Solid Waste Management in Maputo City and its Health Consequences, Mozambique

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Mozambique

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Solid Waste Management in Maputo City and its Consequences on Citizen Health, Mozambique

A thesis submitted in partial fulfillment of the requirement for the degree of Master of Public Health

By:

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Declaration:
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The thesis **Sheila Barbosa Faquir** is my own work.

Signature… 

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Dedication

I would like to dedicate this thesis to my Mother Mrs. Zubaida A. Barbosa, for her moral support all through this Master program. I would also dedicate this degree to my husband Mr. Valetin Chernysh for his tireless efforts and support given me to finally complete this public health degree. Finally, I dedicate this thesis to my family members for giving me the strength and courage of completing this Master degree.

Acknowledgement

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During this master I did many friends and, actually, a new family. This master wouldn't have been possible without their support, encouragement and advice. To all my classmates, I say thank you! I would like to extend my sincere thank to Nelson Dunbar for providing valuable advices and contributions for this thesis.

Thank you to all my friends, especially thanks to my friend Eliasara Antunes who contribute to this thesis.

Special thanks to my parents and my husband, for their support and encouragement over the year. My eternal gratitude goes to my mother, for her prayers.

Abbreviation

AGRESU	Assistance to Solid Waste management in Greater Maputo Areas
AIDS	Acquired Immune Deficiency Syndrome
CBO	Community Based Organizations
CDC	Central for Disease Control
CMM	Maputo City Municipality
COWI	International Consultant Company
EDM	Electricity of Mozambique
FMECD	Federal Ministry for Economic Cooperation and Development
GDP	Gross Domestic Products
GIZ	Assistance to solid waste management greater Maputo area,
H5N1	Influenza A Virus Subtype
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
IESE	Institute of Social and Economic Studies
INCAF	Continuous Household Survey, Mozambique
INE	Institute of National Statistics
ISWM	Integrated Solid Waste Management
LBSSE	Locally based small scale enterprise
MDGs	Millennium Development Goals
M&E	Monitoring and Evaluation
MICOA	Ministry for the Coordination of Environmental Affairs
MMC	Municipality of Maputo City
MOH	Ministry of Health
MSW	Municipal Solid Waste
NGO	Non Governmental Organization
SWMS	Solid Waste Management System
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNICEF	United Nations Children's Fund
USAID	United States Agency of International Development
USD	United States Dollar
WB	The World Bank
WHO	World Health Organization
WILSA	Network for Defense of Sexual and Reproductive Health, Rights of Women and Law in Southern Africa

Abstract

Background: Solid waste management in Maputo remains a challenge as urban population and consumption patterns continue to increase. The health effects related to solid waste are increasing especially in developing countries, including Mozambique despite lack of information.

Objective: To explore potential health risks associated with solid waste and disposal among the general population, residents nearby disposal sites, workers and waste pickers.

Methodology: Literature review of relevant information on SWM and its health impacts was done. A framework (DPSSEA) was used as a tool for analysis in this study.

Findings: The study highlighted that the process of SWM affects human health, the aesthetic and environment of the city. Diseases and health conditions such birth defects, low birth weight, respiratory diseases and skin diseases, injuries, death among others were associated with landfills and incineration of solid waste disposal. Vector and water borne diseases such as malaria, diarrhea, typhoid, cholera, etc., were associated with types of waste particularly organic waste. The link of diseases to solid waste and disposal methods are weak and require further evidence.

Conclusion and Recommendation: The potential links between diseases and exposal to solid waste is proving by few studies and requires further evidence. These diseases are not specific to Maputo context due to lack of information on health impacts of solid waste. Adopting integrated solid waste management approach would assist the Municipality of Maputo in minimizing health consequences from exposure to waste. Continuous monitoring and evaluation of health effects of solid waste exposure are important success factors.

Keywords: solid waste management, health effect, developing countries, Maputo, Mozambique.

Word count: 13,080

Introduction

I am a social scientist with an Honors Degree in Sociology from Eduardo Mondlane University in Maputo, Mozambique. During my undergraduate studies I published some scientific articles and co-authored a study entitled "Representations and Practices of Sexuality among the Youth and the Feminization of AIDS in Mozambique, 2007". This was published by WILSA and looked into the various dimensions of the feminization of HIV and AIDS in the country.

I am now a permanent consultant at the international consulting company COWI Lda. and have been for the last nine years. I have a 10-year professional experience. Having worked in the field of Health in Mozambique and as a Social consultant at COWI, I have acquired great skills in field work assignments related to social studies, particularly in areas bearing on HIV/AIDS, water and sanitation. My social professional experience also covers research related to Health Impact Assessment, Environmental& Social Impact Assessment, population resettlement plans, resettlement methodology and analysis (having worked with the Centre for Disease Control, OURGUT, Millennium Challenge Corporation and Millennium Challenge Account, Vale Moçambique, World Bank and other NGO´s).

During this time, I have also acquired a large experience in qualitative and quantitative research. I have managed, coordinated and implemented large projects and have provided technical and financial support in the design and testing of the research tools, organization, training and monitoring of fieldwork teams, budget conception and financial control, as well as data analysis and writing of reports.

I believed that my training in the area of social sciences, coupled with my work experience in the field of Health, has given me a special sensitivity to the importance and scope of public health. However, my interest in the area of public health has another motivating factor. I happen to believe that public health will become a study area of interest owing to a combination of many socioeconomic factors, in Mozambique, which will affect human and environmental health

Chapter I: Country Background Mozambique

1.1 Geography

Mozambique, **Error! Reference source not found.**, is a country located in the south eastern region of Africa with a total population of 25.2 million people. According to national statistics data more than half of the Mozambican population is younger than 21 years. This is around 13.000.000 people (INE at al. 2013).

Figure 1: Map of Mozambique

1.2 Human development indicators

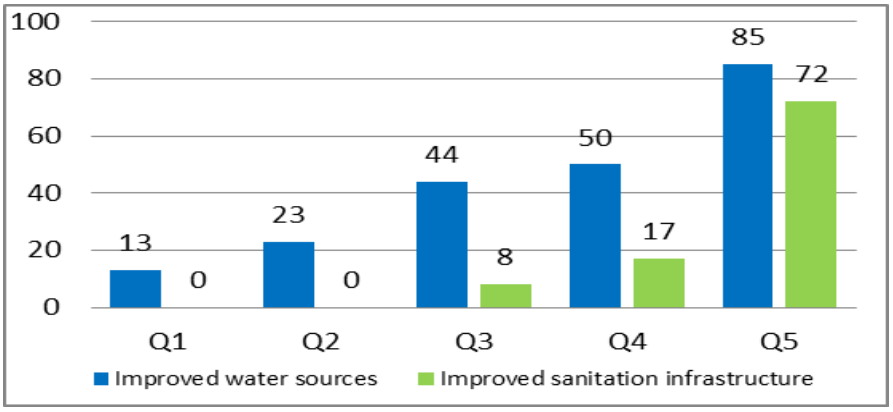
The rate of population growth is estimated at 3%, and is strongly affected by high fertility rates (5.5 children per women). The DHS report (INE et al 2013) reveals a fertility rate of about 4.5%; 48% of girls aged between 20-24 had their first child before they turned 18.The rural population grows slightly faster than the urban population. In other words, almost 70% of the Mozambicans continue to live in rural areas. Population growth is highest in Tete (4.9%), Maputo Province (4.5%) and Niassa (4.5%) and lowest in Maputo city (1.4%).

In the Human Development Report for 2014 Mozambique is placed within the 10 countries with the lowest Human Development Index (HDI) at 178 (out of 187 countries); (UNDP 2014). The trend shows that human development is growing at a very slow pace; between 2008 and 2013

Mozambique has only moved one position in the HDI. In 2008 the HDI was estimated at 0.366 and in 2013 it rose to 0.393. Those trends are corroborated by the results of the last poverty survey (2008-2009) which shows a stagnation of the reduction of poverty at 54% despite the impressive economic growth rate at an average of 7% for the last 10 years, one of the highest in Africa. According to an IESE report, poverty is not reducing due to development policy choices which put an emphasis on capital intensive, rather than on employment/labour intensive investments (IESE 2012).

A closer analysis of the human capital development trends between 2007 and 2013 shows significant progress in indicators related to (i) access to primary education and literacy rates for the population from 15 years over; reduction of child mortality for children younger than 5 (from 200 to approximately 97 per 1000). Nutrition is one of the areas that have registered slow improvements; more than 43% of the children below the age of 5 years are stunted (INE et al. 2013). Malnutrition is much more prevalent in rural areas where 46% of the children suffer from insufficient growth as compared to 33% in the cities.

Figure 2: Access to Improve Water and Sanitation in Mozambique

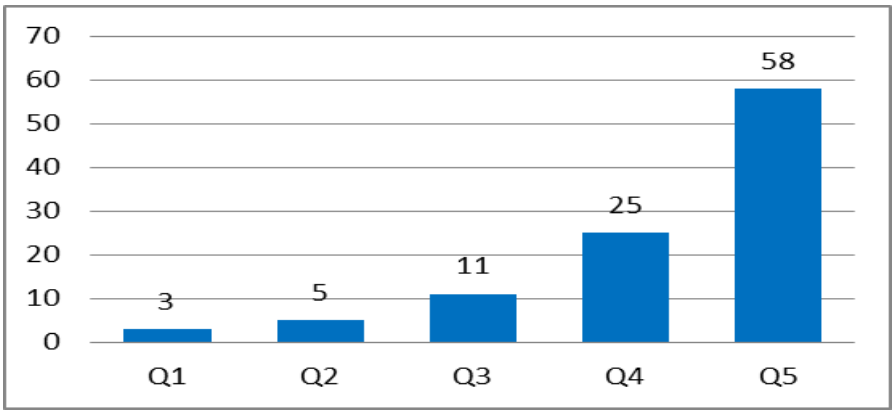


Source: UNICEF 2014

According to a recent report published by UNICEF, **Error! Reference source not found.**, only 13% of the Mozambican population have access to drinking water at their homes and 40% to improved water sources (water pumps, covered boreholes, etc.) there is still 16% of the population that have access to unsafe sources of water, from open sources such as rivers and stagnant water. Along the last years the investment on sanitation has been very low, and the improvements in this field have lagged behind in relation to access

to safe water. According to a UNICEF report (UNICEF 2014) only 24% of Mozambicans have access to adequate sanitation, while 36% still lack adequate facilities. This places Mozambique far behind in the race to achieve MDG7.

Figure 3: Primary and Secondary School Attendance



Source: UNICEF 2014

Data from INCAF (continuous household survey) show that more than half of the Mozambican population lives in rural areas, with agriculture as the main source of income (INE 2013a). Women are disproportionally represented in the agriculture sector accounting for almost 80% of the labour force. For the remainder, 20% or so, employed in sectors other than agriculture, a significant proportion of them work in the informal sector with no access to decent work. The investment of the government in agriculture accounts only for 10% of GDP.

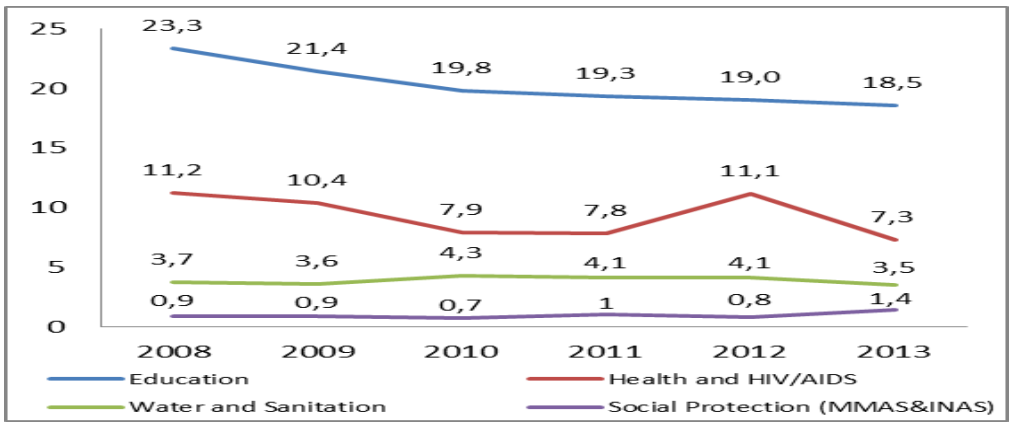
There is a structural difference in the evolution of human development indicators in Mozambique with a visible imbalance between rural and urban areas. Access to social services is limited in rural areas where more than half of the population lives and translates inequalities between the different poverty quintiles. The **Error! Reference source not found.** illustrates the results of increasing levels of inequality, where those on the upper quintiles have better access to basic services.

