WASTE–TO–WEALTH POTENTIALS OF MUNICIPAL SOLID WASTE:

THE CASE OF GA-EAST MUNICIPAL ASSEMBLY, GHANA.

By

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DECLARATION

I, Benedicta Abiti, declare that this research report, submitted in partial fulfilment of the requirements for the award for the Degree of Master of Science in International Cooperation Policy, is wholly my own original work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

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DEDICATION

This research work is dedicated my daughter, Elizabeth Senam Afi Agbemavor as I welcome her to the world.

I also dedicate this work to all persons who work in sustaining solid waste management in Ghana.

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ABBREVIATIONS AND ACRONYMS

AMA	Accra Metropolitan Assembly
AdMA	Adentan Municipal Assembly
GEMA	Ga East Municipal Assembly
DPCU	District Planning Coordinating Unit
FMENCNS	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
FAFM	Free Africa from Mosquitoes
GHG	Greenhouse gases
PHC	Population and Housing Census
GSS	Ghana Statistical Service
EIONET	European Environment Information and Observation Network
MFE	Ministry for the Environment, New Zealand
MSW	Municipal Solid Waste
NEMC	National Environmental Management Council - Tanzania
NEMC	National Environment Monitoring Council
GWMA	Ga West Municipal Assembly

ABSTRACT

A sustainable waste management system has become an integral part of resource management. As the world experiences increase in population and urbanization, over dependence on virgin resources has come to the fore of socio-political discussions. In Ghana, population is increasing due to more economic activities especially in the cities. This is affecting the waste management system of the cities. The purpose of this research was to understand the waste management practices of the Ga East Municipal Assembly (GEMA) of the Greater Accra region of Ghana. The paper focused on ascertaining the composition (waste mix) of the municipal solid waste, what resources could be recovered from this waste and the socio-economic benefits of waste-to-resource to the municipality. The researcher therefore used exploratory research design to examine the situation in the municipality in addition to using acceptable (sustainable waste management) practices in some advanced countries as theoretical reference point. Both secondary and primary data were collected from administrative personnel and operators of the "Abloradgei" dumpsite of GEMA using interview and observation. The results shows that majority (48.8%) of the municipal solid waste is organic materials whiles the remaining (51.2%) are inorganic materials such as plastics, paper, glass, clothing and debris. The result also shows that majority (81%) of the collected municipal solid waste is through door-to-door method, while 63% of the municipal solid wastes are collected with no sorting from source, no modern treatment and no resource recovery system exists in the municipality. However, the municipality depends solely on conventional landfilling. This situation is alarming and does not conform to sustainable waste practices where waste must be collected, sorted and treated to recover resources for use again by the society in order to minimize the overall harmful effect of

the waste, whiles conserving resources towards a sustainable future. It was observed that the municipality could take advantage of waste-to-resources by compositing organic materials to achieve natural gas, recycling plastics to diesel fuel and/or other plastics; aluminium to beverage cans, building and furniture frames, cars' chases, and other aluminium products which lead to a significant reduction on greenhouse gases. Also clothing could be reused, recycled, or graded and used for insulators in cars, furniture and buildings which would also reduce the dependence on virgin materials. The overall net effect is improving water supply, energy savings, reducing deforestation and global warming and above all not compromising to sustainable society. It is therefore recommended that the municipal engage on public health, sanitation and waste management education to bring positive attitudinal change, collaborate with research institutions towards sustainable waste-to-resources projects, and thus improving market for waste processing industry to boost recycling and resource recovery.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The term “waste” in this generation raises an issue that is worth considering. In Circular Economy, waste is identified as a resource which is misplaced, and therefore more accurate to refer to it as “by-product” instead of “waste”. This idea thus follows the principle of the “zero waste” natural ecosystem, where a waste of one trophic level becomes a resource to another level, and thus ensuring a closed loop system which enables the movement of material through the system without waste. With continuous unsustainable growth of mankind, the natural ecosystem which has measures in place to ensure a no-waste cycle of material has been exchanged for an artificial man-made ecosystem by the intensification of human activities and urbanisation. The problems associated with the man-made system are of concern to many organizations. The production of waste is an inevitable aspect of human existence, especially with increase in population and its associated problems. Versilind et. al. (2002) described waste as a consequence of everyday life – of all creatures. Everybody is responsible for the generation of waste. Every sector of the national economy – farms, mines, and factories as well as businesses, institutions, and households – contributes to the mounting mass of unwanted materials requiring disposal (Nadakavukaren, 2006). However, “municipal waste comprises waste from private households and similar institutions, as well as domestic-type waste produced by trade and industry” (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (FMENCNS), 2006). Municipal waste includes, for example, household waste, separately collected bulky waste, biowaste, market waste, road-sweeping waste, paper and glass. The generation of solid waste, was a

result of when humans abandoned nomadic life and begun to live in communities, around 10,000 BC (Versilind et. al., 2002). As the years went by, groups of people have resorted to various means of clearing the waste in order to make life comfortable. Today, many nations face a looming waste management crisis, as their landfills reach capacity and continue to degrade the environment (Kallman, 2008). Kallman would not be wrong in linking waste management to environmental quality and also to human health. This is because, poor waste management is manifested in the environment and also affects the health of the people around, which leads to a negative impact on the economy. So, quality environment, health and some aspects of economy could depend on the quality of waste management, i.e. how sustainable the waste is generated, collected, transported and disposed-off or recycled in an area. In order to manage waste effectively and or to ensure a closed loop system, Uriarte (2008) identifies five important stages of products which are prevention, reduction, recycling, treatment and disposal. Countries especially developing ones are still straggling with the waste management issue and Ghana is one of them. This paper gives highlights of the challenges of the waste management system of a municipality in Ghana and proposes ways of making it sustainable.

Ghana, a developing West African country has experienced rapid population growth for the past decade. According to the 2010 Population and Housing Census (PHC) conducted by Ghana Statistical Service (GSS), as at September 26, 2010, the total population of Ghana was 24,658,823 compared with a total population figure of 18,912,079 in 2000. This result shows a population growth of 30.4% within this 10-year period and hence recording annual intercensal growth rate of 2.5% compared with 2.7% recorded in 2000 (GSS, 2012). The results also indicated that Greater Accra region is second to Ashanti region with a 16.3% of the Ghanaian population whiles Ashanti region has 19.4% of the total population of Ghana.

According to Thompson (2010) this population growth has contributed to municipal waste production that far outstrips the country's capacity for containment and processing. "Municipal solid waste management in Accra, Ghana, is at present delivered in an unsustainable manner" (Boadi & Kuitunen, 2003). This is obvious in the generation, collection, transportation, and disposal or recycling of the waste. Currently in Accra, the capital city of Ghana, there is a severe waste management challenge. The ignorance and bad attitudes of some inhabitants and passer-bys accounts for the indiscriminate and irresponsible dumping of solid waste in street corners, in-between houses, on parks, in gutters, drains, wetlands, and in water ways. To add to that, more waste is generated than collected causing a deficit of solid waste left in the environment to pose problems such as flooding and diseases, to mention a few, due to blocked water ways and unclean environment. Furthermore, the collected waste is mostly hauled unto dumpsites un-separated and untreated, resulting in environmental pollution and greenhouse gas emissions among others. According to the Mayor of Accra, Mr. Fred Vanderpuije, 2,200tonnes (thus 0.97kg/person) of solid wastes are generated every day in Accra (Accra Metropolitan Area) in 2011. However, 400 tonnes of this solid waste are left uncollected and therefore are not properly disposed off through the metropolitan waste management system **(**The Statesman, 2011). This translates to about 240g of waste per person left uncollected. The uncollected waste, finds its way into gutters and nearby streams, causing air-borne diseases, polluting water bodies, and choking gutters which usually cause floods. In recent years, residents of Accra encountered severe flooding during the rainy seasons (May to July) and Sam Jr**.** (2002) identified possible causes of the increased incidence of floods as ranging from inadequate flood management practices to poor waste management. Insanitary land filling, and surface dumping, despite the environmental, social and economic problems associated, seems to be the only way of managing waste in

Accra. Most of the municipalities and districts, due to the initial low cost of operation of the dumpsites, have resorted to surface dumping or landfill sites as ways of managing their waste. One of such municipalities is the Ga East Municipal Assembly (GEMA) in the Greater Accra Region of Ghana.

The GEMA pointed out poor environmental sanitation as a major contributory factor. The municipality identified some contributors to the sanitation problem in the municipality with bad attitude and ignorance of inhabitants, inadequate numbers of refuse containers, irregular and untimely refuse collection, lack of engineered final disposal site, inadequate machinery and equipment, inadequate education on environmental sanitation, absence of bye-laws and its enforcement, inadequate budgetary allocation, inadequate motivation of environmental health staff, lack of logistics and transport and inadequate capacity of staff, as the major ones (GEMA, 2009). According to the action plan by GEMA (2009), over 68% of waste collection and disposal is covered by the polluter-pay system and the cost recovery from operation and maintenance of the final disposal is also catered for through the pay-as-you-dump policy, which, according to the action plan, cannot recover completely the cost of maintenance of the site.

The unresolved issue of solid waste management in the city of Accra and its surrounding communities has been a priority to successive governments for years now. Answers to questions relating to how best to solve the solid waste problem is still sought for by the GEMA. The GEMA is however convinced that if a more scientific method like waste to energy is introduced, there could be total cost recovery and revenue generation, in addition to eliminating the social and environmental problems faced at present. An improvement of the solid waste collection and disposal in Accra will alleviate the flooding problems in Accra according to Sam Jr. (2002), and will solve other environmental and social problems in addition to creating more jobs for the youth. In

2009, the Ghana Science Association (GSA) held a workshop with stakeholders with the view of providing a thorough insight into the plastic waste problem and how to solve it. Points arrived at included "(1) plans to permanently get rid of existing plastic waste, by going beyond collecting them from gutters, beaches and streets. (2) Guidelines must be evolved and popularised to promote proper disposal of plastic waste and minimise indiscriminate littering. (3) Measures must be instituted to reduce future overuse and wastage of plastic" (Addai, 2009).

Some developed countries are noted for efficient waste management approaches. For example Germany which started with land filling is now managing waste with other technologies which are environmentally friendly and economically sustainable. Information from the German Ministry for the Environment, Nature Conservation and Nuclear Safety (MENCNS, 2010) mentions that, in the past, waste was simply land filled, but it has since been recognized that waste contains valuable raw materials which can be used to conserve natural resources. Also, German waste management is an important industrial sector and provides high-quality technology for the efficient use of waste as a resource and the environmentally sound disposal of the remaining residual waste (MENCNS, 2010). Recycling has emerged to be the most important form of managing waste for the European Union for the future. Moavenzadeh et.al, 2002 mentioned that, resource recovery can solve most environmental problems as well as reduce the consumption of virgin materials and water.

