KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,
KUMASI

SOLID WASTE MANAGEMENT CHALLENGES IN BANTAMA SUB-METRO, KUMASI

BY

RICHARD KWADWO OSEI (BEd Agric)

PG 6510311

A THESIS SUBMITTED TO THE DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF SCIENCE (MSC) DEGREE IN ENVIRONMENTAL SCIENCE

MARCH, 2014

DECLARATION

I hereby declared that this thesis is my own work towards the MSc and that what fellow is the result of the author's original work thorough supervision. This work has not been submitted previously either wholly or partially to the Kwame Nkrumah University of Science and Technology, Kumasi, or elsewhere except references to other people's work which have been duly acknowledged.

Osei Richard Kwadwo (PG 6510311) …… ……

(Student Name and ID) Signature Date

Certified by:

Dr. Philip Kweku Baidoo …… ……

(Supervisor) Signature Date

Certified by:

Rev. Stephen Akyeampong …… ……

(Head of department) Signature Date

ABSTRACT

Waste issues seem to be a boring subject that does not excite many people, however, its consequences if overlooked can wreck the health and existence of any well meaning people. The study investigated solid waste management challenges in Bantama Sub-Metropolis, Kumasi. It analyzed solid waste management challenges in the Bantama Sub-Metropolis, Kumasi and suggested possible measures to manage the challenges. The three main techniques used in gathering the primary data were: preliminary field investigation, questionnaire survey and face-to-face interview. The following key findings were established to be the solid waste management challenges in the Bantama Sub-Metropolis. These are: In adequate skip supply for storing waste, lack of routine collection of waste, lack of operational vehicles and routine maintenance, unfair charge on waste per dump at transfer stations, regular vehicle breakdown, inadequate waste collection vehicles, high volume of waste generated, lack of funds, lack of continuity between planning circle, lack of interdepartmental waste management coordination, insufficient budget allocation for landfill operations, small containers, height of containers, insanitary transfer stations, bad roads leading to high transport cost, traffic congestion, vehicle wear and tear at landfill site, weak enforcement of environmental regulations, lack of logistics, high cost of receptacles, lack of storage receptacles at point of generation of solid waste, receptacles not durable, lack of easily accessible skip and air pollution. In the light of these challenges enumerated above, the research recommended the provision of adequate skips and durable receptacles at a lower cost, regular collection of waste, provision of adequate operational vehicles and routine maintenance, "Pay as you dump policy" should re-strategize to ensure fairness at the transfer stations, provision of adequate recycling units, provision of specialized vehicles to execute certain functions best within waste collection to disposal site, provision of

specified route to ease traffic congestion, KMA should strengthen avenues for customers to voice their complaints, strengthen education and awareness of waste management to politicians, procurement of waste related equipment or machinery should involve those with relevant technical expertise, keeping of accurate and effective waste collection data, KMA should explore other sources of fund from corporate bodies e.g. VAC, AGC, GGB etc. and intensify sharing responsibility with other stakeholders, KMA should factor the need for the closure and rehabilitation of their landfill sites into their disposal charges, adequate resourcing of Waste Management Institutions, strengthen coordination of effects by key role players related to waste management (finance, planners, councilors and procurement) and provision of adequate land space for the treatment and disposal of waste.

DEDICATION

This work is dedicated to God Almighty, my dearest brother John Berfi. My lovely wife Gloria Adjei (Mrs) and children (Celestina Berfi Osei, Christabel Berfi Osei, Antionette Berfi Osei and Gloria Berfi Osei)

ACKNOWLEDMENT

To write such comprehensive material to meet specific target, one needs support from the Almighty God with whom all things are possible. As human, I must also appreciate the numerous contributions made by other people for this work to materialize.

My sincere appreciation goes to the dynamic supervisor, Dr. P. K. Baidoo, Senior lecturer in the Department of Theoretical and Applied Biology KNUST for his valuable assistance, constructive criticism and guidance given me throughout this project work in spite of numerous tasks.

I would like to thank Prof. Kwesi Obiri-Danso for similar role played towards the success of this work.

I extremely grateful to KMA – Waste Management Department, private waste collection institutions (Asadu Royal waste collection company, Meskworld waste collection company and Ve-Mark waste collection company) all operating in the Bantama Sub-Metropolis for their contribution towards the success of this project.

Special thanks go to Mr. L. B. Acheamfour (KMA statistician) and Mr. Kwame Poku Antwi for their countless support throughout the period.

My profound gratitude to my brother Mr John Berfi for his financial assistance and my lovely wife Gloria Adjei (Mrs) for her prayers throughout the study

I thank all my friends who have really supported me to reach this far. May God richly bless you all.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABREVIATIONS

AGC - - - -	Ashanti Goldfield Company
VAC - - - -	Volta Aluminum Company
UNEP - - - -	United Nations Environmental Programme
SWD - - - -	Solid Waste Department
KMA - - - -	Kumasi Metropolitan Assembly
EPA - - - -	Environmental Protection Agency
RCRA - - - -	Resource Conservation and Recovery Act
MSW - - - -	Municipal Solid Waste
UNESCO-EOLSS - -	United Nations Educational, Scientific and Cultural Organization-Encyclopedia of Life Support System
NIMBY- - - -	Not in My Back Yard
IWMS - - - -	Integrated Waste Management System
USEPA - - -	United State Environmental Protection Agency
ADB - - - -	African Development Bank
GSS - - - -	Ghana Statistical Service
GGB - - - -	Guinness Ghana Breweries
GEF - - - -	Global Environmental Fund
IMO - - - -	International Maritime Organization
EGSSAA - - -	Environmental Guidelines for Small Scale Activities in Africa
MLGRD - - -	Ministry of Local Government and Rural Development

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Solid waste management is a growing environmental and financial problem in countries throughout the world (Hari*et al*., 1994). Despite significant efforts made by some countries in recent decades to improve solid waste management services, most municipalities and metropolitan cites in developing countries still face major challenges in properly handling the growing volume of waste produced in their cities (Majani, 2000; Kaseva and Mbuligwe, 2003; Ketibuah*et al.*, 2009). Increasing population, economic activities, urbanization and industrialization especially in developing countries such as those in Africa, have drastically increased the amount of waste generated (Taylor, 1999)

Waste collection systems vary widely between different countries and regions. In Ghana, waste collection services are often provided by local government authorities or by private waste management companies (Ketibuah *et al.*, 2009). The two collection methods practiced in Ghana are the communal and the franchised methods. The communal method of waste collection has several waste collection points called transfer stations located in the communities where all the waste are gathered from households and from other public institutions before they are transported to the disposal sites. In the franchise method of waste collection, the waste is collected from homes, institutions and in public places and transported to the disposal sites. The communal collection is used in areas where the residential houses are not well planned and there are no good road networks to ensure house to house collection (Ketibuah *et al.*, 2009).

In our rapidly urbanizing global society, solid waste management will be a key challenge facing all the world's cities. In West Africa in general and Ghana in particular, the issue of collection,

management and disposal of solid waste continues to feature prominently in major towns and cities across the region. The contamination of water bodies -leading to the spread of water-borne diseases, health hazards from the stench emanating from uncollected and decaying garbage, air contamination, garbage-chocked drains and gutters, the plastic waste menace, irresponsible disposal of refuse in communities are some of the challenges (www.ghanaweb.com, 2011).

Waste issues seems to be a boring subject not many get excited about; however its consequences if overlooked can wreck the health and existence of many well meaning people. "Managing solid waste well and affordably is one of the key challenges of the 21st century, and one of the key responsibilities of a city government. It may not be the biggest vote-winner, but it has the capacity to become a full-scale crisis, and a definite vote-loser, if things go wrong".-UN—HABITAT (2010). It is stated that a city that cannot effectively manage its waste is rarely able to manage more complex services such as health, education, or transportation (www.ghanaweb.com, 2011).

1.2 PROBLEM STATEMENT AND JUSTIFICATION OF THE STUDY

The uncontrolled manner in which solid waste is disposed of at most open dumpsites creates serious health problems to humans, animals, and environment. The environment is degraded in a number of ways. Soil is contaminated by being in contact with solid waste and leachate. Dumping site and some of the waste from the site finds its way into the river (Environmental News Service, 2007). The health risk and the effects on the quality of livelihood caused by this practice calls for comprehensive approach to the assessment of the effect of waste dumpsites on the environment.

The current solid waste management practice within Bantama-Sub-Metropolis is highly dissatisfied by residents. The situation ranges from delayed in collection of skips with refuse

overflowing for several weeks. It was against this background the study was conducted to investigate waste management challenges in Bantama Sub-Metro, Kumasi.

Despite the magnitude of the situation, very little research on solid waste management has been carried out in the Sub-Metropolis. The study will serve as a reference point to the Metropolitan Assembly and waste management institutions as far as solid waste management is concerned. In this case, the study seeks to investigate solid waste management challenges in Bantama Sub-Metro, Kumasi.

1.3 OBJECTIVE OF THE STUDY

The main objective of the study was to investigate solid waste management challenges in Bantama Sub-Metro, Kumasi.

1.3.1 Specific Objectives

The specific objectives were to:

- estimate the quantity of solid waste evacuated to landfill site within a month in BantamaSub-Metropolis, Kumasi.
- determine the avenues for collection and disposal of solid waste generated in the Sub-Metro.
- investigate stakeholder's challenges in solid waste management in the Bantama Sub-Metropolis.
- examine residents' willingness to pay for waste collection services.

CHAPTER TWO

LITERATURE REVIEW

2.1 SOLID WASTE

Solid waste can be classified into different types, depending on their source; household waste is generally classified as municipal waste; industrial waste as hazardous waste, and biomedical waste or hospital waste as infectious waste. The term "solid waste" is any garbage, refuse, sludge from waste treatment plant, water supply treatment plant, or air pollution control facility and other materials, including solid, liquid, semisolid which contained gaseous material resulting from industrials, commercials, mining and agricultural operations from community activities (Moeller, 2005).

2.1.1 Sources and Types of Solid Waste

The sources of solid waste are residential, commercial, municipal, industrial, treatment plants and agricultural. The various types of solid waste that are generated include food waste, rubbish, ashes and demolishing and constructional waste. Solid waste can be classified into different types depending on their sources:

- Household waste generally classified as municipal waste,
- Industrial waste as hazardous waste, and
- Biomedical waste or hospital waste as infectious waste

In Ghana solid waste refers mainly to:

- ✓ Domestic waste (waste from food preparation, sweeping, discarded household items),
- ✓ Municipal waste (waste generated in commercial centre's),
- ✓ Industrial waste (e.g. wood waste, waste from abattoirs and food processing industries, metal scraps from garages). (Poku, 2009).

The knowledge of the sources and the types of waste generated coupled with the amount of waste generated is very important information required for the design of facilities for effective handling and management of the waste to protect the environment and public health (Tchobanoglous*et al*, 1993).

2.1.2 Components of Solid Waste

Information on the composition of solid waste is important in evaluating alternative equipment needs, systems, and management programme and plans for solid waste collection (Tchobanoglous*et al*., 1993). For instance, if wastes are generated from a commercial facility that consists of only paper products, the use of special processing equipment such as shredders and balers may be appropriate. Separate collection may also be considered if different city collection agencies are involved. According to Mizpah*et al*.(2009), the composition of solid waste in Kumasi is predominantly made of biodegradable materials and large percentage of inert materials which include wood ash, sand and charcoal. Table 1 shows the solid waste composition in the Kumasi area.

Table 1 Waste composition data in Kumasi

Waste component	Percentage
Biodegradable or organic	64
Paper	3
Plastic	4
Metals	1
Inert	22
Wood	3
Textiles	3

Source:(Mizpah *et al,* 2009)

2.2 THE CONCEPT OF WASTE MANAGEMENT

The business of keeping our environment free from the contaminating effects of waste materials is generally termed waste management. Gbekor (2003), referred to waste management as involving "the collection, transport, treatment and disposal of waste including after care of disposal sites". Similarly, Gilpin (1996) defined waste management as "purposeful, systematic control of the generation, storage, collection, transportation, separation, processing, recycling, recovery and disposal of solid waste in a sanitary, aesthetically acceptable and economical manner" while Schubeler *et al*. (1996) focused on municipal solid waste management which they define as "the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste in urban areas". It can be deduced from these definitions that waste management is the practice of protecting the environment from the polluting effects of waste materials in order to protect public health and the natural environment. Thus, the priority of a waste management

system must always be the provision of a cleansing service which helps to maintain the health and safety of citizens and their environment (Cooper, 1999). Further, Gilpin (1996) regards the business of waste management as a professional practice which goes beyond the physical aspects of handling waste. It also "involves preparing policies, determining the environmental standards, fixing emission rates, enforcing regulations, monitoring air, water and soil quality and offering advice to government, industry and land developers, planners and the public". Waste management, therefore, involves a wide range of stakeholders who perform various functions to help maintain a clean, safe and pleasant physical environment in human settlements in order to protect the health and well-being of the population and the environment. Effective waste management is, however, a growing challenge to all municipal governments, especially in developing countries.

If solid waste management is to be accomplished in an efficient and orderly manner, the fundamental aspects and relationships involved must be identified and understood clearly (Tchobanoglous *et al*., 1993). On the basis of this, solid waste management incorporates the following: source separation, storage, collection, re-use, transport and disposal of solid in an environmentally sustainable manner.

The Ghana Environmental Protection Agency has noted that waste management is essential in the present day context for the following reasons:

1. To protect human health against waste-related hazards and risks
2. To prevent pollution of the environment and its natural resources like air, water and land
3. To produce energy which could be an alternative for the fast depleting fossil fuels and other conventional sources of energy?
4. To make optimum use of the waste generated (EPA Ghana, 2002)

2.2.1 Solid Waste Management Processes

The key elements in solid waste management include: waste generation, storage, collection, transfer and transport, processing and recovery and final disposal site. This means that when waste is generated, it is first stored in either dust bins or skips. It is then collected and finally disposed of in landfill site. When waste is collected, it can be transferred from small collection equipment like tricycle to a bigger truck for final disposal. On the other hand, waste collected can be processed and recovered for materials to be reused. These elements are further explained below.

2.2.1.1 Solid Waste Generation

Waste generation is described as the quantity of materials or products that enter a waste stream before composting, incineration, recycling and land filling (Business Directory.com, 2009). Waste generation includes all the activities in which materials that are no longer of value and are either thrown away or gathered together for disposal. Solid wastes are generated from residential areas, commercial or public places, industries, treatment plants and agricultural activities. According to (Kerala ENVIS Centre, 2009), solid waste generation is mainly due to industrial and domestic activities. Solid waste generated from industrial activities is of hazardous as well as non-hazardous nature, while solid waste generated from domestic sources are mostly organic.

2.2.1.2Waste Generation Quantities

According to the European Union municipal waste generation report of 2008, Municipal waste quantities in Europe is growing and more than 306 million tones are estimated to be collected each year with an average of 415 kg/capita. About 18 million tones of waste are generated in

Greater London each year which covers an area of 1,587 square kilometers (Browne and Allen, 2007). In Ghana, about 3 million tones of solid waste are generated annually with an average of 0.45 kg per capita. Accra, the capital city and Kumasi the second largest city, combine to generate about 3,000 tones of solid waste daily (Mensa and Larbi, 2005). According to the Mayor of Kumasi Metropolitan Assembly, the city of Kumasi in 2009 generated an average of 1,500 tones of solid waste daily. Out of this quantity, the KMA is able to collect about 1,300 tones leaving the remaining 200 tones uncollected due to inadequate waste collection logistics (Major of KMA, 2009).The manufacturing industry, construction and demolition, mining, quarrying and agriculture are the main sectors that contribute to waste generation in Kumasi (Sarpong, 2009). Determining the total amount of waste generated is very important information when selecting the right kind of logistics in waste collection and transport. This will guide the selection of specific equipment for collecting the waste, designing waste collection routes, material recovery facilities and disposal facilities (Tchobanoglous *et al.*, 1993)

2.2.1.3 Calculation of Municipal Solid Waste Generation Quantity

According to United Nations Educational, Scientific and Cultural Organization-Encyclopedia of Life Support System (UNESCO-EOLSS undated) the major factors affecting the quantity of MSW are population, standard of living etc. Modeling of these factors is a challenging task. As a conventional duty of a local government in most countries, population surveys are readily available. All other factors which are difficult to transfer to numerous parameters are synthesized in an MSW Generation rate Coefficient G_R. The generation of MSW in a city can be formulated by the following equation:

$$\mathbf{G_T = G_R\ M \times 10^{-3} \times 365}$$

Where:

G_T = Generation of MSW of the city (ton/a)

G_R = MSW Generation Coefficient (kg/person/d)

M = Population in the city

2.2.1.4Storage

Storage is the process where waste is stored before it is collected Tchobanoglous *et al.*, 1977. It could store in a skip or dustbins and not thrown away indiscriminately. According to them, storage is of primary importance because of the aesthetic consideration.

Waste receptacles at points of generation are intended for the storage of waste between collection days. Aspects to take into account in the choice of receptacle are: size, cost, availability, durability, type of waste and ease of handling by waste generators and waste collectors (Waste management toolkit (undated).