1.3 Health System and Financing

The Mozambican National Health System consists of the Ministry of Health (MoH), provincial heath directorates, hospitals and in addition it includes the National Council to Fight HIV and AIDS.

On the overall the budget allocation to social sectors in Mozambique has decreased over the last 5 years to a 35% of the GDP. Estimates by UNICEF (2014) indicate that to continue with the current level of investment in social sectors, namely health, education, water and sanitation and social protection the Government of Mozambique should commit at least 40% of its GDP to ensure progress in the sector(see **Error! Reference source not found.**).

Figure 4: Trend of Health Expenditure 2008-2013 in Mozambique



Source: UNICEF 2014

The overall budget allocation for the health sector by the Mozambican Government has increased in nominal value, from approximately USD 90 million in 2009 to 437 million meticais in 2013. In terms of impact on the health budget, this increase meant that the share of the health sector is supported by External funds, directly into the Health Ministry (MHO), has decreased from 60% in 2009 to 40% in 2013. Additional to the direct support to the health sector, there was a budget forecast of additional 350 million dollar directed through vertical funding mechanisms.

Sanitation

Sanitation is one of the areas that requires additional investment. Investments in sanitation have been very low. This has contributed to the

creation of an environment that promotes environmental related diseases such as cholera, diarrhoea, malaria and pulmonary diseases. The Expenditures for water and sanitation account for 1.5% of the Government total expenditures.

Chapter II: Problem Statement, Justification, Objective & Methodology

2.1 Problem Statement

Increasing population growth, urbanization and rise in community living standards accelerate solid waste generation in the world. Today it is estimated that that there are about 3 billion urban residents generating 1.2 kg solid waste per person per day which amount to 1.3 billion tons solid waste per year and is expected to increase to 2.2 billion tons by 2025 with a higher contribution from lower income countries (Elmira et al. 2010).

Globally, solid waste management costs about $ 205.4 billion USD and will increase to 375.5 billion by the year 2025(FMECD 2012). In most cases the available public funds are not sufficient to provide for an adequate and extensive service provision and results in technical (limited equipment and improper maintenance) and organizational (insufficient and under-qualified staff) hazards that then cause poor service delivery with severe consequences for public health and the environment (Idem).

Waste generation in sub-Saharan Africa is approximately 62 million tons per year. This amount is less as compared to Europe and Central Asia Region, Middle East Asia and Pacific regions and among other regions in the world (Hoornweg et al. 2005). Per capita waste generation is generally low in this region, but with a wide range from 0.09 to 3.0 kg per person per day, with an average of 0.65 kg/capita/day (Eric 2003).

The inadequacy, out datedness and lack of systematization of information on solid waste in Mozambique constitute a serious problem for a broader understanding of the situation of waste, as well as for the services linked with the matter Solid Waste Management in Maputo is the sole responsibility of the Municipality of Maputo City with the exception of hazardous waste (MICOA, Environmental Ministry) and Biomedical waste (Ministry of Health) (CMM 2008). Maputo with 1.2 Million inhabitants produces approximately 1.000 ton of waste per day which exceed the projected quantity of 850 tons of waste/per day by 2016, and costs approximately 5, 4 Million US dollar to collect and dispose of annually (FMECD 2012).

About 82% of the population in Maputo had access to regular waste collection system in 2012 as compared to less than 40% in 2004, and Maputo has an average waste collection of 760 ton/day (Idem). Despite the increased access to solid waste management systems (SWMS), it is not known which proportion of the population is currently utilizing the available SWMS in Maputo.

Even with current efforts, the Municipality of Maputo is faced with huge challenges due to the management of Urban Solid Waste which involves various stages from production, treatment, transport, and collection to deposit. Compounded with these are defective water supply and disease conditions that may derive from improper waste management (AGRESU 2007).

Poor waste management results in negative health consequences for city residents, particularly those living near the dumpsites due to the potential of the waste to pollute water, food sources, land, air and vegetation. Exposure to solid wastes increases health risk (allergies, infectious disease and respiratory damage), injuries risk (spinal damage, fractures, damage to eyes, etc.) and accidents (such as fires explosion). Such risks are higher in developing countries where the exposure is greatest with least level of protection (WB 2006).

A sustainable solid waste management system to control generation and disposal of waste is the only alternative. In the absence of such a system, the problem of waste will continue to pose increasing threats to humans, the environment and health in Maputo. Thus, this thesis inquires into the problem of waste disposal and seeks to describe how it impacts on the health of city dwellers.

2.2 Justification

Environmental hazards due to poor waste management are responsible for about a quarter (1/4) of the total burden of disease worldwide and about 35% are in sub-Saharan Africa (WHO 2006). Common diseases and injuries resulting from poor solid waste management include cholera, diarrhoea, malaria, respiratory tract infections, etc.

Solid waste management has become a major development problem in Maputo city in the last years, with severe consequences for human health and the environment (FMECD 2012). The increased rural to urban migration, population growth and development in Maputo serve as driving forces behind increased waste generation that is beyond the waste management capacity of the municipality. Lack of capacity by the Maputo Municipality to properly manage SW can result in poor air and water quality and adverse environmental health impacts that require immediate attention.

Very little research on solid waste management has been carried out in Maputo City, and this is a limitation for a broader understanding of the magnitude of the problem and the impact on health of the citizens. Indeed, given the variety and diversity of pollutants, exposure and contact

pathways, risk perception becomes more complicated which in turn makes the knowledge of possible impact on human health less reliable. Health risk can occur from the first moment when a person has contact with solid waste, from collection to the last step of disposal.

However, the relationship is more complex and not linear because it depends on many different related factors such as quantity and composition of the waste, temperature, water, time, age, sex, population migration, etc. If combined these factors generate different and multiple outcomes that can be dangerous or not to human health (Mattiello 2013 & Sylvester 2002). For example, there is organic waste while compost at home is beneficial as fertilizer, but others which take long to decompose (eg. meat, bones, etc.), not only cause odors, but due to their composition and under action of time and temperature they can be infectious.

Therefore, the study aims to explore to what extent solid waste pollution/exposure in Maputo city has an impact on the environment and on human health in order to promote a healthier environment by influencing public policies to address the root causes of health risks. Additionally, the study will contribute to the existing body of knowledge on solid waste health risks and also stimulate further research on the subject in other municipalities in Mozambique.

2.3 Objective

2.3.1 General Objective

The general objective is to explore the main factors contributing to solid waste generation and management in Maputo; appraise their public health consequences and the pathways through which they occur in order to provide recommendations for policy on the subject.

2.3.2 Specific Objectives

1. To describe the most important types and sources of solid waste in Maputo city and the factors contributing to their accumulation,

2. Describe the formal and informal mechanism of disposing solid waste disposal in Maputo city,

3. Critically review the health consequences of solid waste and waste disposal practices; and analyze the underlying mechanisms contributing to their bad health impacts.

4. Provide an overview of good practices and challenges of SWM systems in low income countries,

5. Use the findings for recommendation to health and environmental sectors in order to strengthen the SWM for reducing the health consequences on the population.

2.4 Scope Study

Geographically, the study area covered is Maputo city, in the south of Mozambique. Maputo city was chosen because it is a growing city just like other metropolitan/urban areas and, as such, is facing a bigger problem of managing its solid waste effectively. Contextually, the study focused on solid waste generated by household and informal market. The reason for this choice is because about 68.5% of organic and 9.5% of plastic waste generated in Maputo city comes from these two sources (see figure 6, on 3.2.2.section)

2.5 Methodology

In this section a discussion will be offered of the methodology applied to accomplish this study. The study was mainly library based and relied on documentary evidence from other countries with similar context. Research articles and other supportive information and material were necessary because due to time limitation was not possible to carry out data collection, which would be appropriate for the objective of this study.

2.5.1 Study design

A literature review of grey literature, published and unpublished articles, was performed to obtain information specific to the thesis objectives. Maputo city municipality reports and guidelines were also obtained. Official websites of Mozambique and other national and international wastes management organizations were also used to gather relevant reports and articles. A conceptual framework adapted from available literature was used to analyze and discussed the findings in an orderly manner.

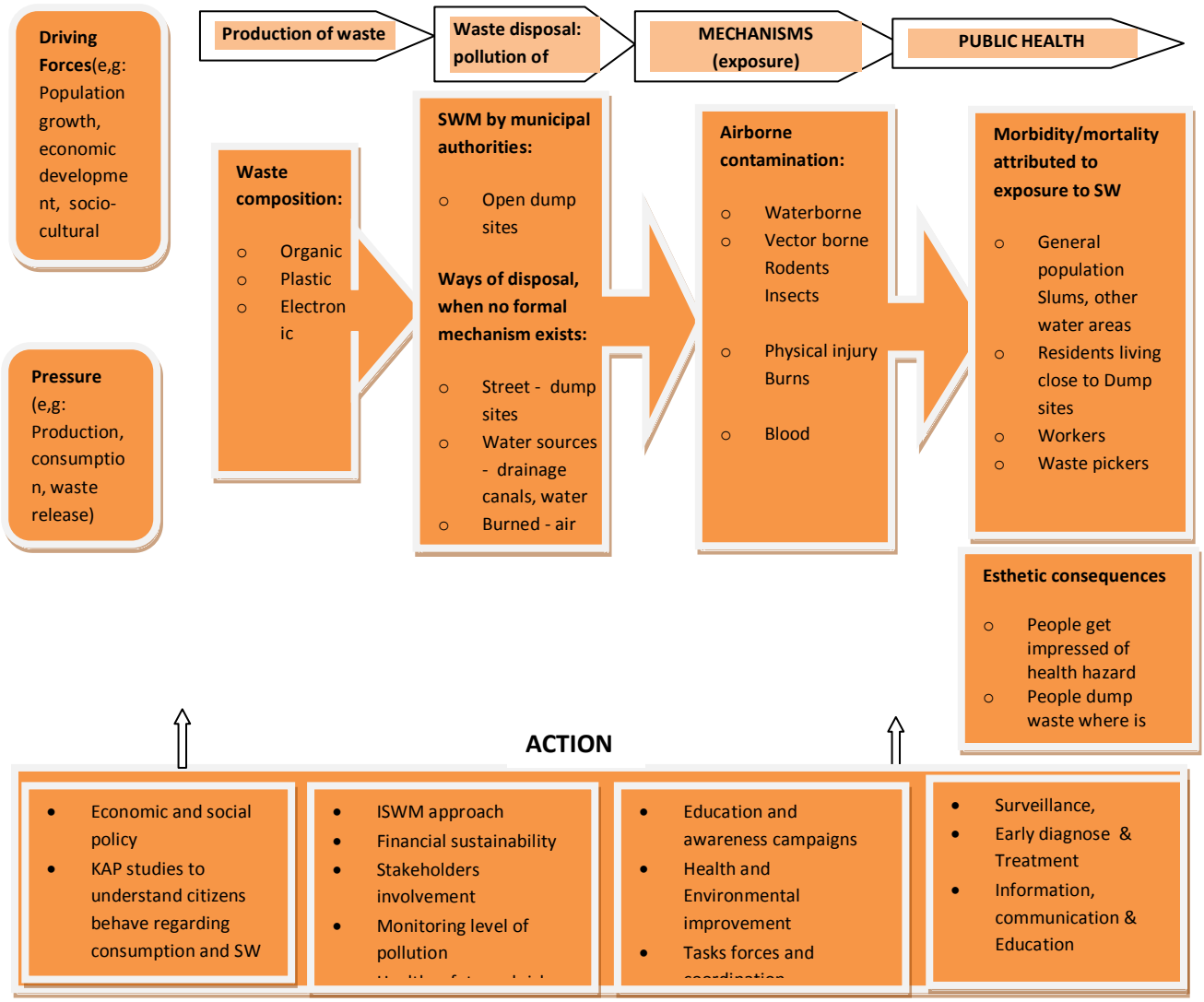
The applied methodology consisted mainly in a literature review. Search tools like Google and specialized online search engines like Pubmed and Google Scholar were used for searching online materials and libraries like Cochrane Library, VU Library, KIT Library were visited to find particular journals and publications relevant for the study. Additionally, a small number of key informant interviewers was taken to clarify and add to the data collection.

