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CHARACTERIZATION OF DIVERTED SOLID WASTE IN KUMASI

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CHARACTERIZATION OF DIVERTED SOLID WASTE IN KUMASI

By

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Technology

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Of

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In

Water supply and environmental sanitation

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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 or material which has been accepted for the award of any degree of the university, except where due acknowledgement has been made in the text.

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Dedication

THIS THESIS IS DEDICATED TO MY LATE FATHER, MR. MAHAMUD ADAM

Abstract

The current practice of Solid Waste Management (SWM) in Ghana is that of disposal model. It is increasingly difficult to site new landfills within big cities due to scarce space and public outcry. Moreover, cost of constructing new landfills inevitably affects tight local budgets. The life of the only landfill in Kumasi could be extended if strict diversion program was implemented. Informal diversion of SW seems a common place in the city, although this activity is not seen by city authorities to contributing to the wider SWM system. To provide a scientific evidence of what these informal activities mean is what provoked this research. The objective of the study was to assess the activities of informal SW diversion and pay as you throw in selected communities in order to provide understanding and insight into SW recycling. Seven communities were selected for this study. Ten SW fractions were diverted: dense plastic, metal, glass bottle, ceramic, wood, fiber, leather, old tires, and plastic film. The weight and volume of all fractions for a diversion period of 199 days were 3587.36kg and $18m^3$. Plastics and metals were 8.97kg, and 5.17kg respectively. The remaining 3.89kg represented the other 8 fractions – this explains the value in plastics and metals in the informal sector. The average diversion rate was found to be 0.55%/d against ~21tons/d for point generation and disposal each. The 0.55% against an estimated generation of 1227tons/d saves collection and disposal costs of ~$3000/m (~¢6000/m). From this, it is evident that the city landfills more than it diverts. A diversion rate of 0.55% represents only what occurs at the communal container points by collection attendants out of estimated 13% of recyclables in the waste stream. Also, there was an average reduction by 28% of waste land filled as a result of PAYT. From the study, more diversion rate can be achieved if the informal diversion activities were considered part of the overall SWM structure with opportunities and incentives provided.

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List of Abbreviations

PAYT	Pay-As-You-Throw
UP	Unit Pricing
VR	Variable Rates
SR	Source Reduction
MSWM	Municipal Solid Waste Management
SWM	Solid Waste Management
SW	Solid Waste
KMA	Kumasi Metropolitan Assembly
GSS	Ghana Statistical Services
KNUST	Kwame Nkrumah University Of Science and Technology

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CHAPTER ONE

1. INTRODUCTION

1.1 Background

The objectives of municipal solid waste management have evolved from the primary concerns of environmental health protection to considering human safety, resource conservation and reduction of, as much as possible, the environmental burdens of waste management(energy consumption, pollution of air, land and water and loss of amenity) (Mc Dougall, 2000; Mizpa et al., 2009).

The emphasis on landfill disposal is a concern from global environmental perspective. As garbage, particularly organic material, decomposes in landfills, it releases methane, a highly effective greenhouse gas. Reducing the amount of organic material disposed of in landfills reduces greenhouse gas emissions from such facilities (Miranda, 1996). Increasing land filling and incineration costs, tight local budgets, and growing environmental concerns have fundamentally changed the mission of many solid waste agencies. Faced with rising disposal costs, many have responded with variety of programs designed to divert waste from the “disposal stream”, or the stream of refuse headed towards land filling or incineration. Reflecting widely adopted waste –management hierarchies, diversion strategies include waste-reduction education, composting, and recycling programs (Skumatz, 1993).

Diversion results when residents resolve to reduce the amount of recyclable material thrown away and wasted by disposal in the landfill. Solid waste diversion is also the prevention of discarded materials from landfill using environmentally responsible strategy. Landfill diversion can also be achieved through recycling of: paper, glass, metals, textile, plastic, and other resource materials. Materials could also be diverted through reuse, biological treatment, and incineration. Diversion prolongs the life of landfill; bringing disposal cost to a minimum; generates less supply of virgin (costly) materials for production process.

The unbearable cost of solid waste management has led to the adoption of alternative strategies including unit-pricing (pay-as-you-throw (payt) or variable rate (vr)) by many nations especially in Europe and North America in order to ease the many bottle necks working against cost recovery and other factors. Over the last twenty-years, a growing number of cities across North America have been using the user-pay principle used commonly for water, electricity, and other services (Skumatz, 2006). However a variety of circumstances may encourage a community to consider unit pricing for waste collection; high disposal costs(tipping fees), increasing per capita generation, diminishing landfill capacity, changing labor costs, a desire to encourage recycling or reduce waste, statewide or regional diversion requirements, and grassroots lobbying efforts(Miranda, 1996).

Unit pricing or payt is a strategy in which customers are provided an economic signal to reduce the waste they throw away, because garbage bills increase with the volume or weight of waste they dispose (Skumatz, 2006). The estimated cost of operating the landfill in Kumasi is US$250,000 per month excluding cost of land use and facility closure. The Government of Ghana bears 95% of landfill management cost. Average waste collection cost are US$350,000 per month with waste generators bearing 15% and the municipal authority 85%. The total annual cost is approximately US$ 7.2 million (KMA, 2008, Mizpa et al., 2009). In the same premise, the growing costs of waste collection and disposal necessitated the implementation of unit-pricing in Kumasi in 2008, in an attempt to recover some of the cost of waste collection.

Most of the major cities in Ghana have no engineered landfills except Kumasi and Tamale which have not also been managed well and have been reduced to semi-engineered landfills.

As a result no daily covering material is put on waste, leachate leaks around uncontrollably, especially during rainy seasons rendering leachate treatment ineffective with its attendant pollution of underground water. Least is said about the capital city, Accra where huge tonnage of solid waste is generated daily, yet all, “landfills” (purely dump sites) have reached their capacities. This coupled with high scarcity of land in the cities make it increasingly complex when the solid waste management subject is raised. Undoubtedly this situation could have been a catalyst for the adoption of alternative models of solid waste management – the diversion strategy.

Informal recycling is common throughout Africa, Asia, and Latin America (Medina, 1999 as cited by Mensah, 2010). Recycling and for that matter diversion of solid waste has received little or no attention in major cities in Ghana. However, informal diversion activities occur in most of the cities including Kumasi; providing some employment for those engaged in it. Some of these people include; itinerant buyers who move from house-to-house to buy recyclables and re-usable materials, waste pickers who pick from streets and institutions, informal picking from collection vehicles on route(door-to-door collection) to disposal sites, recovery of materials at communal collection points by collection attendants and informal picking by “scavengers” at the final disposal site. Eventually, these diversion activities in a way reduce in part the absolute quantities of solid waste reaching the landfill. This may reduce the collection and disposal costs and prolongs the life of the landfill. Provision of some insight into the activities of the informal diversion sector provoked the researcher to carry out this study which will help us ascertain what materials are diverted, and in what quantities. This research focuses on the diversion activities at the communal collection points.

1.2 Problem statement

This era still grapples with the traditional practice of solid waste management – where solid waste management in many developing countries like Ghana is narrowed to only collection, transportation, and final disposal without any form of treatment (diversion). Population growth coupled with rapid urbanization bring with it enormous generation of solid waste in the cities. The costs of collection and disposal of these volumes of waste are on the increase. The practice of sending all volumes of waste to the landfill invariably cause rapid reduction in landfill volume and landfill life as well. The growing public concern about the environmental impacts of landfills generates another uphill task of the popular "not in back yard" attitude which makes it daunting when fresh lands are needed for siting and construction of new landfills close to residence. The tendency of siting landfills at distant areas then results. Consequently, distant landfills will attract high energy consumption on transportation of waste, with effect on operational and maintenance costs. The sustainability of this unidirectional practice (that is the disposal minded model) remains a big question to be answered.

1.3 Objective of the study

To assess the activities of informal solid waste diversion and Pay-As-You-Throw (PAYT) in Selected communities in order to provide understanding and insight into solid waste recycling.

Specific objectives include the following:

1. To characterize the diverted solid waste at communal collection points in selected

Communities:

a. to determine the types of solid waste fractions diverted

b. to determine the quantities of diverted solid waste fractions

2. To estimate the generation, disposal and diversion rate

3. To determine the trend and possible reduction in solid waste land filled due to PAYT

1.4 Justification

Diversion enhances the life of landfill and reduces the quantity of waste collected. This nonetheless will bring collection and disposal costs to a bearable minimum; generates less expensive supply of virgin materials.

A more comprehensive planning, design and implementation of any successful treatment/diversion (reduction, reuse, recycle, composting, and thermal treatments) options for a community would need some basic information. The outcome of this solid waste diversion characterization study could serve as support in this direction. This study is the first of its kind in this country and may serve to provoke further studies in this discipline for better development and improvement of the overall waste management structures.

1.5 Scope of study

Seven (7) communities were selected from two sub-metropolitan areas out of ten sub-metropolitan areas of Kumasi as a result of inadequate resources. The research centered on characterization of diverted solid waste at communal collection points, determination of possible reduction in land filled waste arising from pay-as-you-throw. The characterization of diverted solid waste included: the type of material diverted, the quantity of diverted material, and estimation of disposal, generation and diversion rate.

1.6 Limitation

The limitations of the study are:

I. Informal Diversion activities at the household, on-route (door-to-door), itinerant buyers, the retailers, and at the landfill levels were not included in the study as a result of inadequate resources.

II. Communal container attendants were hesitant to participate in the work especially information concerning PAYT and the quantitative field survey.

III. Some monthly disposal data were not available for some study communities. For example complete disposal data for Bomso-2007 was absent, which made comparison of before and after PAYT/UP data difficult.

1.7 Organization of report

This report is made up of five chapters. Chapter one captures the introduction. This presents the background; the objectives; the problem statement; the justification; and the scope of the study. Chapter two unfolds review of relevant literature. Chapter three presents the research approach and methodology. Chapter four presents the results and discussions while chapter five presents the conclusions and recommendations of the study.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Solid Waste Diversion

A more environmentally oriented view of urban solid waste management includes reuse, recycling and recovery activities, and safe disposal of waste in sanitary landfills (Isa Baud, 2004).

Minimization of solid waste is highly preferred, but practically diversion is the bed rock. Diversion is preventing resource materials from ending at land fill as waste. Diversion is not only good for the environment, but it brings economic benefits. Reducing or reusing materials cuts cost of purchasing raw materials into the process of production.

Waste diversion or landfill diversion is the strategy of preventing waste at the landfill. The progress of diversion can be observed by comparing the volume of the landfill from one year to the next. Minimal or same growth of the landfill means that policies regarding landfill diversion are successful. Landfill diversion can occur through reuse, recycle.

Reuse comprises the recovery of items to be used again, perhaps after some cleaning and refurbishing (Tchobanoglous et al., 1993). Reuse of materials and products is regarded as more socially desirable than recycling the same materials (Hui et al., 2006 as cited by Aquah, 2010).

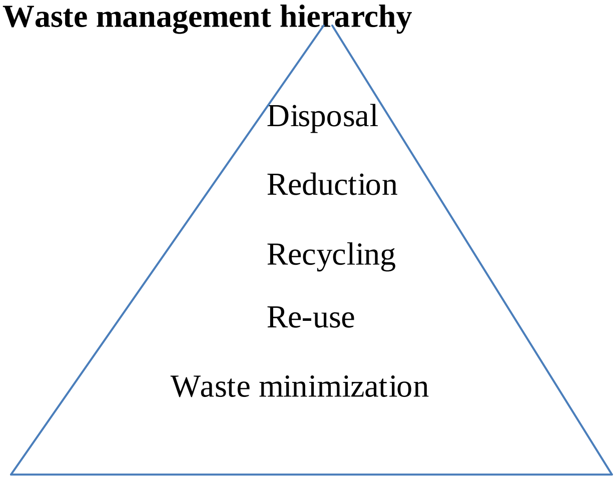
Recycling refers to taking back used materials and processing them into new products in order to channel these products away from landfills. Recyclables may include glass, Paper, metals, plastic, textiles, and others. Some waste products can go through biological or thermal treatment.