1.2 Statement of the Problem

Among all the ten (10) regions of Ghana, the Greater Accra region is experiencing rapid socio-economic development. However, the region is also getting its share of challenges

associated with rapid development which is typically faced by developing cities. Greater Accra region has the highest population density due to urbanisation and rural-urban migration with an estimated population growth of 38.0% between 2000 and 2010 (GSS, 2012).

The Ga East Municipal Assembly, a member of the 10 assemblies of the Greater Accra region is also facing huge waste management problems. With the increasing influx of people from other parts of the country and rapid urbanization, huge amounts of human and industrial waste are generated at an alarming rate, with some disposed-off indiscriminately. About 35% of waste generated daily in the municipality left uncollected, creates various kinds of inconveniences in addition to posing health hazards to the people. In most developing countries, waste management activities are perceived to be economically unattractive and therefore considered to be the sole operations of the government and its agencies. However, due to rapid urbanisation and increase in population, government resources towards ensuring sound and improved sanitation continue to decline. The Municipal Assembly is thus, considering various ways and especially a scientific way of improving the waste disposal and management system, which is economically viable enough to be sustained. However, to achieve a sustainable waste management system by the municipality, it is important to understand detailed components of the solid waste generated and disposed at GEMA, and develop scientific mechanisms or systems necessary to transform this solid waste to demand resources that can add value to the society. The researcher therefore intends to examine the waste management practices of GEMA, compare it with best practices from advanced countries and assess how to create value from this municipal waste toward a sustainable society.

1.3 Research Questions

Based on the problem, the following research questions were derived for the study.

i. What are the current detailed constituents of the municipal solid waste of GEMA?
ii. What are the waste management practices of GEMA?
iii. What are the resources that could be derived from the waste based on German waste-to-resources techniques?
iv. What are the socio-economic impacts or benefits of these derived resources to GEMA?

1.4 Objectives of the Study

This study sought to appraise the waste-to-resource potentials of the solid waste components in GEMA.

There are four specific objectives of the study. They are to:

1. Ascertain the current detailed components of the solid waste in GEMA.
2. Understand the waste management practices of GEMA.
3. Ascertain the resources that could be derived from the waste based on German waste-to-resources techniques.
4. Assess the socio-economic impact of the resources derived from the solid waste.

1.5 Significance of the Study

1. The research will bring out an overview of the existing waste and its unused resource potentials. It will propose adequate separate collection and sorting technologies and following waste treatment options for the pilot region.

2. The results will be used as a proposal to donor agencies and partner organisations for implementation. It will help to solve the sanitation problems related to waste management in the municipality, create employment opportunities and income for the youth and a source of revenue for the municipality. It will serve as an example for other municipalities and districts to improve their waste management system.
3. The research will add to existing literature for future references.

1.6 Limitations of the Study

Ga East Municipal Assembly is among the ten (10) districts in Greater Accra region. There are many dumpsites across the region. However, due to time and cost constraint, the researcher focuses on Abloradgei dumpsite site for this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter would focus on discussing existing literature that is relevant to the study. The various definitions and classification of waste, waste generation, sustainable waste management, and an examination of the current wealth of waste would be discussed.

2.2 The Natural Ecosystem, and Man-Made Ecosystems

Man's quest to meet his ever-increasing needs has brought about the evolution of the ecosystem. The natural ecosystem has its way of managing the material and energy flows in a way that ensures no waste. For instance, considering the material and energy flows of an aspect of the natural ecosystem where the sun provides all the energy needs of plants, which are eaten by an herbivore, making use of all the energy. The carnivore, using the herbivore as food, utilizes the energy as well. Worms and bacteria in the soil, also work on the dead carnivore and the droppings of all the animals in the cycle to decompose into nutrients and soil for plants to utilize. It would be noticed that, there is actually no "end" for the energy and material flow in the system: it ensures a continuous circular flow without waste. With industrialisation, this system has been exchanged for the linear ecosystem which uses more material and energy to produce goods and services for human consumption without taking into account the end-of-life of the products. This system ensures a continuous production of waste in the system. The main problems of concern here are:

- Constant reliance on the limited resources to satisfy unlimited needs.

- Production of various wastes in the system that needs more space and resources to manage.

In order to eliminate or reduce the problems, the circular economy model has been designed to ensure and continuous flow of resources in the ecosystems. It imitates the natural ecosystem with modern ideas of the life cycle of products. The three ecosystems are represented in figure 2-1 below.

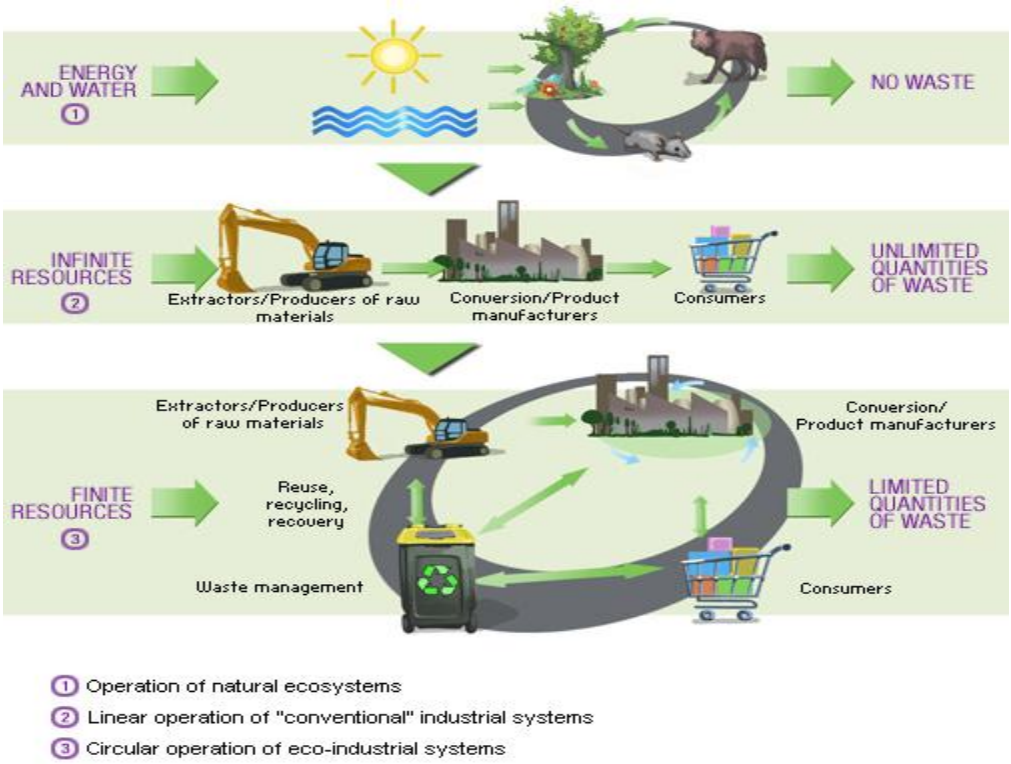

Figure 2-1: Natural Ecosystem versus Linear System and Circular Economy System System

(Source: GDF SUEZ, 2013)

As can be seen from the figure, whiles linear operations of conventional industrial systems demand unlimited resources from limited sources and produce unlimited waste, the circular operation of eco-industrial systems, manages the flows while allowing us to

maintain our modern life sustainably, and thereby sharing the main idea of the natural ecosystem. To be able to understand the concept of the circular economy model with relation to waste to resource activities, the next topic would explain the definitions of waste.

2.3 Definition and Classification of Waste

According to Uriarte (2008), waste consists of products of human, animal and economic activities that are regarded as useless. The Basel Convention in 1989 defined waste as "substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law". The European commission also defines it as "any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard" (EIONET, 2009), whereas OECD defines it as "materials that are not prime products (i.e. products produced for the market) for which the generator has no further use for own purpose of production, transformation or consumption and which he discards or intends or is required to discard" (EIONET, 2009). There are some common ideas among the four definitions: a substance; not desired or useless; actually, intended to be or required to be thrown away. We can thus generally define waste as any substance that is not desired and therefore is or intended to be thrown away. This research thus would focus on solid substances which are regarded as useless and thus thrown away.

Waste can be classified in several ways depending on the purpose or objective of the classification. While some people would classify waste for administrative and management reasons, others do it for educational purposes and others still for easy identification. Those, who have the aim of just identifying waste, will classify it based on

the physical state, chemical composition and source. The three main physical states of waste which could be a form of classifying waste are solid, liquid and gas. Combinations and overlaps of these states also give other types of waste. Figure 2-2 below gives one way of classifying waste and shows the overlaps.

Figure 2-2: Classification of Waste

(Source: mfe.gov.nz, 2013)

The figure shows that hazardous waste, being in the middle of the diagram, is either present in all the three types or it is a combination of all the types of waste. One way of classifying waste for administrative purposes is by the source of the waste, where for example solid waste is classified into three main types based on the sources and for institutional arrangements for waste collection and disposal. The European Union classifies solid waste into two broad groups; municipal and industrial, as shown in figure 2.3-2. This study would focus on municipal solid waste which includes all domestic waste, market waste and rubbish, as shown with blue arrows in figure 2-3.

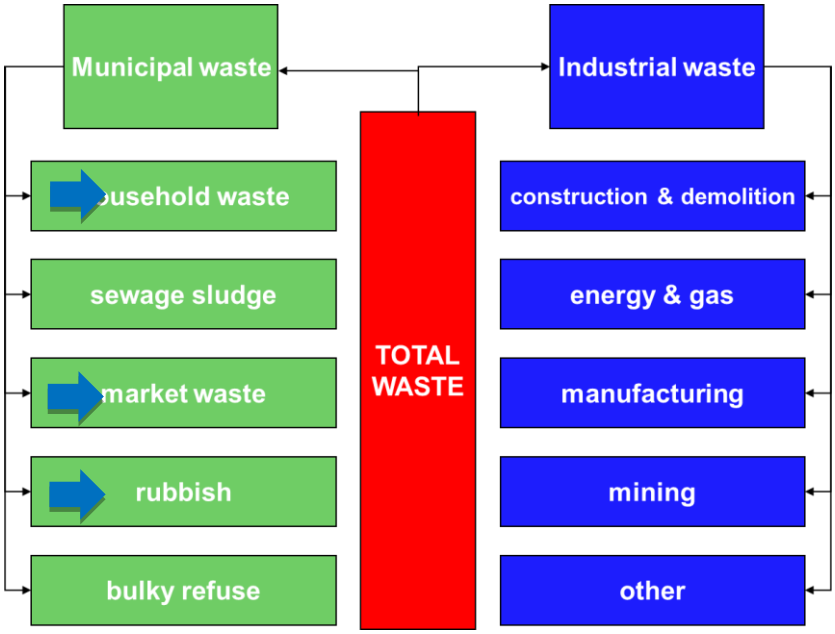

Figure 2-3: Classification of Solid Waste

According to UNEP (2013), "Municipal solid waste" (MSW) refers to a mixed collection of wastes produced in urban areas which may differ in nature, quality and quantity from one place to another due to levels of living standards and culture of the people. This confirms that, different regions classify waste differently. There is the European waste catalogue which gives detailed description of all the types of waste that exist.

