware industries. Generally, in the industrial area the state of cleanliness is better than that found in the commercial area. This is due to the more controlled nature of the activities and more orderly disposal of industrial waste products by the industries concerned.

The tourist area is located along the maritime coast of Maputo Bay. It offers many facilities. There is infra structure for sports and recreation, services, hotels and beach access. Sommershield and Polana A neighbourhoods are in the tourist area. This area is clean and the state of cleanliness is good. One of the reasons for this is that the activities of several Non Governmental Organizations (NGOs) are concentrated in this area. For example, the Environmental Work Group (GTA) carry out their waste collection activity along the maritime coast from Costa do Sol beach to the Aldeia dos Pescadores neighbourhood. Many student groups are also well organized and collect empty bottles, cans and sweep roads along the beach to raise funds for their graduation ceremonies or other student activities.

The harbour area extends some 2.5 kilometres from the Matola River estuary to the harbour school located near the beginning of the Marginal Avenue (Robert Mugabe Square). In the harbour precinct there is a container terminal that handles shipping containers; also facilities for departure and arrival of passengers; and a naval dockyard. The harbour borders on Alto Maé B, Central C, Polana A. The Mozambique railway area (CFM) also falls in this zone. The state of cleanliness in this area is good and similar to the industrial area, due to the generally more controlled nature of the activities and more orderly disposal of harbour and railway waste products by the rail and harbour authorities.

The neighbourhoods of Central C, Polana A and B and Sommershield, form a service area, this is the second largest land use zone (after the commercial district). It includes institutions of State administration, diplomatic representatives, offices, financial

institutions and insurances offices. The state of cleanliness in this land use zone is better than in any of the land use zones mentioned above.

Finally, green open spaces cover 52.6 hectares and occur within Central C (39 ha), Alto Maé B (3.8 ha), Sommershield (2.8 ha) and Polana A (7 ha). There are also public gardens covering 23.8 hectares within Alto Maé A (0.5 ha), Alto Maé B (1.3 ha), Central A (0.5 ha), Central C (9 ha), Polana A (5.5 ha), Malhangalene B (7 ha). The waste generated in these areas is mainly garden refuse. The public gardens are managed by the Municipal Directorate of Gardens and Parks, which have their own sweepers. As a consequence the state of cleanliness in these areas is good and is similar to that of the harbour and tourist areas.

1.2.5 Social problems that aggravate the MSWM system

1.2.5.1 Illiteracy

The statistical data from the last Census (1997) shows that 15 per cent of the capital's population cannot read or write – the national average illiteracy was 60.5 per cent. In Maputo City, illiteracy is higher amongst women than men, 22.6 and 7.1 respectively. Despite the lower percentage of illiteracy in the city, the average educational level of the citizens is grade five, i.e. they have received primary schooling. This poses a challenge for the efficient dissemination of information on waste collection and disposal. It also indicates the extent to which citizen education on appropriate waste management must be addressed when planning future waste collection and disposal services for Maputo City.

1.2.5.2 Unemployment and poverty

Information on unemployment rates in Maputo are scarce and show some discrepancies e.g. the labour force, as enumerated in Census 97, includes economically active unemployed people, while the Ministry of Labour regards only those unemployed persons registered with that Ministry as being without employment. The 2002 statistics from the Ministry of Labour show 6802 unemployed; this is 5.6 per cent of all registered unemployed in the country. However, many people are working in informal activities, mostly in the tertiary informal sector of the economy. The tertiary sector accounts for 68.1 per cent of Maputo's working population. This shows that the urban labour market cannot absorb the economically active population in formal activities. Earnings from informal activities are not sufficient to support urban standards of living

and the social conditions of unemployed people have a negative impact on the city's MSWM system.

Morais (2002) in his *A Future For The Excluded* states that, "where there is no job, therefore there is no future" and concludes that, "without doubt, micro enterprise has an important role in poverty alleviation and must be looked to for a solution to a massive problem of unemployment". This suggests that micro enterprises for waste collection in Maputo City might solve two problems: solid waste amounts and poverty alleviation.

Ibraimo (1994) in her book *Poverty, Employment and Demography Issues in Capital Cities of Mozambique* (Portuguese Version) concludes that: "1) Extreme poverty affects 68% of households. 2) Poverty is greatest in households of median cities, 73%, in small cities 63%, and for Maputo, 61%. These differences are in accord with the nature of the employment available and levels of income generation".

After the General Peace Agreement of 1992, thousands of military soldiers were demobilised; the centralized economy was transformed into a liberal economy that allowed privatisation; and consequently thousands of workers lost their jobs; The Mozambique Workers Organization – Central Trade Union in their *2005 Report* state that in Maputo City 2367 workers lost their jobs in 2004 and 120 000 were employed in the informal sector.

1.2.5.3 Obsolete systems for collection of waste

By observation, Maputo City has an obsolete system for the collection of waste, particularly from city high-rise buildings. Few buildings have waste collecting chutes that are in good condition and properly maintained. There is also insufficient space for collection and intermediate storage of the wastes generated from large buildings. This compounds the difficulty of Maputo's MSWM. Efficient collection of waste streams from buildings housing large numbers of people must be given priority in future waste collection and disposal. The current system of placing large waste collection containers in the streets and expecting residents to carry waste to these common receptacles should be avoided. Building by building waste collection would also allow waste sorting at source; more efficient collection and lower costs; waste-collection tax evasion could be better controlled and the itinerant waste pickers could be placed at fixed locations.

1.2.5.4 Informal land occupation and settlement

The Municipal Directorate of Markets and Fairs recognises three types of markets. There are 14 official markets with infrastructure; 25 official markets without infrastructure; and eight informal (recognised but not formally proclaimed) markets without infrastructure. There are also a large number of unofficial markets. These are known as “dumba-nengue” a word derived from Cichangane and Cironga local languages. Dumba means, “trust, believe” and nengue means “leg”. The derivation is because vendors in these informal markets must trust their legs because they must frequently run away from the municipal police. These informal markets and settlements are largely uncontrolled and their waste products aggravate the MSWM system in the city.

1.2.5.5 Coexistence of rural and urban culture and behaviour

The last Census held in 1997 shows the percentage of people living in Maputo City that speak different languages. The languages spoken in Maputo are Cichangane 34.1%, Portuguese 25.1%, Cironga 20.7%, Cichopi 5.0%, Citswa 4.8%, Bitonga 4.1%, other Mozambican languages 4.1%, foreign languages 1.1%, and unknown 1.0%. There are also different nationalities: Europeans 14.8%, Sotho 9.9%, South African 2.3%, other from southern Africa 6.7%, other Africans 6.3%, Indians 5.7%, Pakistan 5.0%, and other 9.9%, showing different social composition within the city. These figures show that Maputo must consider different cultures and behaviour when dealing with waste in the city. Different cultural norms must be considered in planning future waste collection and disposal. Culturally appropriate schemes would promote sustainable development and environmentally acceptable collection and disposal.

1.2.5.6 High indexes of rural to urban migration

The rural migration to urban areas has different motivations. Looking for jobs and better life conditions is dominant. Maputo City is the major centre of economic growth and thus attraction for rural migrants. Thus, many Mozambicans from different parts migrate to Maputo City. The majority of these people live in informal settlements surrounding the city. This aggravates the problems of the already weak MSWM system.

All of the above social problems constrain effective planning, training and information dissemination for waste collection and disposal and have a negative effect on the city's waste management system.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL BACKGROUND

The literature review covered books, governmental and municipal documents (Reports, Laws, Regulations and Statistics) and articles in web sites. This enabled the researcher to become familiar with the theoretical concepts and the experiences of other countries in Municipal Solid Waste Management.

A summary of literature review findings from UNEP (2001) – *SWM: Regional Overviews* and Palczynski (2002): *Study on Solid Waste Management Options for Africa* is as follow:

2.1 Waste characterization and composition

Waste characterization data specific to African cities are not generally available, though some regional evaluations have been made. The composition of waste varies depending upon such diverse variables as urbanization, commercial enterprises, manufacturing and service sector activities.

Most countries in Latin America and the Caribbean have reports on waste quantification and characterization. Waste quantities generated range between 0.3-1.0 kg/inhabitant/day (this includes commercial, market, and street-cleaning wastes). On average, wastes are very moist (approximately, 45-50% moisture) and have a high organics content (40-50%). Organic content (and, therefore, moisture) tends to be higher in poorer countries.

European countries are probably the most advanced in the world in terms of preparing and maintaining updated municipal waste composition and characterization information. Solid waste programs routinely perform waste sorts in their development phase and national statistics offices maintain yearly standard composition figures, which are used as the basis of system planning.

2.2 Waste collection, transportation and transfer

Most major cities in Africa have an established municipal waste collection system. Collection is carried out by human - and animal-drawn carts (wheelbarrows, pushcarts), open-back trucks, compactor trucks and trailers. Collection rates across the continent

range from 20-80% with a median range of 40-50%. Private operators also provide service on a fee basis to households and commercial establishments. No differentiation is made in the collection of different types of waste, although some municipalities have implemented higher taxes for commercial waste.

There is considerable variation in collection and transport systems in South and West Asia. The most important issue in collection for most countries of the region is the irregularity or lack of municipal service for squatter settlements or congested low-income areas. Collection rates vary from 20%-90% of municipal wastes. The frequency of scheduled collection is partly governed by climate and by the system in use. In the poorer countries of the region, collection rates can be lower than 50%.

A number of large cities in Latin America and the Caribbean have fairly good waste collection coverage. The waste collection system of all other cities in the region is still deficient. Frequency varies all the way from daily to once a week (not including the many areas of cities which are not serviced at all). Throughout South America, Mexico and Costa Rica, transfer stations have been installed or are in the process of being installed. The transfer stations are usually owned and operated by the agency responsible for solid waste management in the city.

Waste collection in Europe differs considerably among regions and countries, based on densities and degree of economic development. Most Western European countries organize waste collection in twice-weekly, weekly, or biweekly routes using 120 or 240-liter rolling carts, which are collected with semi-automated compactor trucks, usually having dual self-dumping lifts. Transfer in most cases consists of the compactor truck or other type of collection vehicle (such as an open truck, pickup truck, or wagon) arriving at the transfer facility and dumping its load of waste into a pit or onto a tipping floor. A front-end loader or bulldozer usually loads the waste onto a conveyor or a chute, from which it goes into a special compacting container. These are usually of large capacity and have high compaction ratios and are used to densify the waste for more efficient long-haul transportation.

Sound practice depends on well-chosen collection frequency and timing. In developing or tropical cities, collection occurs as often as once per day. In most industrialized cities, collection occurs once or twice per week and even more frequently in urban areas where storage space is limited.

2.3 Composting

Backyard composting is limited. Some NGOs promote the practice in Benin, Cameroon, Egypt, Ghana, Kenya, Nigeria, South Africa and Zimbabwe but the practice does not have a significant impact on MSWM at the city level. Backyard composting is a longstanding tradition in countries like Australia, Japan and New Zealand, especially in rural towns. Centralized composting has not been successful in Latin America and the Caribbean.

2.4 Landfills

Landfills range in type from uncontrolled open dumps to secure sanitary landfills. In Africa landfills are primarily open dumps without leachate or gas recovery systems. The overwhelming majority of landfills in Africa are open dumps. Several are located in ecologically or hydrologically sensitive areas and are generally operated below the standards of sanitary practice. Uncontrolled, open dumps are not a sound practice, but controlled dumps and sanitary landfills can provide effective disposal of a city's MSW in accordance with appropriate local health and environmental standards. Landfilling is an unavoidable component of all European waste systems. In certain Northern European countries, less than half of the waste may be land filled; while in southern countries like Greece and Spain, or Eastern European countries such as Hungary and Poland, virtually all waste finds its way to land burial. The European Union Landfill Directive (1999) identifies three kinds of landfills: for hazardous waste, for municipal waste and for inert materials. Monofills - landfills for one particular material - are also recognized in the directive. The use of landfills in Latin America and the Caribbean has increased significantly in the last decade. All capital and other large cities in South America, Mexico, Costa Rica and Trinidad and Tobago have landfills of some sort. Many of these landfills, however, are more like controlled dumps.

On-site scavenging disrupts landfill operations in many parts. The majority of waste pickers work without proper protection, sometimes lacking basic protection such as shoes. The average income for a waste picker is frequently above minimum countries wage.

2.5 Financing

For developing countries in general, financing options for waste disposal include taxes, user fees, bank financing (for private service providers) and international aid. The central government is the main mechanism by which these options are exploited. The Treasury generally controls the collection of taxes and the flow of funds to municipalities.

MSWM services account for a high percentage of the municipal budgets in developing countries. An average of 50% of their municipal operating budget is spent on MSWM and of this, 70% is spent on collection. In general, there are three sources of funds, namely, municipal taxes, fees charged for services and subsidies from municipal revenues received from government sources. There are several forms of levy: (a) direct fees based on waste volumes; (b) indirect fees derived from, for instance, property taxes; and (c) fees collected with payment of electric bills, or with water bills based on floor area and annual rental values of properties.

In South and West Asia most urban administrations do not have adequate financial resources to establish and maintain all aspects of sound waste management. They have difficulty raising loans for major improvements in collection, transportation and disposal. Solid waste management consumes 20% (or much more) of the total municipal funding for services and within this the salaries and wages component is usually over 75% of the annual expenditure on MSWM. Funds for capital investment are inadequate. Cities often have difficulty raising loans for infrastructure needs and must rely on agencies such as the World Bank, or national agencies such as the Housing and Urban Development Corporation in India. A great handicap to financial planning is that most municipalities do not actually know what the various components of MSWM cost them, as financial reporting systems are poorly organized. In addition, the funds needed for operations, maintenance, etc., may come from different categories of the municipal budget and be administered by departments other than that for solid waste.

The financing of solid waste systems in Western Europe is widely accepted to be a government responsibility. In most cases, local jurisdictions, mostly at the municipal level, have a statutory responsibility for collection of residential waste. The extent to which this function is actually performed by the government varies.

Financing mechanisms depend mainly on the management system used, but politics also weigh in the decision making process. Large-scale financing of solid waste operations has become available through bilateral and multilateral agencies such as the World Bank, the Interamerican Development Bank and the governments of industrialized countries (the German government has provided a significant contribution). These financing projects include technical assistance for institutional strengthening as well as for investment in infrastructure.

2.6 Maintenance

Poor maintenance of collection equipment is a well-documented problem in most developing countries. It is not uncommon for one-third or more of the municipal fleet to be out of service at any one time. For developing countries, the use of imported or a high technology collection vehicle that cannot be procured or repaired locally makes this problem still worse.

2.7 Management and planning

Solid waste management in most African countries is characterized by inefficient collection methods, insufficient coverage of the collection system and improper disposal of municipal wastes. Specific waste management legislation is generally not available, although it is being drafted in some countries.

Professionals in Latin America and the Caribbean agree that management and planning are the central issues that need to be addressed urgently to improve services in MSW. The actual execution of day-to-day MSWM operations is carried out by a combination of official municipal workers and fee-based contractors from the private sector.

2.8 Private sector involvement

In all countries there is some level of private sector involvement in solid waste management. This involvement comes at all points in the waste management chain (during recycling, collection, transport and disposal) and is carried out by all sizes of enterprises, from large-scale multinationals to small-scale enterprises. The efficiency of these private sector enterprises varies significantly. The informal sector represents a significant part of the economy and waste recuperation and recycling is an important activity.

2.9 Definitions of Waste and Municipal Solid Waste

The definition of waste is complex. The complexity results on the one hand from the characteristics of waste types and on the other from the diversity of sources producing wastes.

Bilitewski et al (1997) in their *Waste Management* state: "The term waste is defined in the German Waste Act of August 27, 1993. According to this definition, wastes are portable objects that have been abandoned by the owner (subjective definition). The term waste can also be used in reference to the orderly disposal of garbage as required for the protection of public health and in particular of the environment (objective definition)³".

The United Nations Environment Programme glossary of terms (2000) defines wastes as: "substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law".

The South African Environmental Conservation Act 73 of 1989 defines waste as: "any matter, whether gaseous, liquid or solid or any combination of these states, originating from any residential, commercial or industrial area or agricultural area identified by the Minister of Environment Affairs as an undesirable or superfluous by-product, emission, residue or remainder of any process or activity".

The Mozambique National Environmental Act (20/97 of 1st October 1997) defines waste as: "any matter or objects requiring orderly disposal to protect the public welfare".

Speight (1996) in his *Environmental Technology Handbook* states: "waste is any material that is especially hazardous to human health, air, or water, or which are explosive, flammable, or cause disease; which is poisonous, noxious, or polluting and whose presence on the land is liable to give rise to an environmental hazard; hazardous waste is waste material that is unsuitable for treatment or disposal in municipal

³ In this definition are not included those wastes covered by the Animal Carcass Removal Act, the Animal Disease Act, the Plant Protection Act, the explosives Act, the nuclear Energy Act, mining wastes and wastes emitted as gaseous substances or discharged into surface waters or water treatment facilities.

treatment systems, incinerators or landfills and therefore requires special treatment". From this same book (p.144) he states: "It is appropriate to consider non-hazardous chemical waste (solid waste, the municipal refuse and garbage produced by human activities) along with hazardous waste because it may not be non-hazardous in all situations and may interact with hazardous wastes or produce a hazardous waste by chemical reaction. Thus a waste that is currently classed as non-hazardous can, depending upon the circumstances, be reclassified as hazardous".

The Resource Conservation and Recovery Act of the United States defines solid waste as: "Garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining and agricultural operations, and from community activities⁴". The same legislation defines hazardous waste as "a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may: (1) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed".(Speight 1996)

Bernstein et al (2004) in their *Social Assessment and Public Participation in MSWM* state that: "a solid waste may be semi-solid, solid or even a liquid and is generally perceived by society as lying within the responsibility of the municipality to collect and dispose of it".

From the above it can be seen that there are several approaches to defining waste. One approach is based on "product" appearance; another on economic value; a third on origin; a fourth on physical state; a fifth on toxicity; and, finally, portability. Thus the term waste encompasses:

- By-product, emission, residue, remainder, garbage, refuse, sludge, pollutant;
- That is regarded as undesirable, discarded, disposable, abandoned, having no perceived use (no longer being useful);

⁴ This definition does not include the solid or dissolved materials in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges that are subject to permits.

- Which is generated by (or through) communities, residential, domestic, household, commercial, mining, industry, agricultural, activities, operations or processes;
- That can be gaseous, liquid, solid, or any combination of these states;
- Can also be hazardous or non-hazardous;
- And either portable or non-portable.

Bernstein et al (2004) identify sub-categories of General Urban Waste: “household garbage and rubbish, yard waste, commercial refuse, institutional refuse, construction and demolition debris, street cleaning and maintenance refuse, dead animals, bulky wastes, abandoned vehicles and sanitation residues”. Thus, Municipal Solid Waste as considered in this dissertation is a particular sub-set of general urban waste (see Table 2.1).

The UNEP *Solid Waste Management: Glossary* (2000) defines Municipal Solid Waste (MSW) as: "all solid waste generated in an area except industrial and agricultural wastes. It sometimes includes construction and demolition debris and other special wastes that may enter the municipal waste stream. It generally excludes hazardous wastes except to the extent that they enter the municipal waste stream. Sometimes MSW means all solid wastes that a city authority accepts responsibility for managing in some way".

