**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLGY**

**KUMASI-GHANA**

# MUNICIPAL SOLID WASTE MINIMISATION THROUGH HOUSEHOLD WASTE SEGREGATION IN BANTAMA, KUMASI



**BY**

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## DECLARATION

I, hereby declare that, except for references to other people's work which have been duly acknowledged, this write-up, submitted to the Department of Pure and Applied Biology, KNUST, Kumasi is the result of my own original research and that this thesis has not been presented for any degree elsewhere.

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## DEDICATION

This work is dedicated to my sons Kenneth, Richard and Gregory Adjei- Frimpong.

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## ABSTRACT

Solid waste management costs large amounts of money in many countries for its collection, transfer and disposal. Garbage elimination without separation creates increased difficulty in the disposal process in landfills, as well as dissipation of potential reusable and recyclable components. This study examined the implementation of source waste separation, reuse and recycling at the household level as a means of managing municipal solid waste.

Data were collected through field observations, questionnaire, interviews and actual measurement of masses of segregated household wastes. The results indicated that the low income residents produced the highest fraction of organic waste of 84.4%, whilst those of the lower middle and upper middle were 81.0% and 53 .0% respectively. Recyclable waste produced were 4% for low, 17% for lower middle and 32% for the upper middle group. For non recyclable waste, the three income residents produced 12%, 3.3% and 8.2% respectively.
The results also indicated that the bulk of household wastes in the community Bantama was organic, which was almost 80% of the total waste. This amount of waste can effectively be used to make good compost that householders can use as manure for backyard gardening. It was also observed that the residents were willing, and would be able to practice segregation at the household level when educated, encouraged and motivated. Yet these wastes were left on the streets and in drains to cause health and environmental problems.
It is therefore recommended that householders should be educated, encouraged and motivated to do waste segregation in order to reduce the amount of wastes that go to our limited landfills.

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# CHAPTER ONE

## 1.1 INTRODUCTION

The management of solid wastes is one of the challenges facing many urban dwellers in the world. An aggregation of human settlement has the potential to produce a large amount of solid waste; the collection, transfer and disposal of that waste has been generally assumed by municipal governments in the developed world. The format however varies. In most urban areas garbage is collected either by a government agency or a private collector, and this constitutes a basic and expected government function in the developed world. Germany for instance has been very successful in its fight against growing garbage heaps. A major part of the success of this program is the proper sorting of the garbage and effective recycling. (Ketibuah *et al.,* 2005)

Municipal solid waste (MSW) management has become a major issue of concern for many under developed nations, especially as population increases. The conventional MSW management approach- based on collection and disposal has failed to provide efficient and effective services to all urban residences. For example, according to Adedibu and Okekunle (1989), Lagos, Nigeria has been characterized as the "dirtiest" capital in the world. In most parts of the city, streets are partially or wholly blocked by solid wastes, whiles drains and market places are also 'chocked and littered with solid wastes respectively. This deplorable situation is not unique to Lagos, but exists in most African countries. Kulaba (1989) has also observed that on average, city authorities in Tanzania collect only 24% of the refuse. In Kinshasa, Zaire, Mbuyi (1989) points out that household waste collection and street cleaning

are restricted to wealthy neighbors, whiles in the remaining areas, household wastes are dumped along roads, illegal dumps and in storm water drains, or are buried.

In Ghana for instance, population continues to rise in almost an astronomical form. Unemployment continues to rise, and urban centers are flooded with rural dwellers constantly migrating into the cities to seek greener pastures. Industrialization, often resulting in growth and development has always been synonymous with high standard of living. Extraction of resources, accompanied with the packaging of refined goods, has resulted in the generation of huge volumes of wastes. (Fei-Baffoe, 2008).



The unavoidable sighting of polythene bags, water sachets, plastic and glass bottles, wood, metallic and paper packages are just few cases in point. This chain of development has resulted in uncontrolled generation of solid waste in urban centers.

In Accra, amount of waste collection is about 56% as stated by Ghana Landfills guidelines (Ghana EPA Newsletter, 2002).

Municipal Solid Waste (MSW) are those durable goods, non-durable goods, containers, packaging materials, food wastes and yard trimmings, and miscellaneous organic waste arising from residential, commercial, institutional and industrial sources (Fei – Baffoe, 2010).

MSW may be grouped into two broad categories as organic and inorganic. The organic form exists in three groups as putrescible, fermentable and non-fermentable. A study conducted by the AMA indicates that 65% of MSW in Ghana are degradable organic wastes. (AMA (WMD) Accra, 2002).

Waste segregation at source which is employed by many developed countries to manage their waste involves the separation of solid waste into various components by waste generators. In this study, householders were encouraged to compost or sell useful waste components through segregation in the home, only the non-biodegradable solid waste such as polythene bags were disposed off at refuse dumps for collection, thereby reducing the amount of waste reaching the landfill.



## 1.1 OBJECTIVES

The general objective of this work was to manage municipal solid wastes in Bantama through household waste segregation. The specific objectives were to:

- Assess socio-economic characteristics of the households and how it influences waste generation in Bantama.
- Assess the general waste situation in the Bantama community.
- Educate the people on waste segregation and let them separate their waste into three fractions [organic, recyclable and non-recyclable (inorganic)]
- Measure the different waste fractions of individual households in the Bantama community and hence determine the largest waste fraction and total waste generated in a day.
- Measure the accuracy of segregation of wastes into categorized fractions by householders.
- Use the organic component of household wastes (biodegradable) to make compost
- Determine the components of wastes that can be sold by householders for extra income.

## 1.2 RESEARCH QUESTIONS:

- What are the socio-economic attributes of residents of Bantama?
- What is the general waste situation in Bantama?
- What are the various waste fractions (percentages) of individual households in Bantama and which component is the largest?
- What is the total amount of waste generated in Bantama per day?
- How accurate can householders separate their waste into categorized components?
- Can household organic waste be used to make good compost?
- Which components of household wastes can be sold for extra income?

## 1.3 STATEMENT OF THE PROBLEM

In Ghana, lack of infrastructure for adequate solid waste treatment has resulted in waste collection being the main means of waste management. The collected wastes are disposed off at landfills. These landfills are however not enough to contain the huge tons of wastes generated daily. Much of these wastes are therefore found in streets, drains and market places. The repercussions of this are environmental and health hazards.

The scenario is however the exact opposite in developed countries like Germany where solid waste is better managed through segregation at source. This study therefore sought to measure the extent to which waste segregation can be adopted to manage municipal solid wastes in Ghana, with Bantama as the study area.

## 1.4 JUSIFICATION FOR THE STUDY

As in other developing countries, increase in population has resulted in increase in waste generation. The result is the generation of refuse dumps close to residential areas, posing severe health and environmental problems. There is difficulty in clearing wastes in the city due to lack of equipment. Some use can be made of the biodegradable component of waste generated. This study was therefore justified to reduce the amount of waste meant for refuse dumps, in order to reduce some of the waste reaching landfill sites. The choice of study site was necessitated by the huge tons of solid wastes generated daily in the Bantama Sub-Metro (K.M.A., 2011).This made the area ideal for the purpose.

It was expected that through implementation of recommendations from the study, the amount of wastes that gets to refuse dumps in Bantama and hence landfills would be greatly reduced through segregation of waste in homes. Householders would be able to make some extra income by selling recyclable and reusable components of the wastes they generate, and also be able to use composted organic wastes as manure for backyard gardens. Segregation would also limit the effect of land pollution and areas around refuse dumps would be cleaner and odour free.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 CONCEPTS IN WASTE MANAGEMENT

### 2.1.1 Definition of Waste

The term waste has been defined in various ways. The Longman dictionary of contemporary English defines waste as "the unwanted material or substance that is left after you have used something." According to the German waste Act of August, 1993, wastes are portable objects that have been abandoned by the owner.

Gilpin (1996) provides a more elaborate definition of the term waste. According to him, "the concept of waste embraces all unwanted and economically unusable by-products or residuals at any given place and time, and any other matter that may be discarded accidentally or otherwise into the environment." Gilpin also suggests that what constitutes wastes must occur in such a volume, concentration consistency or manner as to cause a significant alteration in the environment. Thus, apart from waste being an unwanted substance that is discarded, the amount of it is important. What one person considers as waste may also be useful to another person, as observed by Davies (2008) that "what people consider as waste materials or substances are considered to be value for others."

Waste therefore refers to any substance (solid, liquid, gas) discarded into the environment by the owner at a particular time, which causes significant nuisance or adverse impacts in the environment. Waste is heterogeneous, but its definition does not give information on composition (Fei-Baffoe, 2008).

### 2.1.2 Classification of Wastes

According to Baabereyir (2009), there are a number of criteria that are usually employed to classify wastes into various types to serve as bases for development of appropriate waste management practices. These criteria include source, physical state and material composition. For example, the classification of wastes by physical state is as shown in Table1 below:



**Table 1: Classification of waste by their physical state**

| Types of Waste | Examples |
|---|---|
| Solid | Food Waste, Plastic, Paper, Debris, etc. |
| Liquid | Sewage Sludge, Waste water from Bath House and Kitchen |
| Gaseous | Smoke from Vehicle Exhaust, Fumes from burning waste dump, Factory Smokes |
| Radioactive Waste | Radiation, Uranium, Plutonium, Excess Energy |

**Baabereyir (2009)**

Solid waste (on which this study is based) can be defined as "an unwanted material with insufficient liquid content to be free flowing" (Fei-Baffoe, 2008). It refers to all materials arising from human activities that are normally solid and are discarded as unwanted.

Municipal solid wastes (MSW) can also be defined as "those durable goods, non durable goods, containers and packaging materials, food wastes and yard trimmings, and miscellaneous organic wastes arising from all residential, commercial, institutional and industrial sources" (Fei-Baffoe, 2008). MSW is normally assumed to include all of the wastes generated in a community, with the exception of wastes generated by municipal services, treatment plants, and industrial and agricultural

processes (Tahobanoglous *et al.*, 1993). In the urban context, the term MSW is of special importance. It refers to all wastes collected and controlled by the municipality, and comprises diverse categories of wastes. It comprises wastes from several different sources such as residential wastes, commercial wastes, institutional wastes and some industrial wastes (Table 2).

**Table 2: Sources and types of municipal solid waste**

| **Sources** | **Typical Waste Generated** | **Type of Solid waste** |
|---|---|---|
| Residential | Single and multifamily dwellings | Food waste paper, cardboard, plastics, textile, Glass, metals, special waste (bulky items, consumer electronics, batteries, oil, tire) and household hazardous waste |
| Commercial | Stores, hotels, restaurants, markets office buildings | Paper, cardboard, plastics, wood, food waste, glass, metals, special waste, hazardous waste |
| Institutional | School, government center, hospital, prisons | Paper, cardboard, plastics, wood, food waste, glass metal, special waste, hazardous wastes |
| Municipal Service | Street cleaning, landscape parks, beaches sites, recreational areas | Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational areas. |
| Constructional and demolition | New construction sites, road repairs, renovation sites, demolition of buildings | Wood, steel. Concrete, dirt |
| Process (Manufacturing etc) | Heavy and light manufacturing refineries, chemical plants, power plants, mineral extraction and processing | Industrial process wastes, scrap materials, off, specification products, slay, tailings |
| Agriculture | Crops, orchards, vineyards, diaries, feedlots, farms. | Spoilt food wastes, agriculture wastes, hazardous waste (e.g. pesticides). |

**World Bank/IBRD, 1999.**

### 2.1.3 The concept of waste management

Generally, waste management refers to the process of keeping the environment free from the contaminating effects of waste materials. According to Sehubeller *et al.*, (1996), solid waste management is the collection, transfer, treatment, recycling, resource recovery and disposal of solid wastes in urban areas. Gbekor (2003) also defines waste management as "the collection, transport, treatment and disposal of wastes, including after-care of disposal sites". Similarly, waste management has been defined as "purposeful systematic control of the generation, storage, collection, transport, separation, processing, recycling, recovery and disposal of solid waste in a sanitary astatically acceptable and economical manner (Gilpin, 1996). In his view, Cooper (1999) noted that the priority of a waste management system must always be the provision of a cleaning service, which helps to maintain the health and safety of citizens and their environment. Tanaka (1998) has also noted the purpose of SWM to be the preservation of the living environment and improving public health through the restriction of the waste discharge, appropriate sorting, storage, collection, transport, recycling and conservation of a clean living environment.

Thus, from the above definitions, the core business of 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.

### 2.1.4 Models of waste management

To achieve waste management objectives and abide by environmental policies, models or systems of waste management have evolved. This decision support models involve the use of methods and tools such as cost benefit analysis (CBA), live cycle analysis (LCA) and integrated waste management (IWM). (Fei-Baffoe, 2010).

### 2.1.4.1 Cost Benefit Analysis (CBA)

CBA usually convert all economic, social and environment impact into monitory terms. Economic impacts are readily obtained by the cost of building waste management facilities and the revenues generated from such facilities. Social and environment impact are estimated by the cost of abating pollution from a waste treatment facility and or how much the public is willing to pay for an environmental improvement. These estimations go into deciding which waste management options offers the best profit. In the opinion of Fei-Baffoe (2010), maximizing economic impact is usually the dominant factor in CBA at the costs of environmental and social criteria, which is not a sustainable approach to waste management.

### 2.1.4.2 Life Cycle Analysis (LCA)

LCA as a waste management model involves the "evaluation of the environmental aspect and potential impacts throughout a product's Life cycle from raw material acquisition, through production, use and final disposal (Fei-Baffoe, 2010). Very recent waste management systems are concerned with whole Life Cycle of product with the aim of making a complete assessment of systems environmental impacts. This approach is essentially for waste minimizing as it afford the producers the opportunity to alternate production routes and waste reduction strategies. LCA is however, a specific and technical environmental accounting process that is unable to deal effectively with social issues. LCA covers environmental and economic sustainability but does not consider social aspect such as health effect predictions and therefore cannot be considered a sustainable waste management system.

### 2.1.4.3 Integrated Waste Management (IWM)

In recent years, the concept of IWM has become popular as a new approach to waste management. As defined by the world resource foundation (WRF), cited in environmental council (2002), IWM refers to "the use of a range of different waste management options rather than using a single option". In other words it is an approach which relies not only on technical solution to the waste problem, but on a range of complementary techniques in holistic approach. The approach involves the selection and application of appropriate technology, techniques and management practices to design a programme that achieves the objectives of waste management (Tahobanoglous *et al.*, 1993).

The concept of IWM seem to have emerged from the realization that technical solution alone does not adequately address the complex issues of waste management and that there is the need to employ a more holistic approach to waste management. As argued by Rhyner *et al.*, (1995), A single method for waste management is frequently unsatisfactory, inadequate, and not economical. Sehubeller *et al.*, (1999) have also observed that in the IWM approach, all stakeholders participating and affected by the waste management regime are brought on board. Furthermore, issues such as social, cultural, economic and environmental are considered in the design of an IWM project.