2.4 Waste Generation

According to OECD (2004), waste is generated at various stages of human activities, and its composition and quantities mostly depend on consumption patterns and also on economic and production arrangements. Globally, calculating the amount of waste generated annually is a problem for the United Nations body in charge of the environment. This is due to a lack of reporting by many countries and the inconsistencies in the way countries report i.e. the variations in definitions and surveying methods employed by countries. This paper would hence sight some statistics reported on some

countries. In the U.S. for example, the amount of municipal solid waste increased from 88.1milliom tons in 1960 to 250million tons in 2008 and 2010 with a per capita per day amounts of 2kg (4.5lb and 4.43lb respectively) (EPA, 2009; 2011). According to Miller (2007) the United States of America leads in solid waste production by generating about one-third of the world's solid waste with only 4.6% of the world's population. He added that, the U.S. again leads the per capita amounts with 2kg/person/day, which amounts to 720kg/person annually. This is thus higher than the weighted average of waste generated in the OECD countries which is 390kg per person annually. The UNEPA (2013) reported a per capita solid waste generated in Bangalore, India and Manila, Philippines to be 400g/d (146kg/c/a) whereas it is 460g/d (168kg/c/a) in Asunción, Paraguay. Inhabitants in Vienna, Paris and Australia recorded between 1100g/c/d and 1800/c/d (403 to 659kg/c/a). A careful look at the numbers shows that developing countries generate less municipal solid waste than developed ones.

2.5 Principles of Sustainable Waste Management

Kellert (1997) attributes the difficulty to find adequate space and means to dispose of waste products to a combination of the effects of population growth, increased industrial activity, and introduction of several manufactured products.

Generations have indulged in several ways of managing the waste they generate. Kellert (1997) defines waste management as "the methods by which people dispose of discarded materials, including garbage and hazardous materials resulting from industrial and mining processes". Even though until the 1970s when it was outlawed by some governments, open dumping was the most commonly used method of urban waste management, it persists in some areas, (Nadakavukaren, 2006). Waste management practices usually

differ based on the level of development of the country, the geographical characteristics and industrial procedures and also on the types of wastes to manage. In poor cities of Asia, Africa, Central and South America, many people, commonly known as "waste scavengers" are door-to-door waste collectors and landfill sorters. These waste management workers are mostly people on the lowest level of the social scale who earn their living amidst dangerous working conditions and handling hazardous waste without physical or social protection. The most common methods of disposing solid waste are land filling, incineration and composting. In 2010, municipal solid waste in the U.S. was managed by discarding, combustion with energy recovery, and recovery (as shown in fig. 2-4).

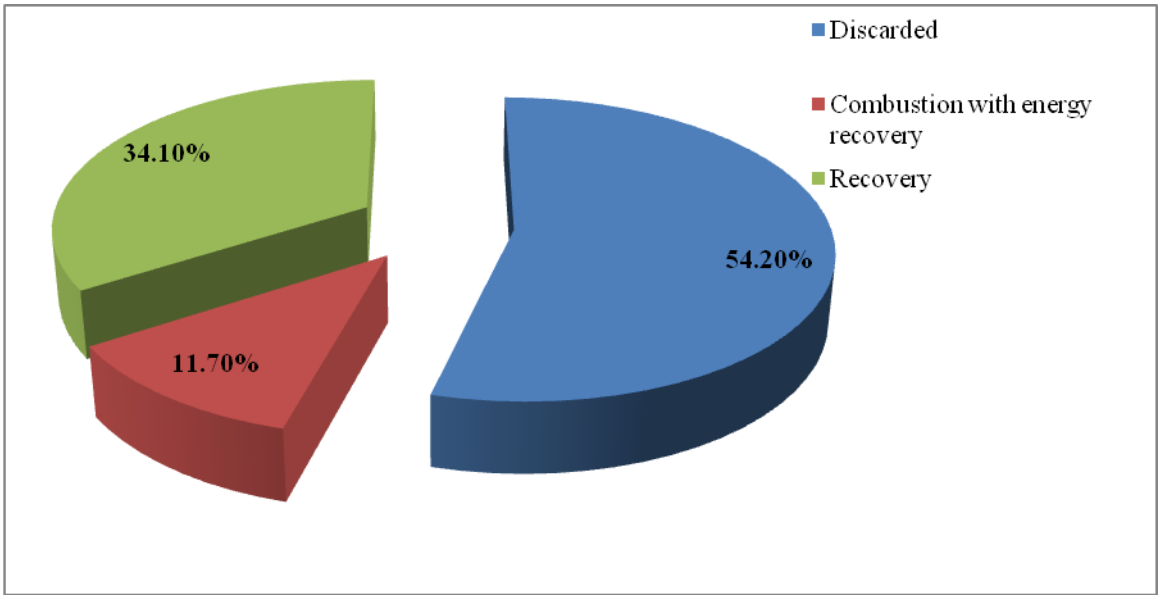

Figure 2-4: Management of NSW in the US in 2010

Source: USEPA, 2011

Waste impacts negatively on the environment and human life mainly through the air, water and soil, by contamination, reducing availability to human use and aesthetic

prejudice. Waste which is not sustainably managed poses numerous risks to life and environment and economic challenges in the long run.

The National Environmental Management Council - Tanzania (NEMC) in their Technical Note for Principles for Sustainable Municipal Solid Waste Management in 2011 mentioned the following effects of unsustainable waste management:

- Uncollected wastes often end up in drains, causing blockages which result in flooding and unsanitary conditions.
- Uncollected waste degrades the urban environment, discouraging efforts to keep streets and open spaces in a clean and attractive condition. Solid waste management is a clear indicator of the effectiveness of a municipal administration - if the provision of this service is inadequate large numbers of citizens (voters) are aware of it.
- Flies breed in some constituents of solid wastes, and flies are very effective vectors that spread disease.
- Mosquitoes breed in blocked drains and in rainwater that is retained in discarded cans, tires and other objects. Mosquitoes spread disease, including malaria and dengue.
- Rats find shelter and food in waste dumps. Rats consume and spoil food, spread disease, damage electrical cables and other materials and inflict unpleasant bites.
- Plastic bags are a particular aesthetic nuisance and they cause the death of grazing animals which eat them.
- Waste collection workers face particular occupational hazards, including strains from lifting, injuries from sharp objects and traffic accidents.
- Dumps of waste and abandoned vehicles block streets and other access ways.

- Dangerous items (such as broken glass, razor blades, hypodermic needles and other healthcare wastes, aerosol cans and potentially explosive containers and chemicals from industries) may pose risks of injury or poisoning, particularly to children and people who sort through the waste.
- Heavy refuse collection trucks can cause significant damage to the surfaces of roads that were not designed for such weights.
- Waste items that are recycled without being cleaned effectively or sterilized can transmit infection to later users. (Examples are bottles and medical supplies.)
- Polluted water (leachate) flowing from waste dumps and disposal sites can cause serious pollution of water supplies. Chemical wastes (especially persistent organics) may be fatal or have serious effects if ingested, inhaled or touched and can cause widespread pollution of water supplies.
- Landfill gas (which is produced by the decomposition of wastes) can be explosive if it is allowed to accumulate in confined spaces (such as the cellars of buildings).
- Methane (one of the main components of landfill gas) is much more effective than carbon dioxide as a greenhouse gas, leading to climate change.
- Fires on disposal sites can cause major air pollution, causing illness and reducing visibility, making disposal sites dangerously unstable, causing explosions of cans, and possibly spreading to adjacent property.
- Former disposal sites provide very poor foundation support for large buildings, so buildings constructed on former sites are prone to collapse.
- The open burning of waste causes air pollution; the products of combustion include dioxins which are particularly hazardous.
- Aerosols and dusts can spread fungi and pathogens from uncollected and decomposing wastes.

- Large quantities of waste that have not been placed according to good engineering practice can slip and collapse, burying and killing people.
- Waste that is treated or disposed of in unsatisfactory ways can cause a severe aesthetic nuisance in terms of smell and appearance.
- Liquids and fumes, escaping from deposits of chemical wastes (perhaps formed as a result of chemical reactions between components in the wastes), can have fatal or other serious effects (NEMC, 2011).

The list of the risks and effects of unsustainable solid waste management could be endless. In view of this, most governments have sought various means of solving the waste management issue without it having an economic strain on them. There are sustainable waste management principles and approaches which some countries have adopted to manage the solid waste generated. Among them are;

i. Zero waste
ii. Waste hierarchy
iii. Integrated solid waste management
iv. Resource recovery

The waste hierarchy and integrated solid waste management approaches are similar in their principles and methods. There is therefore a relationship between these approaches. UNEP (2005) considers the waste management hierarchy as a key element of integrated solid waste management.

2.5.1 Zero Waste

This principle aims at designing goods and services to ensure a full usage of all resources. As adopted by Zerowaste International Alliance (2004), the term Zero Waste is defined as "Zero Waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use. Zero Waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health." This definition could be summarised as a goal which directs human behaviour in a way that ensures a waste-free flow of materials in a syatem. The Zero waste principle emphasises on eliminating waste, reducing the use of resources and encouraging recycling, reusing and repairing.

2.5.2 Waste Hierarchy

According to UNEP (2005) the waste management hierarchy is globally well-known and is often considered the fundamental basis of modern Municipal Solid Waste Management (MSWM) practice.