2.5.2 Search Strategy

The literature search was done using different database search engines with the help of keywords. The above mentioned search tools were used. Various documents and reports on SWM and successful case studies were searched, but less was found related to the Maputo context. For this reason, other cities were used as reference. Most relevant documents were on top list of almost all search engines, which helped shape this document. ~~They are all listed in the Annex~~

2.6 Conceptual Framework

Figure 5: D-P-E-E-A: Conceptual Framework



Structure and content of the conceptual framework

The conceptual framework is an essential tool in order to explore, describe and analyze information systematically. The framework above was adapted by the author from WHO (n.d), although it is based on the Driving forces-Pressures-State-Exposures-Health Effects-Actions framework (DPSSEA) developed by the World Health Organization (WHO).The DPSSEA is a "representation of the way in which various driving forces generate pressures that affect the state of the environment and ultimately human health, trough the various exposure pathways by which people come into contact with the environment" (WHO n.d)

The adaptation for health purposes has resulted in a framework which takes into consideration human health consequences due to poor solid waste management (SWM) in Maputo city. The components on each box were disposed in a certain order to better understand the linkage between SWM and human health consequences. It also provides definitions of the main concepts of Municipal Solid Waste Management (MSWM) system.

The framework describes how different driving forces (such as population growth, urbanization, policies, cultural, etc.), may exert pressure on the environment (production, consumption, etc) which will directly affect the volume of solid waste (SW) produced in town/urban and as well the composition of generated SW. The type of generated SW may determine the SWM method used. The access or lack of access to these methods (due to political decisions, availability, awareness, economic and socio-cultural factors, etc.), may influence or determine the choice of SWM in place. The SWM method practiced on the site can affect the quality of the environment, which may in turn have negative public health consequences, after people become exposed or come into contact with various hazards in the environment (such as food, air and water), as a result of a SW not properly managed. Actions have to be taken, at each step, to identify and control the driving forces in order to avoid negative human health effects and prevent the occurrence of communicable diseases.

The framework takes into consideration that the above described linkages are more complex. For this reason, it is important to establish causal effects. There are multiple factors related to driving forces affecting human health and consequences vary from country to country depending for example on the age of the person, GDP, lifestyle, geographical and weather conditions, socio-economic and cultural factors (WHO n.d & Khatib n.d).

2.7 Study limitations

- Lack of information related to driving forces contributing to solid waste generate, in the context of Mozambique, have limited our analyses,

- Lack of access to stakeholders to get recent information related to Maputo city,

- Lack of studies on the inter-linkages (driving forces and health consequences) has been mentioned as an obstacle to quantify the impact of the exposure to solid waste that causes health effects.

- Methodological limitations (Gouveia& Prado 2010):
    - studies from the literature reviewed revealed that in terms of epidemiology there is no causal relationship between the exposure and the disease (it could not be assumed that people living close to solid waste dump site are necessarily exposed to the toxic products present in the site), thus the exposure routes are uncertain (it is about probabilities):

    - The potential confounding variables (such as smoking, access to health facility, age, socioeconomic situation, etc.) is difficult to control, and

    - The health consequences of some of the waste hereby mentioned is unclear (the pathway and level of exposure need to negatively impact human health).

Chapter III: Findings

Each determinant of the framework will be analyzed primarily from reviews from studies done in Mozambique. However, due to lack of literature from Maputo on SWM and health impacts, findings from other studies in similar settlements will be used.

3.1 Driving forces and Pressure

The findings of the study were guided by the framework (Figure 5) on solid waste management mentioned above. The presentation of the findings also follows the specific objectives. This chapter covers objective 1 to 3.

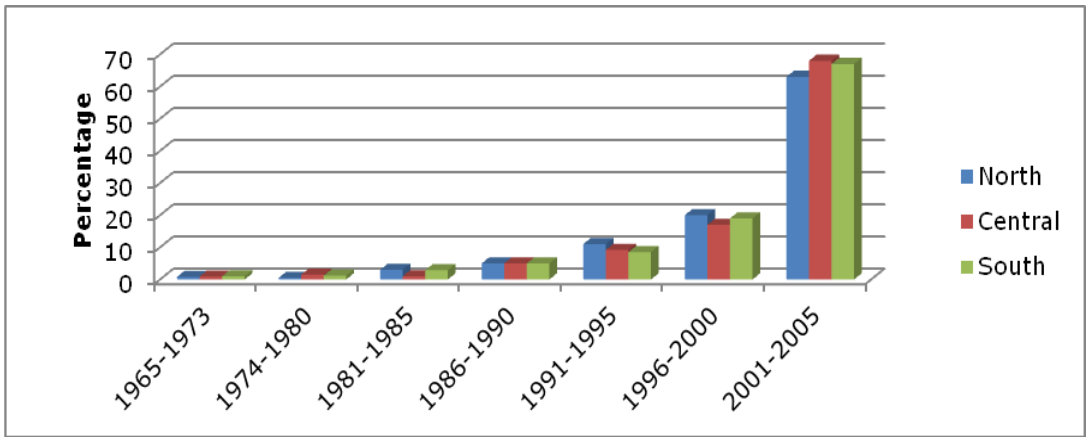
A number of driving forces give rise to increased solid waste generation in Maputo city. As in many urban sites in developing countries, forces such as economic growth and development, rural to urban migration, socio-cultural factors and lack of environmental awareness on proper waste management are the leading forces and pressures that increase solid waste generation in Maputo city (Ribeiro & Buque 2013).

3.1.1 Growth, economic development and globalization

Improved economic development and globalization contributes and determines the volume and composition of wastes generated by households, formal and informal institutions (UNDP 1996). Currently, Mozambique has seen a *boom* on the development of retail industries, offices, tourism industries, extractive industry and production of aluminium (Mozal). The majority (60%) of these activities and major institutions generating waste are concentrated in Maputo City (Ferrao 2006).

According to a study done by Maposse in 2011, development in retail industries attract young people from rural areas without professional experience and that give rise to an increase in informal trading, rapid urbanization and mass production of uncontrollable waste in Mozambique as shown in figure 6.

Figure 6: Trends of Formal and Informal Growth in Mozambique



Source: Maposse 2011.

Currently, 75% of the active working population consists of (64.9%) people who migrated from rural settings. They practice informal trade of goods (including processed and unprocessed food, fruits, vegetables, plastics, et.), and services. These activities do not require special infrastructure or a license from the municipality; therefore, it is practiced in road sides (Maposse 2011). Households (90.7%) in Mozambique are the main users of road-side trade.

In Kampala, people who are involved in informal trade or markets have poor attitudes and engage in indiscriminate waste disposal practices. As a result, organic waste generated increases mainly with plastic and organic waste (Kulabako 2010). The pictures below illustrate waste generated by informal trade along the road side in Maputo city, and local markets, in suburban sites.

Figure 7: Waste generated by Informal Traders in Maputo City

Source: www.google.com: Urban and suburban area, Maputo, Mozambique.

Growth and development emerge with the improvement of personal income generation (Ferrao 2006). The improvement in life conditions and influencing by globalization lead to rising demand for food and other essentials that

eventually shift consumption patterns from traditional to industrialized food. The exponential increase in the use of plastics is the main cause of SW in the streets and in the drainage channels in urban areas of Mozambique (Ribeiro & Buque 2013).

Additionally, due to the lack of MSWM in Maputo city the dumping of waste generated from this activity is usually located close to residential areas and road sides, as shown in the pictures below.

Figure 8: Solid waste on street Side in Maputo

Source: www.google.com: Maputo city and other urban areas, Mozambique.

This creates difficulties for households to carry out basic hygiene around their residential site, therefore affecting the environment. As a consequence this affects the health of the inhabitants and, on top of that, it affects the aesthetic appearance of the city.

3.1.2 Rural to urban migration

There is increasing population density in Maputo city as a result of migration from the rural to urban areas where the living conditions are severely degraded (Araujo 2003).

A large number of studies reported that these residential areas (slums) keep the original rural characteristics; the houses are built by precarious materials (cuttings, clay, reeds, etc.,) and without following an urban plan (Idem). The households are living in "urban poverty and lack safe, secure and healthy shelter with basic infrastructure, such as piped water and adequate provision for sanitation, drainage and removal of household wastes with limited or no safety net" (Sheuya 2008).

This scenario has been changing over the years with the improvement of personal income; the poor neighborhoods haven been replaced by cement houses.

3.1.3 Socio-cultural factors, practices and behavior

Socio-cultural factors and lack of awareness of SWM highly influence the effectiveness of the household SWM practices and attitudes. As practiced in rural areas, open burning and dumping of waste inside backyard or close to residential area has become common in Maputo city (Araujo 2003).

The majority of Mozambican citizens do not have much knowledge about environmental issues. The Government of Mozambique has been implementing an SWM Strategy for citizens' environmental education in the management of SW, consisting of public awareness campaigns on the need for changes in behavior and attitude towards SW. However, the intervention is not systematically disseminated to all people (Ribeiro & Buque 2013).

Additionally, lack of environmental awareness combined with less literacy of people, tends to increase inappropriate SW disposal, as a result, create extra workload, human and financial resource burden on local government. This happens often the communities do little in terms of better living conditions because they believe that this is Government responsibility (UNDP 1996).

3.2 Waste composition

The quantity and rate of solid waste generated in most African countries including Mozambique depends on the population, level of industrialization, socio-economic status of the citizens and the kinds of commercial activities practiced (Babayemi & Dauda 2009). The high dependency on modern technology and packaged food products has created a suitable environment for high waste generation even in poorer suburbs. This section focuses on the sources and characterization of MSW, the type of waste produced, where, and the producers of SW in Maputo City.

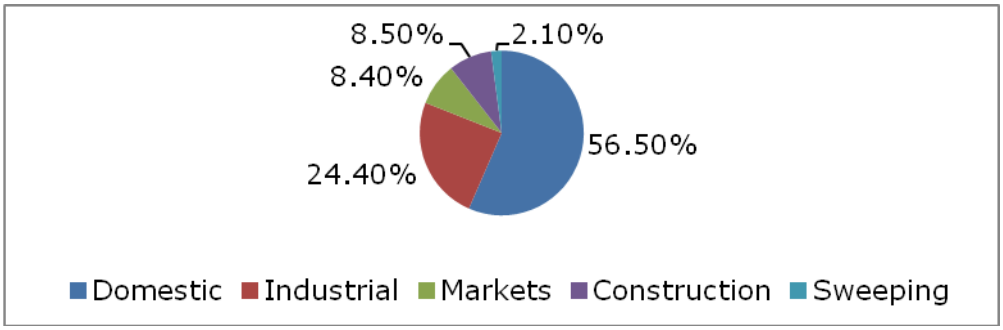
3.2.1Characterization of Municipal Solid Wastes in Maputo

The characterization of solid waste constitutes the very first step in MSWM practices. It is estimated that Maputo city generates a quantity of waste over 1000 tons per day (FMECD 2012).

Municipal solid wastes in Maputo City consist of five main sources of waste, namely domestic, industrial and or commercial, markets, construction and sweeping wastes (Agresus 2007). The quantification of waste is also base on the main sources of waste characterization such as domestic waste (594 tons/day), followed by industrial and or commercial waste (275 tons/day),

markets (89 tons/day), constructions (90 ton/day) and sweeping (22 tons/day) as shown in figure 9 below.

Figure 9: Characterization of Municipal Solid Waste in Maputo

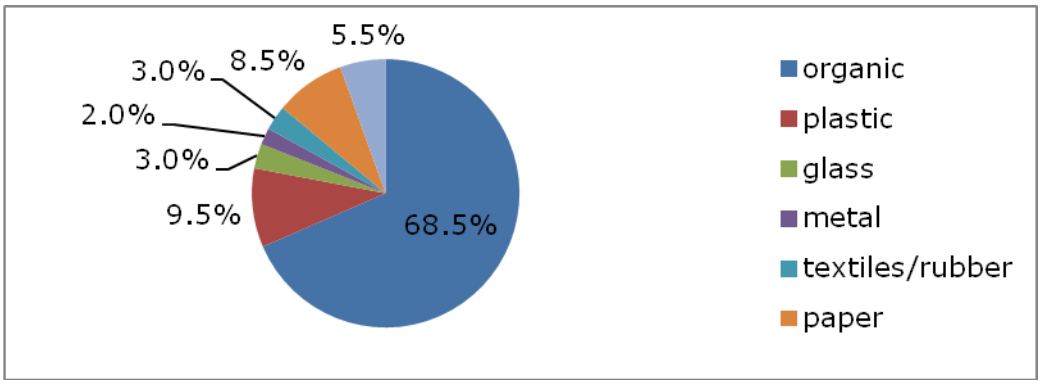


Source: Agresus 2007

3.2.2 Types of Municipal Solid Waste

Types of waste generated vary from organic waste including food waste with high quantities of plastic waste also produced from food containers; beverages and packaging in Maputo City. About 68.5% of all Municipal solid wastes generated in Maputo are organic waste followed by plastic waste (9.5%) and paper waste (8.5%). This pattern is similar when disaggregated by the formal and informal waste management sector of main city and the suburbs of Maputo City (figure 10).