The hierarchical representation of elements in IWM is prevention and minimization, reuse, recycling, energy recovery, composting, incineration and disposal (Figure 1)

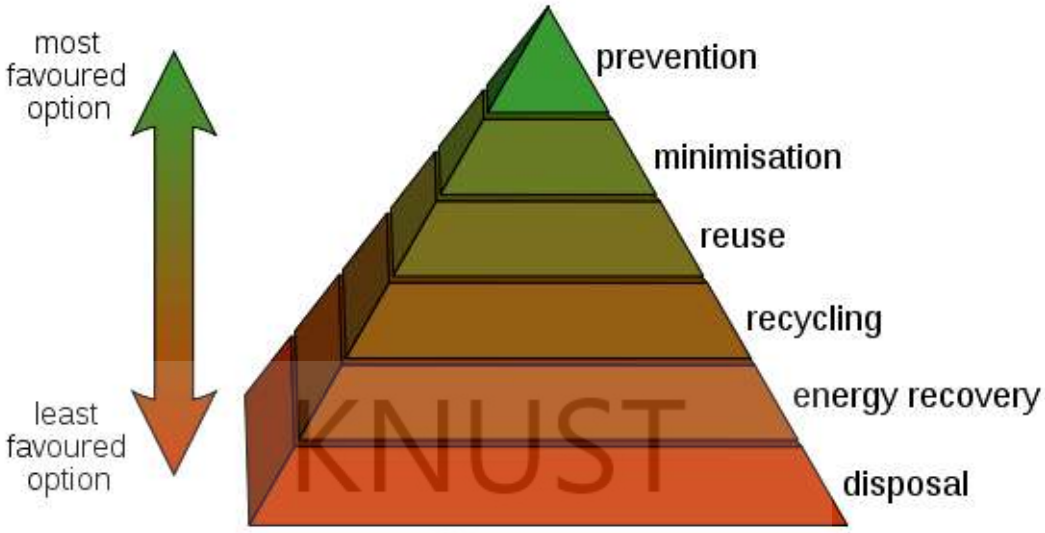


**Figure 1: Diagram of waste hierarchy**

**PREVENTION** involves the avoidance of waste generation all together. This is however impossible for any individual or group of people, the option that is most favored in the waste hierarchy is therefore to minimize waste generated.

**MINIMIZATION** deals with the reduction of the amount of waste one generates by buying products which contain less packaging and which can be easily recycled or buying refill items. Manufacturers can also reduce waste generation by avoiding the use of needless, countless and unsustainable packaging for their products. They can start by using recyclable materials or less packaging to coat their selling products.

**REUSE** also involves making use of purchased items over and over again. For example, glass jugs can be used to hold tooth brushes in the bath room, used as a pen holder or even a flower vase. Glass and plastic bottles can be used to store water in

the fridge, oil in the kitchen etc. Shopping bags can be used in place of black polythene bags, or even black polythene bags can be washed and used again instead of being thrown away on the streets. Old clothes, shoes, bags etc, can also be sent to people in the village as farm garments.

**REPAIR**: More often than not, when an item breaks down, the first reaction is to throw it away and buy a new one, however if the item such as electrical goods, electronic items, toys and clothes are repaired, it can be used again, thereby saving the environment and also some money.

**RECYCLING AND ENERGY RECOVERY**: These involve the making and creating of used materials into new useful products in order to save cost and energy. For example, it takes the same amount of energy to make one new aluminum can from raw materials as it does to make twenty recycled ones, thus a 95% energy saving .Composting of organic waste, which is a form of recycling reduces the amount of waste being sent to landfill site, this is especially important as landfill space is running out.

**INCENERATION**: this involves the burning of waste into ashes in other to dispose it off. In most towns in Ghana with health facilities, small incinerators have been built as part of the health provision infrastructure. These simple incinerators have provided several years of service in dealing with relatively small quantities of hazardous hospital waste.

**DISPOSAL**: This is the final and least preferred option after recycling. It involve sending waste to landfill site, since landfills are limited, the amount of waste being sent there should be minimal, this can be achieved through waste segregation as source in the homes.

IWM and the waste hierarchy are both essential for effective waste management and can reduce the environmental hazards associated with waste disposal. "It is therefore important for stakeholders in the waste sector to realize that an integrated approach which constantly strives to move up the waste hierarchy can be a useful tool for sustainable waste management" Baabereyir (2009). In spite of efforts by municipal authorities to improve waste management, most countries in the world still resort to the bottom of the waste hierarchy. In Ghana for instance, the bulk of the solid waste collected by municipals is disposed of in landfills. This study therefore sorts to apply the elements of IWM at the household's level, with non- biodegradable waste being the only waste component that got to the landfill site.

#### 2.1.4.4 Sustainable Waste Management (SWM)

SWM is an integral part of sustainable development which seeks to "meet the needs of the present without compromising the ability of the future generation to meet their own needs" (WCED, 1987). The amounts of waste generated and how it is managed have profound implications for the quality of the environment and for the prospects of future generations. Thus in keeping with the objective of sustainable development, sustainable waste management can be regarded as an approach to waste management that, in addition to protecting human health and the environment, ensures that the scares resources of the environment are conserved for both present and future generation of humanity.

In line with the waste hierarchy, the best way to achieve sustainable waste management is to reduce the amount of waste we produce (Girling, 2005). Where waste is unavoidable, a sustainable approach is to encourage reuse and recycling of products to prevent wastes from getting into the waste stream and this is what this research work sort to encourage.

### 2.1.5 Nature and Causes of the Waste Problem in Developing Countries

Although data is generally lacking in the waste sector of developing countries, available studies suggest that solid waste management is generally characterized by inefficient collection methods, insufficient and improper disposal of municipal waste (Onibokun and Kumuyi, 1999, Hardoy *et al.,* 2001, Pacione 2005). Major urban settlements are therefore characterized by waste accumulations and poor environmental sanitations (United Nations Habitat, 1989, Hardoy *et al.,* 2001). Uncollected refuse accumulate in drains, roads and open places disrupting community life and creating additional problem in the operation of other public services (United Nations Habitat, 2002).

According to Pacione (2005), most poor city governments in developing countries have great difficulty regarding safe disposal of solid wastes. He estimates that, between one third and half of all solid wastes generated in third world countries remain uncollected and the collection rate could be as low as 10-20% in some cases, and in some cases up to 60% of the waste generated within urban centers' in poor countries remain uncollected .

In Africa, studies have documented the abysmal solid waste situation in major cities. According to Palczynski and Scotia (2002), the Nigerian city of Port Harcott, River state has a severe municipal waste problem. They have stated that the city which was once known as the "Garden city" for its trees and clean streets has now gained the nick name "Garbage city" because of the appalling waste situation which now characterizes it.

In Senegal, Dakar has a very poor waste disposal situation. According to Palczynski and Scotia (2002), discarded paper, fruit skins, old cloths and other wastes have become part of the landscape of the city of Dakar.

The accelerated growth of the global urban cities implies an increase in waste generation. Swilling and Hutt (1999) have also reported that in Johannesburg South Africa, waste collection is inadequate giving rise to waste accumulations with implications of public health and the environment.

In Abidjan, Cote d'Voire, only some 54% of wastes generated by residence of the capital city were removed for disposal with the remaining waste pilling up in mounds all over the city and clogging drains and streams (Pacione, 2005).

Upon investigation in Dares Salaam Tanzania, Kironde (1999) also reported that most parts of the city never benefited from a public waste disposal service.

In Ghana, 58% of the solid waste generated is dumped by householders into designated dumping sites, 25% is dumped elsewhere in non-designated site, and only 5% is actually collected. The quantity uncollected varies from place to place and could be as high as 20% in the two largest cities of Accra and Kumasi (GSS 2002).

In many cities, households' waste collection is restricted to wealthy neighbors, while in the remaining areas waste is dumped along roadside, illegal waste dumps and in stormed waste drains (Mbuyi, 1989). Hardoy *et al.,* (2001) have also provided the table below which shows low performance in waste collection in some cities in the developing world, including Ghana.

**Table 3: Solid Waste Collection is Selected Cities in Developing Countries**

| **City (Country)** | **Percentage of Solid Waste Collected** | **Year** |
|---|---|---|
| Accra (Ghana) | 10 | 1989 |
| Addis Ababa (Ethiopia) | 60 | 1998 |
| Ahmadabad (India) | 65 | 2000 |
| Baroda (India) | 05 | 1994 |
| Kampala (Uganda) | 10 | 1993 |
| Kumasi (Ghana) | 30 | 2000 |
| Latin American cities | 50-70 | 1999 |
| Lusaka and other cities (Zambia) | 10 | 1997 |
| Mombassa (Keny6a) | 40 | 2000 |
| Ouagadougou (Burkina Faso) | 30 | 1995 |
| Sao Paolo (Brazil) | 70 | 1998 |

**Hardoy *et al.,* (2001)**

Several factors have been identified as courses of the poor waste management systems in developing countries. Linden *et al.,* (1997) for instance have identified ten courses of the problem as follows:

Inappropriate technologies

Enforcement inefficiencies

Lack of financing

Lack of training or human resources

Lack of political support

Lack of legislation

Police conflict among levels of government or overlapping responsibilities.

Rapid increase in waste generation.

Lack of awareness among the public.

Limited land areas due to land tenure issues.

These factors, according to the report have made it difficult for many developing countries to keep their city environments clean and safe for the population.



### 2.1.6 Constraints in Waste Management in Developing Countries

Many researchers have elaborated on factors that militate against solid waste management in developing countries and classify them into various constraints. Below is a detailed examination of these constraints.

#### 2.1.6.1 Financial and Economic Constraints

According to Lohse (2003), there is a gap between financial resources and municipal resources and municipal expenditures needs and that this financial gap is widening as urban population expand, increasing the demand of infrastructure and services including waste disposal. "Most municipalities lack the autonomy to establish their tax basis, rate structures and enforcement procedures and so cannot raise revenue to commensurate with their expenditure requirements (Lohse, 2003).

Zurbrugg (2002) also explains that low fees usually charged for waste collection and insufficient funds from central municipal budgets cannot finance adequate levels of service. 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 government for cost recovery and the heavy reliance on states subsidies for waste management projects. Onibokun and Kumuyi (1999) have also blamed the lack of financial autonomy among municipal government on excessive central government control on the lucrative sources of revenue, a situation which leave local governments with few options.



### 2.1.6.2 Institutional Constraints

Inefficient institutional arrangements adversely affect urban management in poor countries generally and environmental service delivery in particular (Ogawa 2002, UN – Habitat 1989, Zurbrugg2002). Armah (1993) has also stated that no single agency is usually designated to coordinate the activities of waste sector agencies, whilst Ogawa (2002) has observed that the lack of coordination among the relevant sector agencies often results in different agencies duplicating one function.

### 2.1.6.3 Technical Constraints

Most developing countries have inadequate and inappropriate technologies employed in municipal solid waste management. Apart from high acquisition and maintenance cost involved, developing countries actually lack the engineering capacity to support the operation and maintenance of such sophisticated equipment like compacters and skip lifts. Yet this is the equipment usually employed by municipal authority and private sector waste contractors in many poor countries ( Armah, 1993, Achankeng, 2003). Zurbrugg, (2002) has also observed that adoption of the conventional waste

collection vehicles used in rich countries constraints solid waste management operation in developing countries.

Achankeng (2003) has again stated that the high cost of new equipment compels many poor countries municipal governments to import used equipment from western countries. Such equipment arrives already near the end of their useful life and so frequently requires repairs due to breakdowns. In the absence of spare parts and the required engineering skills to maintain trucks, only a small part of the fleet usually remains in operation after a short period of their use. There is therefore the need to research into waste management practices that can be employed even in the presence of technical constraints-hence this research. Bartone (1995) reports that many officers in charge of solid waste management, particularly at the local level have little or no technical background and training in engineering or management. Without adequately trained personnel, a project initiated by external consultants could not be continued; therefore the development of human resources in the recipient country of external support is essential for the sustainability of the collaborative projects (Bartone, 1995).

According to Bartone *et al.*, (1991) developing countries lack overall plans for solid waste management at the local and national levels. As a result, a solid waste technology is often selected without due consideration of its appropriateness in overall solid waste management systems. Ogawa (2002) has suggested that in large metropolitan areas where there is more than one local government, coordination among the different local government and among agencies in urban management is

critical to achieving the most cost effective alternatives for solid waste management for the entire city.

### 2.1.7 Inadequate Personnel for Waste Management

Many researchers in Africa and other developing countries have confirmed that the lack of qualified waste management personnel have resulted in failure of government to undertake effective and sustainable waste management in the cities. Onibokun (1989) and Ogawa (2002)) have attributed the poor waste disposal situation in poor countries to the general lack of qualified personnel in the waste sector. Ogawa (2002) again attest to this observation by noting 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. According to him, many officers in-charge of solid waste have little or no technical background training in engineering or waste management. Most municipal authorities are unable to attract suitably qualified personnel for the various aspects of waste management such as planning, operations and monitoring (Onibokun, 1989). At the Namilyango College in Kampala Uganda, researchers carried out a study and found out that the failure of waste management programmes in Kampala and other Ugandian cities was largely the result of lack of trained manpower or personnel to execute waste management programmes. Kironde (1999) has also stated that generally in Dar Esallam Tanzania, employees in the waste sector are poorly paid and have very poor condition of service which makes many people shun the job in the waste sector including laborers. Hanrahan *et al.,* (2006) have also reported that the general lack of institutional and managerial capacities for urban environmental management among governments in Asian cities have resulted in difficulties in

managing waste in these cities. According to the 18th section of the United Nations commission on sustainable development report on waste management in Ghana, inadequate skill and capacity of waste management staff is one of the causes of waste problems in Ghana. Without sufficiently trained personnel, solid waste management project cannot be effective. Poor country cities will therefore continue to struggle with the implementation of their waste management programme unless their staffs are adequately trained and motivated.



## 2.2. THE CONCEPT OF HOUSEHOLD WASTE MANAGEMENT IN GHANA

Household waste is waste that is generated in the day to day operation of a household. It includes everything from lawn clippings to burn out light bulbs. A busy household can generate a great deal of waste, and the amount of household waste can increase radically in developed nations which rely heavily on packaging for a wide variety of products (Http//:www.wisegreek.com/topics/household-waste.htm).

In many countries in the world, (including Ghana) people are usually required to pay for household waste collection, with cost being billed on the basis of how many Cannes of garbage a house or building generates.
(Http//:www.wisegreek.com/topics/household-waste.htm).

One of the issues with household waste is that not all of it is in fact waste, and people can radically reduce the amount of waste which gets thrown away by thinking before tossing something in the garbage bin. Paper, glass, bottles, cans and numerous other items can be recycled or reused.

