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SPATIAL DISTRIBUTION OF SOLID WASTE COLLECTION POINTS IN KMA AND THE COMMUNITY PERCEPTION ABOUT SOLID WASTE MANAGEMENT

BY

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CERTIFICATION

I hereby declare that this submission is my own work towards the MSc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

There is a considerable amount of indiscriminate refuse disposal in many urban areas, most especially of the third-world countries. This study focuses on the spatial distribution of solid waste collection points in the Kumasi metropolitan assembly. It further examined the attitudes and perceptions of the community on the collection points usage and the solid waste management system. The methodology employed involved the use of GPS to pick the coordinates of the solid waste collection points, GIS to produce maps; and a questionnaire through which 400 copies were distributed accordingly across all the nine sub metropolitan areas in the metropolis, 322 were filled and returned completely and successfully, and were used for the analysis to make a generalization. The study area is sub-categorized or zoned into 9 sub metropolitan areas (locations) of which Subin, Oforikrom, Kwadaso, Nhyiaeso and Suame sub metros had 13(10.4%),20(16%), 19(15.2%), 15(12%) and 8 (6.4%) respectively. The rest are Tafo, Bantama, Asokwa and Manhyia sub metros also with 11(8.8%), 18 (6.4%), 11(8.8%) and 10(8.8%) respectively. Thus, it was assumed that almost all the inhabitants in the nine mentioned sub metropolitan area above dispose their solid waste in the legal collection points, therefore, 10 collection points each in the various sub metros were sampled in a stratified manner. And SPSS was used to analyse the data gathered using the questionnaire; and the results were discussed and presented using frequency and cross-tabulated tables, and charts on the attitudes of the community usage of the solid waste collection points and their perceptions toward the refuse management system. The study discovered a total of 125 solid waste collection points distributed unevenly across the nine sub metropolitan areas (locations) in the Kumasi Metropolitan Assembly. Of the 125 Solid waste collection points, all seem legal and certified and authorised by the KMA, Waste management department(WMD) with a few satellite ones which seem temporal. The solid waste collection points are made up of two types of collection facilities: Roll-on Roll-off

(roro) and skip collection containers, the former are 21 (16.8%), while the later are 104 (83.2%). The research also revealed that the number of indiscriminate solid waste disposal increases as you move from high to low density settlement areas, while the sizes of the refuse heaps increase from low to high density settlement areas. Finally, the study find out that no municipal solid waste management can be effective without proper monitoring of its disposal activities, and public enlightenment.

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TABLE OF CNTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Solid waste consists of everyday items that are used and then thrown away as waste. Waste are primarily generated from homes, school, public place /parks [EPA Ghana, 2006]

Man in an attempt to satisfy his daily needs, gets engaged in the production of goods and services .In the process waste is generated (Beede and Blown, 1995).Virtually all aspect of man's production activities generate waste (Mohammed, 2007). The way and manner these waste are handled, stored, collected and disposed of can pose risk to the environment and to the public health.

Solid waste generation is experiencing a rapid increase all over the world as a result of continuous economic growth, urbanisation and industrialisation.It is estimated that in 2006 the total amount of municipal solid waste (MSW) generated globally reached 2.02 billion tonnes representing about 7% annual increases since 2003. It is further estimated that between 2007 and 2011, the global generation of solid waste rose by 37.39% equivalent to roughly 8% per year (Global Waste Management report 2007)

Solid waste management in the urban areas is one major challenge facing city planners and lack of adequate resource contributed to the poor state of solid waste management (Obrilih, et al, 2002, Mato 1999 Doan 1998 and Mwanthi et al, 1997). Wanless (2009)noted that waste differ from developed and developing nations, urban and rural areas etc.

Increase waste generation and indiscriminate disposal in the major urban centres of Africa have shown that the problem of waste management has become a major challenge which has rendered abortive most effort being made by city planners and local governments

According to KMA, waste management department, 2014, an average person in Kumasi generate about 0.35 to 0.54 kg of solid waste per day and almost 90% of the total urban waste is generated from households and commercial or public places.

The inability of successive government to manage solid waste effectively in Ghana has become an issue of great concern.This is so because apart from the distribution of aesthetic of land scope by the waste dumpsites, some of the municipal solid waste (MSW) contains both organic and inorganic toxic pollutants (heavy metal that threaten health of human beings(sridhalr et al 1989). Proper management of solid waste is critical to the health and well-being of urban resident (World Bank, 2003). In urban areas especially in the rapidly urbanizing cities of developing world, problems and issues of municipal solid waste (MSW) management are of immediate importance.According to the Zurbrugg (2003), there is phenomenal increase in the volume and diversity of solid waste generation.

1.2 Problem statement

Kumasi, the capital of Ashanti region has been experiencing immense population growth since its existence. As such there is also increase in residential, commercial, industrial and institutional land use leading to urban expansion.The simultaneous increase in population and settlement expansion of the city has a direct effect on the increase in solid waste generation.According to KMA waste management department, 2014, about 90% of waste generated in Kumasi is from residential and commercial sources.

Due to this the department in collaboration with the environmental health directorate i.e. (WMD and RESD) have created a number of designated solid waste collection sites for community storage for onward hauling and transportation to the final disposal sites. Despite this, refuse or waste is still seen to be littered in and around the entire metropolis day in and day out.

A lot of undesignated refuse dumps have been created especially on our main roads making the area clumpy and very congested. Improper waste disposal is also another issue of concern and should be addressed.

Storm drains and other waste passage have been turn to refuse dump sites which causes excessive flooding during raining season and sometimes leading to unpleasant odour due to stagnation of water bodies.

KMA, WMD, noted that there is improper allocation and distribution of solid waste collection sites in Kumasi, leading to setbacks which need to be addressed. Proliferation of illegal waste collection sites and indiscriminatedumping of refuse at any available space has become a common scene in the major towns of Kumasi and there seem to be no available map showing the distribution of refuse collection point in Kumasi. Thus these maps produced at the end of this study will be of vital importance to both planners and managers who are concerned with the management of solid waste in the metropolis.

1.3 Aim and objectives

The primary aim of this study is to examine the spatial distribution of communal solid waste collection sites in Kumasi with a view to understanding the criteria for sites selection and the community perception of solid waste management.

The following specific objectives seek to be achieved

To locate all the communal solid waste collection sites in Kumasi spatially.

To study the type of solid waste collection sites

To map the solid waste collection sites using GIS

To find out the criteria used for sites selection of properly located collection sites by KMA WMD and RESD and to be able to suggest and predict more sites using the site selection criteria.

To assess the community perception of solid waste management in their area.

1.4 Justification

The alarming rate at which heaps of solid waste occupy most of the street of the cites in Ghana, coupled with the fact that most Ghanaians use methods seen to be insanitary has not only constituted unpleasant odour but has also brought about the breeding of rodents, insects and other pest of public health importance with their attendant diseases outbreak.

Increase in commercial, residential and infrastructural development due to population growth and urban expansion in Kumasi is directly affecting the amount of waste generated in Kumasi. This is of vital importance to the study of the spatial distribution of solid waste collection sites for both planning and management purposes.Poor distribution of solid waste collection sites triggers indiscriminate waste disposal into places like water ways causing flooding and congestion in our street and into open spaces and uncompleted building causing unpleasant odour due to water stagnation and diseases to human settlement.

Flooding on our major road and market centres as experienced early this year and still being experienced is due to silt and solid waste blocking the drains and other outlets provided. The high incidence of improper waste management related disease such as cholera, typhoid, diarrhoea are common in urban areas. (Fobil, J.N. *et al*, 2007.).

This research is to study the spatial distribution of properly sited solid waste collection sites, the criteria for sites selected for these sites by the WMD and examine the attitude of the community on the usage of solid waste collection sites and their perception on the refuse management system to come up with suitable recommendations toward better solid waste management strategy.

Furthermore, there is no existing map showing the spatial distribution of the sites in Kumasi. Hence the study is aimed at filling the gap by producing a map showing the spatial

distribution of the sites which will be of great importance for both planning and management purpose

1.5 Scope and limitations

The spatial scope of the study concerns only Kumasi metropolitan assembly, this comprises all the nine sub metropolitan areas of the metropolis. In terms of the depth of investigation, the research is restricted to the spatial distribution of solid waste collection points, their geographical location (coordinates) and addresses and the criteria for site selection of solid waste collection points by the waste management department of KMA and the attitudes of the community on the usage of the solid waste collection points and their perception on the refuse management system.

The limitations of this research is no more than the fact that, the researcher had only little familiarisation with the various solid waste collection points scattered in the study area before the field work and the study area which comprises the whole KMA is very large, as such, there might be overlapping and encroachment in some cases with respects to the locations (areas) of the solid waste collection points, as he only recorded what the inhabitants have told him as the name of the area. However, the researcher tried as much as possible to minimize all sorts of errors.

CHAPTER TWO

LITERATURE REVIEW

2.1 Waste

Waste is more easily recognised than defined. Something can become waste when it is no longer useful to the owner or it is used and fails to fulfil its purpose (Gourlay, 1992 cited by Freduah, 2004), though now waste is defined more technically as "MINT", Material IN Transition by the District environmental sanitation strategy and action plan (DESSAP). What this actually means is that, waste itself is not waste but always useful at every stage. There are basically two types of waste namely liquid and solid waste. But for the purpose of the study, the focus is on solid waste. This is discussed in the next section of the review.

2.1.1 Solid Waste

The term solid waste has been defined differently by various authors. Solid waste is any material that arises from human and animal activities that are normally discarded as useless or unwanted (Tchobanoglous *et al*, 1993). According to Zerbock (2003), solid waste includes non-hazardous industrial, commercial and domestic waste including:

• Household organic trash

• Street sweepings

• Institutional garbage and

• Construction wastes.

The Ghana Innovation Market Place (2009) popularly known as 'GIM` defines solid waste as neither wastewater discharges nor atmospheric emissions, arising from domestic, commercial, industrial, and institutional activities in an urban area. Operationally, it can therefore be said that solid waste is any material which comes from domestic, commercial

and industrial sources arising from human activities which has no value to people who possess it and is discarded as useless.

2.1.2 Sources of solid waste.

Tchobanoglous *et al,* (1993), classified types of solid waste in relation to the sources and generation facilities, activities, or locations associated with each type

Food waste*:* Food wastes are all the animal, plant or vegetable residues resulting from the handling, preparation, cooking, and eating of foods (also called garbage). The most important characteristics of these waste is that they are highly putrescible and will decompose rapidly, especially in warm weather. Often, decomposition will lead to the development of offensive odours. In many locations, the putrescible nature of these wastes will significantly influence the design and operations of solid waste collection.

Rubbish*:* Rubbish consists of combustible and non- combustible solid wastes of households, institutions and commercial activities. This excludes food wastes or other highly putrescible materials. Typically, combustible rubbish consists of materials such as paper, cardboard, plastics, textiles, rubber, leather, wood, furniture, and garden trimmings. Non-combustible rubbish consists of glass, tin cans, aluminium cans, ferrous and other non-ferrous metals, and dirt.

Ashes and Residues*:* These are materials remaining from the burning of wood, coal, coke and other combustible wastes in homes, stores, institutions, and industrial and municipal facilities for purposes of heating, cooking and disposing of combustible wastes. These are referred to as ashes and residues.

Special waste*:* Special waste includes street sweepings, roadside litter, and litter from municipal containers, catch-basin debris, dead animals and abandoned vehicles.

The Centre for Environment and Development (2003) has also classified types of solid waste based on origin (food waste, rubbish, ashes and residues, demolition and construction, agriculture waste), based on characteristics (biodegradable and non-biodegradable), based on the risk potential (hazardous waste and non harzadous). The Centre also enumerated sources of solid waste as residential, waste from shops, commercials establishment, hotels, restaurants, eating stalls, slaughter houses and others. This has confirmed the sources and types of solid waste outlined by Tchobanoglous *et al*, (1993). Based on the types of solid waste enumerated by Tchobanoglous *et al*, (1993) and the Centre for Environment and Development (2003), it can be said that types of solid waste include the following. Food waste, rubbish, ashes and residues, demolition and construction, and agriculture waste. The sources of solid waste also include domestic, commercial and industrial.

2.1.3 Components of Solid Waste

Solid waste consists of many different materials. Therefore, a detailed understanding of the composition of solid waste will indicate the management methods that will be used. Solid waste is composed of combustibles and non-combustible materials. The combustible materials include paper, plastics, yard debris, food waste, wood, textiles, disposable diapers, and other organics. Non-combustibles also include glass, metal, bones, leather and aluminium (Denison and Ruston 1990; Kreith 1994 and Zerbock 2003).

2.2. Solid Waste Management

The term solid waste management has been viewed differently by various authors. Kumah (2007) defines solid waste management as "the administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of waste". However, Tchobanoglous et al, (1993), provide a more comprehensive definition of solid waste management. According to them, solid waste management is:

".....that discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations and that is also responsive to public attitudes".

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

2.2.1 Solid Waste Management Processes

The key elements in solid waste management include: waste generation, storage, collection, transfer and transport, processing and recovery and final disposal. This means that when waste is generated it is first stored in solid waste refuse containers; either rolls on/off or skips. It is then collected and finally disposed of in landfills. Also, when waste is collected it can be transferred from small collection equipment like the tricycles introduced by zoomlion to a bigger truck for final disposal. On the other hand, waste collected can be processed and recovered for materials to be reused.

2.2.2 Solid Waste Management in Ghana

Over the years, solid waste disposal in Ghana has become a major challenge to MMDAs. As a result of urbanisation and increasing populations, Metropolitan Assemblies find it difficult to deal with the large quantities of solid waste generated. This is due to the fact that, people resort to indiscriminate dumping as the only means to managing their domestic solid waste thus resulting in littering and heaping of waste. This section of the review analyses solid waste management processes in Ghana with KMA as a case study. These include collection

and disposal as well as waste management regulation and policy in Ghana. The next sub-section discusses solid waste generation inKMA.

2.3 Waste Generation

Waste generation encompasses those activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal (Momoh and Oladebeye, 2010). According to UNEP (2009), in 2006 the total amount of municipal solid waste (MSW) generated globally reached 2.02 billion tones, representing a 7 per cent annual increase since 2003. It is further estimated that between 2007 and 2011, global generation of municipal waste will rise by 37.3 per cent, equivalent to roughly 8 per cent increase per year (UNEP, 2009). The programme also says that, as per WHO estimations, the total health-care waste per person per year in most low income countries, is anywhere between 0.3kg to 0.5kg.

2.3.1 Solid Waste Generation According to Mensah and Larbi (2005), based on an estimated population of 22 million and an average daily waste generation per capita of 0.45 kg, Ghana generates annually about 3.0 million tonnes of solid waste. That notwithstanding, the causes of this increase should have been enumerated by the organisation and therefore, has not exhausted the issue on discussion. It is accepted that solid waste generation is increasing at a faster rate globally as indicated by UNEP and this is confirmed by Mensah and Larbi (2005) concerning solid waste generation in Ghana. Waste generated daily in Accra was between 1500-1800 tonnes. According to Anomanyo (2004) about 1800 tonnes of municipal solid wastes were generated per day in the Accra Metropolis and the average waste generated per capita per day was estimated at 0.5 kg. He attributed this to the rate of population growth in the Metropolis which stood at 3.5 per cent. Waste from domestic sources include, food waste, garden waste, sweepings, ash, packaging materials, textiles and electric and electronic waste with organic waste being the major component. This constituted about 65 per cent of the solid waste component. According to him, the high proportion of food and plant waste was due to

the fact that Ghana's economy largely depended on agricultural products for export and domestic consumption. But the waste rate of AMA was about 2000 tonnes a day with per capita waste generation of 0.45kg (AMA, 2009). Also, according to KMA (2013), the current domestic waste generation rate in Kumasi was approximately between 1500-1800 tonnes a day. This was based on the projected population of over 2,000,000. According to Ketibuah et al (2010), in Kumasi the bulk of household waste is found to be organic waste which includes food waste and putrescible waste with an average of 55 per cent. Having discussed the quantities and composition of waste generated in the two Metropolises, this leads the discussion on solid waste collection in the next sub-section.

2.3.2 Storage

Tchobanoglous *et al*, (1977) explain storage to mean where solid waste is stored before it is collected. It could be stored in a skip, roll on/off or dustbins and not thrown away indiscriminately. According to them, storage is of primary importance because of the aesthetic consideration.

2.3.3 Collection

The element of collection includes not only the gathering of solid waste, but also the hauling of waste after collection to the location where the collection vehicle is emptied (Kreith, 1994). According to Kreith (1994), the most common type of residential collection services in the United States include "curb", "set out-setback" and "backyard carry". According to the USPS (2000), in the city of Thimphu in Bhutan, the collection of solid waste from households, commercial set-ups was done in concrete receptacles placed at strategic points and conveyed by trucks/tractors. Accordingly, there were concrete bins and containers provided at various locations from where the waste was lifted for disposal. Individual bins/containers were also placed alongside the shops in certain areas, which were emptied directly into the trucks/tippers. This prevents people from dumping waste indiscriminately.

On the other hand, the building of these concrete bins and containers may be expensive to do in Ghana. However, in Ghana and for that matter, Kumasi, concrete platforms are built, on which metal skip and roll on/off containers are placed.

2.3.3.1 Solid Waste Collection

According to Tsiboe and Marbel (2004), there are basically three methods of household waste collection in Accra which is replicated in Kumasi.

• Waste Management Department (WMD) curb side collection by trucks directly outside each house. According to them, this collection method was provided weekly in the high-income residential areas like Patase, Kwadaso estate and Nhyiaeso by compactor trucks. This type of solid waste collection is popularly known as door to door refuse collection or better still, house to house refuse collection.

• WMD collection from communal containers to which people must bring their own waste. These were restricted to low-income areas like Aboabo, Asawase and a host of other areas amounted to over 125 communal containers. Households that could not afford the house to house collection service took their waste to any of these communal containers and from which the waste management department and other private waste management companies collected the waste and disposed of it at the landfill site (Stephens et al 1994: 25) cited in Tsiboe and Marbell (2004).Door-to-door collection services in middle-income areas like Labadi. According to Anomanyo (2004), for the purpose of effective waste collection, the city was demarcated into waste collection districts where a company was contracted by AMA to collect waste in one district or two. Fifteen (15) waste collection companies were contracted. These include: Liberty Waste Service Company, Vicma Waste Construction, Ako Waste Management Limited, Gee Waste Limited and Daben Cleansing Construction Services Limited. The main types of vehicles used by AMA were compaction and skip trucks. The wastes were taken by road directly to the disposal sites. There were no waste transfer stations.

According to him, solid waste collection in the city was carried out both on franchise and contract basis. On the franchise basis, a house-to-house collection was done in high income areas and the contractors charged the households some fees with weekly collection frequency. These areas were well-planned residential areas with access roads described as first and second class areas and include areas as Airport residential area and Cantonments. Each household had plastic containers with covers. These contractors then paid a tipping fee to the AMA for the use of its dump site. The user fees charged form about 20 per cent of general service to the beneficiaries whose wastes were collected. On contract bases, waste contractors were paid by AMA to perform both block and communal container collection. Block collection occurred in middle-income residential areas including Dansoman, Adabraka, Kaneshie and other parts of Accra. Approximately 75 per cent of the waste generated was collected in these areas. Central communal skip collection occurred in low income high population density and deprived residential areas such as James Town, Nima and other parts of Accra where houses were not well planned with poor or even no access roads (third class areas). Market places were also covered under this arrangement. Residents deposited their waste in such communal containers and the frequency of collection was at least once daily. Waste generators here did not pay user charges. He added that despite the strategies put in place for the collection of waste in Accra, maximum waste collection was not achieved. Between 65 and 75 per cent of waste was collected per day.