The World Bank *Glossary of MSWM terms* (2000) states: "Municipal Solid Waste (MSW) includes non-hazardous waste generated in households, commercial and business establishments, institutions, and non-hazardous industrial process wastes, agricultural wastes and sewage sludge".

Bilitewski et al (1997) in their *Waste Management* present Municipal Solid Waste (MSW) as: "Household, bulky, household-like commercial, yard, open market, C&D [construction and demolition] waste; street sweepings; municipal sewage, sanitary district, wastewater treatment and water treatment sludge".

The Final Status Quo Report of the City of Cape Town, *Integrated Waste Management Plan* (2004) states: “Municipal solid waste generally comprises domestic, industrial and commercial wastes. Primarily households generate the bulk of municipal solid waste. The broad definitions of the different waste stream are as follows: Household waste means any solid waste (including garbage, refuse) derived from households;

Commercial solid waste means all types of solid waste generated by stores, offices, restaurants, warehouses and other non-manufacturing activities, excluding residential and industrial wastes; Institutional solid waste means solid waste originating from educational, health care (excluding medical waste), correctional and other institutional facilities; Non-processing waste generated at industrial facilities such as office and packaging wastes”.

The United States Environmental Protection Agency (EPA) states that, "MSW includes wastes such as durable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous wastes from residential, commercial, institutional and industrial sources (Bilitewski et al: 1997)".

Bernstein et al (2004) in their *Social Assessment and Public Participation in MSWM* states that, “Municipal Solid Waste (MSW) refers to wastes arising from domestic, commercial, industrial and institutional activities in an urban area. Municipal solid wastes encompass all those wastes that are neither wastewater discharges nor atmospheric emissions”.

For the purpose of this dissertation Municipal Solid Waste is taken to be the portable, solid, non-hazardous by-product (garbage, refuse) that is regarded as undesirable and has been discarded, disposed of, or abandoned as having no perceived use (or no longer being useful) and which is generated by residential (domestic, household) and commercial, activities or processes and which requires orderly disposal to protect public welfare and the environment.

For Maputo City MSW includes solid wastes generated from households (any garbage, refuse, yard trimmings), household-like commercial wastes (all types of solid waste generated by stores, offices, restaurants, open markets, warehouses and other non-manufacturing activities). It also, includes institutional solid waste (waste originating from educational, health care (excluding hazardous medical waste), correctional and other institutional facilities, non-processing waste generated at industrial facilities such as office and packaging wastes and street sweepings. The study does not encompass municipal sewage, sewage sludge, wastewater treatment and water treatment sludge, industrial or hazardous wastes.

Table 2.1 Urban waste types and characteristics

Waste type	Characteristics
Construction & Demolition (C&D) waste	Construction debris, construction site debris, excavated material and road construction debris.
Organic waste	Biodegradable component of waste (e.g. food and yard waste).
Excavated material	Uncontaminated, naturally clean or fill soil and rock material.
Sanitary district sludge	Sludge from small or large local sanitary districts.
Yard waste	Grass clippings, leaves, and the tree branches from gardens, public places, graveyards and green spaces.
Household waste	Waste, predominantly from private households, associated with municipal or private collection; food scraps, old newspaper, discarded paper from miscellaneous sources, wood, lawn trimmings, glass, cans, furnace ashes, old appliances, tyres, worn out furniture, broken toys, etc.
Commercial waste	Waste with characteristics similar to household waste where collection and disposal is done in the same manner. Means all types of solid waste generated by stores, offices, restaurants, warehouses and other non-manufacturing activities, excluding residential and industrial wastes.
Discards/Residues.	Waste remaining after recycling or material recovery.
Municipal sewage sludge	Sludge generated at municipal or industrial wastewater plants including dried/dewatered or otherwise treated sludge.
Market waste	Waste generated in markets, fairs, etc., such as vegetables, fruit and nonreusable packaging material.
Production-specific industrial waste	Wastes from industries, businesses, or other facilities, which can be treated as municipal waste.
Wastewater treatment residue	Rakings, sand, and grease trap residue from

	wastewater treatment plants, as well as residues from canal and gutter cleaning.
Street sweepings	Wastes generated during street cleaning, including road surface break-up, tire tread, leaf litter and road salt.
Recyclables	Waste material that can be reused or processed into intermediate or new products.
Hazardous waste	Pesticides, Radioactive waste
Municipal Solid Waste (MSW)	Household, bulky, household-like commercial waste, yard, market, C&D waste; municipal sewage, Sanitary district, Wastewater treatment, water treatment sludge. Generally comprises a domestic, industrial and commercial waste stream.

Elaborated from: Bilitewski (1997); IWMP (2004); Turk (1978); Lombard et al., in Fuggle & Rabie (1994)

2.10 Definition of Municipal Solid Waste Management

Lombard et al (1992) state that, “the management of waste is a multi-disciplinary exercise and requires the input of a team, with a wide field of expertise, in order to deal comprehensively with the many facets of the waste management problem. Management is the execution of planned controls so as to achieve a desired outcome”.

Bernstein et al (2004) in their *Social Assessment and Public Participation in MSWM* state that, “Municipal Solid Waste Management (MSWM) refers to the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste generated in urban areas; is a major responsibility of local government and a complex service involving appropriate organizational, technical and managerial capacity and cooperation between numerous stakeholders in both the private and public sectors. MSWM encompasses: refuse storage and collection, street and drain cleaning, solid waste transfer and transport, solid waste disposal and resource recovery; also involves vehicle maintenance repair; financial management; administrative activities such as routing, scheduling and record keeping; staff management and development and strategic MSWM planning. Generally, these facilities fall within the jurisdiction of the municipality, but the private sector often manages some domestic refuse and the wastes from large-scale industries, hospitals and large office complexes”.

Bilitewski et al (1997) state that, “waste management encompasses the collection, transport, storage, treatment, recovery and disposal of waste; also the sum of all measures of waste avoidance, non-harmful treatment, recovery, reuse and final disposal of waste of all types while giving due consideration to ecological and economic aspects. Aside from the organizational, structural and technical measures of waste treatment the following should also be considered: i) When further waste treatment is neither economically nor technically feasible, controlled landfilling should be the final method of residual waste disposal; ii) Thermal treatment of waste for energy recovery and the reduction of the total waste quantity (energy recycling); iii) Biological treatment of organic waste for the improvement and development of cultivated soil (biological-natural cycle); iv) Chemical-physical conversion of hazardous and reactive organic and inorganic waste into a form which allows environmentally appropriate storage followed by thermal or material recovery or disposal and; v) Treating and processing waste into primary and secondary materials and the associated conservation of primary resources and primary energy (raw material recycling)”.

Municipal waste collection and disposal regulations from Portugal and Brazil consider waste management as “operations that encompass collection, transport, storage, treatment, recovery and disposal of waste, including the management and planning of disposal sites after closing”. (Regulamentos Municipais de Remoção e Eliminação de Resíduos Sólidos: Lisboa-2004, Coimbra-1995, Braga-1995, Porto-2006, Rio de Janeiro-2003).

Kocurek and Woodside in Speight (1996) states that, “waste management refers to an organized system for waste handling in which chemicals pass through appropriate pathways leading to elimination or disposal in ways that protect the environment”.

The World Bank (2000) *Urban Waste Management*: glossary of MSWM terms states MSWM is: “Supervised municipal solid waste management from their source of generation through collection or street sweeping, recovery and/or treatment/ processes to disposal”.

Thus, for the purposes of this study Maputo’s Municipal Solid Waste Management (MSWM) will be regarded as an organized, planned and supervised system for solid waste handling; a multi-disciplinary exercise that requires the input of a team, with a wide field of expertise; that encompasses refuse storage and collection, street cleaning, transport, disposal and resource recovery/recycling and composting of solid waste; that

involves vehicle maintenance and repair; financial management; administrative activities such as routing, scheduling and record keeping; staff management and development and strategic MSWM planning; it will be regarded also as a complex service involving appropriate organizational, technical and managerial capacity and cooperation between numerous stakeholders in both the private and public sectors and a major responsibility of local government as well as of all the inhabitants; that involves also policies, legislation and regulations; training, education and awareness programs; community and public participation which the final aim is to achieve a desired outcome in ways that protect the environment including the management and planning of disposal sites after closing.

CHAPTER THREE: METHODOLOGY

3.1 Data collection

During the field observations in Maputo data was collected through formal recorded interactive interviews, the administration of questionnaires, informal interviews, direct observations, listening to broadcasted interviews and from photographs.

In Cape Town study visits were also made to the Bellville, Muizenberg and Faure municipal landfills, to the Athlone and Wynberg transfer stations and to the private Wasteman Group Company. These study visits introduced the researcher to landfill operation methods, sorting processes at the sites, the type of infrastructure used as well as to the general organization of urban solid waste management. In Maputo, the new Mavoco landfill (for hazardous waste) was also visited.

Reports and written data were found in Maputo at Maputo's Municipal Library and Eduardo Mondlane University Library - Arquivo Histórico de Moçambique; In Cape Town, at the University of Cape Town specialised areas of the Chancellor Oppenheimer Library: the Knowledge Commons, African Studies, Government Publications and Current Journals.

3.1.1 Formal and Informal Interviews

Formal recorded interviews were conducted with senior staff in the Municipal Directorate of Hygiene and Cemeteries. The chiefs of respectively, collection, control and disposal sectors were interviewed. (It was not possible to interview the sweeping sector chief because he was not available at the time.) Waste collection drivers, road sweepers, collection crew and disposal workers were also interviewed but no recordings of these less formal interviews were made. In order to conduct interviews credential letters were required. These were authorised and issued by the Directors of each sector. Once these letters were issued the interviews could take place. Before the formal interviews, prior arrangements were made with the people to be interviewed. The objectives of this study and the interview plan were given to the interviewees when the time and place for the interview was arranged with them individually.

Informal oral interviews were conducted with members representing Non Governmental Organizations that deal with environmental matters and waste collection. Specifically,

contact was made with the Group of Environmental Work (GTA), the Association of Environmental Friends and the Mozambique Association. These discussions were conducted to obtain some idea how these NGOs relate to the municipality regarding waste collection and disposal and to obtain their views on MSWM in the city.

Informal waste collectors were also interviewed, as well as a representative of a small enterprise involved with domestic waste collection. Conversations with waste pickers took place when such persons were found scavenging in the city.

Annex Ai-1 gives an indication of the type of questions that were asked and the interview plan.

Finally, interviews with Municipal Councillors responsible for Maputo's MSWM which were broadcast by the Mozambique Radio on 10th November 2005 (Maputo City Day) as well as on 17th January 2006 were taped and studied. These interviews were not conducted by the researcher but as they relate to the current municipal waste situation in Maputo City and the so called 'Mirror Campaign' aimed at relocating informal street vendors from the city streets to official markets they were helpful and are consequently included.

3.1.2 Questionnaires

The questionnaires were directed to the Director of the Maputo Directorate of Hygiene and Cemeteries, the Head of the Hygiene Department and to the chiefs of the collection, sweeping, control and disposal sectors. Questionnaires were also used to obtain information from the former Director of the Directorate of Hygiene and Cemeteries and National Government officers in the Ministry for Coordination of Environmental Affairs' Directorate of Impact Assessment and Urban Department. These questionnaires aimed to collect data and opinions as to the adequacy of the Maputo MSW collection system as well as information relating to the organizational structure employed for Maputo SWM. These questionnaires were delivered personally to the respondents to ensure that they were received and would be completed personally. They were also personally collected after completion to ensure a high response rate. The questionnaire used will be found in Annex Aii-2b.

Questionnaires were also used to obtain responses to MSWM from Maputo citizens, as well as owners of commercial and industrial enterprises. The objective was to find out their degree of satisfaction with municipal waste collection services and their

willingness to pay higher collection fees for an improved service. The questionnaire for citizens was completed by focus groups, while commercial and industrial owners or managers completed questionnaires individually. The citizen focus groups were conducted amongst neighbourhood residents, market vendors and students at schools. (Annex Aii-2a and Aiii-3b)

For neighbourhood residents the criteria used to select participants were: persons over 18 years old who indirectly pay waste collection fees because they have electricity supplied to their homes.

At markets and schools groups were gathered together during breaks (20 minutes) in order to not disturb their main activities. The market controllers and class heads were helpful. Students from the Pedagogical University of Maputo helped as facilitators in the process. Prior to running the focus groups short training sessions were held for the 25 geography students who assisted in the research.

Groups of five students were assigned to each of the five city districts according to their place of residence. Each student was asked to access 255 citizens (50 people in neighbourhood groups, 75 people in market groups, 100 students in school groups). Each student was also asked to administer the questionnaires to owners or managers of 15 commercial and 15 industrial enterprises in the assigned city district. During the three weeks taken by this survey responses were obtained from 6375 persons drawn from 37 of the city's 66 neighbourhoods, from 34 of the 47 city markets. Thus 56% and 72.3% coverage of neighbourhoods and markets was attained. In addition, 15 secondary schools and three Higher Educational institutions were surveyed. (Annex Aiii-3a Neighbourhoods, markets, schools surveyed) This survey is discussed further in section 5.7.1.

3.1.3 Direct Observations

Direct observation was made by walking and collecting data along all roads and avenues in the central city. The locations of municipal refuse containers, of informal disposal areas and of litter prevalence sites were observed and mapped over the period (June-December 2004; June-December 2005). While mapping the locations of municipal refuse containers citizen behaviour regarding waste disposal into municipal containers was also observed and recorded.

Direct observations were also made at Hulene disposal site. Here data was gathered on the amount of waste disposed of, the operational methods being employed and the equipment being used to both deliver waste to the site and for managing the waste on the site.

At the zones peripheral to the city centre observations of container locations, citizens' behaviour regarding waste disposal and how people use recyclables were made from traverses conducted by car.

3.2 Analysis of data

Collected data were analysed comparing waste generation produced per capita in each of the city's districts in Maputo City as well as waste generation produced per capita and disposal in Maputo City with other cities and countries. The points of view of the stakeholders, their perceptions of each other, and sound practices over the world were also compared.

Maputo's Municipal Solid Waste collection and disposal were compared within the city's districts and to other developing and developed cities and countries.

A map showing the location of waste containers was produced for this study using the data collected. The map was produced at DINAGECA (National Directorate of Geography and Mapping) and drawn by CENACARTA (National Centre of Cartography) it is attached to this report. (Annex Aiv-4a); Annexes Aiv-4b,c,d and Av-5 were produced by the author.

CHAPTER FOUR: THE CURRENT SITUATION OF MUNICIPAL SOLID WASTE MANAGEMENT (MSWM) IN MAPUTO CITY

4.1 Current Maputo Municipal Solid Waste Management Procedures

4.1.1 Current administrative structure for MSWM in Maputo

The current Maputo City Council was elected in 2003 having campaigned under the “lemma” slogan. The lemma campaign was “You and me will improve Maputo’s face”. This means that all citizens have been asked to contribute to solving problems that affect the city. This dissertation is an example of a contribution to the lemma campaign as it seeks to improve Maputo’s face by addressing the city’s waste management problem.

Maputo City Council operates through eighteen Directorates; six support services; and seven district administrations. Municipal Solid Waste Management falls under the Directorate of Hygiene and Cemeteries and has the following organizational structure: (Figure 4.1)

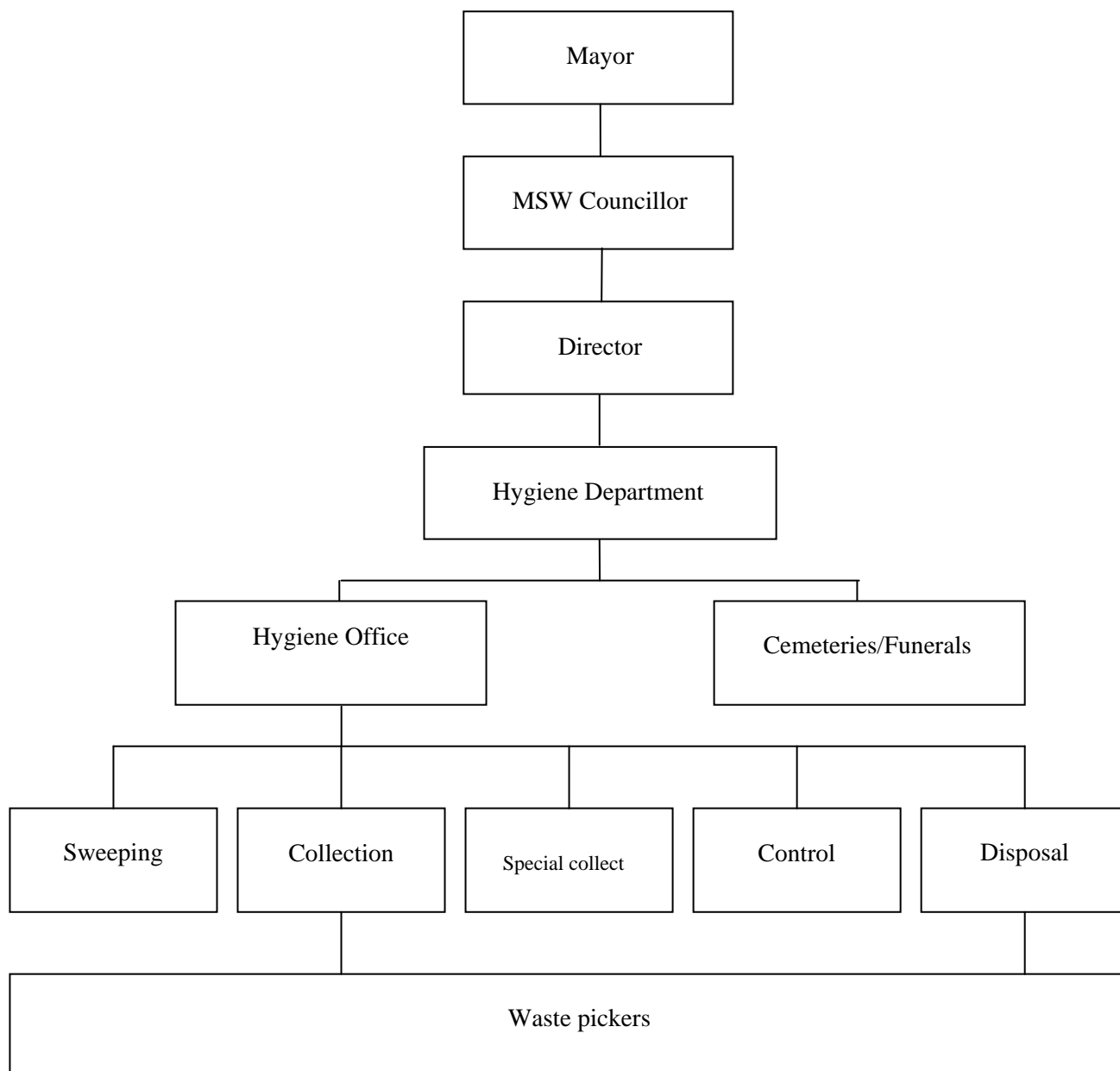


Figure 4.1. Maputo's MSW organizational administrative structure

The total personnel involved in the Directorate of Hygiene and Cemeteries is slightly over 800, of which 426 are hygiene department workers. Figure 4.2 shows the functions of personnel deployed in the Hygiene Department:

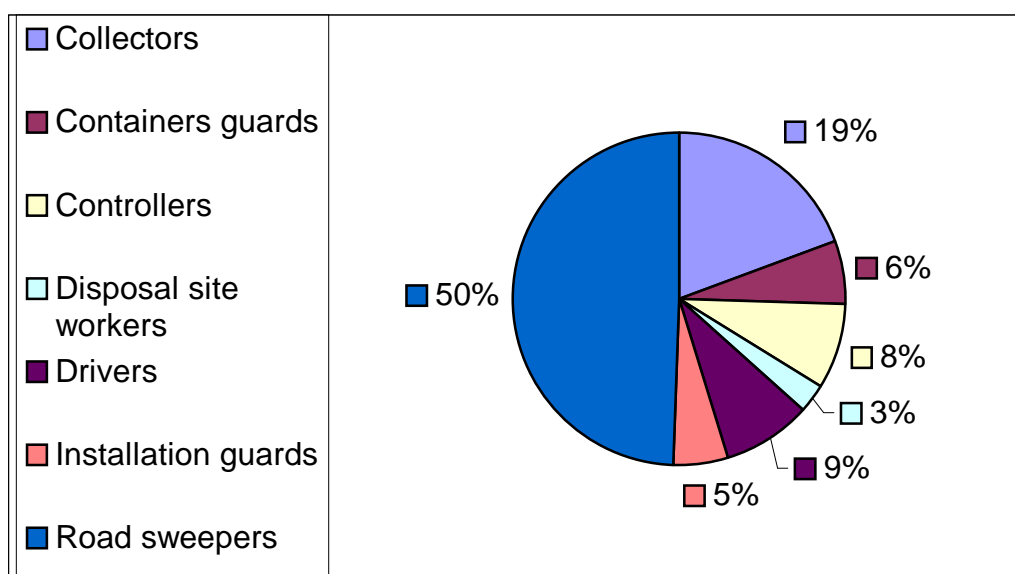


Figure 4.2. Hygiene Department Personnel – 2004

Source: MDHC – Department of Human Resources

The functions performed by Health Department staff are as follows:

Collectors remove waste from the municipal public containers and place it into trucks or compactors. Container guards are responsible for the public containers around the city, their job is to ensure that containers are not vandalised or stolen (not to collect litter or to ensure that waste is properly disposed of in the containers). Installation guards are responsible for the security of site equipment and infrastructure for all municipality properties excluding containers. The disposal site workers show collection drivers where to dump waste loads on the disposal site and the caterpillar operators spread waste within the site. Waste site controllers take note of all vehicles going in and out of the disposal site, collect disposal fees and issue receipts. Drivers are the persons responsible for collection trucks, compactors and support vehicles. Road sweepers sweep roads and avenues.