Other things such as used cloths and bags considered waste may be useful to others. Items like food scraps and lawn clipping can be composted instead of being thrown away, cutting down unwanted waste and directly contributing to the health of the environment by reclaiming nutrient (http; // www.wisegreek.com / topics / household-waste.htm).

### 2.2.1 Composition of Household Waste

In Ghana, data show that the overwhelming majority of households generate more organic waste than any other waste type. Household waste in Ghana ranges between 50% and 95% of organic waste. A household survey conducted by Baabereyir (2009) in Accra, Ghana for instance suggests that about 94.9% of household waste is organic waste such as food and garden waste as shown on Table 4 below.

**Table 4: Household Waste Generated in Accra**

| Waste Item Generated | Percentage |
|---|---|
| Organic Materials | 94.9 |
| Paper / Cardboard | 0.36 |
| Plastic Polythene | 0.9 |
| Leather / Textile | 0.4 |
| Dust / Ashes | 0.2 |

**Baabereyir (2009)**

The study further shows that the number of households whose waste output are dominant by materials other than organic are insignificant. The report also shows that poorer communities generate very high amount of this organic waste relative to the wealthier communities.

Benneh *et al.*, (1993) have also stated that residential domestic wastes forms the bulk of all sources of solid wastes in urban areas. These household wastes are known to

have high densities with high moisture content, and the organic component practically account for about 70% to 90%, whilst tins, cans and papers are responsible for about 5% to 10% of the total waste produced.

Ketibuah *et al.,* (2005) have also provided the average household waste composition in Kumasi (Table 5).

**Table 5: Household Waste Generation in Kumasi**

| **Components** | **Percentage** |
|---|---|
| Organic waste | 55 |
| Miscellaneous | 28 |
| Rubber/Paper | 7 |
| Paper/Cardboard | 5 |
| Metal | 2 |
| Wood | 1 |
| Glass | 1 |
| Fabric | 1 |

**Ketibuah *et al.,* (2005)**

### 2.2.2. Household Disposal Arrangements

In his study, Baabereyir (2009) indicated that household waste disposal arrangement in Accra and Secondi –Takoradiin Ghana include house -to- house collection, road side collection, tract visit and central container collection (Table 6)

**Table 6: Waste disposal arrangements**

| Means of waste disposal | Percentage in Accra | Percentage in Sekondi-Takoradi |
|---|---|---|
| Home collection | 24.2 | 15.0 |
| Roadside collection | 15.0 | 24.3 |
| Private waste collection | 16.8 | 03.6 |
| Central container | 32.9 | 43.4 |
| Waste dump | 07.1 | 09.3 |
| Other | 03.3 | 04.3 |

**Baabereyir (2009)**



In Kumasi, two systems of waste collection are employed (i.e. House-to-house and Communal). The house-to-house collection system attracts a fee of GH¢5 per 1st Class, GH¢4 for 2nd Class and GH¢3 for 3rd Class residential areas respectively. The rates are charged per bin per month, but the service is enjoyed by only 33% of the population. The communal collection component on the other hand attracts 10Gp per head load of waste deposited at the communal storage facility. The report however says that the impact of the services as well as its efficiency is affected by the unplanned nature of the metropolis.

(Http//:www.wisegreek.com/topics/household-waste.htm)

Although low income communities generate more organic waste and therefore need more frequent collection services to prevent waste decomposition and contamination of their surroundings, in Ghana, cities waste collection efforts are rather concentrated in the wealthier communities where the waste generated largely consist of packaging materials and thus require less regular collectors. The city authorities' usual arrangement for this trend is that, the poor do not pay for waste disposal but the

wealthier communities do (Baabereyir, 2009). Backyard composting of organic waste by poorer households would go a long way to solve this problem.

## 2.3. THE CONCEPT OF WASTE SEGREGATION AT SOURCE

A lot has been said and written about waste segregation, and how effective it is when used to manage solid waste. According to a report published by Elmo on October 14th 2007, waste segregation is the process of separating trash from biodegradable ones, recyclable materials and trash that need to be dumped. The biodegradable wastes are those that break down easily by bacteria action. Examples of these are peelings of fruits and vegetables, fish, intestines, chicken and pork bones egg shells, rotting foods, manure, glass sticks and ashes. The report also indicates that it is a fairly easy task to do waste segregation, and so one should apply the method to minimize the trash a particular household generates. In the segregation process, one should separate and keep these wastes in a temporary metal or plastic bin with a cover.

Waste segregation has been used in many developed countries to manage municipal solid waste effectively. For example in Stuttgart – Germany, household waste is separated into different fractions placed in bins of different colours, the most part of the waste which are miscellaneous is incinerated, bio and garden waste are decomposed and the rest such as paper, glass, scrap metal and packaging material are recycled. Bulky waste is normally collected and reused or sent to landfill site. Management of waste in this way has resulted in little or no indiscriminate dumping of refuse as it is estimated that all the waste is collected for household waste to be efficiently treated in Ghana, segregation at source must be considered as it is practiced in Stuttgart Ketibuah *et al.*, (2005).

In Ghana waste collection companies often do not collect waste promptly from residential areas. This results in waste bins overflowing with wastes, which emanate strong stench and breed houseflies. If organic wastes were collected in separate plastic bin, it would take a long time to fill up. This means that the bin can remain closed for a long time, and this will virtually eliminate stench and flies. The inorganic wastes that do not smell can be collected in sacks and kept for a longtime without any nuisance. Thus waste segregation can reduce the inconveniences that people go through when domestic wastes are not collected promptly. It is therefore, important to adopt waste segregation even if there are no facilities to recycle the accumulated wastes. Indeed it will be difficult for a major recycling program to succeed in a country like Ghana where the chunk of wastes is littered on the environment and the rest is collected in bulk. The program will not have enough wastes to recycle. Waste segregation generates recyclable materials, which can encourage investors to establish recycling factories. However, the best strategy would be to promote waste segregation at the household level alongside recycling (Osei- Bonsu, 2013).

## 2.4. COMPOSTING

Composting is defined as the biological decomposition and stabilization of organic material. The final product of such a process should be free of pathogens and weed seeds, and of sufficient quality that it can be applied to land without adverse environmental effects. At the most basic level, composting requires virtually no additional materials, structures, or work, so it has the inherent properties of an appropriate and sustainable technology. The extent to which materials, labor, and

knowledge are appropriately applied toward the refinement of a composting process ultimately determine its efficiency and effectiveness, however, this should not be taken to mean that complexity and efficiency are mutually dependent. The design proposed herein outlines an effective method by which composting of yard and food waste will produce humus that can be spread directly on crops as a soil conditioner, immediately increasing yield (Http//:www.wisegreek.com/topics/household-waste.htm).

In Africa however, composting has been tried in various countries at different scales with very poor results (Mustafa *et al.* 2002). Composting on industrial scale was tried in Dakar, (Senegal), and Abidjan (Cote d' Ivories') but they soon failed because of no demand for the final product. International NGOs have sponsored small scale composting in Benin, Cameroon, Egypt, Kenya, Nigeria, South Africa, and Zambia; but the practice has not had significant impact on the cities MSW reduction. The reason is poor quality of the manure resulting from inadequate segregation of waste (UNEP-IETC 1996). Segregation at the household level would not result in the situation above, as the amount of waste involved would be relatively small and easier to separate.

### 2.4.1Characteristics of Good Compost

Any organic material can be composted, ranging from sewage sludge to the organic component of municipal solid waste. In general, the quality of the compost obtained can be predetermined prior to the process by a method of source separation to remove traces of heavy metals, large man-made particulate matter, and toxic elements from the substrate. American guidelines for compost suitable for vegetable

farming include requirements for organic content, carbon-to-nitrogen ratio (C: N), particle size, pH, and stability. Most global standards require that the composting process occur above a certain temperature to eliminate pathogens.

**(**Http//:www.wisegreek.com/topics/household-waste.htm)

Organic content refers to the measure of carbon based materials in compost. It is desirable that this be greater than 50% of the total mass of the compost based on dry weight.



Carbon-to-Nitrogen Ratio (C/N Ratio) indicates the amount of nitrogen in the soil relative to the amount of carbon. An acceptable range is 20:1 to 35:1.

Particle size should be minimized through a mulching or shredding process. Most guidelines stipulate that particles should not exceed 2.5 cm in diameter.

The recommended pH range for agricultural compost is between 5.0 and 8.0.

Stability is a measure of the extent to which the decomposition of organic material in compost has been completed. Immature compost may become anaerobic when stored or transported, leading to problems of odor and development of toxic compounds. Maturity, the state at which compost is deemed stable enough for use on soil, is often estimated empirically by the length of the composting process that a material has undergone. A more sophisticated method of ascertaining stability involves measuring the oxygen uptake of the compost, reasoning that when aerobic activity stabilizes to a low level, the dominant microbial process of composting has ceased. Http//:www.wisegreek.com/topics/household-waste.htm).

Soils in Ghana are predominantly described as sandy loams. Sandy soil typically is characterized by low water retention capacity and higher rates of erosion compared to clayey soil types. Tropical soil in particular is characterized by low content of organic matter. The use of compost on sandy and/or tropical soil can benefit consumers by increasing water

content and water retention of the soil, and enhancing the aggregation of soil particles (allowing for more optimal porosity of the soil and hence better aeration). Greater water retention capacity also reduces soil erosion by helping to hold soil in place and preventing cracking of the soil, increasing its defense against erosion from wind and weather events (Offira, 2010).

### 2.4.2. Benefits of using compost

The benefits of using compost have become more evident and measurable. Because of its many attributes, compost is extremely versatile and beneficial in many applications. Compost has the unique ability to improve the properties of soils and growing media physically (structurally), chemically (nutritionally), and biologically. Although many equate the benefits of compost use to lush green growth, caused by available nitrogen, the real benefits of compost are long-term and related to its content of living organic matter.

(http://earth911.com/news/2007/04/02/benefitsofusingcompost.)

#### 2.4.2.1. Physical Benefits

**1. Improved structure**

Compost can greatly enhance the physical structure of soil. In fine – textured (clay, clay-loam) soils, the addition of compost will reduce bulk density, improve friability (workability) and porosity, and increase its gas and water permeability, thus reducing erosion. When used in sufficient quantities, the addition of compost has both an immediate and long-term positive impact on soil structure. It resists compaction in fine-textured soils and increases water-holding capacity and improves soil aggregation in coarse-textured (sandy) soils. The soil-binding properties of compost

are due to its humus content. Humus is a stable residue resulting from a high degree of organic matter decomposition. The constituents of the humus act as soil 'glue,' holding soil Particles together, making more resistant to erosion and improving the soil's ability to hold moisture (http://web.extention.illinois.edu/homecompost.benefitsanduses-compost).

**2. Moisture Management**

The addition of compost may provide greater drought resistance and more efficient water utilization; therefore, the frequency and intensity of irrigation may be reduced. Recent research also suggests that the addition of compost in sandy soils can facilitate dispersion by allowing water to more readily move laterally from its point of application (http://web.extention.illinois.edu/homecompost.benefitsanduses-compost)

**2.4.2.2. Chemical Benefits**

**1. Modifies and stabilizes pH**

The addition of compost to soil may modify the pH of the final mix. Depending on the pH of the compost and of the native soil, compost addition may raise or lower the soil/compost blend's pH. Therefore, the addition of a neutral to slightly alkaline compost or an acidic soil will increase soil pH if added in appropriate quantities. In specific conditions, compost has been found to affect soil pH even when applied at quantities as low as 10 – 20 tons per acre. The incorporation of compost also has the ability to buffer or stabilize soil pH, whereby it will more effectively resist pH change. (http://soilplantlab.missouri.edu/soil/compost.)

Compost will also improve the cation exchange capacity of soils, enabling them to retain nutrients longer. It will also allow crops to more effectively utilize nutrients, while reducing nutrient loss by leaching. For this reason, the fertility of soils is often tied to their organic matter content. Improving the cation exchange capacity of sandy soils by adding compost can greatly improve the retention of plant nutrients in the root zone.

**2. Provides nutrients**

Compost products contain a considerable variety of macro and micronutrients. Although often seen as a good source of nitrogen, phosphorus, potassium, compost also contains micronutrients essential for plant growth. Since compost contains relatively stable sources of organic matter, these nutrients are supplied in slow-release form. On a pound-by-pound basis, large quantities of nutrients are not typically found in compost in comparison to most commercial fertilizers. However, compost is usually applied at much greater rates; therefore, it can have a significant cumulative effect on nutrient availability. The addition of compost can affect both fertilizer and pH adjustment (lime/sulfur addition). Compost not only provides some nutrition, but often makes current fertilizer programs more effective. (http://soilplantlab.missouri.edu/soil/compost.)

**2.4.2.3. Biological Benefits**

**1. Provides Soil Biota Plants**

Their activity is largely based on the presence of organic matter. Soil microorganisms include bacteria, protozoa, and fungi. They are not only found within compost, but proliferate within soil media. Microorganisms play an important

role in organic matter decompositions which, in turn, leads to humus formation and nutrient availability.

Microorganisms can also promote root activity as specific fungi work symbiotically with plant roots, assisting them in the extraction of nutrients from soils. Sufficient levels of organic matter also encourage the growth of earthworms, which through tunneling, increase water infiltration and aeration.

(http://soilplantlab.missouri.edu/soil/compost.)

**2. Suppresses Plant Diseases**

Disease incidents on many plants may be influenced by the level and type of organic matter and microorganisms present in soils. Research has shown that increased population of certain microorganisms may suppress specific plant diseases such as pythium and fusarium as well as nematodes. Efforts are being made to optimize the composition process in order to increase the population of these beneficial microbes. (http://soilplantlab.missouri.edu/soil/compost.)

**2.4.2.4. Other Benefits of Compost**

Some other benefits of compost have been identified, and have led to new uses for it. These uses and uses are described below.

**1. Binds contaminant**

Compost has the ability to bind heavy metals and other contaminants, reducing both their leaching ability and absorption by plants. Therefore, sites contaminated with various pollutants may often be improved by amending the native soil with compost. The same binding effect allows compost to be used as a filter media for storm water treatment and has been shown to minimize leaching of pesticides in soil systems.

**2. Degrades Compounds**

The microbes found in compost are also able to degrade some toxic compounds, including petroleum (hydrocarbons). This is one of the reasons why compost is being used in bioremediation of petroleum contaminated soils.

http://soilplantlab.missouri.edu/soil/compost.)



**3. Wetland restoration**

Compost has also been used for the restoration of native wetlands. Rich in organic matter and microbial population, compost and soil/composts blends can simulate the characteristics of wetland soils, thereby encouraging the re-establishment of native species.