According to KMA (2014), there are two modes of waste collection in the Kumasi Metropolis. These are house-to-house and communal collection. According to the Kumasi Metropolitan Assembly, Sak-M Company Limited, Meskworld Limited (ML), Kumasi Waste Management Limited (KWML), Zoomlion Gh. Ltd, Venmark Co. Ltd, Asadu Royal Waste and Anthoco were contracted for solid waste collection. This service covers theentire Kumasi Metropolis but payment for the service was irregular. A monthly fee of GH¢7 and GH¢10 per

household is charged for 120L and 240L bins respectively which has currently been reviewed to GH¢10 and GH¢15 respectively. Additionally, the communal collection was awarded to the above mentioned waste management contractors. The total quantities collected used to be weighed at the Oti engineered landfill site at Dompoase and payment based on a rate of GH¢ 15 per tonne but currently, according to the management of the landfill, the weighing bridge is broken down and therefore an average weighted tonnage is used.

From the above assessment, it can be deduced that there are basically, two main modes of waste collection in AMA and KMA. These are door-to-door or house-to-house collection and communal collection which are carried out in the high class and low class residential areas respectively. In KMA, waste collection is charged per house. However, the door-to-door collection may not favour the poor or low income areas and therefore there is the likelihood of poor waste collection services in these areas. Additionally, attention on collecting solid waste in these areas will be less. So there is the tendency for residents to dump waste any how because of poor collection service.

However, to use income as measure to stratify residential areas in cities like Accra and Kumasi may be misleading. This is because those living in the supposedly low income residential areas may be well to do than those residing in the high income areas as indicated by Stephen et al (1994) and accepted by Tsiboe and Marbell (2004). This means that Tsiboe and Marbell did not critically examine the text before accepting it. Instead, the class of buildings, willingness and ability of the people to pay for the collection service should have been considered.

2.3.4 Disposal

Solid waste disposal is the ultimate fate of all solid wastes. It is actually the final stage of the solid waste management process. They are collected and transported directly to landfill site. Having explained the various elements in the diagram by some authorities, the next section

analyses in further details the final disposal methods of solid waste. Several methods of solid waste management have evolved over the years. These methods according to the Centre for Environment and Development (2003), vary greatly with types of wastes and local conditions. For the purpose of this analysis, this section is divided into early practices of managing solid waste and contemporary methods of waste management systems.

2.3.4.1. Solid Waste Disposal

According to Anomanyo (2004), waste disposal from households in AMA took different forms. These are represented in figure below.

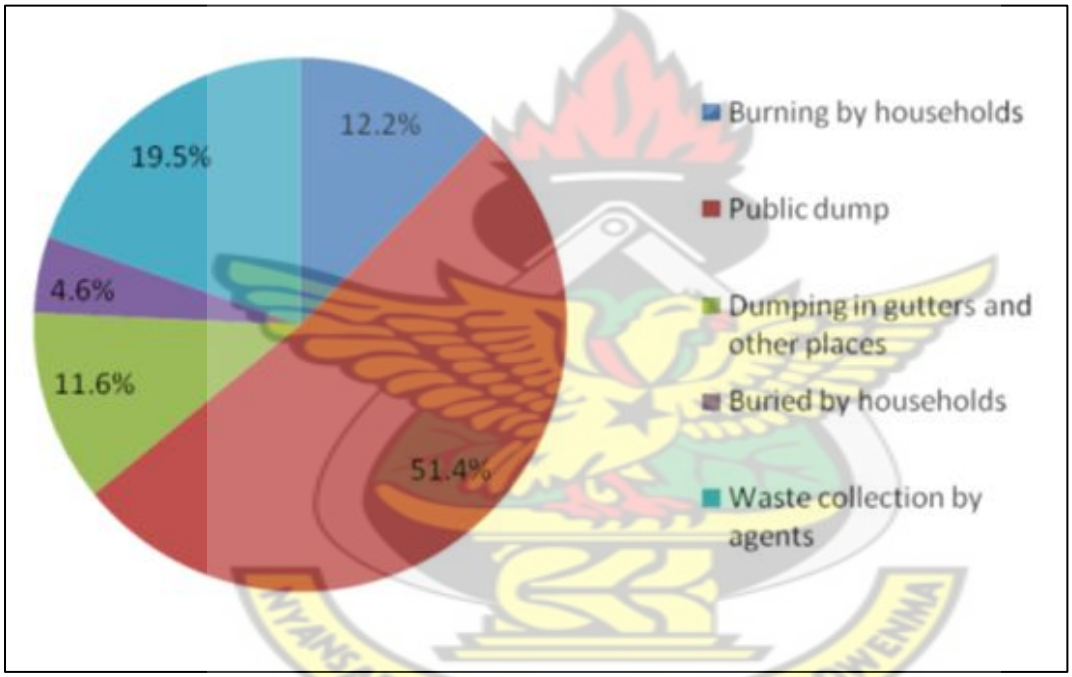

Figure 2.1 Ways of solid waste disposal

It can thus be ascertained that out of the about 1800 tonnes of waste generated, only 19.5 per cent was collected. Anomanyo (2004), further added that between 1991 and late 2001, the AMA's Municipal solid waste in the Accra metropolis was deposited at Mallam, a suburb of Accra. This dumping at the Mallam site however was stopped in late 2001 as the dump capacity had been exceeded and objections from nearby residents. Waste dumping was henceforth shifted to Djanman which unfortunately could not last as it was filled to capacity

in just three months. These abandoned Mallam and Djanman sites were mountains of dumps and since they were neither landfills nor were there controls to their spread and emissions, they are of great concern as a result of their threat to human health, leachate and landfill gas formation. According to him the dump site was an old stone quarry at Oblogo in the McCarthy Hills of Accra. Before it begun to be used in early 2002 there was an installation of clay lining. The site had no engineered containment of leachate. AMA was only able to compact the waste to guarantee some level of proper dumping and hence "this site was considered a controlled dump rather than a properly engineered landfill" (Anomanyo, 2004). He further added that since the formal systems of solid waste disposal could not cope with the ever-increasing volume of solid waste being generated in Accra, the public itself employs various means of waste disposal. Waste was thus disposed of indiscriminately especially in watercourses and drainage channels and also through burning.

According to KMA (2014), a well-engineered sanitary site was used at Dompoase where waste was placed compacted and covered at the site. A weighbridge was also available andattached to a control room where the waste was weighed and inspected before being accepted into the landfill. A maintenance bay and offices were also at the site. Heavy-duty equipment were available for spreading of waste, compaction and covering. Grading and gravelling of access roads are other vital activities at the landfill site.

Comparing the two Metropolises in terms of waste disposal in landfill, KMA has well designed sanitary landfill which meets all the requirements. These include weighbridge, access roads, maintenance bay, leachate measures, and heavy duty equipment for spreading waste, compacting and covering.

2.3.5 Transfer and Transport

According to Kreith (1994), transfer and transport involves two steps: (1) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (2) the

subsequent transport of the wastes, usually over long distances to the final disposal site. The former is actually the haulage of waste from the solid waste collection sites to the bigger transfer stations which are normally situated at the outskirts of the community to store the solid waste of all the collection points located in the community. The latter is actually the transfer and transportation of the accumulated solid waste collected and stored at the various transfer station located in the communities to the final disposal sites normally being a properly engineered landfill site or a temporal landfill site as in the case of a trench.

2.4 Early Practices of Solid Waste Management

According to Tchobanoglous *et al*, (1993), the most commonly recognized methods for the final disposal of solid wastes were:

• Dumping on land, canyons and mining pits

• Dumping in water

• Ploughing into the soil

• Feeding to hogs

• Reduction and incineration

Some of these unwholesome practices of solid waste identified during the early disposal practices still exist in cities, towns and villages today. Indiscriminate dumping on opened land and dumping in gutters particularly are clearly evident in towns and cities, while dumping in water especially people living in coastal towns is a common activity. Burning of dumps is also common in peri-urban and rural communities in Ghana and in many other less developed countries. A study carried out in Ado-Akiti in Nigeria by Momoh and Oladebeye (2010), showed that, the methods of solid waste disposal include dumping of waste in gutters, drains, by roadside, unauthorized dumping sites and stream channels during raining season and burning of wastes on unapproved dumping sites during the dry season. This has gone to confirm that the practices of solid waste disposal in the 1950s still exist today and study area

is not an exception. On the other hand, Momoh and Oladebeye's (2010), assessment of waste situation in Ado-Akiti in Nigeria is questionable as they did not further explain what brought about the indiscriminate dumping. It could be that people dumped the waste any how because they were no skips or dustbins for the people to store their waste for collection.

2.5 Contemporary Methods of Managing Communal Solid Waste

In the contemporary era, the methods of managing communal solid waste include source reduction, sanitary landfills, composting, recycling, and incineration (Denison and Ruston, 1990). These methods are examined below.

2.5.1 Source Reduction

Denison and Ruston (1990) viewed source reduction as any action that reduces the volume or toxicity of solid waste prior to its processing and disposal in incinerators or landfills. This view is similar to the one given by Kreith (1994). According to him, source reduction focuses on reducing the volume and /or toxicity of waste generated. Source reduction includes the switch to reusable products and packaging, the most familiar example being returnable bottles. According to USPS (2000), in the city of Thimphu in Bhutan to reduce waste problems in future, reduction in waste generation would be the most important factor. Examples of possible reduction at the consumption level include reuse of containers (including bags), better buying habits, and cutting down on the use of disposable products and packaging (USPS, 2000).

It is agreed that, source separation and resource recovery is an important method in waste management. This is because there is nothing like waste on this earth. Wastes that are discharged may be of significant value in another setting, but they are of little or no value to the possessor who wants to dispose of it. According to Tsiboe and Marbel (2004), Austria, the Netherlands, and Denmark developed a waste management processes to efficiently

resolve the waste disposal problem by essentially coaxing their citizens to separate their domestic solid waste into glass, paper, plastic categories; thereby enabling easy collection and consequently reuse. As suggested by the three authors, one way of effectively managing solid waste is to minimise solid waste generation through source reduction.

2.5.2 Sanitary Landfill

Sanitary land filling includes confining the waste, compacting it and covering with soil. It not only prevents burning of garbage but also helps in reclamation of land for valuable use (Centre for Environment and Development, 2003). The placement of solid waste in landfills is the oldest and definitely the most prevalent form of ultimate waste disposal (Zerbock, 2003). He further argued that "landfills" are nothing more than open, sometimes controlled dumps. According to him the difference between landfills and dumps is the level of engineering, planning, and administration involved. Open dumps are characterized by the lack of engineering measures, no leachate management, no consideration of landfill gas management, and few, if any, operational measures such as registration of users, control of the number of "tipping fronts" or compaction of waste (Zerbock, 2003).

Furthermore, landfills are one form of waste management that nobody wants but everybody needs (Kreith, 1994). According to him, there are simply no combinations of waste management techniques that do not require landfilling to make them work. Of the basic management options of solid waste, landfills are the only management technique that is both necessary and sufficient. According to Kreith (1994), some wastes are simply not recyclable, many recyclable wastes eventually reach a point where their intrinsic value is completely dissipated and they no longer can be recovered, and recycling itself produces residuals. He further highlighted that the technology and operation of modern land fill can assure the protection of human health and the environment.

In contrast to what the various authors have said about sanitary landfill as an option for waste management, they have failed to recognize that land fill in itself has some disadvantages as it is costly to construct and maintain, can pollute ground water through leaching, location is a problem in terms of availability of land particularly in the cities. Other critical factors such as gas recovery, composting, waste to energy recovery, storm water control, distance to any settlement and water body were not clearly spelt out by the authors. Therefore, there could be an alternative which is recycling.

Figure 2.2 KMA engineered sanitary landfill at Dompoase

2.5.3 Recycling

According to Momoh and Oladebeye (2010) recycling has been viewed as a veritable tool in minimizing the amount of household solid wastes that enter the dump sites. It also provides the needed raw materials for industries. According to them, it has been established that, it is the best, efficient and effective method of solid waste management system. However, this may not be cost effective in developing countries like Ghana. The United States Environmental Protection Agency (USEPA), (1999), has recommended recovery for recycling as one of the most effective waste management techniques. According to USEPA,

recycling turns materials that would otherwise become waste into valuable resources and, it yields environmental, financial, and social returns in natural resource conservation, energy conservation, pollution prevention, and economic expansion and competitiveness. More importantly, a sizeable portion of what is thrown away contains valuable resources like metals, glass, paper, wood, and plastics that can be reprocessed and used again as raw materials (USEPA, 1999).

Kreith (1994) has also added that, recycling is the most positively perceived and doable of all the waste management options. According to him recycling will return raw materials to market by separating reusable products from the rest of the municipal waste stream. The benefits of recycling are many, he added. It saves precious finite resources, lessens the need for mining of virgin materials which lowers the environmental impact for mining and processing. For example, according to the Institute of Waste Management cited by Tsiboe and Marbel (2004), UK recycles only 11per cent of its household waste, Italy and Spain only 3 per cent, Netherlands 43 per cent, Denmark 29 per cent, and Austria 50 per cent respectively. Having proposed recycling by different authors as the best option to manage solid waste in modern times; they have forgotten about the cost component which is key to successful implementation of any recycling project. Even developed countries are not able to successfully do it. But alternatively, it may be the best option for effectively managing solid waste in Kumasi and Ghana as a whole.

2.5.4 Incineration

According to the Centre for Environment and Development (2003), incineration is a controlled combustion process for burning combustible waste to gases and reducing it to a residue of non-combustible ingredients. According to the Centre, during incineration, moisture in the solid waste gets vaporised and the combustible portion gets oxidised and vaporised. Carbon dioxide, water vapour, ash and non-combustible residue are the end

products of incineration. Incinerators have the capacity to reduce the volume of waste drastically, up to nine fold than any other method (Kreith, 1994). According to him incineration can also recover useful energy either in the form of steam or electricity. He however recognised that the main constraints of incineration are high cost of operation, relatively high degree of sophistication needed to operate them safely and economically as well as the tendency to pollute the environment through emissions of carbon dioxide. Having assessed the major methods that have been proposed by the various authors, literature has further revealed that there is an alternative method of managing solid waste effectively which is synonymous to waste reduction and recycling as mentioned earlier on. This forms the next section of the review.

2.6 Integrated Solid Waste Management

Although considerable efforts are being made by many Governments and other entities in tackling waste-related problems, there are still major gaps to be filled in this area (UNEP, 2009). According to UNEP (2009), the World Bank estimates that, it is common for municipalities in developing countries to spend 20 to 50 percent of their available budget on solid waste management, even though 30 to 60 percent of urban solid wastes remain uncollected and less than 50 percent of the population is served. The programme (UNEP) suggested that if most of the waste could be diverted for material and resource recovery, then a substantial reduction in final volumes of waste could be achieved and the recovered material and resources could be utilized to generate revenue to fund waste management. This forms the premise for the Integrated Solid Waste Management (ISWM) system based on 3Rs (reduce, reuse and recycle) principle**.**ISWM system has been pilot tested in a few locations (Wuxi, PR China; Pune, India; Maseru, Lesotho) and has been well received by local authorities. It has been shown that with appropriate segregation and recycling system significant quantity of waste can be diverted from landfills and converted into resource

(UNEP, 2009). Similarly, the United States Environmental Protection Agency (1999) has said that if a state or local government wants to plan for and implement ISWM, they have to consider a hierarchy of methods which are reduce, recycle, and incinerate/landfill.

Having discussed extensively by different authors on the methods that can be used to manage solid, the next section assesses the problems facing effective solid waste management in developing countries.

2.7 Problems of Managing Communal Solid Waste

According to Ogawa (2005), a typical solid waste management system in a developing country displays an array of problems, including low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control.

He categorised these challenges into technical, financial, institutional and social constraints. He further discussed these constraints in relation to the sustainability of solid waste in developing countries.

2.7.1 Technical Constraints

According to him, in most developing countries, there are inadequate human resources at both the national and local levels with technical expertise necessary for solid waste management planning and operation. Many officers in charge of solid waste management, particularly at the local level, have little or no technical background or training in engineering or management.

2.7.2 Financial Constraints

Ogawa (2005) intimated that, solid waste management is given a very low priority in developing countries, except perhaps in capital and large cities. As a result, very limited funds are provided to the solid waste management sector by the governments, and the levels of services required for protection of public health and the environment are not attained. The

problem is acute at the local government level where the local taxation system is inadequately developed and, therefore, the financial basis for public services, including solid waste management, is weak. This weak financial basis of local governments can be supplemented by the collection of user service charges. However, users' ability to pay for the services is very limited in poorer developing countries, and their willingness to pay for the services which are irregular and ineffective.

2.7.3 Institutional Constraints

He indicates that, several agencies at the national level are usually involved at least partially in solid waste management. He however, indicated that, there are often no clear roles or functions of the various national agencies defined in relation to solid waste management and also no single agency or committee designated to coordinate their projects and activities.

".....The lack of coordination among the relevant agencies often results in different agencies becoming the national counterpart to different external support agencies for different solid waste management collaborative projects without being aware of what other national agencies are doing. This leads to duplication of efforts, wasting of resources, and unsustainability of overall solid waste management programmes. The lack of effective legislation for solid waste management, which is a norm in most developing countries, is partially responsible for the roles/functions of national agencies not being clearly defined and the lack of coordination among them" (Ogawa, 2005:). According to him, Legislation (Public Health Act, Local Government Act, Environmental Protection Act) related to solid waste management in developing countries is usually fragmented.

Zurbrugg (2009), further added that, solid waste collection schemes of cities in the developing world generally serve only a limited part of the urban population. The people remaining without waste collection services are usually the low-income population living in peri-urban areas. According to him, one of the main reasons is the lack of financial resources

to cope with the increasing amount of generated waste produced by the rapid growing cities. Often inadequate fees charged and insufficient funds from a central municipal budget cannot finance adequate levels of service. He indicated that, apart from financial constraints that affect the availability or sustainability of a waste collection service; operational inefficiencies of solid waste services such as deficient management capacity of the institutions and inappropriate technologies affect effective waste management. Zurbrugg (2009), therefore underscores the key challenges of waste management which include financial and institutional constraints.

2.8 Waste Management Regulation and Policy

According to the Ministry of Local Government and Rural Development (MLGRD) (2004), general waste management in Ghana is the responsibility of the MLGRD, which supervises the decentralized Metropolitan, Municipal and District Assemblies (MMDAs). However, the ministry indicates that, regulatory authority is vested in the Environmental Protection Agency (EPA) under the auspices of the Ministry of Environment and Science. The Metropolitan, Municipal and District Assemblies are responsible for the collection and final disposal of solid waste through their Waste Management Departments (WMDs) and their Environmental Health and Sanitation Departments (EHSD). The policy framework guiding the management of hazardous, solid and radioactive waste includes the Local Government Act (1994), Act 462, the Environmental Protection Agency Act (1994), Act 490, the Pesticides Control and Management Act (1996), Act 528, the Environmental Assessment Regulations 1999, (LI 1652), the Environmental Sanitation Policy of Ghana (1999), the Guidelines for the Development and Management of Landfills in Ghana, and the Guidelines for Bio-medical Waste (2000). All these Acts and Regulations emanate from the National Environmental Action Plan (MLGRD, 2004).

Furthermore, the ministry has published the National Environmental Sanitation Policy (NESP) since May 1999. Accordingly, the policy looks at the basic principles of environmental sanitation, problems and constraints. The role and responsibilities assigned to communities, ministries, departments and agencies and the private sector impinge on environmental management and protection, legislation and law enforcement and the criteria for specifying services and programmes, funding, equipment and supplies. Out of the National Sanitation Policy, the MLGRD has also developed a technical guideline document titled The Expanded Sanitary Inspection and Compliance Enforcement (ESICOME) Programme guidelines.

The programme guidelines which are implemented by the MMDA's, routinely looked at four broad areas namely; effective environmental health inspections (Sanitary Inspections), dissemination of sanitary information (Hygiene Education), pests/vector control and law enforcement. All MMDAs have developed waste management and environmental health plans to help solve the numerous sanitation problems. Generally, the National Environmental Sanitation Policy Co-ordination Council (NESPoCC) is responsible for coordinating the policy and ensuring effective communication and cooperation between the many different agencies involved in environmental management in their respective Districts.

The ministry further indicates that in an effort to address the problem of waste management, Government has over the years put in place adequate national policies, regulatory and institutional frameworks. Due to this the Environmental Sanitation Policy (ESP) was formulated in 1999. This policy has currently been amended and strategic action plans developed for implementation according to the report. Various relevant legislations for the control of waste have also been enacted. These include the following:

• Local Government Act, 1990 (Act 462)

• Environmental Assessment Regulations, 1999 (LI 1652).