In 2006 compulsory retirements and institutional reforms are being undertaken in an attempt to rationalise and streamline waste management in Maputo. The personnel figures given above will change because of this.

In 1992, Mozambique set up a National Commission for the Environment, a structure that in 1994, two years after the Rio Summit, became the Ministry for Coordination of Environmental Affairs (MICOA). A National Program for Environmental Management was approved in 1995. This program outlines the objectives, activities and means to

implement Agenda 21. The National Environmental Policy was brought into being through Resolution 5/95, of August 3rd 1995. The main objective of this policy is to improve the life quality of the Mozambicans. MSWM in Maputo is subject to the provisions of these programs and resolutions; the city is thus also subject to national administrative structures.

It has been shown that there is a complex administrative structure for MSWM in Maputo. But it has also been shown that policies to promote environmental management have been adopted and actions are being taken to streamline waste management in the city. An attempt is being made to improve waste collection and disposal in order to achieve the National Environmental Programme objective.

4.1.2 Waste Generation in Maputo City

In Maputo City, the main sources of Municipal Solid Waste are residential houses and apartments, commercial establishments, schools, government offices, entertainment areas and hotels. These produce the following:

- Garbage (waste from preparation of food);
- Trash (paper, wood, garden refuse, cans, glass and crockery);
- Ashes (residue from fuel and combustion of solid waste);
- Bulky wastes (furniture and appliances).

In addition the municipal infrastructure (streets and public places) produces streets refuse (street sweepings, branches and leaves from trees and interestingly wilted flowers from city cemeteries). Medical units generate non-infectious medical wastes.

Maputo City has different rates of waste generation per-capita between the central city and its periphery. Estimates made by the Municipal Directorate of Hygiene and Cemeteries in 1998 and by GTZ (a German governmental organization) in 2002, are shown in table 4.1.

Table 4.1 Estimates of MSW generation in Maputo (kg per capita per day)

	1998	2002
Central City	0.65 – 0.75	0.54 – 2.16
Peripheral	0.25 – 0.50	0.45 – 0.55

Source: MDHC 1998 and GTZ Project 2002.

Maputo is growing: its population, area and waste generated are all increasing. Table 4.2 shows estimates of the increasing waste generated in tonnes as well the increased population and city area in hectares for 1998, 2003 and 2004.

Table 4.2 Estimates of Increasing MSW generation, Population and Area of Maputo

	1998	2003	2004
MSW generated	300 tons/day	455 tons/day	660 tons/day
Population	987943	1073938	1216873
Area*	6250 ha	9442 ha	10208 ha

*Not included: railway, airport, green lands, military and agricultural areas as well as Inhaca island, and Catembe Districts.

Elaborated from: Cuna (2004); MDHC (2004); NIS (2002); MD of Mapping (2002)

In 2002, the GTZ also studied the composition of MMSW as a percentage of wet weight this is as follows:

Table 4.3 Composition of MSW in Maputo – 2002
(Percentage of wet weight)

Waste Component	Central City	Peripheral
Organic material	67	29
Garbage	4	6
Paper	13	2
Plastic	10	4
Metals	2	1
Glass	4	1
Others	-	57

Source: AGRESU/GTZ Project, 2002.

4.1.3 Temporary Storage

“On-site storage is where solid waste generated is stored for collection by the municipal authority or its contractor” (WHO-EHC, accessed 14.Sept.2005). In Maputo City, individual householders temporarily store their solid waste on their properties in metal or plastic bins, plastic bags, baskets and dishes of different sizes and capacities. But in Maputo the municipality does not collect domestic waste from private properties! It is the responsibility of householders to take their waste from their properties and to deposit it in large waste receptacles (also termed bins or skips) that the authorities place at intervals on public roads. Commercial establishments, schools, government offices, entertainment areas and medical units use metal or plastic containers of larger sizes and capacities and these are collected by the municipality.

In Maputo City the public waste receptacles are metal containers of various sizes: the smallest is 1100l, the mid size is 6 m³ and the largest is 10 m³. These containers are placed in different locations and either singly or in groups. It is frequent for three or four 1100l containers to be placed together while 6 m³ containers are found in pairs. The

10 m³ containers are usually found alone. Only the 1100l containers are covered by lids, but due to the excess amount of waste deposited in them they are in fact seldom covered. In general the 6 and 10 m³ containers are in a better state of repair than the 1100l containers. This is due to the more robust construction of the larger containers and also because the smaller units have to be handled more frequently. The distance of these public waste receptacles to houses varies from 10 to 300 m.

As there is no control over the type of waste, the frequency with which it is deposited by householders, or access to waste receptacles by waste-pickers, sanitary and aesthetic conditions at waste receptacle locations vary widely. In locations where receptacle volume exceeds waste generation and waste-pickers do not remove waste from the receptacles conditions are good. In places where receptacle volume is inadequate waste overflows and is scattered by waste-pickers as well as by wind and scavenging animals. In these instances conditions are poor.

4.1.4 Collection in Maputo City

Due to the system of waste management in Maputo two phases of collection must be recognised: primary and secondary.

In the city centre domestic helpers, commercial establishment employees, or junior family members undertake primary collection (from point of waste generation to municipal public receptacles). The waste is transported from homes and offices in plastic bags of different sizes and types, in dishes, by muscle-powered vehicles and by wheelbarrows. In the more rural parts of the city primary collection is made by small entrepreneurs.

Domestic helpers generally carry out waste when they are released from work. Normally this occurs between 16.30 and 19.00, from Monday to Saturday while commercial employees carry out their wastes when the establishments close. The commercial establishments from Monday to Friday close between 15.30 and 19.00 and on Saturdays between 13.00 and 15.00. Junior family members typically take out waste from 17.00 to 23.00. The small entrepreneurs working on a fee basis in peripheral districts perform their work during the day. They collect garbage from the residences and sweep the roads and avenues in rural areas. They use muscle-powered vehicles (Tchovas) and wheelbarrows to transport waste from generation point to municipal receptacles. This can be regarded as good practice.

Due to the size of the municipal waste receptacles, junior family members generally leave their waste on the ground near a container, making it accessible to scavenging animals. Domestic helpers frequently throw their bags of waste from a relative distance. Sometimes the bags burst open or miss the receptacle, causing litter and unsanitary conditions around the municipal waste receiver. When the municipal receptacles are full of waste, citizens leave their waste on the ground near the container. Whenever waste is not correctly placed in the municipal waste receptacles, collection crews take more time collecting the waste that is not in the container. Further, collection crews are not responsible for collecting the litter and refuse dispersed around the container.

NGOs, communities, local partners, are also involved in primary waste collection. This occurs mainly in the coastal zone and is a service preformed as a civic service as part of the lemma campaign.

The Maputo primary waste collection system leaves much to be desired. It is a feature of waste collection that requires attention in Maputo's future MSWM planning.

A variety of secondary collection systems is used in Maputo City to collect waste from the public waste receptacles and to transport it to the disposal site. The Municipal Directorate of Hygiene and Cemeteries (MDHC) provides a free collection service (the cost of the service being recovered through a levy on electricity payments); private operators also collect waste (usually from larger commercial and industrial premises, though also from some wealthy neighbourhoods) under contract to the municipality which remunerates them for this service.

The official time for municipal solid waste collection is from 9.00 pm to 6.00 am daily, but in reality collection occurs at any time. The collection of waste from the public receptacles is made by vehicle compactors in the case of the 1100l receptacles, skip loaders are used for the 6 m³ receptacles and Roll-on Roll-off loaders for the 10 m³ public waste receptacles.

The City Cleanliness Ordinance, Chapter V, Article 28 states that wastes must be deposited in municipal waste receptacles daily between 17.00 and 20.00. However, most citizens do not know this. Interviews undertaken as part of this research, with approximately four hundred people depositing their waste into municipal containers between 20.00 and 23.00 revealed that most people (240 out of 400) do not know of this

regulation relating to the time for waste disposal. This suggests that the regulation must be made known to the citizens and enforced.

During the interviews the waste disposal behaviour of citizens was also noted. Many Maputo citizens were seen to dispose of their waste in inappropriate places and not in the municipal receptacles. There is clearly room for public education on appropriate waste disposal behaviour.

4.1.5 Transfer

Maputo City has no transfer stations or other processing facilities for the MSW. Once secondary collection is undertaken the waste is taken directly to the Hulene waste disposal site.

“Transfer activities often increase efficiency, for both small- and large-scale systems. In small-scale transfer, micro-enterprises or cooperatives bring waste to a centralized area for pickup by private or municipal trucks. In large-scale transfer, waste is transferred from a compactor or small truck to larger trailer trucks. Both types of transfer activities save fuel, reduce wear and tear on trucks and shorten the amount of time spent travelling to and from the landfill” (WHO-EHC, 14.Sept.2005).

As Maputo city increases in size it will be necessary for intermediate transfer stations to be established in order to achieve the advantages given in the previous paragraph.

4.1.6 Transportation

Once collected Maputo City waste is transported to the dump site in a variety of ways. The municipality normally uses compactor vehicles of 1100L; skip loaders of 6 m³; and Roll-on Roll-off (Ro-Ro) vehicles capable of handling of 10 and 16 m³ waste receptacles. They also use open backed trucks and tractors that tow open trailers. The municipality's 2004 operational fleet for waste transportation is show in table 4.4. The small entrepreneurs tend to use muscle-powered vehicles (Tchova), tractors, wheelbarrows and donkey carts to transport waste.

Table 4.4 Maputo MSW transportation equipment - 2004

Equipment type	Vehicles	Make
Compactor 1100 L	6	Scania/Iveco
Skip Loader 6 m ³	4	Mercedes Benz
Ro-Ro 10 m ³	4	Scania/Iveco
Open Vehicle 5 m ³	2	Tata
Open Vehicle 7 m ³	2	Scania/Iveco
Closed Vehicle	1	Mercedes Benz
Tractors (2,5 m ³)	5	Massey Ferguson

Source: Department of Transport and Maintenance, MDHC.

At the time this study was being conducted seven of the vehicles in the municipal fleet were completely out of order and four others were awaiting repair, i.e. 46% of vehicles are out of action. Some vehicles have been purchased since 2001 but the majority are more than five years old.

The number of vehicles that are non-functional is seriously affecting transportation of MSW to the Hulene dump. With fewer vehicles operating the frequency with which waste receptacles can be emptied is decreased, resulting in receptacles overflowing before they can be removed. Once waste has spilled from the receptacle it also takes longer for the waste to be collected, further lengthening collection frequency. Collection vehicle maintenance is a topic requiring immediate attention in Maputo.

4.1.7 Disposal: Hulene Site, Equipment and Infrastructure

The Hulene waste disposal site is located in a former wetland. The Hulene River – used by riparian residents as a source of water –, borders it on the west. The entire site is surrounded by residential properties, some homes being situated less than 20 metres from the edge of the unfenced site.

The total area of the site is 12 hectares, however only eight hectares are available for waste disposal due to a portion of the site having been invaded by informal housing and a further portion being allocated for a civil war cemetery. (Due to the high water table the area has, however, never been used as a cemetery.)

The Maputo City disposal site is an open, partly-controlled, dumpsite, called Hulene. It is located in a neighbourhood B with the same name. It is some 10 km north of the central city. The site operates 24 hours a day. There are three shifts: 06.00 - 13.00; 13.00 - 20.00; and 20.00 - 6.00. It is managed by the City's Directorate of Hygiene and Cemeteries. The Hulene disposal site is now the only legal disposal site in the city. (Before Hulene was started in 1973 an earlier disposal site was located where today the District 2 neighbourhoods of Munhuana and part of Chamanculo B are found.)

Hulene receives different types of wastes from all economic and geographical sectors of the city. Estimates are that approximately 70 per cent of the total Municipal Solid Waste generated in the city is disposed of at Hulene. (The other 30 per cent being illegally dumped). In rural districts, many people bury or burn their waste. Because the Hulene site has no weighbridge, accurate data on received waste is poor. The mass of waste dumped has been estimated from a record of the number of vehicles entering the site as well as from the load recorded for each vehicle. e.g. 20 x 3 tonne entries = 60 tonnes waste. This study estimates that approximately, 360 tonnes of solid waste is being received daily at Hulene. Vehicles entering the site dump their loads where directed with little or no regard for the type of waste they are carrying. Domestic refuse, organic materials that could be composted, office waste, non-infectious medical waste as well as industrial waste all find their way onto the dump.

On-site there are twelve salaried municipal employees who register entries, direct vehicles, spread waste and guard and control the site. These employees have had little or no training in solid waste management.

There are also approximately one hundred waste-pickers, of different ages and gender, sorting various recyclables. The majority of these waste pickers are 20 - 40 years old. There is no organised system of waste-picking and as waste is deposited onto the dump it is scavenged by the waste-pickers. They collect scraps of food, cardboard, pieces of wood, old metal and plastic bags. The items collected are sold to buyers who come to the dumpsite or who operate stalls close to the dump or at markets such as Xipamanine, Xiquelene and Hulene. To support the waste-pickers in their work, there are about ten persons selling food, water and soft-drinks to those working on the dump.

Once the waste has been picked-over the site's bulldozers spread and partially compact the waste. There is no heavy-duty waste compactor and no attempt is made to cover the waste with inert soil, or other cover material, once it has been spread.

The tipping fees for waste disposal at Hulene are shown in Table: 4.5.

Table 4.5 Hulene waste disposal tipping fees-2004

Quantities	Cost in MT
1 m ³	15000
2 m ³	30000
3 m ³	45000
4 m ³	60000
5 m ³	75000
6 m ³	90000

US\$1~ Meticais 25 000

In 2004 the tipping fees collected from the Hulene disposal were as shown in Table 4.6.

Table 4.6 Tipping fees collected at Hulene Site – 2004

Month	Sum collected MT
March	19 600 000
April	19 800 000
May	17 800 000
Jun	19 400 000
July	18 600 000
August	21 100 000
September	19 300 000
October	19 900 000
Average	19 400 000

Source: Calculated from Hulene Registration Book – 2004

The Hulene waste disposal site is not suitable as a site for a sanitary landfill. It is situated on a former wetland, is close to a river as well as to residential areas. The soil is

permeable and sandy. The site is also not managed and operated as a landfill; there is no separation of waste entering the site; compostable materials are not removed; waste is not compacted nor covered with inert soil. The site is unfenced, there is no capping to prevent the entry of rainwater into the waste pile and there is no leachate control or monitoring system. A smoke haze covers the area due to the wastes smouldering and burning beneath the surface.

A new and properly engineered waste disposal site is definitely needed by Maputo City.

4.1.8 MSW Partners and Private Operators

Maputo's MSW partners are, among others, GTZ (Germany Cooperation for Development) which supports MSM office administration and capacity building; UCCLA (Luso African Capital Cities Union) which provides uniforms, 1100L containers and brooms; World Medicine - Mozambican Community helps train citizens in procedures and methods of waste disposal and publicises the timetable for waste collections by means of notices pasted on city waste containers.

During 2004 around fourteen private companies were working together with MDHC under contract to provide cleaning and waste collection services in Maputo. These companies are paid by the MDHC for the services they provide. These services supplement those provided by the city. Their methods of operation are essentially the same as those of city staff; they clean specific neighbourhoods and are also responsible for carting waste receptacles to Hulene to dispose of the collected waste.

4.2 Legal controls

The country's authorities at national and local levels are conscious of and committed to addressing solid waste problems. An overview of the central government programme (2005-2010) on the environment shows that it gives special attention to environmental management at national level. It requires that the country's development not affect the environment negatively and that natural resources, which are the base of the country's development, must be exploited and used without compromising the economic, social and cultural needs of the present and future generations. Thus, the government is committed to developing a system of environmental management as part of an integrated programme of sustainable development and to define the duties, obligations and competence required from those involved in environmental management. Among

other national actions, research with regard to infrastructure systems such as water supply, drains, hygiene, sewers and solid waste management are mentioned. The local government programme (2004-2007) for Maputo City aims to reduce poverty, improve the urban environment, promote public management and strengthen gender equity. The actions are to reinforce the urban management capacity with special emphasis for developing municipal and community potential, thus improving life quality for Maputo's citizens.

All this shows that the country's authorities are considering solid waste matters at both national and local levels and attempts are being made to streamline waste management.

A brief review of national legislation relating to the solid waste and Environment overlapping this study follows:

The new Constitution of the Republic (the 3rd since 1975) states⁶:

"All citizens shall have the right to live in and the duty to defend, a balanced natural environment".

"The State and local authorities in collaboration with environmental associations shall adopt policies to defend the environment and to ensure a balanced use of all natural resources" (Art.87: Right to environment).

The National Environmental Act (20/97 of 1st October 1997) defines waste as:

"any matter or objects requiring orderly disposal to protect the public welfare";

and hazardous waste as:

"[Waste] which poses risk because of its flammability, explosiveness, corrosivity, toxicity, radioactivity or other characteristics that pose a danger to human life or health or to other animals and to the quality of the environment".