**4. Erosion control**

Coarser composts have been used with great success as mulch for erosion control and have been successfully used on site s where conventional erosion control methods have not performed well. In Europe, fine composts has been mixed with water and sprayed onto slopes to control erosion.

(http://soilplantlab.missouri.edu/soil/compost.)

**5. Weed control**

Immature composts or ones which possess substances detrimental to plant growth (phytotoxins), are also being tested as an alternative to plastic mulches for vegetable and fruit production. While aiding in moisture conservation and moderating soil temperatures, immature composts also act as mild herbicides.

Potential market for compost clearly exists in Ghana's urban areas to sustain composting and waste reuse, but lack of incentives and economic benefits is a limitation to the sustainability of community-based composting projects.

For a community-based composting project to be sustainable, it must be incentive driven and must generate economic benefits to participants.

## 2.5. RECYCLING

Recycling is the process of making or manufacturing new products from a product that has originally served its purpose. If these used products are disposed of in an appropriate, environmentally friendly way, the process of recycling has been set in motion. Items that are made from materials such as aluminum, plastic and glass bottles and certain kinds of paper. (http://www.benefits-of-recycling.com/whatisre)

### 2.5.1. Glass Recycling

Glass recycling is the process of turning waste glass into usable products. Glass waste should be separated by chemical composition, and then, depending on the end use and local processing capabilities, might also have to be separated into different colors. Many recyclers collect different colors of glass separately since glass retains its color after recycling. The most common types used for consumer containers are colorless glass, green glass, and brown/amber glass.

(http//www.epa.gov|osw/conserve/materials/glass.htm)

**1. Glass reuse**

Reuse of glass containers is preferable to recycling according to the waste hierarchy.. In some developing nations like India and Brazil, the cost of new bottles often forces

manufacturers to collect and refill old glass bottles for selling carbonated and other drinks.

### 2.5.1. Paper Recycling

Paper recycling is the process of recovering waste paper and remaking it into new paper products. There are three categories of paper that can be used as feed stocks for making recycled paper: mill broke pre-consumer waste, and post-consumer waste. Mill broke is paper trimmings and other paper scrap from the manufacture of paper, and is recycled internally in a paper mill. Pre-consumer waste is material which left the paper mill, which has been discarded before it was ready for consumer use. Post-consumer waste is material discarded after consumer use, such as old magazines, old newspapers, office waste, old telep1hone directories, and residential mixed paper. Paper suitable for recycling is called "scrap paper". The industrial process of removing printing ink from paper fibers of recycled paper to make deinked pulp is called deinking.(http://en.wikipedia.org\wiki\paper-recycling)

Metal recycling involves the collection of metal from discarded products and its transformation into raw materials to use in manufacturing a new product. Both recyclers and manufacturers alike promote the process of recycling metal, as the energy used to produce the recycled secondary material is far less than the energy required to produce metal initially from raw ores.

### 2.5.3. Aluminum Recycling

To illustrate the energy saved by recycling metal, let's take a look at aluminum cans. Producing an aluminum can from recycled aluminum requires just 5 percent of the energy originally required to create an aluminum can from primary raw materials.

This energy savings is significant; recycling a single aluminum can saves the energy equivalent of a 100-watt light bulb burning for four hours. Aluminum cans are among the most highly sought-after containers in the recycling industry, and with 54 billion cans recycled annually, they are the most commonly recycled consumer product. Almost all curbside recycling programs will accept aluminum cans as well as aluminum foil.



### 2.5.4. Steel Recycling

Similarly to the energy saved with aluminum recycling, the amount of energy saved in using recycled steel is 74 percent compared to manufacturing a steel product using virgin ores. It is quite remarkable that the steel industry has been recycling steel into new products for more than 150 years. Steel is the most commonly recycled material in the United States, and it can be recycled and turned into new steel products an infinite number of times. Steel containers, lids and household items are accepted by almost all curbside recycling programs. (Http/www.oscarwinski.com/metals-recycle.).

### 2.5.5. Scrap Metal Scrap Recycling

Metal, which includes both ferrous metals such as iron and steel, and nonferrous metals like aluminum, copper, tin and brass, can be reclaimed from many household appliances and used in the manufacturing of new products. Washers, dryers, refrigerators, stoves, ovens and water heaters are all valuable sources of this scrap metal. A few curbside recycling programs will accept these appliances, but in most areas you will need to take them to a local metal recycling center. To save yourself the trouble, when you purchase a new appliance, ask the delivery representatives to

take the old one with them for recycling. (Http/www.oscarwinski.com/metals-recycle.).

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1. THE STUDY AREA

Bantama is located in the Kumasi Metropolitan District of the Ashanti Region of Ghana. It is one of the constituencies represented in the parliament of Ghana. Its geographical coordinates are $6^0$ 42' 0" north, $1^0$38' 0" west.

Like other parts of Ghana, sections of the Bantama Community are engulfed with both conspicuous and inconspicuous filth, because it has serious problems with its waste management, from waste generation through storage to disposal.

Most people living in this suburb are mostly middle income earners, and are engaged in both formal and informal jobs and self employed. The famous Bantama Market is located in this area, and is the main seat of all commercial activities in this suburb. Also, the Komfo Anokye Teaching Hospital, a very important medical centre for the Northern part of the nation, and the Kumasi Cultural Centre are located within the Bantama suburb. The suburb also houses the Kumasi Race Course, a section full of filth, and which also served as the main haven for the city's "Kayayo" Community. Figure 2 below is the map of Bantama.

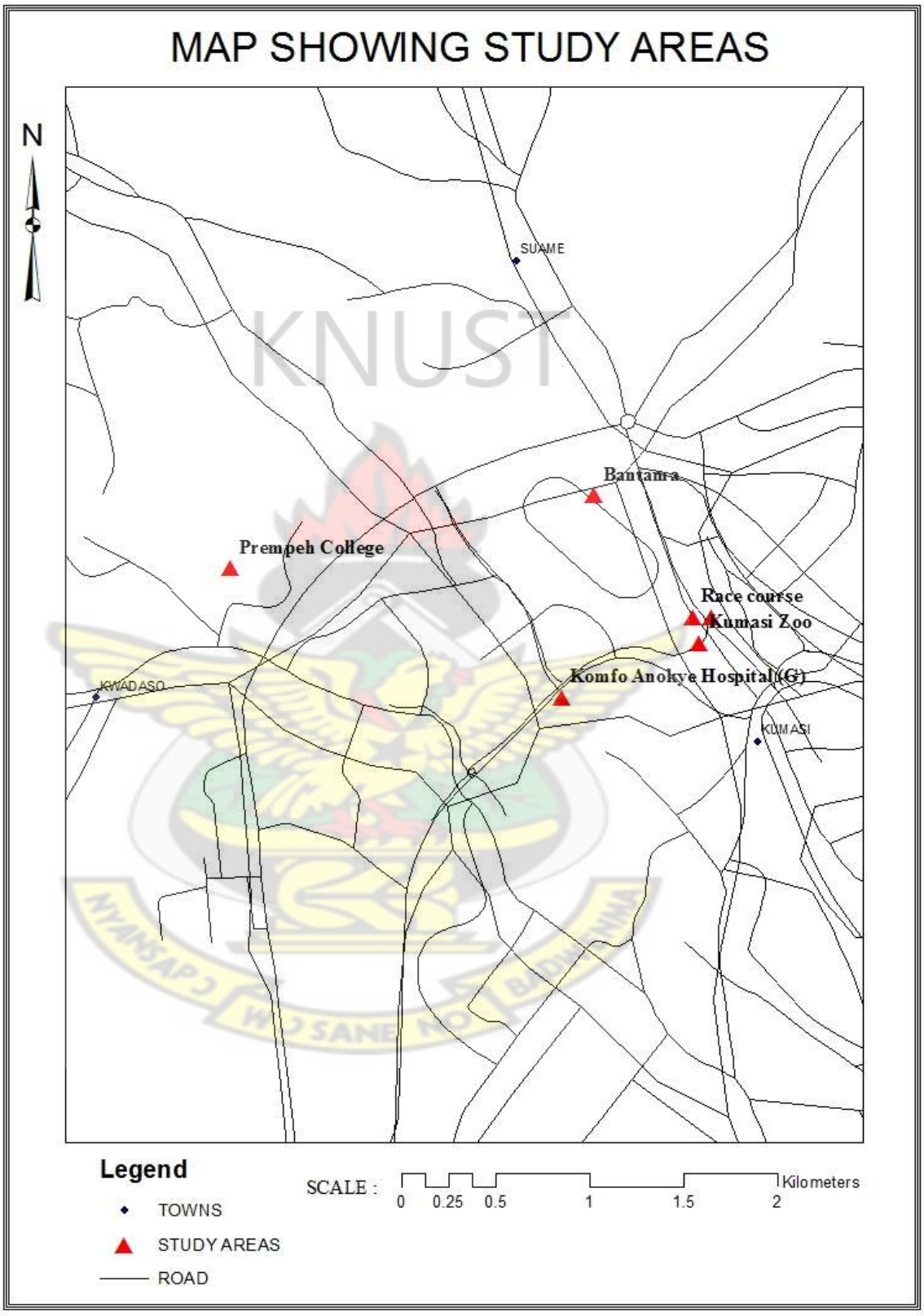


**Figure 2: Map of Bantama**

## 3.2. METHODOLOGICAL APPROACH

The methodological approach used in this study involved both quantitative and qualitative data collection. The method included interviews, questionnaires and field observations. This method was chosen as a result of the varied nature of the data required, and the different sources from which they had to be gathered.

Also, several researchers have indicated that, using the two approaches together have more merits than demerits, as stated by Bryman (2004), "combining different methodologies in a single study enhances the researcher's claim for the validity of his or her conclusions if they can be shown to provide mutual confirmations".

Robson (1993) has also stated that there is no rule that only one method must be used in an investigation, he emphasized that using more than one method in a single investigation have substantial advantage, even though it almost inevitably adds to the time investment required. Creswell (2003) and Grix (2004) have also recognized that, there is much to be gained from effusion of qualitative and quantitative methods in a single study of social phenomenon. Some researchers had however argued against the combination of the two methods in a single study. Guba and Lincoln (1985) in their study had this to say "combining qualitative and quantitative approaches is inappropriate and represent failure to recognize the distinction between a paradigm and a method". They argued that the use of any data gathering technique involves commitment to the approach with which it is usually associated and this makes method combination inappropriate. Hughes (1990) has also opposed the idea of combining the two research strategies in a single study with reason that research methods carry epistemological commitment, and the use of any data collection technique is not simply an issue of collecting data but a commitment to either positivism or interpretesm.

### 3.3 RESEARCH POPULATION AND SAMPLE

The entire population of Bantama was regarded as the study population for this research; the reason was that all residents of Bantama were involved in some aspect of solid waste management. They either generated waste or required waste disposal services or were affected by waste disposal. According to the 2000 population and housing census by the Ghana Statistical Service, obtained from KMA(2011), the population of Bantama is 306,248 with a total household of 22,548 and an average household size 5.3

250 households were selected as the population sample due to financial constraints and proximity. A household was defined as individuals who occupied the same living space and normally share food and amenities.

Based on questionnaire responses, three locations in Bantama, namely the race course area, Prempeh College campus and senior Doctors' quarters at Komfo Anokye Teaching Hospital were selected to represent low, lower middle and upper middle income areas respectively. As stated earlier, generally, the Bantama sub-metro according to the Ghana statistical service in Kumasi is a middle income community. But a detailed look indicates that the three residential areas mentioned above exist in the community.

### 3.4METHODS OF DATA COLLECTION:

As stated earlier, the methods of data collection used in this research included field observation, administration of questionnaire, interviews and waste sampling. The equipment used included weighing scales (top pan balances), plastic waste bins of empty mass of 0.15kg and safety equipments like gloves and nose masks. The top pan balance had a load/subdivision of 250kg/100g.

### 3.4.1 Field Observation:

Field observation was one of the methods of data collection used in this research. Observations are a form of evidence that do not depend on verbal behaviours and the method enables the investigator to observe the phenomenon under study directly(Yin, 1994). The field observations involved observation of waste situations and other conditions that affected waste management in the Bantama community. Waste disposal sites were also observed and some ZoomLion (a private waste management company) workers were also followed on their waste collection rounds to observe waste situations in the residents.



### 3.4.2 Questionnaire

Questionnaire was administered to each of the250 households selected. They were responded to by the mother or wife of the household, if available, otherwise the father or husband or any adult who was available. The six-page questionnaire took an average of 25 minutes to administer.

The researcher and a few friends distributed and retrieved the questionnaire in a period of two weeks. A total of 224 questionnaires were retrieved. The rest were either not retrieved or not answered.

The questionnaire elicited the following information:

i. Household socio-economic characteristics
ii. Household waste management activities
iii. Waste management activities in the Bantama community
iv. Knowledge about waste segregation and its importance. Responses to the questionnaire were analyzed using Microsoft Excel.

### 3.4.3 Interview

Another useful way of collecting data is by interviews, this is because the technique allows respondents to report on themselves, and also bring out their views, beliefs and interest. (Freebody, 2003). According to Robson (1993), interview has a number of advantages over questionnaire. In his view, there is a guarantee that all questions will be answered and respondents will have the opportunity to ask questions where they did not understand. Reliability can also be checked by asking the same questions differently.

Respondents for the interview were selected from key stakeholders such as officials from the Kumasi Metropolitan Assembly (KMA); Zoom Lion waste Collection Company and institutions like Prempeh College. Based on the objectives set for the study, interview schedules were developed for each of the groups listed above in other to address issues specific to their respective roles in waste management. Interviews schedules for the KMA was the most detailed and it had various sections such as stakeholders in the waste sector, the waste situation in Kumasi, resources for waste management, constraints and participation.

Interview with Zoom Lion officials (Private Waste Company) covered issues relating to their contract, finance, logistics, personnel and constraint they face. For institutions like Prempeh College, the issues bordered on their waste generating activities, means of waste disposal, available services for waste removal, payment for the service and their general perception about the waste situation around their premises and in the Bantama community as a whole.

First, letters were written to inform potential interviewees of the study and to request interviews with them. Copies of the interview schedules were attached to the letter of introduction to let them know the issues to be covered in the interviews.

Follow-up visit were later made to confirm arrangement for the interviews. A day before each appointment, telephone calls were made to remind the participant of the meeting time and to confirm if they would be able to keep their appointment. Those who could not make it had the day and time re-scheduled. Before interview started, interviewees were also reminded that the interview was for the purpose of research and were assured of confidentiality and anonymity in the use of information provided. They were also made aware of the audio recording of the interview in order to save time. Some, however, objected to the recording and so their responses had to be written down.

At the end of each interview, "thank you" was said to show appreciation for being granted audience. These measures ensured that, interviews were very successful and so data needed for the study were adequately and efficiently obtained.