• Criminal Code, 1960 (Act 29).

• Water Resources Commission Act, 1996 (Act 522).

• Pesticides Control and Management Act, 1996 (Act 528).

• National Building Regulations, 1996 (LI 1630).

The Ministry also collaborated with the Ministry of Environment, Science and Technology (MEST), EPA and the Ministry of Health have prepared the following guidelines and standards for waste management:

• National Environmental Quality Guidelines (1998)

• Ghana Landfill Guidelines (2002)

• Manual for the preparation of district waste management plans in Ghana (2002)

• Guidelines for the management of healthcare and veterinary waste in Ghana (2002)

Handbook for the preparation of District level Environmental Sanitation Strategies and Action Plans (DESSAPs).

It is observed from the above that, despite the numerous sanitations regulations and policies that have been put in place by the MLGRD to deal with the solid waste menace in the country, there has not been any improvement in the area of solid waste management. Rather it has moved from bad to worst and therefore has failed to achieve its goal of clearing filth in the country. Secondly, drawing from the views given by the Sanitation Country Profile Ghana and the National Report for Waste Management in Ghana, it can be said with certainty that MMDAs are the primary authorities to manage solid waste at the local level.

2.9 Problems of Waste Management

In Ghana, Boadi and Kuitunen (2004), pointed out some of the problems affecting solid waste management. These include: weak institutional capacity and lack of resources; both human and capital. They also indicated that, home collection of waste is limited to high and, some middle income areas while the poor are left to contend with the problem on their own. This

leads to indiscriminate disposal of waste in surface drains, canals and streams, creating unsanitary and unsightly environments in many parts of the city. Furthermore, MLGRD (2004), summarises the challenges of solid waste management in Ghana as follows: poor planning for waste management programmes; inadequate equipment and operational funds to support waste management activities; inadequate sites and facilities for waste management operations; inadequate skills and capacity of waste management staff; and negative attitudes of the general public towards the environment in general.

It can therefore be said that the main challenges facing solid waste management in developing countries and for that matter Ghana include: inadequate funds to support waste management, inadequate equipment to support waste storage, collection and disposal, low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control.

There are potential risks to environment and health from improper handling of solid wastes. Direct health risks concern mainly the workers in this field, who need to be protected, as far as possible, from contact with wastes. There are also specific risks in handling wastes from hospitals and clinics. For the general public, the main risks to health are indirect and arise from the breeding of disease vectors, primarily flies and rats. The most obvious environmental damage caused by municipal solid wastes is aesthetic, the ugliness of street litter and degradation of the urban environment and beauty of the city. More serious, however, and often unrecognised, is the transfer of pollution to water, ground water. Air pollution can be caused from the inefficient burning of wastes, either in open air, or in plants that lack effective treatment facilities from the gaseous effluents.

Uncontrolled hazardous wastes from industries mixing up with municipal wastes create potential risks to human health. Traffic accidents can result from toxic spilled wastes. There is specific danger of concentration of heavy metals in the food chain, a problem that

illustrates the relationship between municipal solid wastes and liquid industrial effluents containing heavy metals discharged to a drainage/sewerage system and /or open dumping sites of municipal solid wastes and the wastes discharged thereby maintains a vicious cycle. Municipal Solid Waste Management System involves various activities like storage, collection, transportation, disposal etc. These activities even if properly controlled and with proper precautionary measures adopted, may have adverse impact on land, water and air environment, human and environmental health,aesthetics and quality of life. The Environmental and Health Impact Assessment may help in assessing the potential adverse effects of these activities and in formulation of precautions which could prevent these effects from taking place.

2.10 Environmental And Health Impact of solid waste

Epidemiological studies have shown that a high percentage of workers who handle refuse, and of individuals who live near or on disposal sites, are infected with gastrointestinal parasites, worms and related organisms. Contamination of this kind is likely at all points where waste is handled.

Although it is known that vector insects and rodents can transmit various pathogenic agents (amoebic and bacillary dysentery, typhoid fever, salmonellosis, cholera, yellow fever, plague and others), it is often difficult to trace the effects of such transmission to a specific population. During the last decade of the 19th century as well as during the 5 initial years of 20th century, millions of people died due to Bubonic Plague in India, which had linkages to poor management of Solid Waste. More recently a study by the US Public Health Service has demonstrated the relationship of 22 human diseases to improper solid waste management.

The organic fraction of Municipal Solid Waste is an important component, not only because it constitutes a sizable fraction of the solid waste stream, but also because of its potentially adverse impact upon public health and environmental quality. A major adverse impact is due

to its attraction of rodents and vector insects for which it provides food and shelter. Impact on environmental quality takes the form of foul odours, unsightliness, land, water, air and noise pollution. These impacts are not confined merely to the disposal site. On the contrary, they pervade the area surrounding the site and wherever the wastes are generated, spread or accumulated. Unless an organic waste is appropriately managed, its adverse impact will continue until it has fully decomposed or otherwise stabilized. Uncontrolled or poorly managed intermediate decomposition products can contaminate air, water and soil resources.

Most development activities are expected to have a beneficial effect on human health by increasing the resources available for food, education, employment, water supply, sanitation and health services. Proper management of municipal solid waste should have minimum effects on environment and health impacts.

Environment and Health Impact Assessment of Municipal Solid Waste Management is intended to identify and predict the impact of these activities and to suggest preventive measures as appropriate on the environment and on people's health and well-being and to interpret and communicate information about the impacts.

2.10.1 The significance of environmental and health impact assessment

The significance of Environment and Health Impact Assessment is aimed at improving the information support for proper management of municipal solid waste. Infrequent collection and rapid decomposition of wastes provide an attractive feeding and breeding site for flies, rats and other scavengers. Human and animal faecal matter or hospital wastes are often mixed with the refuse. Domestic and on occasion industrial, solid wastes are disposed of in open spaces within residential areas. Collection and disposal of refuse can consume up to 50% of a municipal operating budget, according to the waste management department of KMA. In many otherwise good systems, only 50-70% of the refuse is regularly collected. The problem

is organizational rather than technical. Refuse disposal is often a non-profit making business and thus is treated as an unwanted side-effect of development. Attention should be paid to storage, collection, transport, and intermediate transfer to bulk transport and final disposal.

In many places waste recovery is an important unorganized private industry employing many thousands of scavengers who may live or work on refuse dumps. They are referred to as human scavengers or waste pickers and are frequently ignored in urban project plans although their activities may be vital to the life of the city. Many consist of abandoned children and destitute families. They live and work under extensive health risks, which are largely undocumented, and suffer severe exploitation and deprivation. Possible health hazards include raised levels of infant mortality, hand and leg injuries, intestinal and respiratory infections, eye infections, lower back pain, malnutrition, skin disorders and exposure to hazardous waste. Water supply, for drinking and washing, and sanitation facilities are usually very poor at dumpsites. Health and welfare facilities are required. Waste collectors may make a substantial contribution to urban waste management. They may reduce the volume of waste by 10-20%. However, private collection at source may only operate in the wealthy areas where refuse contains items of value. Observers agree that the issue of waste collectors cannot be evaded. Their positive role in the management of municipal solid waste should be recognised and their lot improved.

2.10.2 Communicable disease

Houseflies may be important in the transmission of enteric infections, particularly those responsible for infantile diarrhoea and dysentery. Disease transmission by houseflies is greatest where inadequate refuse storage, collection and disposal (leading to increased breeding) is accompanied by inadequate sanitation. Thus flies gain greater access to human faeces and then to food. Refuse must be collected daily to prevent fly breeding.

2.9.3 Non-communicable disease

Once collected in poorly operated disposal sites, rubbish may contaminate groundwater with nitrates, heavy metals and other chemicals. Incineration of wastes may pollute the air with particulates and oxides of sulphur and nitrogen. The slag and ashes from incinerators may result in leacheates that are rich in heavy metals and other potentially toxic substances.

2.9.4 Injury

Combustible gases will be generated from waste heaps for more than 20 yearsand these travels under roads and through ducts to create a hazard in buildings and land fill sites. People collecting rubbish may be injured by sharp objects including glass, metal and wood. These may lead to puncture wounds and lacerations which may become infected and cause serious morbidity. Composted solid waste can cause injury to farmers as sharp objects are not always properly removed.

2.9.5 Aesthetics aspects

Foul odour is emitted at the disposal site due to continuous decomposition of organic matter and emission of methane, hydrogen sulphide, ammonia, etc. The problem is intensified if proper mitigation measures are not adopted. Odour is also emitted at the collection points if quick removal of wastes is not practised. Spreading of the waste in the area adjacent to the dustbin due to activity of rag pickers cause degradation of aesthetic quality. Uncontrolled disposal and open burning of wastes at the landfill sites create poor vision. Domestic rats, birds and other scavenging animals act as reservoirs for many organisms transmissible to people, including plague, forms of typhus, leptospirosis, trichinosis, psittacosis, salmonella infection and bovine tuberculosis. Chemical control of insects and rodents is not very effective because of widespread resistance. The essential basis of control remains denial of access to food and harbourage, by covered storage and efficient removal. Mosquitoes, vectors of dengue and yellow fever, breed prolifically in discarded containers that trap rainwater.

Culex mosquitoes, vectors of filariasis, breed and polluted stagnant water. Such breeding sites often occur where drains are choked by solid waste.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the methodological aspect of the research, comprising the spatial and non-spatial techniques used in both data gathering and analysis.

3.2 Study Area

Kumasi is located in the transitional forest zone and is about 270km north of the national capital, Accra. It is between latitude 6.35º – 6.40º and longitude 1.30º – 1.35º, an elevation which ranges between 250 – 300 metres above sea level. The land area of the Metropolis is about 254sq/km and approximately ten (10) kilometres in radius. There are 103 communities. The Kumasi Metropolis is the most populous district in the country. It has a Population of 2,035,064 (2010 census) with an annual growth rate of 4.8% as against 3.1% of Accra Metropolitan District. The population of Kumasi is projected to 2,396,458 by the year 2015. There are more males (50.2) in the Metropolis than females (48.8). This translates in a sex

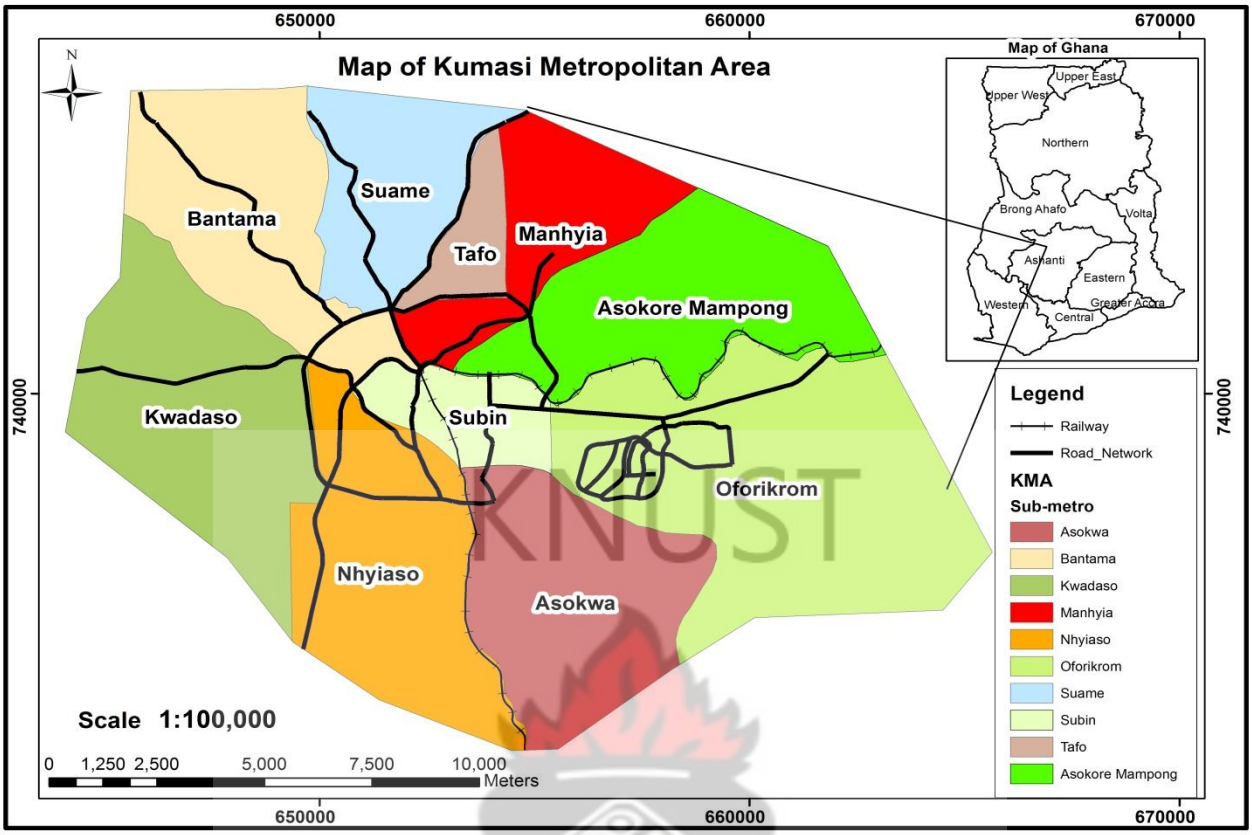

Figure 3.1 Map of Kumasi Metropolitan Area

3.2.1 Population Density

The Kumasi Metropolitan Area has a total surface area of 254 sq km (2000 populationcensus) with a population density of 8,012 persons per sq. km. The average household size in the Metropolis is 5:1. The average number ofhouseholds per house is 3.4. This relatively large number of households per house isdue largely to the large population in the metropolis. Kumasi Metropolis is not only entirely urban. It is estimated that 48%, 46% and 6% of the Metropolis are urban, peri-urban and rural respectively. About 86% of the active population in Kumasi is economically active. The economic activities sustaining the livelihood of the residents in the Metropolis can be categorized into Service, Industry and Agriculture.

3.2.2 Service Sector

The service sector is the economic backbone of Kumasi. Majority (72%) of the economically active labour force are employed in this sector. This sector has made Kumasi a hub for commercial activities in the country. The activities carried out by players in this sector are wholesale and retail in nature. They cover all kinds of commodities ranging from food stuffs, clothing, building materials, office and educational stationeries to herbal and orthodox medicines. The need for ancillary services to support economic activities in the Metropolis has attracted other relevant service providers. The banking and insurance sector coupled with other relevant institutions have contributed immensely in creating a conducive environment for smooth running of business transactions in Kumasi. Another group of service providers that have contributed tremendously to the creation of productive employment ventures and revenue generation in the Metropolis are the Telecommunication Sector, Transport Sector, Hotels, Restaurants and Traditional caterers (chop bars), hairdressers and dressmakers/tailors.

3.2.3 Industrial Sector

Kumasi is a hub for scattered pockets of industrial activities in the country. Notable among them are the agglomerated small-scale mechanical garages, wood processing companies and food processing companies as well as construction firms. This sector has contributed quite significantly to productive employment creation (23%) and revenue generation. Suame Magazine (the biggest mechanical garage in West Africa) and Asafo mechanical garages have impacted positively on productive employment creation and revenue generation in Kumasi. Suame Magazine, which is located at the northern section of Kumasi, is a hub of agglomerated small-scale mechanical garages that both manufacture vehicle parts and provide other mechanical services not only to the Metropolis but to the whole West Africa sub-region. Its presence in the Metropolis has made Kumasi a well-known mechanical garage in the sub-region of West Africa.

Other industrial centres that have contributed immensely to job creation and sustainable source of income for a section of the active labour force in the Metropolis are the beverage processing industries. Notable among them are the Guinness Ghana Brewery Limited (GGBL) and the Coca Cola Bottling Company. In addition to these large scale companies are micro, small and medium – scale enterprises that produce fruit juice and fresh yoghurt among others. Timber processing firms and plywood manufacturing companies located along the Asokwa-Ahinsan-Kaase stretch are other industrial centres that have significantly contributed to sustainable livelihood in Kumasi by providing productive employment and revenue. The semi-finished products of these companies are exported to the international market to generate foreign exchange as well as sold to domestic furniture workers to create jobs.

Another area of interest is the handicraft industry which comprises of basket weavers, potters, wood carvers and cane weavers. Although they are spread metro-wide, majority of them are concentrated at Ahwia.

3.2.4 Agricultural Sector

Agriculture in Kumasi consists of farming, aquaculture, horticulture and some animal rearing. Farming is limited to small scale staple crops production including maize, plantain, cocoyam, cassava and traditional (tomatoes, pepper etc. and exotic (carrots, cabbage etc.) vegetables in the peri-urban areas. In terms of food crops it is a net importer. Most of the foodstuffs are brought in from the adjoining districts as well as distant areas such as Techiman, Nkoranza and Ejura.

3.2.5 Transportation

Residents in Kumasi have three modal choices available for commuting to all parts of the country as well as neighbouring countries in the Sub – Region and the rest of the World. These are the air, rail and road. Though there are rivers and streams meandering through the

city, their size and depth do not support water transportation. Kumasi has one airport located in the Manhyia Sub Metropolitan Area. This airport supports all air travel to and from the city. Presently, there are a number of private airline companies operating domestic passenger services for people traveling to and from Kumasi. These are Antrak, Air, Starbow, City Link, 540 and AWA to mention a few. Their operations strictly adhere to scheduled times. Accessibility to and from the airport is connected with an asphalted road making it excellent for vehicular transportation. The Ghana Railway Company used to operate passenger rail service between Ejisu to Kumasi and Takoradi to Kumasi daily.

The strategic location of the rail station in Kumasi, i.e. at the heart of Kumasi, gives the service a unique opportunity to positively contribute to the improvement of transportation in the Metropolis. It was the desire of the Metropolis to have a reliable, regular and properly scheduled passenger rail service that would operate at frequent intervals during each working day. Unfortunately this dream has been shattered with the collapse of the existing unreliable services. This collapse has been attributed partly to the obsolete nature and poor conditions of infrastructural facilities. Kumasi has a total of 1,921 km length of road networks linking residents to virtually all parts of the Metropolis. The road network in Kumasi can be categorized into arterials, collectors and local roads. It has the Trans Saharan roads linking the country to the landlocked countries in the West Africa sub-region, which is the Accra – Kumasi –Tamale road. Furthermore, it has eight arterial roads which carry in-coming and outgoing traffic from Kumasi. These roads are Barekese route, Bosomtwe route, Buokrom route, Ejisu route, Obuasi route, Sunyani route, Mampong route, Offinso route. In addition to these arteries Kumasi has a number of collector roads which collects traffic from local roads to primary roads as well as distribute traffic from the arterial roads to the access roads.

3.2.6 Tourism

Kumasi, the capital of the Asante kingdom, has outstanding rich cultural heritages, which are depicted in festivals, like the Akwasidae, funerals and child naming ceremonies. There is no doubt that Kumasi and for that matter the Ashanti Region, constitutes the very core of the cultural and tourism heartbeat of Ghana. Coupled with this heritage is the accolade, the Garden City of West Africa. Notable tourist sites in the Metropolis include the following, Manhyia Palace, Centre for National Culture, Prempeh II Museum, Okomfo Anokye Sword, Fort St. George (War Museum) and Kumasi Zoological Gardens

3.2.7 Hospitality Industry

There are a number of hotels, hostels, restaurants and traditional catering serviceswith a wide variety of menu both continental and local dishes. Kumasi has vibrantnightclubs that make the weekends lively and vibrant. Travel and Tour Agencies aswell as tour guides exist to provide auxiliary services. The importance of this subsector to the economy cannot be overstated.

3.2.8 Health Care

The Metropolitan Health Services are organized around five (5) Sub Metro Health Teams; namely, Bantama, Asokwa, Manhyia North, Manhyia South and Subin. The Metro Health Team is led by its Director of Health Services who has the overall responsibility for planning, monitoring and evaluating the performance of the Health Sector in the metropolis. The city has a number of health facilities in both the public and private sectors. Notable among them are the Komfo Anokye Teaching Hospital (KATH), which is one of the two (2) national autonomous hospitals, four (4) quasi health institutions, five (5) health Care Centres owned by the Church of Christ and the Seventh-Day Adventist Church. In addition, there are over two hundred (200) known private health institutions and 13 Industrial Clinics in the metropolis.