Law 8/97 of 31st May 1997 (related to the system of municipalities in the country) defines the special norms that guide the organization and function of Maputo municipality. Among other functions waste collection and disposal is made a municipal

⁶ Free translation from the Portuguese text by the author

council task. Article 6, 1(b) requires the city to address environment, basic hygiene and life quality; Article 45, 3 (p) relates to fee collection, treatment and disposal of solid waste; Article 46, (d) stipulates collection processes, treatment and disposal of solid waste, including medical waste and pesticides;

Under Law 11/97 of 31st May 1997, Article 25, 1(b) relates to collection systems, waste treatment and public hygiene. While under the same Article point 1(i) refers to environmental management.

The National Policy on Environment was approved through resolution 5/95, of August 3rd 1995. The main objective of this resolution is to secure proper life quality for Mozambican citizens. It aims at ensuring that the management of both the environment and natural resources is done in such a way that these components maintain their functional and productive capacity in order to meet the needs of both present and future generations. It also aims to develop an environmental awareness among people so as to allow for public participation in the management of the environment and natural resources.

To promote environmental integration and development in the process of decision making there is also:

- A National Council for Sustainable Development (Article 6, National Environmental Act) with the duty of coordinating the actions for environmental management for sustainable development.
- A Regulation on Environmental Impact Assessment (EIA): No 76/98 RB No 51 Series I; 29/12/98.
- A further Regulation on Environmental Impact Assessment (EIA): Decree 45/2004; requiring an Impact Assessment Study and the issue of an environmental licence for all infrastructures relating to waste management and disposal. This regulation also requires that vehicles used for waste transportation and all waste management operators require licenses.

A National Ministry for Coordination of Environmental Affairs (MICOA) was created in December 1994. This Ministry is responsible for the implementation of the National Environment Management Programme (NEMP) and the National Environmental Policy. However, within this Ministry there is no unit responsible for formulation of a National Environmental Waste Management Plan (NEWMP). The structure, role and function of

such a unit should be designed, taking into account the different waste management sectors, Environmental and Institutional waste bodies and committees. The senior staff members of this unit should be representative trained persons coming from different waste generating sectors for example, Municipal, Industrial, Agricultural, Mining, Medical, Pesticides and Commercial. In addition, overall solid waste management plans at both the national and local levels are essential for using the scarce resources most effectively. Therefore, the formulation of national and local strategic plans for solid waste management should be considered in future planning SWM.

A summary of the solid waste regulation used by the MDHC follows:

The main regulation for MSW collection and disposal currently in use is the Maputo City Cleanliness Ordinance of November 5, 2001. It has 13 chapters, 51 articles and two single page annexes. Chapter one contains 11 articles and outlines the cleanliness of public places (object, cleanliness timetable, private roads, scope of cleanliness, collection of special wastes, waste storage, waste transportation, cleanliness crew, norms of waste collection and disposal, domestic landfills and transgressions); Chapter two has seven articles and is related to yard refuse and cleaning (scope refuse, compulsory cleaning, refuse collection, agriculture growth, composting plants, special collection from yards and disposal prohibitions); Chapter three has four articles and outlines building cleanliness (compulsory cleaning, hygiene system, overflow sewers and drain water); Chapter four has five articles and is related to receptacles (receptacle models, acquisition, maintenance, location and identification); Chapter five has three articles and deals with wastes (disposal timetable, collection contracts and owner of waste collected); Chapter six has four articles and deals with crematoriums and garbage landfills (garbage landfills, private crematoriums, procedures for oven usage and waste picking); Chapter seven has six articles and deals with receptacles collection (excreta collection system, receptacle models, collection fees, inquiries, compulsory collection fee and period/time of collection); Chapter eight has two articles and is related to dead animals and diverse detritus collection (collection conditions and inspection prior to collection of dead animals); Chapter nine has five articles and deals with sewer and drain cleanliness (scope of sewer and drain cleaning, initiatives by authorities to ensure sanitary cleanliness, opening sewer lids, sewer conservation and collection timetable); Chapters ten and 11 have one article each and are related to water transportation services and prohibited attitudes respectively; Chapters 12 and 13 also have one article

each and are related to fees and fines and final dispositions. Finally annex one and two are tables of fees and fines.

There are some problems with this Cleanliness Ordinance. For example, chapter three (building cleanliness) article 19 point number 9 refers to article 53, which does not exist in the regulation (this suggests a plagiarized document or fault when updating the old regulation to the new situation). Nevertheless, the ordinance has useful information that should be disseminated to Maputo's citizens, enforced and upgraded to current environmental circumstances. However, the presentation and structure of the ordinance does not help to promote the solid waste management approach. In future planning waste collection and disposal for Maputo City this regulation needs attention and should be considered for revision.

All this shows that there is goodwill to streamline solid waste management in the country and particularly in Maputo City. Policies and legislation are being adopted to improve waste collection and disposal and to promote environmental management. The main gap is that policies and legislation need to be enforced, suggesting that control mechanisms need attention, to ensure effectiveness.

4.3 Attitudes to cleanliness, collection and disposal

Two weeks of observations at two waste collection points in the Alto-Maé A and B neighbourhoods were undertaken. From 20:00 to 23:00 citizen attitudes and behaviour related to cleanliness, collection and disposal of waste was noted and recorded. A further two weeks were spent observing at Coop and Malhangalene neighbourhoods from 16:00 to 21:00. In all cases it was noted that waste was carried out to the municipal disposal receptacles by domestic helpers, establishment employees and junior family members. Methods for disposal left much to be desired; junior family members had difficulty using the containers properly. It was also noted that collection crews took 10-15 minutes for a normal collection at a waste collection point, but 30 minutes to one hour when waste was out of containers.

Official work hours in Maputo are 07:30 to 15:30. Outside these hours most city streets, avenues and roads are open to small traders. They sell different commercial and non-commercial marine fish species, grilled chickens, meat, fish and non-consumable goods. This practice is in fact against municipal regulation and because there is no collection of wastes from these activities they contribute to poor basic hygiene and quality of life. In

District 1 “night street traders” are mostly along Marginal, Eduardo Mondlane, 24th July, Ahmed Sékou Touré, 25th September Avenues and 25th Square. In other districts this phenomena does not occur to the some extent.

In Maputo the municipal waste controllers and municipal police unit do not collaborate with the national police or controllers from companies, central government, the community and private units in curbing inappropriate citizen conduct. To combat the waste nuisance those in authority must work together. Intensive formal and informal basic education, lead by the municipal authorities, should be provided in an integrated manner. Local and religious communities, vendors in open markets, private and government control bodies, schools, the commercial sector, private security services, local authorities, Non Governmental Environmental Organizations (NGOs), churches and individual citizens must all be engaged. The mass media (private and government) can play a significant and positive role. Advertisements in public places, meetings and other convenient forms of communication must be used to disseminate information. Rather than Portuguese, other languages must be used to reach non-Portuguese speakers (which are the majority).

From the informal interviews conducted it is deduced that the majority of Maputo’s population thinks that MSWM in the city is a task exclusively and entirely for the municipal council and for the national government. This attitude needs to be changed so that each citizen perceives solid waste as a personal problem too. Effective management of solid waste requires the cooperation of the general public. It is, therefore, important to ensure that public and decision makers' awareness activities are incorporated into the SWM planning. Once the interests of the public and decision makers in improving solid waste management are created, the effectiveness of solid waste management will be significantly improved. Enhanced awareness of decision makers may lead to changing national socio-economic and industrial development policies and associated government programmes in favour of improving solid waste management systems. For instance, more financial and tax incentives may be introduced to encourage the development of recycling industry and business, or labourer protection programmes may be provided to improve wages and working conditions of labourers, including solid waste management workers.

4.4 Current problems

The current problems influencing MSWM in Maputo City are of different types: social, economic, political and biophysical. This section focuses on problems relating to the generation, storage, collection, transportation, treatment and disposal of municipal solid waste.

4.4.1 Generation

Table 4.2 shows that the amount of waste being generated in the city is increasing. A consequence is that the MSWM system is not able to handle it properly and that the environmental, public health and problems of city aesthetics are being exacerbated.

4.4.2 Temporary storage

The municipal waste bins or skips are placed on public roadsides and generally waste generated between collections exceeds container volume. The result is waste overflowing. As collection is irregular and high temperatures (28 – 30° C) decompose waste quickly, unpleasant odours, flies, cockroaches, mice and other vermin multiply. In addition, winds spread odours and cause waste to be blown around the city affecting the environment and consequently the life quality of the citizens. A further problem is that 6 and 10 m³ waste receptacles are not easy to use for most junior family members.

4.4.3 Collection

In both primary and secondary phases Maputo's MSW collection is facing problems. The main difficulty in the first case is related to weak knowledge of correct waste disposal into municipal receptacles amongst those involved (domestic helpers, establishment employees and junior family members).

Secondary phase collection experiences many problems. The number of vehicles that are non-functional, the high frequency of down time for collection vehicles (especially skip loaders and Ro-Ro) is seriously affecting transportation of MSW. Down time causes collection frequency to be decreased, further weakening the already stressed collection and transportation system.

The use of different vehicle makes (Scania, Iveco, Mercedes Benz, Tata and Massey Ferguson) add to the problems of mechanical maintenance. With few trained personnel in vehicle maintenance the time needed to fix non-operational vehicles increases.

Further problems are lack of spare parts locally, or weak management to the existent stock of spares (cases of missing spare parts are known). In addition, well-trained drivers to operate these high technology vehicles are required.

4.4.4 Transportation

In Maputo the 6 and 10 m³ waste receptacles are not covered. The result is that wastes fall along the route when transported to the disposal site. This aggravates the existent general state of the city's cleanliness.

4.4.5 Treatment and disposal

Hulene waste disposal site is not suitable as a site for a sanitary landfill. The location in a former wetland, close to a river used by riparian residents, to residential areas, to an airport, primary school; the soil is permeable and sandy; the site is open and unfenced; it has no weighbridge; there is no heavy-duty waste compactor; waste is not covered with inert soil or other cover material; there is no separation of waste entering the site thus, compostable materials are not removed and domestic refuse, organic materials, office waste, non-infectious medical waste as well as industrial waste are mixed and all find their way onto the dump. In addition, there is no capping to prevent the entry of rainwater into the waste pile and there is no leachate control or monitoring system; a smoke haze covers the area due to the wastes smouldering and burning beneath the surface; the site is characterised by vermin, flies, odours and dust.

Further problems are that a portion of the site has been invaded by informal housing; the site employees have had little or no training in solid waste management; there is no organised system of waste-picking;

All this shows that solid waste is not being treated and disposed of properly at the Hulene site and this has negative effects on the environment, public health and city aesthetic.

CHAPTER FIVE: OBSERVATIONS AND RESULTS

5.1 Waste Generation

Observations were made at Hulene disposal site over a two week period to obtain data on the amount of waste disposed of. The mass of waste dumped was estimated from the official record of the number of vehicles entering the site as well as from the load recorded for each vehicle. This method has disadvantages. As there is a tipping fee for waste disposal (see table 4.5) the load recorded for each vehicle is not always that actually transported. The tendency is for most private sector vehicles to declare low loads in order to pay as little as possible (for municipal vehicles disposal is free). On the other hand the capacity recorded for municipal vehicles (example, 7 m³), as well as for private vehicles under contract to the city, is often an over estimate of load as no allowance is made for partially loaded vehicles to be appropriately recorded. Consequently, this estimate of the waste quantity disposed of at Hulene must be regarded as an approximation. Similarly, the results presented below may have some weaknesses as it is not easy to accurately determinate the amount of waste produced in Maputo City for the following reasons:

- 1) Municipal vehicles entering the site bring waste from all districts and collected by compactors of 7 m³; skip loaders of 6 m³; open back trucks of 5 and 7 m³; Ro-Ro of 6 and 10 m³ and tractors of 2.5 m³. Waste collected from open markets is normally by skip loaders and Ro-Ro of 6 and 10 m³.
- 2) As Hulene received all types of waste at the time these observations were being made, it was often not clear whether waste was of domestic origin or not.
- 3) The city's rural districts burn and bury their wastes and this is not reflected in the statistics. Nevertheless, to cross check, the results obtained were compared to the skips' available capacity and good agreement was found.

Table 5.1 shows the number and capacity of Municipal and private vehicles entering the Hulene site in 2004 and provides estimates of the mass of waste being deposited. A density of 400 kg per m³ has been assumed for waste carried in compactor trucks and a density of 200 kg per m³ for uncompacted waste carried by trucks and tractors and in open skips. The density for compacted waste is in accord with expected values provided by Nair (1993) and Lederman (1976). The density of 200 kg per m³ for uncompacted waste is higher than the figure used for industrialised countries (150 kg m⁻³) to allow for the increased wet weight of wastes in developing countries (section 2.1 and Table 4.3).

Table 5.1 Municipal and private vehicles entering the Hulene site – 2004

Number of Vehicles	Vehicle capacity	Number of Collections	Volume Collected per day m ³	Volume per week m ³	Density in kg per m ³	Mass per day (ton)	Mass per week (ton)
6	7	6	252	1764	400	100.8	705.6
4	6	12	288	2016	200	57.6	403.2
4	10	12	480	3360	200	96	672
2	5	9	90	630	200	18	126
2	7	6	84	588	200	16.8	117.6
5	2.5	9	112.5	787.5	200	22.5	157.5
			1306.5			311.7	2181.9
Private							
100	2.5	1	250	1750	200	50	350
All City			1556.5			361.7	2531.9

From 2004 vehicle entries to the Hulene site the total amount of waste being deposited is around 360 and 2500 tonnes per day and per week respectively. Thus, the solid waste collected in Maputo City in 2004 was found in this study to be 360 tonnes per day (one tonne being equivalent to 1000 kg). This figure is not in agreement with the estimate provided by the municipality – 660 tonnes per day. “Currently Maputo City with around two million of inhabitants generates 660 tonnes of waste daily (Machava referring the MSW councillor in Daily Journal Noticias: 666 – 15.06.06:3-4). See also table 4.2, chapter 4.

The city’s estimate that daily waste disposal increased by 205 tonnes or 68.9 per cent between 2003 and 2004 (Table 4.2) must thus be viewed with caution and some scepticism. The estimates of increased daily waste disposal from 1998 to 2003 (five years) of 155 tonnes, or 31 tonnes increase per day each year, are more realistic. The difference between 2003 and 2004 is a very large increase for one year despite the current favourable climate for running business in the city and the high rural migration and is deemed to be an error.

A cross check of the waste generated by the city is possible because the capacity of waste receptacles placed in the city is known as is the frequency of collection. A waste density of 300 kg per m³ is used for the 1100l receptacles as these contain mainly

domestic and household wet wastes rather than paper and plastics. (It is these receptacles that are compacted to a density of 400 kg per m³ in compactor vehicles for transport to Hulene). Waste generation within the city is, however, not uniform. Table 5.1.1 provides details of the number of containers counted in each district, how frequently these are collected, appropriate densities and determination of the mass of waste generated per week in 2004.

Table 5.1.1 Waste generated by Districts in Maputo City – 2004

	Number of containers	Volume Available m ³	Collection Frequency per week	Volume collected per week	Density kg/m ³	Mass per week (ton)
District 1						
1100 L	189	207.9	21	4365.9	300	1309.77
6 m3	45	270	15	4050	200	810
10 m3	5	50	15	750	200	150
Total D1						2269.77
District 2						
1100 L	11	12.1	21	254.1	300	76.23
6 m3	4	24	6	144	200	28.8
10 m3	5	50	6	300	200	60
Total D2						165.03
District 3						
1100 L	0	0	7			
6 m3	6	36	6	216	200	43.2
10 m3	1	10	6	60	200	12
Total D3						55.2
District 5						
1100 L	0	0				
6 m3	6	36	6	216	200	43.2
10 m3	0	0				0
Total D5						43.2
Total all Districts						2533.2

District 1, the central business district (CBD), is the major generator, producing on average 2200 tonnes of solid waste mass per week. This is 90 per cent of the city total. This is because collection coverage is more concentrated in this district; waste buried and burned in peripheral districts is not accounted for. But this waste is also not transported to Hulene.

Collection from Maputo peripheral districts is made by tractors of 2.5 m³ capacity and represents 10 per cent of the total. The city's outlying districts thus generate 260 tonnes of solid waste mass per week.

This method of determining waste generated in Maputo is in very close agreement to the determination that was made from vehicles entering the Hulene disposal site and thus provides confidence that Maputo's waste generation is close to 2500 tonnes per week, a figure approximately half of that estimated by the city authorities.¹

5.2 Collected mass per unit area of city districts

Table 5.2.1 provides details of Maputo waste collection by city district. Mass collected per district was determined from waste volume containers available, density and collection frequency. The area of each district was obtained from official municipal statistics. District 1 clearly has the greatest waste production per unit area (273 kg per hectare per day) and thus has potentially the biggest problem of waste disposal. As District 1 covers the Central Business District of Maputo the fact that it produces more waste per hectare than other parts of the city is not surprising. However, Table 5.2.1 shows that Maputo waste collection is largely concentrated in District 1. The mass of waste collected from the others districts combined (37.62 tonnes per day) is a small percentage of total daily waste collection (10 per cent). Clearly the city's waste collection effort is being focussed on the CBD and waste collection from most of the city's districts deserves greater attention.

¹ Since the fieldwork for this study was completed a weighbridge has been installed at Hulene. During 2006 a mean mass of 360 tonnes of waste per day has been measured.

Table 5.2.1 Waste collected in tonnes per hectare

Districts	Volume Available m ³	Waste Collected tonne/day	Waste Collected tonne/week	Area (ha)	Tonne/ha/day
D1	527.9	324.25	2269.77	1186.1	0.2733
D2	86.1	23.57	165.03	704.2	0.0334
D3	46	7.88	55.2	1243.8	0.0063
D5	36	6.17	43.2	4751.7	0.0012
D4	0	0	0	2324	0

5.3 Available volume per unit area

A measure of waste collection potential is volume of waste container space available in each of the city's districts. Table 5.3.1 shows the cubic meters available for waste collection in each district of the city. Available volume is again highest in District 1 (0.4450 m³/ha). Space for waste collection per hectare is far lower (by an order of magnitude) in the other city districts. The implication of this is both that better collection should be expected in District 1 (as is found), but also that problems associated with poor waste collection—when collection is disrupted for any reason—will be greater in the Central City.

Table 5.3.1 Volume available per unit area

Districts	Volume Available m ³	Area (ha)	m ³ /ha
D1	527.9	1186.1	0.4450
D2	86.1	704.2	0.1222
D3	46	1243.8	0.0369
D5	36	4751.7	0.0075
D4	0	2324	0

Table 5.3.2 provides a neighbourhood-by-neighbourhood breakdown of waste collection within the central city area. It shows that within District 1, Alto Maé A and Central B are best catered for in terms of waste collection. Despite the better availability of waste containers and waste collection volume in District 1, the neighbourhoods of Sommersfield, Coop and Polana A are in fact the neighbourhoods that have the best state of cleanliness despite having lower waste collection volume available per unit area (0.09, 0.31, 0.38 m³/ha respectively). In these neighbourhoods there are embassies, diplomatic bodies and governmental offices and the homes of wealthy families. In these neighbourhoods, waste is collected from each premises in clear plastic bags. Residents in these areas are not required to place their waste in public containers.