The estimated 13% proportion of glass, plastics and metals in the household waste stream in Kumasi (Aquah-Mensah, 2010) is a good indicator of a direction the city waste authorities could take to salvage these materials. With committed efforts, a greater percentage of these fractions could be captured and converted into other products to prevent piling at the land fill.

2.2 Integrated solid waste management and Diversion

Integrated MSW is a strategy based on the hierarchical approach of pollution prevention-based, mandating recycling to minimize disposal and maximize the capture and recovery of resources (Wagner et al., 2006).

Figure 2- 1: Waste management hierarchy



Source: Isa Baud (2004)

The waste management hierarchy (fig. 2-1) is a tool that policymakers have used to rank waste management options according to their environmental benefits. Separation at source and recycling take an important place in the waste management hierarchy.

2.3 Collection, Disposal and Environment

Though modern disposal costs are relatively higher, collection is still a large portion of solid waste costs. More communities are implementing programs to divert solid waste from land fill and incinerators (Everett W. et al., 1996).

Isa Baud (2004) explains that the primary perspective on SWM developed in the nineteenth century in Europe and exported to colonies around the world, was that of public health. Solid waste accumulating in densely populated urban areas posed health hazards, which local authorities sought to control by providing effective collection, transport and disposal services. The organization of such basic services was carried out through local government, Health departments, in both British and French administration systems. No attention is given to the prevention of waste production or to the minimization of waste or the promotion of recycling and reuse.

The transferred 'narrow' system of viewing and executing SWM has certainly impacted the systems in Ghana as well –making SWM a complex and a "Gordian knot" to deal with. No deliberate attempt is made by the KMA to consider integrating diversion into the overall SWM structure. As a result all solid waste generated is headed towards landfill.

2.4 Informal Diversion and Actors

Waste diversion through recycling and reuse is carried out on an informal basis which is not widely recognized as contributing to waste management in the city of Kumasi (Mizpa et al., 2009).

A study in the Hyderabad city by Isa Baud (2004) explains that itinerant waste buyers go from door-to-door purchasing 'dry' wastes items from households and domestic workers throughout the day.

Street pickers, itinerant buyers, communal collection point's pickers (attendants of communal bins), dump site scavengers, and wholesale buyers are the observed groups involved in diversion activities in Kumasi. Retail traders mainly carry out sorting, cleaning, and stock the waste into sufficient quantities before selling it.

In Kumasi, most of these buyers either use hand carts to transport materials bought, or small Kia trucks to carry materials to points of sale to middle men and whole sellers; others retail at the Dompoase land fill. The wholesalers transport their commodities (mostly metal scraps and plastics) to Accra where recycling enterprises exist. Some of the plastics are sold to palm oil sellers in markets, local drink producers, and herbal preparation groups, however the safety of using these recovered materials for food packaging have been criticized heavily by the Ghanaian media recently. Retailers have however explained that they use boiled water to disinfect these plastic bottles before selling to buyers- they claim their livelihoods depend on this informal economic activity.

2.5 Legislation and Regulation of the Informal Diversion sector

Isa Baud (2004) in his study of the Hyderabad city, states that the legality of the actors/enterprises in the commodity chain goes down from recycling units to pickers. The recycling units are most often registered enterprises units with single ownership or proprietorship.

The activity of the informal waste pickers is unregulated and not generally tolerated in Kumasi, because their activities are considered a threat to surrounding environment, unaesthetic, insanitary, and not orderly. For these reasons the local authority pretends to allow for the informal recoveries of waste materials.

There is however no single recycling unit or enterprise or composting activity in Kumasi city. This is a worrying trend as opportunities and incentives are virtually absent for participatory recycling activities by residents.

Among the legislation and regulation issues according to the Environmental Sanitation Policy (2010), Environmental sanitation involves a wide range of actors with different levels of responsibilities and therefore laws are required for regulating activities. Responsive regulations that provide the right incentives are necessary to improve on enforcement management. Some of the critical areas identified are;

- Weak and/ or outdated and poorly enforced environmental sanitation legislation
- Lack of regulation for mainstreaming alternative uses of wastes through appropriate incentives
- The challenge of not incorporating and adhering to international conventions into domestic law. To respond to these challenges, the policy again indicates mainstreaming of alternative uses of wastes (solid and liquid) through appropriate technologies and incentives; develop regulation to support waste reduction, reuse, recycling, and recovery.

2.6 Pay-as-you-throw (payt) or variable rate (vr) or unit pricing (up)

Unit pricing receives attention as a municipal solid waste management tool with the potential to encourage waste reduction and recycling. Ordinarily, communities either charge residents a flat fee for waste collection services or finance the services with local tax receipts. Under these financing schemes, individuals essentially face a zero marginal cost to producing more garbage, even though collection and disposal costs for that waste do increase (Miranda et al., 1996). Payt is recognized as major economic approaches to supporting 3Rs policy of reduce, reuse, and recycle (Sakai S. et al., 2008).

Under a variable-rate system, customers are provided an economic signal to reduce the waste they throw away because garbage bills increase with the volume or weight of waste they dispose. Variable-rate is being adopted in thousands of communities in America to create incentives for additional recycling in the residential sector (Skumatz, 1993).

2.6.1 Operation of PAYT/VR/UP

Under a unit pricing system, residents pay by the unit of garbage that they set-out for collection. If the system is volume-based, then is usually a bag, can, or tag. If it is weight-based, then residents pay by the pound. By this, residents reduce the amount of garbage through waste reduction behavior, or through municipal diversion programs, like curbside recycling and yard waste composting (Miranda, 1996). In Kumasi, the unit pricing was introduced in 2008 mainly in an attempt to recover some of the cost invested into collection of solid waste. Although not perfected, the UP in Kumasi is the lead example in Ghana where other local authorities of cities are motivated to adopt. The UP system in this case is volume-based with the use of the can or “container”. Residents drop their waste using individual or own cans and various container types (plastic or metal or broken plastic or metal buckets) with varying sizes. These “containers” attract different prices. Prices are determined by collection attendants at points of drop (communal container points).

2.6.2 Challenges with the PAYT

The first challenge with the system is the absence of standardization of the cans or containers used. As a result, some residents throwing away their waste feel cheated as they have to spend time negotiating price with collection attendants. This may discourage the high level patronage of the PAYT in the city. Secondly, there are no comprehensive in-built incentives to encourage source separation and diversion. For example, a structure requiring residents to throw away waste unmixed so that the payment for the non-recyclable materials are reduced because the recyclable waste is put aside and not paid for. Moreover, the PAYT has no auxiliary recycling program hence; space in a form of curb-side for storing diverted solid waste materials is not made. Therefore the informal activities of diversion by collection attendants are considered unlawful even though this is positive in the sense of sustainability of the environment and urban development. The most challenging issue is the unavailability of recycling enterprises in the city of Kumasi. This includes plastic and metal recycling centers which are rather situated several hundred kilometers away in Accra from Kumasi. This is a big disincentive to the actors in the diversion/recycling business as they have to transport their materials finally to Accra before wholesales can be made.

2.7 Outcomes Associated with PAYT

2.7.1 Increased Recycling/Diversion and Source Reduction

PAYT has had enormous impact on reduction and recycling in combination with the use of complementary measures that also promote recycling (Oshima, 2006; Kusumoto, 2003; Sakai et al., 2008). According to Miranda (1993) most authors contend that variable fees increase recycling participation and recycling tonnage. In a survey of 1000 local recycling coordinators in USA, the respondent identified variable collection rates as the most effective strategy to encourage recycling and does have similarly positive effects on composting. Participation in Seattle's backyard composting program is high, and in San Jose, California, unit pricing increased yard waste collection set outs by 61%. In the Tompkins County, New York survey, 16% of the respondents said they composted more because of variable waste collection rates.

Some suggest that source reduction and recycling are complementary-that unit pricing creates greater awareness of the waste stream, including households to pursue both increased recycling and waste minimization techniques. Others raise the possibility that the two are substitutes for one another-that households participating in recycling program will be less likely to source reduce because they are already "doing something" for the environment(Scot B. et al., 1996).

2.7.2 Decreased land filled waste and Source Reduction (SR)

An important effect of payt is a reduction in the amount of residual waste generated. Waste reduction is generally assessed on the basis of the amount of residual waste shipped to the disposal facility (Canterbury, 1994; S. Sakai et al., 2008).Source reduction – avoiding the cost of collection, processing, and other costs certainly has the potential to be tremendously cost-effective method of waste management (Skumatz, 2000).

According to Skumatz (2000), the standard solid waste management hierarchy places source reduction or waste prevention as the most preferred method of solid waste management. However, limited efforts toward these programs have been hampered by the difficulty associated with measuring impacts of these programs. Source reduction programs have received less attention than recycling and yard waste programs.

Scot B. et al. (1996) indicates that source reduction is more difficult to measure than waste diversion, and there is less agreement as to the effects of variable rates. Generally Communities in the USA utilizing variable rates have reported an average reduction in waste land filled of 28%, with a range of 25% to 50%. Communities in the USA that implement variable rates in conjunction with recycling programs have routinely reported 25% to 45% reduction in tonnage going to the disposal facility (Skumatz, 1993).

There is always Preliminary evidence that part of the decrease in waste land filled results from waste minimization behavior (over and above recycling participation) on the part of the community residents (Miranda et al., 1996).

Some authors take issue with the claim that unit pricing causes people to reduce their waste. These authors claim that there is no conclusive evidence that variable rates cause residents to purchase reduced packaging products, or pursue other source reduction activities. These authors suggest, instead, that observed level of waste reduction are explained by garbage compaction and illegal disposal (Scot et al., 1996). Changes in the mindsets of residents in response to payt have had impact on waste control by reduction and reuse, which should be a priority of waste management (Sakai et al., 2008).

2.7.2.1 Methods of measuring Decreased Land filled waste/Source Reduction

Two primary categories of measurement methods by Skumatz (2002);

- Cross-section or comparisons between large numbers of communities at the same point in time. Here the communities where PAYT exist could be compared with other communities without PAYT but share similar characteristics. Also, a community's before PAYT and after PAYT (Table 2-1) can be compared to see if there is detectable reduction or increase in waste levels.

- Time series analysis, in which we develop models that estimate the impacts based on casual factors that underlie waste behavior. This is where several years data of waste amounts is assembled and plotted for trends in the waste behavior over that period.

Table 2-1 compares 1994 single family garbage set-outs in San Jose with garbage set-outs in Fiscal year 1993.

Table 2- 1: Land filled waste in San Jose before and after Unit pricing by Miranda, 1996

		Fiscal year 1993(before unit pricing)	Fiscal year 1994(after unit pricing)	% change
Land filled garbage	total(tons)	250,000	197,900	-21%
	per Household(lbs./month)	224	177	

2.7.3 Undesirable Diversion

In Japan 4% of municipalities were concerned about illegal dumping when they introduced payt. Illegal dumping was already a problem in most of these municipalities before the introduction of payt (Sakai et al., 2008). The occurrence of illegal dumping resulting from the adoption of payt most likely depends on the individual characteristics of a municipality, and also likely to be related to local features. In Kumasi, it is equally worrying that some residents do practice illegal dumping even when there existed no payt in the city. Some waste collection companies indicated that environmental education packages are tailored towards changing attitudes of residents.