3.3 Method of data collection

The research data, consisting of both primary and secondary data were gathered through pre field work and detailed field survey.

3.3.1 Pre- field work

The pre- field work started with review of literature from related journals, records from the respective government agencies like the waste management department of KMA and the other waste management companies that operate within the Kumasi metropolis and the Kumasi metropolitan assembly in general. Other sources include internet and textbooks. The list and addresses of the solid waste collection points, and other records were collected from the KMA waste management department. This served as a guide to identify, locate, number and distinguish their type. And there was a preliminary reconnaissance to all the identifiable communal solid waste collection points with respect to their types through which familiarization was achieved. Moreover, the criteria for site selection of the communal collection points by the waste management department in the study area were obtained through secondary means of data gathering, principally through interviewing the personnel at the waste management department.

3.3.2 Detailed field survey

Global Positioning System (GPS) was used to take the coordinates of all the communal solid waste collection points, through which a database was created and used to record the coordinates, locations and addresses of the communal solid waste collection points in and around the metropolis. A digital camera was used to take pictures of all the solid waste collection points in and around the metropolis so as to show their types and nature. Moreover, an interview with the top personnel of the waste management department of KMA was conducted to find out the criteria they used for the site selection of the communal collection points in the study area. And finally, a questionnaire was administeredto analyse the

community usage in the study area as well as their perception of the waste management practices in their communities.

3.4 Samples and Samples Techniques

The study area is sub categorised or zoned into nine sub metros administratively and these administrative zones were used for the purposes of this study. The study area contains about 125 solid waste collection points with 13 collection points located in Subin, 20 in Oforikrom, 8 in Suame, 11 in Asokwa, 19 in Kwadaso and 10 in Manhyia. The rest are Bantama sub metro with 18 collection points, Nhyiaeso and Tafo with 15 and 11 respectively. It was assumed that 100% 0f the inhabitants in the nine sub metros dispose off their solid waste in the identified solid waste collection points, therefore, only 10 locations were sampled in a stratified manner. 400 copies of questionnaires were distributed accordingly, 322were filledand returned completely and successfully, thus used for the analysis to make a generalisation.

3.5 Method of data analysis

3.5.1 Spatial data analysis

3.5.1.1 Georeferencing and digitizing

The Kumasi metropolitan assembly was zoomed and extracted from satellite imagery, Googleearth imagery to be specifically. The extracted image was then imported to geographicinformation system (GIS) software, specifically ArcGIS 9.3, and then georeferenced and digitized to produce a digital map. Population density map was also produced based on the field experience and satellite imagery observation (2013). Land uses and housing pattern were used as guide.

3.5.1.2 Mapping the distribution of the solid waste collection points

The coordinates of the solid waste collection points taken during the fieldwork were imported into ArcGIS 9.3 as a textfile, then converted to shape file to show the spatial distribution of the solid waste collection points on the digital maps. Points (dots) of different shapes and colours were used to show the collection points; the types of collection points. Some aspects ofthe information gathered from the interviews with the personnel from the waste management department and the landfill unit was also included in the mapping elated discussions.

3.5.2 Non Spatial data analysis

The questionnaire distributed in the field were retrieved and analysed using SPSS software. Frequency distribution and cross tabulation of parameters were carried out to come up with tables for some parameters and charts for others depending on the appropriateness. Some aspects of the information gathered from interviewing the personnel of the waste management department was also included in the non-spatial aspects discussions.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter has been split into two i.e. spatial and non-spatial data analyses. The former discussed the mapping aspect of the research and the distribution of the communal solid waste collection points over space whilst the later presented the criteria used by the waste management department of KMA and the environmental health directorate for selecting a site to fix an authorised or legal waste collection point and also discuss the aspect of community attitude concerning the usage of the collection points and the perception towards the refuse management systems, all in KMA.

4.2 Social characteristics of respondents

The average age of the respondents was 49.5 years with a standard deviation (SD) of 14.5. The minimum age was 22 years and the maximum 90 years. (7.5%) of the respondents had no formal schooling at all and 12.7% had Primary education. Middle school Form 4 and Junior High School had the highest percentage of 30.4%.(29.2%) went through Secondary/ Vocational / Technical institutions with 20.2% having had tertiary education. (58.4%) were government employees, 33.9% had private employment and 7.7% were unemployed. Majority were average income earners (51.6%) and 26.4% werelow income earners. 22% of them were also high income earners. (63.1%) of the respondents were married and 22% single. (11.8%) and 2.2% were divorced and separated respectively. Christians formed the majority of respondents (77.6%) and 21.7% being Muslims.

Table 4.1 Social Characteristics of respondents

VARIABLES	FREQUENCY = 322	PERCENTAGES (%)
Sex Male	115	35.7
Female	207	64.3
Occupation Government	188	58.4
Private	109	33.9
Unemployed	25	7.7
Level of education		
No schooling	24	7.5
Primary	41	12.7
JHS/ middle form 4	98	30.4
SHS/vocational/technical	94	29.2
Tertiary	65	20.2
Income level		
High (above GHC 400)	71	22
Average(GHC 200-400)	166	51.6
Low(below GHC 200)	85	26.4
Marital status		
Married	203	63.1
Single	74	22.9
Divorced	38	11.8
Separated	7	2.2
Number of children		
1-3	211	65.5
4-6	77	23.9
7+	34	10.5
Religious affiliation		
Christian	250	77.6
Muslim	70	21.7
Traditionalist	2	0.7

Source; field survey, 2013.

4.3 Spatial Data Results

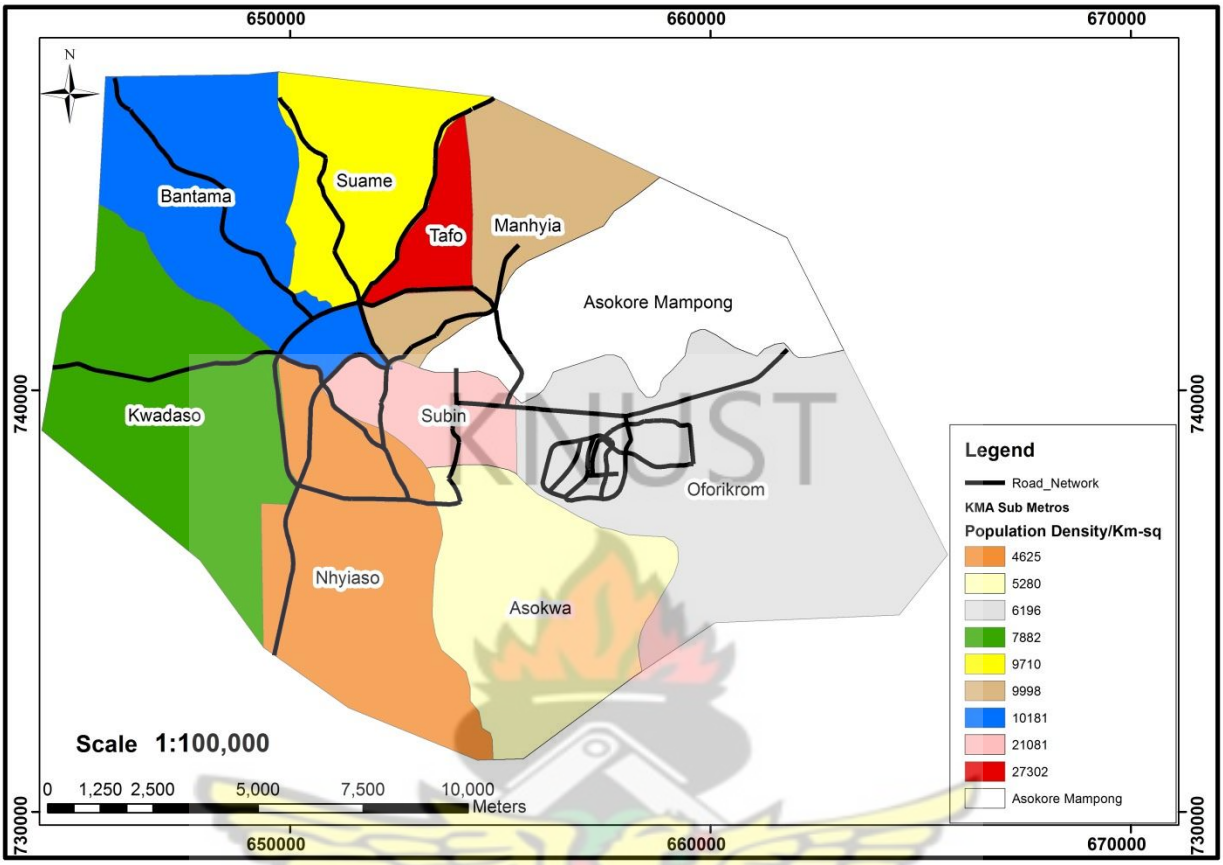

Figure 4.1 Population Density Map of KMA.

The Figure 4.1.above shows the population density map of the Kumasi Metropolitan Assembly with the various sub metros and their respective population densities. The sub metro with the highest population density being the Oforikrom sub metro with a population of 303,106 representing 17.6% of the total population followed by the Bantama sub metro also with a population of 260,474 representing 15.1% of the total population and the sub metro with the lowest population being the Nhyiaeso sub metro also with a population of about 134,486 also representing 7.8% of the population.

Table 4.2 Population of KMA

SUB METRO	POPULATION	PERCENTAGE
Kwadaso	251,215	14.6
Nhyiaeso	134,486	7.8
Subin	174,004	10.1
Oforikrom	303,106	17.6
Asokwa	140,161	8.1
Manhyia	152,225	8.8
Tafo	146,024	8.5
Suame	161,199	9.4
Bantama	260,474	15.1
TOTAL	1,722,894	100

Source; 2010 Population Census

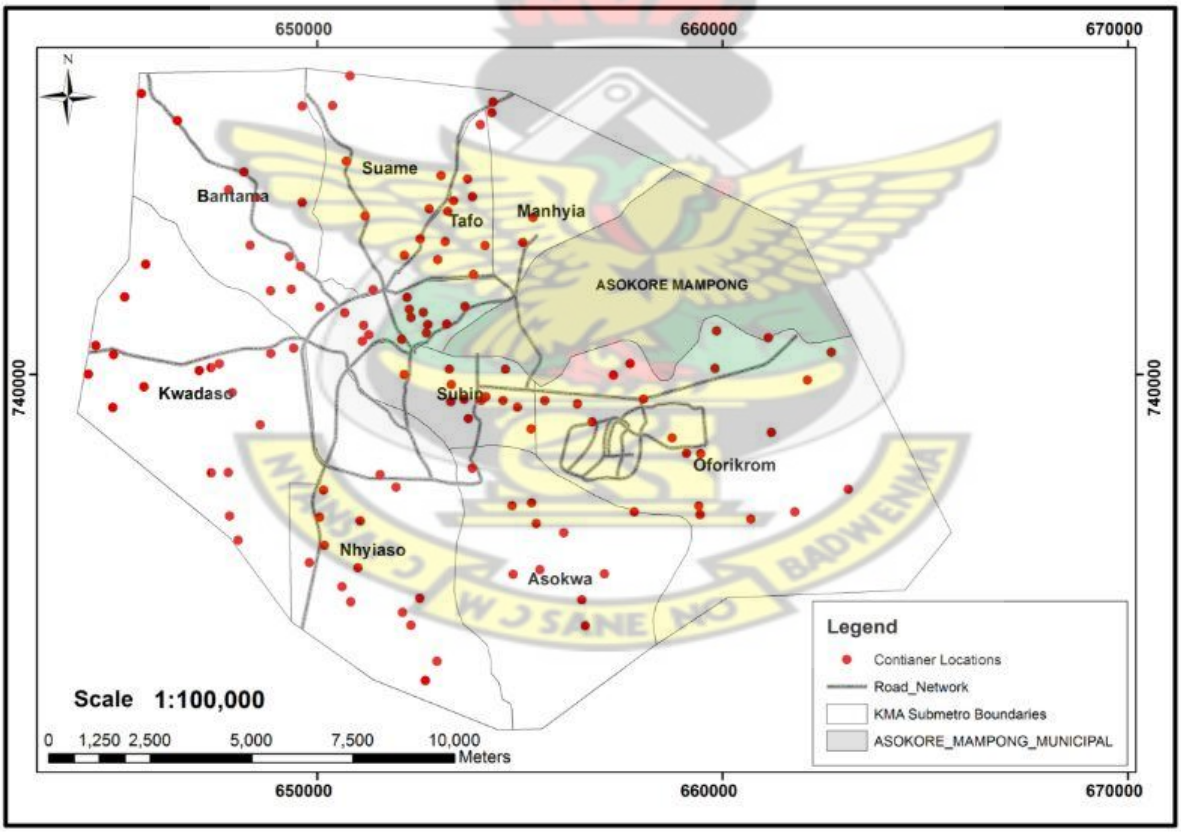

Figure 4.2 Solid Waste Collection Sites Distribution Map

The Figure 4.2.above also shows a distribution map of the various solid waste collection points scattered in the various sub metros in the Kumasi Metropolitan Assembly. A total of 125 solid waste collection points were located and counted throughout the study area. Oforikrom sub metro was the sub metro with the highest number of sites i.e. 20 sites representing 16% of the total number of sites followed by the Bantama sub metro with 18 sites representing 14.4% of the sites and the sub metro with the lowest number of sites was the Suame sub metro which had only 8 of the sites scattered throughout the sub metro also representing 6.4% of the total solid waste collection sites in KMA.

Table 4.3 Sub metro and the sites distribution.

SUB METRO	NUMBER OF SITES	PERCENTAGE
Oforikrom	20	16
Kwadaso	19	15.2
Bantama	18	14.4
Nhyiaeso	15	12
Subin	13	10.4
Asokwa	11	8.8
Tafo	11	8.8
Manhyia	10	8
Suame	8	6.4
TOTAL	125	100

Source; Fieldwork, 2013.

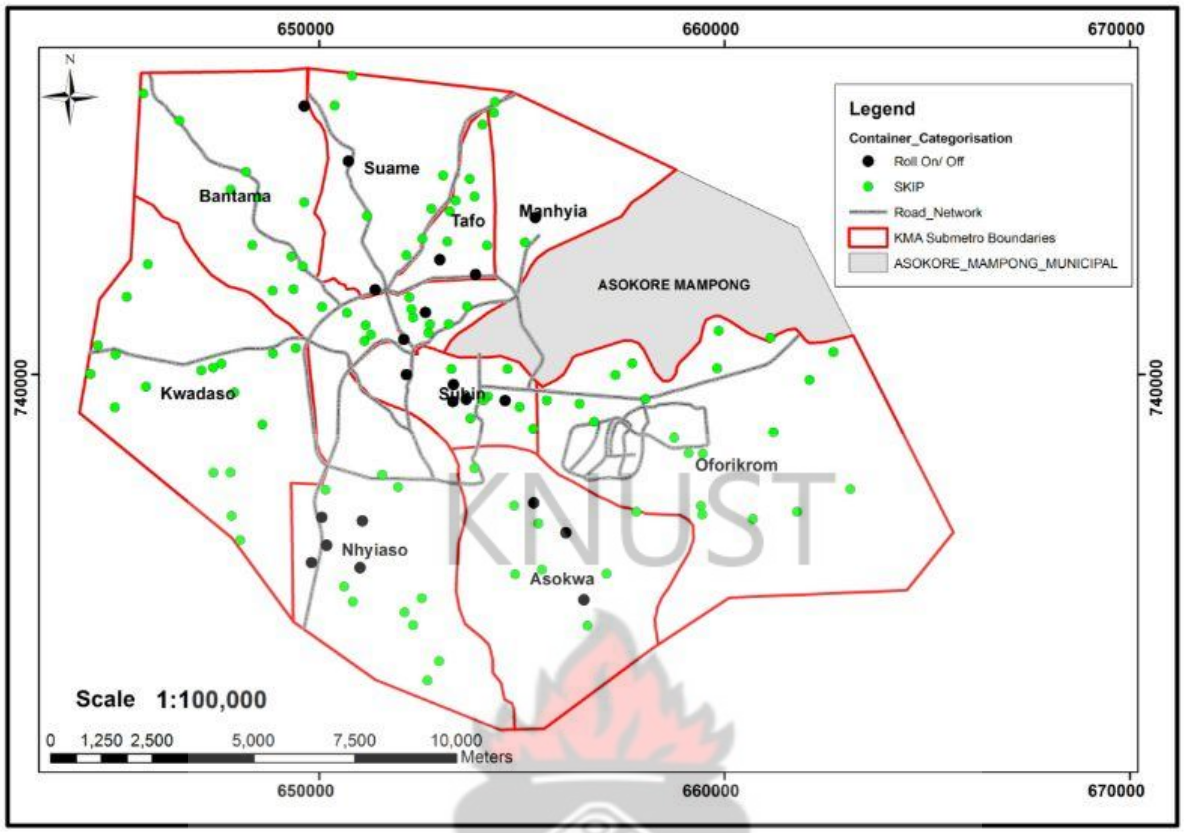

Figure 4.3 Container Categorisation Map

The Figure 4.3.above is a container categorisation map showing the types of solid waste containers placed at the various sites in the metropolis. The green coded sites are the ones with skip containers and they are in the majority i.e. out of a total of 125 sites, it is made up of 104 representing about 83.2% and the remaining 21 sites made up of roro containers also representing 16.8%.

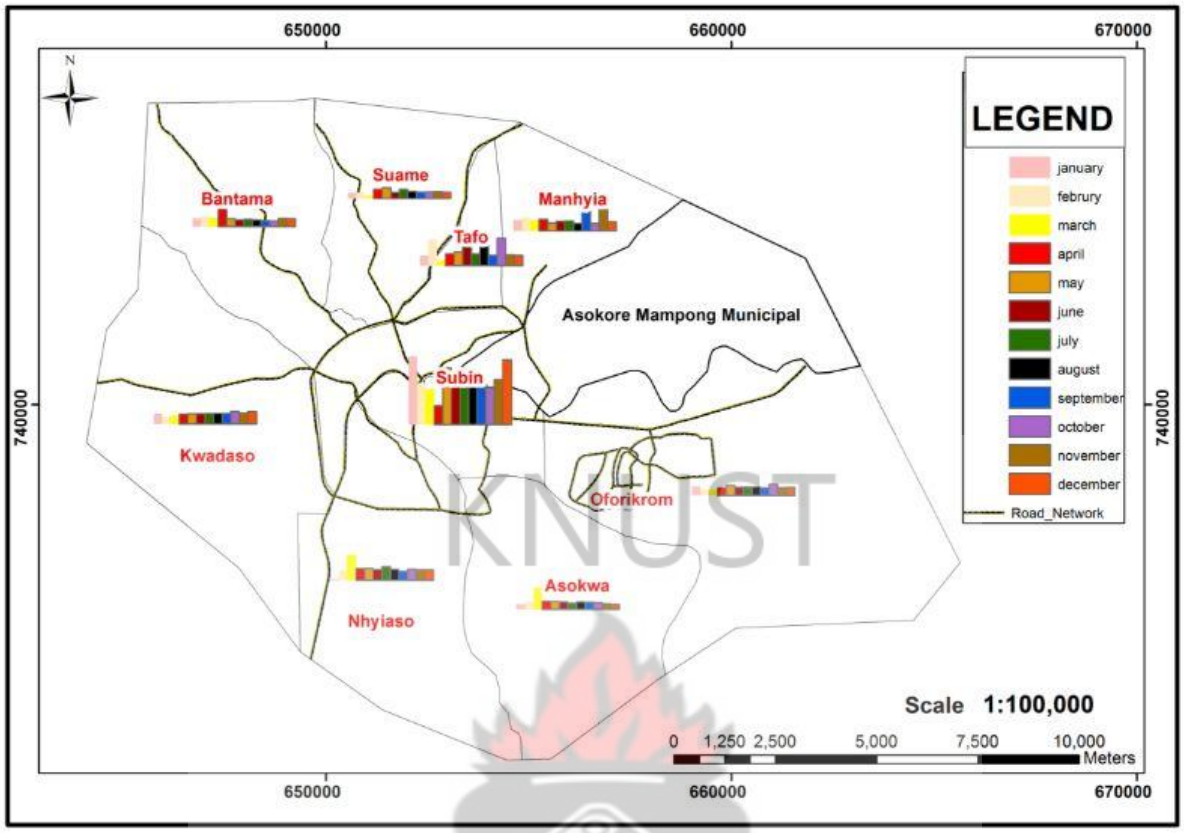

Figure 4.4 Monthly Tonnage Map of all the nine sub metros in KMA for year 2013.