### 3.4.4 Education Project

An adult from each of 150 out of the 224 households who were willing and readily available were educated on waste segregation and its importance as well as how to identify the various waste components and separate them. The education programme was designed as shown in Table 7 below.

**Table 7: Design of Education Project**

| Objectives | Indicators | Specific Activity |
|---|---|---|
| - To educate householders on solid waste and waste segregation. | -Knowledge on waste segregation according to the coloured bins provided. | Meeting with available householders |
| - To reduce wastes to be disposed to refuse dumps. | - To appoint some of the educated householders to also educate other members of their household on source reduction. | Demonstration of source reduction of household waste |
| - To use organic waste to make compost. | -To educate householders on how to use organic waste to make compost. | - Householders were engaged in composting. |

### 3.4.5 Waste Sampling at Source

After the education programme, we (my hired men and I) tried to find households who would like to participate in the sampling. After some field visits, the three locations mentioned in section 3.3 above were considered; upper middle income (doctors and senior nurses' quarters at Komfo Anokye teaching hospital), lower middle income (Prempeh college campus) and low income (race course area); all in the Bantama sub –metro. By moving from door to door, explaining to the households the aim and sampling procedure, people were asked about their general willingness of participating. Where willingness was assured, the household was selected to participate.

75of the 150households who took part in the education programme were selected (30 from low, 25 from lower middle and 20 from upper middle). Each household was given three waste bins of different colours and also a number which was used to identify their waste bins (Plat 1).

Households were asked to separate their waste into three fractions namely organic, recyclable and non-recyclable (Table 8).



**Table 8: Description of waste components**

| Waste component | Descriptions | Examples |
|---|---|---|
| Organic waste | Food and garden waste | Kitchen waste, food left over, weeds from garden, etc. |
| Recyclable / Reusable | Waste that can be converted to useable forms or can be used again | Plastic and glass bottles, metals tins and cans, scrap metals, old clothes, shoes, bags, etc. |
| Non-recyclable | Non-biodegradable waste and waste that have no use again | Polythene bags, diapers, sanitary pads, cells, etc. |

The sampling started on Monday 14th March 2011 and ended on Sunday 3rd April 2011 making a total of 21 days.

Every evening, the research team (the researcher and her hired men) collected the waste fractions from the households. Each waste fraction was weighed separately with the top pan balance in kilograms (Plate 2).

When there was rain or where waste could not be separated by householders, only the total weight was measured. In all, 1330 (543,446 and 341 from low, lower middle and upper middle income levels respectively) waste fractions and 1345 total

wastes (556, 449 and 340 respectively) were sampled (Table 9). Some samples were not considered because they had faeces in them. Also some people were not present at home during the weighing and forgot to leave their waste bins outside the house.

**Table 9: Number of samples obtained**

| | Total waste | Waste fractions |
|---|---|---|
| Number of samples assumed | 1575 | 1575 |
| Number of samples collected | 1374 | 1360 |
| Number of samples considered | 1345 | 1330 |
| Difference between assumed and considered | 230 | 245 |

**Plate 1: Some of the waste bins provided for householders.**

**Plate 2: Weighing of masses of waste**

### 3.4.6 Statistical Analyses

Data obtained from the sampling were analyzed using descriptive statistics to obtain the following information:

- Average household size
- Average of each waste component per household.
- Total waste generated per household per day
- Percentage waste composition
- Total waste generation in the Bantama Community
- Per capita waste generation
- Percentage of wastes that was adequately separated by each income level.

The accuracy of segregation of wastes into categorized fractions by householders was measured as percentage of wastes correctly segregated as follows:

- Total mass of wastes found in the wrong bin (example plastic wastes in organic waste bin) for a household on a particular day = x

- Total mass of waste of that household for that day =y
- Amount of waste correctly segregated by that particular household on that day =y – x
- Percentage of wastes correctly segregated by that household on that day T, = (y-x\y) *100%
- On days that there were no wastes in a wrong bin, percentage of wastes correctly segregated by that household T, =100%
- Average percentage of wastes correctly segregated by that household during the period = sum of T \ number of days used for sampling.



### 3.5 COMPOSTING OF ORGANIC WASTES

Organic wastes were composted for three months (01/08/2011to 01/ 01/ 2012) using aerobic composting method. Materials used for the composting was obtained from a day's collection of organic waste of the twenty five households on the Prempeh Collage Campus (Plate 3). The total mass of the waste was 100kg. Four heaps, each measuring 1.2m by 1.5m was made by first placing some stones at the bottom of each heap to prevent water logging and also to allow for aeration. 15cm thick layer of grass and vegetable materials were placed on top of the stones followed by a 10cm layer of old compost. This was to start the decomposition process. The layer was then mixed with some soil and ash. The ash was to adjust the pH of the compost. The mixture was then sprinkled with water to provide microbial activity and rapid breakdown of the material. Organic matter was then added and the process was repeated for each heap until each heap reached the stated dimensions. The compost heaps (windrows) were turned every two weeks with a digging fork to allow aeration

and also minimize the amount of methane gas generated and also sprinkled with water to ensure effective decomposition. The heaps were also tested by driving a long stick into them from one side to the middle and feeling it in the palm. When it feels warm, it means the decomposition process is still going on. This was done so that they were fully decomposed after three months. The end of the decomposition was then identified by the earthly smell of the compost. Compost samples were analyzed to ascertain their characteristics at the faculty of renewable natural resources – Kwame Nkrumah University and Science Technology.



**Plate 3: Making of Compost Pile**

### 3.6 SELLING OF SOME COMPONENTS OF HOUSEHOLD WASTE

Householders were also assisted to sell old clothes, shoes and bags at the central market at a place called "Afletie Adwosuo". Plastic and glass bottles were also sold at the central market whiles metal cans and tins were sold at the Suame Magazine and Akwatia Line in Kumasi (Plates 4).

**Plat 4: Some waste items sold**


**(A): Metal Cans**

**(B): Plastic Bottles**

**(C): Glass Bottles**

**(D): Discarded Bag**



## 3.7 METHODOLOGICAL LIMITATIONS

The first limitation of this study was the small sample size of 150 householders. For upper middle income level households for instance, (which were selected from the Doctors and Senior Nurses' Quarters at Komfo Anokye Hospital) only 20 households were willing to take part in the study. A much larger sample size would have increased the number of replicates and increased precision. The second

limitation was limited resources for which reason I was able to provide only 75 out of 150(50%) households with waste bins.

Sometimes, householders refused access into their homes, others were not present at certain times for the waste components to be measured for which reason their average waste composition were based on less than the twenty one stipulated number of days (In some cases the collection were based on only ten days and others even less).As mentioned earlier, some householders also placed faeces in some of the waste bins and so had to be thrown away without taking the masses.

# CHAPTER FOUR

# RESULTS

## 4.1 SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLDS IN BANTAMA

Four socio economic attributes, namely household size, education, occupation and income were considered, based on questionnaire responses. These attributes have been widely acknowledged as important influences on solid waste generation (Environment and Urbanization, assessed online at http:/eau.sagepub .com\content\19\527)

### 4.1.1 Household Size in Bantama

Table 10 below indicates the average household size of each of the three income brackets in the Bantama community.

**Table 10: Household size in Bantama.**

| Income area | No of households | Household population | Household size |
|---|---|---|---|
| Upper middle | 52 | 275 | 5.3 |
| Lower middle | 65 | 403 | 6.2 |
| Low | 107 | 834 | 7.8 |
| Total | 224 | 1512 | 6.8 |
| | | | |

The upper middle residents had a population of 275 for the 52 households, giving an average household size of 5.3. The 65 lower middle households had a population of 403 with an average household size of 4.2, whiles the low income group had 107

households with a population of 834, giving an average household size of 7.8. The mean household size for the three income groups was therefore found to be 6.8.

### 4.1.2 Educational Status of Heads of Households in Bantama

Table 11below also describes the educational status of household heads in the study area.

**Table 11. Educational status of heads of households in Bantana**

| Educational Background | Low Income | | Lower Middle Income | | Upper middle Income | |
|---|---|---|---|---|---|---|
| | FREQ. | (%) | FREQ. | (%) | FREQ. | (%) |
| **No formal** | 39 | 36.4 | 11 | 16.9 | 3 | 5.8 |
| **Primary** | 41 | 38.3 | 29 | 44.6 | 6 | 11.5 |
| **Secondary** | 21 | 19.6 | 12 | 18.5 | 11 | 21.2 |
| **Tertiary** | 6 | 5.6 | 13 | 20.0 | 32 | 61.5 |
| **Total** | 107 | 100 | 65 | 100 | 52 | 100 |

Majority of the household heads in the low income group (74.7%) either had no formal education or had just primary education, with 19.6% having secondary education. Only 5.6% of heads of households in this income bracket had tertiary education. In the upper middle group, 61.5% of the household heads had tertiary education, whiles 21.2% and 11.5% had secondary and primary education respectively, with 5.8% having no formal education. A total of 63.1% of the heads of households in the lower middle income bracket had primary education, whiles 16.9% had tertiary education, the rest had no formal education.

### 4.1.3 Occupation and Average Monthly Income of Household Heads

Tables 12 and 13below also represent the occupation and average monthly income of the heads of households respectively.

**Table 12: Occupational profile of heads of households in the three income brackets of the Bantama community**

| Occupation | Low income N=107 | | Lower Middle income N=65 | | Upper middle income N=52 | |
|---|---|---|---|---|---|---|
| | FREQ | % | FREQ | % | FREQ | % |
| Artisan | 31 | 29.0 | 9 | 13.8 | 4 | 7.7 |
| Self employed | 54 | 50.5 | 20 | 30.8 | 10 | 19.2 |
| Civil/Public service | 10 | 9.3 | 26 | 40.0 | 37 | 71.2 |
| Others | 12 | 11.2 | 10 | 15.4 | 1 | 1.9 |
| Total | 107 | 100 | 65 | 100 | 52 | 100 |

Over 50% of heads of households in the low income bracket were self employed, with only 9.3% being civil or public servants. 71.2% of those in the upper middle income bracket were civil or public servants, with 7.7% and 19.2% being artisans and self employed respectively. 1.9% represented others such as people employed as shopkeepers.

**Table 13: Average monthly income of heads of households in  of Bantama**

| Income area | Monthly income (cedi) |
|---|---|
| **Low** | < 500 |
| **Lower Middle** | 500-1000 |
| **Upper middle** | >1000 |

The upper middle group earned relatively high income of at least 1000 Ghana cedis monthly. The lower middle income group also earned between 500 and 1000 Ghana cedis, with most of those in the low income bracket earning less than 500 Ghana cedis.

## 4.2 ASSESSMENT OF THE GENERAL WASTE SITUATION IN THE BANTAMA SUB-METRO

The waste situation was assessed using responses from questionnaires and interviews, and also field observations.

### 4.2.1 Field Observation

Direct field observation in the Bantama community showed poor environmental conditions due to inadequate disposal of solid waste. Many places were engulfed with waste. The Race Course area was full of rubbish and filth with flies hovering around and foul stench which made the place unsuitable as a market place.

There was however, a vast difference between the relatively wealthy middle income ones on one hand and the poor informal low income areas on another hand. The doctors' quarters and the Prempeh college campus were generally clean due to regular cleaning and waste removal practices, in contrast with appalling environmental condition at the Race Course. Much of the wastes generated in these

areas remained uncollected daily, a situation which led to accumulation of waste in the community (Plate 5).

**Plate 5: Uncollected waste in the Bantama community**

(A) (B)

**Trash at the race course area**

***(C):*** **Piled up waste behind Prempeh College.**

**(D): Wastes around empty waste container at Sofoline**

### 4.2.2 Responses on Waste Situation

Respondents were asked to indicate the commonest items that were found in their waste. Table 14shows that majority of the households, 179 representing79.9% had organic waste as their major waste component. The Table further shows that the number of households who had other waste components as their major waste was very minimal.

**Table 14: Major waste item reported by residents of Bantama**

| Major waste item generated | N=224 Frequency | Percentage of households |
|---|---|---|
| **Organic material** | 179 | 79.9 |
| **Paper/cardboard** | 20 | 8.9 |
| **Plastic/polythene** | 6 | 2.6 |
| **Metal** | 7 | 3.1 |
| **Glass** | 8 | 3.8 |
| **Other** | 4 | 1.8 |
| **Total** | 224 | 100 |



Table 15, indicates the responses when residents were asked about the way they stored their waste for disposal.

**Table15. Types of waste containers used for waste storage**

| Type of waste container | N=224 Frequency | Percentage of households |
|---|---|---|
| Closed | 79 | 35.3 |
| Open | 112 | 50.0 |
| Polythene/sac/box | 23 | 10.3 |
| Other | 10 | 4.5 |
| Total | 224 | 100 |

35.3% of the respondents indicated that their wastes were stored in closed containers, whiles 50.0% indicated that their wastes were stored in open containers.10.3% also indicated that their wastes were stored in polythene bags, sacks or boxes, whiles

4.5% indicated that their wastes were stored in other places such bushes behind their houses.

**Table 16 Means of waste disposal in the Bantama neighborhood**

| Residential area | | Low income | | Lower Middle income | | Upper middle income | |
|---|---|---|---|---|---|---|---|
| | | Frequency | % | Frequency | % | Frequency | % |
| Means of Waste Disposal | Home collection | 0 | 0.0 | 20 | 30.8 | 39 | 75 |
| | Roadside Collection | 11 | 10.3 | 13 | 20.0 | 25 | 25 |
| | Central container | 62 | 57.9 | 26 | 40.0 | 0 | 0 |
| | Other | 34 | 31.8 | 6 | 9.2 | 0 | 0 |
| Total | | 107 | 100.0 | 65 | 100.0 | 52 | 100.0 |

75% of the upper middle income earners disposed of their wastes by home collection, 30.8% of the lower middle income earners disposed wastes by home collection whiles none of the lower income earners employed this collection method (Table 16).

Only 25% of the upper middle income earners disposed of their wastes by roadside collection. 20.0% and 10.3% were realized among the lower middle and low income earners respectively. Central container disposal method was not practiced among the upper middle income earners, but 40.0% and 57.9% were realized among the lower middle and low income earners respectively.

The householders were also asked to describe the general cleanliness of their household and the Table 4.8 shows the respondents' views on environmental cleanliness in their neighborhood.

**Table 17 Environmental cleanliness in neighborhood**

| Residential area | | Low income | | Lower middle income | | Upper middle Income | |
|---|---|---|---|---|---|---|---|
| | | Freq. | % | Freq. | % | Freq. | % |
| Description of neighborhood | Very clean | 0 | 0 | 7 | 10.7 | 48 | 92.3 |
| | Clean | 37 | 34.6 | 46 | 70.8 | 4 | 7.7 |
| | Dirty | 70 | 65.4 | 12 | 18.5 | 0 | 0 |
| Total | | 107 | 100.0 | 65 | 100.0 | 52 | 100.0 |



To the question, "are you satisfied with your waste disposal services?"