Undesirable diversion takes several forms. One is that residents put their garbage in commercial dumpsters. Mc Henry County, Illinois reports problems with commercial “dumpster dumps”, and ten Illinois solid waste officials in Browning and Becker’s survey rate dumping in commercial dumpster the most serious problem with unit pricing in their communities. Residents may also dump their garbage on the side of the road. Road side dumping was also cited in Browning and Becker’s survey, and 51% of residents in Reschovsky’s study of Tompkins County reported some increase in littering after the county adopted variable rate (Miranda et al., 1996).

2.7.4 Customer Resistance and political feasibility

Unit pricing (UP) sometimes causes citizens to resist the loss of “free” garbage service. If people never realized they were paying for waste collection before, they could be resistant to start paying directly for it. However residents of unit pricing communities strongly support, at least in the long run, their town’s systems. Policy makers may shy away from VR because they fear that they will be unpopular (Skumatz et al., 2006). This seems true because policy makers in major cities (apart from Kumasi) in Ghana dread the idea of implementation of UP, leaving the cities continually dragged into unforeseeable SWM difficulties.

CHAPTER THREE

3. RESEACH APPROACH AND METHODOLOGY

3.1 Description of study area

Kumasi is the second largest city in Ghana after Accra. It is the capital of the Ashanti Region. The city has ten (10) sub-metros, but only six are vibrant while the rest are dormant as a result of inadequate resources. The sub-metros represent districts. These six (6) sub-metros are: Manhyia sub-metro at northern end; south- eastern part is Asokwa sub-metro district. The western part is Nhyiaeso sub-metro district. The north-west and south-west is Bantama sub-metro, and the eastern part is Oforikrom sub-metro with the central part being Subin sub-metro.

The sub-metros have been zoned to enhance efficient waste collection by private companies largely and the local authority, Kumasi Metropolitan Assembly (KMA) as well. This study focuses on two (2) sub-metros: the Asokwa and the Oforikrom representing zone one and two. The companies responsible for collection in these areas are the Mesk world co. Ltd and ABC Ltd respectively.

Fig 3-1: Location of Kumasi and study areas

3.2 Location and climate

The Kumasi city lies within latitudes $6^{0}35$ and $6^{0}40$, longitudes of $1^{0}30$ and $1^{0}35$. The city spans an area of 254 km^2. Kumasi almost placed at the Centre of Ghana presents it with a good opportunity in relation to political, economic, cultural and social life. The infrastructure (roads, electricity, telecommunication) are in good shape. In terms of drainage, four drainage basins exist with a gentle slope. The encroachments of flood plain areas coupled with other factors result in occasional flooding in low lying areas. The city has a climate of the sub-equatorial type having double maxima rainfall regime of about 214.3mm in June and 165.2 in September. Averagely the temperature ranges between 21.5 to 30.7 and humidity averages at 84.16% at 0900 GMT and 60% at 1500GMT.

3.3 Population

Table 3.1 shows the population and number of houses in the six study communities. Populations are based on the2000 and 2010 population and housing census conducted.

Table 3- 1: Population and Houses of study communities

community	2000	2007	2008	2009	2010	2011	houses
AYIGYA	30,283	43,624	45,959	48,419	51,011	53,741	1,181
KOTEI	4,373	7,252	7,796	8,380	9,008	9,683	367
BOMSO	9,005	12,196	12,736	13,300	13,889	14,504	453
KENTINKR	3,222	4,876	5,173	5,488	5,823	6,178	206
GYENYASE	10,914	18,748	20,254	21,882	23,640	23,640	939
ATONSU-AGOGO	45,778	130,473	151,531	175,987	204,391	204,391	2,489

Source: GSS (KMA, 2012)

3.4 Housing

Tenement housing; Indigenous housing; New Government housing, and High-cost housing are the four categories of housing for the purposes of planning in Kumasi (strategic sanitation plan-Kumasi, 1993; Kotoka, 2001 as cited by Aquah-Mensah, 2010). These four categories of housing and their characteristics are shown below.

Table 3- 2: Characteristics of categories of housing in Kumasi.

Parameter	Tenement	Indigenous	New Government	High cost
Population (%)	22	60	8	10
Population density(per ha)	300-600 persons	80-250 persons	50 persons	10-15 persons
Population density(per house)	4-10 families/40-100 persons	4-10 families/20-50 persons	1-2 families	1-2 families
Description of house	2-3 storey buildings with 20-30 rooms	Single storey buildings with 5-10 rooms and interior compound	Rows of detached single storey buildings in walled compounds with 2-3 rooms	Detached single family buildings on large plots with 5-8 rooms and outhouse

Source: strategic sanitation plan-Kumasi, 1993.

3.5 Dompoase Sanitary Landfill

Located at the south-east of kaase, the Dompoase landfill begun operation in 2004. The site is a 100-acre piece of land on which this engineered landfill was constructed including stabilization ponds for the treatment of leachate and septage. It has a design life of 15 years; 5 years each for three phases of development. It receives solid waste as well as special waste from the metropolis. Scavengers pick solid waste materials from mixed solid waste stream as the collection vehicles empty their content into cells.

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3.6 Sample size

Six (7) communities in two Sub-metros (5 communities from Oforikron sub-metro and 2 from Asokwa sub-metro) were chosen for this study. These communities are: Kotei, Atonsu, Ayigya, Ayigya-zongo, Gyenyase, Kentinkrono, and Bomso. Communal collection points in the seven communities represented seven sampling points. The consideration of this sample size was based on data availability before and after the introduction of the Pay-As-You-Throw (PAYT) policy, and also the presence of the activities of informal diversion at those points. Two private collection companies (ABC & Sak-M) have been responsible for collection of solid waste from the two Sub-metros; Oforikrom and Asokwa since 2007.

3.7 Data collection

Primary data was collected through quantitative field analysis of Diverted solid waste stream; measurements of the analyzed fractions in pounds were converted into kilograms. Secondary data from landfill records was extracted for six communities including; Kotei, Bomso, Ayigya, Kentinkrono, Gyenyase, and Atonsu.

3.7.1 Sorting procedure

The existing process of informal waste diversion at the communal collection points facilitated the sorting and separation of solid waste fractions. Stocked-piled of sorted –mixed solid waste were separated into fractions during quantitative field measurements. This sorted-mixed waste solely represented the voluntary diversion works routinely done by secondary storage container attendants (or care takers or collection attendants) in study communities.

3.7.2 Quantitative field measurement and Data Recording

The weight analysis method was applied using a sensitive scale. The management of the respective private waste collectors in the study communities was contacted through the waste management department. Purpose of research was explained to officials who then communicated the information to their secondary storage container (or communal collection points) attendants in the field. Field visits were made to communities as follow-ups to educate attendants and to make arrangements for commencement of quantitative field analysis.

Three measurements of diverted solid waste materials were carried out. Measured materials were put aside while subsequent recovered materials were kept together separately, awaiting next moment of measurement. The first two measurements were consecutive (17th and 25th of November), while the last measurement was done four weeks after the second measurement due to some logistical constraints.

The weight of each captured fraction of solid waste was measured in pounds and recorded. The disposal amounts representing periods of capture for individual study points were also recorded (extracted from land fill data).The weight sum of all solid waste fractions were added to disposal quantity to produce point generations for each study point. These were used to compute diversion quantities and rates.

Plate 1: Captured fractions

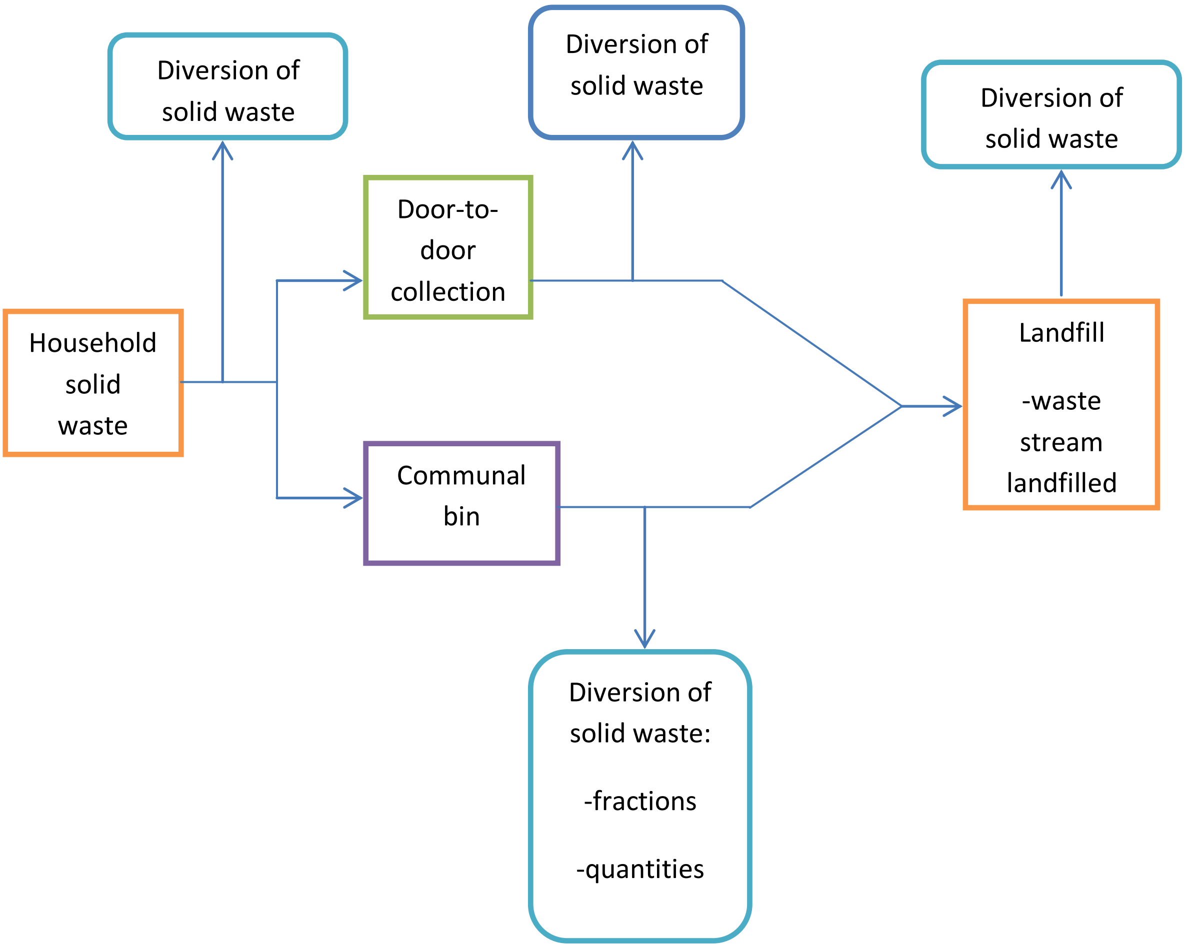

Figure 3- 1: Solid waste flow showing points of diversion

Table 3- 3: Frame work for achieving objectives and analysis of data

Feature of objective	Activity	Variable	Definition
1a diverted waste fraction	1 analyses of waste stream	Identification of the waste components	Elements in the diverted waste stream
1b diverted waste quantity	Measurement of fractions (by weight)	diversion	Amount of waste prevented from being land filled
2 estimate generation and diversion rate	Record disposed diverted quantities of waste	generation	Total (Diverted plus disposed) quantities
		Diversion rate	Diversion divided by generation times 100
3 possible reduction in land filled waste due to PAYT	applying standard evaluation technique(measuring tonnages before and after (PAYT/VR)	Reduction in waste	Difference in waste disposed before and after PAYT (with 2007 as base line)

The following equations were additionally used for obtaining objective three:

$$\text{Average yearly waste disposal tonnage} = \frac{\Sigma(\text{monthly waste for all months})}{\text{No. of months} - \text{ missing month(s)}}$$

$$\text{Percentage change }(\%) = \frac{Q_s - Q_b}{Q_b} \times 100$$

Where, Q_s = average yearly tonnage after PAYT, Q_b = average yearly tonnage of the base year (before PAYT).