Alto Maé A has good volume available per unit area (1.3 m³/ha) but in fact the rate of cleanliness is lower. Although Alto Maé A is a residential area with a middle-income population, it is bordered by Xipamanine neighbourhood (District 2), which has the biggest market in Maputo. To cater for waste from the market 28 m³ of waste collection volume is located in Alto Maé adjacent to the market. The availability of waste collection volume in the neighbourhood is thus not as favourable as it first appears. Another reason for Alto Maé A having a poorer state of cleanliness is that the city's major informal mega market – Estrela Vermelha, is located in this area without the necessary infrastructure to support the market activities.

Alto Maé B has 76.2 m³ (more than Alto Maé A) but the available volume per unit area is lower (0.82 m³ per ha). This neighbourhood is divided in two parts: residential (North), with a middle-income population, and an Industrial zone (South).

The rural District 4 is anomalous. No collection currently occurs in this district. However, with the improvement of the city's waste collection it is likely that in the future collections will occur in this district. This will add to the waste volume that will find its way to the official disposal site.

Table 5.3.2 Volume available per unit area and per capita in CBD neighbourhoods

Neighbourhood	Land use	Volume m ³	Area (ha)	m ³ /ha	Population	L/capita
Alto Maé A	Rm	64.7	47.3	1.367	13 000	4.97
Central B	C	53.7	55.3	0.971	17 300	3.10
Alto Maé B	Rm	76.2	92.3	0.825	18 500	4.11
Malhangalene A	Rm	36	46.8	0.769	12 300	2.92
Central A	C	45.4	60	0.756	15 300	2.96
Polana B	C	51.6	79.3	0.650	15 000	3.44
Malhangalene B	RL	50	94	0.531	20 000	2.50
Polana A	C	38.5	100.5	0.383	12 600	3.05
Central C	C	57.5	174.8	0.328	11 600	4.95
Coop	R+	20.8	65.8	0.316	7 500	2.77
Sommersfield	R+	33.5	370	0.090	13 400	2.50

Key to Land Use

R+ - Residential area with wealthy families

Rm - Residential area with middle-income population

RL - Residential area with low-income population

C – Commercial

5.4 Waste produced per capita (kg per day)

One measure that permits a comparison of waste generation and disposal in Maputo City with other cities and regions is waste produced per capita. Table 5.4.1 provides comparative waste generation in some African cities. (See also chapter six, table 6.1)

Table 5.4.1 Waste generation rates (in kg per capita per day) for African cities.

City	Ton/day	kg/capita/day	Population in millions	year
Cape Town	6000	0.5-2.5	2.5	2002
Dar-Es-Salaam	2000	0.34-0.39	3.5	1996
Durban	5000	0.5-1.5	2.0	2003
Accra	1200	0.5	1.6	2004
Ibadan	-	0.5	-	2001
Dakar	-	0.5	-	2001
Abidjan	-	0.5-0.8	-	2003
Lusaka	1400	0.5	1.5	2001
Tema	900	0.5	141,479	2004
Nairobi	1000	-	2.1	2001
Maputo	360	0.4	1.1	2004

Sources: Anomayo (2004); UNEP (2001); The World bank (2001); Palczynski (2002); City of Cape Town State of Environment Report (2002)

It is evident from Table 5.4.1 that Maputo at 0.3 kg per capita per day is not out of the ordinary when compared to developing countries (0.3 – 0.6 kg per capita per day). It also has identical waste generation per capita as Dar-Es-Salaam. It is however lower than the more developed cities of the world (0.7 – 1.8 kg per capita per day) and to the South African cities of Cape Town (0.5 – 2.5 kg per capita per day) and Durban (0.5 – 1.5 kg per capita per day). Nevertheless, in the central city waste per capita is far closer to the levels of waste for developed countries. Table 5.4.2 shows that District 1 in fact exceeds the average waste production of developed countries (at 2.07 kg per capita per day). This suggests that although on average Maputo is in accord with developing cities, in reality Maputo's waste production is skewed by the large amount of waste from district 1. If this District were omitted from the analysis Maputo's waste generation per capita would be below that of most developing countries. The average waste produced in the city as a whole is 0.3 kg per person per day.

Table 5.4.2 Waste produced per capita in Maputo Districts

Districts	Volume available m ³	Collected mass per week (tonnes)	Collected mass per day (tonnes)	Population	kg/capita
D1	527.9	2269.77	324.25	156,500	2.07
D2	86.1	165.03	23.57	162,650	0.14
D3	46	55.2	7.88	210,551	0.03
D5	36	43.2	6.17	232,008	0.02
D4	0	0		228,244	0
Total	696	2531.9	361.7	989,933	0.3

5.5 Available capacity per capita

An indication of better potential and a good situation for good waste management is given by available capacity per capita. This is shown in Table 5.5.1. The table shows that despite a lower population in District 1 it is in that district where there is a better potential for good waste management (3.3 litres per capita). As was mentioned above, District 1 is the central city business area. In other districts the capacity available per capita decreases, the volume decreases and the population increases. Table 5.5.2 provides a neighbourhood-by-neighbourhood breakdown of available capacity per capita within the central city area. A better potential for good waste management is found in Alto Maé A (4.9 litre per capita). Alto Maé A, Central C, Alto Maé B are commercial and residential areas but include formal and informal markets (Central, Povo, Mandela 1 and 2, Estrela Vermelha).

Table 5.5.1 Available capacity per capita per District

Districts	Volume (L)	Population	L/Capita
D1	527 900	156,500	3.37
D2	86 100	162,650	0.52
D3	46 000	210,551	0.21
D5	36 000	232,008	0.15
D4	0	228,244	0

Table 5.5.2 Available capacity per capita per Neighbourhood

Neighbourhood	Volume (L)	Population	L/Capita
Alto Maé A	64 700	13 000	4.97
Central C	57 500	11 600	4.95
Alto Maé B	76 200	18 500	4.11
Polana B	51 600	15 000	3.44
Central B	53 700	17 300	3.10
Polana A	38 500	12 600	3.05
Central A	45 400	15 300	2.96
Malhangalene A	36 000	12 300	2.92
Coop	20 800	7 500	2.77
Malhangalene B	50 000	20 000	2.50
Sommersfield	33 500	13 400	2.50

5.6 Waste disposal

Section 4.1.7 in chapter 4 gave information about the Hulene disposal site. Observations at Hulene showed that the salaried municipal employees work the site without basic equipment such as gloves, uniforms, boots and masks, thus exposing them to health risks.

During the rain season (summer) the collection vehicles entering the site frequently dump their loads near the entrance. This is because once the dump is wet and muddy the vehicles are unable to get to the location assigned for dumping. This obstructs the access ways, resulting in further difficulties for on-site management. A positive feature of the rain season is that the smoke and haze that cover the area, due to the wastes smouldering and burning beneath the surface, are reduced, as is odour from the dump. This has a positive effect on the environment and on public health.

As the site there is no weighbridge² the information on waste quantities recorded at the central office is thus weak. This lack of essential information affects planning for future solid waste management.

At the time of this study was being conducted the cardboard and paper recovered on-site was not being collected. Normally these materials are collected by recycling enterprises. (The reasons for materials not being collected by the recycling enterprises are not known.) However, the space allocated for these materials to be kept pending collection is small, so without collection two problems occurred. The volumes of waste waiting recycling negatively affected site management and the motivation of the waste pickers who collected cardboard and paper dropped. As a general state of happiness and willingness to work is good for both the municipal employees and the waste pickers, incentives should be provided to encourage those working on-site to collect and recycle as much waste as possible.

At Hulene disposal site, millions of meticaís worth of recyclable materials are being thrown out and dumped. To reduce poverty and improve the quality of life in the city a “new system” of solid waste collection and disposal must be considered. A system is needed that will allow for waste reduction with sorting at source and recycling of recovered materials. Useful wastes must be given value so that more products are reused and recycled, resulting in lower amounts of waste needing to be dumped, increasing the municipal budget and saving citizens money. Apart from this a new, properly engineered, waste disposal site is needed to avoid all current negative impacts to the environment; public health; aesthetics and tourism.

² A weighbridge was commissioned in August 2006 after the fieldwork for this study had been completed.

Table 5.6.1 Hulene disposal site compared to other African cities with respect to waste pickers

City	Disposal Type	Waste pickers
Cape Town	Landfills (6)	Yes
Dar-Es-Salaam	Vingunguti dumpsite	Yes
Durban	Landfills (6)	Yes
Maputo	Hulene dumpsite	Yes
Accra	Oblogo dump	Yes
Dakar	Mbeubeus dump	Yes
Tema	Kpone	Yes
Marondera	Marondera dump	Yes
Bindura	Bindura dump	-
Rusape	Unsupervised dump	-
Cairo	Katamaya I, II dumps	Yes

Sources: Anomayo (2004); UNEP (2001); The World Bank (2001)

From table 5.6.1 it is evident that a common aspect of all African waste disposal sites (landfills and open dumps) is the presence of waste pickers.

5.6.1 Processing/Recovery/Sorting/Recycling

Currently there are no formal processing facilities for MSW in Maputo City. Processing, recovery and sorting of recyclable waste is done on an informal basis by waste pickers, waste collection crews, people with no accommodation and street children. Most householders do not practice recycling or sorting of their waste.

Glass is no longer being recycled in Maputo city as there is no glass recycling facility. The only factory for this purpose Mozambique-Glass (Vidreira de Mozambique) has not operated since the 1990s. Cardboard and paper are recycled in two factories. One located in district 5 called Fapacar (Factory of papers and cardboards) and other called Reclaim in the Matola District. This suggests that locally there is opportunity for recycling cardboard and paper.

Informal collectors of cardboard are called “Mashocos” in the locally language and these collect cardboard from commercial establishments and from public municipal containers. This material is sold at Metical 1000 (0,0025 US\$) per piece to women-buyers at markets such as Fajardo, Estrela Vermelha, Mandela, Vulcano, Xipamanine, Hulene and Chiquelene. The cardboard is then used to strengthen baskets to facilitate transportation of goods, or is used by households as packaging for cakes made at home for sale. As the later activity relates to the storage and transport of edible items use of recycled cardboard for packing must be controlled and well organized to avoid the spread of diseases that may affect public health.

Although they play a valuable role the work undertaken by the waste pickers around the city and on the dumpsite cannot be regarded as a sustainable approach to recycling and MSWM for Maputo City. However, in the future planning of solid waste collection and disposal for the city, a role for those currently earning a livelihood through waste picking must be considered.

5.7 Official Responses

The questionnaires aimed to collect data and opinions as to the adequacy of the Maputo MSW collection system as well as information relating to the organizational structure are shown in table 5.7

Table 5.7 Adequacy of the Maputo MSW collection system and organizational structure

Factors to consider	Responses				Percentage			
	1	2	3	NA	1	2	3	NA
Collection frequency	2	6	1		25	62.5	12.5	
Efficiency of collection	6	3	0		62.5	37.5	0	
Availability of facilities for MSW treatment	0	0	0	9				100
Level of downtime of collection vehicles	0	3	6			37.5	62.5	
Adequacy of personnel - collection and disposal	2	5	2		25	50	25	
Safety on the job	6	1	2		62.5	12.5	25	
Workers health	6	2	1		62.5	25	12.5	
Organizational structure	1	7	1		12.5	75	12.5	

Key: 1- Weak/Low; 2- Sufficient/Adequate; 3- Good/High; NA- Not applicable

Table 5.7 shows that official opinion is that waste collection frequency is sufficient. (In fact collection is made daily as recommended for tropical countries by UNEP).

However, due to the high level of downtime of collection vehicles the collection frequency is decreased. Daily collection frequency was noted in District 1; and in peripheral neighbourhoods 2 to 3 times a week. Official opinion recognises the low level of efficiency of waste collection as well as the fact that downtime is high. It also recognises that there are no facilities for MSW treatment (e.g. transfer stations, recycling or composting).

The officials questioned also indicate that personnel for MSW collection and disposal are adequate but also recognise that the provision of safety equipment (gloves, boots, googles, overalls) for workers is weak. The fact that MSW workers are not provided with health insurance or other medical facilities is also recognised as a weakness.

Most officials responding to the question are of the opinion that the organisational structure for Maputo MSW is adequate. One respondent thought that the structure is good and another that it is weak. This is possibly not surprising as the officials are all part of the structure, but it does indicate that there is room for improving the organisational structure and to have all senior employees regarding it as "good".

All of the above shows that there are many different interventions that could be made to improve the effectiveness of Maputo's Municipal Solid Waste Management.

5.7.1 Public Responses

Maputo citizen responses to the MSWM questionnaires are shown in Tables 5.7.1 to 5.7.4. (The method used to gather these responses is discussed in section 3.1.2). In tables 5.7.5 the responses of commercial and industrial enterprises is recorded to indicate their degree of satisfaction with municipal waste collection services and their willingness to pay higher collection fees for an improved service.

Table 5.7.1 Degree of satisfaction with municipal waste collection services including Commercial and Industrial

Maputo City	Good	Sufficient	Not sufficient	Total
Responses	168	1189	5018	6375
Percentage	2.6	18.6	78.7	100

Table 5.7.2 Degree of satisfaction with MW Collection services by district including commercial and industrial.

Districts	Good	%	Sufficient	%	Not sufficient	%	Subtotal	%
1	127	9.9	509	39.9	639	50.1	1275	100
2	10	0.7	305	23.9	960	75.2	1275	100
3	7	0.5	129	10.1	1139	89.3	1275	100
4	13	1.0	109	8.5	1153	90.4	1275	100
5	11	0.8	137	10.7	1127	88.3	1275	100
Total	168	2.6	1189	18.6	5018	78.7	6375	100

Table 5.7.3 Willingness to pay higher collection fees for an improved service: including commercial and industrial.

Maputo City	Yes	No	I don't know	Total
Responses	2572	2908	895	6375
Percentage	40.3	45.6	14	100

Table 5.7.4 Willingness to pay higher collection fees for an improved service by district: including commercial and Industrial.

Districts	Yes	%	No	%	I Don't Know	%	Subtotal	%
1	975	76.4	130	10.1	170	13.3	1275	100
2	712	55.8	401	31.4	162	12.7	1275	100
3	603	47.2	365	28.6	307	24.0	1275	100
4	161	12.6	1015	79.6	99	7.7	1275	100
5	121	9.4	997	78.1	157	12.3	1275	100
Total	2572	40.3	2908	45.6	895	14.0	6375	100

Table 5.7.5 Commercial & Industrial willingness to pay higher collection fees and degree of satisfaction with MW Collection services.

Degree of Satisfaction	Good	Sufficient	Not Sufficient	Total
Responses	95	429	226	750
Percentages	12.6	57.2	30.1	100
Willingness to pay	Yes	No	I don't know	Total
Responses	662	20	68	750
Percentages	88.2	2.6	9	99.8

The responses of Maputo citizens to the question asking their degree of satisfaction with municipal waste collection services show that 78.7 per cent of those responding think that the existing service is not sufficient, 2.6% think the service is good and 18.6% think that it is sufficient. However, 45.6% of respondents are not willing to pay more to have an improved waste collection service. This is marginally higher than the 40.3% that are willing to pay more to have improved waste disposal service. There is a distinct variation in responses by city district. The residents of the central city districts (1, 2 and 3) being willing to pay more for improved waste services while the residents of the peripheral (more rural) districts are not so inclined. (It is likely that this response is due

to the fact that the rural districts currently have extremely poor waste services and residents are not prepared to pay for a service that they do not currently receive).

Amongst the commercial and industrial sectors 57.2% of respondents held the view that the waste disposal service is sufficient, 12.6% thought it was good and 30.1% deemed it to be not sufficient. However, commercial and industrial enterprises are willing to pay higher collection fees for an improved service (88.2 per cent being willing). This suggests that a nuanced approach to increasing the fees paid for waste collection and disposal might be appropriate: charging commercial and industrial establishments a higher tariff than residential areas. Further cross-subsidization between central districts and rural districts should also be considered to improve Maputo's MSW collection and disposal practices. Maputo's waste management system must aim to become financially self-sustainable in time.

CHAPTER SIX: DISCUSSION

Maputo's solid waste management procedures display a 'train' of constraints, from generation through collection or street sweeping, recovery and treatment processes, to disposal. These constraints are due to various factors of different dimensions (see section 4.4): they are discussed in this chapter. The approach will be to identify the constraints and then to suggest possible ways of addressing them. The International Source Book on Environmentally Sound Technologies (ESTs) for Waste Management (2001) will be used to source practical solutions.

6.1 Waste Generation

It is known that waste generation varies from country to country and from city to city around the world; it also varies within countries and cities. This variation is due to different technical, financial, institutional, economic and social levels of development.

The United Nations Environment Program (2001) provides the following comparative figures: African countries have an average waste generation per capita of between 0.3 and 0.6 kg per day. The equivalent figure for South America and the Caribbean countries is 0.3 to 1.0 kg per capita per day; Asian countries generate between 0.4 and 1.5 kg per capita per day; and European countries generate 0.9 to 1.9 kg per capita per day.

Rekacewicz (2004) give the range of average daily waste generation in kilograms per capita as: Africa 0.5 - 0.8; Asia 0.5 - 1.4; Europe 1.0 - 2.0.

Yu-Tzu Chiu (2002) in his *Solid waste in Asia*, states that waste generation rates have a strong correlation with the level of economic development of a country. High-income countries (Japan, Singapore) generate 1.5-2.0 kg/capita/day. For middle income countries (Indonesia, Malaysia, Thailand) and low-income countries (India, Pakistan, Philippines) the figures are 0.75-1.0 kg/capita/day and 0.4-0.6 kg/capita/day respectively (www.worldbank.org/html/fpd/urban/publicat/waste.pdf and www.mem.dk/aarhus-conference/issues/NIS/assesasia.htm Accessed 19.04.06).

These figures show that the waste generated in Maputo City is not comparable to that generated in developed cities of European Countries. However, the amount generated

falls at the low end of the range for developing countries of Africa, Asia and South America and the Caribbean (see table 6.1).

Table 6.1 Waste generation in some African and Asian cities

Africa	kg/capita/day	Asia	kg/capita/day
Cape Town	0.5 - 2.5	Kathmandu	0.2 - 0.5
Dar-Es-Salaam	0.34 - 0.39	New Delhi	0.3-0.6
Durban	0.5 - 1.5	Dhaka	0.5
Maputo	0.4	Colombo	0.2 - 0.9
Accra	0.5	Manila	0.3 - 0.7
Ibadan	0.5 – 0.8	Hanoi	0.55
Dakar	0.5 – 0.8	Islamabad	0.6 – 0.8
Abidjan	0.5 - 0.8	Djakarta	0.8 – 1.0
Lusaka	0.5 – 0.8	-	-
Tema	0.5	-	-

Sources: UNEP (2001); The World Bank (2001); Zurbrugg (2002); Rekacewicz (2004); Palczynski (2002)

The amount of solid waste being generated in Maputo City is increasing (Table 4.2) and Maputo's MSWM system is not able to handle it properly.

Suresh (1998) in his *Urban Waste Management* states that, “cities are now grappling with the problems of high volumes of waste, the costs involved, the disposal technologies and methodologies and the impact of wastes on local and global environment”. These problems all apply to Maputo.