2.2.1.5 Waste Collection

The term waste collection includes not only the collection of solid waste from various sources but also the hauling of these wastes to the location where the contents of the collection vehicles are emptied (Tchobanoglous *et al*., 1993).

Waste collection is also described as a component of waste management which results in the passage of waste materials from the source of production to either the point of treatment or final disposal site **(**Sampson, 2003).

The way and manner in which waste is collected in terms of vehicle types, capacities, and staffing levels depends on the nature of the collection. According to Tchobanoglous *et al*.

(1993), waste collection starts with the containers holding materials that is no longer useful and ends with the transportation of the solid waste to a location for processing or disposal.

In high income areas, the private waste collection companies collect the waste directly from households with compactor trucks for dumping whiles in low and middle income areas, residents carry their waste to public waste containers provided by the Waste Management Department at communal collection points (Boadi and Kuitunen, 2003).

Household and Commercial Waste Collection

Household wastes are generally generated from homes and gathered in waste bins, plastic or metal containers, and plastic bags for collection by waste collector using a waste collection vehicle. The wastes generated from households are carried to central waste collection point (transfer stations) where they are loaded into a vehicle and either sent to a landfill site or to an alternative waste treatment facility. The amount of waste generated from households and commercial places far exceeds the volume collected. According to Boadi and Kuitunen (2003), 60% of the total waste generated in Accra is collected annually leaving the 40% uncollected. KMA, Waste Management Department (2009), and the private waste management companies in Kumasi, their inability to collect all the waste generated from the households and the commercial areas are as a result of poor road network within the city, inadequate waste collection containers and the frequent break down of bulldozers and compactors at the landfill site. Households therefore resort to alternative ways of disposing their waste (Boadi and Kuitunen, 2003). For instance in high income areas waste bins are not emptied in time forcing residence to hire individuals to dispose of the waste at the central collection points. In low income areas, the

containers are not removed in time and this causes people to dump waste in unauthorized dumps such as canals, water bodies, and surface drains (Boadi and Kuitunen, 2003).

Logistics of Solid Waste Collection

Past methods of planning for and operating waste collection systems are under pressure, resulting from the need to improve the collection systems to protect the environment and public safety. Sampson, (2003) stated in his report that waste collection and transport has significant environmental, health and safety implications as well as the economic cost due to the types of logistics that are used to collect and transport the waste. The total quantity of waste generated keeps increasing in recent times. The nature and type of waste produced in our technological society (the way society uses technology to achieve specific goals) gives the complexity (state of not being simple) of the type of logistics requires for the collection of waste. There are a number of barriers that limit efforts to improve the efficiency of waste collection logistics. These are:

- Access restrictions, meaning that not all properties can be serviced by the same vehicles,
- The inconsistent nature of waste production, with variations occurring on a weekly and seasonal basis and from street-to-street and region-to-region,
- Ineffective matching of vehicles to rounds, and
- Variations in material delivery points over time, a situation that will arise more frequently as material reprocessing and delivery to new markets increases **(S**ampson, 2003).
- To improve the performance of waste collection logistics the following may be considered:
- Collection and use of operational performance data to inform future planning,
- Partnership working, e.g. through shared depots,

- Raising the issue of logistics earlier in the planning phases of integrated waste management systems,
- Phased introduction of new collection schemes such that transport problems can be addressed and costs more fully understood prior to full scheme adoption,
- Improved understanding of the capabilities of the asset-base,
- Effective periodic work scheduling and routing, and
- Contingency planning, e.g. for unplanned closure of waste disposal facilities.

Waste Collection Materials

Waste containers are used for storing waste and they are usually made of metal or plastics. Common terms used for waste containers are dustbins, rubbish bins, litter bins, garbage cans, bin trash and rubbish barrel (Hamdu, 2009). These bins are classified according to their usage as indoor bins, curbside bins and public bins for public areas. Indoor bins are traditionally kept in the kitchen to dispose of food waste but in recent times they are also used in the offices to dispose of papers and other office waste. The top of these bins are sealed to trap the odour inside the bin that the garbage tends to emit. Though most of them have to be opened manually, some have pedals, which open the lid when stepped on. Indoor bins are also lined with garbage bags which keep the bin clean, facilitate the removal of the garbage and allows disposal with minimal contact with the contents. Curbside bins consist of three types, which include the trash cans, dumpsters and wheel bins (Hamdu, 2009). All of these are placed at the gate of the residence to dispose of their waste and emptied by waste collectors. In areas where there is recycling or energy/nutrient recovery service, separate bins are placed at residences to receive items that can be recycled or used as biogas or compost. Bins in public areas such as parks are placed alongside

paths frequently used by people to encourage them to dispose of their waste inside them to avoid littering the environment.

Waste Collection Service

Solid waste collection systems and methods in Kumasi are inadequate to cover a large part of the city, particularly, in poor squatter settlements, and inaccessible neighborhood to collect all the expected waste to be generated in the cities (Boadi and Kuitunen, 2003). The principal types of waste collection methods are collecting co-mingle or non-separated waste at source and waste at source separated. Waste collection methods vary widely between different countries and regions. Domestic waste collection services are often provided by local government authorities, or by private industry. Developing countries do not have a formal waste-collection system even though these countries are now adopting some of the popular waste collection systems around the world. For instance in Australia, the curbside collection is the method of disposal of waste where every urban domestic household is provided with three bins: one for recyclables, another for general waste and another for garden materials. These bins are provided by the municipality if requested. In Ghana the Metropolitan, Municipal and District Assemblies are responsible for the collection and final disposal of solid waste through their Waste Management Departments (WMDs) and their Environmental Health and Sanitation Departments (www.ghanadistrics.com, 2013).

There are two main types of waste collection services that are delivered by the private operators in the Kumasi metropolitan area. These are house-to-house and community collection services. The patronage of the house-to-house collection services increased from 2.1% of the population in 1999 to 20.8% as at March, 2005 (Peter *et al.*, 2009), (Table 2).

Table 2 Estimation of house-to-house coverage in Kumasi

Year	Projected Population	No. of houses served	No of persons served	Percentage %
1991	1,112,423	900	23,130	2.1
2000	1,170,270	2,200	56,540	4.8
2001	1,231,124	4,300	64,810	6.9
2002	1,295,143	4,902	125,981	9.7
2003	1,362,490	9,376	240,963	17.7
2004	1,433,339	11,110	285,527	19.9
2005	1,507,873	12,219	314,028	20.8

Source: Peter *et al.*, 2009

2.2.1.5 Solid Waste Transport

Wastes are collected from one location and transported using vehicles to another location for processing. Solid waste transport has a wide range of social and environmental effects in urban areas such as noise pollution, air pollution, contribution to traffic congestion, involvement in traffic accidents, and the deposit of dirt and waste on the road network. Waste transportation by road in recent times has come under severe criticism because of the danger it poses to the people and the environment.

Vehicles Used in Waste Transportation

Waste collection vehicles are trucks specially designed to pick up smaller quantities of waste from points of generation and haul to landfill and other recycling or treatment facilities. These

vehicles are often called garbage trucks, dustbin lorry and dump trucks. There are five different models of waste collection vehicles in the world. These are: Front loaders, Rear loaders, Side loaders, Pneumatic loaders and Grapple trucks (Hamdu, 2009).

In developing countries like Ghana, the rear loaders are mostly used in collecting the waste. The loaders have an opening at the rear that enables the waste collector to throw waste bags or empty the contents of the bins into it (Hamdu, 2009).

2.2.1.7 Processing and Recovery of Solid Waste

The element of processing and recovery includes all the technology, equipment, and facilities used both to improve the efficiency of other functional elements and to recover usable materials, conversion products or energy from solid waste (Tchobanoglous *et al.,* 1977). In the recovery, separation operations have been advised to recover valuable resources from the mixed solid waste delivered to transfer stations or solid waste processing plants (Tchobanoglous *et al.*, 1977).

2.2.1.8 Disposal of Solid Waste

The term "disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid wastes, hazardous wastes, or any constituent thereof may enter the environment or be emitted into air or discharged into any waters, including ground waters, from community activities (US Law-Solid Waste Act 2,1999).

According to KMA-WMD (2006), a well-engineered sanitary site was used at Dompoase where waste was placed compacted and covered at the site. A weighbridge was also available and attached to a control room where the waste was weighed and inspected before being accepted into the landfill. A maintenance bay and offices were also at the site. Heavy-duty equipment

were available for spreading of waste, compaction and covering. Grading and gravelling of access roads are other vital activities at the landfill site.

Early Concepts of Waste Disposal

During the first century of the industrial revolution, the dominant methods of waste disposal were known as dilute and disperse. The amount of waste produced during this period was relatively small compared to present times and factories were usually located near streams and rivers to take advantage of the availability of cheap running water for the transportation of raw materials, finished goods and discharging of waste into the streams and rivers. Because the population at this point in history was sparse and the quantity of waste being produced was small, dilute and disperse was used in removing waste from the immediate environment (Botkin and Keller, 2003). With increase in the amount of waste and population in the latter part of the 20th century, the concept of dilute and disperse became incapable of handling the increasing amount of waste being produced as a result of industrialization. Containers, be it simple tanks, trenches, waste metal drums had the potential to leak or break and spill their waste. According to Botkin and Keller (2003), some of these leaks resulting from waste disposal practices have led to the current situation whereby many people do not trust the government or industry to deal adequately with waste disposal in order to prevent public health hazards. It is no surprise then that no one wants to have a waste site situated around his or her home. This attitude is termed NIMBY- not in my back yard.

2.3 MODERN TRENDOF MANAGING SOLID WASTE

In modern times, the move has been to consider wastes as a resource. The idea is to consider all waste as reusable, thus there would be no such thing as waste. Waste when produced would be a resource to be used again. This is what has been termed the zero waste movement (Zero waste New Zealand, 2000). Zero waste forms the core of the concept called industrial ecology (Zero waste New Zealand, 2000). Industrial ecology is the study of relationships among industrial systems and their links to natural systems. Under this concept, industrial society will function just like the natural ecosystem whereby waste produced by one part of the system becomes a resource for another section of the system (Kelly *et al.*, 2002). The dominant concept today however in the management of waste is integrated waste management (IWM), defined as a set of management alternatives that include reuse, source reduction, recycling, composting, landfill and incineration (Ibid, 2003). The ultimate aim of reuse, source reduction and recycling is to cut down the quantity of municipal waste ending up in landfills and incinerators. Generally, conditions of waste disposal in Ghana are similar to those in many developing countries within the tropical climates. The overwhelming majority of landfills in Ghana are open dumps even though these are strongly discouraged in the national sanitation policy. The most feasible options for solid waste disposal (SWD) (Charles, 2007) are:

- ✓ Incineration
- ✓ Controlled dumping,
- ✓ Sanitary land filling,
- ✓ Composting, and

Complex systems for waste disposal that are coupled with energy recovery such as gasification and pyrolysis are not considered to be financially and technically sustainable in Ghana and are

thus not considered. (Mensa and Larbi, 2005). These feasible options for solid waste disposal are elaborated below.

2.3.1 Incineration

The UN Environmental Protection Agency (2006) states that, incineration is the process of destroying waste material by burning it. Incineration is often alternatively named "Energy-from-waste" or "waste-to-energy"; this is misleading as there are other ways of recovering energy from waste that do not involve directly burning it. Incineration is carried out both on a small scale by individuals and on a large scale by industries. It is recognized as a practical method of disposing of hazardous waste materials, such as biological medical waste. Many entities now refer to disposal of wastes by exposure to high temperatures as thermal treatment. Incineration converts waste materials in to heat, gas, steam and ash. Communities near incinerators have objected to them because of fears about possible emissions of gaseous pollutants (Bach *et a*l., 2009**)**.

In Ghana the national policy recommends small scale incineration plants for the treatment and disposal of health care and hazardous wastes. In most towns with health facilities small incinerators have been built as part of the health provision infrastructure. These facilities involve simple designs with lateritic bricks, cement blocks and metal. Local firewood is the most common energy source and the facilities are easily operated and maintained by environmental health staff of the District Assemblies. These simple incinerators have provided several years of service in dealing with relatively small quantities of hazardous hospital wastes. However, in reality many of such facilities have no environmental controls and often comprise nothing more than combustion of medical and chemical waste in an oven or open pit (Mensah and Larbi, 2005).

2.3.2 Open Dumping

Open dumps was a popular method of waste disposal in the early parts of the 20th century. This involved disposing the waste in open dumps without any cover or protection. Dumps were usually located in areas where there was land in abundance. A common site for open dumps is abandoned mines, quarries, swamps and hillsides. The waste is usually piled up as long as the equipments being used can manage to move in and out of the dumpsite. Open dumps are popular in developing countries as a means of waste disposal (Tchobanoglous *et al*, 1993). It is practiced in the households on a smaller scale and periodically burned to reduce the volume of waste and in some instances it is leveled and compacted. This is a common practice in Ghana (Tchobanoglous *et al*, 1993).

2.3.3 Sanitary Land Filling

Disposing of waste in landfill involves burying the waste in pits and this is the most common practice in most countries. It is the most cost effective method of disposal, with collection and transportation accounting for 75 percent of the total cost **(**Bassis, 2009**)**. In a modern landfill, refuse is spread thin, compacted in layers and covered by a layer of clean earth. Pollution of surface water and groundwater is minimized by lining and contouring the fill, compacting and planting the uppermost cover layer, diverting drainage, and selecting proper sites not subject to flooding or high groundwater levels. The best soil for a landfill is clay because clay is less permeable than other types of soil (Mensa and Larbi, 2005). Materials disposed off in a landfill can be further secured from leakages by solidifying them in materials such as cement, fly ash from power plants, asphalt, or organic polymers.

A properly-designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. Older, poorly-designed or poorly-managed landfills can

create a number of adverse environmental impacts such as wind-blown litter and generation of liquid leachate. Another common by-product of landfills is gas (mostly composed of methane and carbon dioxide), which is produced as a result of anaerobic break down of organic waste. This gas can create odour problems, kill surface vegetation, and is a greenhouse gas (Hamdu, 2009).

2.3.4 Composting

Composting is a biological process in which micro-organisms, mainly fungi and bacteria, convert degradable organic waste into humus-like substance. This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants. The process of composting ensures that the waste produced in the kitchens is not carelessly thrown and left to rot. It recycles the nutrients and returns them to the soil as nutrients. Apart from being clean, cheap, and safe, composting can significantly reduce the amount of disposable garbage. The organic fertilizer can be used instead of chemical fertilizers and is better when used for vegetables. It increases the soil's ability to hold water and makes the soil easier to cultivate. It helps the soil to retain more of the plant nutrients (Mensah and Larbi, 2005). Generally, conditions in Ghana are very conducive for composting in terms of the waste composition and weather conditions. However, composting has never flourished as an option for refuse treatment and disposal. Most local authorities feel, based on local experience, that the running costs of composting plants are excessive and unjustifiable (Mensah and Larbi, 2005). The only known large composting plant in Ghana was built with external donor support and commissioned in the early 1980s. During its early years of operation the plant was useful in helping reduce the volume of waste. However, high maintenance costs adversely affected its sustainability. In the

last few years most of the mechanical components have been decommissioned and the plant currently operates only for demonstration purposes.

Marshal (1995) states that, waste materials that are organic in nature, such as plant material, food scraps, and paper products, are increasingly being recycled. These materials are put through compost and/or a digestion system to control the biological process to decompose the organic matter and kill pathogens. The resulting stabilized organic material is then recycled as mulch or compost for agricultural or landscaping purposes.

2.3.5 Recycling

Recycling of bio-degradable domestic waste into nutrient stable compost can result in both reduction of waste and reduction in water pollution through substitution of chemical fertilizers by compost in urban agriculture. In a case study of urban agriculture farmers in Harare, Kisner (2008) recommended that the current farming practices of using chemical fertilizers were leading to underground water pollution through eutrophication and leaching. The composting of MSW and availing of such compost to urban agriculture farmers could assist in pollution mitigation.

Though high- and low-value recyclables are typically recovered and reused, these make up only a small proportion of the total waste stream. The great majority of the waste (~70 percent) is organic. In theory, this waste could be converted to compost or used to generate biogas, but in situations where rudimentary solid waste management systems barely function, it is difficult to promote innovation, even when it is potentially cost-effective to do so. In addition, hazardous and infectious materials are discarded along with general waste throughout the continent. This is an especially dangerous condition that complicates the waste management problem (EGSSAA, 2009). Recycling turns materials that would otherwise become waste into valuable resources. Collecting used bottles. Cans, and newspapers and taking them to the curb or to a collection

facility is just the first in a series of steps that generates a host of financial, environmental, and social returns. Some of these benefits accrue locally as well as globally (US EPA, 2011).

2.3.6 Source Reduction

At the national level, there are several methods which can be employed to reduce the production of waste. These include redesign of packaging, encouraging the use of minimal disposable material necessary to achieve the desired level of safety and convenience; increasing consumer awareness of waste reduction issues; and the promotion of producer responsibility for post-consumer wastes (UNEP, 1996). These goals may be achieved through a variety of measures, including legislative action and the creation of market forces and economic incentives which would drive these reforms forward; applicability of each goal and method would depend on circumstances present in each situation (Zerbock, 2003).