In Germany, the European Union waste management hierarchy under the new circular economy law, which is shown in figure 2-5, is the foundation of the waste management system. From the figure, it could be seen that the most preferred choice is preventing the waste at the production stage whiles the least preferred are options that deal with the waste already generated. This hierarchy is not much different from the Zero Waste SA

hierarchy. Both advocate the basic idea of preventing the waste first and disposing, the last option. "The waste management hierarchy is one of the guiding principles of the

Figure 2-5: Waste Hierarchy of European Union
Source: European Commission, 2012

Zero Waste SA Act 2004, and is regarded in South Australia's Waste Strategy 2011-2015 as a key element for guiding waste management practices in South Australia, while still recognizing the need for flexibility based on local and regional economic, social and environmental conditions" (Zero Waste SA 2012). This hierarchy is illustrated in figure 2-6.

Figure 2-6: Waste Management Hierarchy
Source: Zero Waste SA (2012)

The figure shows that avoiding waste is the most desired and the best option of managing waste, while disposing or land filling should be the least preferred to manage waste, or in other words, the last resort. Emphasis is placed on designing strategies and programs for avoiding and reducing waste. It could be confidently concluded that the basis of the solid waste hierarchy is one key element of sustainable waste management considered by organizations in drawing plans to solve the waste management problems. The hierarchy is explained further.

- ***Avoid***

This is the ultimate zero waste challenge; the highest point on the hierarchy (Zero Waste SA, 2012). It is an important method of waste management that ensures the prevention of waste material being created. There is the belief which I support that, "garbage that is not produced does not have to be collected" (Masters & Ela, 2008). Decisions are taken to achieve this goal as early as the designing phase of a product in order to produce goods that would not end up in the garbage at the end of their lives.

- ***Reduce***

This follows the same principle as the avoid method. It deals with designing production processes so as to reduce the volume of waste generated at the end life of the product. In another way, Miller (2007) explains this as reducing the amount of products that an individual consumes thereby aiming at living a simple life. In short, less demand will lead to less production.

- ***Reuse***

This includes using second-hand products, repairing broken items instead of buying new ones, designing products to be refillable or reusable, etc. therefore, reliance will be on items that can be used over and over again instead of throwaway items. By reusing the waste materials, it reduces the demand on raw materials, energy needs and controls pollution.

- ***Recycle***

Recycling refers to "a process in which used materials are turned into new materials (Thomson, 2011). US Environmental Protection Agency refers to recycling as "the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products" (EPA, 2013). The chemical and physical composition of the materials could be maintained in the forming of the new product. The waste product usually is composed of a single type of material, making it relatively easy and less costly to recycle into new products. Products like PET bottles, aluminium cans and paper could be easily recycled while other products like computers, phones and electrical gadgets are difficult and relatively expensive to recycle since they are composed of several materials.

- ***Recover***

Recovery ensures that waste products are not landfilled. Thus, once these waste materials are collected and sorted, they are either recycled or incinerated (Thompson, 2011). In other ways, waste from one industry is a resource for another. An example is cleaned exhaust heat from a factory used as heating for a zoo nearby. Another type of recovery is the waste–to–energy combusting which involves burning waste materials to generate energy. Materials, especially residual waste which cannot be reused or recycled are dried

to remove excess liquid, compressed and burned to generate energy. Fobil, Karboo and Armah (2005) explored the potential utilisation of Accra municipal solid waste to generate energy. They therefore divided Accra Metropolitan Area (AMA) into three zones: zone A, zone B, and zone C. Their results showed that, organic waste in MSW has energy content between 16.28MJ/kg and 17.50MJ/kg whiles paper and cardboard in MSW has energy content between 16.82MJ/kg and 19.23MJ/kg. Their results show that "MSW in a typical low-income country is wet with low calorific values between 14 MJ/kg and 20 MJ/kg and an average energy recovery efficiency of about 40%."

- ***Treat***

Where wastes cannot be avoided, reduced or recycled, they should be treated and disposed of appropriately. Treatment could be by physical, chemical or biological means. The aim of treatment is to destroy, convert or immobilise the hazardous constituents and to reduce the waste's potential for hazard. Hence, treatment is done for any of the following purposes:

- Volume reduction - reducing the volume of the hazardous parts of the waste by concentrating the hazardous components, either by filtering or absorbing.
- Destruction – conversion of the hazardous substances to non-hazardous ones either by chemical, biological or thermal processes. For example, incineration destroys organic wastes by combustion at high temperature.
- Containment – containing the wastes to prevent its pollutants reaching the environment. This might be done by solidification or stabilisation.

Whichever treatment or disposal option is selected for hazardous wastes, it must be secured, as waste materials can attract children or scavengers or may be subject to misuse.

- ***Dispose***

As mentioned earlier, this should be the last resort. When all the other methods are applied and there is still waste, then it could be properly land filled after treatment. Whereas a sanitary landfill is suitable for municipal solid waste, a secured landfill should be applied for hazardous wastes. Incineration could also be applied to some waste at this point and the ashes obtained after incineration could also be landfilled.

2.5.3 Integrated Solid Waste Management

The Integrated Solid Waste management aims at solving the waste problem by considering the whole life of the product (potential waste material) and the whole waste management system including waste prevention and resource recovery to arrive at a solution that is socially, economically, and environmentally suitable for a particular area. "Integrated waste management is based on the concept that all aspects of a waste management system (technical and non-technical) should be analysed together, since they are in fact interrelated and developments in one area frequently affect practices or activities in another area" (UNEP, 2005). According to Masters and Ela (2008) the approach is aimed at;

- reducing the amount of solid waste that has to be burned or buried
- reducing pollution associated with mining, use, and disposal of resources
- reducing the rate of consumption of scarce resources.

Table 2.1 shows the methodological components of this approach given by Masters and Ela (2008), in no strict order. However, in order for an integrated solid waste system to be successful, the authorities of all governmental and other institutional levels, and

communities, should work at it by incorporating, coordinating and implementing the approach.

Table 2-1: Methods of Integrated Solid Waste Management

Method	Detail methods
Source reduction	• reduce toxicity • less packaging • product reuse • more durable products • on-site mulching and composting
Recycling	• collecting • processing • using recycled materials in products • composting
Disposal	• combusting with energy recovery • landfill • incineration without energy recovery

Source: Masters and Ela (2008)

To improve these methods considered by Masters and Ela (2008) towards a sustainable waste management practice, various directives have been considered by both the EU and Germany as a country. Across EU, the use of landfilling as a method of managing waste has come to stringent scientific scrutiny. Conventional landfilling has been considered unsafe, as it contains both harmful and biodegradable substances. These harmful substances may leach into water bodies which may lead to unsafe environment. On the other hand biodegradable substances in conventional municipal solid waste (MSW) will generate biogas such as methane (which is about 21 to 25 times of carbon dioxide potential of global warming) which significantly contributes to global warming (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2006). Figure 2-7 shows the problems associated with landfilling. However, some member states (Germany,

Austria) allow landfilling method of waste management for only pre-treated municipal waste.

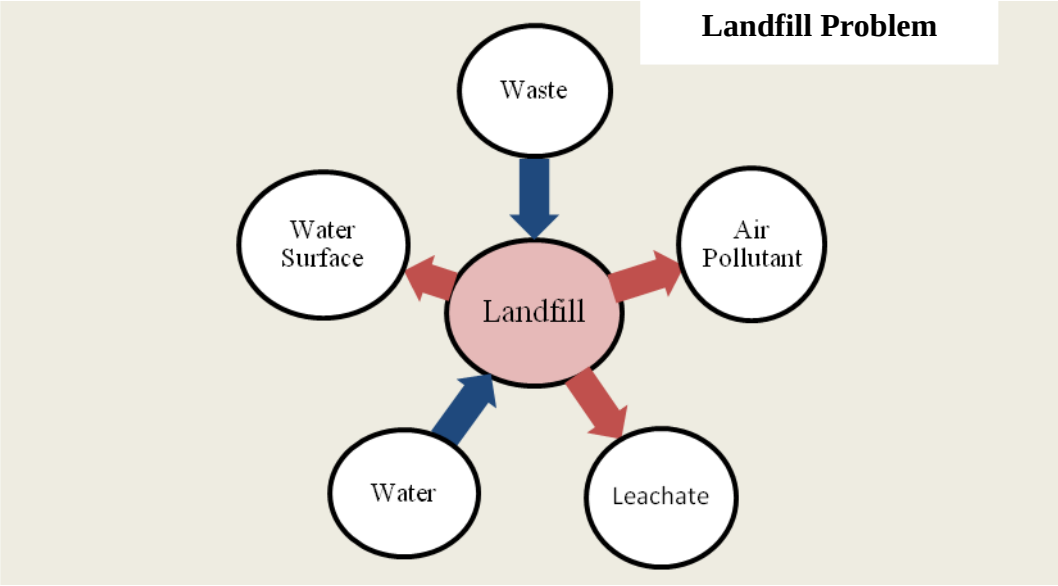

Figure 2-7: Landfill Problem
Source: *2006 Municipal Solid Waste Management Report*, (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2006).

These adverse effects of conventional landfilling have led to radical reduction of the practices across the European Union member states. Germany has experienced a radical and steady reduction of landfilling as a result of the introduction and enforcement of "landfill ban for untreated municipal waste" since 30 June, 2005 whiles increasing other municipal waste management methods such as recycling, mechanical-biological treatment and incineration which are considered eco-friendly and economically efficient and effective for the conversion of waste to useful resources (Eurostat, 2011), as shown in figure 2-8.