Srinivas (undated) in his *SWM: A Policy and Program Matrix* states that, “most local governments and urban agencies have, time and again, identified solid waste as a major problem that has reached proportions requiring drastic measures. There are three key trends with respect to solid waste - increase in sheer volume of waste generated by urban residents; change in the quality or make-up of waste generated; and change in the method of disposal of waste collected, by land-fill, incineration etc”. Again, Maputo is no exception.

UNEP (2001) states that, “SWM in most African countries is characterized by inefficient collection methods, insufficient coverage of collection system and improper disposal of municipal wastes”. While Palczynski (2002) in his study *Solid Waste Management Options for Africa* states that, “in Africa there is usually no differentiation in the collection of different types of waste”.

As there is no differentiation in the collection of different types of waste in Maputo the entire quantity of waste generated must be disposed of either by burning, burying or dumping at the Hulene site. Further, the municipal waste bins or skips placed on public roadsides are inadequate and waste generated between collections exceeds container volume. The result is waste overflowing from containers and once this occurs many Maputo citizens were seen to also dispose of their waste in inappropriate places and not in the overflowing municipal receptacles. In addition, 6 and 10 m³ waste receptacles are not easy to use. Thus as currently there is no formal waste reduction activity in Maputo City there is a real need for waste reduction in order to reduce the amount of wastes generated in both industrial production and private consumption. Waste reduction would help address both the problem of overflowing skips and the problem of capacity at the Hulene waste disposal site.

The International Source Book on Environmentally Sound Technologies (ESTs) for Waste Management states that, "waste reduction should be the first step in dealing with Solid Waste Management. It minimises the quantity of waste produced, thus reducing costs of collection, transport and disposal. Other benefits are that disposal sites last longer and using resources more efficiently reduces costs".

6.2 Waste Composition and Composting

Palczynski (2002) in his study of *Solid Waste Management Options for Africa* states that, “the composition of waste varies depending upon such diverse variables as urbanization, commercial enterprises, manufacturing and service sector activities”.

Table 6.2 shows the waste composition from selected countries of Africa and Asia. The most marked feature of the table is that the waste streams in African and Asian cities have such a high biodegradable organic content.

The UNEP (2001) *Newsletter and Technical Publication for South America and the Caribbean States* states that, “on average, municipal wastes in this region are very moist

(approximately, 45-50%) and also have a high organic content (40-50%)". The high organic content in the Maputo waste stream, which constitutes some 67 per cent of total municipal solid waste, is in the same range as that of Africa, Asia, South America and the Caribbean countries. However, this high organic content can be regarded as a condition favourable for composting as a method for reducing waste volumes destined for the Hulene dump. Composting will divert organic matter from the landfill and reduce gas and leachate risks.

The *UNEP Newsletter and Technical Publication: MSWM: Sound Practices-Composting*, states that, "high organic content is essential for composting". It also states that, "while many biowaste composting facilities have failed, the great preponderance of source-separated composting systems are successes. Composting projects based on yard, garden, restaurant and market waste, quietly thrive in every corner of the globe. The biological composting process is so basic that it is very likely to succeed if there is an appropriate input stream and proper handling".

The same Newsletter suggests that in developing countries the high animal and vegetable waste content of the waste stream, means that the mixed waste stream is sufficiently compostable to produce good compost on a small or medium scale. Support and enhancement of existing materials recovery activities, or their introduction where none exist, can ensure the compostability of the waste stream and result in the production of good quality compost.

Currently, there is one small composting plant in Maputo City, located within Tunduru Garden in the centre of the CBD. It manufactures compost from garden refuse and tree leaves. The Directorate of Parks and Gardens manage it. Formerly a composting plant for domestic waste was located in the Xipamanine neighbourhood, District 2, near the major open market of the city. It has not been used since the 1980s. The reasons for this are not known.

The production of compost from organic waste in Maputo would have at least three benefits. Firstly, it will reduce the volume of waste to be dumped at Hulene site; secondly it will provide a nutrient to the soils where it will be applied; thirdly more jobs can be created and unemployment reduced.

The compost produced could be used for agriculture in the green zones in the Infulene Valley or in rural districts with agricultural characteristics. Excess could also be used as

daily cover at Hulene, as currently the waste is not covered. Due to the availability of land and the requirements for composting plants districts 4 and 5 will be more viable for composting. Studies will be needed to find suitable sites.

Setting in place appropriate collection and transfer systems to ensure that compostable waste is kept separate could enhance the compostable fraction of Maputo's waste stream. Experience of composting worldwide show that this is feasible:

The City of Cape Town has two composting plants (Sacks Circle and Radnor in Parow), which manufacture compost from domestic waste. Approximately 60000 tonnes of domestic wastes is processed annually at these sites of which 60 per cent is used for composting and 40 per cent rejected and returned to the landfill. (City of Cape Town State of Environment Report Year 5, 2002:142)

In Durban, Johannesburg and Pretoria there are community-composting centres. Residents drop off their garden waste and it is composted and resold for household-sized gardens. By taking only yard wastes small-scale composting avoids the problem of mixed wastes. In the larger municipalities of South Africa, garden waste is not collected. Instead, there are "greens" disposal yards in designated suburbs to which residents can bring their yard waste for composting; these neighbourhood depots also serve as drop-off centers for glass, cans and paper. This type of waste reduction program is suitable for areas where gardens are large and residents have vehicles to transport their wastes to the depots. There are sections of cities across Africa that could benefit from the adoption of such small-scale composting programs. In Brazzaville (Congo) peri-urban farmers practice small-scale composting, applying the compost to their fields. There are operating composting systems in Benin and Cameroon. Backyard composting is a longstanding tradition in countries like Australia, Japan and New Zealand, especially in rural towns and local governments are promoting composting by making available inexpensive compost bins, along with "how-to" leaflets and demonstrations. Solid waste management authorities are also composting garden and park waste to reduce wastes prior to land filling (in www.or.jp/ietc/ accessed. 19.04.06).

6.2.1 The Jakarta composting experiments

The development of community-based composting in Jakarta represents an example of sound practice for composting in a developing country (UNEP, 2001).

Aid from Australia, Germany, the Netherlands and New Zealand helped to initiate pilot projects in Jakarta in the 1980s. Later, the Harvard Institute for International Development (HIID) and the Centre for Policy Implementation Studies, supported by the Government of Indonesia and the Jakarta City government, worked on a model for operating small-scale, neighbourhood composting in Jakarta. Starting around 1992 several small composting enterprises were set up in Jakarta.

The Jakarta experiments incorporated sound practices in small-scale composting in similar cities, while enhancing the role of the informal sector. The project trained individuals already involved in materials processing and taught them the basics of composting. A second element was compost market stimulation through training the intermediate buyers of recyclables to understand the physical and commercial properties of compost.

In the pilot project, measures were taken to protect workers health and it is important that these are observed when private entrepreneurs take over and operate composting plants as businesses.

The Jakarta research project provides a good example of how cities can begin to examine possible sound practices in the composting of municipal solid wastes. An assessment of small-scale, multi-source composting projects in Jakarta and Bandung, done in 1994, suggested that such composting can achieve important reductions in wastes and can contribute to the improvement of the neighbourhood environment. The Jakarta composting project showed that good management and market research and a consistent institutional support system are critical to the lasting success of such projects.

6.2.2 European biowaste

For industrialized countries, the European biowaste system described earlier represents a sound practice, because it is a system-wide approach to composting: beginning with separation protocols and continuing through to compost marketing.

One significant element in the success of European composting systems is the tight regulation of European landfills and the imposition of landfill bans against recyclable, compostable and combustible materials. This has created a positive economic and institutional environment where composting systems can successfully compete against landfilling. (UNEP, 2001 Newsletter and Technical Publication: *MSWM: Sound Practices- Composting*)

A second element is the integration of separate collection with source separation of biowastes, this provides a large stream of clean material to European composting facilities.

A third element of success is the predominance of relatively small and frequently modular, composting facilities, each processing 10-100 tons of compost per day, specifically designed for source-separated organics. These work better and provide more flexibility than the larger, more complex installations that were originally designed for mixed solid waste. (UNEP, 2001 Newsletter and Technical: *MSWM: Sound Practices- Composting*)

The soundness of European composting is also related to the aggressive stance of European governments and the European Union in setting and enforcing compost standards. (UNEP, 2001 Newsletter and Technical Publication: *MSWM: Sound Practices- Composting*)

Table 6.2 Waste composition (percentage wet weight) from selected cities of Africa and Asia.

Cities	Biodegradable	Paper	Plastic	Glass	Metal
Dhaka	70	4.3	4.7	0.3	0.1
Kathmandu	68.1	8.8	11.4	1.6	0.9
Bangkok	53	9	19	3	1
Hanoi	50.1	4.2	5.5	-	2.5
India	42	6	4	2	2
Manila	49	19	17	-	6
Accra	65	6	3.5	3	2.5
Marondera	43	38	15	< 1	4
Dar-Es-Salaam	59.8	8.7	1.9	0.4	2.8
Ibadan	55.8	12.9	6.3	1.8	-
Kampala	75	-	-	-	-
Tema	85.1	4.9	3.4	1.9	2.6
Maputo	67	13	10	4	2

Sources: Kaseva (1996); UNEP (2001); The World Bank (2002); Zurbrugg (2002); Rekacewicz (2004); AGRISU/GTZ (2002).

6.3 Waste Collection and Transportation

In Maputo City the number of vehicles that are non-functional, the high frequency of down time for collection vehicles (especially skip loaders and Ro-Ro) is seriously affecting transportation of MSW (section 4.4). However, Maputo's MSW expenditure on maintenance seems to be low, suggesting that this may be the reason for many collection vehicles being out of operation at any time (figure 2.1). Maputo is not

unusual in this respect. Palczynski (2002) in his *Study on Solid Waste Management Options for Africa* states that, “Nairobi experiences 70 per cent vehicle immobility” and the *SWM Sourcebook Africa, Regional Overviews and Information* states that, “one reason for lower collection rates is that waste collection vehicle immobilization is as high as 70 per cent” (UNEP, 2001). The IETC/UNDP (1999) states that, “in 1996, the City of Harare failed to collect refuse from nearly all of its residents because only seven of its 90 trucks were operational”. And UNEP (2001) states that, “in most developing countries and cities there are many areas that receive no collection at all while in developed countries rarely are sections of a city completely unserved and collection generally reaches all or most of the population at some level of effectiveness; In addition, in developing countries the level of service is low and many collection activities involve the informal sector while in industrialized countries collection tends to be more professional and institutionalised”.

“SWM in most African countries is characterized by inefficient collection methods, insufficient coverage of collection system and improper disposal of municipal wastes” (UNEP, 2001). This is an accurate portrayal of the situation in Maputo.

Studies and research on solid waste management are scarce in both Mozambique and Maputo. The lack of research and specialized studies in MSWM activities has led to the selection of different and incompatible technology, equipment and vehicles for waste management. Waste collection vehicles are of different makes, imported from different countries, making maintenance problematic. In addition, local industry cannot supply spare parts, lack of which is largely responsible for the high down time of collection vehicles and therefore, for irregular and insufficient solid waste collection and disposal services.

Lack of research has also led to inadequate placement of communal waste receptacles. The number of receptacles opposite hospitals, health centres and bus stops is not adequate (see annex: map of location containers). Overflowing communal waste receptacles create conditions in which disease vectors can thrive, they also give a poor visual appearance to the City. On the other hand, opportunities for Maputo’s MSWM are severely constrained by low levels of human resource development. There is a lack of human resources with the technical expertise necessary to operate the high technology compactor vehicles used for solid waste collection. Without adequately trained personnel, collection and transportation could not be improved. Therefore, the

development of human resources is essential for an effective solid waste collection and overall MSWM system.

Furthermore, the 6 and 10 m³ waste receptacles are not covered. Wastes consequently fall along the route when transported to the disposal site. This aggravates the existing generally poor state of the city's cleanliness.

Many Maputo citizens were seen to dispose of their waste in inappropriate places and not in the municipal receptacles, this severely restricts effective collection. The weak public awareness and lack of school education about the importance of proper waste disposal for health and well being of people, must therefore be addressed. There is a need for strengthening public awareness and school education to improve waste disposal and consequently effective collection and transportation.

There is a complex administrative structure for Maputo's MSWM (section 4.1.1). The complex administrative structure attached to the lack of human resources leads to poor coordination of overall plans for solid waste management. This occurs at both local and national levels and also within respective Directorates. As a result, a solid waste technology is selected (some times) without due consideration to its appropriateness in the overall solid waste management system and different approaches arise. For example, foreign assistance was requested for one component of the solid waste management system (the provision of containers) without regard for how this would affect the total system and whether the containers would be cost-effective. The support provided was 1100/ waste containers. However, as the coverage and frequency of solid waste collection service is weak and solid waste generated already overflows larger containers or is dumped at illegal sites, the provision of more small containers, although not bad, has had little impact on overall solid waste management effectiveness. In this case, the weak collection coverage and low frequency of collection is the major constraint and it would have been most cost-effective to provide resources to upgrade the collection service rather than to provide additional 1100/ containers.

The effect of different departments being involved with different aspects of waste management is that different approaches arise. For example, the city Street Ordinance requires that commercial establishments prevent street vendors from selling their wares outside commercial establishments and generating wastes. But the Municipal Directorate of Markets and Fairs is attempting to address the same problem by relocating street vendors to official markets in the hope of seeing a cleaner city.

However, neither commercial establishments nor the municipal police are enforcing the Street Ordinance. As a result, the cleanliness of neighbourhoods differs. In Alto Maé A, and Central C and B, the state of cleanliness is not as good as in Polana A, B or part of Central A. In this case, the enforcement by owners in Polana A, B, and part of Central A is more effective than the 'mirror campaign'. The fines levied on establishment owners that allow vendors opposite their establishments are issued by the Trade Directorate. However, fines are seldom if ever levied.

The various institutions involved in solid waste management in Maputo City require better coordination for effective implementation of a solid waste management. However, as mentioned earlier, solid waste management in Maputo City suffers from the lack of coordination among the relevant institutions, which often results from the lack of clear roles. To ensure effective solid waste management, the roles and responsibilities of the various institutions involved should be defined clearly and a coordination mechanism must be established. This could be done by drafting new or amending existing legislation. A working group involving officials from the various institutions should be set up to discuss the roles and responsibilities of their respective institutions.

6.3.1 Transfer Stations

Transfer stations play an important role in the waste management process. However, as was mentioned in section 4.1.5, Maputo City has no transfer stations or other processing facilities for MSW.

The *SWM Sourcebook/2.1:2* states that, "transfer stations are not common in MSWM in African cities. The point of disposal of the MSW is located within the perimeter of the city, within easy reach of vehicles and collection crew".

Thus, Maputo is not out of line compared to African countries. However, the city of Cape Town has two transfer stations. The Athlone Refuse Transfer Station with a containerised system where 600-800 tonnes of waste is handled daily and the Wynberg Drop off Facility, which handles 270 m³ of waste daily. The Wynberg transfer station caters for garden refuse, residential garbage and builders' rubble. Waste delivered to this site is sorted and stored in containers of 10 and 30 m³. Trailer-trucks transporting three containers at a time take waste each morning to the Muizenberg landfill. At the Athlone transfer station, waste is unloaded onto a conveyer belt that carries it to

containers into which it is compacted. At night the waste is taken by rail to the Vissershok Landfill (City of Cape Town State of Environment Report Year 5, 2002; Data collected by the author at Wynberg during a study visit, April 2006).

There are several advantages of intermediate transfer stations: collection vehicles do not have to make long journeys to landfills for every load of waste they collect; initial sorting of waste to separate recyclables and compostable materials is easily achieved; citizens can also easily dispose of excessive waste themselves; transport from the transfer station to the landfill can be via rail using special waste containers capable of a high degree of waste compaction, thus reducing the number of trips to the landfill.

“Throughout South America, Mexico and Costa Rica, transfer stations have been installed or are in the process of being installed and are usually owned and operated by the agency responsible for solid waste management in the city” (UNEP, 2001).

As Maputo City is increasing in size distances to the present and future landfill sites will also increase. Transfer stations will be one way of improving collection efficiency, allowing collecting vehicles to make more collections per day as they will not have to go all the way to the dump site. At the transfer station preliminary sorting of waste to remove recyclables and compostable materials could also take place, thus reducing the volume of waste going to the landfill.

6.4 Treatment and Disposal

6.4.1 Treatment

Currently there is no formal processing, recovery, recycling or sorting of Municipal Solid Waste in Maputo City. Therefore, domestic refuse, organic materials, office waste, non-infectious medical waste as well as industrial waste are mixed and all find their way onto the Hulene dump. However, the activity of waste picking at street bins, illegal dumps and at Hulene dumpsite is increasing.

Johannessen and Boyer (1999) in their *Overview of Solid Waste Landfills in Developing Countries of Africa, Asia and Latin America* indicate that on-site scavenging disrupts landfill operations in many parts of Africa. In Accra, Ghana, waste pickers sorted through waste from incoming garbage trucks, before and immediately after unloading and often prevented the compactor from levelling and compressing the newly disposed waste. Uncontrolled scavenging at controlled and semi-controlled dumps also took

place in South Africa. Table 6.5 shows the numbers of waste pickers in selected countries of Africa, Asia and South America.

Johannessen and Boyer (1999) state that, “the municipality of Belo Horizonte, Brazil, organized waste pickers through a city program, also that waste pickers in Rio de Janeiro were removed from the landfill’s tipping front and given a designated space near the reception area of the landfill, both with positive results”.

Organization of Maputo’s waste pickers, to increase their effectiveness in recovering recyclable materials and sorting compostable materials from the general waste stream, would be one way of quickly having an effect on Maputo’s MSWM. This initiative would not require capital or high technology and would create employment for a number of unskilled persons. It is an option that is appropriate for Maputo.

At Hulene dump the employees have had little or no training in solid waste management. They work under poor conditions and are not provided gloves, boots, odour masks, uniforms, brooms, wheelbarrows, or radio communicators. Thus, their social status is low and due to their social status, citizens’ attitudes to those involved in solid waste, work including waste pickers, is not positive. Citizen attitudes lead to disrespect for those involved with waste work, this in turn produces low work ethics and poor quality of work. Proper training for staff involved with MSWM and providing them with uniforms and personal protection equipment would both increase their effectiveness and improve their self-image and social standing. Although some financial resources will be needed to do this it would also be a quick and appropriate way to improve MSWM in Maputo.

Although 68.1 per cent of Mozambique industry is located in Maputo it is not being used to produce equipment needed for solid waste management or to encourage recycling. For example, the Plastex factory produces 120l plastic refuse bins, which are sold in local markets at metical 2 575 000 (around \$US 103) but the bins being used for MSW are being imported. Local industry is also not absorbing and processing recyclable material. The weak industrial base for recycling activities is a constraint on the improvement of solid waste management in the city. Studies and research in MSWM are required in order to adjust the local industry production to MSWM needs. This would reduce costs by replacing imported equipment with items that could be produced locally.

6.4.2 Disposal

The overall goal of urban solid waste management is to collect, treat and finally dispose of solid wastes in an environmentally and socially satisfactory manner using the most economical means available. (The World Bank – USWM in www.worldbank.org – accessed 10.05.06);

Bilitewski et al (1997) in their book *Waste Management* state that, “Waste Management activities can be reduced to two primary goals: i) Household, city and municipal waste has to be removed regularly; ii) The collected waste must be disposed of in a manner that does not adversely affect public welfare.