The most effective way to reduce waste is not to create it in the first place. By reducing and reusing, consumers and industry can save natural resources and reduce waste management cost. Unfortunately, the amount of waste generated in the United States has been increasing. Between 1960 and 2009 the amount of waste each person creates increased from 2.7 to 4.3 pounds per day (USEPA, 2011). This results in about 243 million tones of waste generated in the US in 2009. Waste prevention ,or source reduction is the strategy behind reducing and reusing waste ,by designing, manufacturing, purchasing ,or using materials in way that reduce the amount or the toxicity of trash created, less waste is generated and fewer natural resources are used (USEPA, 2011). Reuse is often part of the waste prevention strategy, stopping waste at the source due to preventing or delaying a material‘s entry in the waste collection and disposal system. Source reduction refers to any change in the design, manufacture, purchase or use of materials or

products (including packaging) to reduce their amount or toxicity before they become municipal solid waste. Source reduction also refers to the reuse of products or materials.

2.4 INTEGRATED SOLID WASTE MANAGEMENT

This involves the evaluation and integration of all the functional elements of waste management for effectiveness and economic efficiency. Because waste management objectives and goals vary from one municipality to another the assessment of various options to integrate the functional elements of solid waste management should be driven by stated goals and objectives (Babanawo, 2006). A number of African countries have been implementing integrated waste management (IWM). It refers to the complementary use of a variety of practices to safely and effectively handle municipal solid waste (Palczynski, 2002). The strategy used to develop an integrated waste management system is to identify the level or levels at which the highest values of individual and collective materials can be recovered. The most favorable is reduction, which suggests using less to begin with and reusing more, thereby saving material production, resource cost, and energy. The least desirable is land filling (Palczynski, 2002).

A community or a municipality is said to have developed an Integrated Waste Management System (IWMS) when all of the functional elements of waste management have been evaluated for use, and all of the interfaces and connections between elements have been matched for effectiveness and economy to meet community waste management goals and objectives (Babanawo, 2006).

2.5 CHALLENGESOF MANAGING SOLID WASTE

Ogawa (2005) categorized the challenges faced by most solid waste management system in a developing country into technical, financial, institutional and social constraints. He mentioned that, in most developing countries, there typically is a lack of human resources at both the national and local levels with technical expertise necessary for solid waste management planning and operation. Many officers in charge of solid waste management, particularly at the local level, have little or no technical background or training in engineering or management.

Another technical constraint in developing countries is the lack of overall plans for solid waste management at the local and national levels. It was also stated by Ogawa (2005) that, solid waste management is given a very low priority in developing countries, except perhaps in capital and large cities. As a result, very limited funds are provided to the solid waste management sector by the governments, and the levels of services required for protection of public health and the environment are not attained.

On institutional constraints, Ogawa (2005) indicated that, lack of effective legislation for solid waste management, which is a norm in most developing countries, is partially responsible for the roles/functions of the relevant national agencies not being clearly defined and the lack of coordination among them. However, as these facilities are usually considered unwanted installations and create not-in-my-backyard (NIMBY) syndromes among the residents, no local government is willing to locate them within its boundary (Ogawa, 2005).

2.6 SOLID WASTE CHALLENGES IN DEVELOPING COUNTRIES

Researchers have identified several factors that militate against solid waste management efforts in poor country cities. In a GEF/UNDP/IMO Regional Programme report, for instance, Linden *et*

al., (1997) identified ten common constraints to be militating against solid waste management efforts in Asian countries. These were:

1. Inappropriate technologies/processes
2. Enforcement inefficiencies/non-existent; illegal dumping
3. Lack of financing
4. Lack of training/human resource
5. Lack of political support
6. Lack of legislation
7. Policy conflict among levels of government/overlapping responsibilities
8. Rapid increase in waste generation/limited data
9. Lack of awareness among public, and
10. Limited land areas; land tenure issues.

These factors, according to the report, frustrated the waste management efforts of municipal authorities in Asia and made it difficult for them to keep their city environments clean and safe for the populations. After studying the solid waste problem in Tanzania, Kironde (1999) has also attributed the abysmal performance of the waste sector to resource constraints including the scarcity of financial, physical, human and technical resources for the organization of waste management operations.

In a study of the solid waste problem confronting the city of Kampala, Uganda, researchers from the Namilyango College (2001) identified several causes of the waste problem including the lack of dumping sites, ignorance of the masses about the need for proper waste disposal, inefficient collection methods, poor government attitude towards waste management, poverty of the people, corruption among public officials and lack of trained personnel for waste management. These

have posed serious constraints to the waste sector and dampened efforts towards waste management in the city. Many other writers have elaborated on how the factors cited above (plus others) interact to aggravate the solid waste problem in poor country cities. What follows from here is a detailed examination of the factors responsible for the abysmal waste situation in poor country cities (Baabereyir, 2009).

2.6.1 Lack of Good Governance and Civil Society

The low status of environmental services in poor country cities has also been blamed on the lack of good governance which promotes the well-being of the people, and on the lack of civil society action to exert pressure on governments to live up to their social responsibilities (Devas, 1999; Kwawe, 1995; Hashmi, 2007). Due to 'bad governance', municipal governments in poor countries show little regard for the wellbeing of the citizens and so renege on their responsibility to provide basic infrastructure and services to keep the cities clean, healthy and safe (Hashmi, 2007).

Commonly, autocratic styles of administration by supposedly democratic regimes alienate public opinion and participation in urban management (Devas and Korboe, 2000; Hashmi, 2007), a situation which does not augur well for effective waste management. From a governance point of view, the fact that the ordinary residents of cities, especially the poor, are denied participation in decision-making about issues that affect them means that their concerns may never be taken on board and their needs for such services as water, sanitation and waste disposal are therefore unlikely to be met (Devas, 1999; Devas and Korboe, 2000).

According to the UNDP (2005), civil society action is critical for establishing strong safeguard policies and no government can achieve sustainable development without the active involvement

of a fully-fledged civil society. In spite of the important role that civil society can play in promoting good governance and the general interest of society, civil society pressure or action is generally weak in developing countries, and even non-existent in many areas. Kwawe (1995) has observed that tax-paying citizens have the right, and in fact, the duty to call on government to maintain infrastructure and provide services where these are lacking. However, this is generally not the case in many poor countries because urban residents lack the ability to organise themselves to pressurize local governments to live up to expectation. In Uganda, the Namilyango College (2001) which investigated the solid waste problem in the city of Kampala, partly blamed the poor environmental conditions in the city on the unconcerned attitude of the public and the failure of residents to hold the authorities accountable for the situation.

2.6.2 Lack of Legislation and Enforcement

The lack of legislation on solid waste management has also been cited as being partially responsible for the undefined roles of agencies in the waste sector as well as the lack of coordination among them. In the report of their African Development Bank (ADB) sponsored literature-based study of solid waste management options for Africa, Palczynski and Scotia (2002) noted that "no country [in the study] has specific waste management legislation even though legislation is being drafted now in some countries". Ogawa (2002) has also observed that legislation related to solid waste management in developing countries is usually fragmented and several acts (such as public health, local government and environmental protection acts) include clauses relating to solid waste management. A case in point is that of Dar es Salaam which reportedly has 58 pieces of legislation dealing in one way or the other with the environment including solid waste (Onibokun, 1999). Such rules and regulations are, therefore, to be enforced by different agencies with duplication of responsibilities and gaps in the regulatory provisions

which constrain the development of effective solid waste management systems. Furthermore, some of the laws are completely out of date and therefore of little use. The lack of adequate legislation makes it difficult to assign clear mandates to urban sector institutions connected with waste management, a situation which greatly constrains the waste sector (Baabereyir, 2009).

Besides the scarcity of legislation on waste management, Onibokun (1999) has also noted the inability or unwillingness of municipal officials to enforce existing laws on environmental sanitation including the scanty legislation on waste disposal. This situation is particularly grave in the major cities where there is a general lack of public compliance with waste disposal laws if they exist at all (Ogawa, 2002). The non-enforcement of waste disposal laws engenders lack of fear of the law among the public and encourages negative waste handling practices such as littering and dumping of waste in drains and at roadsides. Such practices worsen the waste disposal situation and increase the burdensome tasks of waste collection, transportation and disposal for the resource-constrained municipal authorities. Thus, inadequate legislation and non-enforcement of waste disposal laws greatly constrain efforts to address the solid waste problem that currently confronts developing country cities. In line with what Girling has suggested (for the UK) it seems evident that the solution to the waste crisis in poor country cities cannot be found in prayers of wishful thinking, but rather in legislation, enforcement and penalties

2.6.3 Institutional Constraints

Inefficient institutional arrangements adversely affect urban management in poor countries generally and environmental service delivery in particular (UN-Habitat, 1989; Ogawa, 2002; Zurbrugg, 2002). According to UN-Habitat (1989), it is characteristic of developing countries to have several agencies involved in the delivery of solid waste and other municipal services. Furthermore, Ogawa (2002) has observed that there are often no clear roles or functions of the

various agencies involved in urban environmental management. At the same time, no single agency is usually designated to coordinate the activities of waste sector agencies (Armah, 1993; Attahi, 1999). Ogawa (2002) has, therefore, observed that the lack of coordination among the relevant urban sector agencies often results in different agencies duplicating one function. In the case of externally supported solid waste management projects, it is common for different agencies within the same country or city to act as counterparts of external support agencies for different waste management projects without any collaboration of efforts (Ogawa, 2002). Institutional inefficiencies of this nature can lead to duplication of functions, gaps in service delivery and waste of already scarce resources, or even the collapse of solid waste management programmes (UN-Habitat, 1989). Zurbrugg (2002) has also noted deficient management capacities of institutions involved in urban environmental management in poor country cities. Solving the waste problem in poor cities will, therefore, require improvements in the institutional arrangements and capacity building for waste management and other aspects of the urban environment. Ogawa (2002) has suggested that in large metropolitan areas where there is more than one local government, coordination among the different local governments and among agencies in urban management is critical to achieving the most cost effective alternatives for solid waste management for the entire city.

2.6.4 Technological Constraints

The technologies employed in municipal solid waste management in most developing countries are also said to be inappropriate and inadequate. Zurbrugg (2002) has observed that adoption of the conventional waste collection vehicles used in rich countries constrain solid waste management operations in developing countries. Apart from the high acquisition and maintenance costs involved, developing countries actually lack the engineering capacity to

support the operation and maintenance of such sophisticated equipment like compactors and skip lifts. Yet, this is the equipment usually employed by municipal authorities and private sector waste contractors in many poor countries (Armah, 1993; Achankeng, 2003).

Besides, the high cost of new equipment compels many poor country municipal governments to import used equipment from western countries. Such vehicles arrive already near the end of their useful life and so frequently require repairs due to breakdowns. In the absence of spare parts and the required engineering skills to maintain the trucks, only a small part of the fleet usually remains in operation after a short period of their use (Achankeng, 2003).

2.6.5 Inadequate Personnel for Waste Management

The poor waste disposal situation in poor country cities has also been attributed to the general dearth of qualified personnel in the waste sector (Onibokun, 1999; Ogawa, 2002). According to Onibokun (1999) most municipal authorities are unable to attract suitably qualified personnel for the various aspects of waste management such as planning, operations and monitoring. Ogawa (2002) corroborates this observation when he notes that developing countries characteristically lack the technical expertise required for solid waste management planning and operation and this is usually the case at both national and local levels. He argues that many officers in charge of solid waste management have little or no technical background training in engineering or management. Without sufficiently trained personnel, however, solid waste management projects cannot be effective and sustainable. Ogawa (2002) has observed that in many cases, solid waste management programmes initiated by external consultants have collapsed in the hands of local management due to the lack of expertise and loss of funding. Lohse (2003) has also observed that local governments in developing countries generally lack the required capacity and technical expertise to accomplish effective and sustainable waste management programmes.

Several studies in Africa and elsewhere in the developing world confirm the dearth of qualified waste management personnel and how this results in failure to undertake effective and sustainable waste management in the cities. One example was the study carried out by researchers at the Namilyango College in Kampala (Uganda) who found that the failure of waste management programmes in Kampala and other Ugandan cities was largely the result of a lack of trained manpower/personnel to execute waste management programmes. Kironde (1999) also found that human resources for waste management in Dar es Salaam were very inadequate in terms of managerial and technical staff and even labourers.

The general shortage of staff in the waste management sector of developing countries is also connected with the low esteem accorded waste management personnel (Onibokun, 1999). In most cultures, there is a negative public perception regarding work which involves the handling of filth (Hanrahan *et al.*, 2006), a situation which may be influenced by the practice in many developing countries where households without toilet facilities dispose of human excreta together with household solid waste (Songsore and McGranahan, 1996; Hardoy *et al*., 2001). This situation leads to disrespect for waste and sanitation work and in turn induces low morale among waste labourers (Ogawa, 2002). The lack of public appreciation and respect for waste management jobs makes many people, even the poorly-educated and unemployed, reluctant to take up employment as waste labourers. It therefore seems that poor country cities will continue to struggle with the implementation of their waste management programmes unless they train and motivate staff for the sector.

2.6.6 Financial and Economic Constraints

Many writers have cited the scarcity of funds as a major constraint to solid waste management in all developing countries (Cointreau, 2001; Ogawa, 2002; Lohse, 2003; Pacione, 2005). Lohse (2003) has described the problem of municipal finance in developing countries as "the gap between financial resources and municipal expenditure needs". According to him, this fiscal gap is widening as urban populations expand, increasing the demand for infrastructure and services including waste disposal. Lohse (2003) explains that one reason for the municipal finance gap is that "most municipalities lack the autonomy to establish their tax basis, rate structures, and enforcement procedures, and so cannot raise revenues commensurate with their expenditure requirements". In the context of Nigeria, Onibokun and Kumuyi (1999) have blamed the lack of fiscal autonomy among municipal governments on excessive central government control of the lucrative sources of revenue, a situation which leaves local governments with few options. Ogawa (2002) has also observed that the finance problem in developing countries is most acute at the municipal government level where the local taxation system is inadequately developed and therefore the financial basis for public services is weak. He attributed the problem of finance to the low capacity of local governments for cost recovery and their heavy reliance on state subsidies for waste management operations. This view is corroborated by Attahi (1999) who investigated the waste problem in Abidjan, Cote d'Ivoire, and found that even with an elaborate system of taxes and levies such as the drainage tax levied on landed properties; state subsidies sustain most municipal programmes including waste management. According to his study, only 30 percent of the cost of waste management is recovered in Abidjan. Zurbrugg (2002) maintains that the low fees usually charged for waste collection and insufficient funds from central municipal budgets cannot finance adequate levels of service.

2.7 SOLID WASTE MANAGEMENT IN GHANA

Solid Waste Management is defined as the direct generation, collection, storage, transport, source separation, processing, treatment, recovery and disposal of solid waste (www.ghanaweb.com, 2011).

Ghana like most developing countries is faced with serious solid waste management problems. All over the country solid waste is ultimately disposed of in both authorized and unauthorized waste dumps. All kinds of wastes, regardless of their nature, are being dumped indiscriminately into depressions, sand pits, old quarries, beaches, drains and even in certain areas, along streets, without due regards to the nuisance and harm caused to the environment (GEPA, 2002).

On a daily basis, each household generates garbage or waste items that are no longer needed or which are not being used fall in the category of waste and we tend to throw them away (Danso, 2011). Danso (2011) also indicated that, in the 2000 Population and Housing Census, Ghana's population was 18.9 million. With an average daily waste generation per capita of 0.45 kg, Ghana generates annually about 3.0 million tons of solid waste. Accra, the capital, and Kumasi, the second largest city, with a combined population of about 4 million and a floating population of about 2.5 million generate over 3,000 tons of solid waste daily. According to Danso, (2011) solid waste generation levels in the country can be classified into different types depending on their source: Household waste, public or general waste (in markets, lorry parks, open spaces, streets, etc.) Industrial waste, (Saw dust/wood shavings, metal scraps, etc). Biomedical waste or hospital waste (Surgical waste, swabs materials, etc). Institutional wastes are generated from institutions such as schools, offices, stores, department, etc.

2.7.1 Solid waste collection and disposal

Home collection of waste is limited to high and some middle income areas while the poor are left to contend with the problem on their own. This leads to indiscriminate disposal of waste in surface drains, canals and streams, creating unsanitary and unsightly environments in many parts of the urban cities in Ghana (Danso, 2011).

Generally, conditions of waste disposal in Ghana are similar to those in many developing countries within the tropical climates. The majority of landfills in Ghana are open dumps even though these are strongly discouraged in the national sanitation policy. The methods for solid waste disposal in Ghana are: uncontrolled dumping of refuse controlled dumping, sanitary land filling, composting, and incineration (Danso, 2011).

2.7.2 Environmental issues

The decomposition of waste into constituent chemicals is a common source of local environmental pollution. This problem is especially acute in developing nations; very few existing landfills in the world's poorest countries would meet environmental standards accepted in industrialized nations, and with limited budgets there are likely to be few sites rigorously evaluated prior to use in the future (Zerbock, 2003).In the absence of proper methane venting and/or flaring, the gas seeps into porous soil surrounding the waste and eventually migrates into basements and homes, posing an explosion risk. Carbon dioxide is a second predominant gas emitted by landfills; although less reactive, buildup in nearby homes could be a cause of asphyxiation (Zerbock, 2003).