Figure 10: Types and composition of Municipal Solid in Maputo City



Source: Agresus 2007

Municipal solid waste composition in many African cities has similar patterns to those shown in figure 10 above. Studies conducted in Abuja, Nigeria (Ayuba et al. 2013) and Juba, Southern Sudan (UNEP 2013) also found organic waste to be the highest single quantity of MSW produced, though

with lesser quantities compared with Maputo City. Comparing with studies conducted by (Habitat, 1996), organic waste is the highest in Accra, Ghana (85%); Uganda, Kampala (75%) and Rwanda, Kigali (94%).

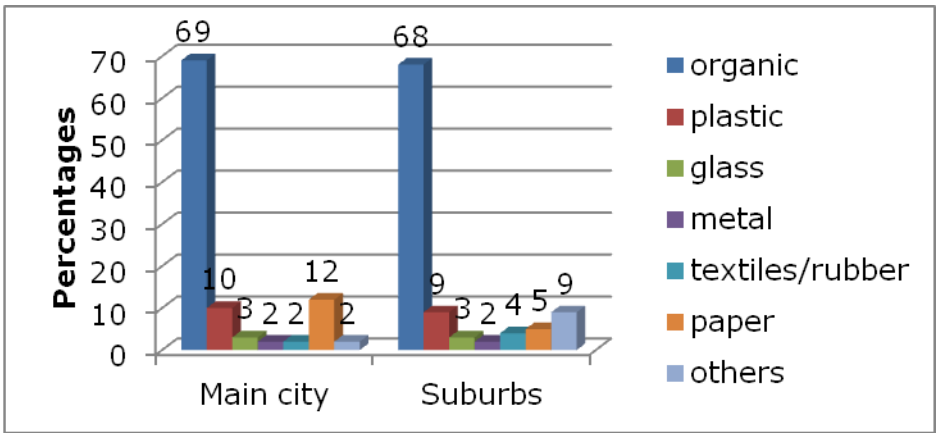
Findings show also that in municipalities there are both non-hazardous wastes (e.g. a discarded paper, glass, metals as well as regular yard and kitchen residue) and hazardous wastes (e.g. expired medication, used batteries discarded cleaning materials, paints and solvents) (Dawson and Mercer 1986; Wagner 1999).

3.2.3 Sources and Producers of MSW in Maputo City

The main source of MSW generation in Maputo City is domestic household waste. Household wastes produced are mainly of organic origin and are generally treated by the producers themselves because the municipal authorities have no capacity to cover some of the suburban and peri-urban neighborhoods.

According to available information, there is no significant difference in the major forms of MSW produced between Maputo main city and the suburbs of Maputo City, except for paper waste in the main urban city as shown in figure 11 below.

Figure 11: Distribution of MSW by Maputo Main city and Suburbs



Source: Agresus 2007

3.3 Current waste management practices in Maputo city

Solid Waste Management (SWM) refers to all activities from the first point of generation to the disposal, and includes "collection, storage, transportation, processing, treatment, recycling and final disposal of waste" (Rouse 2008). To this definition the study added "waste separation" as one of the SWM elements.

The section will analyze the performance of the current SWM in Maputo city, focusing on how the Municipality of Maputo city (MMC) is structured, its responsibilities, the SWM process, stakeholder participation, Current practices and SWM process, sustainability and challenges.

3.3.1 Responsibility and organization

SWM in Maputo city is under the responsibility of the Municipality of Maputo city (MMC), except for Hazardous waste (under MICOA and Environmental Ministry) and Biomedical waste (under Ministry of Health) (CMM 2008). Solid waste management is operated by the Directorate of Hygiene, represented by the councilor in charge of Hygiene. The Directorate of Hygiene is responsible for the "execution of collection services, contracting, supervision and disposal site management", while urban district administrations are responsible for street sweeping" (FMECD 2012).

Municipal solid waste management (MSWM) process adopted is still conventional and only includes removal/collection, transport and disposal of municipal solid waste (MSW), cleaning the public roads and pavements and removal of MSW, management of municipal cemeteries, management activities in the area of prevention and promotion of Health. MSW includes household waste, commercial waste, hospital waste, debris, biomedical waste, hazardous waste, special waste, etc., (Idem).

In order to improve the SW service provided in Maputo, Maputo SW sector has been receiving financial support and technical assistance, including strategic orientation of SWM and the ongoing external service in Maputo, from the Word Bank and German bilateral cooperation, respectively. Since 2002, German cooperation has been supporting the project AGRESU (assistance to solid waste management in the greater Maputo area, provided by GIZ) and in 2007 the World Bank started with financial backing through Pro-Maputo program (Municipal development program) (Idem).

3.3.2 Process of waste management in Maputo City

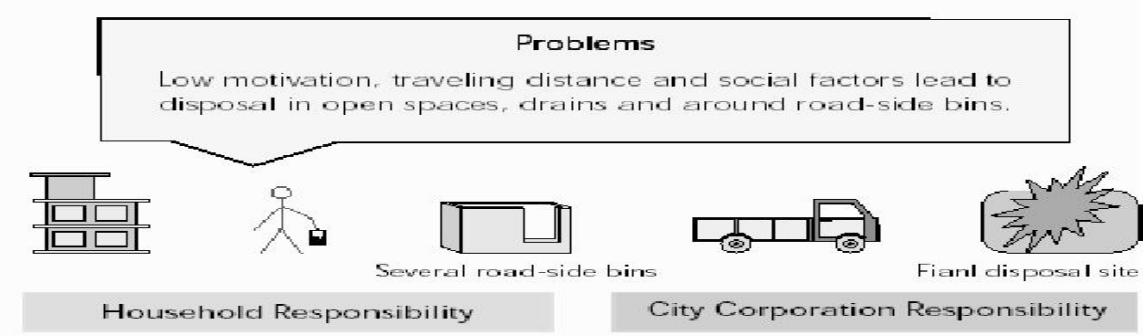
Waste collection service

The total waste produced in Maputo is 1000 ton/day (including household) and 760 ton are collected daily. Collection coverage is about 82%, including urban and suburban areas (FMECD 2012). SW collection services are restricted to urban, suburban neighborhoods and it is practically non-existent in peri-urban areas. There is no data on how many households are

using the SWM service therefore it is difficult to evaluate the collection coverage.

The same study mentioned that collection service provided for households differs for urban, suburban and peri-urban areas. Maputo city is served mainly by public containers placed in the main roads and plastic bag collection collected door to door, whereas the suburban area is only served by big containers, which are also placed along the main roads (WB 2006). The residents have to handle the waste from home to outdoor or to the container that is sometimes placed far away. Then, SW is collected by private companies and transported to the official municipal disposal site Hulene (final disposal site). Below is shown the schematic diagram to show how conventional SWM is done, in general. Both diagrams (conventional SWM and community based approach), were used only as an illustration and not as part of the study framework.

Figure 12: Distance as factor influencing appropriate SWM



Source: Haile 2011 (diagram was adapted from Rahman et al. 2005).

However, from personal observation no containers are available for all Maputo city neighborhoods. Since there is unavailability of containers and another official disposal system in the city, residents feel forced to dispose theirs wastes on the road or adopt other traditional SW methods.

For instance, a qualitative study conducted in Tambo town, Ethiopia (2011), indicated that household attitude related to collection is influenced by the distance where the containers are placed. The study found that a significant number of residents living near the main road, where the containers had been placed, had adopted effective SWM compared with residents living far from the containers, who disposed SW in inappropriate places. The same results were found to residents who have access to private/community based SW collector. Additionally, studies developed in India and Kenya reported that waste collection and transport is affected by lack of information about the collection schedule (Hazra and Goel

2009), and not affordable service, poor roads and insufficient vehicles for collection, lack of private sector participation and lack of knowledge about SWM methods by authorities (Henry et al. 2006).

Maputo peri-urban sites are the most affected with lack or absence of any SWM service, with narrow and unpaved streets, further hindering access to the means SW collection. The literature review shows that due to the absence of a formal disposal SWM the most common disposal practiced in these sites are waste burial, burning or disposal in small bins, throw away on drainage ditches or other inappropriate places (Ribeiro & Buque 2013).

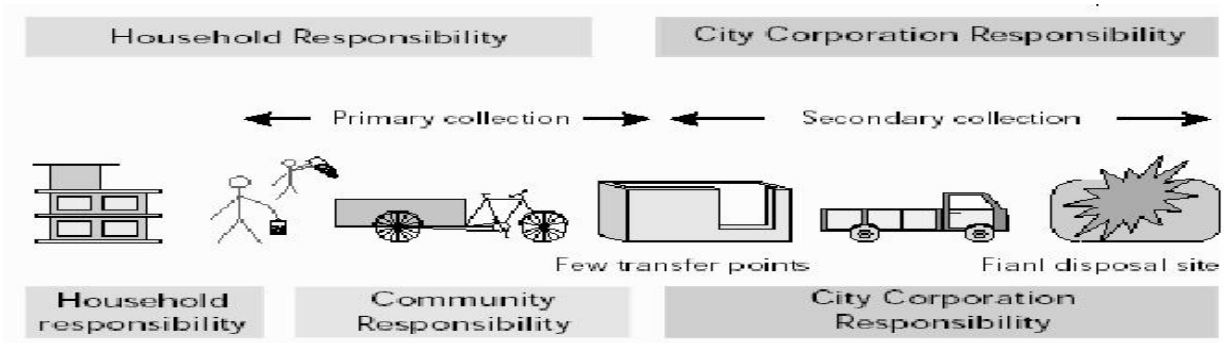
Since 2008, non-household waste producers (commercial sector and other organizations in the urban area) have been responsible for collection and disposal of their self generated solid waste. "They have to contract a licensed service provider and pay an additional contribution to the city's cleaning services". However, their financial contribution is still below planned because of their resistance to pay (FMECD 2012).

Private sector service for waste collection

Municipalities have the authority to establish different arrangements for the optimization of SWM services with hiring public, mixed or private enterprises (IBAM 2008). Private services was contracted to collect door to door plastic bags containing domestic solid waste or collect from the containers (with $1.1m^3$) placed on public road sides in the main city (FMECD 2012). From field observation, the plastic bags are used in neighborhoods covered by MCC services which are placed in front the house, whereas the containers are used by residents living in the buildings. The number of people using the containers is not determined, which results in overcrowding of the container.

Primary collection in suburban area has been done by locally based small scale enterprises (LBSSE) and by private companies. The LBSSE is responsible to collect from household a larger container located in reachable place for the residents and near the main roads for easy transportation. Then, private company transport to the final municipal disposal site (Idem). The diagram (13) below illustrates the community based approach on SWM process.

Figure 13: Diagram of community-based approach on SWM process



Source: Haile 2011 (diagram was adapted from Rahman, et al. 2005).

Studies identified that there are many actors that may have an interest in adequate SWM that could be involved, such as National and local government, NGOs, community, private contractors, recycling associations, Ministry of Health, Environment and Finance (Shekdar 2009) . Initially, a city cleaning fee was paid directly to the private company.

However, with the introduction of the cleaning fee, the fee shall be paid to the municipality and many are not satisfied with the new agreement and payment done by MMC (MMC 2008).

Box 1: Private Vs community participation in SWM

There is a successful example of a locally based enterprise initiative in primary collection in Maxaquene "A" neighborhood, Maputo city suburb area. It used to have waste collection door to door or pre-established fixed points within the neighborhood where to collect. Waste collection was done through "tchovas", carts pulled by animal traction or tractors with trailers as transport. Waste collection using "tchovas" the operators run all around the neighborhood collecting waste door to door, and then transfer to the containers, for the secondary collection. The advantage of using "tchovas" is its ability to adapt to the physical conditions of the urban and peri-urban areas, as well low demand for maintenance. However, usually the service is limited because requires a second transport to the final disposal.