The public has increasingly embraced the second goal over the last 40 years. This has led to a situation where environmental hygiene and the protection of the environment have becoming important values. Therefore, efficiency is not the only consideration when it comes to the choice of treatment method and disposal option”.

Turk (1978) in his *Environmental Studies* states that, “the least acceptable disposal method is the open dump. That there are serious ecological problems with open dumps; the dump itself is a potential source of disease; fires are uncontrolled and are smoky and polluting; rain erodes open dumps and the polluted water flows into nearby rivers and ground water reserves; and dumps are ugly”.

“Landfills in Africa are primarily open dumps without leachate or gas recovery systems. Several are located in ecologically or hydrologically sensitive areas (in open lots, wetland areas, next to surface water sources) and are generally operated below the standards of sanitary practice” (UNEP, 2001).

“In most developing countries, dumpsites, sanitary landfills and composting are the most common methods used for municipal waste disposal due to their relative low cost. Incineration is seldom used due to the high costs involved” (UNEP in www.or.jp/ietc/ accessed 19.04.06).

Maputo’s Hulene waste disposal site is an open dump and fits within the methods used in African developing countries. However, in developed countries, waste disposal options include methods of processing that use more advanced technology. Sanitary landfilling in engineered cells and incineration are most common.

In the *UNEP Newsletter and Technical Publications for MWSM* it is stated that, “landfilling is an unavoidable component of all European waste systems. In certain Northern European countries, less than half of the waste may be land filled; while in southern countries like Greece and Spain, or Eastern European countries such as Hungary and Poland, virtually all waste finds its way to land burial. Small municipal landfills, often in wetlands or low areas, are generally uncontrolled, do not require weighing of the waste, charge no fees, have no environmental controls and are frequently burned over to reduce the volume of the waste. No cover is used and closure is informal, if it takes place at all”. Poor disposal of MSW is thus not only a feature of the African continent.

Disposal of Maputo’s waste at the Hulene dump must be phased out. As has been indicated this site is highly unsuitable for waste disposal: it occupies a former wetland; leachate drains to a stream that defines one edge of the site; it is surrounded by residential areas (some houses being only metres away from the edge of the dump). A priority in Maputo’s SWM must be to identify one or more new waste disposal sites. Although open land is available reasonably close to the city it will not be easy to persuade people living close to the chosen sites to accept that waste must be disposed of in their neighbourhood. Political will to establish a new waste disposal site will be needed together with sound geo-technical studies of the underlying geology, hydrology, wind directions and access routes. The chosen site will need to be sufficiently large to allow for many decades of waste disposal. It must be suitable for properly engineered lined cells to be constructed, for leachate monitoring systems to be installed and be located close to a source of soil to cover each day’s compacted waste. It is likely that a new general waste disposal facility could be established in close proximity to Maputo’s new hazardous waste disposal site as this site has appropriate geo-technical requirements.

Table 6.5 Waste Pickers and disposal types in Africa Asia and South America

Countries	Cities	Disposal Type	Waste Pickers
South Africa	Cape Town	Muizenberg landfill	35 – 40
South Africa	Cape Town	Faure landfill	10 –15
South Africa	Cape Town	Bellville landfill	50 - 60
South Africa	Durban	Bisasar Road landfill	-
South Africa	North West Province	Krugersdorp landfill	> 600
Tanzania	Dar-Es-Salaam	Vingunguti dumpsite	109
Mozambique	Maputo	Hulene dump	100
Ghana	Accra	Malami dumpsite	-
Kenya	Nairobi	Dandora dumpsite	-
Philippines	-	Carmona landfill	25 - 50
-	-	Boipatong landfill	100
Indonesia	Jakarta	Bantar Gebang landfill	<640
Philippines	-	San Mateo landfill	-
Malaysia	-	Permetang Pauh landfill	-
-	Mexico City	Bordo Xochiaca dump	300 to 500

Sources: Johannessen (1999); Kaseva (1996); Palczynski (2002).
Personal observations.

6.5 Other constraints

The general conditions in Mozambique affecting MSWM were mentioned in section 1.2, chapter 1. Opportunities for MSWM are severely constrained by low levels of human resource development. There is a lack of human resources with technical expertise necessary for solid waste management planning and operation at both the national and local levels. Many of Maputo's solid waste management workers have little or no technical background or training in waste management. Thus, without adequately trained personnel, solid waste management can not be improved. Therefore, the development of human resources is essential for the effectiveness and sustainability of solid waste management system. For an effective solid waste management in Mozambique particularly in Maputo City, human resource development should be part of the overall plans of SWM. Without local human resources, effective solid waste will be not succeed.

Social, economic and political development plays an important role in solid waste management. Obviously, an enhanced economy enables more funds to be allocated for solid waste management, providing more financial support. However, Mozambique has weak social, economic and political development bases and therefore, insufficient funds for sound development of solid waste management system. The solid waste management budget for Maputo City is given in chapter 1 (1.2.2.1) and is considered by the Municipal authorities as insufficient to maintain a clean city. As a result, the levels of services required for protection of public health and the environment are not attained. In addition, the collection fees system for solid waste collection is weak. Therefore, the financial basis for public services, particularly for solid waste management is weak too. This weak financial base could be supplemented by the collection of user service charges. However, users' ability to pay for the services is very limited and their willingness to pay for the services (which are irregular and ineffective) is not high. (Tables 5.7.3 to 5.5.5) An effective strategy for raising funds needs to be researched in order to ensure its effectiveness.

In addition to the limited funds, the local government lacks a good solid waste fee collection system. These are currently collected by the Mozambique Electricity Company, as mentioned early. From fee collection by the said company, through coordination to delivery of the funds to the city's Directorate for Cleansing is a long and complex process and takes some time. As a result, the limited financial resources

available for the sector are depleted quickly and this often leads to the failure of solid waste management services, thus losing the trust of service users.

The government at national and local levels have limited funds for solid waste management so measures to reduce and recover the expenditure and increase revenues must be developed. There is a need to turn solid waste management systems to more self-financing programmes. The scarce funds must be effectively used to develop different alternative cost-cutting, cost-recovering and revenue-raising schemes (e.g., waste minimization, deposit-refund system for recyclable materials, import or sales tax on certain packaged products, collection of user service charges) and implement studies on appropriate economic incentive measures.

Private sector participation in solid waste management collection and disposal services is also a way to reduce the financial burden of the government. Such schemes could draw not only investment finance from private companies but also managerial expertise and technical skills.

Experience in developing countries, which are reported elsewhere, indicate that privately operated services are generally more cost-effective than public sector services. Therefore, the use of private sector resources through a contractual arrangement provides a potential alternative towards self-financing solid waste management in Maputo City.

Effective application of economic incentive measures and private sector resources in solid waste management requires human resources to design and manage such schemes. Aside from human resources development in technical aspects of solid waste management, human resource development in financial planning and management is also necessary.

The current execution of day-to-day MSWM operations in Maputo City is carried out by a combination of official municipal workers (mainly), fee-based contractors from the private sector, small enterprises, non-governmental and community organizations. But these groups have no clear roles and functions. No single institution has been designated to coordinate their activities. This lack of sound coordination among the national and local institutions results in different institutions doing the same thing without being aware of what others are doing. This leads to unnecessary duplication of

efforts, wasting the scarce resources available and reducing the effectiveness of the solid waste management programmes.

Section 4.2 dealt with legal controls. It was noted that legislation is not enforced. The lack of effective legislation for solid waste management is partially responsible for the roles and functions of the various institutions not being clearly defined and the lack of coordination among them. This is a specific example of the general situation that UNEP (2001) has found in developing countries:

“legislation related to solid waste management in developing countries is usually fragmented and several laws (e.g., Public Health Act, Local Government Act, Environmental Protection Act, etc.) all include some clauses, rules and regulations regarding solid waste management”.

In Maputo the different institutions do not enforce the rules and regulations. In the City there are five districts and coordination among them is critical to achieve cost-effective alternatives for solid waste management in the metropolitan area. The lack of a coordinating body for the five districts often leads to non-integrated and ineffective programmes for solid waste management. There is often duplication of responsibilities and gaps or missing elements in the regulatory provisions. Therefore, comprehensive legislation, which avoids the duplication of responsibilities, fills in the gaps of important regulatory functions and is enforceable, is required for effective development of Maputo’s solid waste management system.

The institutional capacity of institutions involved in solid waste management is generally weak due to the 1976-1992 civil war and other historical factors. So in addition to providing these institutions with clear mandates, they must also be provided with sufficient human and financial resources to fulfil their mandates.

CHAPTER SEVEN: CONCLUSION: POSSIBLE KEYS TO SUCCESSFUL MUNICIPAL SOLID WASTE MANAGEMENT IN MAPUTO

The discussion in the preceding chapter indicated that there are several constraints faced by both Mozambique and Maputo City in developing and implementing effective municipal solid waste management systems. However, there is no single and uniform key to remove, improve or open any of these constraints. Some constraints are harder to remove, improve or open than others.

The *International Source Book on Environmentally Sound Technologies* indicates that: “Environmentally sound technologies for Waste Management are highly dependent on the environmental, economic, climatic, cultural and social context in which the technology is set; a sound practice not only achieves the management of MSW, but also in the process, takes into account the specific physical, environmental, social and political background conditions that tend to make SWM difficult”.

Diverse measures (keys) are required to produce a successful outcome in Solid Waste Management. For Maputo’s MSWM a combination of the following measures and approaches may lead to a successful outcome.

7.1 Waste Reduction

The *International Source Book on Environmentally Sound Technologies* states that, “the key concepts of waste reduction are: reducing waste at source; source separation of waste; materials recovery for reuse; recycling waste materials; reducing use of toxic or harmful materials”.

The following tools for promoting Environmental Sound Technologies for waste reduction and materials in Maputo City could be used:

7.1.1 Promote educational campaigns (Intensive and extensive formal and informal education)

Education of both the government authorities responsible for waste management and the general public is identified as one of the most critical actions necessary in Maputo City to help find solutions to the solid waste problem. Government authorities should be seen

to lead good waste management by example. This education should inform people of the environmental, health and economic impacts of current solid waste generation and disposal habits. Such education will help give the public ownership of the problem and should help promote involvement by the public by providing information on methods of waste reduction, recycling and materials reuse that they can adopt.

There are many sources of information that can be used for educational purposes, namely posters, comic books, videos and Internet sites. These can be obtained from UNEP offices.

7.1.2 Study the waste stream (quantity and composition)

Information regarding the quantity and composition of the waste streams for Maputo City is scarce. This information is crucial to enable the set-up of recovery and recycling systems, of markets for recyclables and to identify problems with existing waste management practices. With this information the municipal authorities could decide whether to take a facilitative or regulatory role to decrease and manage different portions of the waste stream.

7.1.3 Support source separation, recovery and trading networks

Apart from informal source separation, recovery and local recycling would be appropriate for Maputo City as quantities of waste are large enough to support viable trading networks. In addition, Maputo's location close to South Africa, which has a good tradition of recycling, could make delivery of most recovered materials to outside markets economic. Separation of items such as paper, cardboard, glass bottles, aluminium cans and steel for reuse or recycling can be achieved simply and without great cost. Separation of the items could either be carried out at "curb-side", where items such as paper and cardboard, glass and metals are put in small separate containers for collection, or where there is no curb-side collection, recoverable items could be put in large collection containers located at convenient points. These could be at schools, shopping centres or in similarly convenient areas.

7.1.4 Facilitate small enterprises and public-private partnerships by new or amended regulations

Small enterprises involved with SWM are already in place to some extent in Maputo. An example is the collection and sale of aluminium cans, which is done in many of the

different districts of Maputo City. Other small enterprises are the privately operated waste collection contractors Uaene Gama de Serviços Limitada and ADASBU. There is another small enterprise which collects and packs 340 ml glass bottles (Heineken, Windhoek, Castle, 2M, Laurentina and so on) for resale to private companies e.g. FERSOPE (Fernando Soares Pereira), a well-known enterprise from Tete Province, which buys bottles for packaging “Lawidzane” and other local drinks. Given the large population and the high levels of unemployment, opportunities for such enterprises should be expanded.

7.1.5 Assist waste pickers

Waste picking is widespread in Maputo City. Technical assistance and organisation is needed to make this activity safer for those involved and also more efficient as a means of reducing the volume and mass of waste that goes to landfill.

7.1.6 Reduce waste via legislation and economic instruments

After consulting with major stakeholders selective waste legislation to encourage packaging reduction, product redesign and coding of plastics should be considered.

The bulk of non-biodegradable waste in Maputo waste stream appears to be derived from the packaging of imported goods. Packaging could be reduced through selective waste reduction legislation. It might be argued that the Maputo City markets are too small to impose special packaging requirements on distant exporters. The city is at the end of the line for many waste streams generated by manufacturing countries. Consequently, special measures, for example surcharges, taxes, or deposits, may be needed for plastics, cans or bottles. Funding thus obtained could be used to ensure these materials can be sorted and transported to destinations where recycling can be carried out.

7.1.7 Export recyclables

Exporting recyclables is really only possible for materials that have sufficient value. This is unlikely to be a viable option for Maputo. Export markets for scrap metal and compacted aluminium cans should, however, be investigated further as these are financially viable options that are being used in neighbouring South Africa.

7.1.8 Promote innovation to create new uses for goods and materials that would otherwise be discarded after initial use

Given the relatively low labour cost in Maputo, value could be added to recovered waste materials by making waste materials into new products. This type of enterprise would require investigation of potential markets. These could be to the local public, to tourists, or for export.

Reuse of items such as glass bottles and food containers is not common in Maputo. However, Fernando Soares Pereira (FERSOPE) is a good example of innovation and the reuse of glass bottles. The Ministry of Technology and Science could lead this initiative.

7.1.9 Reducing the use of substances, which produce toxic or hazard waste

Reduction in use can only be achieved through formal and informal education of the general public. It will be necessary to provide information on alternative products that are not toxic or hazardous. Legislation that prevents the importation of such products could also be introduced.

7.2 Composting

Composting is known to be a waste management system with many successes worldwide. Several scientific studies have been undertaken by research teams, which have shown beyond any reasonable doubt that composting is a technologically appropriate method for waste treatment in developing countries. The following statements show this:

Composting is “... a classic method of waste treatment. It is an ecological sound treatment method, because the organic share of the waste (generally about 40% by weight in household waste) is returned to the natural cycle. In comparison to other waste treatment methods, composting has only minor negative effects on the environment”. (Bilitweski et al: 1997)

“Composting is the aerobic degradation of biodegradable waste under controlled conditions. Because of the high proportion of organic matter in [developing country] waste, composting is an attractive option. Moreover, the compost product can be used for soil fertilization purposes”. (Hoornweg et al: 2000)

“Composting, sanitary landfill with gas flaring or recovery and alternative fuel use by garbage fleets provide new opportunities that tap into carbon financing and other global emission-based financing. These instruments provide new markets that can potentially support the implementation of composting and gas recovery where earlier end-user markets (such as farmers and power grids, respectively) were inadequate to justify the use of these technical choices”. (The World Bank, 2002)

“Composting solid waste for use as a soil amendment, fertilizer, or growth medium is important in many countries. Asian countries in particular have a long tradition of making and using compost. In Western Europe, a range of modern technologies is used to produce compost; there is so much small- and medium-scale composting operating successfully in India and China; centralized composting is a successful, cost-effective, environmentally sound waste management approach in Europe (and increasingly in North America)”. (UNEP, 2001)

“Composting is the biological decomposition of complex animal and vegetable materials into their constituent components. Composting is a natural process through which bacteria and other organisms decompose organic matter in a favourable environment. The most common form of composting, aerobic composting, takes place in the presence of oxygen. Aerobic bacteria require a mix of approximately one part nitrogen to at least 30 (and no more than 70) parts carbon in their food supply. Aerobic bacteria also require at least 40% but not more than 60% water as well as a plentiful supply of oxygen. In the absence of any one of these four factors, the composting process will fail. The products of aerobic composting are water vapour, carbon dioxide and decomposed organic material, called humus”. (UNEP, 2001)

Anaerobic composting, also called anaerobic digestion, takes place in the absence of oxygen. Anaerobic bacteria live in the absence of oxygen and can consume mixtures with a higher proportion of nitrogen and lower proportion of carbon. Anaerobic digestion can also occur at higher levels of moisture. The products of anaerobic digestion are CO₂, methane gas and decomposed organic material. To recover the gas, anaerobic systems are enclosed to produce a slightly pressurized environment. Anaerobic composting is more technologically advanced than aerobic composting.

Composting bacteria operate on the surfaces of compostable materials. That means that composting works well with small particles of waste and poorly with large pieces of

organic material. For this reason, size reduction or shredding is frequently required prior to composting to allow for adequate bacterial decomposition.

All solid waste composting is based on one or both of these biological processes. Differences in technology relate to input materials, pre-processing techniques and the way in which the environment for bacterial action is created and maintained.

Composting is the only solid waste management technology that depends on bacteria for its correct functioning (wastewater treatment also depends on bacterial action, but it is not a solid waste system). The task of maintaining the correct environment for bacteria requires significantly different areas of knowledge and different management strategies than operating a collection system or incinerator or running a landfill. This is important to consider in any analysis of the success or failure of composting systems. (UNEP, 2001)

The UNEP Newsletter and Technical Publication: *MSWM: Sound Practices-Composting* provides the following guidelines for sound composting practice:

- The waste stream must be compostable.
- Mechanical pre-processing of mixed solid waste does not work well enough in most cases.
- Manual pre-processing of mixed waste does work on a small to medium scale for the highly compostable waste streams in developing countries.
- Economic factors related to landfills, markets and materials recovery must support composting.
- Separation and composting techniques and scale must be appropriate for the input stream.

7.2.1 Composting options for Maputo

The process of composting is similar in all areas of the world, but there are practical differences between industrialized and developing countries. The main differences relate to the waste stream to be composted, the agricultural traditions relating to production and use of compost and the physical infrastructure of the built and natural environment.

7.2.1.1 Small scale (backyard) composting

Backyard composting can be a formal strategy for the management of the organic waste stream in a region. Backyard composting represents the smallest scale of composting and is a sound approach when:

- a significant number of households have individual or collective yards or gardens and there is enough room for a compost pile;
- composting is culturally familiar to most people; and
- the waste stream to be composted contains primarily vegetable matter, since it is easier to control rodents and insects when little animal matter is present.

As many residents of Maputo do not have backyards and composting is not culturally familiar this is not an option that could be used to handle Maputo's municipal waste stream.

7.2.1.2 Decentralized neighbourhood or business-scale composting

Such facilities can provide a waste management opportunity to a small group of people at a relatively low cost. Small-scale composting uses the wastes of a number of households, shops, or institutions; the composting is done on unused land, beside community gardens, or in parks. This may be called multi-source or decentralized composting, in contrast to backyard composting, where the wastes are from one source. These sites, which usually process less than five tons of waste per day, can be smaller than municipal sites and generally reduce the need for movement of compostable materials.

Sound practice for siting neighborhood composting sites requires that they:

- be accessible to all who want to use them;
- be clearly designated with signs that all users and non-users can read or interpret;
- be sited with the agreement of the surrounding land users;
- have adequate fencing or control to prevent their becoming an open dump; and
- have appropriate soil to absorb leachate.

For neighbourhood compost piles to work, the UNEP *Sound Practices – Composting Manual* (2001) indicates that there must be a compost monitor or supervisor within the user community who takes responsibility for maintaining order and cleanliness. Sound

practice generally requires backup from the municipal government in terms of technical and logistical support for removal of undesired items or turning of the piles.