The Figure 4.4 above shows a map of the monthly tonnages of the various sub metros in the Kumasi metropolis. Most of the sub metros shows an even distribution and hovers around the same level with the exception of the Subin sub metro which shows high variations. This is because the sub metro host the central business district of Kumasi which comprises Adum, kejetia, cental market and a host of other satellite markets in and around the sub metropolitan area all of which generate a major portion of the solid waste in the Kumasi metropolis.

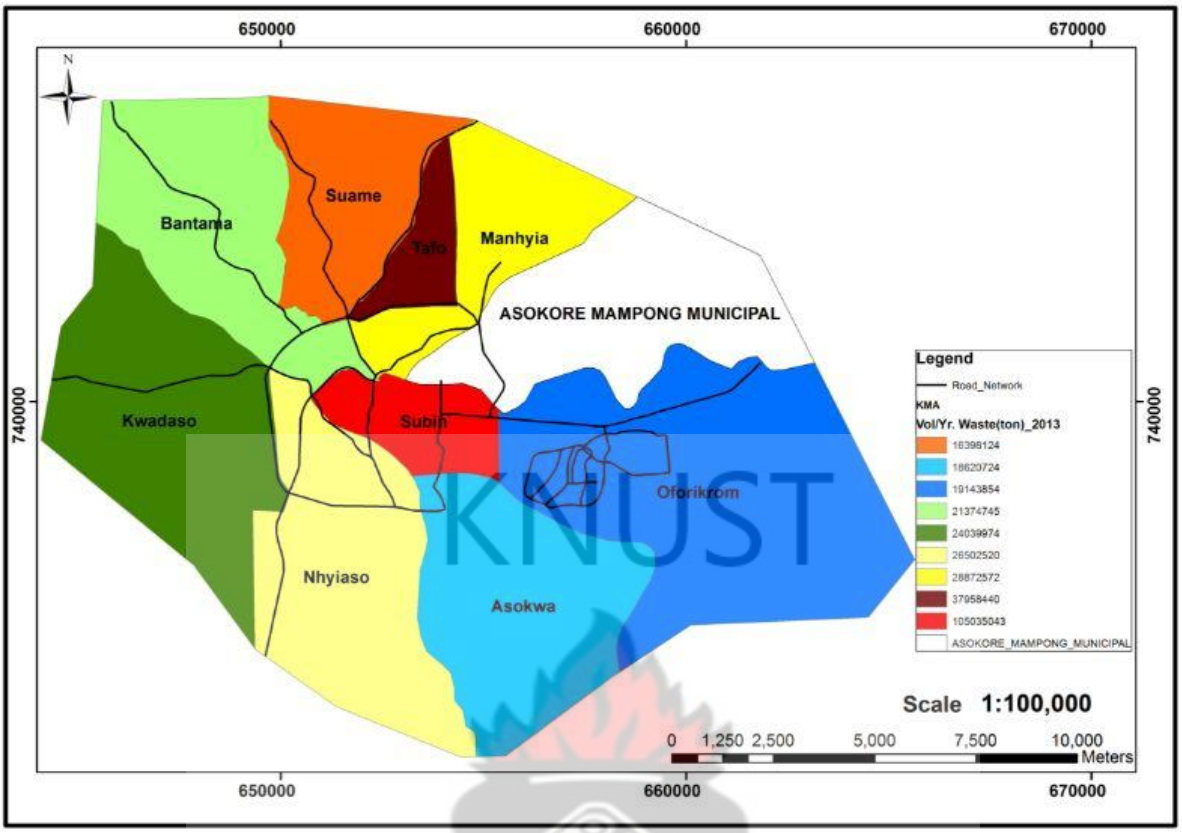

Figure 4.5 Waste Volume/Year Map of KMA

The Figure 4.5. above shows a map of the annual tonnage of solid waste collected from the various sub metros in the year 2013 with the Subin sub metro recording the highest tonnes of solid waste collected in the year under review of about approximately 16,500 tonnes, followed by the Oforikrom sub metro and the lowest tonnages being recorded in the Nhyiaeso sub metro.

Table 4.4 Yearly Tonnages per Sub metro

SUB METRO	TONNAGES	PERCENTAGES
Kwadaso	24039974	6.7
Nhyiaeso	26502520	7.4
Subin	165000000	46.1
Oforikrom	19143854	5.3
Asokwa	18620724	5.2
Manhyia	28872572	8.1
Tafo	37958440	10.6
Suame	16398124	4.6
Bantama	21374745	6.0
TOTAL	357910953	100

Source; KMA, Landfill Unit

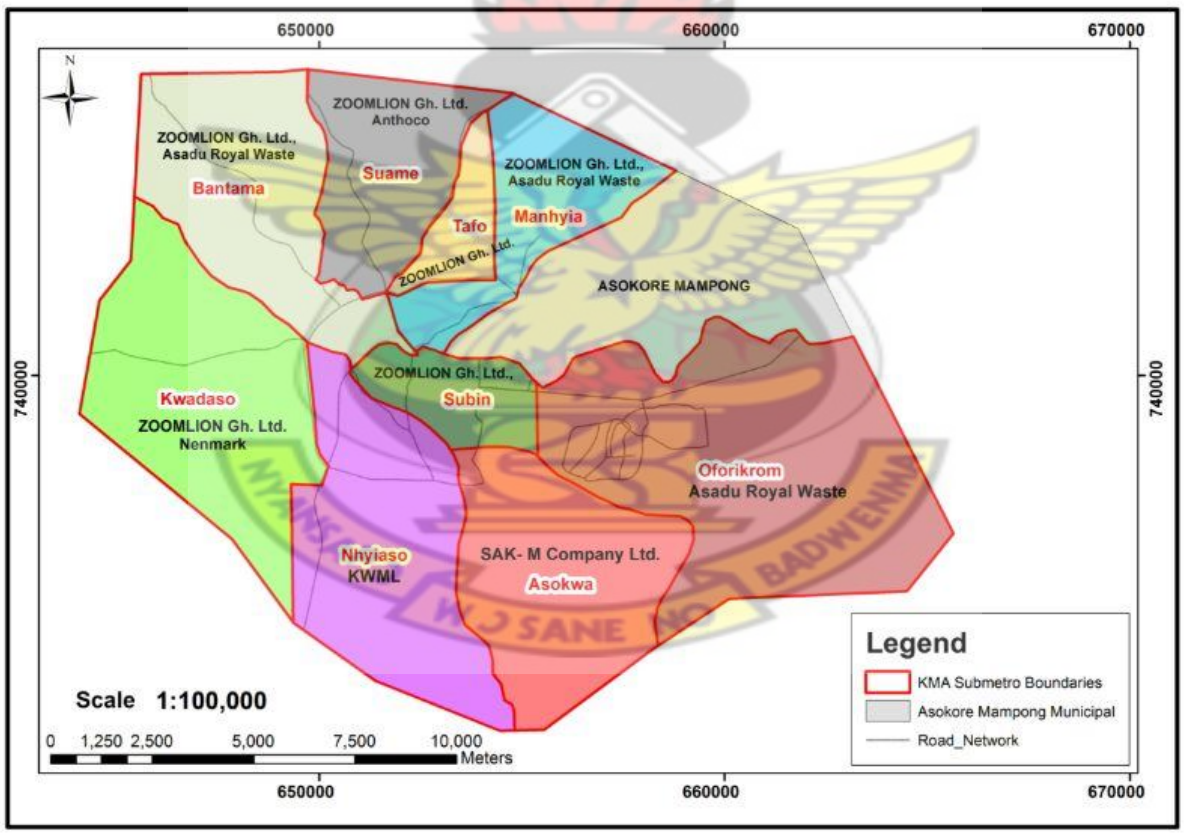

Figure 4.6 Map showing Private Waste Contractors and their Area of Operation.

The Figure 4.6. above shows the various private waste management companies in the Kumasi metropolis and their various areas of operations with Zoomlion Gh. Ltd operating in about five(5) sub metros i.e. Tafo, Subin, Manhyia, Bantama and Kwadaso and Asadu Royal Waste also operating in about three(3) of the sub metros. Venmark, SAK-M, Anthoco and KWML are operating in only one sub metro.

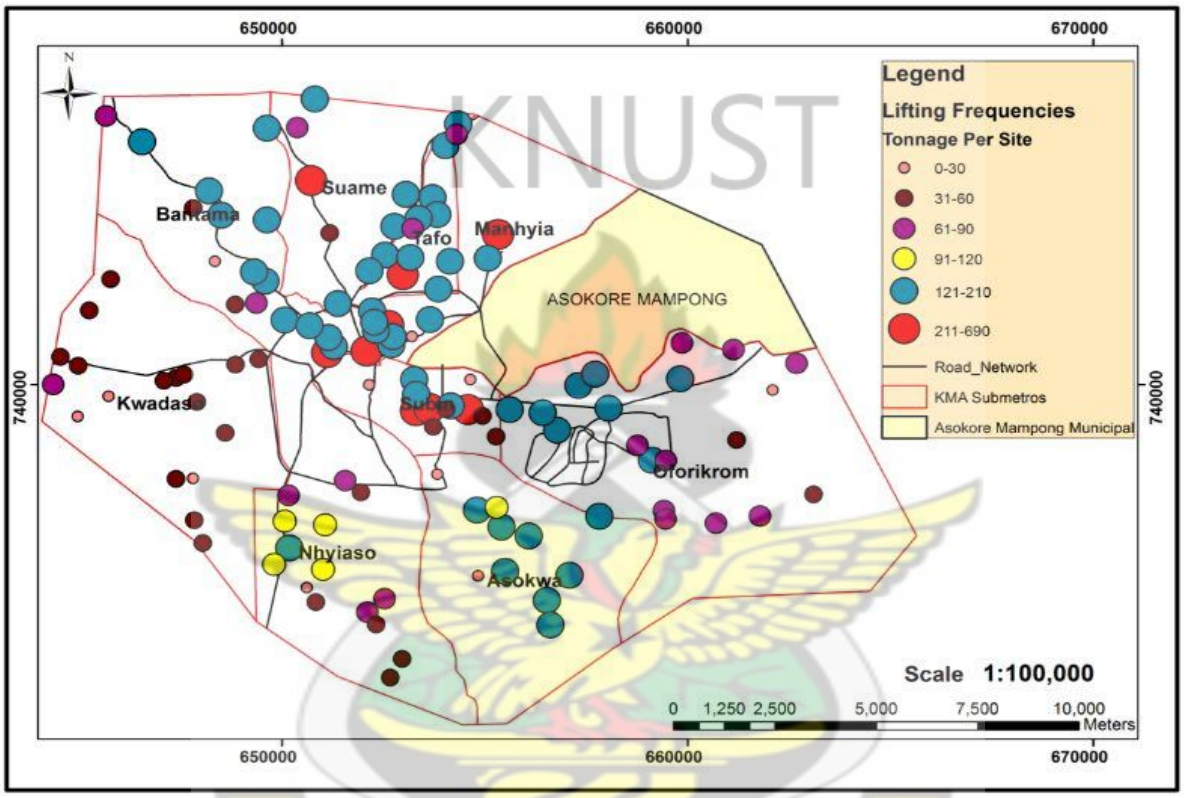

Figure 4.7 Lifting Frequency Map of KMA

This map above also shows the various solid waste collection points in the Kumasi metropolis with their respective lifting frequencies with the sites with the highest lifting frequencies being located in the Subin sub metro and its environs and decreasing lifting frequencies as we move away from the Central Business District (CBD) located in the Subin sub metro to the peripheral areas of the metropolis, though there are some few areas that do not follow the earlier mentioned pattern.

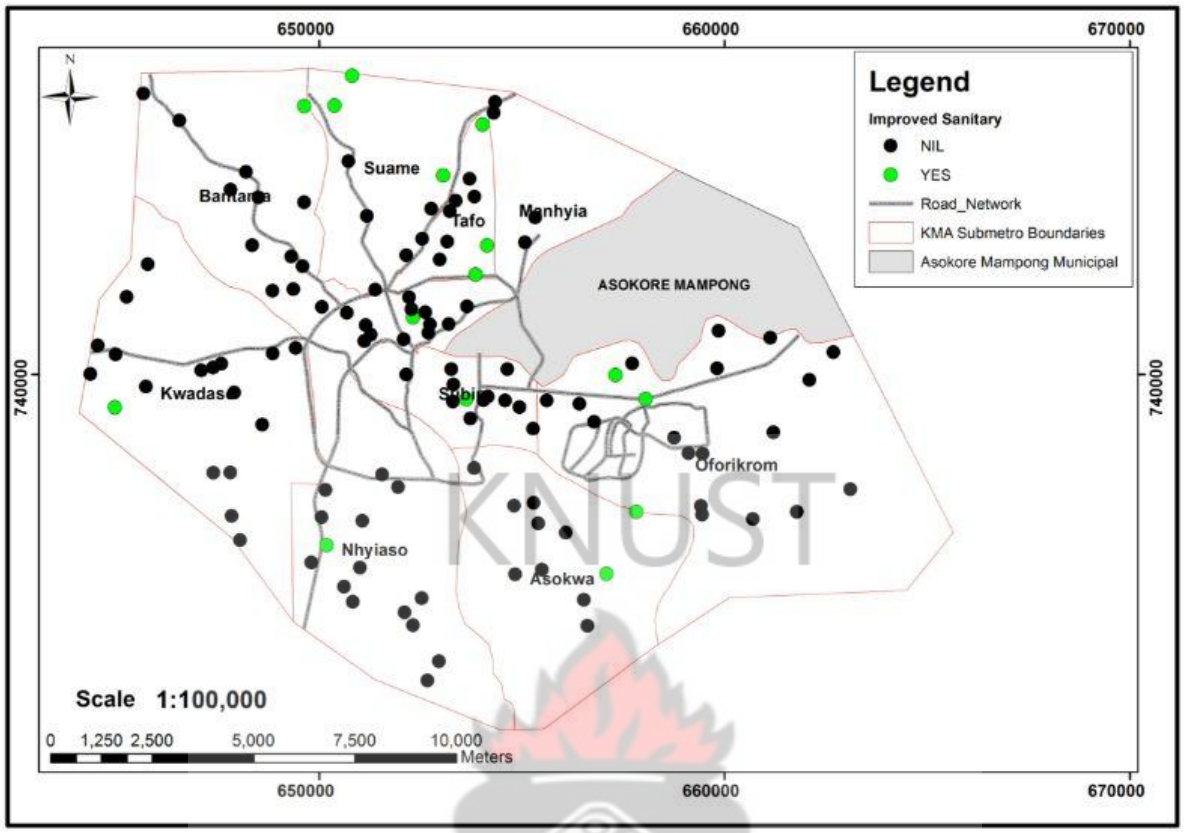

Figure 4.8 Improved Sanitary Facility Sites Map

The Figure 4.8. above shows the various solid waste collection sites in the Kumasi metropolis with the sites with improved sanitary facilities indicated with the green colour code which number about 15 representing 12% of the total number of collection sites and the remaining 110 collection points also representing 88% of the total number of collection points without the improved sanitary facility indicated with the black colour code. These are actually sites that have been well engineered to the standards of modern solid waste collection sites as indicated in the appendix.

4.4 General frequency distribution.

Community attitude on the usage of solid waste collection points and their perception on the solid waste management system (Questionnaire analysis)

The following frequency distribution represented by pie charts and bar charts show the kind of variation among the Kumasi metropolis population in terms of facility usage, attitude towards the solid waste collection points as well as the community perception on the refuse management system.

a. Household storage facility

Most of the households in the Kumasi metropolis stored their household refuse in waste collection bins (66.1%), while very few use means (5.6%) that are other than refuse bag, drum or refuse bin as shown in the on Figure 4.9 below.

Table 4.5 Household storage facilities

TYPE OF RECEPTACLE	FREQUENCY	PERCENTAGE (%)
Refuse bin	213	66.1
Plastic bags	56	17.4
Drum	35	10.9
Others	18	5.6
Total	322	100

Source; Field Survey, November, 2013

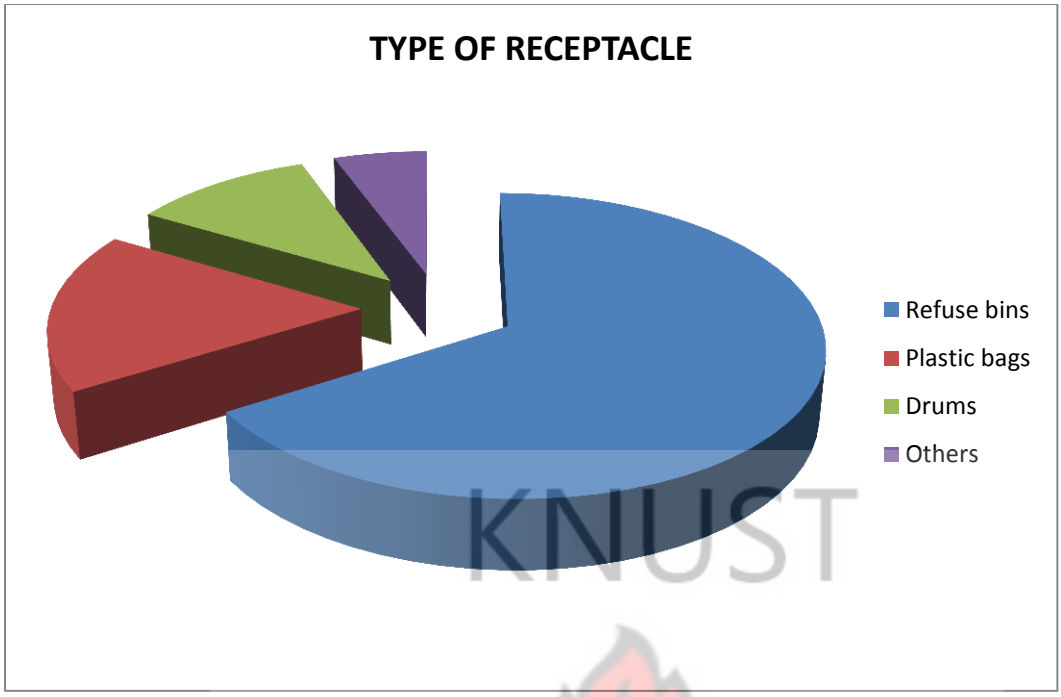

Figure 4.9 Type of receptacle

b. **Provider of household refuse storage facility**

Almost half of the refuse bins (49.2%) being used are provided by the KMA Waste Management Department, whiles the private waste management companies provide the fewest, about (4.6%) as shown in Figure 4.10 below.

Table 4.6 Provider of household storage facility

Provider of household storage facility	Frequency	Percentage
Private waste contractors	15	4.6
Households	232	72.1
Voluntary organisations	44	13.7
Waste management Dept.	31	9.6
Total	322	100

Source; Field Survey, November, 2013.