There are some human health risks associated with solid waste handling and disposal in all countries to some degree, but certain problems are more acute and widespread in underdeveloped

nations. Cointreau (1982) has classified these into four main categories: 1) presence of human fecal matter, 2) presence of potentially hazardous industrial waste, 3) the decomposition of solids into constituent chemicals which contaminate air and water systems, and 4) the air pollution caused by consistently burning dumps and methane release.

Human fecal matter is present in every solid waste system; in developing nations the problem varies with the prevalence of adequate sanitary disposal systems such as municipal sewerage or on-site septic systems, outhouses, etc (Zerbock, 2003). In areas where such facilities are lacking (especially shanty towns and over-crowded municipal districts), the amount of human fecal matter present in the solid waste stream is likely to be higher (Zerbock, 2003).

The usual disease pathways include placing contaminated hands in the mouth or eating food, through vector insects such as cockroaches or mosquitoes, or by directly inhaling airborne dust particles contaminated with pollutants (Zerbock, 2003)

Among the common weaknesses in existing institutional systems are untrained staff, poor pay scales, the lack of incentives to do a good job, and corruption. Related to these are two key problem areas, namely inadequate supervision of workers and inadequate maintenance of facilities. In industrialized countries, one would expect one supervisor for every five to seven collection vehicles, whereas one per 10-30 vehicles is more common in Africa. In addition, supervisors in Africa often have no means of moving about within their service area, so that effective supervision is very difficult.

2.8 WASTE MANAGEMENT CHALLENGES IN THE BANTAMA SUB-METROPOLIS

The current solid waste management practice within Bantama-Sub-Metropolis is highly dissatisfied by residents and has to be investigated. The situation ranges from delayed in collection of skips with refuse overflowing for several weeks to the pile of solid waste left uncollected for several years as may be seen in the pictures below, field Survey, 2012.

Fig. 1Solid waste storage and disposal challenges at Mpatasie

Source: Field Survey, 2012

Fig. 2 Solid waste disposal challenge at Atafoa

Source: Field Survey, 2012

Fig. 3 Solid waste storage challenges at Ampabame

Source: Field Survey, 2012

CHAPTER THREE

METHODOLOGY

3.1 THE STUDY AREA

3.1.1 Location and Size

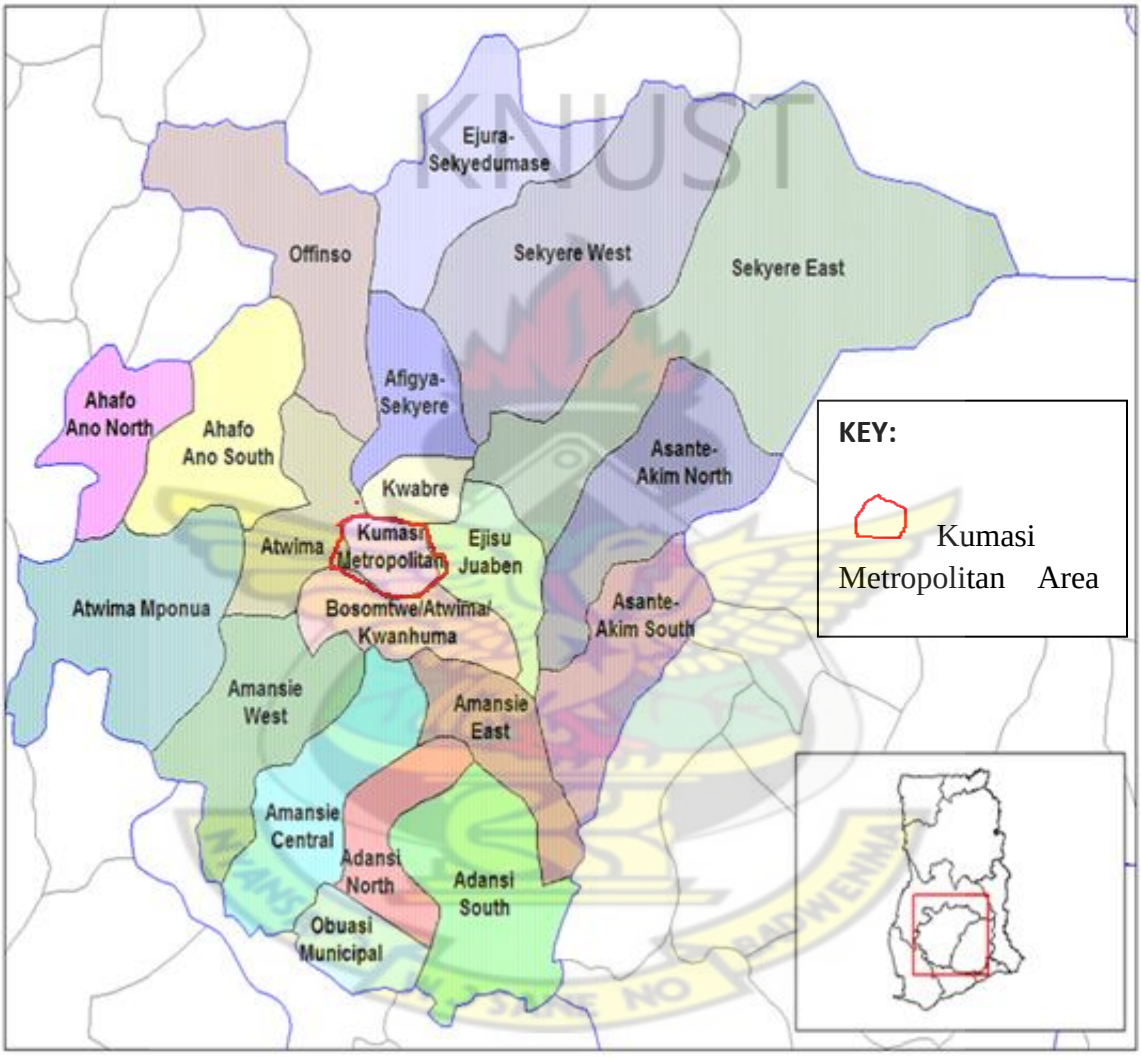

Fig. 4 Map of Ashanti Region Showing District of Ashanti

Source:Town and Country Planning, 2013

The study was conducted in the Bantama Sub-Metro in the Kumasi metropolis, the second largest city in Ghana. Kumasi is the capital of Ashanti Region one of the fastest growing cities in Ghana with an estimated population of 4,780380 (Ghana Statistical Service, 2010). Kumasi is also known as the Garden City of Ghana, located in the transitional forest zone and is about 270 km north of the national capital. The economic activities in the metropolis are grouped in to three- the agricultural sector, the industrial sector and the services sector. The city lies between latitude $6^{0}\ 35^{1} - 6^{0}\ 40^{1}$ N and longitude $1^{0}\ 30^{1} - 1^{0}\ 35^{1}$ W. The elevation ranges between 250 and 300 m above sea level with an area of about 254 km^{2}. The average minimum temperature of Kumasi is about 21.5^{o}C and a maximum average temperature of 30.7^{o}C. The average humidity is about 84.16% at 0900 GMT and 60% at 1500 GMT (Town and Country Planning, Kumasi).

3.1.2 Household Characteristics

Table 3 Average Household Sizes in Kumasi

Kumasi Metropolitan Area	**Average Household Size**
Kwadaso	4.0
Nhyiaeso	3.8
Subin	3.5
Asokwa (Atonso)	3.8
Oforikrom	3.9
Asawase	4.1
Manhyia	3.6
Old Tafo	3.9
Suame	3.8
Bantama	3.8
Average	**3.82**

Source: Ghana Statistical Service, 2010

The average household size in Bantama Sub-Metro is 3.8 persons. The average household size in the Kumasi Metropolis is 3.8. The average number of persons per house is 3.4 as shown in Table 3 above. This relatively large number of persons per house is due largely to the large population in the metropolis. Children constitute 34.0%, the largest proportion of household members in the metropolis. Several factors may account for this high proportion of children of household heads.

Other relatives form the second largest proportion of the population in households in the metropolis constituting between 12.9% and 43.3%. The high proportion of other relatives in

households in the metropolis is attributable to a number of socio-economic factors. The urban setting attracts people to come and stay with relatives whilst actively searching for jobs or their own dwelling units.

3.2 DATA COLLECTION

The two main sources of data obtained for the study were primary and secondary sources.

3.2.1 Primary Data Collection

Primary data were collected through field study, questionnaire survey and face- to-face interviews.

3.2.1.1 Field Study

A field study was carried out in the selected areas of study. In the process, the number of skips in each of the selected areas were counted, the capacity of skips used, the number of days a skip takes to get full and the frequency at which these skips were emptied by the service providers (solid waste collecting institutions within the Metropolis). The distance between skips and human habitats were measured. The field observation involved scouting through the study area to assess the following:

- Communal waste collection points
- Communal waste collection skips

This process gave a general overview of the solid waste management challenges in the Bantama Sub-Metropolis. This guided the formulation of questionnaire survey and interview schedule. Informal contacts were made with KMA - Waste Management Department (WMD) and service providers to gather information relevant for the study.

3.2.1.2 Questionnaire Survey

General information on solid waste management challenges in Bantama Sub-Metro was gathered through questionnaire survey. Data were collected on variables including the following:

- Volume of solid waste evacuated to landfill site in the Bantama Sub-Metropolis
- The avenues for collection and disposal of solid waste generated in the study area.
- Stakeholders challenges in solid waste management in the study area,
- Residents' willingness to pay for waste collection services provided by the service providers.

3.2.1.3 Face-to-face Interviews

Face-to-face interviews were conducted to collect data from the following key stakeholders as far as solid waste management challenges were concerned.

- Kumasi Metropolitan Assembly- Waste Management Department (WMD),
- Solid waste collection companies in the Sub-Metro,
- Transfer station attendants, and
- Residents in the study area.

3.2.2 Secondary Data

A desk study was used to collect data from both local and international sources that were relevant to solid waste management challenges in the Bantama Sub-Metro, Kumasi. It included a systematic review of relevant literature of textbooks, national census, institutional and constitutional publications, academic journals, periodicals, workshop resource materials, seminars and conference papers. A review of documents (letters, and progress reports) and

Archival records (Service records, organizational charts, budgets etc.) was also undertaken as the source of secondary data.

A regular search on the Internet was used to identify some relevant secondary data necessary for the study.

3.3 SAMPLING TECHNIQUES

The following sampling techniques were used to select the areas and respondents for the study. These were: cluster, purposive and stratified. The study area was zoned into two clusters namely: High waste generating communities and low waste generating communities (Table 4)

Table 4Waste Generating Communities and Selected Areas of Study

Waste generating communities	Selected areas	Total
High waste generating communities	Bantama, Bohyen and Abrepo	3
Low waste generating Communities	Adoato, Ampabame, Atafoa Mpatasie, Ohwim and Amanfrom	6
Total		**9**

Source: Field Survey, 2013

A purposive sampling technique was used to select nine (9) communities from the two clusters in which only private sector waste collection companies operate for the survey (Table 4). The selected areas were further stratified into high commercial business areas and low commercial business areas. Collection and disposal of solid waste was done by three (3) private waste collection companies. Twenty-one (21) skips were identified under the operation of these companies (Table 5).

Table 5Selected Areas of Study and Number of Skips Selected

High Commercial Business Areas		Low Commercial Business Areas	
Selected areas	**Number of Skips**	**Selected areas**	**Number of Skips**
Batama	9	Mpatasie	1
Bohyen	1	Adoato	3
Abrepo	3	Ampabame	1
		Amanfrom	1
		Atafoa	1
		Ohwim	1
Total 3	**13**	**6**	**8**

Source: Field Survey, 2013

3.3.1 Purposive Sampling

Purposive sampling technique was used to select 600 respondents for the face-to-face interviews and questionnaire. In trying to stick to the objectives of the study, respondents who can answer the research questions best were selected to be enable to achieve the stated objectives. In this case, these key stakeholders (KMA-Waste Management Department, Waste collection Companies, Transfer Station Attendants and Residents) had the adequate knowledge, necessary information and experience on solid waste management in the study area. The types of data collected from each key stakeholder during the face-to-face session are presented in Table below:

Table 6. ESTIMATION OF QUANTITY OF SOLID WASTE EVACUATED AND REVENUE GENERATED PER MONTH IN THE BANTAMA SUB-METRO.

Name of Transfer Station	Vol. and No. of Skip Selected	No. of Skips Emptied / Site / Week	No. of Skips Emptied/ Site / Month	Ave. Cost of Head load /Resident /Dump GH¢	Ave. Rev. of head load /Skip Fill / Month GH¢	Average Cost of Skip Fill /Dump/ Month GH¢	Ave. Profit Margins /Month
Chief Owusu							
North Dump							
Sefa Boakye							
Gulf Park							
Race Course							
Asanteman School							
Wesley College							
Prempeh College							
Adoato Adumanu							
Adoato New Site							
Adoato							
Ampabame							
Bohyen							
Abrepo Town							
Abrepo Pentecost							
Kumasi Girls							
Mpatasie							
Atafoa							
Ohwim							
Amanfrom							
Total							

C. Avenues for Solid Waste Collection in Bantama Sub-Metro

1. Name of solid waste collection company …….

2. Name of coverage area …….

3. Methods of collection from different sources

☐ House to House collection ☐ Communal collection using transfer stations

☐ Others (Specify)……..

4. How many vehicles do you use in collecting waste in the catchments area…….

5. Are they approved routes by KMA to be used by these vehicles?

☐ Yes ☐ No

6.If yes, indicate the specific routes the vehicles use from the collection points to the final disposal site

……

7. How many of the transfer stations are within your catchments area?

……

8. From the transfer stations where do you send the waste?

☐ Recycling centre ☐ Energy/Compost recovery centre ☐ Incinerations Plants

☐ Landfill centre

9. Does your company have a recycling unit?

Yes ☐ No ☐

10. If No where do you dump your waste?

☐ KMA landfill sites others ☐ (Specify them)……..

D. Challenges faced by Stakeholders in Solid Waste Management.

11.State the main challenges faced by each of the stakeholders in managing solid waste in Bantama Sub-Metro, Kumasi with respect to the following; **storage, collection, transport, and administration.**

1. Challenges faced by KMA

……..

.....

……

……

2. Challenges faced by Service Providers

……

……..

……

3. Challenges faced by Transfer Stations Attendants

……

……

4. Challenges faced by Residents

……..

……

E. Residents Willingness to Pay for the Services Provided by the Service Providers

12. Do you pay as you dump your waste generated?

☐ Yes ☐ No

13. How much do you pay as you dump your waste?

☐ 0.1 – 0.5 GH₵ ☐ 0.6 – 1.0 GH₵ ☐ others specify ……..

14. Are you satisfied with the operation of KMA in solid waste management in your area?

☐ Yes ☐ No

15 If yes, state any two reasons?

……

16. If no, state any two reasons

……

17.What are your recommendations to promote effective solid waste management in your area?

……

Purposive sampling technique was used to select the areas in which the service providers operate. Random sampling was used to select nine (9) communities from the operational areas of the private service providers. From each collection point, data on skips evacuation were collected on weekly basis for four (4) continuous weeks at each collection point. The random sampling method was used to select twenty-one (21) skips from the selected areas within the Bantama Sub-Metropolis for the assessment of the volume of waste evacuated to landfill site, avenues for

waste collection, stakeholders' challenges faced in solid waste management and resident's willingness to pay for services provided by service providers.

3.4 DATA ANALYSIS

The quantitative data collected were analyzed using SPSS (Statistical Package for Social Science) to generate statistical tables and figures for interpretation and discussion. Data analyses were further disaggregated into volume of waste generated in the areas, avenue for collection, stakeholder's challenges and resident's willingness to pay for service provided in the Metropolis.

CHAPTER FOUR

RESULTS

4.1 Socio-Demographic Characteristics of Respondents

4.1.1 Sex of Respondents

The result of respondents sample for the study was 600. Out of 600 respondents, 246 were males representing 41% whilst 354 were females representing 59% of the respondents.

4.1.2 Age of Respondents

The age of respondents for the study is shown in Table 7.The largest (240) respondents representing 40.0% were above 31 years, while 232 of respondents representing 38.67% were between 11-20 years, 122 of them (20.33%) were between 21-30 years whiles only 1% of them were 10 years and below.

Table 7 Ages of respondents

Ages of respondents	Frequency	Percentage
0 - 10 years	6	1.00
11 – 20 years	232	38.67
21 – 30 years	122	20.33
31 and above	240	40.00
Total	**600**	**100**

4.1.3 Educational Level of Respondents

The educational level of respondents is shown in Fig 5 below. It was observed that 43 of them had no formal education (no school), 240 have basic education, 278 of them have secondary education and only 39 of them have been educated up to tertiary level.