The volume of waste and the lack of a culture of composting make it unlikely that this intermediate scale of operation will succeed in Maputo.

7.2.1.3 Centralised Composting

Centralized composting facilities typically have a design capacity of 50 to 200 tons of waste per day. Because of contamination removal through pre-processing, as well as moisture loss and volume reduction during the process of composting, a 100-ton-per-day facility will produce only 30-50 tons of compost per day (in www.or.jp/ietc/ acc. 19.04.06). The mass of waste produced by Maputo City suggests that at least one central composting facility would be required to handle the city's waste.

Central compost systems require open land for establishing and manipulating compost piles. Sound practice requires:

- selection of a site with suitable access for the form of transportation;
- availability of a buffer area between the site and nearby land users, to minimize the nuisance of waste and compost odours;
- appropriate soil for absorption or collection of leachate.

In developing countries, but increasingly in industrialized countries, centralised composting facilities are located at landfill sites. This allows separately collected organics or yard wastes to be processed at the landfill. Siting is simplified as it becomes part of the landfill siting process. (UNEP, 2001)

It would be logical and desirable for Maputo to plan a centralised composting facility in conjunction with the selection of a new landfill site.

7.2.2 Waste stream separation

When waste picking, source separation, or pre-processing at a compost facility recovers non-compostable materials, the resulting waste streams are highly compostable.

7.2.2.1 Yard waste

The composting of yard wastes is a simple aerobic process. The carbon-nitrogen ratio of yard wastes allows them to be composted without difficulty, although in many climates

the moisture and air levels must be managed. Water must be added in many temperate climates, while in rainy climates the material requires drying, frequent aeration, covering, or the addition of paper or woody materials to reduce moisture content. (UNEP, 2001)

Preprocessing of yard wastes is usually limited to shredding or chipping of larger woody wastes. For most yard wastes, sound practice dictates composting in large, elongated piles which are watered and turned to maintain adequate levels of oxygen and moisture.

Yard waste does not form a significant portion of the Maputo waste stream. It should nevertheless be separated and made into compost to reduce the volume of waste going to the landfill. As indicated, there are no significant hurdles to composting yard waste.

7.2.2.2 Kitchen waste

Vegetable and animal wastes represent a highly compostable stream, but one which requires more careful management than yard waste. Kitchen wastes are only compostable if they are separated from mixed household or commercial waste and held for collection in a separate container. This is currently not the case in Maputo as all waste is deposited into large skips for collection. A future MSWM programme for Maputo must consider source separation of kitchen wastes so that these can be made into compost and are diverted from wastes to be landfilled.

7.2.2.3 Mixed solid waste

In Maputo the waste stream contains high levels of organic wastes, but as the main non-compostables are not removed prior to final disposal the mixed waste stream is not currently suitable for composting. However, the waste stream could be rendered compostable if it was sorted prior to disposal. Community collection bins for compostables are one possibility and would, in Maputo, be easier to implement than household collection of compostables. However, as there is no tradition of waste separation in the city and the provision of waste collection receptacles is already inadequate it is unrealistic to expect that a separate set of receptacles for compostable materials can be implemented. In Maputo the practical option will be for mixed waste streams to be pre-sorted at a combined landfill and composting facility.

With the high unemployment that exists and the large number of people already engaged in informal waste-picking in Maputo it would be desirable and feasible for

separation of compostable and non-compostable wastes, as well as recyclables, to be manually sorted. This would also allow for control and education of the waste pickers, improvement of their working conditions and status in society.

7.2.3 Appropriate composting technologies for Maputo

Composting is completed when the compostable materials in the waste stream have been completely converted to humus. Re-wetting the material and observing if it heats up again, which indicates that there are still uncomposted materials in the pile, can be used to test compost. Most aerobic composting systems include a period of active composting, generally from 21 to 60 days and a period of curing, generally from 6 to 24 months. With the heat and humidity of Maputo the lower limits of these ranges will apply. Composting can be accelerated by intensive aeration and inoculation of the piles with suitable bacteria, but this should not be necessary in Maputo.

7.2.3.1 Pre-processing

Pre-processing is necessary to create optimal conditions for bacterial action. Pre-processing consists of three separate types of operations:

- separation or removal of oversize, non-compostable, or dangerous materials;
- size reduction, through chipping, grinding, or shredding, to create many small particles suitable to sustaining bacterial action; and
- blending and compounding, to adjust the carbon-nitrogen ratio, moisture content, or structure of the materials to be composted.

Pre-processing is the most costly part of a composting system. For this reason, sound practice in composting involves minimizing pre-processing to the greatest extent possible by pre-selecting the waste streams to be composted through waste stream separation, as discussed above.

7.2.3.2 Windrow or active pile systems

A sound, simple form of composting suitable for Maputo would involve building piles of compostable material. The piles, called windrows, create the conditions for compost bacteria and other organisms to perform decomposition. Important considerations in planning windrows include:

- the windrows must be of sufficient mass to allow for heat build-up. The composition of the wastes and the climate are the two primary determinants of windrow size. Optimal conditions for Maputo would have to be determined by trial and error.
- the shape of the windrows. This is related to the type of aeration that is used and the type of equipment used to aerate the compost pile. Again trial and error will determine the optimal shape of windrows for Maputo;
- the spacing of the windrows. This will be dependent on the size of the site and type of equipment used.

Active pile systems require manual or mechanical turning of the windrows, with crews using shovels or rakes, or with equipment such as a bulldozer, tractor, or windrow turning machine. Turning aerates the piles, blends the materials, brings about additional size reduction and prevents excessive buildup of temperature to the point of spontaneous combustion. In developing countries, waste pickers may be allowed to work over the windrows to remove recyclables and pieces of wood, as was done in a windrow system in Kathmandu in the early 1990s.

An active pile system is deemed suitable for Maputo because:

- relatively high land use requirements can be met;
- labour for manual handling of materials is available;
- it has low capital cost and low-to-moderate operating costs;
- it can be developed without the need to purchase specialized equipment.
- Mechanical turning could be done with loaders or bulldozers that are already available;
- this system requires limited site infrastructure;
- a variety of compostable materials can be handled.

High technology composting systems requiring the use of custom built towers, rotating drums, or similar devices are not considered to be suitable for Maputo as they increase capital costs, require high levels of maintenance and technical skill and have high operating costs.

7.2.4 Marketing of compost

Effective marketing of the compost is important to sound practice. While sound practice in composting systems depends heavily on marketing of compost, this does not

necessarily require that composting make a profit. Marketing may include any type of beneficial use, ranging from use in agriculture and parks to give-away programs for residents. (UNEP, 2001)

7.2.4.1 Market development

As there is no tradition of compost use in Maputo action will be necessary to stimulate the market for compost. Possible actions are:

- use of compost in public works projects, including some high-profile demonstration projects in parks and gardens;
- giving compost away to garden centers and businesses;
- specifying that government contractors use compost in government-funded construction projects;
- requiring that nurseries supplying plantings to the government use compost.

7.2.4.2 Compost and land application standards

The second important element in sound marketing of compost is the establishment of compost and application standards and guidelines. The European Union identifies three grades of compost ranging from acceptable to very high quality—based on levels of heavy metals present in the final product.

Land application standards connect the compost to its use in agriculture. The standards allow or limit compost use on various crops. Farmers must be given confidence that compost is safe for use and that they will not be penalized at a later date if they use it. Maputo should seek assistance from the European Union in developing standards for use of compost in Mozambique agriculture.

7.2.4.3 Compost use in the public sector

“The successful development of compost systems almost always involves heavy participation of the public sector in using compost in public works projects” (UNEP, 2001). This is a win-win strategy, as it tends to reduce costs and increase effectiveness of public works expenditures while illustrating the value of compost for greening and landscaping. Its effect is enhanced by signs that bring the use of compost to the attention of the public. Both National and Local government in Maputo could stimulate the use of compost in this way.

7.2.4.4 Compost as daily or final landfill cover

A final use of compost is as cover for fresh deposits of MSW, in cases where other cover material is scarce or expensive to transport to the dump. Landfill cover is an excellent use of lower quality compost or compost with large particles in it. An advantage of using compost as cover for landfills is that it substitutes for soil that would otherwise have to be excavated, purchased and transported.

7.2.5 Environmental impacts of composting

Use of compost as a soil conditioner, a fertilizer, or a growth medium has, significant environmental benefits. In addition to returning nutrients to the soil and thus permitting the reduction of artificial fertilizers, compost is waste that does not have to be landfilled. When it is used as daily cover at landfills, it replaces other materials that would otherwise be used for that purpose.

“Gases released from improperly maintained compost piles are a negative effect associated with the composting process. When piles are not properly aerated, colonies of anaerobic bacteria flourish and produce methane gas. The decomposition process also releases carbon dioxide, volatile organic compounds, bacteria and fungi. The release of methane and carbon dioxide contributes to the problem of greenhouse gases in the atmosphere. Poorly operated composting facilities also cause unpleasant odours”. (UNEP, 2001)

Some leachate production is also common from compost making facilities. Leachate from water runoff and condensation at compost facilities occasionally contains levels of biological oxygen demand (BOD) that may exceed acceptable limits for discharge to streams and rivers, but pose few problems if absorbed into the ground or passed through a sand filter. High concentrations of BOD in runoff to surface water is a bigger problem, as this can reduce the amount of dissolved oxygen in streams that is available for aquatic life. Sound practice here is to avoid discharge to water and to capture or direct all leachate to absorption in sand or soil. This would not be a problem in Maputo.

The most significant potential environmental problem arising from compost use is its potential to convey heavy metals to the soil. This is a serious concern and sound practice requires controlling impacts through good separation of the waste stream prior to composting.

The numerous advantages that would accrue to Maputo from the development of a centralised composting facility have been outlined above and there are few disadvantages. Composting is thus an appropriate technology that Maputo must explore fully for future Solid Waste Management for the city.

7.3 Waste collection and transportation

“The vehicles used for collection of MSW must be appropriate to the terrain, the type and density of waste generation sources, the roads over which it must travel, the kinds of materials it must collect, the strength and capacity of working crew and how the load will be discharged. The type of vehicle selected should also be evaluated in terms of capital cost and labour inputs, maintenance requirements and local availability of technical repair expertise and parts. It is also recommended that vehicles that have proven to be effective and reliable be acquired”. (UNEP, 2001)

The following principles should be applied for selection of waste collection vehicles for Maputo:

- Select vehicles that use the minimum amount of energy and technical complexity necessary to collect the targeted materials efficiently. Given the high-energy costs and relative lack of technical backup in Maputo, a trade off relative cost of capital and labour is needed.
- Select equipment that can be locally serviced and repaired and for which parts are available. This is critical in Maputo to ensure ongoing utilization from capital investment in the vehicles.
- Choose animal-powered or light mechanical vehicles in crowded areas or informal settlements where access by larger vehicles is not possible. These types of vehicles are significantly less capital intensive; easy to maintain and have less impact on the environment although they may be perceived as “old fashioned” they would be technologically appropriate for Maputo.
- Choose non-compactor trucks, wagons, tractors and dump trucks. These vehicles are lighter, easy to maintain and offer low capital costs but higher labour requirements. Waste collected in Maputo is already at high density with high proportions of organic waste. Therefore compaction is not necessary.

In addition to careful selection of vehicles for MSW collection the following sound practices should also be followed:

- Provide litterbins in public areas, at beaches, outside food shops;
- Encourage litterbin use through education and enforcement if necessary;
- Clearly define responsibility for emptying litterbins;
- Planning of sweeping routes (length of routes, frequency, sweeping disposal);
- Optimise health and safety by providing sweepers with uniforms, brooms, collector bins and gloves.

7.4 Maintenance

Sound SWM practice requires preventive maintenance of equipment, including vehicles, containers, transfer points and tools. Maintenance must include periodic preventive equipment repair, worn parts replacement, lubrication and replenishing of oils and engine fluids. For waste-related equipment, daily or periodic cleaning or washing is also highly recommended.

Poor maintenance of vehicles used for MSWM in Maputo has been shown to be a significant contributor to the high level of “down-time” in Maputo. Considerable improvement to the city’s SWM could be achieved through proper maintenance of vehicles and equipment. Organisation and political will is required to achieve this.

7.5 Development of Transfer Stations

As was discussed in section 6.3.1 there are several advantages of developing intermediate transfer stations. As Maputo City is increasing in size distances to the present and future landfill sites will also increase. Transfer stations will be one way of improving collection efficiency, allowing collecting vehicles to make more collections per day as they will not have to go all the way to the dump site. At the transfer station preliminary sorting of waste to remove recyclables and compostable materials could also take place, thus reducing the volume of waste going to the landfill.

As Maputo develops a Municipal Solid Waste Management programme the selection and development of intermediate transfer sites should be integral to future planning.

7.6 Disposal via Sanitary Landfill

The problems associated with Maputo's current Hulene waste dump were discussed in section 6.4.2. The current disposal site is highly unsuitable for waste disposal: it occupies a former wetland; leachate drains from it to a nearby stream; houses close to the edge of the dump surround it. As incineration is not an appropriate technology for Maputo because of the costs involved and the low level of technical expertise to support the technology, a priority must be to identify a new waste disposal site. Open land is available reasonably close to the city but geo-technical studies of the underlying geology, hydrology, wind directions, will be needed to decide on site suitability. It is likely that a new general waste disposal facility could be established in close proximity to Maputo's recently established hazardous waste disposal site as this site has all the appropriate geo-technical requirements. The chosen site will, however, have to be much larger than the hazardous waste site to allow for many decades of waste disposal. The new site must be suitable for properly engineered lined cells to be constructed, for leachate monitoring systems to be installed and be located close to a source of soil to cover each day's compacted waste so that all compost generated by the proposed compost facility is not used to cover the residual waste.

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ANNEXURES

Recorded interview plan for workers and officials

Dear worker or official

The questions presented aim to collect information to complete a study on An Examination of Solid Waste Collection and Disposal in Maputo City-Mozambique. All information will be treated confidentially. We thank you in advance for your collaboration. You will have about five minutes to talk about the following questions.

Name: Function

Questions:

For how long have you worked here? (What work do you do?)

What do you think about your work conditions?

What are your main difficulties during the work process?

What would you like to see changed to make your life easier and better?

What do you think about work relationships among workers?

What do you think about work relationships between workers and the Directorate?

Do you think that there is a need for more disposal sites? Where? Why?

Have you some thing more to say?

(Drivers, sweepers, waste pickers)

Thank you for your attention!

Questionnaire for citizens

Dear Citizen

The questions presented aim to collect information to complete a study on An Examination of Solid Waste Collection and Disposal in Maputo City-Mozambique. All information will be treated confidentially. We thank you in advance for your collaboration.

Inquiry Objectives

1. To evaluate Maputo citizens' degree of satisfaction with municipal waste collection and disposal services.
2. Collect data for a report about future options of solid waste collection and disposal in Maputo City.

Questions

I. Evaluate the effectiveness of municipal solid waste collection and disposal services in your neighbourhood. Circle with X on the appropriate number (1, 2, 3).

Good; 2. Sufficient; 3. Not sufficient.

II. Are you willing to pay higher collection fee for an improved service?

Yes. **2.** No. **3.** I don't know.

III. In the table below insert 1, 2, 3, 4, 5 to indicate the Urban District where do you live. Write your neighbourhood in the space provided and mark with X if Male (M) or Female (F).

Urban District	Neighbourhood	M	F

Thank you for your attention!

Questionnaire for officials involved in Solid Waste Management in Maputo City.

Dear official

The questions presented aim to collect information to complete a study on An Examination of Solid Waste Collection and Disposal in Maputo City-Mozambique. All information will be treated confidentially. We thank you in advance for your collaboration.

Inquiry Objectives

1. To evaluate the adequacy of the Maputo MSW collection system and its organizational structure.
2. Collect data for a report about future options of solid waste collection and disposal in Maputo City.

I. Evaluate the adequacy of the Maputo MSW collection system and organizational structure.

Mark X in the table below, as appropriate.

1- Weak/Low; 2- Sufficient/Adequate; 3- Good/High; NA- Not applicable.

Factors to consider	1	2	3
Collection frequency			
Efficiency of collection			
Availability of facilities for MSW treatment			
Level of downtime of collection vehicles			
Adequacy of personnel - collection and disposal			
Safety on the job			
Workers health			
Organizational structure			

Thank you for your attention!

Neighbourhoods, Markets and Educational Institutions Surveyed

District 1

Neighbourhoods: Alto Mae A, B, Central B, C, Malhangalene A, B, Polana A, B.

Markets: Povo, Central, Janet, Estrela, Mandela, Museu, 4 de Outubro.

District 2

Neighbourhoods: Aeroporto A, Chamanculo A, B, Malanga, Minkadjuine, Unidade 7, Xipamanine.

Markets: Fajardo, Malanga, Xipamanine, Praça de Touros, Unidade 7, Lhanguene, 7 de Abril.

District 3

Neighbourhoods: Mafalala, Maxaquene A, B, C, Polana Caniço A, Urbanização.

Markets: Mafalala, Mazambane, Maxaquene-Santo Antonio, Polana Caniço B, 1 de Maio, Khalene, Chai.

District 4

Neighbourhoods: Albasine, Ferroviário, Hulene B, Laulane, Mahotas, Mavalane A, B.

Markets: Hulene, Mavalane, Praça dos Combatentes, Estaleiro, 25 de Setembro, Missavene, Mercado da Paz.

District 5

Neighbourhoods: 25 de Junho A, Bagamoio, George Dimitrov, Inhagoia A, B, Jardim, Luis Cabral, Magoanine, Malhazine A.

Markets: Jardim, Luis Cabral, 25 de Junho, Bagamoio, Volante, Inhagoia, Malhazine.

Educational Institutions: Escola Secundaria Francisco Manyanga, Escola Secundaria Josina Machel, Escola Secundaria Estrela Vermelha, Escola Comercial, Escola Industrial, Instituto Comercial, Instituto Industrial, Escola Secundaria 25 de Junho, Escola Secundaria de Malhazine, Escola Secundaria de Lhanguene, Escola Secundaria 7 de Setembro (anexa a Manyanga), Escola 3 de Fevereiro, Escola 14 de Outubro, Escola a Luta Continua, Escola Unidade 7, Universidade Pedagógica-Maputo, Universidade Eduardo Mondlane, Instituto Superior de Relações Internacionais.

Questionnaire (For Commercial and Industrial establishments)

Dear Citizen

The questions presented aim to collect information to complete a study on An Examination of Solid Waste Collection and Disposal in Maputo City-Mozambique. All information will be treated confidentially. We thank you in advance for your collaboration.

Inquiry Objectives

1. To evaluate the degree of satisfaction of Maputo City commercials and industrials owners related to municipal solid waste collection and disposal services;
2. Collect data that allow the elaboration of a report about future options of solid waste collection and disposal in Maputo City.

Questions

I. Evaluate the effectiveness of municipal solid waste collection and disposal services in your neighbourhood. Circle with X on the appropriate number (1, 2, 3).

1. Good. 2. Sufficient. 3. Not sufficient.

II. Are you willing to pay higher collection fee for an improved service?

1. Yes. 2. No. 3. I don't know.

III. Put in the table below with 1, 2, 3, 4, 5 the Urban District where you make your activities and write the neighbourhood.

District	Neighbourhood

Thank you for your attention!