Table 18, summarizes the responses from the residents.

**Table 18: Quality on wastes disposal service**

| Residential area | | Quality of waste disposal service | | | | |
|---|---|---|---|---|---|---|
| | | Very satisfactory | Satisfactory | Poor | Very poor | Total |
| Upper middle income | Freq | 29 | 20 | 3 | 0 | 52 |
| | % | 55.8 | 38.5 | 5.8 | 0 | 100.0 |
| Lower Middle income | Freq | 3 | 36 | 20 | 6 | 65 |
| | % | 4.6 | 55.4 | 30.8 | 9.2 | 100.0 |
| Low income | Freq | 14 | 11 | 66 | 16 | 107 |
| | % | 13.1 | 10.3 | 61.6 | 1.0 | 100.0 |

Households in the upper middle income area were more satisfied with their waste disposal services, whilst those in the low income bracket described their waste disposal services mostly as poor.

### 4.3 WASTE COMPOSITION IN BANTAMA

As mentioned earlier in chapter three, information on waste composition in Bantama was obtained from actual measurement of masses of waste components.

75 households were made to separate their waste into three categories, namely organic, recyclable and non-recyclable. Tables19 and 20 , and also Figures 3, 4 and 5 present the waste patterns in each of the three income levels, as well as the total waste composition in the Bantama Community over a twenty one day period. They show the different waste fractions of individual households in the three income levels in the Bantama Community, and hence the highest waste fraction.

**Table 19: Waste Composition in Bantama**

| Income area | Number of Households | Household Population | Average Household Size | Total Waste/kg | Waste Components/kg | | | Per Capita Waste Generation/Kg |
|---|---|---|---|---|---|---|---|---|
| | | | | | Organic | **Recyclable** | Non-Recyclable | |
| Low | 30 | 198 | 6.6 | 192.9 | 162.8 | 7.7 | 22.4 | 0.97 |
| Lower Middle | 25 | 161 | 6.4 | 153.1 | 124.0 | 25.8 | 3.3 | 0.95 |
| Upper Middle | 20 | 100 | 5.0 | 54.4 | 28.8 | 17.4 | 8.2 | 0.54 |
| **Total** | **75** | **464** | **6.0(Average)** | **400.4** | **315.6** | **50.9** | **33.9** | **0.82(Average)** |

**Table 20: Summary of Statistical analysis of waste composition in the Bantama neighborhood**

| Waste Component | Residential Area | Mean | P-value |
|---|---|---|---|
| Organic | Low income | 5.42 | 0.00 |
| | Lower Middle income | 4.90 | |
| | Upper Middle income | 1.44 | |
| Recyclable | Low income | 0.26 | 0.00 |
| | Lower Middle income | 1.03 | |
| | Upper Middle income | 0.87 | |
| Non-recyclable | Low income | 0.75 | 0.00 |
| | Lower Middle income | 0.13 | |
| | Upper Middle income | 0.41 | |

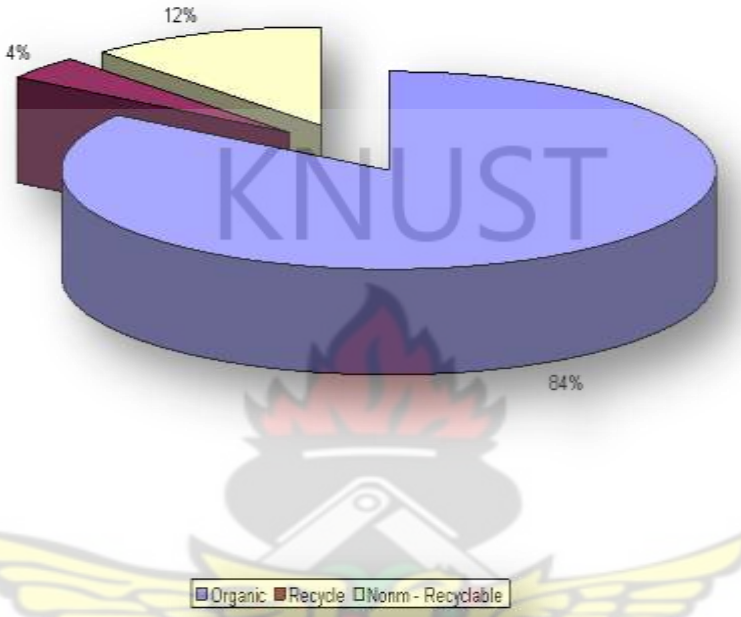


**Figure 3. Waste Composition in Low Income Households**

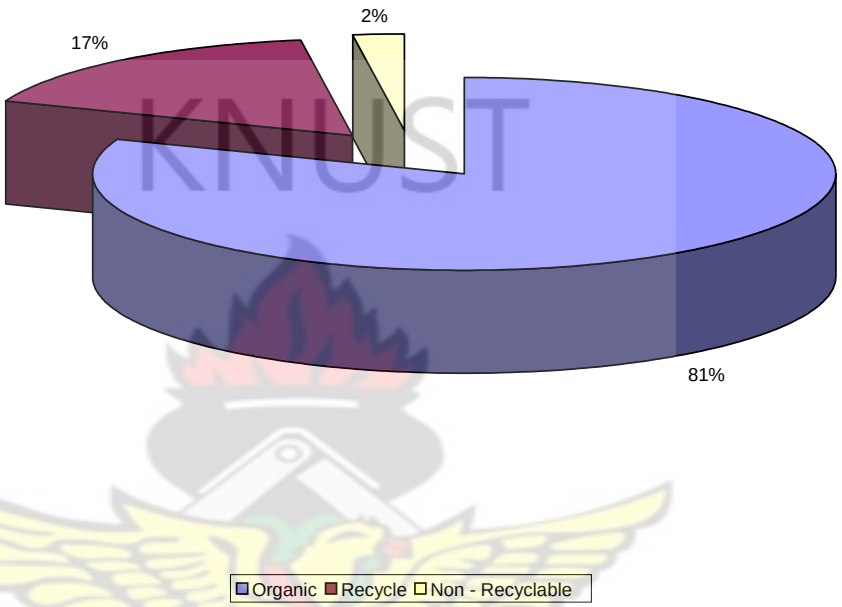


**Figure 4 Waste Composition in Lower Middle Income Households**

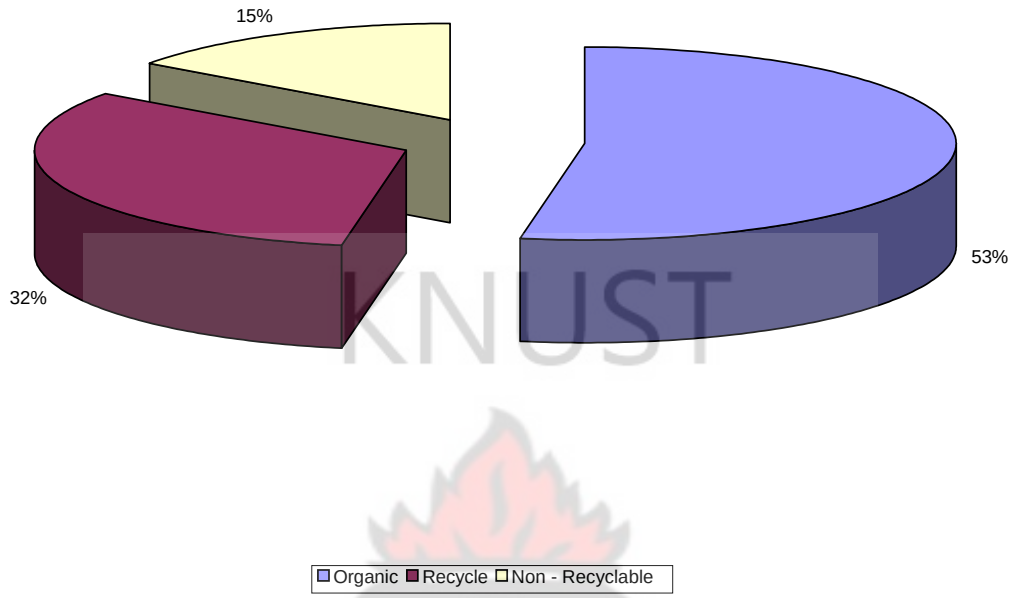


**Figure: 5 Waste Composition in Upper Middle Income Households**

From Table 19 and Figures 3, 4 and 5, households in the low income area produced the highest fraction of organic waste of 162.8kg representing 84.4% and a mean of 5.43, whilst the lower middle income and upper middle income households produced 124.0kg and 28.8kg whose mean were 4. 96 and 1.44 representing 81.0% and 53% organic waste respectively. With a p - value of less than 0.05 (p = 0.00 from Table 20), there is over 95% confidence that the values obtained from the statistical analysis are accurate. It also means that the various waste fractions correlated significantly among the three income brackets.

Recyclable waste of 17.4kg and 25.8kg representing 32% and 17% with mean of 0.87 and 1.03 were produced by the upper middle and lower middle respectively. The low income households produced only 7.7kg representing 4% of recyclables with a mean of 0.26.

The low income households also produced non recyclable waste of 22.4kg representing 12% of their waste with a mean of 0.75, followed by upper middle which produced 8.2kg (15%) with a mean of 0.41.The lower middle income households generated 3.3kg (2%) of non recyclable waste with a mean of 0.13 (Table 20).

It can also be seen from Table 19 that, the low income households with the largest household size of 6.6 has the highest per capita waste generation per day of 0.97kg.The lower middle income residents who had household size of 6.4 also had 0.95kg, whilst the upper middle income which has the lowest size of 5.0 generated a waste of 0.54kg per person per day.

On average, households of the three income levels generated 5.3kg/household/day or 0.82kg/cap/day (Table 19). Of this, organic waste, which was the highest fraction, comprised 315.6 kg (79 %), in agreement with Benneh *et al.,* (1993) that organic waste in urban areas is 70-90kg, but in contrast with Ketibuah *et al.,* (2005) who puts it at 55% in Kumasi. Recyclable waste was also found to be 50.9kg (13%) and non recyclable waste, 33.9kg (8%) as shown in Figure 6. The 306,247 population of Bantama therefore produced a total of 251,122.54kg (251.12 tons) of waste in a day.

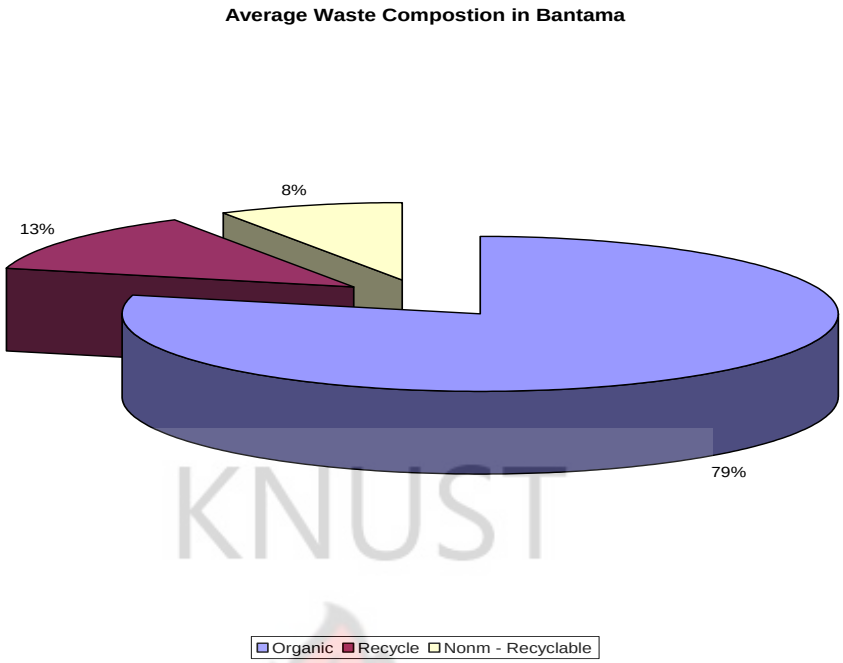


**Figure 6: Average wastes composition in Bantama**

## 4.4 ACCURACY OF SEGREGATION

The accuracy of waste segregation into the categorized fractions by householders was measured as percentage of wastes correctly segregated, which may directly or indirectly measure how well or otherwise the education programme went down with the people.

From figure 7, the upper middle income level households segregated an average of 94% of their wastes correctly. The lower middle income segregated 86% of their wastes correctly, whilst the low income earners were the lowest with 75%correct segregation. The three income level brackets therefore segregated about 82% of their waste correctly.

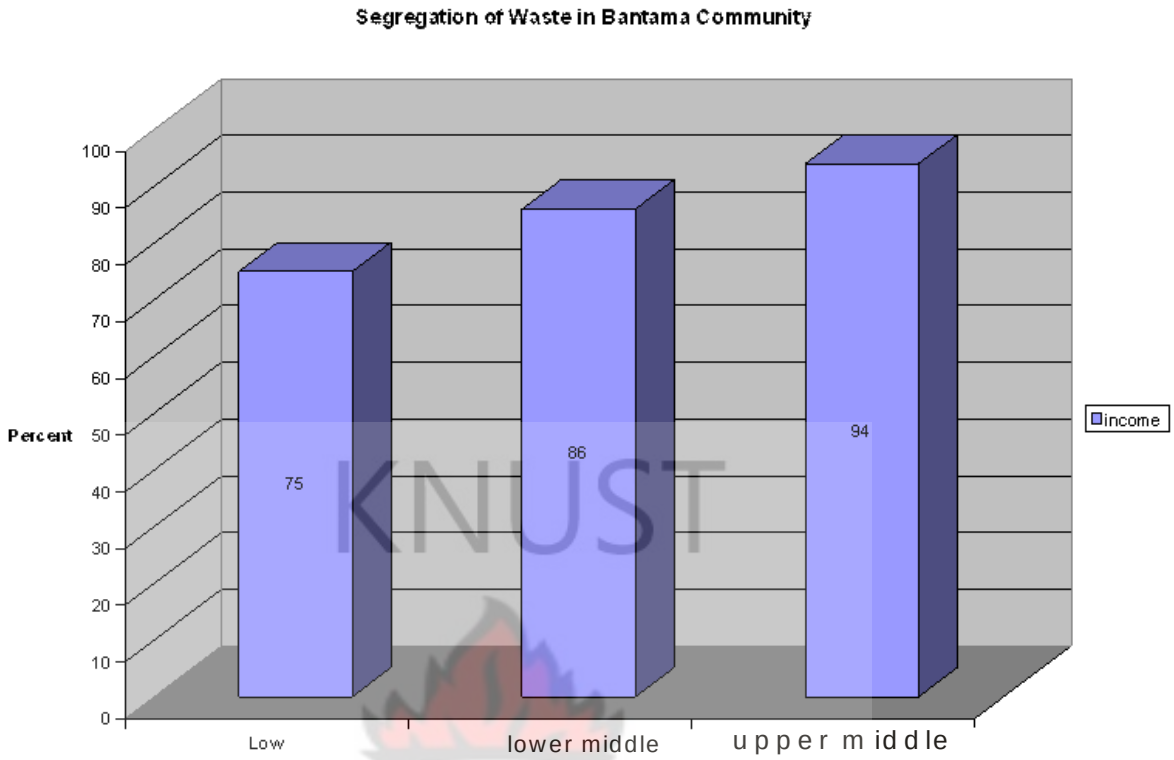


**Figure7: Segregation of Waste in Bantama Community**

4.5. COMPOSTED HOUSEHOLD ORGANIC WASTE

**Table 21 (a): ANALYSIS OF COMPOSTED HOUSEHOLD ORGANIC WASTE**

| NUTRIENTS (% DRY WEIGHT) | NITROGEN | PHOSPHORUS | POTASSIUM | ORGANIC MATTER | CARBON | C:N | pH |
|---|---|---|---|---|---|---|---|
| **SAMPLE ONE** | **1.20** | **1.60** | **1.80** | 67.2 | **38.4** | **30.0:1** | **7.94** |
| **SAMPLE TWO** | **1.40** | **1.60** | **1.60** | **67.4** | **38.4** | **29.0:1** | **7.96** |
| **AVERAGE** | **1.30** | **1.60** | **1.70** | **67.3** | **38.4** | **29.5:1** | **7.95** |



Table 21 (a) presents the results from the analysis of composted household organic wastesfrom the research area. Organic matter was found to be 67.3% by dry weight. Carbon nitrogen ratio was found to be 29.5:1, with the total carbon as 38.4%. Nitrogen, phosphorus and potassium were also found to be 1.3%, 1.6% and 1.7% respectively.Table 21 (b) also gives the microoganisms found when samples of the compost were analysed at the Department of Plant Pathology-KNUST. The report indicated that none of the microoganisms found was harmful to plants or humans.