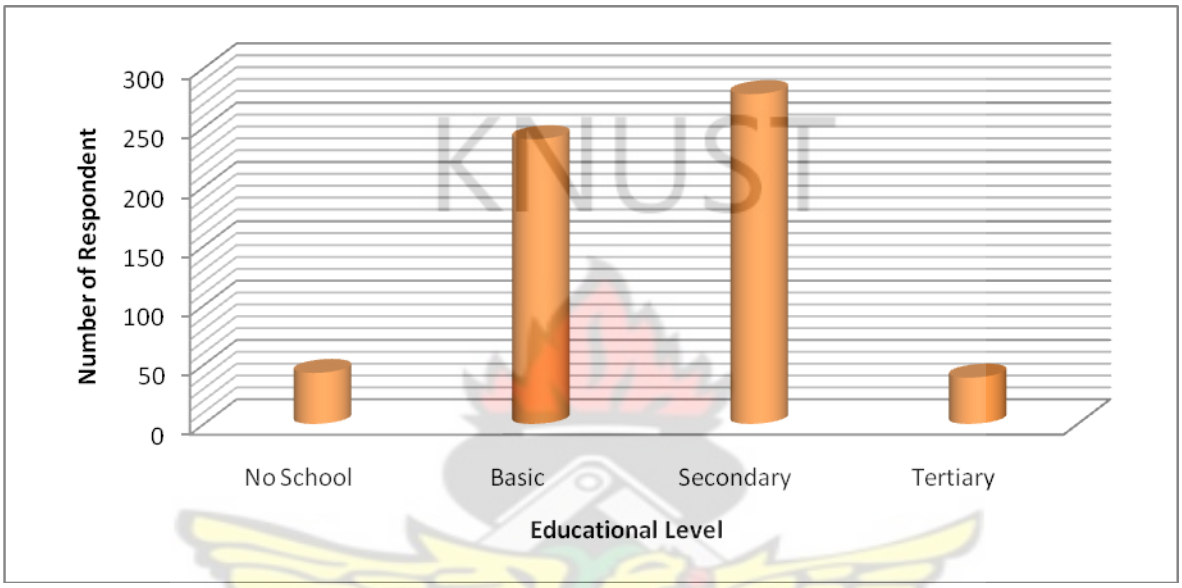

Fig. 5 Educational levels of Respondents

4.1.4 Employment Status of Respondents

Employment status of respondents indicates that 193 of respondents were self employed accounting for 32.16% of the respondents, whilst 95 of them were employed constitute 15.84%, only 56 of them were unemployed representing 9.33% and 256 of them were students accounting for 42.67%. More than 50% of the respondents do not earn any income because they were either students or unemployed (Table 8).

Table 8 Employment status of respondents

Employment status of respondents	Frequency	Percentage
Self employed	193	32.16
Employed	95	15.84
Unemployed	56	9.33
Pupil/Student	256	42.67
Total	**600**	**100**

4.1.5 Living Standard of Respondents

From the questionnaire, 203 of respondents constituting 33.83% were of middle income status while 397 of them representing 66.17% indicated low income and none of the respondents belonged to the high income group.

4.1.6 Household Size of Respondents

Data from the questionnaire revealed that 373 of respondents (62.17%) have household size between 1–5, 204 of them (34%) have between 6 and 10 in each household whilst 23 of the respondents (3.83%) have household size above 10 (Fig. 6).

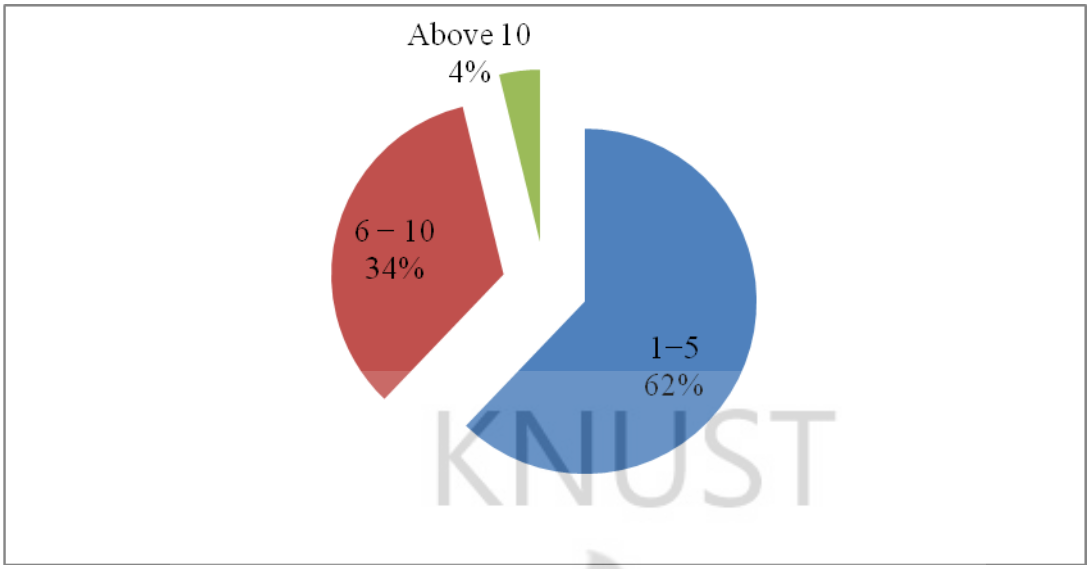

Fig. 6 Household sizes of respondents

4.2.0 Estimation of Solid Waste Quantities Evacuated to Landfill Site per Month in Bantama Sub-Metropolis.

4.2.1 Communities and Number of Skips Selected

Table 9 below shows communities and number of skips selected for the study. Purposively, 21 skips were selected for the study. The largest number of skips (9) was selected from Bantama, whilst 3 skips each were selected from both Adoato and Abrepo; 1 skip each was selected from Ampabame, Bohyen, Mpatasie, Atafoa, Ohwim and Amanfrom.

Table 9 Number of skips in the sub-metropolis

Selected Communities	Number of Skips	Selected Skips
Bantama	9	9
Adoato	3	3
Ampabame	1	1
Bohyen	1	1
Abrepo	3	3
Mpatasie	1	1
Atafoa	1	1
Ohwim	1	1
Amanfrom	1	1
Total	**21**	**21**

4.2.2 Volume of Skips Selected and Number of Skips Emptied in a Week

Data from the questionnaire administered revealed that total number of skips identified in the selected communities was twenty-one (21) and the volume of each skip was 12 m^3. Total volume of skips was 252 m^3. Largest combined volume of skips (108 m^3) was identified at Bantama, while the least volume of skip (12 m^3) was identified in Ampabame, Bohyen, Mpatasie, Atafoa, Ohwim and Amanfrom.

Again, data on skips emptied at site per week per month revealed that Bantama recorded the largest number of skips, 6 and 25 respectively while Atafoa recorded the least number 1 and 2,respectively. The total number of skips emptied at site per week per month was 21 and 82 respectively (Table 10)

Table 10 Number of Skip's Emptied at Site/Week /Month

Community	**No. of Skips Selected**	**Total volume of Skips (m^3)**	**No. of Skips Emptied at Site / Week**	**/ Month**
Bantama	9	$108m^3$	6	25
Adoato	3	$36m^3$	4	14
Ampabame	1	$12m^3$	2	8
Bohyen	1	$12m^3$	2	8
Abrepo	3	$36m^3$	3	13
Mpatasie	1	$12m^3$	1	4
Atafoa	1	$12m^3$	1	2
Ohwim	1	$12m^3$	1	4
Amanfrom	1	$12m^3$	1	4
Total	**21**	**$252m^3$**	**21**	**82**

4.2.3 Volume of Waste Evacuated to Landfill Site in Bantama Sub-Metro

The largest volume of waste per week was recorded at Bantama (72 m^3) and per month was 300 m^3. The least volume of waste per week was recorded at Atafoa as 12 m^3 and per month as 48 m^3. The total volume of waste recorded in week in all the communities was 252 m^3 and for 1 month it was 984 m^3 (Table 11).

Table 11Volume (m^3) of Waste Evacuated/Week /Month in Bantama Sub-Metropolis

Community	**No. of Skips Emptied at Site**		**Vol. of Waste Evacuated (m^3)from Community to Landfill Site**	
	/ Week	**/ Month**	**/ Week**	**/ Month**
Bantama	6	25	72	300
Adoato	4	14	48	168
Ampabame	2	8	24	96
Bohyen	2	8	24	96
Abrepo	3	13	36	156
Mpatasie	1	4	12	48
Atafoa	1	2	12	24
Ohwim	1	4	12	48
Amanfrom	1	4	12	48
Total	**21**	**82**	**252**	**984**

Source: Field Data, 2013

4.2.4 Cost of Head load at Dump per Residents

It was observed from the study that 312 of respondents representing 52% indicated that they pay 5 Gp and below per head load per dump whiles 258 of them amounting to 43% paid between 0.6 – 1.0 GH₵ per head load per dump. Only 30 of them representing 5% indicated 1.0 GH₵ and above per head load per dump.

4.2.5 Average Revenue per Skips at Site

The largest amount (GH₵ 2,900.00) generated per skip filled per month was recorded at Bantama whilst the least (GH₵360.00) revenue was recorded at Atafoa. The average revenue generated per skips filled per month in all the communities was GH₵ 13, 947.00.

It was also observed that maximum cost of skips per dump per month was recorded at Adoato while the least cost per dump per month was recorded at Atafoa. The sum of skips emptied per week in all the communities was 21, (per month) 85. Average cost of skips per dump at a site was GH₵ 1,111.00, GH₵ 2,376.00 per week and GH₵9,185.00 for the month, Table 12

Table 12 Average revenue per skips fills per week per month and average cost per dump at site per week per month

Community	Average Revenue (GH¢)			Average Cost of Skips (GH₵)		
	/Skip Fill	/Week	/Month	/Emptied at a Site	/Week	/ Month
Bantama	116	696	2,900	71	426	1,775
Adoato	187	748	2,618	130	520	1,820
Ampabame	185	370	1,480	130	260	1.040
Bohyen	200	400	1600	130	260	1.040
Abrepo	213	639	2,769	130	390	1,690
Mpatasie	190	190	760	130	130	520
Atafoa	180	180	360	130	130	260
Ohwim	185	185	740	130	130	520
Amanfrom	180	180	720	130	130	520
Total	**1,629**	**3,567**	**13,947**	**1,111**	**2,376**	**9,185**

4.2.6 Profit Margins (Monthly) of Waste Collection Companies

The largest profit (GH₵ 1,125.00) was recorded at Abrepo with total evacuated skips of 13, whilst the least (GH₵ 100.00) was recorded at Atafoa with total evacuated skips of 2. Total profit margin (monthly) in all the communities was GH₵ 4,651.00(Fig. 7).

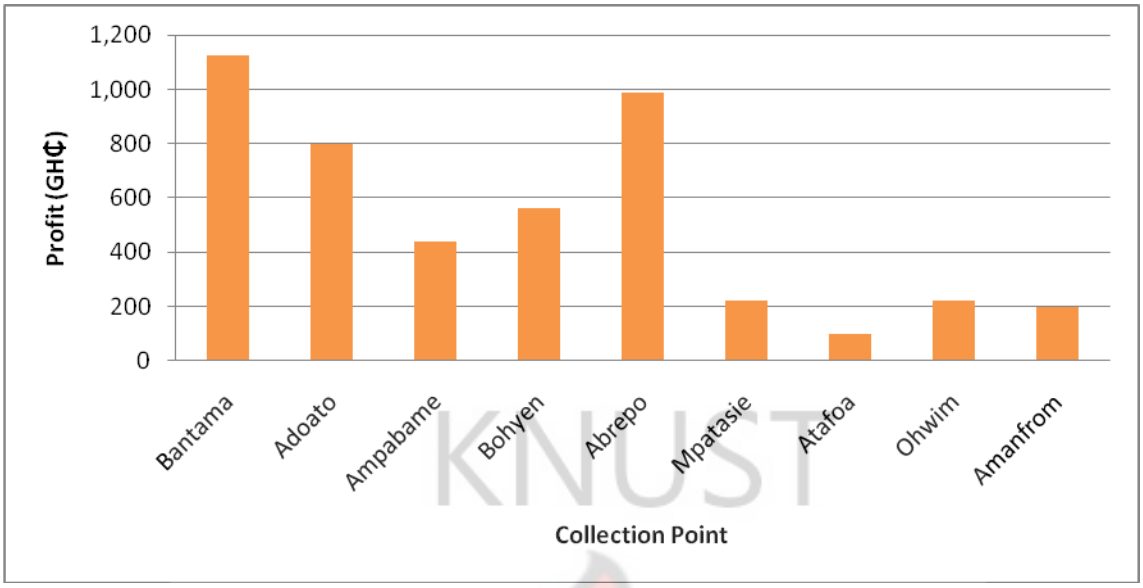

Fig. 7 Profit margins (monthly) of waste collection companies

4.3 Avenue for Solid Waste Collection in Bantama Sub-Metropolis

4.3.1 Solid Waste Collection Companies

The waste management companies operating within the Bantama Sub-Metro are Asadu Royal waste company which covers 52% of the communities and Ve-Mark and Meskworld waste companies which covers 24% each of the communities.

.

4.3.2 Method of Solid Waste Collection

Data from the questionnaire administered revealed that the common collection method used by the companies in their operations was communal collection using transfer station.

4.3.3 Number of Vehicles Used by Waste Collection Companies

Results obtained from the study indicate that the total operational vehicles used by the companies were 4. Out of the 4, Asadu Royal waste collection company has two (2) vehicles for its

operations whilst Ve-Mark and Meskworld waste collection companies have one (1) vehicle each.

4.3.4 Routes Used by Waste Collection Companies for Disposal of Waste

It was observed from the study that KMA has no specific routes to be used by the waste collection companies for disposal of solid waste collected from the transfer stations to KMA landfill site for disposal. However, route to be used for disposal of waste were determine by the companies to enable them minimize transport cost.

4.3.5 Solid Waste from Source of Generation to Transfer Station and finally to Landfill Site

Waste from source of generation is sent to transfer station using tricycle, wheelbarrow and by hand/head load. At the transfer station, waste was stored in skips till it gets full and only vehicles were used for its evacuation to final disposal site. In Fig. 8 below, dark blue arrows represent the tricycle, wheelbarrow, hand load / head load for caring waste from households to transfer station. The three (3) deep green arrows indicate vehicles moving from transfer station to landfill site

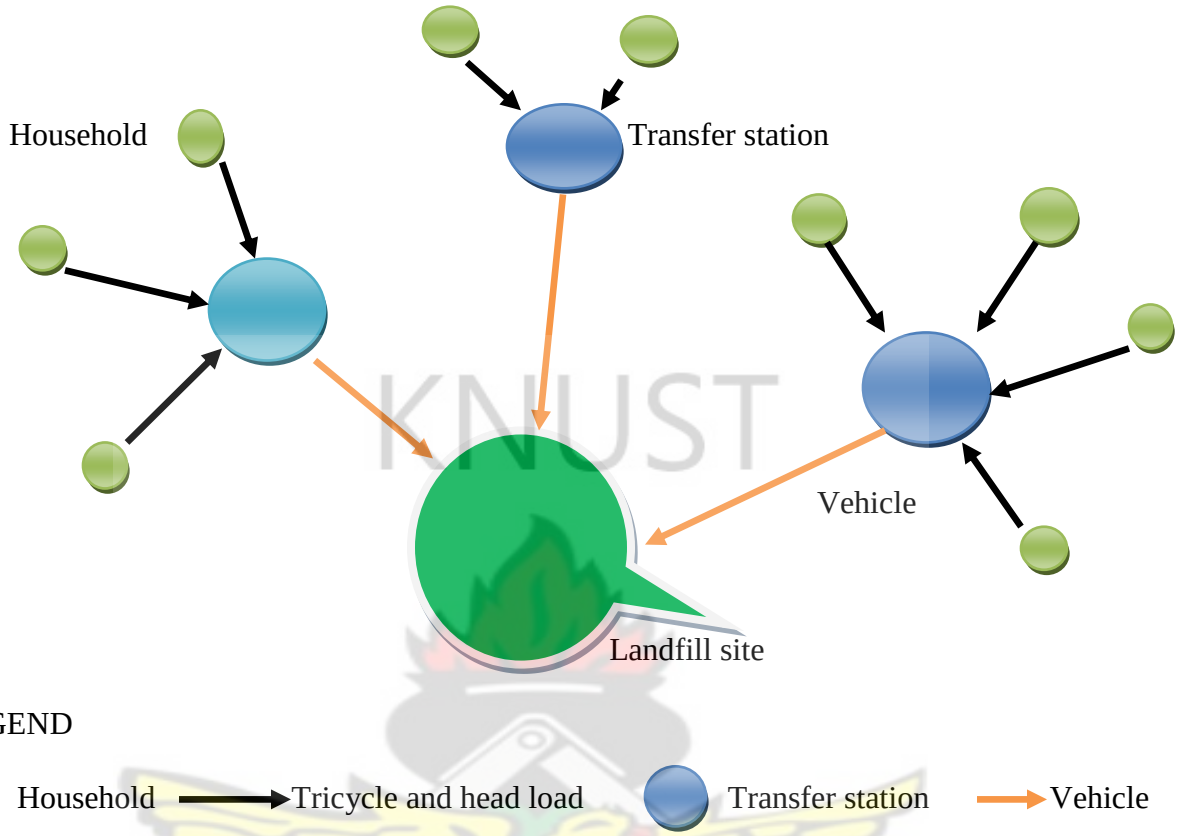

Fig. 8 Flow of waste from source of generation to transfer stationsand finally to landfill site

4.3.6 Waste Collection Companies and Number of Transfer Stations in its Catchment Area

The study revealed that there were 20 transfer stations allocated to waste collecting companies in the Bantama Sub-Metropolis. Meskworld waste collection company has five (5) transfer stations within its catchment area, while Asadu Royal waste collection company has eleven (11) transfer stations in its operational area and Ve-Mark waste collection company has only four (4) transfer stations in its catchment area.