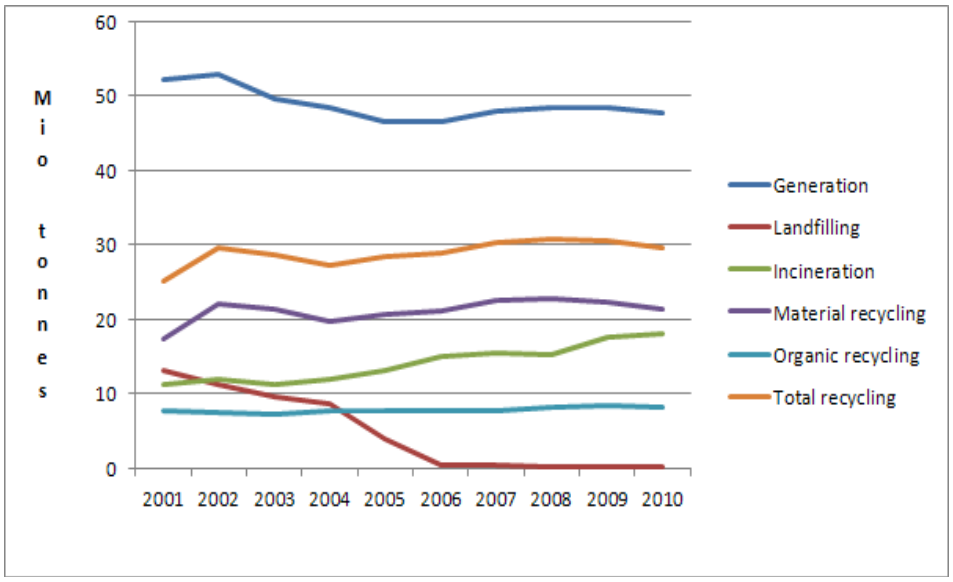

Figure 2-8: Development of Landfilling, Incineration and Recycling of MSW in Germany
Source: EEA (2013). *Municipal Waste Management in Germany.*

2.5.4 Resource Recovery from Municipal Waste towards Sustainable Wealth Creation

Resource recovery involves processes to obtain useful material(s) from waste rather than discarding it. Recovery of resources involves the removal of selected materials from the solid waste and using technologies or method such as recycling, energy generation and compositing to obtain valuable resources. The core objective of resource recovery is to selectively and efficiently remove those products that practically benefit the society, reduce waste to society to its barest minimum and reduce societies' over dependence on virgin resources toward a sustainable development (Wikipedia, 2013).

Compositing

Composting involves the use of microorganism to break organic matter (waste) into carbon dioxide, water, heat, and compost (US EPA, 2008). According to UNEP (2009)

composting is a biological decomposition of biodegradable solid waste through a controlled aerobic process conditions necessary to produce a stable and nuisance-free outputs or products which are safe for use by the society. Composting method enhances waste reductions (Zerbock, 2003) whiles its outputs are best used as agricultural inputs such as manure or further processed as fertilizer (Worldwastesystems, 2012). During anaerobic digesting process, biogas may be captured and further refined to obtained fuel (methane gas) which can be used for domestic heating and cooking (Environment Canada, 2013). However, the volume of this biogas depends on the composition of the biowaste used as feedstock (Environment Canada, 2013).

Energy Generation from Waste

According to Garthe and Kowal (2006) "resource recovery usually means heat recovery by incineration." The use of incinerators as a method of managing waste has significantly contributed to reduction of greenhouse gases (GHGs) from municipal waste. Waste incinerations also promote resource optimisation by producing or generating eco-friendly energy which are converted to electricity for district heating and process heating. Again, high-tech incinerators reduce waste by about 90%, making the residue or slag from the incineration plant economically easy to dispose or better still used as substitute for grit and gavels used in industrial construction and road development.

Resource Recovery through Recycling

Generally, global population continues to increase rapidly and this has amounted to unprecedented demand pressure on resources. According to UNEP (2009) global consumption of plastic materials has increased from 5million tones in 1950 to 100 million

tons in 2009 showing a growth of about 2000%, thus 20times what was consumed in 1950. This results implies that more virgin resources are been used every day to meet the ever increasing demand of plastic. Today, uses of plastics include packaging, PET bottles, plastic shopping bags, and appliances with plastic component among others and thereby ensuring high demand for the raw material and also making it a major component of municipal solid waste. However, this unsustainable demand for virgin resources for plastics manufacturing can be minimize only if these municipal solid waste are recycled.

Recycling of municipal waste is a resource recovery practice that involves the collection and selection of materials from waste for reuse. In most advanced countries such as Germany, Japan, US, UK, etc. most recycling practices focus on the collection and reuse of single-use beverage containers such as aluminium beverage cans, aerosol cans, steel food cans, PET and HDPE plastic bottles, paperboard cartons, jars, cardboards and magazines. These materials are relatively easy and less costly to recycle because they are generally made from single raw materials. Although some materials are not common feedstock to recycling plant, today's high tech recycling plants give waste management industries the opportunity to recycle materials such as PVC, PP, LDPE, and PS. (MartinFrost, 2013).

The use of mechanical-biological waste treatment (MBT) is a relatively effective and efficient method of recovering material from residual waste and also reducing organic components going into landfill. Mechanical Biological Treatment (MBT) is generally a waste treatment processing system that involves both mechanical and biological treatment processes. The core objective of mechanical-biological treatment (MBT) is to enhance the use of mixed collected waste and reduce the environmental effect due to waste disposal in landfill (Molleda & Lobo, 2011). Figure 2.9 is a typical potential MBT process.

MBT is an integrated waste management system with several waste processes technologies such as Material Recovery Facilities (MRFs), sorting, and composting or anaerobic digestion plant (Molleda & Lobo, 2011). The mechanical part of MBT

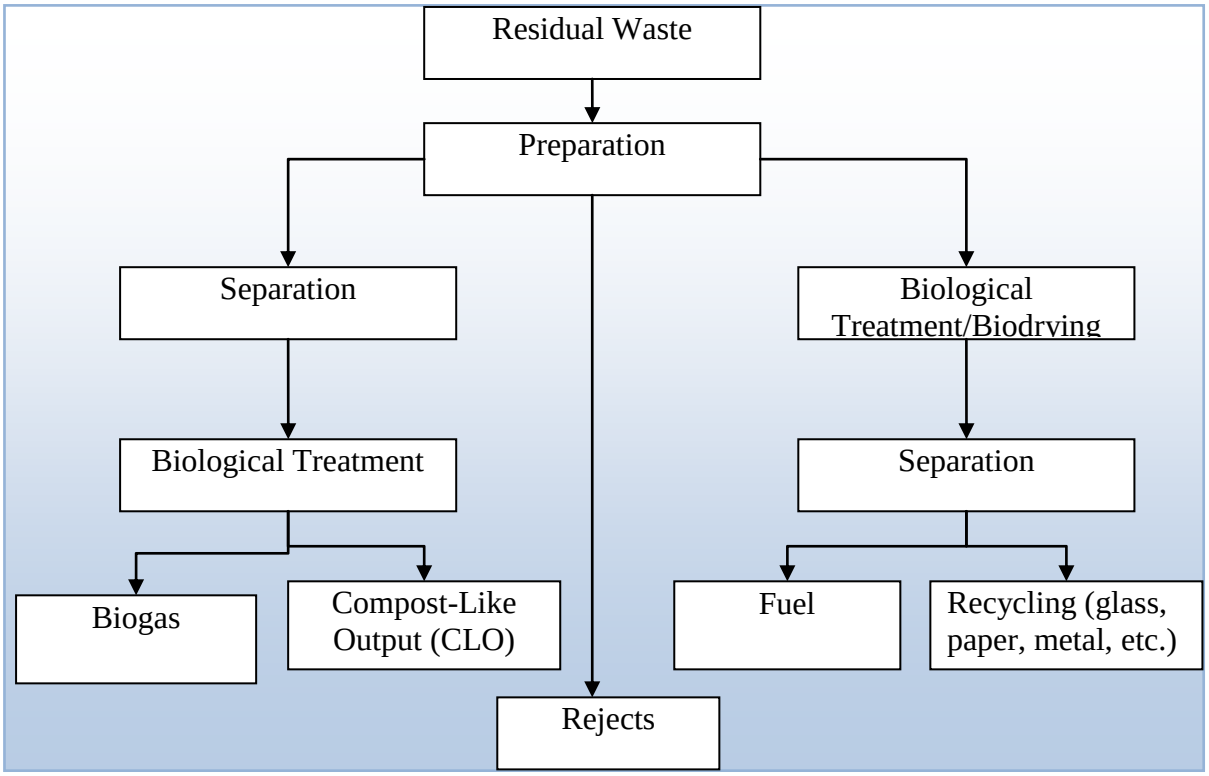

Figure 2-9: Potential Mechanical Biological Treatment Options

Source: UK Department for Environment, Food & Rural Affairs, 2013

generally include automated (or manual) sorting to ensure that recyclable materials such as plastics, glass, papers, and metals are separated from in the waste mix for recycling or process further. This part of the MBT includes the use of eddy and magnetic separators, conveyors, shredders, etc. However, the biological aspect of MBT involves anaerobic, composting and biodrying system. The anaerobic digester uses anaerobic microorganism which breaks down biodegradable materials of the waste mix to generate biogas (used as energy source) and soil improving residuals. However, the composting system uses aerobic microorganism to break organic materials in the waste stream to compost and

carbon dioxide whiles the biodrying system ensures that the waste materials undergoes drying process through heating process using aerobic microbes.

With increase in the global population, there is enough pressure on demand for goods and services which is transferred onto natural resources which are fast depleting. The use of recycling technology is thus vital to the sustainability of this demand. Modern recycling practices incorporate sorting approach to disposing of waste material in individual households before they are collected to the recycling plants as feedstock. These approaches facilitate and reduce process cost of recycling. Across the EU, Germany has the highest recycling rate of 48 %, (274 kg per capita) followed by Sweden with 36 % (171 kg per capita) and Belgium with a rate of 36 % (175 kg per capita) (Eurostat, 2011). Germany's high rate of recycling may be contributed significantly by its 42 MBT plants with waste treatment capacity of over 51,000,000 tons per year (Waste Consult International, 2013). Again Germany's milestones in waste management are also contributed by its stringent waste management legislations and governance systems (Eurostat, 2011; German RETech Partnership, 2010; FMENCNS, 2006).

2.6 Waste Legislations and Governance Systems towards Sustainable Resource Optimization

Waste management policies are important part of promoting a clean environment towards a sustainable waste management practice and efficient use of resources. Even though the EU member states are governed by common EU policies and guidelines to ensure waste management best practices, Germany has been thriving towards stringent and high standard waste management practices since its first law came to force in 1972. The revision and enforcement of these policies has led to innovation and the use of high-tech

waste management system necessary to promote efficient use of resources through the conversion of waste into valued resources (FMENCNS, 2006).

German packaging ordinance in 1991 brings producers/manufacturers as essential part of waste management (European Environmental Agency (EEA), 2013). This legislation ensures that producers become responsible for the collection of products when they become waste. This responsibility on producers and distributors begins when the product is manufactured and continues till the products become waste or are disposed into the environment. The introduction of "The Close Substance Cycle and Waste Management Act" gives preference to the avoidance and recycling of waste over waste disposal whiles "The End-Of-Life Vehicle Ordinance" gives consumers the right to return end-of-life vehicles at no charge or cost to manufactures who are obliged to respect and abide by the recycle quota and the avoidance of certain materials in productions as prescribed by the law. The enactment of "The Battery Ordinance" also enforces consumers to return waste batteries to the collection points of either local authority or retailers. This regulation also enforces manufacturers to recycle the waste batteries returned to them and also ensure that non-recyclable batteries are disposed safely as required by law (German RETech Partnership, 2010; FMENCNS, 2006).