**Table 21 (b): Microorganisms present in compost sample**

| Microorganism | *Aspergillus niger* | *Aspergillus versicolor* | *Aspergillus tamari* | *Aspergillus mucor* |
|---|---|---|---|---|
| score | 1 | 3 | 2 | 1 |

**Key: 1 = < 1/3 2= > 1/3 3 = 3**

# CHAPTER FIVE

# DISCUSSION

## 5.1 SOCIO ECONOMIC CHARACTERISTICS OF HOUSEHOLDS IN BANTAMA

As stated earlier in chapter four, the socio economic characteristics of the households in Bantama area were determined based on four parameters. These were household size, education, occupation and income of household heads.

### 5.1.1 Household Size

Household size in Bantama increased from the upper middle income area through the lower middle to the low income area; depicting the situation that prevails in such income areas in many cities in Ghana. The reason may be attributed to the fact that the people at the low income level give birth to more children as a result of lack of birth control. On average, household size for all 224 households was 6.8, higher than the 5.3 given by the Ghana Statistical Service in the 2000 census. This may be one of the reasons for the generation of more waste in the community now than in 2000, confirming Fei-Baffoe (2008)'s assertion that increase in population increases waste generation.

### 5.1.2 Educational Status of Household Heads

The proportion of household heads with secondary and tertiary education increased as one moved from low income through the lower middle income to upper middle income level , whiles those with no formal and primary education decreased along the same line. These observations may be as a result of financial scarcity on the part of the low income bracket.

Educational status also influenced food choices and materials purchased, and consequently, waste generation; in the low income households where many of the heads did not have secondary and tertiary education, the mothers or the wives were mostly market women or petty traders, and this significantly affected the quantity and composition of wastes they generated. Relatively more of the waste generated was high in organic composition, in agreement with literature as indicated by Baabereyir (2009). The upper middle income group however consumed more processed and packaged products, producing more recyclable wastes.



### 5.1.3 Occupation and Income

With relatively high education, the middle income household heads had more secured jobs and so earned higher income than their low income counterparts. This resulted in the waste pattern discussed in 5.1.2 above.

## 5.2. ASSESSMENT OF THE GENERAL WASTE SITUATION IN THE BANTAMA COMMUNITY

As mentioned earlier in chapter four, the waste situation was assessed using information from field observation, and responses from questionnaire and interviews.

### 5.2.1 Field Observation

It was observed that households in the middle income class stored their waste in large plastic wheeled bins which they placed in front of their houses for collection by waste collectors. The bins were either purchased by the householders from the market or supplied by the Zoomlion waste company for a fee. In the low income area

however, waste were stored in uncovered waste containers, polythene bags, old buckets and sacks which frequently attracted rodents and domestic animals like dogs, sheep and goats. The waste, which was not collected frequently easily got scattered and found their way into drains and gutters. People's attitude towards waste disposal in low income areas was very appalling. They literally threw rubbish on the streets, in drains and in gutters, especially on the days when it was raining. Even where there was an empty container at a refuse dump, wastes were thrown on the ground as seen in plat 5(D) in chapter four.



If householders are able to derive some benefits from waste through composting and recycling, waste would be better managed, the community would be cleaner and people would be healthier.

### 5.2.2 Responses on Waste Situation

Responses on the Waste Situation in the community corresponded with the observations made in the field.

Most people in the upper middle income area (75%) enjoy the best form of waste collection (home collection). This kept their homes clean and safe whilst the low income dwellers who relatively poor were resorted to either central container or other means like dumping in the nearby bush, which were eventually washed into gutters and drains.

When asked about payment for their waste disposal, the middle income residents said they paid an average of five cedis a month for their waste disposal , whilst the low income households paid one cedi(at community waste dump) or nothing at all (burned, buried or dumped in open places). These low income earners said they could not afford the five cedis cost of waste disposal for the home collection method.

Despite the fact that the low income households could not afford payment for their waste, it should not be used as a criterion to discriminate against them when planning disposal arrangements for residents. The reason is that, when disasters such as floods occur, which are partially caused by chocked gutters as a result of indiscriminate waste dumping, money spent by municipal authorities to clear up the mess far outweigh how much is spent to ensure adequate waste management in these low income areas; more so, lives lost in these events cannot be revived.

Responses from interviews conducted were analyzed by mainly summarizing the views of respondents. According to officials of the Kumasi Metropolitan Assembly, waste management consumes a lot of money and therefore inadequate funds really affect their operations. When asked why waste in low income communities was not collected frequently, the response was that these low income communities generated most of the waste could not pay for their waste disposal. This assertion was confirmed by the field observation as it was observed that most people in the wealthier homes were always busy and did not stay at home to make too much waste. The officials also lamented that inadequate equipment and skill affected their operations, and also the inability of the law enforcement agencies to prosecute offenders discouraged them (KMA) from arresting people who engaged in indiscriminate waste dumping.

Encouraging householders to separate their waste at source would go a long way to reduce this indiscriminate waste dumping – this is what this research sought to encourage.

## 5.3 WASTE COMPOSITION IN BANTAMA

The low income households produced the highest amount of organic waste (84%) because most of the household mothers were market women who sold organic foodstuffs such as yam, cassava, plantain etc. These women prepared local foods like *fufu, ampesi*, etc for their families resulting in large amounts of organic waste. Most of the middle income households, however, hardly had time for cooking because of their busy schedule and therefore consumed assorted and fast foods like fried rice with vegetables, as well as can foods and drinks. This accounted for their relatively high percentage (32% & 17%) of recyclable waste (metal tins and cans, bottles etc) as compared with low income households which produced 4%. The low income households also produced a relatively high percentage of non recyclable waste of 12% of their waste as compared with the lower middle income group which had only 2%. This was to be expected as people in these households made use of so much black polythene bag. They held almost every item they purchase in a black polythene bag – even cooked foods, regardless of the health implications. They leave their houses to purchase cooked foods from vendors without carrying any bowls, only to return with the food in polythene bag. Most of them also did not practice birth spacing so used a lot of diapers. The lower middle income households however used shopping bags (like cain - woven baskets and plastic baskets) and therefore produced less of the non recyclables. As it was to be expected, household size influences the quantity of waste generated, as it can be seen from the Table 19, where the low income households with the largest size of 6.6 has the highest per capita waste generation per day of 0.97kg. The lower middle income group with household size 6.4 has 0.95kg, whilst the upper middle income which has the lowest household size of 5.0 generated a waste of 0.54kg per person per day. Confirming the assertion that

household size is directly proportional with quantity household waste generated (Ketibuah *et al.*, 2005)

## 5.4 ACCURRECY OF WASTE SEGREGATION

From the results presented in chapter four, it can be deduced that the upper middle income householders were the most effective at the waste segregation, whilst the low income householders were the least successful at the exercise. The total average (accuracy of segregation) was 327.5kg out of a total waste of 400.4kg (82%), representing a general successful trend of segregation. So, one can conclude that the education programme went down well with the people, and that when educated and motivated, segregation of waste at the household level which would encourage waste reuse, and eventually reduce landfill wastes will not be a difficult task for the people.

## 5.5COMPOSTED HOUSEHOLD ORGANIC WASTE

From literature, organic matter refers to the measure of carbon based materials in compost. From the Table 20, the organic matter was found to be an average of 67.3% of the mass of the compost by dry weight. This amount is adequate as it is desirable that organic matter in good compost for agriculture be greater than 50% of the total mass by dry weight.

Carbon nitrogen ratio which indicates the amount of nitrogen in the sample relative to the amount of carbon was found to be 29.5:1 on average. This ratio is within the acceptable range of 20:1 to 35:1 from literature. (Http://soilplantlab.missouri.edu/soil/compost). The pH was also found to be 7.95, within the acceptable range of 5.0 and 8.0 recommended for agricultural compost.

Total carbon was also found to be an average of 38.4%. Total carbon is a direct measurement of all the organic and inorganic carbon in the compost sample. Nitrogen was also found to be 1.3%, in agreement with the normal range which is 1.0% - 5% for most compost. Phosphorus and potassium were determined to be 1.60% and 1.7% respectively. (Http://soilplantlab.missouri.edu/soil/compost).

The compost was also found to be free of pollutants like harmful pathogens as indicated by Table 21(b). From the analysis above, it can be established that household organic wastes in Bantama could be used to make compost that could be used as manure for backyard farming or any other small scale farming.

### 5.6. INCOME FROM SELLING OF SOME WASTE COMPONENTS

Some of the waste items sold included

- Metal tins and cans such as lactogen, milo, cerelac and cowbell cans, as well as mackerel and sardine tins. The cans were sold at 20p each while the tins were sold at 10p each. On average, 51 cans and 85 tins were sold daily for the period of 3 weeks making a total of GH¢392.7.These waste components were sold at the Suame magazine. The artisans at the magazine buy and use these wastes for making simple equipment like coal pot, dust pan, dust bins, wire gauze, etc.
- Plastic bottles such as voltic water bottles were sold at 50p per kilogram. Other plastic bottles were sold at 20p, 10p and 50p. An average of 4.20p was realized daily from these bottles, making a total of 84 cedis. The bottles were cleaned and disinfected to hold oil, herbal medicines, parazone, etc.

- Glass bottles. These were sold at an average of 6 cedis daily for 21 days making a total of 126 cedis. The glass bottles are used for the same purpose as the plastic bottles. The broken ones are used to make beads.
- Used clothes, shoes and bags. An average of 3cedis 65pesewas was realized from the sale of these items for 16 days making a total of 58cedis 40pesewas. These were sold at a place called afleetie adwosuo' at the central market. These items are purchased and sent to the village for sale.



For the period of 21 days that was used for the research a total of 661.1 cedis was realized from the sale of these items. In a year therefore, the 306,248 population of the Bantama community can realize an average of 11,522.03cedis from the sale of some of their waste. These wastes are however left in the homes, drains and gutters to cause nuisance, diseases, environmental degradation, flooding. The researcher therefore wishes to emphasize that people should be encouraged and motivated to engage in waste segregation, re-use and recycling, for this will go a long way to reduce the waste problems in the Bantama community.

# CHAPTER SIX

# CONCLUSION AND RECOMMENDATION

## 6.1 SUMMARY OF FINDINGS

The study has been concerned with minimizing municipal solid waste in Bantama through household solid waste segregation.

To summarize the findings, the research questions are answered as follows:

- Majority of the household heads in Bantama were middle income earners with a sizeable percentage being low income earners. The average household size was found to be 6.8 higher than the 4.9 estimated by the Ghana statistical service in the 2000 population census.
- Most of the household heads in the lower and upper middle class are either public or civil servants, earning at least ¢500 a month.
- Generally the waste situation in the Bantama community was appalling. Many places were engulfed with waste.
- Education of the people on waste segregation went down well with them, evident in their being able to segregate about 82% of their waste accurately.
- On average, the various waste fractions (percentages) of households in Bantama were: organic - 79%, recyclable/reusable - 13% and non-recyclable - 8%. The largest waste component was therefore found to be organic. The low income households produced more waste with their organic being the highest component, whilst the upper middle produced more recyclable waste .than the other income level group. Bantama produces a total of 251,122.54kg (251.12 tons) of waste in a day.
- The organic waste was used to make compost which when analyzed was found to be good manure that can be used in place of inorganic fertilizers in any

backyard garden or backyard farm. Challenges such as space, time and lack of land for backyard farming however discouraged many of the householders from taking part in the compost making exercise.

- Waste components such as plastic and glass bottles, metal tins and cans, old newspapers, old clothes shoes and bags were sold for an extra income of¢661.1 for the 21-day research period.
- The amount of waste transferred to the dumping site decreased to only about 8%.



## 6.2 CONCLUSION

From the research findings, it can be concluded that the current waste disposal methods in Bantama are not effective, evident in the fact that wastes remains uncollected for days (or even weeks) or are dumped in drains and gutters. It can also be concluded that a large percentage (79%) of the waste in Bantama is organic, which makes composting a good option for the area. A reasonable percentage (13%) of the wastes can also be reused or sold to recycling firms by residents for extra income. This would reduce household wastes meant for landfill to only about 8%. Residents in Bantama can segregate about 82% of their 251.12 tons daily wastes correctly. It can therefore be concluded that municipal solid waste in Bantama can be minimized through household waste segregation.

## 6.3 RECOMMENDATIONS

The following recommendations are made based on the findings of this research:

- The government, donor countries and stakeholders in waste management should consider solid waste segregation at source as a better alternative

to the current available waste management options such as: pay as you dump and the polluter pays policy. The reason is that those who cannot pay will dump their waste at illegal places when no one is watching. Some residents confessed to this during the study.