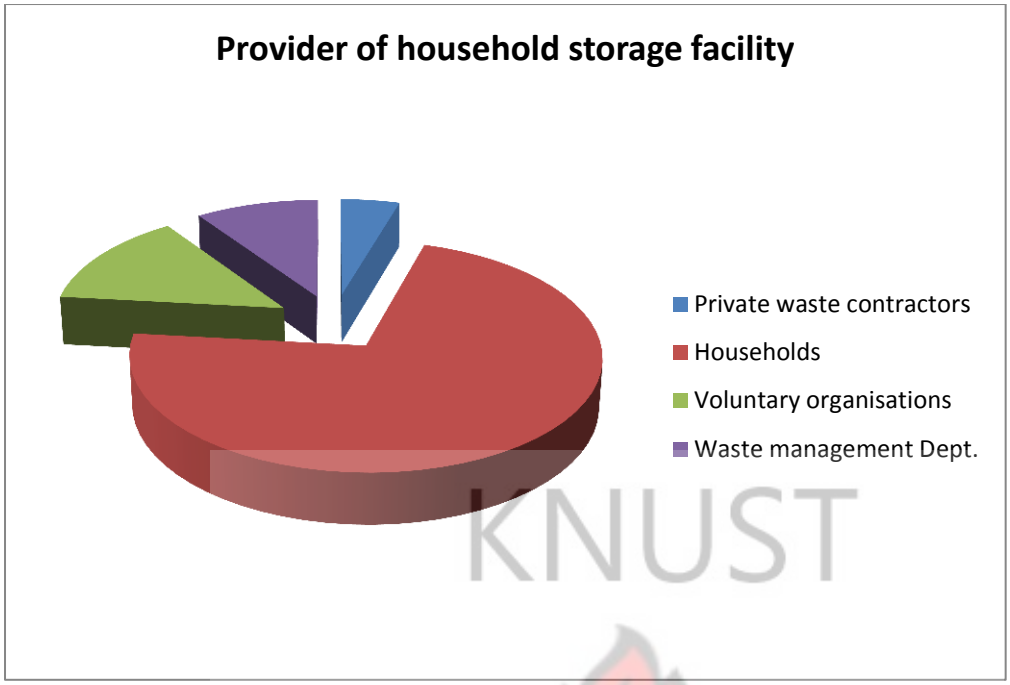

Figure 4.10 Provider of household storage facility

c. Refuse transporter from the household to the collection points

Most of the households in the Kumasi metropolis use paid labourers to dispose off their refuse (46%), while few households rely on adult men from within the community to dispose off their refuse (15.5%) as shown in the Figure 4.11 below.

Table 4.7 Refuse transporter from the household to collection point

Method	Frequency	Percentage
Paid labourers	148	46
Adults	50	15.5
Children	124	38.5
Total	322	100

Source; Field Survey, November, 2013.

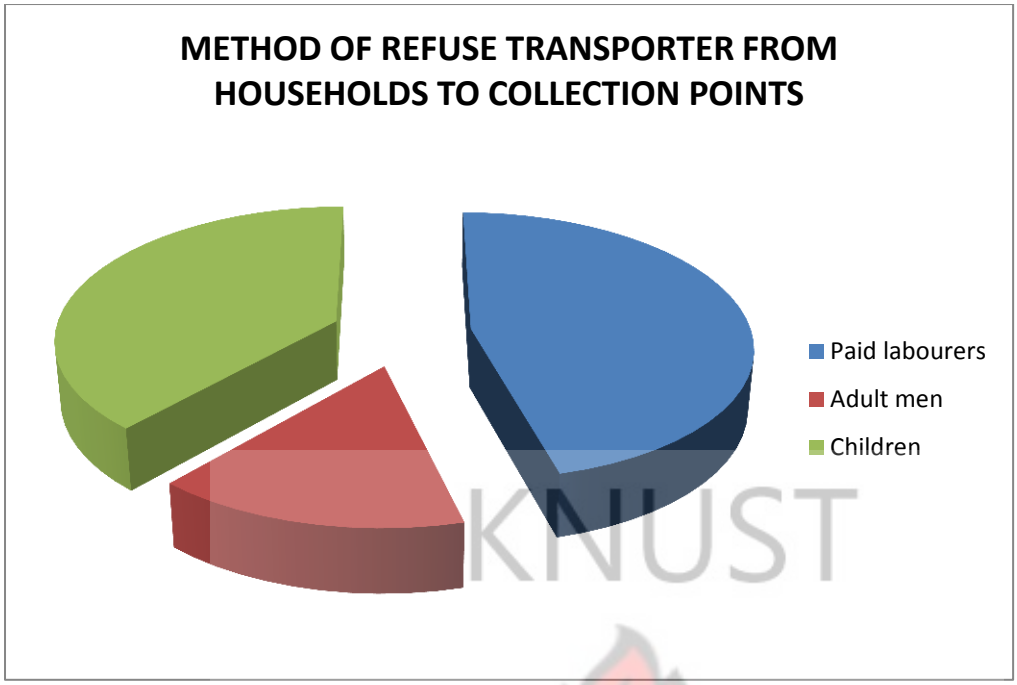

Figure 4.11 Methods of refuse transporter from the households to collection points

d. Frequency of household refuse disposal

Highest percent of the households in the Kumasi metropolis dispose off their refuse daily (68.6%), while the fewest dispose off their refuse occasionally (6.2%) as shown in the Figure 4.12 below.

Table 4.8 Frequency of household refuse disposal

Frequency of disposal	Frequency	Percentage
Daily	221	68.6
Weekly	81	25.2
Occasional	20	6.2
Total	322	100

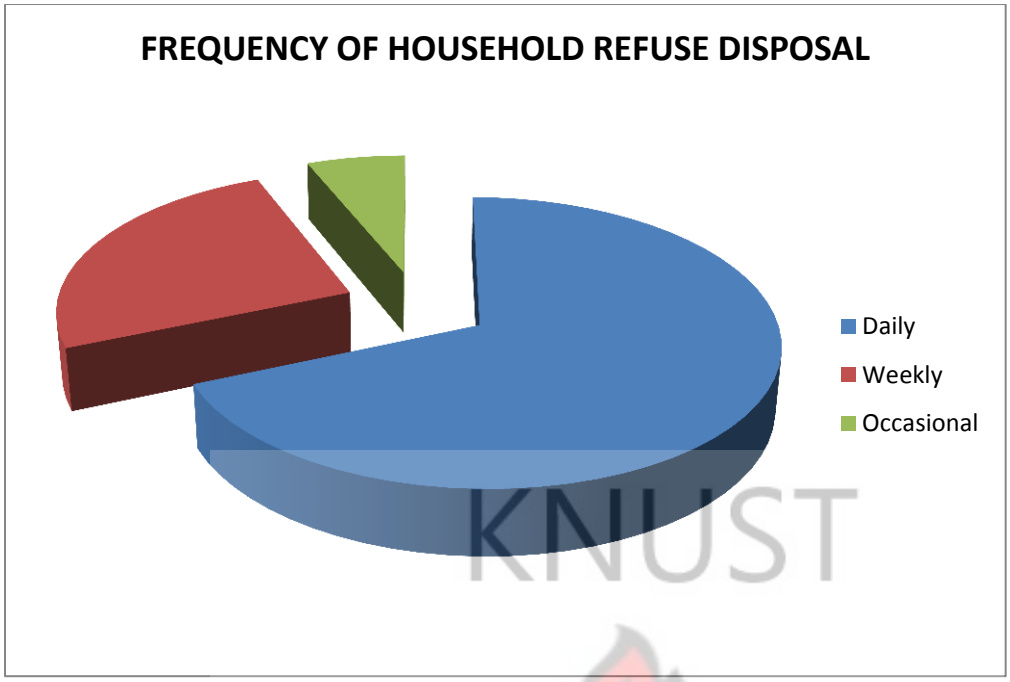

Figure 4.12 Frequency of household refuse disposal

e. Sites for refuse disposal

Most of the respondents admitted to disposing off their refuse at the various solid waste collection points in the metropolis (81.7%), whilst very few of them admitted disposing off their refuse at places like open space, water channels and roadside.

Table 4.9 Sites for refuse disposal

Site	Frequency	Percentage
Collection points	263	81.7
Water channels	11	3.4
Road side	15	4.7
Open space	15	4.7
Others	18	5.5
Total	322	100

Source; Field Survey, November, 2013

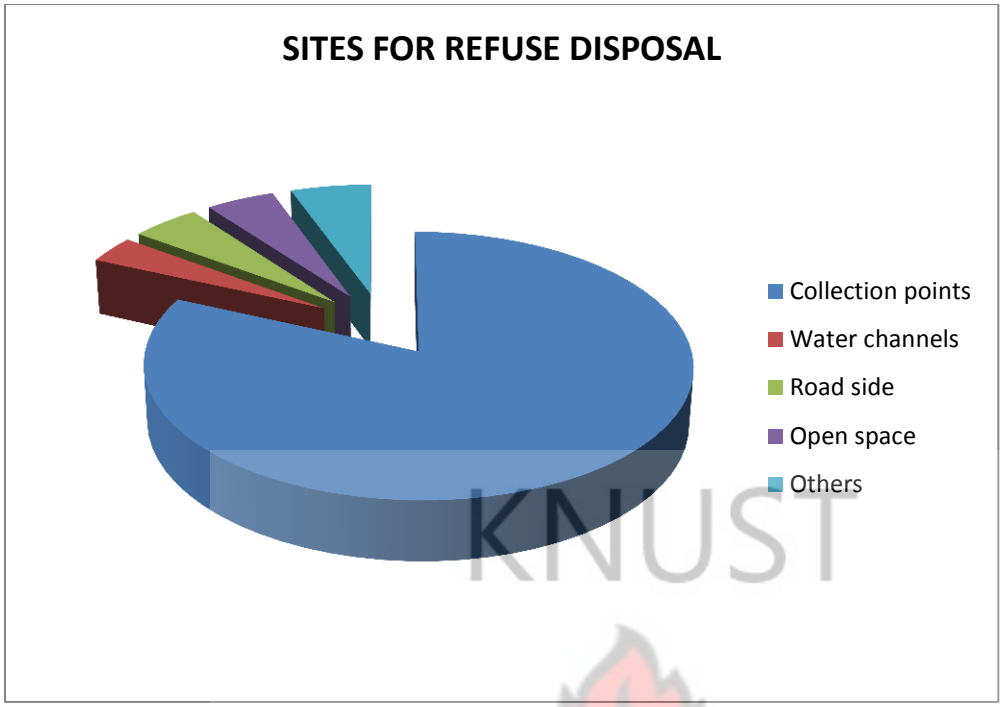

Figure 4.13 Sites for refuse disposal

f. Distance from household to the collection points

More than half of the population (53.4%) walks more than 150m to be able to dispose of their refuse, while only (7.8%) walks a distance less than 150m to be able to dispose of their waste as shown on Figure 4.14 below.

Table 4.10 Proximity to collection points

Distance	Frequency	Percentage
50m	4	1.2
100m	21	6.6
150m	122	37.9
More than 150 m	175	54.3
Total	322	100

Source; Field Survey, November, 2013

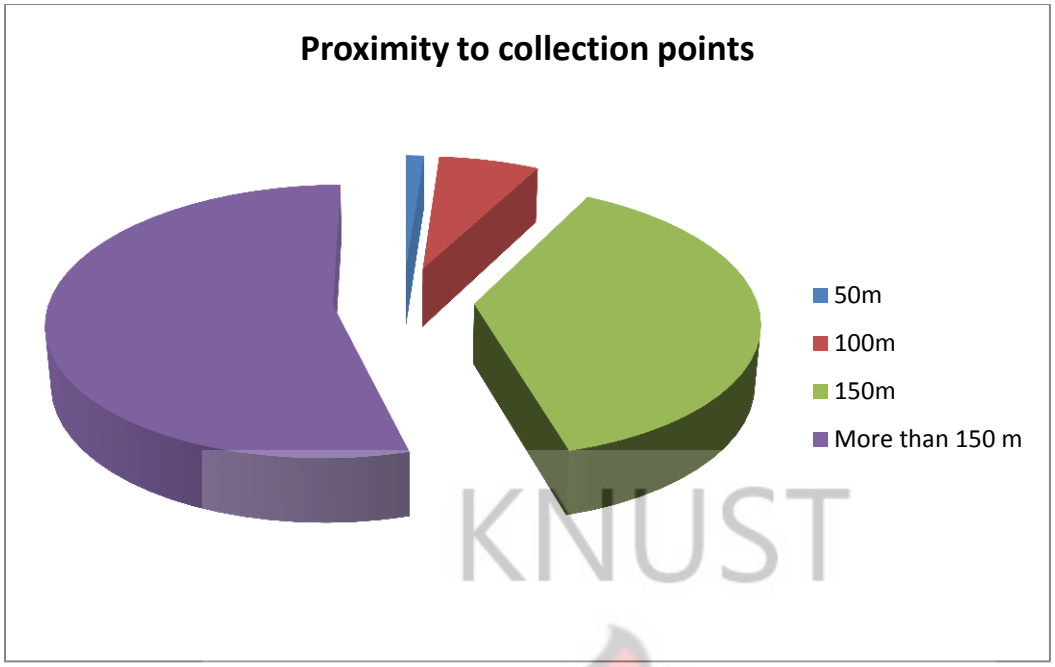

Figure 4.14 Proximity to collection points

g. Refuse evacuator from the collection points

Most of the respondents (60.3%) admitted that it was the private waste management companies that were responsible for the evacuation of waste from their communities, others also admitted (20.2%) it was done by the KMA Waste management department, others also said (6.8%) it was done by the community leaders and the rest believed it was done by voluntary organisations(12.7%) as shown in the Figure 4.15 below.

Table 4.11 Refuse evacuator from the collection points

Refuse evacuator	Frequency	Percentage
Waste management dept.	65	20.2
Waste contractors	194	60.3
Voluntary organisations	41	12.7
community	22	6.8
Total	322	100

Source; Field Survey, November 2013

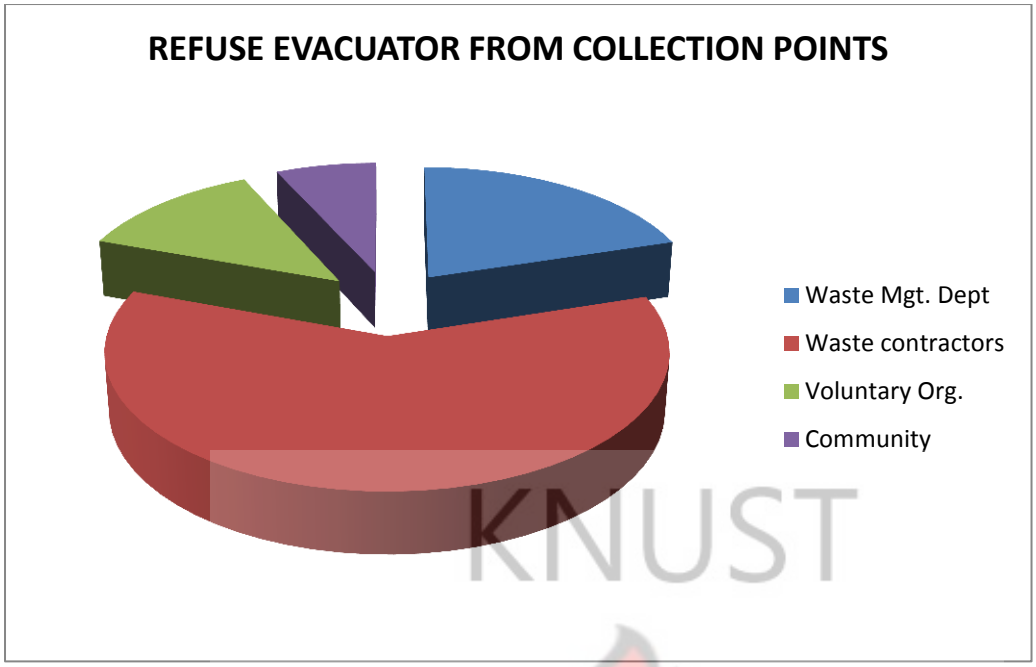

Figure 4.15 Refuse evacuator from collection points

h. Frequency of refuse evacuation from the collection points

A greater percentage of the respondents (33.2%) admitted that evacuation was carried out as and when collection container is full, whiles about (26.7%) of the respondents admitted to a weekly evacuation of refuse and about (22.7%) admitted to inconsistent refuse evacuation.

Table 4.12 Frequency of refuse evacuation from the collection points

	Frequency	Percentage
When container is full	107	33.2
Weekly	86	26.7
Inconsistent	73	22.7
Not at all	56	17.4
Total	322	100

Source; Field Survey, November, 2013

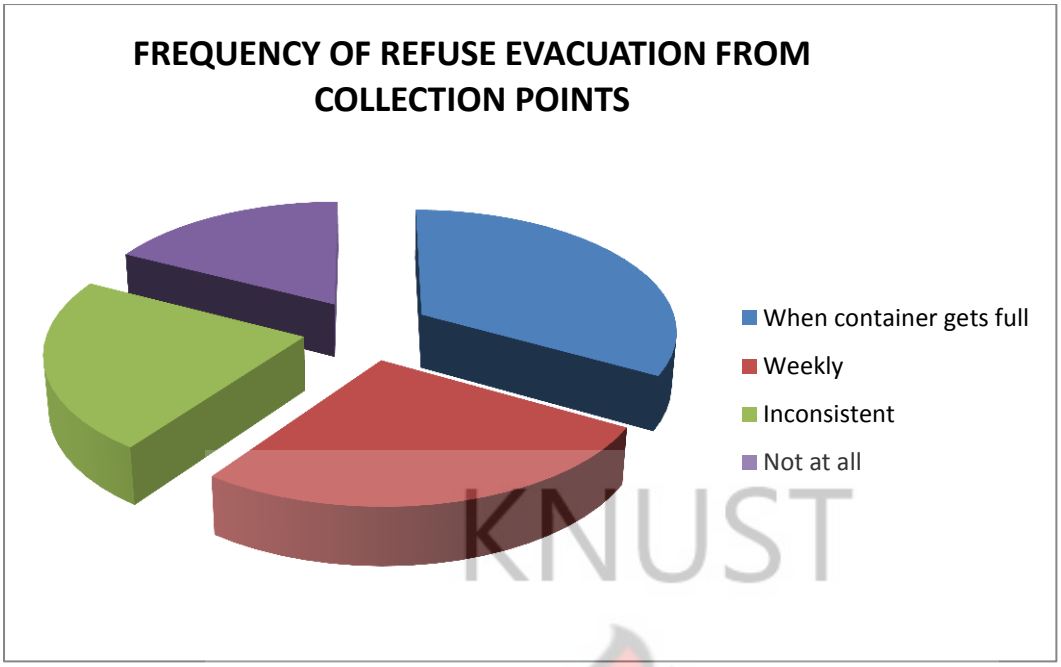

Figure 4.16 Frequency of refuse evacuator from collection points

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter considers the findings gathered on the sample from the study population and discusses it in line with the objectives, literature review, and the key variables of the research.

5.2 Spatial Data Analysis

The solid waste collection points of KMA irrespective of legal(authorised) or illegal (unauthorised) have been located and numbered to come up with a total of 125collection points distributed unevenly across the nine (9) sub metropolitan areas in the whole Kumasi metropolis. Although the distribution of the collection points is generally uneven, but the unevenness is less in certain areas (locations) and more in other areas (Figure 4.2). And this has to do with the settlement pattern and the population density of the area. (Figure 4.1)

The settlement pattern of KMA has been categorised into two based on population density. The first category is the high to medium density settlements which includes places like Bantama sub metro, Oforikrom sub metro, Subin sub metro, Kwadaso sub metro and their peripheral areas respectively whilst the second category is the medium to low density settlement which include Suame, Tafo, Nhyiaeso, Asokwa and Manhyia sub metros. The case of Subin sub metro is one that needs careful consideration in that, though it is not the highest populated sub metro, it accounts for almost about 46.1% of the total refuse generated and collected daily in the kumasi metropolis due to the fact that it is the central business district of the metropolis and everyday an estimated 100,000 people enter and leave the CBD for the purposes of trading(buying and selling), which generates a whopping 600 tonnes of refuse daily particularly in Adum and Kejetia. (Figure 4.5), according to the KMA, waste management department (2013).