3.7.3 Data analysis

This section is concerned with the analysis of results obtained from:

- Quantitative field measurements of diverted solid waste fractions from study communities
- Landfill disposal data from 2007 to 2010 of study communities

Microsoft Office Excel was used to analyze all results from quantitative field measurements and disposal data from landfill.

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CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings from the study and discussion relating the objectives of the research. It focuses on the characteristics of diverted solid waste (types and quantities of materials diverted) from secondary storage points (communal points of collection); and possible reduction in solid waste volumes engendered by PAYT/VR or other factors.

4.2 Characteristics of survey sites and respondents

Table 4-1 shows the survey site's characteristics. Except Atonsu that had 2 containers, the rest of the six (6) communities had one container each for secondary storage, but all storage containers were 14m3 volume. Out of nine (9) attendants, there were two each for Ayigya and Ayigya zongo then each attendant for Kotei, Atonsu, Gyenyase, Kentinkrono, and Bomso. Also, there were two waste pickers for Ayigya and one each for the rest of the six (6) communities; however none of the immediate surroundings of the containers was fenced.

Table 4- 1: Characteristics of Survey Sites

Community	Number of containers	Capacity of containers	Number of Attendants	Number of waste pickers	Fencing of container site
Ayigya	1	14 m^3	2	2	no
Ayigya zongo	1	14 m^3	2	1	no
Kotei	1	14 m^3	1	1	no
Atonsu	2	14 m^3	1	1	no
Gyenyase	1	14 m^3	1	1	no
Kentinkron	1	14 m^3	1	1	no
Bomso	1	14 m^3	1	1	no

Table 4-2 indicates the working hours of waste pickers (container attendants), gender, buyers of their commodities, and whether there are interference in their activities by scavengers.

Four (4) females are attendants in four communities, while three males attend to three communal containers each. This shows that more women are interested in issues concerning sanitation and the environment. Averagely, the working hours range from 5am to 7pm. They could not tell the amounts of materials traded in a specified period when interviewed. Three attendants demonstrated their frustration over the stealing of some of their sorted materials by scavengers and other unknown people. For example in the Ayigya container, the attendant said he is most times discouraged from doing informal diversion as a result of the insecurity mentioned above. This is partly due to the open nature of these communal container sites where people have access to them easily. Some attendants indicated they trade their commodities at the Dompoase landfill site (the main landfill in Kumasi), while some sell to middle men at the collection sites. They however did not have information on quantities of fractions they sell; likely because they do not keep records of their activities.

Table 4- 2: Characteristics of respondents picking waste at collection points

Community	Gender	Working hours	Location of sales of fractions	Quantity of sales	Sabotage by scavenger
Ayigya	male	5am-7pm	Collection site	-	yes
Ayigya zongo	male	5am-7pm	Collection site	-	no
Kotei	female	5:30am-6:30pm	landfill	-	no
Atonsu	Male	5am-6:30	landfill	-	yes
Gyenyase	female	6am-6pm	Collection site	-	yes
Kentinkron	female	5:30am-6:30pm	landfill	-	no
Bomso	female	5am-7pm	Collection		no

Table 4-4 explains the basic information from service beneficiaries regarding PAYT. Two households each from a community was selected (the first and the last houses in a lane and a household from each house) for the interview. Residents said the amount they pay for throwing waste range between 20Gp – 70Gp. Residents did not clearly know whether they set-out more or less waste after the inception of PAYT. As to PAYT being a driver for sorting and separation of waste, 6 households each indicated 'Yes' and' No', while one could not tell. Those who said 'Yes' explained that they keep some materials like glass bottles and some metals to sell to itinerant buyers, while the 'No' category said they send all to public container for disposal. Unanimously, all 14 households responded 'Yes' to price increments in the PAYT since 2008. Three households said they use other means for disposing their waste – this, we consider as part of illegal dumping. Eleven of the 14 households said they throw their waste into the public bin.

Table 4-3: Response from service beneficiaries regarding Pay-As-You-Throw

Community	Number of respondents (household)	Average amount per unit waste (Ghana pesewa)	More waste or less waste to container after unit price	PAYT, a motivation for sorting & separation	Price Increments	Use other means for disposal?
Ayigya	2	20p-70p	-	no	yes	no
Ayigya zongo	2	20p-70p	-	yes	yes	yes
Kotei	2	30p-50p	-	no	yes	no
Atonsu	2	30p-70p	-	no	yes	no
Gyenyase	2	20p-50p	-	-	yes	A 'Yes' and a 'No'
Kentinkrono	2	30p-70p	-	yes	yes	no
Bomso	2	30p-70p	-	yes	yes	no

4.3 Characterization of diverted solid waste fractions

4.3.1 Types and Quantities of diverted solid waste fractions

In all ten (10) solid waste fractions were sorted out (Fig.4-1) in the seven communities although specific fractions were observed in some of the communities and not in others. The household waste fractions were dense plastic (49.7%) of all types, metals (28.6%) of different types, glass bottles (5.7%), leather (1.97%), ceramic (6.58%), fiber/textile (0.03%), and plastic film (0.14%).

The bulk waste fractions that were found to be diverted are foam (0.73%), tires (1.26%), wood/furniture (5.13%).

Figure 4-1 shows the types of diverted solid waste fractions and their percentage by weight. For a total sorting out and separation period of 199 days, there is marked revelation from the analysis (fig. 4-1) that plastics (49.7%) and metals (28.6%) are of great value to the informal waste pickers. Next to these two materials in percentage by weight are ceramic (6.58%), Glass bottle (5.70%), and wood (5.13%) in that order as in table 4-5.

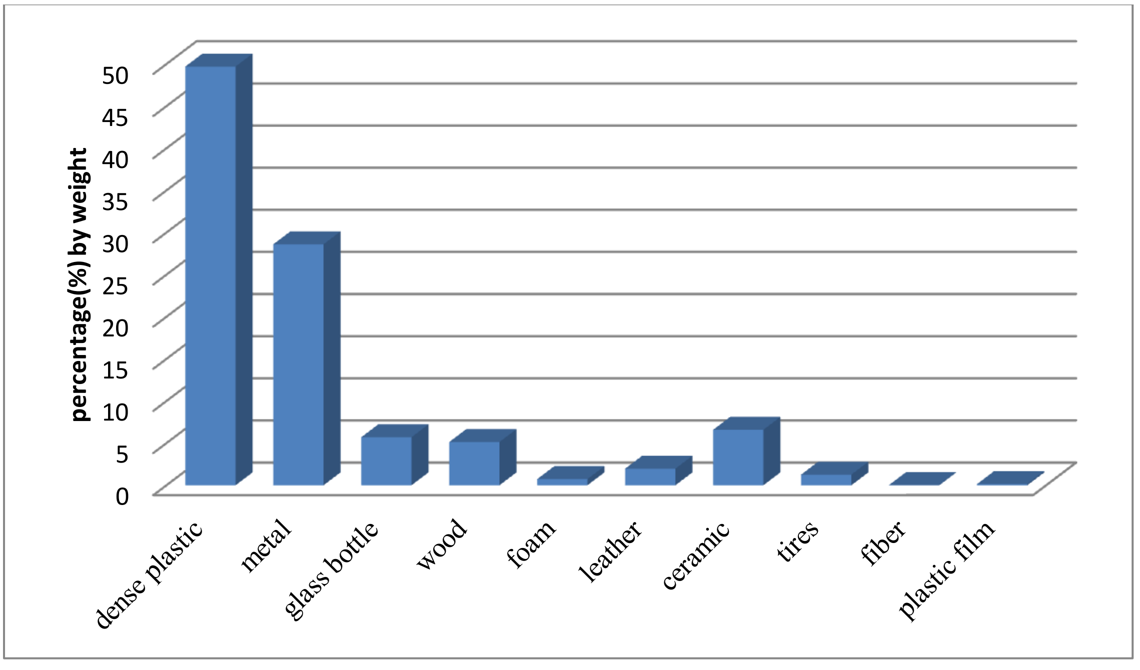

Figure 4- 1: Types of solid waste fractions diverted in percentage by weight

Total weight of 3587.36 kg of all the fractions measured, 1785.93kg and 1028.88kg represents dense plastics and metals amounts respectively with the corresponding percentages in table 4-5. The interest in these two (plastics and metals) may be due to the market availability for it. From un-compacted density of 200kg/m^3 (KMA, 2011), the volume of all fractions diverted is 18m^3. It means this is the volume saved of the landfill. This explains why we should endeavor to divert more materials in order that the landfill life can be prolonged.

Table 4- 3: Diverted Quantities of Waste fractions (kg) at the communal points for a period of 199 days (3 measurements combined)

Waste fractions in Kg	community								
	Ayigy.	**Ayigya zongo**	**Kotei**	**Atonsu**	**Gyenya**	**Kentin**	**Bomso**	**Total**	**%**
Separation period(days)	17	28	28	21	21	56	28		
Plastic dense	194.1	383.56	220.5	230.43	115.21	463.16	178.85	1785.9	**49.7**
metal	63.77	163.97	229.6	121.74	55.16	275.10	119.52	1028.8	**28.6**
Glass bottle	0.00	96.62	42.87	20.18	0.00	19.37	25.40	204.44	**5.70**
wood	0.00	0.00	0.00	54.61	32.79	0.00	96.52	183.93	**5.13**
foam	7.21	9.71	0.00	9.21	0.00	0.00	0.00	26.13	**0.73**
leather	29.35	4.81	7.44	7.49	0.00	6.47	15.10	70.66	**1.97**
ceramic	10.16	0.00	66.22	0.00	0.00	0.00	159.71	236.09	**6.58**
tires	0.00	0.00	0.00	45.27	0.00	0.00	0.00	45.27	**1.26**
fiber	0.00	0.00	0.00	0.00	1.13	0.00	0.00	1.13	**0.03**
Plastic film	0.00	0.00	0.00	4.90	0.00	0.00	0.00	4.90	**0.14**
Total (kg)	304.6	658.66	566.6	493.83	204.29	764.10	595.11	3587.3	100

The disposal quantities for Ayigya and Ayigya zongo communities were put together in the land fill records, therefore in this study the disposal, generation quantities and diversion rate were put together for both communities as Ayigya.