2.7 Solid waste separation and collection in Japan and Germany

An effective waste to resource system would partly depend on the source; that is, the disposing and collection. It was observed that Japan and Germany are among countries with a good record of waste collection system. In these countries, care is taken by households and institutions in separating waste materials. The container and packaging recycling law in Japan ensures that Japanese household waste such as PET bottles, other

plastics, aluminium, other metals, glass, paper, and biowaste are collected separately in different coloured bags for collection by the authorised persons. Different collection bins are provided at vantage points for collecting PET bottles, aluminium cans and other wastes.

The same could be said of households in Germany. Differently coloured plastic bags are provided for the various waste materials. Waste bins are also provided at collection points to collect used clothing, glass (green, white and brown), paper, and so on. Private households usually have four waste bins as shown in figure 2-10:

- Black – for residual waste which is used for energy recovery
- Green – for biowaste including garden waste
- Blue – for paper waste
- Yellow (called “light fraction” in Germany)- for aluminium, tinplate, plastics

Figure 2-10: Waste bins in Germany

These systems of collecting solid waste materials make it easy and cheaper but effective for recycling and energy recovery. Community indulgence and unity is also achieved as

in the case of Japan, where checking of sorted waste materials and pressing of aluminium and PET bottles at community levels are done together by members of the community.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This study focused on solid waste management in GEMA by assessing and evaluating the worth of the hidden resource potentials in the waste that is generated in the municipality. The research was aimed at arriving at values of the resources that could be derived from the waste and how beneficial the resources could be to the people in the sense of economic, environmental and social.

3.2 Study Design

According to Burns and Grove (2001) study design helps researchers to plan and implement the study towards achieving intended results whiles Polit and Hungler (1999) described it as a blue print that provides guidelines towards the controls of interfering factors and achieving the validity of the research results. Brink and Wood (1998) depict that exploratory research aimed at investigating the relevant factors in detail to arrive at an appropriate description of the reality of the exiting situation. Exploratory descriptive research design is generally a field study which strives to develop new ideas and knowledge, and hypotheses for further studies after all problems have been examined (Uys & Basson, 1991).

For the purpose of this study exploratory research design was considered since it is aimed at investigating waste-to-resource and wealth potentials in the GEMA.

3.3 Study Area

For the purpose of this research, Abloradgei, a dumpsite in the Ga East Municipal Assembly of the Greater Accra region was considered for this study. The Greater Accra region houses the political and economic seat of Ghana.

3.4 Data Collection

The researcher employed both primary and secondary data collection approach. Observation and interview constituted the primary data sources while secondary information was obtained from internet, books, newspapers and articles. Also secondary data on the dumpsite and solid waste material analysis were collected from GEMA Sanitation Department on the following:

i. quantities and constituents of solid waste disposed at the site;
ii. qualities and physical state of the various constituents of the waste; and
iii. the existing practices of waste management at the dumpsite.

The secondary data ensured that the research focused on discussion and analysis necessary to develop gap analysis using the best practices as a reference points.

3.5 Research Instrument Used

For the purpose of the research, a structured interview schedule guide was used to gather first-hand information from both waste management administrative personnel and the dumpsite operators of GEMA. The researcher also employed observation technique to data gathering. Photos were then taken where permitted to aid in a better description of the situation and results.

3.6 Data Processing Procedure and Analysis

The waste composition data obtained from the Waste Department of GEMA was critically examined, summarised and tabulated for analysis and discussion on various resources that could be derived from the waste.

Information obtained from interview on waste management practices of the municipality and other stakeholders were also analysed and compared with the theoretical reference point and best practices in Germany for conclusions and recommendations.

CHAPTER FOUR

PROFILE OF GA EAST MUNICIPAL ASSEMBLY

4.1 Introduction

This chapter is focused on solid waste management in GEMA; bringing to light the investigated existing practises of solid waste management in the municipality. The main areas of discussion included; the detailed description of the area under study, amounts and constituents of solid waste generated and collected, treatment and health implications, including the legal framework of the solid waste management in the municipality.

4.2 Profile of Study Area

The greater Accra region, being the smallest of the 10 administrative regions of Ghana, is located on the south-east of the country as shown in red in figure 4.1. However, according to 2010 Population and Housing Census (PHC) conducted by Ghana Statistical Service (GSS), as at September 26, 2010, Greater Accra region is second to Ashanti region in terms of population size of 16.3% whiles Ashanti region has 19.4% of the total population of Ghana. The region houses about 4 million inhabitants with 3,245km² of land area and a population density of about 1,200 inhabitants per km² (GSS, 2012).

Figure 4-1: Map of Ghana and Greater Accra Region
Source: http://goafrica.about.com

The Ga East Municipal Assembly (GEMA) is one of the ten (10) districts in the Greater Accra Region of Ghana, located in the northern part of the region with a land area of about 166sq km and, as at 2010, with a population of about 259,668 people. GEMA share its borders with four other Assemblies: Adenta Municipal Assembly (AdMA) in the east; Ga West Municipal Assembly (GWMA); Accra Metropolitan Assembly (AMA) in its south; and Akwapim South District Assembly in its north (GSS, 2012). Figure 4.2 shows the map of the Greater Accra region with the Greater Accra Metropolitan Area (outlined and in blue) which is made up of 8 of the 10 districts and Ga-East Municipal Assembly in navy-blue colour and red arrow pointing.

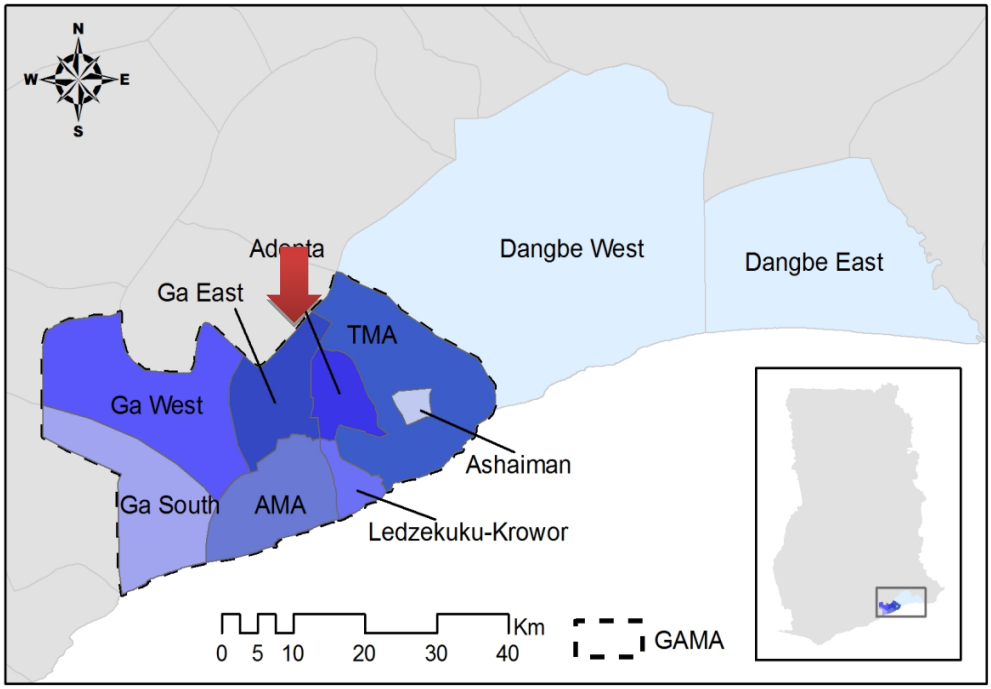

Figure 4-2: Districts in the Greater Accra Metropolitan Area
Source: Verhagen et.al (2010)

The Ga-East Municipality is made up of over 60 settlements where 82% are urban and peri-urban, about 6 health facilities, 4 major markets, 5 notable industries, to mention a few. The Municipality also can boast of a lot of ground water which has been tapped to provide potable water for the rural communities and small towns. The Municipal capital "Abokobi" is approximately 29 kilometres from Accra, the central business centre. In the year 2000, the population and housing census realized a total population of 201,542, a growth rate of 2.3% and an average household size of 6.2 for the municipality. In 2008, the projected population was pegged at 247,313 in 2009 and 264,773 in 2012 by the District Planning Coordinating Unit (DPCU). The growth of the population, according to the DPCU report, is mainly due to the influence of migration inflows, with a concentration mostly along the urban and peri-urban areas of the district particularly

along the border with AMA to the south. These areas include “Madina”, “Dome”, “Taifa” and “Haatso”.

“Abloradgei” is one of the fast developing settlements in the GEMA which is characterized by a dump site best described by the municipal assembly as a crude, un-engineered final disposal site and thus, another major environmental concern to the Assembly (GEMA, 2009). The assembly is not the only beneficiary of the dump site. Neighbouring districts such as the Tema Municipal, Accra Metropolitan and Ga West District Assemblies also find the site helpful. The dump site, located about 1km south of Abokobi and about 500m west of the main psychiatric hospital in the municipality (which has recently become a general hospital) and Nurses Training College, is noticed by its stink about 150m away. Most of the waste from various municipalities are collected, transported and managed mostly by Zoomlion Ghana Ltd, a private waste management company.

CHAPTER FIVE

RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter presents the results on the municipal waste management issues of the Ga East Municipal Assembly. The researcher categorised the results, presentations and discussions into two: the first part focuses on the waste management practices which include the waste mix or composition, method of collecting and transporting and disposing of municipal waste, and waste regulatory system of the area. The second focuses on the resources that could be created from the municipal solid waste based on its composition.

Results are presented in both tabular and graphical forms for discussion and analysis.

5.2 Waste Amount and Waste Collected at GEMA

With increase in population and the increasing amounts of waste produced, the management issue coupling it is of great concern to the municipal assembly. It was noted in the municipality's action plan that, expeditious waste generation and indiscriminate waste disposal by inhabitants and pedestrians is one of the development challenges the Assembly has to manage (GEMA, 2009). Most streets mainly in the highly populated areas are characterized by filth made up of polythene bags of different colours, food scraps, cans and plastic bottles. About 357tonnes of solid waste is generated daily amounting to 130,662 tonnes in a year and approximately 0.85kg per capita per day which is mainly composed of plastics, waste from foodstuffs, metal containers, bottles

and paper boxes just to mention a few (GEMA, 2009). Table 5.1 shows the composition of solid waste generated in the municipality in 2008.