Moreover, the characteristics of solid waste collection points between the high to medium density and the medium to low density is different in the sense that most of the collection points within the former seems to be over used as volumes of refuse heaps were observed during the field exercise most especially in and around the CBD. Asokwa sub metro being a medium density urban extension and the major area functioning as the industrial hub of the metropolis, with industries such as steel, packaging, beverage processing, oil storage etc accommodates only about 11 sites out of about 125 sites which is about 8.8% of the total. The waste management department has categorised these sites legal and illegal sites. The sites that have been allocated by the department are categorised as legal ones where as the sites where people are just disposing off refuse indiscriminately without authority from the waste management department is also categorised as illegal. The former are of two categories, a sided walled piece of land with roof and the container placed in and one which is the bare site without the building and the container placed on the bare land, whilst the later are unauthorised sites like open space, roadside, open drainages, water channels and uncompleted buildings to mention a few.

The spatial distribution of all the solid waste sites as shown in Figure. 4.2, shows that the solid waste collection sites are more concentrated at highly populated areas like the Oforikrom and Bantama sub metros of the Kumasi metropolis with occasional heaps of refuse due to the high volumes of refuse generated at these areas.

Despite the fact that houses in the Subin sub metro are closely packed together more especially in the CBD, the waste management department insisted that a reasonable number of communal solid waste collection point were evenly scatterd across the sub metro though it was admitted not to be adequate. Moreover, although the population of an area is taken into consideration before the site selection, as stated by the waste management department and despite the high population density, at the CBD, yet some of the people or inhabitants had to

travel long distances before getting a place to properly dispose of their refuse. Another reason why the solid waste collection points in CBD is not adequate is that, people agitate for the close down of certain solid waste collection points which could be closer to utilities such as road, waterways and residences etc; or because of bad odour emanating from the solid waste collection point and rather opt for door to door solid waste services and then also, rapid development of these areas into commercial and residential areas of settlement.

In all the solid waste collection points are 125 in number (Figure 4.2) comprising of 45 roll on/ off container sites making up 16.8% and 84 skip container sites also making up 83.2% (Figure 4.3) and only about 15 of these sites have the improved sanitary facility system in place. This facility according to the waste management department of KMA, is a project being undertaken by the government of Ghana (GoG) to help improve on the sanitary conditions of these solid waste collection points scattered nationwide. (Appendix 5). The introduction of this facility at some of the solid waste collection points has helped to reduced heaps of refuse and helped keep the sites cleaner as compared to the bare sites.

From the literature review, it was well known that solid waste generationactually increase with population growth, urbanisation and development as reported by the global waste report management report 2007. So it would have been expected that for the purposes of this study, the highly populated areas would have generated the greater percentage of solid waste in the metropolis. Oforikrom sub metro is the most populous sub metro in the metropolis with about 17.6% of the total though it has the highest number of solid waste collection point of about 20 sites. The metropolis which generated the highest volumes of solid waste for the year ending 2013 was the Subinsub metrothus almost about 49.5% of the total waste generated though it was the 4th most populous sub metro owing to the fact that it contains the CBD, i.e. (Adum, Kejetia, Central market and Asafo market) and a host of satellite markets and public places all of whichcontribute a great deal of solid waste generated in the metropolis because of the

trading activities that go on daily at these areas with atotal solid waste collection points of 13 sites.

With the monthly tonnage of waste generated and collected in the various sub metros, it almost seemed at par for the months with the exception of Subin sub metro whose levels were higher than the rest and very high for the months of January and December 2013, and these came about as s result of a number of ground collection exercises, evacuation exercise and clean up exercises, with the groundcollection exercise and evacuations being attributed to excessive spillages and fires at the central market areas.

5.3 Non spatial data analysis

5.3.1 Criteria for site selection by KMA waste management department

Some members of the waste management department who are directly in charge of solid waste in the metropolis were interviewed during the data collection stage both at the waste management premises and on our numerous field expedition across the nine sub metros in the metropolis and the information below were gathered.

5.3.1.1 Criteria for site selection

The under listed are the criteria set for solid waste site selection in the metropolis as ascertain by the waste management department:

The population of an area is seriously taken into consideration before fixing a solid waste collection point in an area so as to avoid under usage of the site by fixing several collection points in a very low density populated area. This is a waste of resources as there may be other nearby collection points in the area.

The opinion leaders of an area or a community which comprises of the elders, traditional leaders and assembly members may contact the KMA waste management department to make a formal request for the fixing of a communal collection point in the area.

5.3.1.2 Evacuation facilities

The evacuation of solid waste in other words haulage of the solid waste from the various collection points is done by waste management companies who are contracted by the KMA waste management department to undertake this exercise in the various sub metros of operation. The waste management department also has its own buffer trucks i.e. one skip truck, one roll on truck and one compaction truck which is use as buffer support in case of an emergency situation. In cases where some contractors are not able to perform due to one problem or the other, other companies with bigger capacities are made to stand in and work on their behalf. For instance when the contractor at Kwadaso sub metro (Waste Group Ghana) stopped work due to low capacity, Zoomlion Ghana Limited was made to stand in for them until a new company took over.

5.3.1.3 Operations of private waste management companies

Private waste management companies are solely in charge of managing the solid waste collection in the entire metropolis even though the waste management department comes in to support in times of emergency. In all about seven private waste management companies have been contracted by the waste management department to operate in the collection transportation and disposal of solid waste in the nine sub metros in the Kumasi metropolis. According to the department, the contract is given based on the company's capacity to carry out the operation of solid waste management and due to this, some companies handle only one sub metro, others handle two and others even handle three. Some of the companies also are not able to operate fully in one sub metro as such, they are only given a portion of the operational area to operate and the remaining portion to others who have the capacity to operate. For instance in the case of Zoomlion Ghana limited, even though it is operating fully in the Subin, Tafo and the then Asawase (now Asokore Mampong Municipal Assembly) sub

metros, it has been given extra portions of Bantama, Suame and Manhyia sub metros to operate due to the their extreme huge capacity.

1. Zoomlion Ghana limited operates within the Subin and Tafo sub metros fully and operates partly within the Bantama, Manhyia and Suame sub metros. Zoomlion Ghana limited is responsible for the collection, transportation and disposal of refuse in these mentioned sub metros. They are about the only company that provides household collection bins to customers free of charge and also provide their own communal solid waste collections containers at the solid waste collection points for the temporal storage of the waste in the communities.

2. Venmark waste company is responsible for solid waste collection, transportation and disposal at the Kwadaso sub metro. This was a sub metro which was originally being handled by the now defunct Waste Group Limited and handed over to Zoomlion Ghana limited to take charge till Venmark took over as the substantive company in charge. The household bins were distributed by the waste management department sometime back and currently the inhabitants buy their own household refuse bins and the solid waste refuse container placed at the various collection points in this sub metro are provided by the waste management department.

3. SAK - M company limited is also in charge of the solid waste management in the Asokwa sub metro in which the industrial hub of the metropolis is located. i.e. Kaase, Ahinsan and Atonsu. Here too, the provision of solid waste refuse containers and household refuse bins is by the waste management department and not the company as in the case of zoomlion Ghana Limited. This sub metro is made up of both residences and industries like beverage processing companies, timber companies, steel manufacturing companies etc. A tour of these companies showed that most of them of have their own solid waste management plan and

they are in contract with one waste management company or the other for the collection and disposal of their waste.

4. Asadu Royal Waste is the waste management company responsible for the communal solid waste collection exercise at the Oforikrom sub metro and its environs. From the collection stage through transportation unto the final disposal of the waste. They are also a new waste management company which took over from the then ABC waste company which was withdrawn from operating due to poor and inefficient service.

5. Meskworld Company Limited is also one of the private waste management companies operating in the Kumasi metropolis, to be more specific the Manhyia and Bantama sub metros. They used to be very vibrant when they started but due to some operational challenges, portions of their operational areas were given to Zoomlion Ghana Limited to handle in the two sub metros.

6. Anthoco Waste Limited is in charge of the same operations of communal solid waste collection in the Suame sub metro. Due to some challenges also on their path, a portion of their operational area was given to Zoomlion Ghana limited to manage till date.

7. Kumasi Waste Management Ltd (KWML) is also one ofthe waste management companies operating in the Nhyiaeso sub metro. It is one company that seem to be doing very well in its operations in the area of operation. They carry out collection, transportation and disposal of solid waste in the Nhyiaeso sub metro.

5.4. General frequency distribution

The following discussions are in relation to the distribution represented by pie charts and bar charts show the kind of variation among the Kumasi metropolis population in terms of facility usage, attitude towards the solid waste collection points as well as the community perception on the refuse management system.

5.5 Demographic characteristics

The average age of the respondents was 46.5 years; the oldest was 90 and the youngest 22 years. The males were more than the females. Some of them had tertiary education, primary education and no schooling at all with the majority having had secondary education. All respondents either had average or low income with a few unemployed. On the religious front, respondents were either Christians or Muslims with Christians forming the dominant group. Most of them were married with a few either, single, divorced or separated. Mostly, it is the age of a person that really affect how he or she disposes of solid waste in that children tend to dispose refuse off behind peoples buildings and storm drains to pocket the money for sweets. The income levels of contribute in the sense that people living in low class areas are found to generate more refuse than in the high class areas.

5.6 Methods of waste collection and transport

About 46% of the respondents in the study collected and transported their waste through paid labourers (from individual households to containers placed in front of selected houses) and 15% through adult men (from individual households to community storage receptacles for onward transmission to dump site), 38% used children as shown in figure 4.11 and table 4.7. Basically, solid waste collection is the process of transferring solid wastes from storage receptacles into vehicles and then transporting it to the disposal sites (Nyang'echi, 1992). In this study, no vehicles were involved in waste collection but rather people carried waste from the storage sites to the solid waste collection points. Some of the receptacles leaked and dropped some of the waste on the ground and may spread pathogens. Bad odour is also released polluting the air. Water bodies get polluted giving rise to water-borne diseases such as cholera and diarrhoea. Tsiboe and Marbell, 2004) add weight to this fact by stating that in Accra disposal sites are located near the sea and are polluting the Korle lagoon creating an unhealthy environment.

5.7 Factors contributing to improper solid domestic waste management

5.7.1 Income level of respondents

A remarkable number of the respondents had average and low incomes. There was also the problem of unemployment. There was no significant difference between income level and the type of solid domestic waste management practiced. Tsiboe and Marbell (2004) stated in their study that "a combination of poverty, population pressure, and economic hardships is placing a considerable strain on household environments in Accra. Majority of the people in Ghana live below the internationally recognized poverty line of one dollar a day. Satterthwaite (1998) virtually agrees in principle that the waste problem emanates from poverty and lack of funding as a result of low level of economic growth. Financial constraints undoubtedly are a factor that contributes to improper solid domestic waste management. The income level of a person generally contributes to the how he or she disposes off his or her solid waste. In areas like Nhyiaeso which is a high class residential area, indiscriminate dumping of refuse was not observed as compared to places like aboabo which is a low class residency where indiscriminate dumping is often seen and the whole area is untidy. This was clearly due to the inability of most people to pay before dumping.

5.7.2 Type of storage receptacle used

About 33.9% of the respondents used receptacles without covers. Other improvised refuse bins thus, they lacked proper storage receptacles as indicated in figure 4.9 and table 4.5. These attract flies; serve as a breeding place for many insects and vermin which transmit disease. The stench emanating from these open receptacles become a nuisance to people. A study conducted by Benneh et al in 1993 showed that the problem of solid waste in Accra begins at the home. According to Benneh et al (1993), open storage of solid waste was practiced by some 42% of households in Accra and some of the problems associated with this system of waste disposal have been the prevalence of rodents and flies around the home.

5.7.3 Availability of community storage receptacle

Although 81.7% of the respondents had community storage receptacles, The 18.7% of the respondents which did not have these options available to them tend to use other means other than the solid waste sites to dispose of their refuse and this kind of act poses a great health and environmental challenge to the community as a whole had them as shown in figure 4.13 and table 4.9. The presence or otherwise of community storage receptacles may also influence the kind of solid domestic waste management practiced.

5.7.4 Distance to dump site

Majority of the respondents said they lived far away from the dump site (54.3% were too far away and 37.9% were far away from the dump site as shown in figure 4.14 and table 4.10. Significantly, there was no difference between distance to dump site and the kind of dumping practiced. The possibility is that indiscriminate dumping which promotes infection and creates an unsightly scene could be practiced. Gourlay (1992) stated that, " Environmentalists should not only join scientists and other responsible sectors of industry and agriculture to find better ways for disposing of wastes, but to locate convenient places for their disposal.

Location of the dumping sites too can be discouraging, considering the fact that children who are assigned to carry wastes to the dumps may find it inconvenient to walk long distances and out of frustration may dump them anyhow and anywhere. Fasida (1996) also stressed that the paramount consideration in the management decisions involving waste disposal is site location. To eliminate the problem involved in indiscriminate disposal of waste, sites located for waste disposal be "paramount" as quoted by Fasida. The results therefore suggest that the communities have not taken the pains to identify suitable sites to enable them manage wastes well..

5.7.5 Type of refuse dump used in the communities

69% of the respondents used a surface dump at the outskirts of town. This type of dump is not recommended as far as public health is concerned. 20% of them used isolated spots within the communities as dump sites, another adverse state of affairs. Dug trench was used by 6% and 5% used other methods. Surface dumps at the outskirts of towns have serious negative public health implications. Goldsmith (1988) emphasized that improper refuse dump, apart from ruining an area's appearance; also provide a comfortable breeding place for animals and other organisms that spread diseases.

These wastes, according to him, drain into water bodies to contaminate the water sources, the result of which is the rampant outbreak of typhoid fever in the area which is also the case in Kumasi. Since mosquitoes also breed at unhygienic places, the improper dump in the area gives the mosquitoes an opportunity to lay their eggs which are hatched and increase the quantum of mosquitoes and hence a high incidence of malaria. The virus which causes cholera arrests the opportunity of the unhygienic environment to cause infection. The communities therefore must be taught and sensitized to live in a clean environment. But this would be possible if people would change their negative attitude about waste disposal to help reduce the outbreak of diseases. Open dumps are poor methods of disposing of waste because of the environmental problems they cause. Refuse dumps are located on the edges of cities, towns, and villages, sometimes in ecologically sensitive areas, or areas where groundwater supplies are threatened. They serve as breeding grounds for rats, flies, birds and other organisms that function as disease vectors. In poorer areas, uncollected wastes accumulate at roadsides, are burnt by residents, or are disposed of in illegal or inappropriate dumps which blight neighbourhoods and harm public health (Medina, 1997). The sheer volume of domestic solid wastes is already causing serious disposal problems because most of the methods used to dispose them result in some kind of damage to the environment. When these solid

domestic wastes are placed into open dumps, they ruin the attractiveness of the surrounding area. Dumps also provide habitats for disease carrying organisms (Barrow, 1995).

5.7.6 Availability of land for dump site

A greater percentage of respondents mentioned unavailability of land for dump site since with time and increasing development and high population, most of the sites in the Kumasi metropolis are gradually being cornered in a small place as most of the sites have been encroached upon by developers and land availabity is now a big challenge. Without doubt, this situation would promote indiscriminate or crude dumping with its attendant negative public health effects. Fasida (1996) also emphasized that the paramount consideration in the management decisions involving waste disposal is site location. Much attention is not given to the location of sites for waste disposal the result of which is the prevalence of disease outbreak.

5.7.7 Waste disposal method

More than three out of four (85%) of the respondents disposed of their refuse at the refuse dump sites which are mostly surface dumps. This is reiterated by Asomani-Boateng and Haight (1998) who also had 79% of their respondents using the same method. This method of waste disposal according to Mantell (1972) causes environmental problems. They can destroy an area's appearance and provide a home for animals and insects that spread diseases. Barrow (1995) strongly disagrees with this method of disposal practiced by the people by pointing out that when wastes (agricultural wastes) are drawn into streams by run-off water, eutrophication, resulting in 'biological oxygen demand' (BOD) kills the aquatic fauna. The respondents adopted this practice of waste disposal probably due to lack of knowledge on how to manage solid domestic waste. Reports by the World Encyclopaedia (1994 Edition) indicated that recycling is the best method of wastes disposal because it helps to manage

wastes, re-use and lessen environmental hazards as compared with other methods. People should be encouraged to put their waste into useful agricultural inputs such as compost.

5.7.8. Refuse evacuation from the collection points

About (33.2%) of the respondents admitted that evacuation was carried out as and when collection container is full, whiles about (26.7%) of the respondents admitted to a weekly evacuation of refuse and about (22.7%) admitted to inconsistent refuse evacuation as shown in Figure 4.16 and Table 4.12. This type of practice does not really hep in the proper management of solid waste in the metropolis because very often refuse containers at these solid waste collection points are seen to be very full and spilling on the ground which attracts disease causing insects and spreads diseases across the community. This also causes serious environmental challenges as the stench emanating from the site makes the surrounding very unpleasant to live in.Private waste contractors are highly in charge of solid waste evacuation from the solid waste collection point across the whole metropolis, though the WMD and other voluntary organisation and the community were admitted by a session of the respondents to have assisted at certain things. The main challenge with respect to the refuse evacuation by the private waste contractors is the fact that sometimes,especially during the raining season when accessibility at the landfill becomes a big problem. This is due to the slippery nature of the landfill working surface which does not allow the companies to dump the refuse on time and long queues are seen almost all the time at the site during these times and then also other factors like truck breakdown,financial problem etc. are not able to make the contractors evacuate the refuse from the collection points on time and sometimes they are left unattended to for so many weeks without evacuation.

This brings about challenges like excessive refuse spillagesat the sites and this degenerates into offensive odour, attract rodent,insects and pest which are carriers of disease. Some

eventually find their way into open drains and bring about chocked gutters and indiscriminate dumping.

5.7.9 Frequency of household disposal

A greater percentage of the households in the Kumasi metropolis dispose of their refuse daily(47.5%), while the fewest dispose of their refuse occasionally(4.1%) as shown in the figure 4.12 and table 4.8. Due to the fact that greater percentage of the respondent admitted to buying or acquiring their own receptacle, they tend not to acquire the appropriate receptacles (solid waste bin), though the WMD and some private companies do well to provide household with refuse bins the number is on the lower side. A greater number of respondents admitted disposing off refuse generated in the various homes daily at the solid waste collection point (65.6%),while the rest dispose them off either weekly or occasionally. The latter, according to the respondents is basically due to the (PAYD) pay as you dump system introduced by KMA,WMD so instead of disposing their refuse off daily to pay money they prefer piling them for a week or more before trying to dispose it off once in order not to pay more . The stock piling of refuse left uncovered in the households pose a great deal of health and environment risk.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary of Major Findings

This study had attempted to analyse the spatial distribution of solid waste collection points in the Kumasi metropolis in the Ashanti region of Ghana in order to achieve the aim and associated specific objectives of the study. Certain methodologies were carefully employed ranging from field pre work, detailed field work and post field work.

The pre field work consist of review of literature, obtaining the list and addresses of the solid waste collection points from the KMA waste management department to serve as a guide for identifying, locating, numbering and distinguishing their type and legality through which familiarization was achieved.

The detailed field work was divided into spatial and non-spatial data collection. The former consists of the use of a survey device, specifically the Global Positioning System (GPS) which was used to pick the coordinates of all the solid waste collection points; creating a database to record the coordinates, locations and addresses of the collection points; using a digital camera to take pictures of the solid waste collection points in order to show their nature or type. Whilst the latter consists of questionnaires to analyse the attitudes of the community usage of the solid waste collection points and also conducting an interview with personnel from the waste management department to find out the criteria they use for the selection of solid waste collection points in the study area.

The solid waste collection points in the Kumasi metropolis have been located and numbered to come up with a total of 125 solid waste collection sites distributed unevenly across the nine sub metros within the whole metropolis. The solid waste collection points are made up of two

types of collection facilities; roll on/off and skip as stated earlier. The former consists of 15 of these sites (12%) and the latter consists of 110 of these sites (88%).

With regards to the questionnaire analysis, the study area which is already sub divided into nine sub metros of which contains 125 solid waste collection points. Thus it was assumed that 100% of the inhabitants in the nine mentioned sub metros above dispose of their solid waste in the legal solid waste collection points, Therefore only 10 locations were sampled in stratified manner;. 400 questionnaires were distributed accordingly out of which 322 were filled and completed successfully and these were used for the analysis to make a generalisation.