Source: CMM 2008

Waste treatment

In developing countries, which includes Mozambique as well, SWM framework and enforcement system for SW segregation and separation are practically non-existent or dysfunctional (WB 2006).

Maputo citizens are not used to separate waste at home. Solid waste is mixed all in the same place and then collected by the private companies to the final disposal site. Hazardous wastes (eg. syringes), are normally found

mixed within the municipal solid waste collected.

As Scheinberg mentioned in his study, household attitudes regarding waste separation are also affected by real knowledge about how to do it. It is actually the responsibility of municipal authority to promote awareness on household SWM (Scheinberg 2011).

Transport of Solid Waste

Availability of collection vehicles is a challenge for the Maputo Municipality due to lack of financial resources to repair and maintain the vehicles (IBAM 2008). They face frequent breakdowns of trucks and lack of working equipment, which has resulted in lack of regular preventive maintenance until now.

Data from AGRESU project in 2008 refer that the Maputo city municipality was using compacting vehicles to load and unload the containers: 354containersof 1.1m³, 76containersof 6m³and10m³, five containers to suburb an neighborhoods, markets and some areas of urban city. Tractors and "tchovas" are used in suburban or peri-urban sites. The transportation system only served about 50% of the households with access to the road of which approximately25% are in suburban areas (Idem). The number of private vehicles used was not mentioned.

It was noted from the field observation that sometimes the vehicles are not closed or locked while transporting the wastes, especially those run by private companies. These conditions result in air pollution with dust and particles of solid waste from SWM transport vehicles (WB 2006).

Recycling and waste market as a partner on solid waste collection

According to the literature reviewed, from 2006 to 2012, 120ton SW was recycled in Maputo city (FMECD 2012). Populations from rural areas are more often accustomed to re-using materials such as bottles, plastic bottles and glasses (Ribeiro & Buque 2013).

There are few collectors who are members of cooperatives or associations of selective collection Initiatives (Idem). Collecting and selling recyclable activity on Mozambican market is weak due to lack of legal/institutional recognition, economic incentives and lack of transforming industries. A key factor for the success of projects for selective collection is the recognition of recyclable materials as key players in solid waste management.

Final disposal

Up to now, the most common form of waste management performed in Maputo has been the open dumpsite approach, a primitive stage of solid waste management services without any treatment or adequate protection. The official Municipality waste dumpsite in Hulene is located near a residential area (MMC 2008). This method is poor and ineffective. In this way, municipal dumpsites become sources of environmental and health hazards to people directly handling the waste and as well as to those living in the vicinity due to pollution (Nwanta & Ezenduka 2010).

Medical waste has a different treatment. The small units are allowed to use public waste management services, while the larger units are under Ministry of Health waste treatment (FMECD 2012).

3.3.3 Sustainability

In 2002 the Municipality of Maputo, under the World Bank and German cooperation, introduced a different waste fee system to increase its capacity to provide sufficient financial resources for a sustainable and adequate SW service provision. The revenue collection for the waste fee system (the waste fees, proof of service, disposal fees and specific service related fees) is carried out through the electricity provider (EDM) and also through the "Proof of Service" (FMECD 2012).

Waste fee is collected through the electricity bill and is proportionate to energy consumption. All who are connected to the electricity network should pay the waste fee, including household and non-household. The table below shows an example of household waste fee collected in 2010 (Idem).

Table 1: Sample of household waste fee in 2010

Consumption class	Energy consumption/month	Waste fee 2010
Social tariff	0-100 KWh	10 Mtn
Low consumption	0-200 KWh	35 Mtn
Average consumption	201-500 KWh	55Mtn
High consumption	>500 KWh	80Mtn

Source:World Bank 2012.

According to a WB report (Maputo case study in 2012), the household waste fee is not the only source to maintain the SWM system in Maputo. It is however the most important source for financing waste collection and transport. Data from 2011 show that there are 10% of newly connected households annually and at that time more than 90% of all households were covered by the revenue collection system.

The same case study analyzed waste quantities collected, population with access to regular service, total revenues collected and total costs of SWM system. From the table below, it is expected that the revenue rate of growth for the whole period planned can be 97%, as a result of city cleaning fee collection (FMECD 2012). However, the average expected over the whole period for waste collection is 37% (the impact on SWM will be discussed later).

Table 2: Indicators for SWM performance in Maputo City

Item	2004	2007	2010	2012
Collected waste quantities	250 ton/day	400ton/day	600ton/day	760ton/day
Population w/ access to regular service	<40%	<40%	65%	82%
Total costs of SWM system	<$1200 000	$2 406 167	$4 026 041	$5 945 529
Total revenues	$600 000	$1 289 063	$2 484 000	$4 110 000
Costs recovery	<40%	54%	62%	69%

Source: The World Bank 2012.

Increasing on revenues collection shows that Maputo citizens are willing to pay and can afford the chosen system for Maputo. However, the first willingness to pay study (2006)has identified that common citizens are more willing to spend for SWM service improvement, while richer classes assume that they "deserve free service delivery" (FMECD 2012). The study found that the commercial sector and other organizations were not willing to pay either.

3.3.4 Challenges

Literature suggested that the performance of Maputo SWM services has been affected mainly by five factors. These are: economic and financial sustainability, organizational structure, technical limitations for waste collection and disposal, institutional and legal. This analysis was mainly

based on the recent data collected from PROMAPUTO program (WB) and AGRESU project (GIZ), both are initiatives on SWM in Maputo (Idem).

In the past years, due to lack of public funds and the ability to generate its own resources, the Municipality of Maputo has faced the problem of insufficient financial resources for the maintenance and operation of urban cleaning services with regularity and quality. The lack of funds resulted in technical (lack of modern equipment and improper maintenance) and organizational weakness (insufficient and under qualified staff) that then cause poor service delivery with severe effects for the environment and public health (MMC 2008).

With the financial, technical and organizational support from WB and GIZ, MMC has introduced in 2002 its own revenue collection system (the household waste fees, proof of service, disposal fees and specific service related fees) through EDM tax payment and then "Traditional revenues such as property and commercial taxes" started being collected gradually.

Reports showed a significant increase of revenues collected, especially from traditional revenues rather than the waste fee, which allowed MMC to expand SWM service delivery to all Maputo citizens (FMECD 2012). The intervention to improve MMC's performance included also institutional and organizational development support. Thus, such intervention had not only increased revenues of the sector, but brought significant improvement on the service delivery.

The World Bank, GIZ and donors' intervention has been the main SWM service driver of change. What still needs to be clarified is the question concerning whether the MMC is able to maintain the financial and institutional instruments for long-term sustainability and constant improvement of the system in Maputo. Thus, according to the WB and GIZ, MMC is still facing some challenges that need to be addressed:

Box 2: Challenges of current SWM in Maputo

- There is no National policy on solid waste. The current legislation doesn't mention the recycling and reuse of solid waste, and the involvement of waste collectors as drivers of change is not mentioned (Ribeiro & Buque 2013).
- Improvement in Human Resources, focusing on younger employees with higher qualifications and strategic decision to create an attractive and positively perceived work place environment.
- MCC need to adopt modern management approaches in the SWM sector towards decentralization and delegation of responsibilities.
- Involvement of stakeholders that may have an interest in adequate SWM is still weak and needs to be involved as drivers of change, for an integrated SWM approach.

This study reviews workers, waste pickers and residents' health risk and mortality associated with SW exposure. Therefore, it is crucial to review the waste composition and SWM mechanism in order to understand what type of waste and at which level their health is affected. But there is scarcity of data related to the health effects of SW in Maputo city. Findings from developing countries or similar context on health effects of exposure to SW will be briefly reviewed.

Chapter IV: Public Health Consequence

Humans are at risk in all processes of SWM, including workers involved on SWM, waste pickers and residents, especially those who live near the Hulene open dump site. However, the numerous exploration studies done in this area have mentioned that the adverse health consequences of exposure to dangerous substances present in the SW or produced on the SW disposal sites are difficult to measure, "especially if their concentration is very small and there are other exposure pathways" (Giusti, 2009; Mattielo et al. 2013).

This study reviews workers, waste pickers and residents' health risk and mortality associated with SW exposure. Therefore, it is crucial to review the waste composition and SWM mechanism in order to understand what type of waste and at which level their health is affected. But there is scarcity of data related to the health effects of SW in Maputo city. Findings from developing countries or similar context on health effects of exposure to SW will be briefly reviewed.

4.1 Review of the relationship between types of solid waste, disposal mechanisms and health problem

There are several health effects associated with the methods of solid waste disposal. This section focuses mostly on solid waste disposal methods that are more commonly practiced in urban cities that could have similar context to Maputo, Mozambique. Municipal solid waste disposal methods such as land filling, incineration, open dump and burning sites and combusting were discussed with a focus on their health effects.

Health effects associated with solid waste disposal methods

a) Health effects of land filling waste disposal method

Several systematic reviews have been carried out to determine the direct or indirect health effects due to the presence of landfills (Mattiello et al. 2013 & Giusti 2009). Diseases and health conditions such as cancer, birth defects and reproductive disorders, low birth weight, respiratory diseases or symptoms and skin diseases have been evaluated by several studies (Giusti

2009). However, there is very limited or moderate evidence of these diseases, except for few. Despite current evidence, information available is inadequate or insufficient (Porta et al. 2009).

b) Health effects of incineration waste disposal method

Incineration of waste is a major contributor to environmental air pollution through the emission of toxic gases, ashes, residuals and volatile metals. People exposed to those substances face the risk of developing, for instance, cancers of the stomach, colorectal, liver, lung and non-long lymphomas, as mentioned by Mattiello (Mattiello et al. 2013).

c) Health Effects of open dump sites and burning as waste disposal methods

The most common diseases associated with this method are malaria, diarrhea, cholera, irritation of the eyes, skin and noise; and injuries coupled with other vector borne diseases, as shown in box 2 below (Sankoh et al. 2013 & WB 2006).

Box 3: Disease from vectors in contact with solid waste

- Hanta virus, plage, leptospirosis increase with exposure to rat droppings and urine,
- Dengue fever increases where uncollected solid waste exist (i.e., tires, cans), holding water providing mosquito breeding sites,
- Bacterial infections spread by houseflies that have come in contact with fecal matter in solid waste.

Source: World Bank 2006

Open dump sites are also associated with animal feeding diseases, resulting from human fecal matter and toxic food substances in open dumping sites in developing countries. These include tapeworm and whipworm due to improper cooking of domestic animals such as (cows, goats, pigs, chickens, etc). Other diseases such as highly pathogenic avian influenza (H5N1) caused by highly contagious birds have also been associated with feeding on waste in open dump sites (WB 2006).

d) Health effects of composting solid waste disposal method

Composting waste disposal methods have been associated with respiratory and dermal illnesses particularly among workers as compared to the general public or residents living close to waste dump sites. Respiratory illnesses can

occur as a result of exposure to dust, bacteria, fungi and endotoxins release during compost (Harrison 2007; bunger et al. 2000). According to reviews by (Giusti 2009; Domingo & Nadal 2008), irritation respiratory symptoms derived from pollution were found among people residing near composting facilities. .

Type of solid waste and their health consequences

The health effects of solid waste composition, which includes organic, plastic, metals, papers and glass waste will be reviewed below.

a) Health effects of organic domestic waste

Organic domestic solid waste when allowed to ferment in uncontrolled areas poses serious health hazards creating favourable conditions to attract flies, mosquitoes, rats, etc. that speed up the spread of infectious diseases such as diarrhea, cholera, dengue fever, yellow fever, malaria, etc., particularly among waste workers and pickers who are the most vulnerable (Puri et al. 2008).

According to Brodi (2005), the high incidence of diarrhea cases, particularly in children under five in Africa is associated with food contamination caused by vectors including flies and poor hygienic practices related to contamination of organic household waste.

b) Health effects of plastic waste

The human and environmental health consequences of plastic waste are still being uncovered, unlike for the marine environment (European Commission, 2011). However, several chemicals (Bisphenol and phthalates) have been associated with human and animal effects related to cancer and reproductive problems (Galloway et al. 2010).