Table 5.1: Compostion of Solid Waste in the GEMA

Component	Composition (%)
Organic	48.8
Plastic	17.9
Paper	9.6
Metals/Tins	9.1
Bottles/Glasses	7.4
Construction/Debris/Cinder	4.7
Clothing	2.5

Source: *Environmental health and sanitation department 2008*

From the table, it would be noticed that, organic waste forms the majority of the waste generated in the municipality, mainly from households and the markets with no form of separation done before disposal. The door–to–door mode of collection accounts for 81% of the collected solid waste, in addition to containers placed at vantage points in the communities and at the market places. It is worth noting that, 63% of the waste is collected and the remaining waste is dumped off indiscriminately in gutters and other open spaces or blown by the wind to litter the surroundings. This situation suggests that GEMA's waste management practice is not consistent with the best practices in Germany where both householder and manufacturers has the responsibility to ensure that waste is collected and/or returned to the local authority or the manufacturers' waste collecting point (FMENCNS, 2006; Eurostat, 2011).

5.3 Common System of Waste Treatment in GEMA

There is no recycling of the waste in the municipality. Even though some scavengers move from house to house to collect only metal scraps, the amount of reduced waste by their work is not documented and thereby overlooked. The final destination of the collected waste is a main waste dump site at Abloradgei, near "Pantang" and Abokobi, which according to Joynews (2012), the EPA announced the soon closure of the site because it is almost reaching its capacity, and the concerns raised by neighbouring occupants. The Abloradgei dump site (also known as Pantang landfill site), which covered an area of fifty (50) acres during its inception, now is only about ten (10) acres due to sale by the land owners to developers and also by encroachers. The site is managed for about four (4) years now, by Zoomlion Gh Ltd, a private waste management company, whose duty includes ensuring weekly spreading of piled-up refuse by bulldozers, occasionally spray the area with disinfectant and preventing indiscriminate setting of fire on the refuse. According to Addo (2012)[1], in addition to the company's waste collectors, fully loaded waste collection trucks of other waste management companies and other organisations empty their wastes at the site. Among them are:

- Asado Royals waste management company
- Meskworld company
- Jekora Ventures
- Daben waste management company
- Unrest Waste
- Jakomy company
- University of Ghana

[1] This is an interview with Mr. Addo (Assistant Manager at the site) by the researcher on 17th Sept. 2012 at the Abloradgei dumpsite.

According to Addo (2012), the number of trucks dumping at the site per day reduced from 125 to 50 per day, 2 months ago. The reduction could be due to the site reaching its capacity in addition to posing health problems to close by inhabitants. However, Zoomlion Ghana Ltd is at the moment searching for a new site to continue dumping. Mr. Addo added that the net weight of waste from the trucks ranged between 6.8 tons and 12.5 tons. Figure 5.1 shows some of the trucks received at the dumb site, with (a) being the compactor type and (b) the roll-on type of trucks.

Figure 5.1 (a) and (b): Pictures of the trucks mainly received at the dump site

Source: Author's dumpsite photo

Workers at the site disclosed that, the waste dumped at the site include glass, PET bottles, plastic chairs and bowls, gallons, metals and so on. There are over 20 waste scavengers with about 7 females working daily at the dumpsite. They mainly collect metal scraps from electronic waste and sell to middle men who transport it to industries in Tema for melting and possibly recycle or export. The scavengers earn on the average GH¢8 (US $4.2) daily. Because they do not wear any protective clothing during work, they are faced

with a lot of health problems including frequent eye and body pains, headache, colds, cuts and burns due to exposure to smoke from fires they set and mini explosions on the site. It was also observed that the scavengers have very black skin and this could be due to the continuous exposure to the smoke and dangerous gases on the site.

Figure 5.2: Snapshots from the Dumpsite

Source: Author's dumpsite photo

Figure 5.2 shows some aspects of the work of the scavengers who do most of the sorting of the waste and also set fires indiscriminately. Even though they are mostly interested in metal scraps, they separate other waste materials like plastics also.

5.4 Health Implications on GEMA

The dumpsite could be noticed by the smell about 150m away. According to GEMA, the constant unwanted uncontrolled burning of the waste at the dump site is creating serious

air pollution and threatening the lives of people in the surrounding communities. Besides that, it poses health risks to the people as they are more prone to diseases such as malaria. In July 2010, Free Africa for Mosquitoes (FAFM) organization in Accra conducted a research at the refuse dump site and recorded that, mosquitoes known to transmit malaria and other diseases such as elephantiasis and yellow fever, were bred at the site (FAFM, 2010). This is not surprising since malaria continues to top the list of frequent illnesses recorded at the out-patient department of health centres in and around the municipality and accounts for about 40.8% of morbidity in the municipality.

Table 5.2 gives a breakdown of the number of cholera cases and deaths recorded in some districts of the Greater Accra Region as at 31st March, 2011. There has been frequent cholera outbreaks in some regions of the country with some recorded in the first quarter of 2011. During this period, the Greater Accra region recorded a total of 4,190 cases and 36 deaths as at 31st March out of which Ga-East recorded 473 cholera cases and 1 death.

Table 5.2: Recorded Cholera Cases and Death

Districts	Number of cases	Number of deaths
Accra Metropolis	3,207	33
Ga East	473	1
Ga South	119	1
Ga West	253	1
Adentan	38	0
Ledzokuku Krowor	62	0
Tema	28	0

Source: Yankson, Nathaniel Y., 2011

This suggests that about 11.29% (second highest rate among all the districts recorded) of the cholera cases are from Ga East Municipal Assembly. The lack of personal protective

equipment (PPE) at the dumpsites and the indiscriminate disposal of municipal waste in the municipality may play a significant role of spreading this communicable and deadly but preventive disease in the municipality.

5.5 Legal Situation of Waste Management in GEMA

According to the administrative personnel of the municipality, there are a few legislations both at the local and the central government level. According to them the local Government Act, 1990 (Act, 462), Water Resources Commission Act, 1996, (Act 522), Environmental Assessment Regulations, 1999 (LI 1652), Ghana Landfill Guidelines (2002) are important waste management regulations in Ghana and therefore applies to the municipality. However, the biggest challenge is the enforcement of these regulations. According to them this is due to lack of logistics, knowledge of these laws or training of personnel to enforce the rules and more especially logistics to implement them. Also, the country lacks other waste management regulations similar to the Packaging Ordinance, End-of-Vehicle Ordinance, and the Battery Ordinance of Germany and therefore becomes difficult for the municipal to enforce all stakeholders to take responsibility of the waste management process of the country. Lack of law enforcement may lead to indiscriminate disposal of and handling of municipal waste by households leading to poor sanitation and extreme health risk.

5.6 Waste to Resources

Recovery of resource from waste is vital to not only GEMA but to the country as a whole. Waste mix results from the municipality shows that many materials could be recovered for reuse. From figure 5.3 it is observed that the municipal waste of GEMA contains at

least eight (8) materials (organic, bottles, glass, debris, clothing, metals, paper, and plastics) which could be recovered by various technologies.

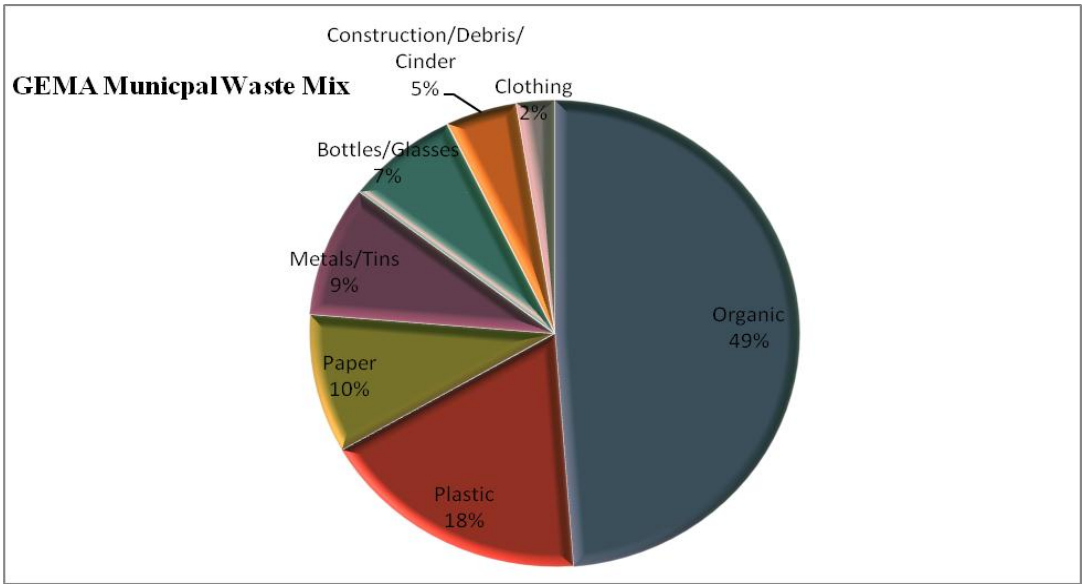

Figure 5.3: GEMA Municipal Solid Waste for Resources Recovery

Source: Author's graph

5.6.1 Wealth Creation through Organic Waste Resource Recovery

From figure 5.3, it is observed that organic waste constitutes the highest component of about 49% of the total waste mix. However, the municipality used conventional method of landfilling to treat it. This implies that various odorous and gases are release to the atmosphere leading to air pollution. Again, the gaseous substances released which includes methane, affects the environment and atmosphere in diverse ways such as the greenhouse gas effect leading to climate change. To continue dumping would require more space which would have otherwise been used for productive activities such as farming, residential facilities, road constructions, health and educational facilities and other socio-economic infrastructures for the municipality. To conform to the best

practices in Germany it is important the organic wastes are pre-treated before landfill (FMENCNS, 2006).

The large organic content of the municipal waste could be put into better use by composting for agricultural purposes or fed into biogas plants to produce energy for use for domestic and commercial heating and cooking or electricity generation. This could reduce the reliance on fossil fuels (oil, coal), reduce deforestation by use of less firewood, cost savings, more employment opportunities, and thus reducing poverty in the community. The agricultural land would also be saved from pollution with the use of manure as fertilizer.