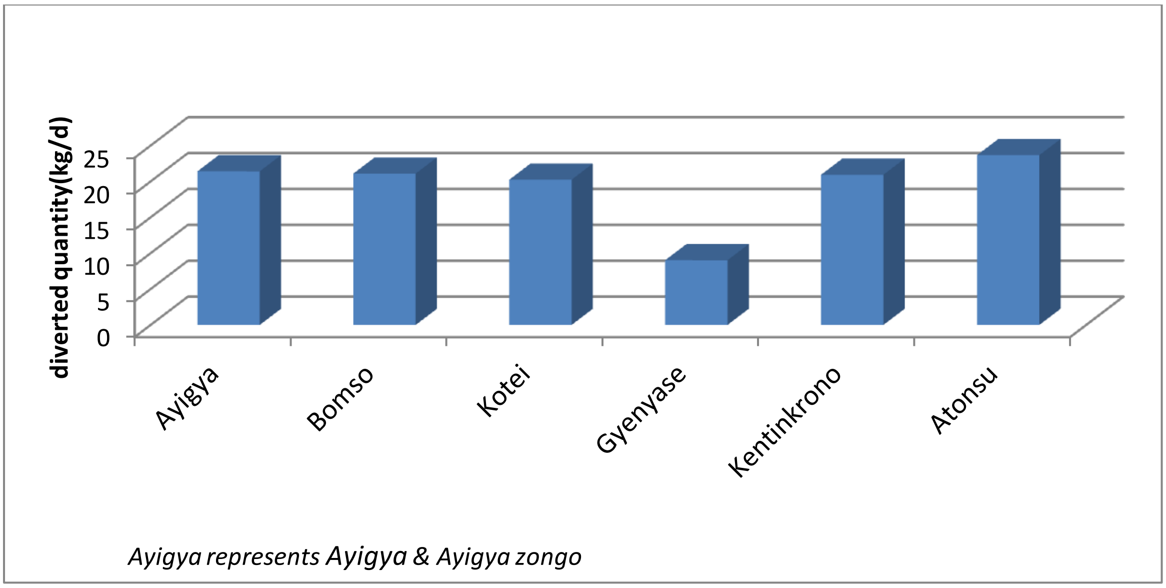

Figure 4- 2: Diversion quantities in kg per day across six communities

From Table 4-6 the total diverted solid waste material of 3587.36 kg for the period of 199 days of accumulation gives a daily diversion of 18.03 kg for all fraction types. This figure is relatively low compared with amount of waste land filled. This may be attributable to the fact that incentives are lacking even for keeping recovered materials at these collection points. In some instances scavengers come to steal from the stocked materials of collection attendants – tracking scavengers to measure their materials in this case can be difficult if not impossible.

Table 4- 4: Diverted Waste quantities per day (kg)

Waste fractions in Kg	community							
	Ayigya	**Ayigy zongo**	**Kotei**	**Atonsu**	**Gyeny**	**Kenti**	**Bomso**	**Total**
Total waste	304.67	658.66	566.69	493.83	204.29	764.10	595.11	3587.36
capture period(days)	17	28	28	21	21	56	28	199
Plastic/d	11.42	13.70	7.88	10.97	5.49	8.27	6.39	8.97
Metal/d	3.75	5.86	8.20	5.80	2.63	4.91	4.27	5.17
Total waste/d	17.92	23.52	20.24	23.52	9.73	13.64	21.25	18.03

4.3.2 The point generation, disposal and diversion rate

The disposal data for the varied periods of accumulation of diverted materials at the different communal collection points were extracted from land fill records. As a result disposal quantities plus diverted quantities produced the point generations at communal collection points representing the study communities. Combined disposal and diverted quantities for the three (3) measurements respectively are indicated in table 4-7.

Table 4- 5: Summary of the waste diverted from the communal waste stream

Quantitative field measurement	Point Generation(kg)	Disposal (kg)	Diverted quantity(kg)
measurement 1	206510.38	204946(99%)	1564.38(1%)
measurement 2	163804.33	162580(99%)	1224.28(1%)
measurement 3	220990.23	219800(99%)	1190.23(1%)
TOTAL	591304.91	587326(99%)	3978.91(1%)

The different storage periods(or accumulation period) of materials at the various communities were used to compute for daily disposals, diverted quantities, point generations and the corresponding diversion rates(table 4-7).The total daily diversion rate then stood at 0.55% for the three combined measurements.

Table 4- 6: Summary of the waste diverted from the waste stream per day

Community	Storage period (days)	Disposal (kg/d)	Diverted quantity(kg/d)	Point Generation (kg/d)	Diversion rate (%)
Ayigya& Ayigya zongo	45	2024.80	21.41	2046.21	1.05
Bomso	28	2729.29	21.09	2750.38	0.77
Kotei	28	1974.29	20.24	1994.52	1.01
Gyenyase	21	5120.00	9.02	5129.02	0.18
Kentinkrono	56	1693.93	20.93	1714.86	1.22
Atonsu	21	7672.86	23.66	7696.52	0.31
Total	**199**	**21215.16**	**116.34**	**21331.5**	**0.55**

The daily diversion rate of 0.55% shown above for all the communities (on the first column on the left of table 4.8 above) for a period of 199 days is quite small. This low diversion rate is purely due to informal activities but if it is formalized more waste could be diverted. This reflects exactly what Kumasi city and Ghana as well are not doing much in terms of waste prevention, re-use, and recycle which are in fact stated in the revised national sanitation policy document (MLGRD, 2010). Clearly there are no pragmatic actions backing these policies which are some of the reasons for the low participation in waste separation and recycling and evidently translated in the 0.55% diversion rate. Land filling seems to be the order of the day where solid waste is collected, transported and buried. Although the rate 0.55% appears small, taking it against an estimated 1227 tons per day of domestic waste generated in Kumasi produces 6.75 tons of waste diverted in a day. Hence the total cost saved in a month is approximately US$ 3333/month (collection and disposal costs are ¢15 and ¢14 respectively) (KMA, 2012). This explains the need for the city authorities to integrate a comprehensive diversion program into the wider SWM system in order to save more costs of collection and disposal of SW.

Acquaa-Mensah (2010) obtained the waste fractions in Table 9 in household waste characterization study of Kumasi city. This means that only 0.55% of diverted waste is far less than the fractions in the waste stream. The diversion rate could be increased if the informal activities are formalized and incentives provided. It must also be noted that the 0.55% is exclusive of activities at house, on-route, itinerant and landfill levels of diversion. This perhaps shows that the figure could have been greater.

Table 4- 7: Fractions from household waste characterization by Acquaa-Mensah (2010)

Waste fractions	Low income (%)	Middle income (%)	High income (%)	Average for Kumasi
Glass	-	1	11	0.8
Plastics	8	10	10	9.4
metals	1	3	3	2.4

4.4 Possible reduction in land filled waste arising from payt

PAYT/VR was introduced in Kumasi in 2008 in an attempt to recover some cost of waste collection. Now to test whether PAYT is an incentive for reduction in solid waste set out for disposal, land fill data for 2007 to 2010 was applied with the recognition that 2007 data serves the baseline year for comparing disposal amounts of “before unit pricing and after unit pricing”. Although 2007 is the baseline year, the 2007 data for the Bomso community was not available; hence 2008 year was used against 2009 in this context. Moreover, data for certain months with respect to some communities were farfetched, hence missing months were subtracted from the 12 months of a year and the averages found to aid comparison of year “before PAYT” and year “after PAYT”.

Unit pricing communities in America typically offer a variety of complementary programs such as recycling drop-off centers, and curbside recycling pickup (Miranda, 1996). The unit pricing in Kumasi is the drop-off kind of system where residents’ drop-off their waste and pay based on the volume of waste they throw away. The real concern is that, it is the can system that is applied, but not standardized hence charges are based on the type of can used by the resident or the one throwing away. This lessens the incentives for reducing waste. Another disadvantage is that some people feel cheated by the amount they are asked to pay because the attendant only charges based on his or her own observation or intuition of the volume of can used in the context.

Table 4-10 displays the average yearly land filled waste before (base year, 2007) and after (2009) PAYT in the study areas. This study demonstrates that there is reduction of 28% in land filled waste after the PAYT in all five communities except for Bomso that showed an increase in land filled waste (comparing disposals during the year of introduction of PAYT - 2008 and a year after PAYT-2009) which is same for the rest of the communities between 2008 and 2009. It is important to also state that all the communities saw some rise in residual waste land filled in 2010. The decrease however may be due to some resistance against the payt system. Burning of waste by some residents; illegal dumping into open drains and other obscured places could be factors, however the extent of these impacts are not known. The number of illegal dump count in the six study communities was beyond the scope of this study. This is because there is no accurate reliable data on number of illegal dumps before PAYT which could allow for comparison of data before and after count on illegal dumps. This limits the work to evidently say that illegal dumps have seen radical increase since the inception of PAYT

However, the traditional attitude of dumping in unapproved areas was not a very serious issue to the private solid waste collectors. They claimed during an interview that the PAYT is not an incentive for increase in illegal dumping because illegal dumping existed with the residents long before PAYT. The officials of the waste companies also indicated that they collaborate with the Environmental Health Division of the local authority to facilitate enforcement of environmental and sanitation regulations and bye-laws.

Table 4- 8: Average Land filled waste before and after Pay-As-You-Throw (PAYT) in six communities

Community	Average Monthly Land filled waste (tons)		
	Fiscal year 2007 (before PAYT)	**Fiscal year 2009 (after PAYT)**	**Percentage change (%)**
Kotei	2169.371	2052.05	-5.41
Ayigya	3904.931	2600.83	-33.39
Kentinkrono	1923.934	1414.04	-26.50
Gyenyase	1398.327	991.968	-29.06
Atonsu	4574.913	2998.344	-34.46
	Fiscal year 2008(during PAYT)	**Fiscal year 2009(after PAYT)**	**Percentage change (%)**
Bomso	2132.43	2413.26	13.16948

Figure 4.4 below displays average yearly waste land filled (tons) from Kotei. It is evident that there was a decrease of about 5.4% in the amount of waste land filled from 2007 to 2008. Although a decrease in waste land filled occurred in 2009, yet this was still lower than the amount of waste land filled in 2007. The low amounts in 2008 and 2009 may be due to some resistance against the PAYT system by residents. As a result residents could dump their waste in unapproved designations other than the communal bin. For Kotei, the increase in 2010 may be that many residents have come to accept the PAYT system, and therefore throw most of their waste set-outs into the communal bin.

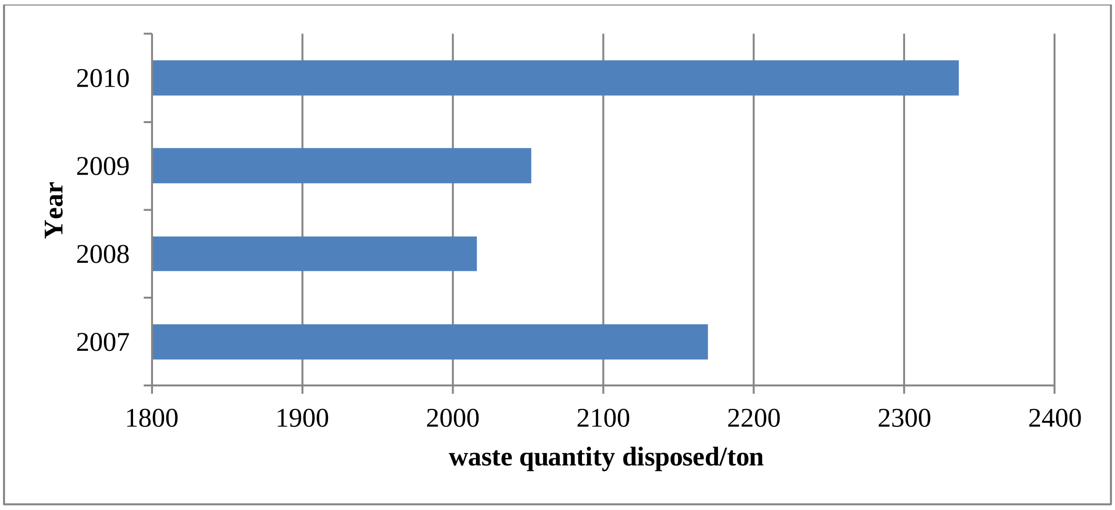

Figure 4- 3: Kotei yearly average waste land filled in tons

Figure 4-4 presents the trend in average waste land filled yearly from Ayigya community. A reduction of 33.4% in waste land filled between 2007 and 2008 may arise from the factor of resisting the PAYT system by residents, but the low quantity land filled in 2009 could result from a combination of resistance to PAYT and increments in pricing of waste thrown away. The minimum paid for waste thrown away was five Ghana pesewa while the maximum was ten Ghana pesewa in the year 2008 – year of introduction of PAYT. This increased to twenty pesewa as minimum and fifty to seventy pesewa as maximum since 2009.These increments can affect the amounts of waste being thrown away by residents. A good number of residents accepting the PAYT as well as population growth could explain the increased trend in 2010 waste land filled.