The post field work consists mainly of the analysis of the data which was also divided into spatial and non-spatial data analysis. The spatial data analysis was Georeferenced and Digitized; and then mapping the distribution of the solid waste collection points. The former consists of extracting the extent of the Kumasi metropolis from Google earth satellite imagery, importing the extracted imagery to ArcGis 9.3 geographic information system (GIS) software and then georeferencing and digitizing toproduce digital maps. Population density map was also produced based on field experience and satellite imagery observation using land uses and housing pattern as guide. While the later consist of importing the coordinates of the solid waste collection points taken during the fieldwork into ArcGis 9.3 as text file and converting them to shapefile to show the spatial distribution of the digital maps. Points were used to show the solid waste collection points; the type of collection point as well as the legality were shown using different symbols (points) in terms of shape and colour variations.

As for the non-spatial data analysis, questionnaires distributed in the field were retrieved and analysed using SPSS software. Frequency distribution and cross tabulation of parameters were carried out to come up with the tables and charts (pie charts) for different parameters depending on the appropriateness to show a kind of variation among the Kumasi metropolis

population in terms of facility usage, the attitude and the perception towards solid waste collection points and the refuse management system. The information gathered by the personnel from the waste management department was used to support discussion in both the spatial and the non-spatial data analysis.

In addition to the waste management department, that is responsible for managing the entire waste in the Kumasi metropolis, there were also seven private waste management companies that have been sub contracted by the department to manage the solid waste situation in the nine sub metros in Kumasi. These are; Zoomlion Ghana Limited, SAK-M Company Limited, Kumasi Waste Management Limited, Venmark Waste Company, Asadu Royal Waste, Anthoco Waste Company and Meskworld Company limited.

The research also found out the criteria used by the waste management department for selecting site to fix a solid waste collection point; the population of the area are taken into consideration before fixing a solid waste collection point so as to avoid underuse by fixing a multiple collection points in very low population density area. Because it is a wasteful resource as there may be likely other shareable collections points in the neighbouring areas.

6.2 Conclusion

Based on the results obtained and the discussions in chapter four and chapter five, it is evident that the application of Geographic Information System (GIS) and GPS in solid waste management has brought up a number of lessons. Firstly, GIS/GPS is capable of showing the distribution and location of solid waste collection points in the Kumasi metropolis. This reveals the evenness or unevenness of the distribution. Secondly, in order to have an efficient solid waste management system, it is very important to know the current picture of distributional relationships of the collection points, as well as the types of the collection points and GIS can handle that as it is capable of integrating both spatial and non-spatial data for effective solid waste collection system. Thirdly, a map of the study area has been created

to show all the solid waste collection points in the metropolis for managerial, planning and developmental purposes.

The criteria for the selection of solid waste collection sites has also been known and determined from the waste management department of KMA and used it to predict more sites for solid waste collection in the whole metropolis. The perception of the community with regards to solid waste management has been greatly assessed in all nine sub metropolitan areas in the Kumasi metropolis

The research revealed that the distribution of the collection points is generally uneven in the study area, and yet the unevenness is less in certain areas and more in others depending on the settlement pattern and the population density of the area. The number of indiscriminate solid waste disposal areas increases as you move from high to low density areas, while the sizes of the refuse heaps increase from low to high density settlement areas. This is because the high density areas are made up of building closely packed together thus providing no space for indiscriminate disposal of solid waste unlike in the low density areas. Moreover, in addition to the settlement pattern, some people from the communities have been approaching the waste management department for the closure of some solid waste collection sites due to one reason or the other which could be proximity to utilities like, waterways, roads, residencies etc. or because of the bad odour among other reasons

Majority of households in the Kumasi use pay labourers to dispose of their refuse. Highest percentage of the households in Kumasi disposeof their refuse daily, whilst few dispose them off occasionally. Majority of the households admitted to disposing off their refuse in the solid waste collection points, while few admitted to disposing theirs off in places other than, water channels, open spaces and unauthorised sites. Most of the households insisted that refuse management in their area was appropriate, few insisted it was inappropriate.

6.3 Recommendations

Based on the results obtained and the conclusions reached, the following measures are recommended for adoption by the stakeholders involved in the management of solid waste in the Kumasi metropolis.

1. There is the need for the use of urban information database that can be generated using remote sensing data and GIS techniques. Top priority should be given to the issues relating to the planned development of the city, adequate roads and links, effective drainage system etc. The staff of the waste management department among other various government departments should be given thorough exposure and training in GIS for its application and implementation in the urban environmental waste management plans. GIS for solid waste management needs to be institutionalised. It needs to be introduced to the contractors, municipal and city council officials to ease information management for both spatial and non-spatial data. GIS can be used as a planning tool for solid waste management. On the other hand, the spatial and non-spatial data of the Kumasi metropolis needs to be updated from time to time to support decision making. Moreover the private waste management companies and other stakeholders involved in the management of solid waste needs to be trained in the use of GIS as a tool for solid waste collection. Short courses, seminars and workshops need to be conducted to build their capacity in solid waste collection. The focus should be based on empowering stakeholders about the importance of information, information needs, collection, storage, analysis and use.

2. There is also the need to carryout extensive mapping of the Kumasi Metropolitan Assembly for future detailed spatial studies on solid waste collection in the metropolis.

3. There cannot be an efficient and effective solid waste management without proper and extensive monitoring and supervision of its generation, collection, storage, transportation and

disposal activities. There is therefore the need to adapt the Integrated Solid Waste Management system in dealing with our solid waste problems.

4. There is the need for intensive public education, public awareness and public involvement to change the public attitude towards solid waste management in the metropolis.

5. Finally, there is the need to focus more on reducing, re use, recycling and recovery of waste.

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APPENDIX

COORDINATES OF SOLID WASTE SANITARY SITES

LOCATION	LAT	LONG	Y_PROJ	X_PROJ	ALTITUDE
Abotanso	6.72971020	-1.61773011	744085.422	652773.801	292.00
Adabraka	6.75350231	-1.60343980	746720.784	654345.996	324.00
Adiembra	6.66009329	-1.63335063	736382.611	651068.449	282.00
Adompom	6.73639233	-1.60919465	744826.989	653715.250	304.00
Adompom Ext	6.73242224	-1.60811791	744388.327	653835.528	311.00
Amakom Div	6.68775206	-1.60524971	739449.724	654166.645	284.00
Amakom Market	6.68688839	-1.60141809	739355.424	654590.521	270.00
Apatrapa	6.71026317	-1.68578630	741914.342	645256.416	253.00
Apinaman	6.63968378	-1.62397932	734128.682	652110.819	268.00
Apiri	6.65589781	-1.66062878	735910.437	648053.855	250.00
Asuyeboa LA	6.69523593	-1.66469693	740259.011	647592.296	272.00
Asuyeboa Mark	6.69439724	-1.66650130	740165.731	647393.074	264.00
Asuyeboa Met P	6.69379357	-1.66918209	740098.178	647096.892	273.00
Atasemanso	6.64968691	-1.63385027	735231.765	651016.389	258.00
Colligate	6.68719190	-1.61005346	739386.279	653635.743	286.00
Daban Kuma	6.64283680	-1.62011853	734478.519	652536.715	276.00
Daban Pnin	6.63679361	-1.62208065	733809.682	652321.634	256.00
Dakodwom	6.67041108	-1.62886187	737524.887	651561.556	270.00
Denkyemuoso	6.69021626	-1.68153919	739698.939	645731.871	259.00
Dome	6.74845498	-1.60628630	746161.762	654032.940	317.00
Edwinase	6.68161609	-1.65557675	738755.748	648604.656	284.00
Fankyenebra	6.66093324	-1.64238581	736472.734	650069.267	289.00
Kokode	6.67100418	-1.66275962	737580.178	647813.746	263.00
Kron Market	6.64545338	-1.63747268	734762.536	650617.177	243.00
Kronkomoase	6.64205577	-1.63548659	734387.448	650837.800	260.00
Kti	6.69388938	-1.60087947	740129.745	654647.866	264.00
Kwadaso Onion	6.69751824	-1.65322403	740514.839	648859.943	283.00
Labuor	6.69048213	-1.61295787	739749.196	653313.620	278.00
Lobito	6.68538007	-1.59818854	739189.654	654948.041	260.00
Maame Kakraka	6.72917074	-1.61362692	744027.054	653227.557	302.00
Market	6.75110115	-1.60373795	746455.175	654313.800	321.00
Mary Akuamoah	6.68694966	-1.60623089	739360.689	654058.422	276.00
Moro Market	6.72237687	-1.61419504	743275.631	653166.883	309.00
Nhyiaeso Old T	6.66760943	-1.62534113	737216.175	651951.665	280.00
Nwamase	6.66127095	-1.66249408	736504.010	647846.020	271.00
Nyankyerenase	6.71753934	-1.68101775	742720.312	645781.396	272.00
Nzema	6.67092238	-1.66653651	737570.002	647396.213	267.00

Odeneho K	6.66700568	-1.64149851	737144.467	650165.519	279.00
Ohwimase	6.68883207	-1.66183543	739551.767	647910.564	278.00
Police Station	6.73711569	-1.61510498	744905.119	653061.674	308.00
Prisons	6.69275371	-1.62344917	739997.120	652153.065	284.00
Santasi Main	6.65467355	-1.64132525	735780.889	650188.425	279.00
Santasi Zongo	6.65085090	-1.64471959	735357.168	649814.304	263.00
Soboro	6.68054874	-1.59516946	738656.369	655283.342	257.00
Sofoline	6.69870495	-1.64807553	740647.624	649428.751	277.00
Sokoban School	6.62873265	-1.61629630	732920.111	652963.671	255.00
Suame P Stn	6.71169179	-1.63034177	742089.090	651385.225	301.00
Tafo Cem	6.71934404	-1.62333651	742937.419	652157.269	293.00
Tafo Cemetary	6.72300015	-1.61977387	743342.808	652549.968	301.00
Tafo Methodist	6.73151960	-1.61232194	744287.194	653371.079	301.00
Tanoso Ang Sch	6.69737382	-1.68826148	740488.388	644986.604	263.00
Tanoso K	6.69302847	-1.69388347	740006.252	644366.376	240.00
Tanoso Market	6.69942403	-1.69225294	740713.910	644544.748	253.00
Techiman	6.68554863	-1.68846130	739180.776	644968.002	258.00
Timpom	6.62441824	-1.61893551	732442.227	652673.187	247.00
Yarewa Zongo	6.69394378	-1.61339080	740131.840	653264.678	292.00
Yf:	6.68289173	-1.60918233	738911.052	653733.394	268.00
Zion	6.68666678	-1.61304035	739327.281	653305.692	274.00

SUB METRO	SITE/LOCATION	CONT. TYPE	NUMBER. OF CONT.	TOILET AVAIL.	SHED PLATFORM	CONT. VOL.	MONTHLY LIFT. FREQ
ASOKWA	AHINSAN ESTATE		1	NIL	NIL	16M3	15
	AHISAN PENTECOST		1	NIL	NIL	12M3	30
	AHINSAN SCHOOL		1	YES	NIL	12M3	30
	APRABO		1	YES	NIL	12M3	30
	ASOKWA LLL		1	NIL	NIL	12M3	4
	ATONSU MAIN		1	NIL	NIL	NIL	30
	ATONSU S LINE		1	NIL	NIL	12M3	30
	ATONSU SCHOOL		1	YES	NIL	14M3	30
	DOMPOASE		1	NIL	NIL	14M3	30
	GYINYASE		1	NIL	YES	12M3	30
	KYIRAPATRE		1	NIL	YES	12M3	30
BANTAMA							
	ABREPO KESE	SKIP	1	YES	NIL	12M3	30
	ABREPO PENTECOST	SKIP	1	YES	NIL	12M3	4
	ADOWATO MARKET	SKIP	1	YES	NIL	12M3	15
	ADOWATO STATION	SKIP	1	YES	NIL	12M3	30
	ADUMANU	SKIP	1	NIL	NIL	12M3	8
	AMANFROM	SKIP	1	YES	NIL	12M3	15
	AMPABAME	SKIP	1	YES	NIL	12M3	30
	ATAFOA	SKIP	1	YES	NIL	12M3	30
	BOHYEN	SKIP	1	YES	NIL	12M3	30

	BRONIKROM	SKIP	1	NIL	NIL	12M3	10
	CHIEF OWUSU	SKIP	3	YES	NIL	12M3	60
	GOLF PARK	SKIP	1	NIL	NIL	12M3	30
	MPATASIE	SKIP	1	YES	NIL	12M3	30
	OHWIM	SKIP	1	NIL	NIL	12M3	30
	RACE COURSE	SKIP	1	YES	NIL	12M3	30
	SEFA BOAKYE	SKIP	2	YES	NIL	12M3	30
KWADASO							
	APATRAPA	SKIP	1	YES	NIL	12M3	8
	ASOYEBOA L/A SCH.	SKIP	1	YES	NIL	12M3	8
	ASOYEBOA MARKET	SKIP	1	YES	NIL	12M3	10
	ASUOYEBOAH METH.	SKIP	1	YES	NIL	12M3	8
	DENKYEMUOSO	SKIP	1	YES	NIL	12M3	4
	EDWINASE	SKIP	1	YES	NIL	12M3	8
	KOKODE	SKIP	1	YES	NIL	12M3	4
	KWADASO MARKET	SKIP	1	NIL	NIL	12M3	8
	NWAMASE	SKIP	1	YES	NIL	12M3	8
	NYANKYERENEASE	SKIP	1	YES	NIL	12M3	6
	NZEMA	SKIP	1	NIL	NIL	12M3	6
	ODENEHO KWADASO	SKIP	1	NIL	NIL	12M3	15
	OHWIMASE	SKIP	1	YES	NIL	12M3	10

	SOFOLINE	SKIP	1	NIL	NIL	12M3	8
	TANOSO ANG. SCH.	SKIP	1	YES	NIL	12M3	6
	TANOSO MARKET	SKIP	1	YES	NIL	12M3	8
	TECHIMAN	SKIP	1	NIL	YES	12M3	4
	TANOSO TOWN	SKIP	1	NIL	NIL	12M3	15
MANHYIA							
	ASHTOWN POST OFFICE	SKIP	1	YES	NIL	12M3	30
	BUOKROM SCH.	RORO	1	YES	NIL	23M3	30
	CPC	SKIP	1	YES	NIL	12M3	30
	DICHEMSO	SKIP	1	NO	NIL	12M3	30
	KROFROM	RORO	1	NO	NIL	23M3	30
	MANHYIA PALACE	SKIP	1	YES	NIL	12M3	4
	MOSHIE ZONGO	SKIP	1	YES	YES	12M3	30
	OYOKOHENE	SKIP	1	YES	NIL	12M3	30
	SALVATION	SKIP	1	YES	YES	12M3	30
	SEPE	SKIP	1	YES	NIL	12M3	30
	ST. ANNES	RORO	1	YES	NIL	23M3	30
	ST. JOSEPHS	SKIP	1	YES	NIL	12M3	30
	YENYAWOSO	RORO	1	YES	YES	23M3	15
NHYIAESO							

	ADIEMBRA	RORO	1	YES	NIL	23M3	8
	APIRE	SKIP	1	YES	NIL	12M3	8
	APRAMAN	SKIP	1	NO	NIL	12M3	15
	ATASEMANSO	RORO	1	NO	NIL	23M3	8
	DABAN KUMA	SKIP	1	NO	NIL	12M3	15
	DABAN PANIN	SKIP	1	NO	NIL	12M3	8
	DAKODWOM	SKIP	1	NO	NIL	12M3	15
	FANKYENEBRA	RORO	1	YES	NIL	23M3	8
	KRONKOMOASE	SKIP	1	YES	NIL	12M3	6
	KRONKOMOASE MKT.	SKIP	1	NO	NIL	12M3	4
	NYIAESO OLD TOWN	SKIP	1	NO	NIL	12M3	8
	SANTASE MAIN	RORO	1	YES	YES	23M3	15
	SANTASE ZONGO	RORO	1	YES	NIL	23M3	8
	SOKOBAN SCHOOL	SKIP	1	YES	NIL	12M3	8
	TIMPOM	SKIP	1	YES	NIL	12M3	8
OFORIKROM							
	ANWOMASO	N/A	NIL	NIL	NIL	NIL	6
	APPEADU	SKIP	1	YES	NIL	12M3	8
	AYEDUASE MKT	SKIP	1	YES	NIL	12M3	15
	AYEDUASE TOWN	SKIP	1	YES	NIL	12M3	30

	AYIGYA AHENBRONUM	SKIP	1	YES	YES	12M3	30
	AYIGYA ZONGO	SKIP	1	YES	YES	12M3	30
	AYIGYA ZONGO PARK	SKIP	1	YES	NIL	12M3	30
	BEBRE	SKIP	1	YES	NIL	12M3	8
	BOADI	SKIP	1	NO	NIL	12M3	15
	BOMSO CEMETARY	SKIP	1	YES	NIL	12M3	30
	BOMSO TOWNSHIP	SKIP	1	YES	NIL	12M3	30
	DEDUAKO	SKIP	1	YES	NIL	12M3	15
	EMINA	SKIP	1	NO	NIL	12M3	15
	KENTINKRONO	SKIP	1	YES	NIL	12M3	30
	KOTEI DEDUAKO	SKIP	1	YES	NIL	12M3	15
	NSENIE	SKIP	1	YES	NIL	12M3	15
	ODIOM	SKIP	1	NO	NIL	12M3	15
	OFORIKROM SCH.	SKIP	1	YES	NIL	12M3	30
	TWUMDUASE	SKIP	1	YES	NIL	12M3	15
	WESTEND HOSTEL	SKIP	1	NO	NIL	12M3	15

SUAME							
	BREMAN	RORO	1	YES	NIL	23M3	30
	KRONOM KWAPRA	SKIP	1	YES	YES	12M3	30
	KRONOM TOWN	SKIP	1	YES	YES	12M3	15
	MAAKRO	SKIP	1	YES	NIL	12M3	10
	SUAME MARKET	RORO	1	NO	NIL	23M3	15
	ABOAHIA	RORO	1	YES	YES	23M3	15
SUBIN							
	AMAKOM DIVISION	SKIP	1	YES	NIL	12M3	30
	AMAKOM MARKET	RORO	2	YES	NIL	23M3	30
	AYAREWA	SKIP	2	YES	NIL	12M3	30
	COLLIGATE	RORO	1	YES	YES	23M3	30
	KEJETIA	RORO	1	YES	NIL	23M3	30
	LABOUR	RORO	1	YES	NIL	23M3	15
	LOBITO	SKIP	1	YES	NIL	12M3	8
	MARY AKUAMOAH	SKIP	1	YES	NIL	12M3	8
	PRISONS	RORO	4	YES	NIL	23M3	
	SOBORO	SKIP	1	YES	NIL	12M3	8
	YF	SKIP	1	YES	NIL	12M3	8
	ZION	RORO	3	YES	NIL	23M3	60
	KTI	SKIP	1	NO	NIL	12M3	5

TAFO							
	ABOTANSO	SKIP	1	YES	NIL	12M3	30
	ADABRAKA	SKIP	1	YES	NIL	12M3	30
	ADOMPOM	SKIP	1	YES	NIL	12M3	30
	ADOMPOM EXT.	SKIP	1	NO	NIL	12M3	30
	DOME	SKIP	1	YES	YES	12M3	30
	EBENEZER MORGUE	SKIP	1	YES	NIL	12M3	30
	MAAME KAKRAKA	SKIP	1	YES	NIL	12M3	15
	PANKRONO MARKET	SKIP	1	YES	NIL	12M3	15
	MORO MARKET	SKIP	1	YES	NIL	12M3	30
	TAFO CEMETARY	SKIP	1	YES	NIL	12M3	30
	TAFO METHODIST	SKIP	1	YES	NIL	12M3	30
	TAFO POLICE STATION	SKIP	1	YES	YES	12M3	30

Plate 1; indiscriminate waste disposal at an open space at Anwomaso in the Oforikrom sub metro

Plate 2; indiscriminate waste disposal in the Subin drain

Plate 3; solid waste collection point with a skip container at Bantama

Plate 4; solid waste collection point with roro container at Suame

Plate 5; improved sanitary facility with skip container at Asokwa

Plate6; improved sanitary facility with roro container at Suame