According to evidence by Galloway et al. (2010 & Lang et al. 2008) bisphenol, a chemical produce from plastic waste is associated with cardiovascular diseases, type2-diabetes and hormone changes in adults. It is also a concern that these adverse effects also associated with increases in prostate cancer, breast cancer, sperm count diseases, miscarriages etc. (Oehlmanne et al. 2009).

c) Health effects of metal waste

Health effects from metal waste contain toxic and poisonous elements that have major effects on humans and the environments. Metals such as lead,

mercury and cadmium derived from scrap metals, plastic or rubbers industries, consumers' products and burning of waste containing such elements. According to the United Nations Environmental programs (UNEP), metals released in the air or on the soil vegetation and water, cause poisoning of humans through inhalation, ingestion and skin absorption that result in nausea, anorexia, vomiting, gastrointestinal, abnormalities and dermatitis as shown in the annex (5) (UNE 2007).

d) Health effects of paper waste

Paper waste when kept dried and collected on time has no direct health effect like other domestic or industrial waste. However, paper waste is most often the most abundant in garbage cans or waste disposal sites, when exposed to rain and sunshine it can decompose and result in pollution of the air, water and soil (Sabesan 2001).

This condition creates breeding ground for biological vectors such as insects and rodents, which are potential vectors for infections like dysentery, diarrhea, typhoid, food poisoning, cholera, worm infection and certain skin diseases that are directly linked with mixed waste disposal (WB 2006).

4.2 Health consequences in relation to specific groups

In this section, we look for evidence from other countries that shows that SW mechanisms may cause health hazards for the general population, people living near wastes disposal, workers and waste pickers.

Household health risk

Household risk can occur from the storage waste at home, collection and to the point of final disposal. However, the resident exposure is not always significant due to less time of exposure and because, generally, household waste does not contain such large amounts of germs (WB 2006).

There are various health hazards that could be related to handling and storage of SW, when it is not done in an appropriate manner. Dropped SW, especially the biodegradable nature, outside the containers is a common practice in Maputo. Since the uncollected waste is accumulated close to home, citizens and the households have direct contact with SW and because it is not protected, the organic waste decomposes rapidly, due to a hot climate, will attract insects, flies, mosquitoes, rats and animals like pigs, dogs, etc. which help to spread diseases such as "diarrhoeal disease, dengue fever, malaria, yellow fever, bancroftianfilariasis", etc., (Puri et al. 2008).

Health risk to people living close to dump sites

People living near SW disposal sites are exposed to environmental health and accident risk. In developing countries, people living near waste processing and disposal sites include infants, young children, women of child-bearing age, and adult people (Landrigan 1998). Studies results focused on health effects on people living near landfill, incinerator and open dumpsite because, according literature reviewed, many studies have focused on these three methods and little is known on health effects due to exposures from composting and recycling (Rushton 2003)

Little is known about health effects associated with disposal of SW in landfills and incinerators in developing countries. Thus, analyzes will be based on the findings from recent (2013) systematic review carried out in this area.

a) Health risks from landfill

(Matiello et al. 2013) reviewed studies (ecological, cohort and case-control) on communities living nearby landfills, which investigate association between landfills and cancer. As outcomes, were considered all cancers, respiratory disease, birth defects and mortality. The studies were carried out in develop countries (Australia, Canada, Denmark, Italy, etc.) and one in Brazil.

Based on the findings from these studies, (Matiello et al. 2013) concluded that there is lack of association between cancer and living nearby landfills. Incidence of cancers in people living at different distances from landfills sites was analyzed and many studies didn't detect any association for the majority of cancer. The same result was found by (Russi et al. 2008), who concluded that epidemiological studies on people living in neighborhoods of toxic waste site have not produced adequate evidence to establish casual relationship between toxic waste exposure and cancer risk. However, few studies found an increased risk for pancreatic and skin cancer in males living nearby (Pukkala and Ponka 2001).

In addition, the same studies investigated the mortality risk in a residential area containing a landfill and after adjustment for age and separated by sex, were found that "liver cancer mortality was not different in populations living distant from the landfill site" (Matiello et al. 2013).

Two studies confirmed the association between nervous system birth defects and landfill containing both toxic substances and urban solid waste (Marshall et al 1997 & Dummer et al 2003). However, confounding factors could have been associated with these results.

An association between respiratory diseases and presence of landfills was investigated and raise of asthma was found only on a site containing toxic from industrial waste.

From the papers reviewed, (Matiello et al. 2013) conclude that evidences are not sufficient to associate total mortality due to exposure to urban solid waste.

b) Health risks from incinerators

Most of the studies of residents living nearby incinerators have evaluated the effects of being exposed to emissions by measuring the distance from the incinerator site or estimating the areas at most risk. The subsequent outcomes were measured: cancers, respiratory diseases, birth defects, cardiovascular diseases, total mortality and skin disease (Matiello et al. 2013).

According to (Matiello et al. 2013), the findings for cancer incident and mortality due to exposure from incinerator are mostly not reliable. A large number of accurate studies carried out in the years 1969-1996 and 2004-2009 were reviewed and reported evidence risk of some cancers in the residents living nearby incinerators. However, recent study, after using advanced technology, morbidity and mortality precisely measured, and dangerous emissions compared in different times, confirmed that the results are highly imprecise and need accurate monitoring of pollution.

A study done by (Cordier et al. 2010) recommended a special attention to risk for urinary tract defects. Vincenti et al. 2008 reported an association between Orofacial defects and exposure to special incinerators.

The results "suffer from poor exposure measurement". Thus, all health effects resulted from exposure to incinerator is consistent if people were exposed for many years and detected later period (Martiello et al. 2013).

c) Health risk from open dumpsite (See annex 4 definition)

People living nearby open dumpsite are at risk to toxic and suffer from anorexia, nausea, vomiting, gastrointestinal abnormalities and dermatitis due to acute exposure of hazardous substances.

Findings showed that there is no waste treatment, even at home and at final disposal level, in Maputo. Hazardous wastes are deposited and sometimes burned in Hulene open dumpsite. In case of metals, plastics or used battery, once deposited are not degraded they can transform in substance (such as arsenic, chromium, mercury, nickel, and zinc), that persist in the environment for many years, can poison people through inhalation,

ingestion and in absorption. There is no data related to association between cancer and SW disposal methods (WB 2006).

Comparing with other age groups, children are mostly vulnerable to toxins because they consume much more food, water, and air per/body weight; "their metabolic pathways are less developed to detoxify and excrete toxins; and any disruption during their growth years can easily disrupt development of their organ, nervous, immune, endocrine and reproductive systems"(Landrigan 1998).

In summary, epidemiological studies on the occurrence of a certain disease in the surrounding area of landfills, incinerators and open dumpsites are very difficult to carry out. The interpretation requires great caution to avoid misleading statements. Unfortunately, many interpretation of certain incidence of cancer or mortality are mostly due to bias (cancer can be associated to other factors like life style, that was not analyzed) because frequently the levels of toxic compounds in the air, in the body of people living nearby were not analyzed. This, for a scientific interpretation statistical analysis is required (Scherenk 2006). Find the summary of health effects associated to exposure from landfills and incinerators in annex…

Workers and waste pickers health risk

Workers and waste pickers handling solid waste all over the world are exposed to high occupational health and injury risks related to the content of the materials they are handling, emissions from those materials, and the equipment being used (WB 2006). The risk for solid waste workers and waste pickers in low income countries is certainly much higher because of more manual activities, which involve more direct contact with waste, less protective equipment, and using few developed technologies with pollution control mechanisms (Idem).

Additionally, workers and waste pickers have occupational health risks, as a result of inappropriate disposal operations practiced. In those countries, wastes are not segregated as recommended, exposing this group to potentially toxic materials, gases and infectious microorganisms.

Even when segregated from other MSW, "they are often placed in large waste rooms that must be emptied manually by workers with picks and shovels". The waste is placed on the ground, requiring being collected by hand; or it is left in an open container/box to be picked up by hand. This process put them in contact with "human fecal matter, paper that may have become saturated with toxic materials, bottles with chemical residues,metalcontainerswithresiduepesticidesandsolvents,needlesandbanda ges(containingpathogenicorganisms)from hospitals, and batteries containing

heavy metals and open burning of waste", which contribute to occupational health problems (WB, 2006).

Studies done in various developed and developing countries report that this factors led to air and water pollution, and after exposed, workers and waste pickers are more likely to have accidents (RR=10), and develop acute Diarrhea (RR=10), infectious disease (RR=6), allergic and non-allergic pulmonary disease (RR=2.6 and 1.4, respectively), chronic Bronchitis (RR=2.5), Coronary Disease (RR=2), injuries (RR=1.3, RR=1.9 for musculoskeletal), etc. These risks are being significantly managed in develop countries, but are still largely unmanaged in most low-income countries (Idem), due to lack of financial resources and political will (Idem).

From the papers reviewed, appears to be a relationship (not accurately quantified), between exposure to SW and increased health and injury risk. I low income countries the risk is higher and protection is less, comparing with develop countries. Bellow a summary of the most common reported occupational health and injury issues in developing countries.

Health risk to people living close to dump sites

People living near SW disposal sites are exposed to environmental health and accident risk. In developing countries, people living near waste processing and disposal sites include infants, young children, women of child-bearing age, and adult people (Landrigan 1998). Studies results will focus on health effects on people living near landfill, incinerator and open dumpsite because, according literature reviewed, many studies have focused on these three methods and little is known on health effects due to exposures from composting and recycling (Rushton 2003)

Little is known about health effects associated with disposal of SW in landfills and incinerators in developing countries. Thus, analyzes will be based on the findings from recent (2013) systematic review carried out in this area.

a) Health risks from landfill

(Matiello et al. 2013) reviewed studies (ecological, cohort and case-control) on communities living nearby landfills, which investigate association between landfills and cancer. As outcomes, were considered all cancers, respiratory disease, birth defects and mortality. The studies were carried out in develop countries (Australia, Canada, Denmark, Italy, etc.) and one in Brazil.

Based on the findings from these studies, (Matiello et al. 2013) concluded that there is lack of association between cancer and living nearby landfills. Incidence of cancers in people living at different distances from landfills sites was analyzed and many studies didn't detect any association for the majority

of cancer. The same result was found by (Russi et al. 2008), who concluded that epidemiological studies on people living in neighborhoods of toxic waste site have not produced adequate evidence to establish casual relationship between toxic waste exposure and cancer risk. However, few studies found an increased risk for pancreatic and skin cancer in males living nearby (Pukkala and Ponka 2001).

In addition, the same studies investigated the mortality risk in a residential area containing a landfill and after adjustment for age and separated by sex, were found that "liver cancer mortality was not different in populations living distant from the landfill site" (Matiello et al. 2013).

Two studies confirmed the association between nervous system birth defects and landfill containing both toxic substances and urban solid waste (Marshall et al 1997 & Dummer et al 2003). However, confounding factors could have been associated with these results.

An association between respiratory diseases and presence of landfills was investigated and raise of asthma was found only on a site containing toxic from industrial waste.

From the papers reviewed, (Matiello et al. 2013) conclude that evidences are not sufficient to associate total mortality due to exposure to urban solid waste.

b) Health risks from incinerators

Most of the studies of residents living nearby incinerators have evaluated the effects of being exposed to emissions by measuring the distance from the incinerator site or estimating the areas at most risk. The subsequent outcomes were measured: cancers, respiratory diseases, birth defects, cardiovascular diseases, total mortality and skin disease (Matiello et al. 2013).

According to (Martiello et al. 2013), the findings for cancer incident and mortality due to exposure from incinerator are mostly not reliable. A large number of accurate studies carried out in the years 1969-1996 and 2004-2009 were reviewed and reported evidence risk of some cancers in the residents living nearby incinerators. However, recent study, after using advanced technology, morbidity and mortality precisely measured, and dangerous emissions compared in different times, confirmed that the results are highly imprecise and need accurate monitoring of pollution.

A study done by (Cordier et al. 2010) recommended a special attention to risk for urinary tract defects. Vincenti et al. 2008 reported an association between Orofacial defects and exposure to special incinerators.

The results "suffer from poor exposure measurement". Thus, all health effects resulted from exposure to incinerator is consistent if people were exposed for many years and detected later period (Martiello et al. 2013).

c) Health risk from open dumpsite (See annex definition)

People living nearby open dumpsite are at risk to toxic and suffer from anorexia, nausea, vomiting, gastrointestinal abnormalities and dermatitis due to acute exposure of hazardous substances.

Findings showed that there is no waste treatment, even at home and at final disposal level, in Maputo. Hazardous wastes are deposited and sometimes burned in Hulene open dumpsite. In case of metals, plastics or used battery, once deposited are not degraded they can transform in substance (such as arsenic, chromium, mercury, nickel, and zinc), that persist in the environment for many years, can poison people through inhalation, ingestion and in absorption. There is no data related to association between cancer and SW disposal methods (WB 2006).