- It was observed during the research that some residents already had some knowledge on waste segregation and its importance, for those who had no idea, just a little education was enough to make them literate on the concept, as such the public should be educated on solid waste segregation and its advantages through media channels such as the radio and television.
- The research showed that some residents in the low income group could not even afford three square meals a day, let alone be able to purchase different waste bins for segregation. They agreed to take part only after they had been provided with bins. The metropolitan assemblies should therefore make it a responsibility for introducing and providing homes with waste bins of different colours for segregation.
- In order to develop the habit of waste sorting in residents, they must be motivated and encouraged. This can be done by making correctly segregated household waste components attract a fee of some sort. This suggestion stems from the researcher's experience where some residents actually had to be given incentives before they agreed to participate in the waste segregation exercise. The argument that there are no funds should not come in; this is because municipal authorities and the National Disaster Management Organization (NADMO) manage to find funds to bring relief to victims when disasters like floods and epidemics

like cholera occur. These problems are partially caused by choked gutters and drains as a result of poor waste management, as confirmed by Mr. Sylvester Azantilow, deputy national co-coordinator, NADMO. He said that many of the floods in the country are caused by filth and choked gutters, after which victims would have to be provided with relief items like food, mattresses, etc.

(http //:www.ghananewsagency.org/details/soci)

It would be a better option to prevent than to rectify, since lives lost in these disasters cannot be bought back with money.

## 6.4 AREA FOR FURTHER RESEARCH

Further research that collects data from a larger sample may be carried out. This would increase the precision of the analysis and enable firmer conclusions to be drawn.

Studies based on the methodology used in this study may be carried out in other sub-metros in Kumasi or in Ghana.

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## APPENDIXES

### APPENDIX I:
### QUESTIONNAIRE FOR HOUSEHILD SURVEY

Dear resident

I am carrying out a study to assess the solid waste situation in this area. The purpose of this questionnaire is to find out about your household waste disposal needs, the waste disposal Services you receive and how you perceive the solid waste situation in this area. The ultimate Goal of the study is to find ways of improving solid waste management in the Bantama community. As a resident of this area your views and ideas are considered very important for the success of this study and it would be very much appreciated if you could spend a little time to answer this questionnaire.

---

**A. Socio-economic characteristics**

1. Which part of Bantama do you reside?
2. How long have you lived in this neighborhood? Years …… months……
3. How many people live in your house? ……..……
4. What is the highest educational attainment of your household head?

- Tertiary (University/Polytechnic) [ ]
- Secondary (College, SSCE) [ ]
- Primary [ ]
- No formal education [ ]

5. What is the employment status of your household head?

- Employed [ ]
- unemployed [ ]

6. . If employed, what is the nature of occupation? ……..
7. Average monthly income of household head ……

**B. General waste situation**

1. Please indicate the items commonly found in your household waste and how often you generate them

| **Common household waste items** (e.g. food waste, paper, plastic) | **How often do you generate this?** (e.g. daily, weekly, occasionally) |
|---|---|
| | |

2. How do you store your waste before disposal?
- In a closed container [ ]
- In an open container [ ]
- In a polythene bag or sack [ ]
- Other [ ] **Please indicate**:……

3. In the table below, please indicate with a tick (√) the type of waste collection service available to your household.

| **Waste collection service** | **(√)** |
|---|---|
| Home collection | |
| Roadside collection | |
| Truck visit | |
| Communal container | |
| Waste dump | |
| Other (Please indicate) | |

4. In the table below, please indicate your service provider and frequency of the service.

| **Service provider** | **Frequency of service** |
|---|---|
| | |

5. Is your service provider able to keep to the agreed schedule for waste collection?
- Yes [ ]
- No [ ] what do you do with your waste then?…….

6. Is a waste dump close to your home or other homes?
- Yes [ ] how close is it to the nearest homes?…….(e.g. distance in metres)
- No [ ]

7. Is the waste dump maintained (e.g. is the waste regularly removed or burned)

- Yes [ ] who maintains it? ……..
- No [ ]

8. Do you suffer any nuisance associated with the waste dump?

- Yes [ ] what do you suffer from?.....
- No [ ]

9. How will you describe the sanitation situation at the waste dump?

- Very satisfactory
- Satisfactory
- Poor
- Very poor

10. Please indicate how you dispose of your waste

- Burning [ ]
- In the bush/ roadside/ drain [ ] specify:…….
- Burying [ ]
- Other method [ ] specify:……..……

11. Why do you dispose of your waste by this method?

- I have no waste collection service [ ]
- I cannot afford service fee [ ]
- Other reason (please indicate) [ ] ……..……

12. Do you know of any environmental problems associated with your method of waste disposal?

- Yes [ ] what are they?.....
- No [ ]

13. Do you find your waste disposal arrangement convenient?

- Yes [ ]
- No [ ]. Why is it not convenient?.....

14. How will you describe the general waste situation in your neighborhood?

- Very satisfactory [ ]
- Satisfactory [ ]
- Poor [ ]
- Very poor [ ]

15. Do you pay for your waste disposal service?

• Yes. [ ]
In the table below, please indicate how you pay for your waste collection service

| How often do you pay? | How much do you pay? | Who do you pay to? | Is it affordable? |
|---|---|---|---|
| | | | |

• No. [ ] Are you willing to pay for your waste disposal service?

□ Yes [ ] why? ……

□ No [ ] why? ……

16. . How much are you willing to pay each month for the following types of service?

| Weekly home Collection | Weekly roadside Collection | Regular block or communal container Service |
|---|---|---|
| GH¢ | GH¢ | GH¢ |

17. Do you think all households/businesses in this city should pay for waste disposal?
- Yes [ ] why do you think so?.....
- No [ ] Why do you think so?.....
- Who should pay?……
- Who should not pay? ……..

18. How will you describe the quality of waste disposal service you receive?
- Very satisfactory [ ]
- Satisfactory [ ]
- Poor [ ]
- Very poor [ ]

19. Do you and your neighbors ever discuss the waste situation in this neighborhood?

- Yes [ ] what have you? ……..……..……..
- No [ ] why don't you? …….

20. If you were to compare with other communities or suburbs in this city, would you say your community receives a fair share of resources for waste disposal?

- Yes [ ]
- No [ ]. Why?…….

21. How would you rank environmental sanitation in your community in relation to others in the city?

- One of the cleanest neighborhoods
- Averagely clean
- Dirty
- One of the dirtiest communities in the city

22. In your view, how can waste disposal be improved in your community?

……..……
……

**C. Knowledge on waste segregation**

1. Are you aware that the waste you generate can be separated into various components?

- Yes [ ]
- No [ ]

2. Have you sold any component(s) of your household waste before?

- •Yes [ ] which component(s)? .....
- No [ ]

3. Do you have a backyard farm?

- •Yes [ ]
- •No [ ].

4. Would you want to establish one?

- Yes [ ]

- No [ ]

5. Are you aware that food wastes can make the soil fertile for farming?
- Yes [ ]
- No [ ]
6. Would you like to ask any question or make some further comments with regard to what we have just discussed?

……

……

……



*Thank you for your time and assistance*

## APPENDIX II

### INTERVEIW QUESTIONS FOR K.M.A OFFICIALS

Designation.…….....

Professional background of officer:…….……

**A. Finance**

1. What are your sources of finance?
2. Are you able to acquire adequate funds for your operations?
3. What proportion of the required funds are you able
4. Do your service clients pay waste disposal levies?
5. Are there any potential sources where you could generate additional funds?
6. In your view, what could be the solution to the finance problem of the waste sector?
7. Have you received any donor support for waste management in recent years?

**B.Personnel**

8. What categories of staff are employed in the waste department?
9. Is it easy to attract staff to the waste sector?
10. Do you have any programmes for staff training?

**C. Land**

11. Are you able to secure enough suitable land for the sitting of waste disposal facilities?
12. How do you respond to the problem of land shortage for waste disposal?
13. What do you consider to be the major constraints to waste management in your city?

**C. private sector participation**

14. Is the private sector involved in waste management in this city?
15. When did private sector involvement start in this city?
16. What prompted the involvement of the private sector in waste management?

*Thank you for your time and assistance*

## APPENDIX III

## MEMBERS OF A HOUSEHOLD THAT PARTICIPATED IN THE STUDY

## APPENDIX IV

## SATISTICAL ANLYSIS OF WASTE COMPOSITING IN BANTAMA

### DESCRIPTIVES

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound | | |
| Organic | Low Income | 30 | 5.4267 | .91498 | .16705 | 5.0850 | 5.7683 | 2.40 | 7.30 |
| | Lower Middle Income | 25 | 4.9600 | 1.11131 | .22226 | 4.5013 | 5.4187 | 2.80 | 7.20 |
| | Upper Middle | 20 | 1.4400 | .61883 | .13837 | 1.1504 | 1.7296 | .48 | 2.93 |
| | **Total** | **75** | **4.2080** | **1.92116** | **.22184** | **3.7660** | **4.6500** | **.48** | **7.30** |
| Recyclable | Low Income | 30 | .2567 | .14639 | .02673 | .2020 | .3113 | .12 | .64 |
| | Lower Middle Income | 25 | 1.0320 | .70021 | .14004 | .7430 | 1.3210 | .03 | 3.00 |
| | Upper Middle | 20 | .8700 | .29397 | .06573 | .7324 | 1.0076 | .30 | 1.80 |
| | **Total** | **75** | **.6787** | **.56024** | **.06469** | **5498** | **.8076** | **.03** | **3.00** |
| Nonrecyclable | Low Income | 30 | .7467 | .16206 | .02959 | 6862 | .8072 | .50 | 1.25 |
| | Lower Middle Income | 25 | .1320 | .03629 | .00726 | 1170 | .1470 | .10 | .27 |
| | Upper Middle | 20 | .4100 | .13195 | .02950 | .3482 | .4718 | .20 | .62 |
| | **Total** | **75** | **.4520** | **.29234** | **.03376** | **.3847** | **.5193** | **.10** | **1.25** |

**ANOVA**

| | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Organic | Between Groups | 211.929 | 2 | 105.964 | 124.675 | .000 |
| | Within Groups | 61.195 | 72 | .850 | | |
| | Total | 273.123 | 74 | | | |
| Recyclable | Between Groups | 9.196 | 2 | 4.598 | 23.595 | .000 |
| | Within Groups | 14.030 | 72 | .195 | | |
| | Total | 23.226 | 74 | | | |
| Nonrecyclable | Between Groups | 5.200 | 2 | 2.600 | 166.542 | .000 |
| | Within Groups | 1.124 | 72 | .016 | | |
| | Total | 6.324 | 74 | | | |

## APPENDIX V

## AVERAGE MASS OF WASTE COMPONETS FOR THE HOUSEHOLDS IN KG

### LOW INCOME

| Household | Household size | Average waste generated (in 3 weeks)/kg |
|---|---|---|
| 1 | 12 | 6.3 |
| 2 | 7 | 3.8 |
| 3 | 8 | 3.95 |
| 4 | 7 | 4.15 |
| 5 | 11 | 5.43 |
| 6 | 6 | 2.62 |
| 7 | 5 | 3.04 |
| 8 | 7 | 2.78 |
| 9 | 6 | 2.49 |
| 10 | 5 | 1.0 |
| 11 | 8 | 3.1 |
| 12 | 7 | 3.16 |
| 13 | 4 | 0.87 |
| 14 | 5 | 3.2 |
| 15 | 6 | 2.91 |
| 16 | 5 | 2.45 |
| 17 | 5 | 4.7 |
| 18 | 9 | 3.51 |
| 19 | 6 | 3.63 |
| 20 | 7 | 2.45 |
| 21 | 5 | 2.86 |
| 22 | 5 | 2.21 |
| 23 | 6 | 0.96 |
| 24 | 5 | 2.8 |
| 25 | 6 | 2.91 |
| 26 | 6 | 3.73 |
| 27 | 5 | 3.31 |
| 28 | 4 | 4.66 |
| 29 | 5 | 1.79 |
| 30 | 5 | 2.8 |

**LOWERMIDDLE INCOME**

| Household | Household size | Average waste in 3 weeks |
|---|---|---|
| 1 | 5 | 2.9 |
| 2 | 8 | 3.98 |
| 3 | 5 | 3.23 |
| 4 | 7 | 3.55 |
| 5 | 4 | 3.57 |
| 6 | 6 | 3.81 |
| 7 | 8 | 3.1 |
| 8 | 3 | 1.6 |
| 9 | 5 | 1.99 |
| 10 | 5 | 2.38 |
| 11 | 6 | 2.7 |
| 12 | 4 | 1.84 |
| 13 | 5 | 2.31 |
| 14 | 5 | 2.38 |
| 15 | 6 | 2.85 |
| 16 | 4 | 2.07 |
| 17 | 6 | 2.38 |
| 18 | 8 | 3.71 |
| 19 | 4 | 3.77 |
| 20 | 7 | 3.24 |
| 21 | 11 | 2.44 |
| 22 | 5 | 1.55 |
| 23 | 8 | 1.98 |
| 24 | 4 | 1.49 |
| 25 | 6 | 1.79 |

**UPPER MIDDLE INCOME**

| Household | Household size | Average waste in 3weeks\|kg |
|---|---|---|
| 1 | 5 | 0.33 |
| 2 | 4 | 1.81 |
| 3 | 6 | 0.79 |
| 4 | 5 | 2.03 |
| 5 | 4 | 1.87 |
| 6 | 5 | 2.16 |
| 7 | 3 | 0.31 |
| 8 | 5 | 0.22 |
| 9 | 3 | 1.89 |
| 10 | 4 | 3.03 |
| 11 | 5 | 2.16 |
| 12 | 5 | 0.33 |
| 13 | 4 | 1.81 |
| 14 | 6 | 0.79 |
| 15 | 3 | 0.31 |
| 16 | 5 | 0.22 |
| 17 | 3 | 1.89 |
| 18 | 4 | 3.03 |
| 19 | 5 | 2.16 |
| 20 | 5 | 0.33 |

**APPENDIX VI**

**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF RENEWABLE NATURAL RESOURCES**

**ANALYSIS SHEET FOR COMPOST**

**DATE…10/ 01/12**

| **SAMPLE** | **NITROGEN** | **PHOSPHORUS** | | **POTASSIUM** | **ORGANIC MATTER** | **CARBON** | **N:C** | **pH** |
|---|---|---|---|---|---|---|---|---|
| | % Total | % Total | mg/g | % Total | % | **%** | | |
| **SAMPLE ONE** | **1.20** | **1.60** | **1.44** | **1.80** | **67.2** | **38.4** | **30.0:1** | **7.94** |
| **SAMPLE TWO** | **1.40** | **1.60** | **0.727** | **1.60** | **67.4** | **38.4** | **29.0:1** | **7.96** |

**CLIENT:** **CHECKED BY: NAPOLEON MENSAH**

**SIGN:……** **SIGN:……..……**