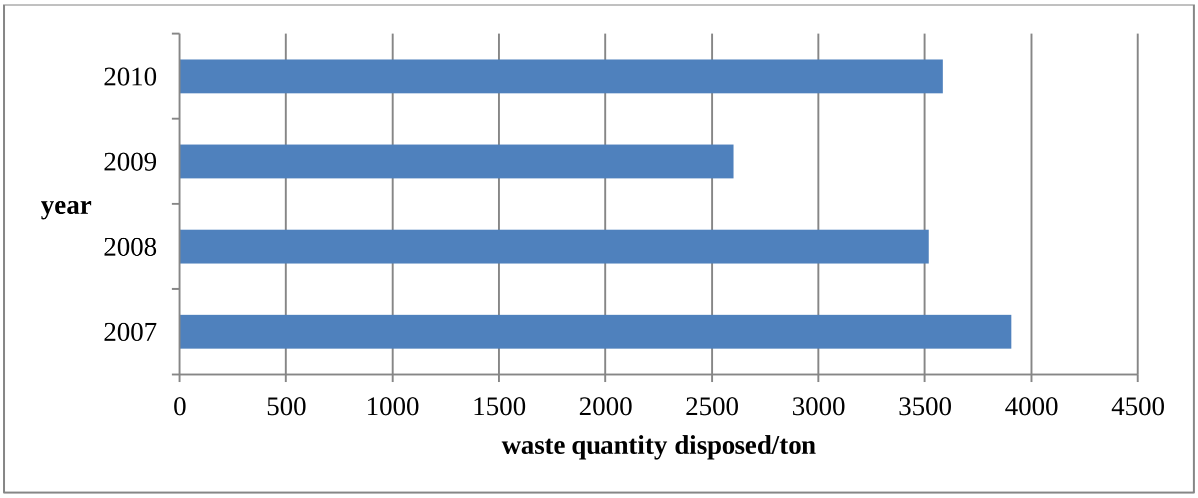

Figure 4- 4: Ayigya yearly average waste land filled in tons

Figure 4.6 shows average yearly waste land filled from Kentinkrono. The reasons for the average land filled waste in this community may share similar characteristics as in Ayigya and Kotei above.

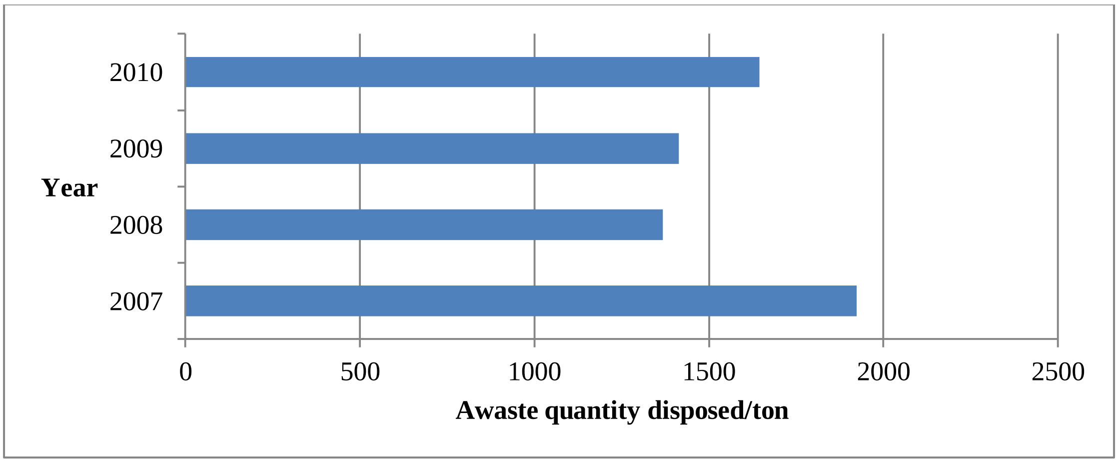

Figure 4- 5: Kentinkrono yearly average waste land filled in tons

Figure 4-6 indicates the yearly average of waste land filled from Gyenyase. Similar reasons as in the case of Kotei, Ayigya, and Kentinkrono may be attributable to the trend in amount of waste land filled from Gyenyase.

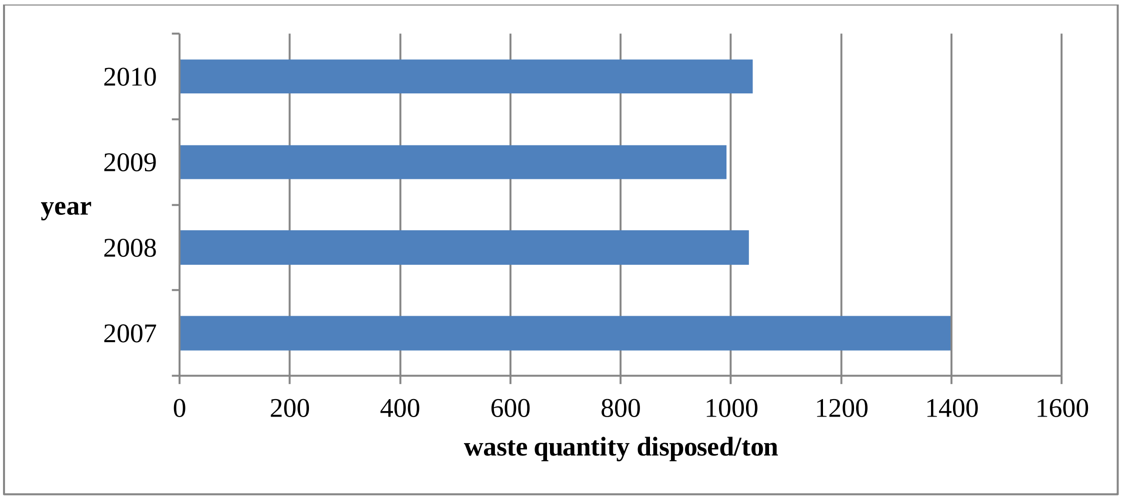

Figure 4- 6: Gyenyase yearly average waste land filled in tons

Figure 4-7 demonstrates the average yearly land filled waste from Atonsu. The pattern in quantities of average yearly land filled waste from Atonsu attract similar reasons as in the case of Kotei, Ayigya, Kentinkrono, and Gyenyase above.

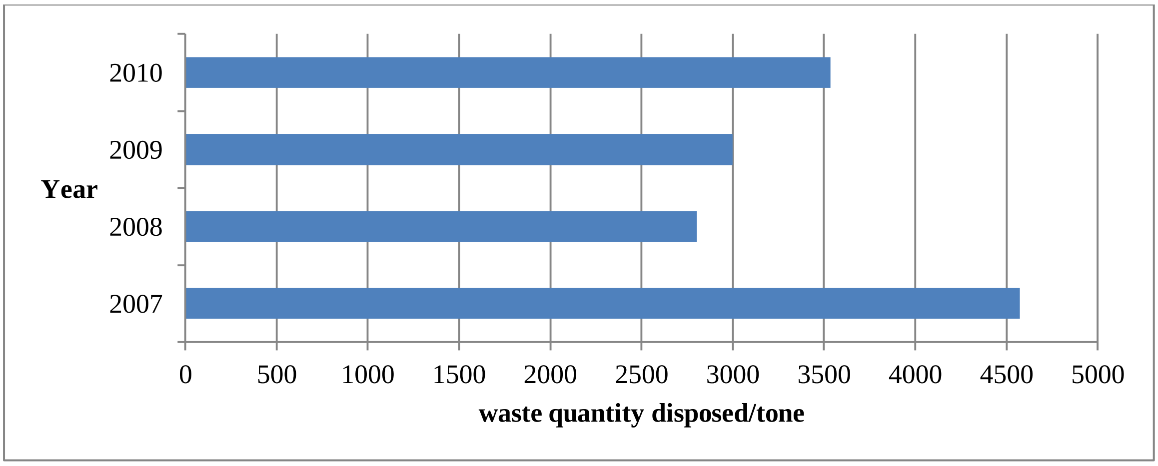

Figure 4- 7: Atonsu yearly average waste land filled in tons

Figure 4-8 shows the Bomso yearly average land filled waste. The pattern of amount of land filled waste depicts decrease in waste amounts in 2008, which however increased in 2009 and 2010. The 2007 land filled data for Bomso was not available at the time of the research, hence the base line year (a year before the PAYT-2007) is not available for comparison with other subsequent years after the PAYT introduction. The 2008 was therefore used as base year.

The Bomso community shares immediate boundary with the KNUST. Similarly, the issues of resistance could have affected the waste set-outs in 2008, while 2009 saw improved acceptance of the payt system. These reasons as well as population growth may explain for the average yearly increase in land filled waste after PAYT in Bomso.

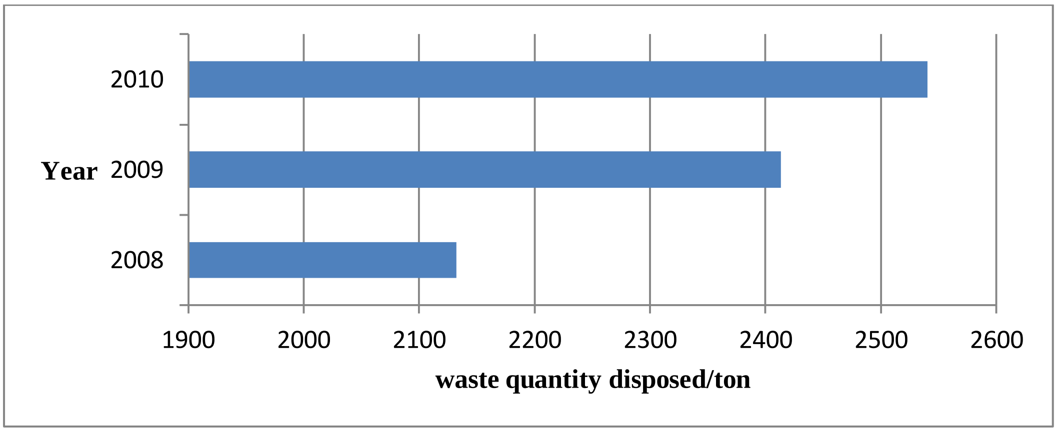

Figure 4- 8: Bomso yearly average waste land filled in tons

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Ten (10) solid waste fractions were diverted from the waste stream at the communal (public) collection points in the six study communities. These fractions are: dense plastics, metals, glass bottles, wood, foam, ceramic, leather, fiber, old tires and plastic film.