4.3.6 Recycling Unit

Result obtained from the questionnaire administered indicates that all the solid waste collection

companies operating in the study area have no recycling unit. Waste collected was transported to KMA landfill site at Dompoase.

4.4 Challenges in the Waste Management Process

Stakeholders involved in solid waste management at Bantama Sub-Metropolis were identified. These include KMA-waste management department, service providers (Private institutions), transfer station attendants and residents in solid waste management. A number of challenges faced by each of them were discussed below;

4.4.1 Challenges faced by KMA

From the data gathered, challenges faced by KMA-Waste Management Department include regular vehicle breakdown, inadequate waste collection vehicles, high volume of waste generated, lack of funds, lack of continuity between planning circle, lack of interdepartmental waste management coordination, insufficient budget allocation for landfill operations, small containers, height of containers and unsanitary transfer stations.

With respect to collection and transport of solid waste, 64.71% indicated vehicle breakdown, inadequate vehicles (11.76%) and large volume of waste (23.53%).

In the issue of storage of solid waste, small container (52.94%), container height (29.41%) and unsanitary transfer station (17.65%).

In disposal of solid waste the data also revealed that highest number (8) of the respondents indicated inadequate landfill site, whilst 6 of them indicated encroachment, and only 3 of the respondents indicated picking at the landfill site.

On the part of administration, lack of funds (8), lack of continuity between planning cycles (4), lack of interdepartmental waste management coordination and insufficient budget allocation for landfill operations (Table 13).

Table 13 Administrative challenges faced by KMA

Administrative challenges	Frequency	Percentage
Lack of funds	8	47.06
Lack of continuity between planning cycle	4	23.53
Lack of interdepartmental waste management coordination	3	17.65
Insufficient budget allocation for landfill operations	2	11.76
Total	**17**	**100**

4.4.2 Challenges faced by Service Providers

Again, it emerged from the study that service providers faced a number of challenges. These include vehicle breakdown, high volume of waste, transport cost, vehicle wear and tear at landfill site, lack of funds, lack of continuity between planning cycle, tender specifications not matching demand for service and lack of accurate waste data.

In collecting and transporting of solid waste, seven (7) respondents representing 41.18%, indicated vehicle breakdown, while periodic high volume of solid waste (5) constitute 29.41%, high transport cost 23.53% and vehicle wear and tear at landfill site 5.88%.

With respect to waste disposal, traffic congestion at landfill site as a result of compactor breakdown was 58.82%, lack of landfill rehabilitation due to funds 29.41%, whilst 11.76% said air pollution as a result of decomposition of organic waste material (Table 14).

Table 14 Service provider's challenges with respect to disposal of waste

Waste disposal challenges	**Frequency**	**Percentages**
Traffic congestion at landfill site	10	58.82
Air pollution	2	11.76
Lack of landfill rehabilitation	5	29.42
Total	**17**	**100**

Administratively, eight (8) of the respondents representing 47.06% indicated lack of funds to provide service, whilst 4 of them constituting 23.53% indicated lack of continuity between planning cycle, 3 of them constitute 17.65% indicated tender specification not matching demand for service and 11.76% of the respondents indicated lack of accurate waste data.

4.4.3 Challenges faced by Transfer Station Attendant's

The study further revealed that transfer station attendant's challenges include small containers, height of containers, air pollution and lack of logistics.

In the case of solid waste storage, Fig. 9 below shows 350 of respondents (58.33%) indicated small container whilst 125 of them (25%) indicated container height making it inaccessible by children and 100 of them representing 16.67% indicated air pollution.

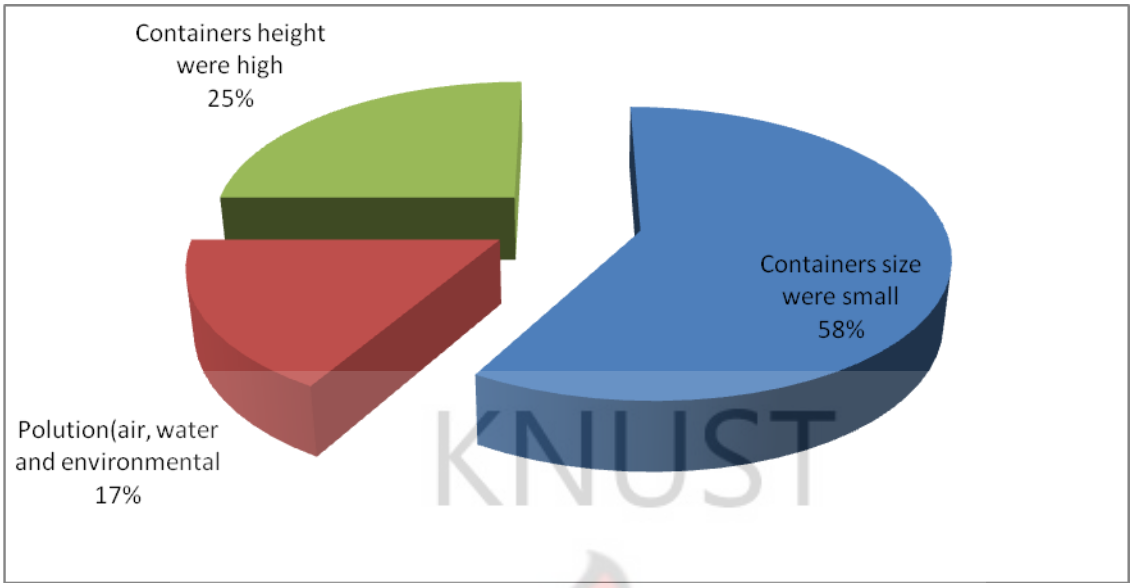

Fig. 9 Challenges faced by transfer station attendants on storage of waste

On the issue of collection of solid waste, it was found in Table 15that 320 of respondents constitute 53.33% indicated small container while 180 of them representing 30.00% indicated container height and 100 of the respondents constitute 16.67% indicated lack of logistics for transfer station attendants.

Table 15 Challenges faced by transfer station attendant's on collection of waste

Collection challenges	**Frequency**	**Percentage**
Lack of logistics	100	16.67
Container height	180	30.00
Small container	320	53.33
Total	**600**	**100**

4.4.4 Challenges faced by Residents

The main challenges facedby residents in terms of storage of waste at the source of generation and transporting waste from source of generation to the nearby transfer stations from the study include high cost of receptacles, lack of storage receptacles at point of generation of solid waste, receptacles not durable, lack of easily accessible skip and air pollution.

In storage of waste, 46.67% of the respondents indicated high cost of container whilst 28.33% indicated lack of receptacles at points of generation of waste, and 25% of them indicated that the receptacles were not durable for storage of waste.

With respect to disposal of solid waste, it was revealed that majority (70%) of the respondents indicated lack of easily accessible skips whilst 30% of the respondents indicated air pollution. Transfer stations like Sefa Boakye, Atafoa and Mpatasie were seen with piled of solid waste left uncollected for months at the time of study. Residents around those transfer stations suffer mostly from air pollution as a result of decomposition of organic materials.

4.5 Residents Willingness to Pay for the Service Provided by the Service Providers

On the issue of resident's willingness to pay for the service provided, the study revealed that 96% of respondents paid as they dump their waste while only 4% of them did not pay.

The study further revealed that 44.45% of the respondents pay between Gp 0.60 andGH₵1.0 as they dump their waste whilst 39.45% of them pay below Gp 50.0, only 16.30% of the respondents said they pay more than GH₵ 1.0.

It was also observed that majority (62.95%) of the respondents indicated that they were not satisfied with KMA's operations in solid waste management while 37.05% of them indicated

their satisfaction of KMA's operations in solid waste management in the Bantama Sub-Metropolis.

The respondents who indicated their dissatisfaction with KMA's operations on Solid Waste Management in the Bantama Sub-Metropolis gave the following reasons:

1. Overflowing containers.
2. Unsanitary transfer stations.
3. Inadequate awareness creation on pay as you dumps policy.
4. Inaccessibility to skips by residents for dumping their waste in most of transfer stations.
5. Periodic failure in service delivery and
6. Lack of customer care.

The other respondents who indicated their satisfaction of KMA's operation on solid waste management in the study area advanced the following reasons:

1. Regular collection of skips, and
2. Sufficient skips at each transfer station making storage and evacuation consistent.

CHAPTER FIVE

DISCUSSION

5.1 Socio-demographic Characteristics of Respondent

This focused mainly on respondent's sex, age, household size, educational level, employment status and living status. The result obtained was based on a sample of 600 completed questionnaires. The sample is made up of 246 males representing 41.0% of the respondents and 354 females, representing 59.0% of the respondents. The large percentage of female respondents was due to the fact that females are mostly responsible for household chores such as cleaning of the homes, fetching of water, cooking and disposal of waste.

The lowest age of respondents for the sample was below 10 years whilst the highest was above 31 years. Respondents within the age group of 31 to61years were responsible for disposing their household waste generated.

In terms of education, 7.17% of the respondents had no formal education, about 40.0% of the respondents had basic education, 46.33% had secondary education and 6.50% of the respondents had been educated up to tertiary level. Formal education generally sensitizes people on environmental hygiene and the dangers of improper waste disposal.

With regard to employment status of respondents, 48.0% of them were employed whilst 52.0% of the respondents were unemployed. Those employed, many were business men and women and their activities contribute to the large volume of domestic waste generated. The result of the study indicated that high domestic activities in the study area contribute to large volume of solid waste generation. This attest to the assertion made by Kerala ENVIS Centre (2009) which stated that generation of waste is mainly influenced by both industrial and domestic activities.

In the case of living standard of respondents, 33.83% are within the middle income status while 66.17% of the respondents are in the low-income status and none of the respondents belonged to the high income group.

Majority (66.17%) of respondents is within the low-income status and the waste generated was mostly of organics; this confirms what Mizpah *et al.* (2009) indicated. According to Mizpah *et al.* (2009), the composition of solid waste in the Kumasi city is predominantly made of biodegradable materials and large percentage of inert materials which include wood ash, sand and charcoal.

With respect to household size, 62.17% of the respondents have household size of 1-5, 34.0% of the respondents are within the household size of 6-10 members and 3.83% of the respondents have household size 11 and above. The large percentage of the household size 1-5 and 6-10 emphasized the fact that the Ghanaian population is increasing in recent times and this explains why the generation in the city is expected to increase by 15% by the year 2010 (KMA-WMD, 2008).

5.2 Estimation of Quantity of Solid Waste Evacuated to Landfill Site in the Bantama Sub-Metro

To estimate the quantity of solid waste evacuated in month in the Bantama Sub-Metro, factors considered were the number of skips available, volume of skips and collection frequency.

Twenty-one (21) skips were identified in the Sub-Metropolis. Out of that number, 9 of them were selected from Bantama, 3 of them each were taken from Adoato and Abrepo while 1 skip each was taken from Ampabame, Bohyen, Mpatasie, Atafoa, Ohwim and Amanfrom. The large number of skips in communities like Bantama, Adoato and Abrepo wasdue to high domestic and

commercial activities in those areas. These activities result in generation of waste mainly from food preparation, sweeping, discarded household items as reported by Poku (2009),in which he described solid waste as domestic waste from food preparation, sweeping, discarded household items or municipal waste (waste generated in commercial centers).

The volume of skips have already been determined by KMA-WMD and the volume of each skip was estimated to be 12 m^3 (KMA-Waste Management Department, 2013). Nine (9) skips identified in Bantama had a total volume of 108 m^3, Adoato (3) and Abrepo (3) 36 m^3 each and Ampabame (1), Bohyen (1), Mpatasie (1), Atafoa (1), Ohwim (1) and Amanfrom (1) have volume of 12 m^3 each. High number of skips recorded at Bantama suggests that business activities in recent times are on the increase which consequently affect volume of waste generated.

It was observed that the frequency at which skips were emptied at site per week varied from one community to another. The highest number of skips emptied at landfill site per week was recorded at Bantama (6). Adoato (4), Abrepo (3), Ampabame and Bohyen (2) each, Mpatasie, Atafoa, Ohwim and Amanfrom recorded 1 each. The total skips emptied at landfill site per week was 21. It was estimated that the average number of skips emptied at site in each collection point in a week was 1, but in the case of Bantama, the situation was quite different. This was because at the time of study, Sefa Boakye (a transfer station) had no skip at the station; hence residents dump their waste at the station without collection. This posed serious health threat to residents, animals and the environment as stated by Zurbrugg (2002). According to Zurbrugg (2002), the uncontrolled manner in which solid waste is disposed of at open dumpsites creates serious health problems to human, animals and the environment. The situation in Sefa Boakye (a transfer station) in the Bantama commonly confirms the assertion made by Zurbrugg (2002). The average

number of skips emptied at landfill site per week, recorded at Adoato, Ampabame and Bohyen, was 2. This was due to large volume of waste generated as a result of high commercial activities and population increased.

It is estimated that total volume of waste generated in the Sub-Metropolis per week is $252m^3$ by total population size of 260,474 (Ghana Statistical Service, 2010). About 25% of the waste generated were from Bantama (the central business community) whilst the remainder was generated from the other communities within the Sub-Metro.

The wastes generated were mainly obtained from residential and commercial such as stores, restaurants, markets, office buildings, hotels, print shops, auto repairs, medical facilities, institutions and construction – mainly food waste, rubbish, ashes, demolishing and hazardous waste as reported by Tchobanoglous *et al.*(1993). According to United Nations Educational, Scientific and Cultural Organization-Encyclopedia of Life Support System (UNESCO-EOLSS, undated),major factors affecting amount of Municipal Solid Waste (MSW) are population, people's diet, social energy resources structure and living standard. The increase in population is directly proportional to volume of waste generated. Therefore, strategic plans are needed by the Sub-Metro authorities to prevent the situation from getting out of hand in future.

The "Pay as you dump policy" was initiated by the Ministry of Local Government in the middle of 1980's and was aimed at involving the public in the management of solid waste they generated.

On the part of "pay as they dump", it was found that all the households within Bantama Sub-Metropolis pay as they dump their waste generated. The amount paid by resident's ranges from Gp 10- GH₵ 1.0.The study revealed that 52% of the residents pay below 0.50Gp per dump while 43.0% of them pay between 0.60Gp and 1.0 GH₵ per dump; only 5.0% of them pay above GH₵

1.0 per dump. The variation in the amount paid per dump was due to differences in volume of waste generated by households. Absence of weighing machines at the transfer stations to determine the weight of waste leads to unfair determination of amount charged since the station attendant uses his/her own judgment. This results in series of misunderstandings in most of the stations.

The total average revenue recorded in all the communities per skip fill was GH₵ 1,629.00 and per week was GH₵ 3,567.00. The highest revenue (GH₵) per fill was recorded at Bohyen whilst the least was recorded at Bantama. Though, large amount of waste was generated at Bantama due to high commercial business activities, low revenue was recorded. The reason was that waste collected from the streets and government offices by Zoomlion Ghana Ltd is dumped without any payment. Others dumped their waste late in the day when the station attendant seems to have closed for the day. These actions stated above influence the amount of revenue generated by the transfer station attendants at Bantama.

Atafoa recorded the least revenue generated and it was due to skip left uncollected for several weeks at the time of the study. Residents were willing to pay for the services provided by the service providers but containers were left uncollected for weeks. The non-collection of waste affected the amount of revenue generated.

Data gathered further revealed that the lowest (GH₵ 71.00) average cost of container per dump was recorded at Bantama whilst the largest amount (GH₵ 130.00) was recorded at all the other communities. This was due to large quantity of waste dumped by Zoomlion Ghana Ltd (street sweepers) without any payment.

According to KMA-WMD, expected average cost of skip per dump is GH₵ 30.0and average cost per dump per resident is Gp 10.0.In practice, however, these amounts are not realistic since the

private waste contractors claim that revenue generated cannot support their operational cost. The result from the study does not confirm the approved revenue generated from communal collection by KMA.

Profit margin is the difference between the average revenue generated per skip fill and the average cost of skips per dump. This is used to assess the effectiveness of "pay as you dump" policy. Profit made by the attendants at each station varies from one community to another. The highest (GH₵ 1,125.00) profit was recorded at Bantama and the lowest (GH₵ 100.00) profit was recorded at Atafoa. The larger the skip, the higher the volume of waste and revenue obtained from the waste generated.