5.6.2 Resource Recovery and Wealth Creation through Recycling

The waste mix also shows that about 51% of its content is non-degradable which can easily be recycled or re-used for several purposes. These non-degradable wastes are glass wares, clothing, plastics, paper, and metals of all kinds. As a result of the lack of education of the inhabitants and proper solid waste management system in the Ga East Municipal Assembly, most of these wastes are not treated sustainably. Currently, these wastes are not separated at source (households, offices, market places, etc.) before they reach the dumpsite. This however, has adverse effect on the environment as they degrade the soil and cause hazards to the environment; and also on the economy as it involves high cost to operate a waste separation plant before recycling. Further consequence of these practices includes excessive use of useful lands which would increase land demand and cost; land conflict, destroying of the soil composition and quality due to introduction of non-degradable substances into the land.

This practice is not consistent with the best practices Germany where households and waste generators have the responsibility to sort wastes (German RETech Partnership, 2010; FMENCNS, 2006). It is also not consistent with the Zero Waste principle which suggests that waste management process should be designed systematically to avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources and not burn or bury them.

However, when these non-organic waste materials are recovered through recycling process, the society will reduce its high dependency on natural raw materials. Aluminium, iron and other metallic packages when recovered will reduce over extraction of virgin aluminium and other metals and hence promote a society that would ensure that our future generations' needs are not compromised today. Paper and glass recycling would greatly reduce the dependence on virgin raw material. Recycling of plastic waste from GEMA would make significant impact on the socio-economic development of the municipality since it would enhance conservation of natural resources, reduced greenhouse gases (GHG) especially when the plastics are being used to produce diesel fuel (UNEP, 2009). There would be increase in jobs for the youth as more investors would enter into the waste management collecting and recycling industry. Again, companies may get quick access to packaging materials and therefore would reduce importation of these materials from other parts of the world.

The solid waste mix of GEMA includes 9.1% metals. These metals include aluminium cans, iron scraps and other metallic waste. Aluminium is produced from bauxite and is used to produce cans and other materials for household consumption. Even though global bauxite deposit is considered "the third most abundant" (Friend of the Earth Europe (Foeeurope), 2013) and most metallic element (International Aluminium Institute, 2008) found in the earth crust" and could last for about 300 years, aluminium recycling is very

important to sustain the economic development. Ghana has being mining bauxite since 1913 (Mineral Commission Ghana, 2013). Exploration and production of aluminium in Ghana and across the world has led to high deforestation, human right violation, soil degradation and release of toxic materials to the atmosphere which lead to human health risk and extinction of organisms. Also mining exploration has contributed adversely to the displacement of rural communities and these affect their social and cultural orientations and their ability to sustain food production to feed their families. In some cases these displaced rural communities are not compensated or where compensation is possible, may delay for many years. The net effect is destabilization of social order and extreme poverty for affected communities.

However, to minimize the extraction of bauxite, it is important to recycle aluminium waste found in GEMA municipal solid waste and the country as a whole. Aluminium wastes are 100% recyclable by using just 5% of the total energy used to extract the alumina ore and to process it further to finished products (Foeeurope, 2013) which are mostly used by beverage and food processing industries. This suggests that GEMA and the country at large would benefit significantly in terms of energy savings and also promoting eco-friendly community since activities such as combustion of fossil fuels to generate huge energy for exploration and processing of bauxite, and clearing of virgin forest (deforestation) for exploration would be significantly reduced.

Due to high resistance of aluminium to corrosion, recycled aluminium products may support various socio-economic infrastructural developments such as the building industry which is significantly shifting from the use of only bricks/blocks and mortar to the use of thick aluminium slates for construction of offices, warehouses and other architectural applications including construction of trains, cars, and stadia (Foeeurope, 2013). Aluminium frames, doors and furniture would also reduce the use of timber for

these purposes and therefore reducing community over dependency on virgin wood lands which leads to deforestation and desertification.

The clothing waste is the least (9.5%) of all municipal solid waste in GEMA solid municipal waste. However, it was observed that this clothing virtually goes into landfilling at the dumpsite. This is due to lack of waste separation techniques in the municipality and at the dumpsite. Clothing waste when properly sorted by the community may support the needy as it may be reused by orphanages. Other sorted grades may be used as insulators in furniture, cars and in the construction industry. This clothing recycling practices in the community may reduce the amounts of chemicals and large quantities of water used during cotton farming and textile processing. It is important to underscore that "water is life" and therefore these practices would help reduced the water burden and frequent shortage of community water supply.

5.6.3 Energy Generation from GEMA Waste

Demand for energy has been on the high side and of great concern to all Ghanaians especially as the population increases and economic activities continue to grow. The country has been depending on hydropower and fossil fuel (oil and coal) since late 1960s. However, energy could be generated from municipal waste. The municipal waste of Ga East Municipality could be used as a feedstock to incinerators to generate energy for the community. In a water wall incinerator the raw municipal waste of GEMA would be directly burned without sorting to generate steam which would then be converted to electricity for the community. With the use of advanced technologies such as mechanical-biological waste treatments (MBT) the community can benefit a lot as it has the capacity to optimise feedstock to generate energy thereby reduce waste by over ninety percent

(Garthe & Kowal, 2006). The generated energy would serve as a substitute for fossil fuel or complement that of hydropower and reduce the cost of energy. Money would be saved on the use of fossil which would be channeled into developmental projects for the communities like roads, improved agricultural production, hospitals and schools. This would enhance productivity and socio-economic life in the community.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Waste management has become an essential part of city management due to increase waste management problems. GEMA is facing high municipal waste management situation. The municipality engages in somewhat high door-to-door collection, whereas 31% of the waste is left un-collected in the municipality. Again, the municipality lacks the necessary modern waste management infrastructure. However, the only available method of treating these wastes is the conventional method of landfilling. The waste mix of the waste shows that various resources could be recovered from the waste to improve socio-economic situation of the municipality by creating jobs, supplying products from recycled materials, reducing reduce climate change effects, reliance on virgin resources, and other environmental and health problems.

However, further research is required to ascertain the feasibility (technical, economic and social) of these wastes-to-resource options observed in this research and also how to build sustainable waste management practices within the cultural context of GEMA. It is therefore important to underscore that this waste management menace could be prevented for a better sustainable society.

6.2 Recommendations

Effective and efficient waste management has been an important part of socio-political policies across the globe. In advanced countries such as Germany, Japan, US, and other EU countries, waste is not considered waste but a material of which valuable resources

can be recovered. These has led to rigorous and stringent policies at community/municipal, national and sub-regional level, and ensure that municipal waste are economically considered and scientifically processed to recover resources at a reduced risk and reuse by the society again without compromising the needs and demands of the future generations.

On the contrary, the Ga East Municipal Assembly waste management system has not taken the necessary opportunities that would promote close-loop waste management system which is improving some societies' wellbeing and sustainability. To shift from these conventional and adverse waste management practices, the assembly should consider the following recommendations.

The researcher recommends two core infrastructures: the hard infrastructure and soft infrastructure.

1. The hard infrastructure deals with tangible infrastructures necessary to build a formidable, effective and efficient waste management system similar to the advanced societies to ensure that high volume of waste are collected, sorted toward a sustainable resource recovery. This would be achieved if proper sorting from source is encouraged or enforced for further processing and recycling; and the necessary logistics and waste processing plants, such as waste management vehicles and bins, incinerators and the right tools are utilized. Indiscriminate disposal of municipal waste suggests that more collection bins should be provided while improving the collection system in the municipality. However, this may bring budgetary and logistics constraints on the municipality towards implementing sustainable waste management practices. It is therefore important that there is collaboration between

other municipalities on the best way of sharing cost and logistics to enable them implement these directions.

2. The soft infrastructural need of the municipality deals with the necessary education, training, policies, regulations, information and governance systems that need to be developed for the municipality. Germany has been at the forefront of waste management policies and governance systems for many years. Importing some of these soft infrastructures would be a step in the right direction if the institutional and cultural context of the people is well considered.

   The indiscriminate disposal of municipal waste by inhabitants and passer-bys is a result of lack of knowledge on the need to have good sanitation, environment and also commitment towards sustainable waste management system. Intensive formal and informal education would help solve the problem. Households should be encouraged to support GEMA waste management process by ensuring that municipal waste are sorted before disposing them at the local collecting places. The municipal Assembly can have collaborations with Governmental institutions such as the National Commission on Civic Education (NCCE), the Ghana News Agency (GNA), and Ghana Broadcasting Corporation (GBC) to develop the necessary educational structures and information geared towards bringing attitudinal change in the society. Also other regulations which would bring manufacturers and distributors to the forefront of collecting waste packaging materials are important. Since such enforcement of these regulations may be resisted by affected companies and households, it is important to underscore that the municipal law enforcement agencies must have the needed commitment towards law enforcement and implementations. Again indiscriminate disposal of waste may be due to high cost of disposing waste by the households. As a developing community, such cost may

demotivate them to dispose waste appropriately. It is therefore recommend that enough consideration is taken on the cost of disposing.

Even though there is private-municipal partnership on municipal waste collection, enough has not been done to bring the menace to order. It is therefore important that the municipal assembly improves its collaboration or partnership with the private collectors and processors to ensure effective and efficient waste collection system. However this may come to pass only if private partners are motivated enough. The Assembly can use the tax advantage approach to improve the sector to attract more investors into the industry.

Waste-to-resources can only be achieved if there is enough scientific research into the municipal mix and what resources can be recovered. This suggests the need for the municipal assembly to collaborate with appropriate research institutions, government and international agencies to develop efficient and sustainable (technical, economical, and social and environmental) technologies to recover resources from these waste towards sustainable development in the community.

It is also recommended that, further research be conducted to estimate the actual economic impact of proposed projects for implementation.

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APPENDIX

A1: Structured interview schedule guide for Ga East Municipal Assembly (GEMA)

Relevant questions asked on the waste management system of GEMA.

SECTION A: Questions to Waste Management Department (office) of GEMA

1. What is the current general composition of the municipal solid waste?
2. What are the modes of collecting waste in the municipal to the dumpsite?
3. Has there been any record on poor sanitation-related diseases in the municipal?
4. Does the municipality employ any modern treatment plant to transform waste to valuable resources?
5. What is the current situation on waste management legislation?
6. Do you employ these legislations and what are the challenges of implementing them?

SECTION B: Questions to Dumpsite workers (Operatives) at GEMA

1. How many trucks does the dumpsite receive per day employ on waste collection?
2. How do you pre-treat municipal solid waste at the dumpsite before dumping?
3. Do other municipalities also use this dumpsite?
4. Does the municipality employ other methods of waste management techniques apart from dumping?
5. Do you use Personnel Protective Equipment when working at the dumpsite?