Total weight and volume of all fractions diverted for a period of 199 days were 3587.36kg and 18m^3 respectively. Notably, plastics and metals were the most captured. 1875.93kg, 1028.88kg, 236.09kg, 204.44kg represented the plastics, metals, ceramic, and glass bottles respectively out of the total above. Following this, the diverted solid waste per day was 18.03kg; from which 8.97kg and 5.17kg stood for plastics and metals indicating the values found in these fractions by informal diversion/recycling actors.

Most expressively, the total diversion rate was found to be 0.55% per day for all materials diverted. This value is far less than estimated recyclables of 13% in the waste stream, although it saves a cost of close to $3000/month for collection and disposal.

It is evident from the study that there was a reduction of about 28% in the land filled waste after PAYT was introduced in the six study communities. However some of the study communities have their disposal quantities gradually increasing likely because of increasing acceptance of the PAYT system and population growth. Moreover it should be noted that the lack of complementary diversion programs will thwart the seeming reduction in residual waste land filled in the years ahead as seen in the 2010 quantities.

5.3 Recommendation

From the research findings and conclusions, some recommendations have been provided below:

I. Opportunities and incentives should be provided by the City authority for the expansion and possible formalization of the diversion/recycling activities perhaps through:

- accepting the activities of the actors in the diversion as part of the overall waste management system
- public-private partnership focusing on diversion of solid waste
- Setting up recycling centers within the city to avoid daunting distances of transporting diverted materials.

II. Standardization of the can system (volume-based pricing) of the PAYT will be a pre-requisite for the improvement of the whole system of unit pricing in the city.

III. Further diversion studies conducted at the household and land fill levels or even in all the capital cities could reveal interesting rates.

List of References

Abel A.M. (2010**): Physico-chemical characteristics of solid waste for treatment options – a case study of Kumasi, Ghana**. MSc. Thesis report, Water Supply and Environmental Sanitation, department of Civil Engineering, KNUST – Kumasi, pp.6 – 45.

Ai H., Yuji H., Makiko S., Ryo H. (2009): **municipal solid waste flow and waste generation characteristics in an urban-rural fringe area in Thailand**, vol.27: pp.951 – 960.

Anf H.Z., Henry M. (2005**): Assessing solid waste recycling opportunities for closed campuses.** Management and Environmental Quality, vol.16 number 3: pp. 250 – 256.

Anna Sadowska-Rociek, Magdalena K., Elzbieta Szczepaniec-Cieciak, Caroline R., Herve V., Mireille Batton-Hubert, Krzysztof P. (2009): **Analysis of odorous compounds at municipal landfill sites,** vol.27: pp.966 – 975.

Bench M., L., Woodard, Harder M. R., Santos N. (2005): **Waste minimization – Home digestion trials of biodegradable waste, Vol. 45: pp. 84-94.**

Bernadette A. Lawryshyn(2012): **The environmental comparison of landfilling Vs. incineration of municipal solid waste accounting for waste diversion**. Waste management, Vol. 32: pp. 1019 – 1030.

Burnley S.J., Ellis J.C., Flowerdew R., Poll A.J., Prosser H. (2007**): Assessing the composition of municipal solid waste in Wale**s, Vol. 49: pp. 264 – 283.

Charles A.A., Richard H., Anthony K. P., Margaret M. Singh (2002**): Diversion from landfill – quality products from valuable plastics**. Resource Conservation Recycle, Vol. 36: pp. 309 – 318.

Cornel waste management institute (2005/2006**): Marketing composts and meeting consumer needs**. Compost fact sheet No. 1, Department of crop and soil science, Cornel University, vol.607: pp.255 – 1187.

Danielle P. S., Arthur L. F., Annie L. B.(2010)**: Reducing solid waste in higher education – The first step towards 'greening' a university campus, natural resources and Env. Studies, university of Northern British Columbia, Canada.**

Elizabeth O.O., Rahji M.A.Y. (2009)**: Determinants of households'' willingness-to-pay for private solid waste management services in Ibadan, Nigeria,** vol.27: pp.961 – 965.

Fehr M. de Castro M. S. M. V., Calcado M. d. R. (2000): **A practical solution to the problem of household waste management in Brazil, Vol. 30: pp. 245 – 257.**

Fehr M., Santos F. C. (2009); **Landfill diversion – moving from sanitary to economic targets**, Vol. 26: pp. 280 – 286.

Hua Z., Ping-Jing H., Li-Ming S. (2008**): Implication of heavy metals distribution for a municipal solid waste management system – a case study in Shangai**, Vol. 405: pp. 257 – 267.

Husaini I. G., Garg A., Kim K. H., Marchant J., Pollard S.J.T., Smith R. (2007); **European household waste management schemes – Their effectiveness an d applicability in England, vol. 51: pp. 248 – 263.**

Ilhan o., Kriton c. (1993): **Improving the efficiency of the solid waste collection system in Izmir, Turkey, through mathematical programming**, Vol. 11: pp. 297 – 311.

Isa Baud (2004**); Solid waste management and recycling**. Kluwer Academic publishers. Printed in Netherlands, pp. 1 – 18.

Jess W. E., Shiv S. (1996): **Curbside collection of yard waste – Estimating Route Time**, Vol. 122: No. 2: pp. 107 – 114.

Karagiannidis A., Xirogiannopoulos A., Perkoulidis G., Mousiopoulos N. (2004): **A step towards Municipality Benchmarking**, Vol.4: pp. 397 –409.

Macdonald D., Vopni P.(1994): **Policy Barriers to 50% Diversion Of Municipal solid waste**, Vol. 12: pp. 257 – 270.

Miranda L. M., Scott D. B., Joseph E.A.(1996**): Unit pricing programs for residential municipal solid waste – an assessment of the Literature.** School of the Environment, Duke University.

Massimiliano M., Anna M., Francesco N. (2009): **The dynamics of landfill diversion – Economic drivers, policy factors and spatial issues, Evidence from Italy using provincial panel data**. Resource Conservation Vol. 54: pp. 53 – 61.

Massimiliano M., Roberto Z. (2008): **Waste generation, waste disposal and policy effectiveness – Evidence of decoupling from European union, Vol. 52: pp. 1221 – 1234.**

Moe C. (2009): **Sustainable kerbside recycling in the municipal garbage contract**, vol. 27: pp.988 – 995.

Petr S., Libuse P.(2000**): Pay as you throw – An attempt of quantitative comparison of Czech and German experience.**

Purcell M., Magette W. L. (2011): **Targeted intervention Strategies to optimize diversion Biodegradable Municipal Waste in the Dublin, Ireland Region, Vol. 31: pp. 2180 – 2189.**

Samonporn S., Vilas N.(2008): **Assessment of factors influencing the performance of solid waste recycling programs,** Vol. 53: pp. 45 – 56.

Sakai S., Kenatsu T., Hirai Y., Yoshida H. (2008): **Unit-charging programs for municipal solid waste in Japan.** Waste management, vol. 28: pp. 2815-2825.

Scott B., Marie L. M. (1996): **The urban performance of unit pricing – an analysis of variable rates for residential garbage collection in urban areas**. School of the Environment, Duke University. Skumatz Lisa A. (1998): **When to charge variable rates – The rural dilemma**.

Skumatz Lisa A. (2000): **Measuring source reduction – pay as you throw as an example**. Skumatz research associates (SERA).

Skumatz Lisa A. (2002**): Measuring source reduction – pay as you throw/variable rates as an example**. SERA.

Skumatz Lisa A. (2002**): Variable rates or "pay as you throw" waste management – answers to frequently asked questions.** Reason Public policy Institute, Los Angeles USA. Policy study Number 295.

Skumatz Lisa A., David J.F. (2006**): pay as you throw in the US – 2006 update and analysis**. SERA.

Skumatz Lisa A. (1993): **Variable rates for municipal solid waste – Implementation experience, economics and legislation**. Policy study Number 160.

Stephen R.S., Sharon J. (2009): **Small-scale home composting of biodegradable household waste – overview of key results from a 3 year research program in West London**, vol.27: pp.941 – 950.

Su J., Huang G.H., Xi B.D., Qin X. S., Huo S. L., Jiang Y. H., Chen X. R.(2010**): Long-term panning of diversion under interval and probabilistic uncertainties**. Resource Conservation Recycling, Vol. 54: pp. 449 – 461.

Thomas W., Keith W., Anthony G. (2006): **An investigation into the kerbside recycling behavior of two Welsh case study authorities**, Vol.24: pp.345 – 353.

Travis Wagner, Paul A. (2008): **A new model for solid waste management – an analysis of the Nova Scotia Municipal Solid Waste strategy, Vol. 16: pp. 410 – 421.**

USEPA (1999**): Collection efficiency – strategies for success.** Solid waste and emergency response. Number: EPA 530 – K – 99 – 007.

USEPA (1999): **Getting more for less – Improving collection efficiency**. Solid waste and emergency response. Number: EPA 530 – R – 99 – 0383.

Wagland S.T., Tyrell S.F., Godley A.R., Smith A. R. (2009**): Test methods to aid in the evaluation of the diversion of biodegradable municipal waste(BMW) from landfill**. Waste management, Vol. 29: pp. 1218 – 1226.

APPENDICES

Appendix A: Results of quantitative field measurements

Table A 1: First Quantitative field measurement of diverted waste fractions in kg from seven communities

	community								
	Ayigya	**Ayigya zongo**	**Kotei**	**Atonsu**	**Gyenyase**	**Kentinkrono**	**Bomso**		
Period of separation(days)	3	14	14	7	7	35	14		
material	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Total weight (kg)	% by weight
Plastic dense	22.9	124.6	62.0	125.8	39.9	347.6	57.5	780.5	49.8
metal	-	33.2	88.5	8.4	-	194.4	55.8	380.5	24.3
Glass bottle	-	46.2	11.0	0.9979	-	-	9.616	67.948	4.34
wood	-	-	-	49.260	-	-	54.24	103.50	6.61
foam	3.175	2.08	-	5.7152	-	-	-	10.976	0.70
leather	21.22	-		6.3986	-	-	4.581	32.208	2.0
ceramic	10.16	-	41.004	-	-	-	86.18	137.	8.7
tires	-	-	-	45.268	-	-	-	45.2	2.8
fiber	-	-	-	-	1.133	-	-	1.13	0.0
Plastic film	-	-	-	4.898	-	-	-	4.89	0.3
total	57.5	206	202	246.8	41.0	542.0	268	1564.	