5.3 Avenuesfor Collection and Disposal of Solid Waste in Bantama Sub-Metropolis

The purpose of a waste collection service is to separate the generated waste from the community for health reasons (Municipal waste management-good practices, undated).

Collection of solid waste in Bantama Sub-Metro has been given to three waste collection companies. The companies include Meskworld waste collection company, Ve-Mark waste collection company and Asadu Royal waste collection company.

These waste collection companies have been given specific areas to operate. Meskworld waste collection company operates only in Bantama whilst Ve-Mark waste collection company operates in Bantama and Abrepo and Asadu Royal waste collection company operates in Adoato, Ampabame, Bohyen, Abrepo, Mpatasie, Atafoa, Ohwim and Amanfrom. Asadu Royal waste collection company has the largest area to operate. The reason was that the company has enough resources to pre-finance its operational cost before the Assembly reimburses them.

The method practiced by the waste collection companies in the Bantama Sub-Metro is communal collection using transfer stations. Waste generated from households is collected at several collection points called transfer stations before it is transported to the final disposal site.

Interestingly, the companies are using only 4 vehicles in their operations. Meskworld waste collection company has only 1 Roll-on roll-off vehicle for its operations. At the time of study, the vehicle was not in good condition resulting in pile of solid waste in most of the transfer stations it covers especially Sefa Boakye (a transfer station in Bantama). This poses serious health threat to humans, animals and the environment as indicated by Moeller, (2005).

Ve-Mark and Meskworld waste companies from the study were found to have the same number and type of vehicles which affected their operations. Asadu Royal Waste Collection Company on the other hand has 2 Roll-on roll-off vehicles used for its operation.

Solid waste collection companies operating in the Bantama Sub-Metro have no specified routes for transport of waste. Waste collected from the transfer stations are transported straight to Dompoase landfill site. Since KMA has no defined routes for transportation of waste, the companies define the shortest routes to use so that it can minimize operational costs. In a study by Hamdu (2009), conducted on improving waste logistics in Kumasi Metropolitan area, it was found that KMA has no define routes for waste transportation. The situation is not different from what is happening in Bantama Sub-Metro.

Twenty (20) transfer stations were identified in all the communities studied in Bantama Sub-Metropolis. Out of the 20, 5 of them have been assigned to Meskworld whilst 11 of them are given to Asadu Royal waste collection company and only 4 of them going to Ve-Mark waste collection Company. According to Mrs. Boateng, (KMA-WMD, PRO) the reason why some

waste collection companies have more transfer stations to operate than the others is due to the differences in their performance.

In spite of large volume of waste generated in Bantama Sub-Metro, waste collected by the companies, are all sent to Dompoase Landfill site because the companies have no recycling unit. The companies explained that they do appreciate the significance of recycling of waste but their current financial standard cannot enable them in the establishment of the recycling unit. Therefore the best option available for them is to send all waste collected to the Landfill site.

5.4 Challenges faced by Stakeholders in Solid Waste Management in Bantama Sub-Metropolis

5.4.1 Challenges faced by KMA

The study identified main challenges faced by KMA in solid waste management in the Bantama Sub-metropolis. These included; frequent vehicle breakdown, inadequate waste collection vehicles, high volume of waste generated, lack of funds, lack of continuity between planning circle, lack of interdepartmental waste management coordination, insufficient budget allocation for landfill operations, small containers, height of containers and insanitary transfer stations.

The frequent breakdown of waste collection vehicles as claimed by the KMA is mainly due to overloading, lack of maintenance and bad road network.KMA waste management department claims that they are willing to put up their maximum best to handle waste generated but the vehicles for hauling of waste were not adequate and its frequent breakdown makes collection of waste difficult. High commercial activities coupled with population increase in recent times has influenced waste generation rate.

KMA waste management department (WMD) disclosed that there are twenty-one (21) skips available to serve 65,517 households at time of the study in the Bantama Sub-Metropolis. Approximately 3,120 households are served by a skip. This is a clear indication that skips available are not adequate to store the volume of waste generated. It was found that a skip takes 4 days to get filled due to high waste generation rate. It is now clear that skips available to store waste generated is small in volume and numbers. It always overflows and left uncollected for some weeks.

Furthermore, the department indicated that their inability to collect all the waste generated from transfer stations was due to poor road network within the Sub-Metro, inadequate waste collection containers and the frequent breakdown of bulldozers and compactor at the landfill site.

Insanitary conditions at most of the transfer stations have the potential to become litter-strewn mini dump sites. In addition to the visual impacts, rodents and vectors are normally associated with these conditions and consequently have negative health impacts.

The waste department further explained that because they have only one engineered landfill site, all the waste generated in the Kumasi Metropolis are sent there making it difficult for them to embark on rehabilitation works. If they do, what it means is that skips will be left uncollected till completion of works.

The main effects of land filling are air pollution from landfill gas. Typically, landfill gas comprises of 50– 55% methane, 40 – 45% carbon dioxide (both of which are green house gases), some hydrogen sulphide and other sulphur compounds. These gases pose health hazard to humans, animals and the environment.

Lack of funds hinders the operations of KMA according to the PRO. Limited municipal budgets results in certain operations being compromised, especially in cases where other priority issues such as housing and sanitation take priority.

She retreated that lack of coordination of efforts by key role players related to waste management (finance, planners, councilors, procurement etc) within a metropolis also hinders progress and achievement of efficient and sustainable waste management in the area.

Apart from the few challenges numerated above, she said that lack of continuity between planning cycles cannot be ignored. This is because political stability and support to planned programmes is critical since the political sphere is the driver of what happens in the metropolis. Where there is no stability, there is a "high staff turn-over"(is the rate at which an employer loses employees) which impedes consistency in service delivery. Furthermore, where there is "no political buy-in", (which means that someone has accepted the idea one proposed and will support it) there will also be less budgetary support, impeding the implementation of planned programmes.

5.4.2 Challenges faced by Service Providers

Service provider's challenges identified from the study included vehicle breakdown, large volume of waste, transport costs, vehicle wear and tear at landfill site, lack of funds, lack of continuity between planning cycle.

They claimed that many of their vehicle breakdowns are symptoms of other problems including old vehicles, poor road conditions, overloading and lack of routine maintenance. The breakdown of their waste collection vehicles result in a pile of waste left uncollected. Delays in evacuation of overflowing skip to landfill site may result in waste being illegally dumped. This is especially the case in situations where transfer stations are considered too far away.

Large volumes of solid waste generated as a result of increase in domestic waste and waste generated in commercial centers is affecting collection frequency by the service providers. To maintain excellent service, vehicles are overloaded which lead to frequent breakdown.

Transport of waste was found to be an expensive aspect of providing waste management services in the Sub-metropolis. This is because there is no specified route for service providers to enhance transportation of waste to landfill site. Motor traffic on roads reduce solid waste evacuation frequency and leads to overloading which consequently breakdown their vehicles. Cost of maintenance and traffic congestion affects their efficiency. Yet, they struggle to meet their contractual mandate of providing at least a weekly waste collection service to all communities. Due to the bad nature of the road leading to the landfill site, the rate of wear and tear of vehicles is at a higher rate, which consequently affects waste collection companies operations.

The delay in payment of subsidies by government through KMA to the companies to run their operations is due to limited funds. This result in waste left uncollected for several weeks. Meskworld and Ve-Mark companies were found using a vehicle each for their operations at the time of study due to lack of funds to embark on routine maintenance.

Lack of continuity between planning cycle was another challenged identified and it has been discussed as a challenge faced by the KMA.

5.4.3 Challenges faced by Transfer Station Attendant's

Main challenges faced by transfer station attendants from the study include small containers, height of containers, air pollution and lack of logistics. Waste deposited at transfer stations in most of the communities were more than the volume of the skip provided. This was manifested in communities where the skips were seen overflowing with solid waste and waste pile around

the skips if not collected when collection of skip is due. Insults are mostly rewarded to station attendants by residents for service not matching the demand.

Due to the height of the skip, children find it difficult to dump waste. In the absence of station attendants to assist them to dump into the skip, the best alternative for them is to throw their on the ground. Waste deposited in the skip at the station consists mainly of organic, paper, plastic, glass, wood and textile. When left uncollected for more than a week, organic components begin to decompose hence polluting the air. Polluted air poses health risk to humans and animals living around.

Lack of logistics is another challenge faced by transfer station attendant's since it influence their operations. Many of the transfer station attendants at post work without appropriate logistics. Few who work with prescribed logistics purchased them by themselves.

5.4.4 Challenges faced by Residents

Numerous challenges faced by residents in the management of solid waste in the Bantama Sub-Metropolis include high cost of receptacles, lack of storage receptacles at point of generations of solid waste, receptacles not durable, lack of easily accessible skip and air pollution.

It was found that waste generated at source by residents is stored in receptacles before it is transported to transfer stations for final disposal. Most (47.0%) of them claim that due to high cost of receptacles, waste is mostly stored in polyethene bags (carriage bags) before it is transported to transfer station for disposal. This has given others the opportunity to embark on illegal dumping which is common in Mpatasie, Atafoa, Ohwim and Amanfrom. Polythene bags are non-biodegradable materials and high use of it today, is posing environmental threat.

Most (28.0%) do not have waste receptacles to store their waste generated, especially the indigent households who cannot afford to purchase durable receptacles for themselves. This lack of receptacle has resulted in littering and illegal dumping especially in gutters as people seek to clear their households of the accumulated waste.

Lack of easily accessible skips in most of the community's enable some residents dispose off their waste generated illegally. This is due to long distances between source of generation and the nearest skip.

Residents also claim that the delay in evacuation of skips results in decomposition of organic matter among the waste generated. This contaminates the air. It is worst when skip is left uncollected for some weeks and transporting from transfer station to final disposal site. The polluted air poses health threat to humans, animals and the environment.

5.5 Residents Willingness to pay for the Service provided by the Service Providers

From the study, it was found that 96% of them pay for the service provided by the service providers whilst only 4% of them did not pay for the service. Those who dumped their waste free of charge were the street sweepers (Zoomlion Ghana Ltd), aged and transfer station attendants themselves. Residents confirmed that the amount paid as they dumped their waste ranges between Gp 10.0 and GH₵ 1.0 and above. It was revealed that 44.25%of the residents pay between Gp60.0 – GH₵ 1.0 per waste dump whilst 39.45% of them pay below Gp 50. 0 per waste dump and only 16.30% of them pay above GH₵ 1.0 per waste dump. What in practice is quite different from what KMA-WMD cost recovery schedule for communal collection which was introduced in late 1980's by the Ministry of Local Government.

In the case of KMA's operations on solid waste management in the Bantama Sub-Metropolis, it was observed that majority (62.95%) of the residents are not happy with the KMA's operations due to the following reasons;

1. Containers always overflowed for several weeks before evacuation to landfill site.
2. Insanitary transfer stations lead to illegal dumping.
3. Unfair charge on waste dumped.
4. Lack of easy accessibility to skips in most of transfer stations.
5. Periodic failure to produce excellent service, and
6. Lack of customer care and complaint handling.

However, 37.05% of the resident's claimed that they are satisfied with the KMA's operation in the solid waste management in the Bantama Sub-Metropolis because to the following reasons;

1. Evacuation of skips to the landfill site is done at regular interval.
2. Twenty-one (21) skips available in the Sub-Metropolis is enough to store quantity of waste generated.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The study set out to investigate solid waste management challenges in the Bantama Sub-Metropolis. The focus of the study was on four factors, which were quantity of waste evacuated, avenues for collection and disposal, stakeholder's challenges and resident's willingness to pay for collection service. From the analyses, it was noted that twenty-one (21) skips (252 m^3) were emptied in a week whilst eighty-two (82) skips (984 m^3) were emptied in a month within the Bantama Sub-Metropolis. There were high heaps of solid waste left uncollected in some transfer stations such as Sefa Boakye in Bantama, Mpatasie, Atafoa, Ampabame and Adoato.

Results obtained proved that collection practice in the study area is communal collection using transfer station. Collection of solid waste is done by three (3) private waste collection companies (Meskworld, Ve-Mark and Asadu Royal) in the Sub-Metropolis. Wastes generated were hauled from transfer stations to landfill site for final disposal using collection vehicles. Waste collection companies do not have specified route for their transportation and no recycling unit. Wastes generated were all sent to landfill site for final disposal. Traffic congestion on roads influences their operational cost and consequently their performance.

It was also discovered that stakeholders (KMA, Service providers, transfer stations attendants and residents) faced numerous challenges in the management of solid waste. KMA's challenges identified were include; frequent vehicle breakdown, inadequate number of vehicles, large volume of waste generated, lack of funds, lack of continuity between planning cycle, lack of interdepartmental waste management coordination, insufficient budget allocation for landfill operations, small container size, container height and insanitary transfer stations.

Service provider's challenges revealed include vehicle breakdown, high volume of waste, transport cost, vehicle wear and tear, lack of funds, lack of continuity between planning cycle and tender specifications not matching demand for service.

In the case of transfer stations attendants, it was found that small containers, height of containers, lack of logistics and bad smell were challenges identified.

Challenges faced by residents from the study include high cost of receptacles, lack of storage receptacles at point of generation of solid waste, receptacles not durable, lack of easy accessibility of skips and air pollution.

It was also noted that residents pay for the service provided but are not satisfied with the KMA's operations on solid waste management in the Sub-Metropolis due to the following; Containers always overflow for several weeks before being evacuated to landfill site, insanitary transfer stations, unfair charge of waste per dump by transfer stations attendants, lack of easy accessibility to skips in most of the communities, periodic failure to produce excellent service by service providers and lack of customer care and complaint handling.

6.2 RECOMMENDATIONS

To effectively handle the challenges enumerated, the following measures are recommended for implementation.

1. Provision of adequate skips and durable receptacles at a lower cost by the government.
2. Regular collection of Waste.
3. Provision of enough operational vehicles and undergo routine maintenance.
4. "Pay as you dump policy" should re-strategize to ensure fairness at the transfer stations.

5. KMA should partner with the private sector to provide adequate recycling units.
6. Use specialized vehicles to execute certain functions best within waste collection to disposal site.
7. Collection and transport of waste should be done at the night to ease traffic congestion.
8. KMA should create avenues for customers to voice their complaints.
9. Strengthen education and awareness of waste management to politicians.
10. Procurement of waste related equipment or machinery should involve those with relevant technical expertise.
11. Provision of effective and accurate waste collection data by the key stakeholders.
12. KMA should explore other sources of fund from corporate bodies e.g. AGC, VAC, GGB etc. and intensify sharing responsibility with other stakeholders.
13. Adequate resourcing of Waste Management Institutions by the government.
14. Strengthen coordination of efforts by key role players related to waste management (finance, planners, councilors and procurement).
15. Provision of adequate recycles unit and protection of land space for the treatment and disposal of waste.
16. Provide training to the staff and drivers to avoid unnecessary break downs.

If the above recommendations given are well taken and implemented, it will ensure a clean environment, bring about effective solid waste management and prevent any possible outbreak in Bantama Sub-Metropolis.

REFERENCES

Abul, S. (2010). Environmental and Health Impact of Solid Waste Disposal at Mangwaneni Dumpsite in Manzini: Swaziland. *Journal of Sustainable Development in Africa,* (1) No. 7, pp.64-78).

African Sustainable Cities Network. Kumasi Metropolitan Assembly, Kumasi, Ghana - http://www3.iclei.org/la21/ascn/member.cfm?city=19. Accessed on 9/2/13.

Attahi, K. (1999). Abidjan, Cote d'Ivoire. *Onibokun, A.G. (Ed).* Managing the Monster. Urban Waste and Governance in Africa. Pp. 11- 48. Ottawa, IDRC.

Baabereyir A. (2009). Urban Environmental Problems in Ghana: A Case Study of Social and Environmental Injustice in Solid Waste Management in Accra and Secondi-Takoradi. http://etheses.nottingham.ac.uk/847/1/Full_thesis_pdf_copy.pdf Accessed; 18/2/2013.

Babanawo R. (2006). Constrains to Sustainable Solid Waste Management in Ghana. http://deposit.ddb.de/cgibin/dokserv?idn=984500952&dok_var=d1&dok_ext=pdf&filename=9 84500952.pdf. Accessed; 16/7 2013.

Bach, H., Mild A., Natter M., and Weber A., (2004). Combining socio-demographic and logistic factors to explain the generation and collection of waste paper, *Resources, Conservation and Recycling* 41: 65-73.

Boafor, T. F., Essilfie, S., Kasim, A.R., Koranteng, D.D., Sulemana, Y., Thompson M. (Unpublished results) Waste Characterisation in the Bantama sub- Metro and options of Waste Treatment

Boardi,K. O. and Kuitunen,M. (2005). Environmental and Health Impacts of Household Solid Waste Handling and Disposal Practices in the Third World Cities: The Case of Accra Metropolitan Area, Ghana. *Journal of Environmental Health*, (68), No. 4, pp. 34-36.

Bogner, J., Abdelrafie M. A., Diaz, C., Faaij, A., Gao, Q., Hashimoto, S., Mareckova, K., Pipatti, R. and Zhang, T.(2007). *Waste Management, In Climate Change: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

http://www.iswa.org/uploads/tx_iswaknowledgebase/Siebel.pdf. Accessed on 18/2/13.