Comparing with other age groups, children are mostly vulnerable to toxins because they consume much more food, water, and air per/body weight; "their metabolic pathways are less developed to detoxify and excrete toxins; and any disruption during their growth years can easily disrupt development of their organ, nervous, immune, endocrine and reproductive systems"(Landrigan 1998).

In summary, epidemiological studies on the occurrence of a certain disease in the surrounding area of landfills, incinerators and open dumpsites are very difficult to carry out. The interpretation requires great caution to avoid misleading statements. Unfortunately, many interpretation of certain incidence of cancer or mortality are mostly due to bias (cancer can be associated to other factors like life style, that was not analyzed) because frequently the levels of toxic compounds in the air, in the body of people living nearby were not analyzed. This, for a scientific interpretation statistical analysis is required (Scherenk 2006). Find the summary of health effects associated to exposure from landfills and incinerators in annex 2…

Workers and waste pickers health risk

Workers and waste pickers handling solid waste all over the world are exposed to high occupational health and injury risks related to the content of the materials they are handling (WB 2006). Additionally, workers and waste pickers have occupational health risks, as a result of inappropriate disposal operations practiced. In those countries, wastes are not segregated as recommended, exposing this group to potentially toxic materials, gases and infectious microorganisms.

Even when segregated from other MSW, "they are often placed in large waste rooms that must be emptied manually by workers with picks and shovels". The waste is placed on the ground, requiring being collected by hand; or it is left in an open container/box to be picked up by hand. This process put them in contact with "human fecal matter, bottles with chemical residues, metal containers with residue pesticides and solvents, needles and bandages (containing pathogenic organisms) from hospitals, and batteries containing heavy metals and open burning of waste", which contribute to occupational health problems (WB 2006).

These risks are being significantly managed in develop countries, but are still largely unmanaged in most low-income countries (Idem), due to lack of financial resources and political will (Idem).

From the papers reviewed, there appear to be a relationship (not accurately quantified) between exposure to SW and increased health and injury risk. In low income countries the risk is higher and protection is less, comparing with develop countries. Bellow a summary of the most common reported occupational health and injury issues in developing countries.

Box 4: Occupational health and injury issues in developing countries

More commonly reported occupational and injury issues:

- Back and joint injuries from lifting heavy waste-filled containers and driving heavy landfill and loading equipment,
- Respiratory illness from ingesting particulates, bio-aerosols and volatile organics during waste collection, and working in smoke and dusty conditions at open dumps,
- Infections from direct contact with contaminated material, dog and rodent bites, or eating of waste-fed animals,
- Puncture wounds leading to tetanus, hepatitis and HIV infection,
- Injury and dumps due to surface subsidence, underground fires and slides,
- Headaches and nausea from anoxic conditions where disposal sites have high methane, carbon dioxide and carbon monoxide concentrations, and
- Lead poisoning from burning of materials with lead-containing batteries, paints and solders.

Source: The Word Bank 2006

Health studies in developing countries shows that a considerable number of waste pickers found at open dumps are children under age of 16 and pregnant women. Sorting and recycling secondary materials is their main source of revenue. As a result of continuous exposure to hazardous waste, they experienced higher disease levels comparing with waste pickers in develop countries (even less comparing with workers from developing country). The most commonly experienced diseases among waste pickers based on health studies of waste pickers conducted in developing countries, are highlighted in the table 3 below:

Table 3: Diseases or conditions associated with waste pickers in developing countries

Disease revealed	Country
• Tuberculosis, bronchitis,asthma, pneumonia, dysentery, parasites, andmalnutrition	Bangalore, Manohar, New Delhi in India
• 70% had upper respiratory ailments 40%hadshin • Disease	AtMetroManila'smainopendump,in1981 750wastepickersstudied
• 85%,incidence of diarrhea • 72%, fever • 63%,coughs and colds • 40%hadchroniccough, • 37%hadjaundice • 29%.,skin ulcers • 15%Eyesorenessor • Redness	Open dumps in Calcutta, India About180wastepickers studied
• Higher prevalence of respiratory diseases (pickers:71%vs.farmers:34%), • Diarrhea(pickers:55%vs.farmers:28%) • Protozoaland helminthicinfestation (32%vs.12%).	Comparative study, Calcutta'sDhapadumpinthe1980's

Source: The World Bank 2006.

Skin disease can be associated with lack of hygiene, which also influence stigmatization among waste pickers. For instance, in Nepal, 73% to 88% waste pickers working in dumpsite reported that did not use soap to wash their feet and hands, respectively. More than 65% did not change their clothing daily and 18% waited more than a week to take baths and

changing clothes. Women pickers bathe do only once a week (Idem).

Chapter V: Discussion, Conclusion and Recommendation

5.1 Discussion

The discussion focuses primarily on public health actions in relation to SW: to monitor health risk due to SW exposure; safety procedures for waste workers; and public awareness towards hazards. Constraints found for the logistics of SWM were briefly discussed, though important, they are not in the direct public health mandate. Possible ways of addressing the gaps were also suggested, based on best practices from other countries that had the same issues and/or have the same context. The selection of these interventions was based on their relevance and the feasibility in the context of Maputo.

5.1.1 Solid Waste Management

MMC is currently adopting conventional WM focused mainly on collection, transport and final disposal in open dumpsite. The quality of waste collection service is poor and SW is not always properly segregated, and often ends up as mixed waste in the open dump site, where it can be burnt. Among this, the main constraints faced by MMC are: cooperation with private sector is deeply mistrusted, lack of involvement of both the government and community on decision making, including waste pickers and the few existing recycling association. Solid wastes are not treated and even less recycled. As a consequence Maputo city is facing environmental and health risks, also loosing economic opportunity from the value of the waste.

Maputo SWM system is financially supported by user fees, MMC tax revenues and donor support (see findings, section 3.3, for more details). Waste management budget is spent mostly on waste collection and transport. As reported in 2011, 82% of the citizens in Maputo are covered by the WM service. The precise coverage still unclear because suburban and peri-urban areas are inadequately served or neglected, although it is known that these areas have the greatest need for these services since people are densely concentrated with less alternative arrangements for waste disposal, creating favorable conditions for disease spread(WB 2012).

Thus, MMC need to adopt the right SWM method where the quality of the system can be improved and made available to all Maputo citizens. Literature that analyzed SWM systems in developing countries suggest to

shift from conventional SWM practice to integrated solid waste management (ISWM). Based on experiences from developed countries, the way forward to ISWM can be done by "public authorities creating a favorable environment and support the sector sustainability, promote waste segregation and recycling". One way to financial sustainability is turning waste into resource (Courtois 2013).

5.1.2 Monitoring of health risks from solid waste exposure

Monitoring health risks has been a challenge for epidemiologists. As noted in the findings, people living nearby waste disposal, workers and waste pickers are exposed to a diversity of hazardous materials (without proper protection), which can lead to potential health risks. However, literature shows that is difficult to measure the health outcome from solid waste due to lack of precise evidence about the substance(s) associated to the disease. Epidemiological studies couldn't yet reach accurate evidences because the emissions from WM process are expected to be a mixture of many substances for which a toxicological profile is unknown.

For the reason given above, many study results are weak due to lack of good exposure information, leading to misclassification. The results are hampered by effects of confounders (such as socio-economic, age, gender, smoking, occupational history and access to health care, etc.,) and lack of complete correction, especially in studies comparing geographically different communities. Therefore, literature shows that studies investigating individuals rather than communities may be the way forward for future monitoring/ evaluations of potential health effects relating to WM, since they can be followed. However, all of study limitations described above would need to be addressed. Also the regulations need to be strengthened in order to prevent occupational and environmental health risks.

Although the health outcomes from SW exposure are not convincing, we know that there some disease that are associated to solid waste and disposal methods. Based on this knowledge, there are some interventions that can be done. For outcomes, such as cancers, which are not expected to occur until many years after exposure, requires exploring analysis for latency which is missing in many studies and costly for developing countries.

This may also include epidemiological studies (e.g. outbreak investigations) to be done, when certain hazards are reported. More sophisticated studies can be complicated, for the reasons given, and the public health department responsible for monitoring should also build on networks, trusting information from established institutions such WHO, CDC, MOH or other health organizations; and seeking assistance from those organization when required. United State (US) is a good reference on that, since has been

implementing surveillance programs for early diagnose and has a national Toxicology program (Idem).

Epidemiologist in develop countries have been using biomarker technology (BT), for estimates the exposure and the health effect.

Box 5 : Monitoring health risks using BT

Epidemiology is ever more making use of developing **biomarker technology (BT)**, both for estimates the exposure and the effect. BT would be especially relevant in situations bellow:

- Where one or two specific substances are of alarm, but is less appropriate to investigate the general exposures emitted from WM process,
- Through biomarkers there is possibility to identify lower level and the total burden of exposure, to do early diagnose of clinical disease and insight into the mechanisms relating exposure and disease. For example, to a potential reduction in misclassification, "the use of urinary nicotine levels can confirm whether someone is currently smoking or exposed to environmental tobacco smoke but wouldn't help the assessment of long-term exposure".,
- In contrast, **biomarkers of genetic propensity** can be costly for use in studies of chronic disease. The field of molecular epidemiology offers the opportunity to combine epidemiology with molecular toxicology to investigate interactions between genetic factors and environmental factors in the cause of disease and identify susceptible groups. However care is also needed to ensure that the chosen biomarkers are appropriate for the epidemiological design.

Source: Rushton 2003.

5.1.3 Safety procedure for solid waste management Workers

Waste workers, in Maputo, often are living in marginal conditions, without any attention from public health agents, leaving them without individual protection equipment, no uniforms or even without proper tools to implement the work under their responsibility. Literature revealed that in developing countries, washing facilities for works are not provided at the work place. This has side effects not only on their health, but has also social negative impact. Workers are also victim of stigmatization because of the nature of the work.

The reason behind this can be due to lack of organizational capacity to monitor, lack of knowledge on SWM and financial constraints. In addition are the lack of education on hygiene, sanitation and health at work place. This information was reported in 2006, the conditions could be changed, since two projects were implemented to improve SWM in Maputo.

The monitoring of waste workers health and safety conditions are not in place nor implemented currently in Maputo. Published literatures suggest specific guidelines for developing countries to improve occupational health conditions for waste workers to help reduce the risks of diseases particularly among waste pickers. Implementing these guidelines start by interrupting pathways of exposure and minimizing the concentration of contaminants. This can be complemented by following some health and safety measures, such as: using protective clothing (shoes, boots, gloves, clothes with visible colors to help locate worker position, etc), respiratory equipment (air filtration, condition and ventilation) medical surveillance standards and protocol, vaccination, controlling emissions and providing good hygiene, etc., (WB 2006).

Waste pickers

Literature shows that conventional SWM systems, practiced in developing countries, fail also for neglecting the contribution of waste pickers. Their contribution in the waste collection process is not recognized and they are being discriminated.

Waste pickers in developing countries, as well in Maputo, work in unsafe conditions and have high occupational health risks, (they are in contact with bottles with chemical, siring from hospital or household, etc.,), even worse if compared with the waste workers. This shows a gap in the existing labour law which doesn't refer to the participation of informal waste pickers and organizations dedicated to the collection and to recycling of urban solid waste in Maputo.

To take advantage of the experiences of informal waste pickers in the current waste management system and as well prevent them from the health risks, it is important to formalize and organize them, create waste pickers associations in the recycling activities. Once formalized, waste pickers received require health care, social security and safety equipment to protect them from occupational risks (UN 2010).

A case study from India, in Pune city, shows that integrating waste pickers into a legal, structured and protective system can effectively succeed to address discrimination and labour right issues and recognize the value of picking and recycling activity. Also, legal recognition allowed Pune municipality to institutionalize a scheme for medical insurance for all registered waste pickers. This action allowed waste pickers to work in safe workplace and prevent them from occupational health risks. Another related example is from Brazil where a study showed that integrating child waste pickers in social programs (family allowance program and cooperative of autonomous pickers of scrap paper and re-used materials), has proven to be

very effective in reducing child labour in waste picking. By doing so, they have prevented the exposure to hazards associated to SW.

Summarizing, most workers occupational health and injury issues could be minimized by implementing some simply safety procedures such wearing protective gear, like gloves and face masks. Waste pickers activities should be controlled and improved: by not allowing child picking, but only registered adults waste pickers, providing modest sorting facilities and improving access to recyclables and preventing health risk. Environmental pollutions from wastes disposal can be prevented by covering the site daily and apply appropriate control of contaminated leachate (WB 2006).

5.1.4 Public Information on hazardous

As noted from findings, the interventions carried out in Maputo have focused on reducing SW and less on health effects or diseases related. Hygiene practices differ and are influenced by socioeconomic, culture and origin/status. The study reveals that level of education and access to information are also factors that influence perception of health risks associated to solid waste among waste workers and procedures.

From my professional and personal experience, it has been observed that WM practices, especially from those who migrate from rural to city, are always associated with the idea of unaesthetic conditions and not to health risks related to SW. The main reason is lack of access to civic education on how to live in city, which has different structure from rural context. It is commonly heard among Maputo citizens, saying that "I have paid the city clean fee, so now is Municipality responsibility to clean the city".

However, the link between level of education and good hygiene practices is not linear. In Maputo context, high level of education doesn't mean having good knowledge on WM or good hygiene practices. Similarly, it is common to see educated people throwing away their garbage in inappropriate places and this is not because of their lack of information, but lack of sensitization on environmental issues or unwillingness to practice appropriate SWM.

Studies carried out in England suggest that public perceptions of the relative health risks reflect not only differences in understanding but underlying social values. The development of effective participatory programs is essential to ensure the public rights and responsibilities to be involved in the assessment and management of hazards in their communities.

5.2 Conclusion

Solid waste management in Maputo remains a challenge as urban population continues to increase with changing consumption patterns that influence waste generation. The health effects related to solid waste are increasing especially in developing countries, including Mozambique.

Solid waste management generation in Maputo is increasing with organic (68.5%), plastic (9.5%) and paper (8.5%) being mostly produced.

Solid waste management in Maputo is improving, however, there are many challenges still being faced by the Municipality in terms of their financial and technical capacities to collect and properly disposed municipal wastes. Thus, majority of the waste currently produced are disposed informally by producers especially in the suburban and peri-urban areas.

Up to date, there is limited information that exists on the health consequences of solid waste in many developing countries including Mozambique. These studies have indicated that vector borne diseases such as dengue and malaria, water-borne infectious diseases such as diarrhoeal and skin diseases, diseases related to air pollution such as asthma and emphysema, and injuries and deaths are associated with SW exposure.

Nevertheless, the current evidence about health outcomes associated with solid waste at a municipal level is insufficient or too weak to conclude a direct health effect, as there are many confounding factors associated with the outcomes. These factors include economic status, age, sex, lifestyle and etc. Thus, the level of exposure is difficult to measure, since the exposure result from a complex mixture of many substances is unknown.

Despite lack of information on health effects, it is observed that vector borne diseases (dengue and malaria), water-borne infectious diseases (diarrhoeal and skin diseases) and respiratory diseases or conditions (asthma and emphysema) do exist in Maputo. Similar diseases and health conditions that exist in other countries are being addressed by monitoring frequently the health risks associated with solid waste.

Monitoring some health risks associated with solid waste can be carried out by: weekly monitoring of vector densities near waste disposal sites (catch insects using fly and mosquito traps), air pollution near sites, spatial and temporal mapping of chronic diseases (cancer, respiratory diseases such as asthma), birth defects and mortality that may be related to potential sources of pollution. In addition, injuries against waste workers and waste pickers can be prevented by providing precautionary measures such as wearing protective clothing, goggles, respiratory equipment and providing proper air filtration.

5.3 Recommendation

Bellow are recommendations based on gaps identified from findings of this study.

For the Ministry of Health and MICOA

1. Monitoring health risks (surveillance) related with solid waste including medium term – health promotion campaigns and advocacy with municipality to implement integrated solid waste management programme (using collected evidence to back up decisions) and short-term for M&E to get a better understanding of solid-waste related health risks in Maputo by collecting data on vectors, pollutants as well as specific diseases and advocating with stakeholders to use such findings.

For Maputo Municipality Authority

1. The Municipality should adapt Integrated Solid Waste Management (ISWM) approach to enhance the current SWM system in Maputo. ISWM SW is the most effective ways to improve waste management system, protect human's health and the environment. The involvement of all stakeholders, including waste pickers and communities, and combined different appropriate SWM activities according to local needs and conditions are critical factors to consider.
2. Long-term – establish partnership between MoH and other health organizations like CDC, WHO and municipality to sustain current MSWMS
3. Develop Information, Education and Communication on occupational and environmental health and injuries related to solid waste managementation and proper waste management practices: by introducing urban hygiene and sanitation education, civic education at schools and for general population, workers and waste pickers.
4. The Municipality should Provide health safety and risk precaution for workers, pickers and drivers by making available to them shoes/boots and protective clothing.
5. Advocate with MOH and partners to provide regular health care monitoring and treatment for waste workers and pickers by:
    - vaccinating against hepatitis A & B, tetanus, typhoid, etc.,
    - Developing medical surveillance standards and protocols including baseline and follow-up examinations (eg. overall fitness and strength, heart conditions, allergies and asthma);
    - Developing information, communication and behavioral change materials on occupational and environmental health and injuries related to solid waste management to improve the current level of knowledge of SWM in Maputo especially among waste pickers.

6. Municipality’s Occupational health program should strengthen the surveillance and ensure mandatory reporting of incidents amongst waste workers, but should also extend to other occupations that create waste, such as medical workers, factories etc and households.

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Annexes

Annex 1: ConventionalWM versus integrated solid waste management

Risks due to Conventional Waste Management	Opportunities from Integrated Solid Waste Management
• Poor efficiencies, undesirable health impacts (such as vector-borne diseases), environmental problems (such as deterioration of ground water quality due leachate contamination) and social issues (such as informal communities working in unsafe conditions) due to centralized approach to waste management Developmental activities and consumption driven lifestyle leading to increased generation of waste Valuable resources go unutilized, • No extensions towards innovation and creation of safe jobs, • Fails to involve all stakeholders, particularly neglecting the contribution of communities and private sector participation • Health hazards to waste workers and prevalence of social evils like child labour, • No attention given to other newer waste streams for special handling as well as recovering resources.	• Combination of centralized and decentralized options with effective pollution control systems (such as leachate treatment and gas capture systems) leading to economic gains due to improved efficiency, overall cost reduction, minimal environmental impacts and social acceptance, • Strategically planned waste minimization and green procurement programs leading to more sustainable consumption patterns along with economic development Facilitates recycling of valuable resources such as plastic, glass, paper and metals, recovery of alternate • energy sources such as Refuse Derived Fuel (RDF) from high-calorific value fraction of waste, recovery of biogas or compost from biodegradable waste • Encourages innovative technology development in newer areas such as waste to energy and recycling and promotes green jobs that ensure safe working conditions Ensures multi-stakeholder participation in decision-making process by involving • Non-Governmental Organization (NGOs), Community Based Organization (CBOs), rag pickers, private sector, residential and commercial communities with the government, • Brings waste workers into the formal economy and providing them with safe working conditions Addresses management of both MSW and other

Source: chapter 5….UN 2010, Shanghai Manual – *A Guide for Sustainable Urban Development in the 21st Century*.

Annex 2: Heavy Metals with Established Health Consequences

Heavy Metal	Sources of Environ mental exposure	Minimum Risk level	Chronic exposure toxicity effects
Lead	Industrial, vehicular emissions, paints and burning of plastics, papers, etc.	Blood lead levels below 10 µg/dl of blood*	Impairment of neu-rological develop-ment, suppression of the haematological system and kidney failure
Mercury	Electronics, plastic waste, pesticides, pharmaceutical and dental waste	Below 10 µg/dl of blood* Oral exposure of 4mg/kg/day**	Gastro-intestinal disorders, respiratory tract irritation, renal failure and neuro-toxicity
Cadmium	Electronics, plastics, batteries and contami-nated water	Below 1 µg/dl of blood*	Irritation of the lungs and gastrointestinal tract, kidney damage, abnormalities of the skeletal system and cancer of the lungs and prostate

Source: UNEP 2007

Annex 3: Major solid waste disposal methods

Composting	• An aerobic, biological process of degradation of biodegradable organic matter
Incineration	• A process of combustion designed to recover energy and reduce the volume of waste going to disposal
Landfill	• The deposition of waste in a specially designated area, which in modern sites consists of a pre-constructed 'cell' lined with an impermeable layer (man-made or natural) and with controls to minimize emissions.
Recycling	• The recovery of materials from products after they have been used by consumers
Sewage treatment	• A process of treating raw sewage to produce a non-toxic liquid effluent which is discharged to rivers or sea and a semi-solid sludge, which is used as a soil amendment on land, incinerated or disposed of in land fill

Annex 4: Definitions of the main concepts used in thesis

Terms	Definition	References
Waste	• There is no universal definition of waste. Waste differs from garbage. The most common definition of waste refers it as "residual object, substance or material considered useless by its owner and is therefore discarded". Waste is as well described as a by-product generated by human activities. • Waste can be classified in four schemes: by physical state (solid, liquid and gaseous), by physical properties (combustible, compostable and recyclable), by material (bottles, paper, plastics, metal, electronic devices, etc.), by origin (domestic, commercial, agricultural, industrial, etc.) • Even perceived as no value, wastes can increase their value if recovered or reused through the process of composting or recycling. In case of no chance to be recycled or reused at the place of generation it is perceived as absolute waste.	Belitewski 1997, Dhamija 2006 & Furedy 1993 White et al 1999
Hazardous and non-hazardous wastes	• Waste can be classified as well as hazardous and non-hazardous. Hazardous waste refers to discarded residues from household and also from specific sectors that contain physical, biological and chemical characteristics in certain quantities to potentially set at risk human health and the environment • Hazardous waste composition is described as infectious, chemical, pharmaceutical, radioactive and anatomical. Healthcare waste (human and animal healthcare is the main source), are the most common type of hazardous waste generated. The most common hazardous generated in household are used batteries, expired medication, cleaning materials, etc • Non-hazardous waste refers to discarded liquid and solid residue that has no physical, biological and chemical components in significant level to lay the environment and human health at risk	Dawson & Mercer 1986 & Goldeman et al. 1986
Solid waste	• is defined as "types of residual substances that have no kinetic mobility and are therefore likely to accumulate on the site where they are produced such as metal, glass, textiles and wood residues" • This definition exclude wastewater (liquid waste), and atmospheric emissions (Gaseous waste) and human excreta	Enger& Smith 2004 Dhamija 2006, Puri, Kumar &Johal 2008
Municipal solid waste	• Is defined to include waste and street sweepings materials discarded for disposal by households, non-hazardous solid waste from industrial, commercial and institutional establishments (including hospitals, canteens/restaurants, hotels and motels), and market waste. • It comprises of food waste, metal and glass,	UNDP 1996 OECD 2012

Terms	Definition	References
	paper, plastic, construction debris, batteries, electric light bulbs, automotive parts and discarded medicines and chemicals. • This definition excludes waste from municipal sewage networks and treatment, municipal construction and demolition activities.Semisolid wastes (sludge and night soil) are treated by liquid waste management systems. Whereas hazardous from industrial and medical wastes are not components of municipal solid waste and usually is quite difficult to detach from municipal solid waste, especially if they are small and spread. Municipality solid waste management (MSWM) systems have to include special procedures for preventing hazardous materials from entering to the municipality solid waste and ensure that the serious consequences that occur when they do will be reduced. Finally, waste from construction and demolition also require separate management procedures • According the Organization Economic Co-operation and Development (OECD), municipal waste is collected and treated by, or municipalities	
Domestic waste	• Domestic waste is generally classified as municipal waste. It refers to non-hazardous waste, generated from general catering and other residential waste. Exclude Commercial waste, General industrial waste General factory waste, Floor Sweepings, office administration waste	http://www.cardiff.ac.uk/osheu/resources/Domestic%20waste.pdf
Waste management	• Refers to the entire cycle of material which include production, consumption, organized collection, transportation, treatment, recycling, resource recovery and disposal wastes, in such ways to reduce the negative effects to the environment and human health • Waste management approach varies from country to country according national regulations/laws, socio-economic, cultural and traditional practices, collection and disposal practices, as will be described on the next chapter. Also is a process that has been on significant transformation over the years.	WHO?? &UNDP 1996
Health	• Based on the World Health Organization health is defined as state of complete physical, mental and social well-being and not merely the absence of absence disease or infirmity	WHO 2012, http://www.who.int/ageing/active_ageing/en/
Environment	Is defined as external conditions influencing the development of people, animals or plants.	Rushton L. 2003.

Terms	Definition	References