Botkin, B. D. and Keller, A. E., (2003). *Environmental science: Earth as a living planet*. John Wiley and Sons. Inc. USA. Fourth edition.

http://searchworks.stanford.edu/view/4823532. Accessed on 9/2/13.

Browne, M. and Allen, J. (2007). Logistics and waste sector- London case study. Transport studies group, University of Wetmaster. A paper presented at the logistics Research Network Conference. 5-7 September 2007. University of Hall.

Centers for Disease and Control, (2009). Solid Waste. Retrieved July 16, from http://www.cdc.gov/nceh/ehs/NALBOH/NALBOH-4.pdf. Accessed on 18/2/13.

Charles T. (2007). Sanitation Policy in Ghana: Key Factors and the Potential for Ecological Sanitation Solutions. *EcoSanRes Programme,* Stockholm Environmetal Institute, SEI Communication. Skockholm – Sweden. Also available at www.ecosanres.org. Accessed on 12/6/2013.

Chifamba, P. (2007). Trace metal contamination of water at a solid waste disposal site at Kariba, Zimbabwe. *African Journalof Aquatic Science, 32*(1), 71-78.

Cointreau, S.(2001). Declaration of Principles for Sustainable and Integrated Solid Waste Management.http://siteresources.worldbank.org/INTUSWM/Resources/siswm.pdf. 18/02/13.

Cooper, J. (1999). Solid Waste Management in Copenhagen. Atkinson,A. and Julio, D. D. (1999).The Challenges of Environmental Management in Urban Areas. Alders hot and Vermont, Ashgate

Danso-Manu K.B (2011). The nature of solid waste management in Ghana: Towards data collection for good management practices. Available from http://dspace.knust.edu.gh:8080/jspui/bitstream/123456789/5427/1/Rachel%20A.%20Ofori.pdf. Accessed on July, 2013.

Definition of waste generation extracted available at BusinessDirectory.com. (9/2/2013)

Environmental News Service. (2007). *Journal of Sustainable Development in Africa.* (12) No.7, 2010). Available from http://www.jsdafrica.com/Jsda/V12No7_Winter2010_A/PDF/An%20Overview%20of%2 www.ens-**news**wire.com/ens/oct**2007**/**2007**-**10**-09-01.html. 12/4/2013.

EGSSAA, (2009).Environmental Guidelines for Small-Scale Activities in Africa http://www.encapafrica.org/EGSSAA/solidwaste.pdf Accessed; July, 2013.

EPA, Ghana (2002). Ghana State of the Environment Report EPA, MES, MLGRD. Ghana landfill guidelines: Best Practice Environmental Guidelines.

Gbekor, A. (2003). Domestic Waste Management. Ghana Environmental Protection Agency (EPA) Newsletter (47) No. 5. Accra, Ghana EPA.

Ghana adopts Chinese technology in addressing waste management http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=206166 Thursday, 1st January, 2013.

Ghana Statistical Service, (2000). Ghana living Standard Survey report of round 4. October, 2000. Ghana. Accessed on the 3/3/2013.

Gilpin, A. (1996). Dictionary of Environment and Development. Chester and New York, John Wiley and Sons

Gouveia N. and R. Ruscitto do Prado (2010): Health Risks in Areas Close to Urban Solid Waste Landfill Sites: Rev SaudePublica Vol. 44; No. 5; pp.1-8).

Goorah, S., Esmyot, M., Boojhawon, R. (2009). The Health Impact of Non-hazardous Solid Waste Disposal in a Community: The case of the Mare Chicose Landfill in Mauritius. *Journal of Environment Health*, 72(1) 48-54

Hamdu, I. (2009). Improving Waste Logistics in Kumasi Metropolitan Area. http://dspace.knust.edu.gh:8080/jspui/bitstream/123456789/495/1/IBRAHIM%20HAMDU.pdf - 9/2/2013.

Hardoy, J. E., Diana M. and David S. (2001).Environmental Problems in an Urbanizing World: Finding Solutions for Cities in Africa, Asia and Latin America,Earth scan, London, 448 pages.

Hari, D., Sharma, S. and Lewis, P. (1994). Waste Containment System, Waste Stabilization, and Landfills Design and Evaluation. Canada. John Willy and Sons, Inc.. Hong Kong.. Also available at www.ilsr.oug. Accessed on 12/4/2012.

Johansson, O. M. (2006). The effect of dynamic scheduling and routing in a solid waste management system: *Waste Management*. (26), Issue 8 Pages 875-885.

Kaseva, M. E. and Mbuligwe, S. E., (2003). Appraisal of Solid Waste Collection following Private Sector Involvement in Dar es Salaam City. Tanzania. Habitat International.

Kelly, L., Richard, A. and Neil, S. (2002). Zero waste: Replacing Waste Management with Discards Management in the Homg Kong Special Administration Region. Institute for Local Self – Reliance. Washington, DC 20009, for Greenpeace, China –

Kerala Envis Centre, (2009). Waste generation. The Kerale state council for science and technology and environment.

http://www.kerenvis.nic.in/Database/Soil_836.aspx. Accessed on 18/2/13.

Ketibuah, E., Asase M., Yusif S., Mensah M. Y. 2, Fischer K. (2005). Comparative Analysis Of Household Waste In The Cities Of Stuttgart And Kumasi –Options For Waste Recycling and Treatment in Kumasi. http://www.codata.org/04conf/papers/Ketibuah-paper.pdf, Accessed: 3 /5/2013.

Ketibuah, E., Asase, M., Yusif, S., Mensah. Y., Fischer, K. (2009). Comparative analysis of households waste in the cities of Stuttgart and Kumasi – options for recycling and treatment in Kumasi. Accessed on 18/2/2013. Available at

http://www.codata.org/04conf/abstracts/EconomicDevelopment/Ketibuah Comparative AnalysisofHouseholdWaste.htm.

KMA–WMD, (2008). Waste Management Department Report. Available at

www.kma.gov.gh//kumasimtro/page.com. Accessed on (1/2/2013)

Linden, O. (Sida), Gomez E.D. (CMC) and Ngoilie, M.A.K. 1997 (Eds). Common Constraints to Waste Management Programs on the East Asian Seas Region: Top Ten Constraints. GEF/UNDP/IMO Regional Programme 1997. National profiles forBrunei, Darussalam, Cambodia, China, Indonesia, Japan, Malaysia, Philippines,Singapore, Thailand and Vietnam. Accessed at: http://www.pemsea.org/pdfdocuments/regional-profiles-from-tropical-coasts-back-cover/tc-obc-vol5-6-no2- 1.pdf. 18/02/13

Lohse, U. 2003. Improving Municipal Finance – A Global Challenge. *Habitat Debate. Innovative Urban Financing*. UN-HABITAT April, 2003. (9) No. 1. Accessed at: http://www.unhabitat.org/hd/hdv9n1/default.asp. 12/04/13

Majani, B. (2000). Institutionalizing Environmental Planning and Management: The Economics of Solid Waste Management in Tanzania. SPRING Research Series no 28. Dortmund, Germany. https://www.fig.net/pub/fig2009/papers/ts04b/ts04b_kyessi_mwakalinga_3219.pdf. 16/7/2013

Mangizvo, R. V. (2008). Management practices at the Mucheke municipal solid waste disposal site in Masvingo City, in Zimbabwe.*Journal of Sustainable Development in Africa*, 10, (2), 147-164

Mayor of London, (2003). *Muni*cipal waste management strategy – Re-thinking Rubbish on London. Published by Greater London Authority.

Mensa, A. and Larbi, E. (2005). Solid waste disposal in Ghana. WELLFACT sheet – Regional Annex in Developing Countries. WELL–Resource CentreNetwork. Available

Mizpah, A., Enerst, K. Y., Moses, M., Jay, S.and Samuel, A. (2009). Comparism of municipal solid waste management system in Canada and Ghana: A case study of the cities London, Ontario and Kumasi Ghana. Waste Management 29: 2779–2786 available at www.elsevier.com/weste/wesman.

Moeller, D. W. (2005). Environmental Health (3rd Ed.). Cambridge, MA:Harvard University Press. environmentalhealthtoday.files.wordpress.com/.../app7akinbodef-pp2.pp. 12/4/2012.

Ogawa, H. (2005). Sustainable Solid Waste Management in Developing Countries, World Health Organization Western Pacific Regional Environmental Health Centre Kuala Lumpur, Malaysia. Presented on the 7th ISWA International Congress and Exhibition. http://www.gdrc.org/uem/waste/swm-fogawa1.htm Accessed; February, 2013

Oyaro, K. (2003, May 13). Month after dump scare, problems persist. InterPress Service News Agency. (Johannesburg). 13/4/2013. www.unep.org/cpi/briefs/2008May14.doc

Palczynski, R.J. and Scotia, W.N. 2002. Study on Solid Waste Management Options for Africa. Project Report. Final Draft Version. Prepared for African Development Bank Sustainable Development and Poverty Reduction Unit, Abidjan. July 2002. Accessed at: http://www.afdb.org/pls/portal/docs/PAGE/ADB_ADMIN_PG/DOCUMENTS/ENVIRONMENTALANDSOCIALASSESSMENTS/SOLID%20WASTE%20MANAGEMENT%20STUDY.PDF. 18/02/13

Obeng, P.A, Donkor, E.A. and Mensah, A. (2009). Assessment of Institutional Structures for Solid Waste Management in Kumasi.Management of Environmental Quality: An International Journal,(20) No. 20, pp 106-120

Poku, O. (2009). Waste disposal management in the peri-urban areas of Kumasi. DFID funded project: R7330, Kumasi, Ghana. Retrieved from www.dfid.com. (11/05/2013)

Rotich, K. H., Zhao, Y., & Dong, J. (2006). Municipal solid waste management challenges in developing countries – Kenyancase study. *Waste Management*, *26*, 92–100.

Sampson, G., (2003). Improving Waste Collection Logistics. Article from the Edge Vision 21 Transport Magazine.

Sarpong, S. (2009). Mayor of Kumasi Metropolitan Assembly. Press released by the Mayor of KMA. 23rd July, 2009, Edition of Daily Graphic.

Schübeler P., Wehrle K. and Christen J., KART (1996), Conceptual Framework Formunicipal Solid Waste Management in Low-Income Countries. UNDP/UNCHS (Habitat)/ World Bank/SDC Collaborative Programme on Municipal Solid Waste Management in Low-Income Countries. Working paper N0. 9 http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/conceptualframework.pdf Accessed; 9/2/2013.

Songsore, J. and McGranahan, G. (1996). Women and Household Environmental Care in the Greater Accra Metropolitan Area (GAMA), Ghana. Urban Environmental Series Report no. 2. Stockholm, SEI/Sida

Taylor, D. C. (1999). Managing resources to collect municipalsolid waste. Illustrative East Asian case study studies. Published by waste management and research SAGE. http//wmr.sagepub.com (12/4/2012).

Tchobanoglous, G., Theisen, H. and Vigil, S. (1993). Integrated Solid Waste: Engineering principles and management issues. McGraw-Hill Publishing Company, USA.

United Nations Environmental Programme (UNEP) (2009). Developing Integrated Solid Waste Management Plan Training Manual, (2): Assessment of Current Waste Management Systems and Gaps Therein. Osaka/Shiga, Japan.

UNEP (undated): Environmental Pollution and Impacts on Public Health: Implications of the Dandora Municipal Dumping Site in Nairobi, Kenya: United Nations Environmental Programme, Nairobi, Kenya

UNDP, 2005. Human Development Report 2005; Russian Federation: Russia in 2015; Development Goals and Policy Priorities. Accessed at: http://www.encyclopedia.com/doc/1G1-148971755.html. 21/11/08

UNESCO-EOLSS (undated): Amount and Composition of Municipal Solid Waste. Accessed on 9th February, 2013 from http://www.eolss.net/sample-chapters/c09/E4-11-03-02.pdf

U.S. Environment Protection Agency (2009). Proposed Revision to Definition of solid waste-frequent Questions. Retrieved April, 12, 2012 from

http://www.epa.gov/osw/nonhaz/municipal/index.htm

US EPA (2011). Waste-Resource Conservation-Reduce/Reuse Recycle

http://www.epa.gov/epawaste/conserve/rrr/reduce.htm Accessed; July, 2013.

US Law-Solid Waste Act 2, (1999). Definition of Solid Waste for RCRA Subtitle C Hazardous Waste http://www.epa.gov/osw/hazard/dsw/ - 5 / 2 / 2013.

Waste Management Toolkit (undated): Municipal Waste Management-Good Practices. Accessed on 9/2/2013. available at http://www.csir.co.za/nre/docs/Waste_Management_Toolkit.pdf

Zero Waste New Zealand Trust, (2000). Profile of a National Campaign September, 2000. New Zealand, Available at www.zerowastenz.comAccessed on the 12/6/2009.

Zurbrugg, C. (2009).Solid Waste Management in Developing Countries. www.sanicon.net 9th February, 2013.

APPENDIX

QUESTIONNAIRE FOR STAKEHOLDERS IN THE MANAGEMENT OF SOLID WASTE CHALLENGES IN BANTAMASUB-METRO, KUMASI:

TOPIC OF THE STUDY: SOLID WAST MANAGEMENT CHALLENGES IN BANTAMA SUB-METRO, KUMASI.

AIM: The purpose of this research is to investigate solid waste management challenges in Bantama Sub-Metro, Kumasi. It is to enable the researcher to write his thesis as partial fulfillment for master of environmental science (MSc). Your assistance in answering the questions honestly and promptly is greatly appreciated. Answers provided will be treated confidential. Thank you for your cooperation.

Questionnaire Number.....

Date of Interview (DD/MM/YY)...../...../20.....

Respondents: KMA ☐ Service Providers ☐ Transfer Station Attendance ☐ Residents ☐

Living Status: Affluent ☐ Middle Income ☐ Low Income ☐

A. PERSONAL DATA

1. Gender of respondent

☐ Male ☐ Female

2. How old are you?

☐ 0-10 ☐ 11-20 ☐ 21-30 ☐ bove 30

3. What is the size of your household?

☐ 1-5 ☐ 6-10 ☐ Above 10

4. Educational level of respondent?

☐ No School ☐ Basic education ☐ Secondary education ☐ Tertiary education

5. Employment status of the respondent;

☐ Self-employed ☐ Employed ☐ Unemployed ☐ Pupil / Student

B. ESTIMATION OF QUANTITY OF SOLID WASTE EVACUATED AND REVENUE GENERATED PER MONTH IN THE BANTAMA SUB-METRO.

Name of Transfer Station	Vol. and No. of Skip Selected	No. of Skips Emptied / Site / Week	No. of Skips Emptied/ Site / Month	Ave. Cost of Head load /Resident /Dump GH¢	Ave. Rev. of head load /Skip Fill / Month GH¢	Average Cost of Skip Fill /Dump/ Month GH¢	Ave. Profit Margins /Month
Chief Owusu							
North Dump							
Sefa Boakye							
Gulf Park							
Race Course							
Asanteman School							
Wesley College							
Prempeh College							
Adoato Adumanu							
Adoato New Site							
Adoato							
Ampabame							
Bohyen							
Abrepo Town							
Abrepo Pentecost							
Kumasi Girls							
Mpatasie							
Atafoa							
Ohwim							
Amanfrom							
Total							

C. Avenues for Solid Waste Collection in Bantama Sub-Metro

6. Name of solid waste collection company …….

7. Name of coverage area …….

8. Methods of collection from different sources

☐ House to House collection ☐ Communal collection using transfer stations

☐ Others (Specify)……..

9. How many vehicles do you use in collecting waste in the catchments area…….

10. Are they approved routes by KMA to be used by these vehicles?

☐ Yes ☐ No

11.If yes, indicate the specific routes the vehicles use from the collection points to the final disposal site……

12. How many of the transfer stations are within your catchments area?.....

13. From the transfer stations where do you send the waste?

☐ Recycling centre ☐ Energy/Compost recovery centre ☐ Incinerations Plants

☐ Landfill centre

14. Does your company have a recycling unit?

Yes ☐ No ☐

15. If No where do you dump your waste?

☐ KMA landfill sites ☐ others (Specify them)……..

D. Stakeholders Challenges in Solid Waste Management.

16.State the main challenges faced by each of the stakeholders in the management of solid waste in the Bantama Sub-Metro, Kumasi with respect to the following; **storage, collection, transport, disposal and administrative.**

18. Challenges faced by KMA

……

.....

……

……

19. Challenges faced by Service Providers

……..

……

……

20. Challenges faced by Transfer Stations Attendants

……

……

21. Challenges faced by Residents

……

……

E. Residents Willingness to Pay for the Services Provided by the Service Providers

22. Do you pay as you dump your waste generated?

☐ Yes ☐ No

23. How much do you pay as you dump your waste?

☐ 0.1 – 0.5 GH₵ ☐ 0.6 – 1.0 GH₵ ☐ others specify ……..

24. Are you satisfy with the operation of KMA in solid waste management in your area?

☐ Yes ☐ No

25 If yes, state any two reasons?

……

26. If no, state any two reasons

……

27. What are your recommendations to promote effective solid waste management in your area?

……

……

……