Table A 2: Second Quantitative field measurement of diverted waste fractions in kg from seven communities

	community								
	Ayigya	**Ayigya zongo**	**Kotei**	**Atonsu**	**Gyenyase**	**Kentinkrono**	**Bomso**		
Period of separation (days)	7	7	7	7	7	7	7		
material	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Total weight (kg)	% by weight
Plastic dense	60.5994	110.4044	62.50503	30.52677	30.88964	60.32779	49.26013	404.5132	48.66614
metal	34.74	22.67962	67.58526	31.9329	25.08366	50.62091	40.279	272.9214	32.8346
Glass bottle	-	12.24699	13.33562	-	-	19.36839	15.78501	60.73601	7.307024

wood	-	-	-	5.35239	-	-	26.48794	31.84033	3.830644
foam	4.036972	7.620352	-	3.492661	-	-	-	15.14999	1.822663
leather	4.944157	-		1.088622	-	3.74817	4.535924	9.797596	1.178728
ceramic	-	-	-	-	-	-	36.24203	36.24203	4.360203
tires	-	-	-	-	-	-	-	-	-
fiber	-	-	-	-	-	-	-	-	-
Plastic film	-	-	-	-	-	-	-	-	-
total	104.3205	152.95136	143.4259	72.39334	55.9733	134.081907	172.5919	1564.56	100

Table A 3: Third Quantitative field measurement of diverted waste fractions in kg from seven communities

	community							
	Ayigya	**Ayigya zongo**	**Kotei**	**Atonsu**	**Gyenyase**	**Kentinkrono**	**Bomso**	

Period of capture(days)	7	7	7	7	7	7	7		
material	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Weight (kg)	Total weight (kg)	% by weight
Plastic dense	60.5994	110.4044	62.50503	30.52677	30.88964	60.32779	49.26013	404.5132	48.66614
metal	34.74	22.67962	67.58526	31.9329	25.08366	50.62091	40.279	272.9214	32.8346
Glass bottle	-	12.24699	13.33562	-	-	19.36839	15.78501	60.73601	7.307024
wood	-	-	-	5.35239	-	-	26.48794	31.84033	3.830644
foam	4.036972	7.620352	-	3.492661	-	-	-	15.14999	1.822663
leather	4.944157	-		1.088622	-	3.74817	4.535924	9.797596	1.178728
ceramic	-	-	-	-	-	-	36.24203	36.24203	4.360203

tires	-	-	-	-	-	-	-	-	-
fiber	-	-	-	-	-	-	-	-	-
Plastic film	-	-	-	-	-	-	-	-	-
total	104.3205	152.95136	143.4259	72.39334	55.9733	134.081907	172.5919	1564.56	100

Table A 4: Point generation, Disposal and diversion rate from the first measurement

Community	Storage period (days)	Disposal (kg)	Diverted quantity(kg)	Point Generation (kg)	Diversion rate (%)
Ayigya		21136	263.7186006	21399.7186	1.23236114
Bomso		37820	268.07314	38088.07314	0.703824368
Kotei		15660	202.6650709	15862.66507	1.277623085
Gyenyase		37880	41.05008	37921.05008	0.108251433

Kentinkrono		38980	542.08	39522.08	0.131794683
Atonsu		53470	246.803034	53716.80303	0.4594683
Total		**204946**	**1564.389926**	**206510.39**	**3.91329188**

Table A 5: Point generation, Disposal and diversion rate from the second measurement

Community	Disposal (kg)	Diverted quantity(kg)	Generation(kg)	Diversion rate (%)
Ayigya	22640	257.27188	22897.27189	1.123591886
Bomso	15720	168.0541228	15888.05412	1.687262253
Kotei	15740	143.42591	15883..42591	1.275953135
Gyenyase	38640	41.05008	38681.05008	0.106124523
Kentinkrono	15500	542.088	16042.088	3.37916117
Atonsu	54340	72.393343	54412.39334	0.133045688
Total	**162580**	**1224.283336**	**163804.2833**	**7.705138602**

Table A 6: Point generation, Disposal and diversion rate from the third measurement

Community	Disposal (kg)	Diverted quantity(kg)	Generation(kg)	Diversion rate (%)
Ayigya	47340	442.343296	47782.3433	0.925746344
Bomso	22880	154.4482	24034.4482	0.642611799
Kotei	23880	220.59065	24100.59065	0.915291468
Gyenyase	31000	107.26995	31107.26995	0.344838844
Kentinkrono	40380	87.95162052	40467.95162	0.217336328
Atonsu	53320	177.6330625	53497.63306	0.344838844
Total	**219800**	**1190.236779**	**220990.2368**	**3.377863889**

Table A 7: Total average diversion rate per day

Community	Storage period (days)	Disposal (kg/d)	Diverted quantity(kg/d)	Point Generation (kg/d)	Diversion rate (%)
Ayigya & Ayigya zongo	45	2024.80	21.41	2046.21	1.05
Bomso	28	2729.29	21.09	2750.38	0.77
Kotei	28	1974.29	20.24	1994.52	1.01
Gyenyase	21	5120.00	9.02	5129.02	0.18
Kentinkrono	56	1693.93	20.93	1714.86	1.22
Atonsu	21	7672.86	23.66	7696.52	0.31
Total	**199**	**21215.16**	**116.34**	**21331.50**	**0.55**

Appendix B: Results of fractions and quantities of diverted solid waste

Table B.1:Raw data on quantities (in kg) of diverted solid waste fractions across seven study communities for all three quantitative field measurements.

KOTEI							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIGHT(DIVERSION IN Kg)**
17-11-2011	PLASTIC	2 WEEKS	3-4 DAYS	11	3	8	3.628739
				10.2	3	7.2	3.265865
				10.4	3	7.4	3.356584
				12	3	9	4.082331
				10.8	3	7.8	3.53802
				10	3	7	3.175147
				11.8	3	8.8	3.991613
				21	3	18	8.164663
				12.4	3	9.4	4.263768
				8.8	3	5.8	2.630836
				11	3	8	3.628739
				12.8	3	9.8	4.445205
				14.8	3	11.8	5.35239
				11.8	3	8.8	3.991613
				13	3	10	4.535924
				TOATAL			**62.0514**
17-11-2011	METALS	2 WEEKS	3 DAYS	11	3	8	3.628739
				11.4	3	8.4	3.810176

				15.4	3	12.4	5.624545
				18.8	3	15.8	7.166759
				20.8	3	17.8	8.073944
				12	3	9	4.082331
				14	3	11	4.989516
				13.8	3	10.8	4.898798
				19.4	3	16.4	7.438915
				21	3	18	8.164663
				15	3	12	5.443108
				15.8	3	12.8	5.805982
				16	3	13	5.896701
				23.8	3	20.8	9.434721
				12	3	9	4.082331
				TOATAL			**88.5412**
17-11-2011	CERAMICS	2 WEEKS	3 DAYS	93.4	3	90.4	41.00475
17-11-2011	GLAS.BOT TLE	2 WEEKS	3 DAYS	27.4	3	24.4	11.06765
				TOATAL			**52.0724**

AYIGYA							
DATE OF MEASUREMENT	SOLID WASTE FRACTION	PERIOD OF ACCUMULATION	FREQUENCY OF COLLECTION	WEIGHT OF CONTAINER WITH CONTENTS (Lbs)	WEIGHT OF CONTAINER WITHOUT CONTENT(Lb)	WEIGHT (DIVERSION IN Lbs)	WEIGHT(DIVERSION (KG)
17-11-2011	PLASTIC	3 DAYS	2 DAYS	28.8	0.8	28	12.70059
				23.4	0.8	22.6	10.25119
				TOTAL			**22.9518**
17-11-2011	LEATHER			19.4	1.4	18	8.164663
17-11-2011				21.8	1.4	20.4	9.253284
17-11-2011				9.8	1.4	8.4	3.810176
				TOTAL			**21.2281**
17-11-2011	FOAM			8.4	1.4	7	**3.17515**
17-11-2011	CERAMIC			23.8	1.4	22.4	
				TOTAL			**10.1605**

AYIGYA-ZONGO							
DATE OF MEASUREMENT	**SOLID WASTEF RACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER WITH CONTENTS (lbs.)**	**WEIGHT OF CONTAINER WITHOUT CONTENT(lbs)**	**WEIGHT (DIVERSION IN lbs)**	**WEIGHT(DIVE RSION IN KG)**
17-11-2011	PLASTI C	2 WEEKS	3 days	39.2	1.8	37.4	16.96435
				33.2	1.8	31.4	14.2428
				33.8	1.8	32	14.51496
				28.2	1.8	26.4	11.97484
				16	1.8	14.2	6.441012
				25.2	1.8	23.4	10.61406
				27.2	1.8	25.4	11.52125
				26	1.8	24.2	10.97694
				16.8	1.8	15	6.803886
				22.8	1.8	21	9.52544
				10	1.8	8.2	3.719457
				18	1.8	16.2	7.348196
				TOTAL			**124.647**
17-11-2011	METALS	2 WEEKS	3 DAYS	26.8	1.8	25	11.33981
				14.4	1.8	12.6	5.715264
				30.8	1.8	29	13.15418
				8.4	1.8	6.6	2.99371
				TOTAL			**33.203**

17-11-2011	BOTTLES	2 WEEKS	3 DAYS	40	1.8	38.2	17.32723
				63	1.8	61.2	27.75985
				4.4	1.8	2.6	1.17934
				TOTAL			**46.2664**
17-11-2011	FOAM	2 WEEKS	3 DAYS	6.4	1.8	4.6	
				TOTAL			**2.08652**

BOMSO							
DATE OF MEAUSREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIGHT(DIVERSION IN Kg)**
17-11-2011	PLASTIC	2 WEEKS	3 DAYS	13.4	0.9	12.5	5.669905
				23.7	0.9	22.8	10.34191
				7.9	0.9	7	3.175147
				23.4	0.9	22.5	10.20583
				26	0.9	25.1	11.38517
				32	0.9	31.1	14.10672
				6.8	0.9	5.9	2.676195
				TOTAL			**57.5609**
17-11-2011	METALS	2 WEEKS	3 DAYS	55.4	0.9	54.5	24.72078
				8.9	0.9	8	3.628739
				12.5	0.9	11.6	5.261671
				50	0.9	49.1	22.27139
				TOATL			**55.8826**
17-11-2011	WOOD	2 WEEKS	3 DAYS	63.5	0.9	62.6	28.39488
				27.8	0.9	26.9	12.20163
				31	0.9	30.1	13.65313
				TOTAL			**54.2496**
	GLAS.BOTT	2 WEEKS	3 DAYS	5.7	0.9	4.8	2.177243

BOMSO CONT'D				9	3	6	2.721554
				14.8	3	11.8	5.35239
				15	3	12	5.443108
				11.4	3	8.4	3.810176
				20.4	3	17.4	7.892507
				19.9	3	16.9	7.665711
				18.4	3	15.4	6.985322
				19.4	3	16.4	7.438915
				22	3	19	8.618255
				25.4	3	22.4	10.16047
				18	3	15	6.803886
				15.4	3	12.4	5.624545
				27.4	3	24.4	11.06765
				36	3	33	14.96855
				17	3	14	6.350293
				44.4	3	41.4	18.77872
				19	3	16	7.257478
				23	3	20	9.071847
				19.4	3	16.4	7.438915
				17	3	14	6.350293
				22	3	19	8.618255
				16.4	3	13.4	6.078138
				9.9	3	6.9	3.129787
BOMSO CONT'D							
				TOTAL			**347.633**

18-11-2011	METALS	4 WEEKS	3 DAYS	12.4	2.9	9.5	4.309128
				11	2.9	8.1	3.674098
				10.4	2.9	7.5	3.401943
				18.4	2.9	15.5	7.030682
				37.8	2.9	34.9	15.83037
				33	2.9	30.1	13.65313
				36.4	2.9	33.5	15.19534
				24	2.9	21.1	9.570799
				22	2.9	19.1	8.663614
				29	2.9	26.1	11.83876
				21	2.9	18.1	8.210022
				30	2.9	27.1	12.29235
				33.8	2.9	30.9	14.016
				19.8	2.9	16.9	7.665711
				49.9	2.9	47	21.31884
				22	2.9	19.1	8.663614
				36	2.9	33.1	15.01391
				34	2.9	31.1	14.10672
				TOTAL			**194.455**

KENTENKRONO							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIGHT(DIVERSION IN Kg)**
18-11-2011	PLASTIC	5 weeks	3-4 DAYS	103	13	90	40.8233
				73	13	60	27.2155
				106	13	93	42.1841
				107	13	94	42.6377
				14	3	11	4.98952
				11.8	3	8.8	3.99161
				12	3	9	4.08233
				12	3	9	4.08233
				9	3	6	2.72155
				14.8	3	11.8	5.35239
				15	3	12	5.44311
				11.4	3	8.4	3.81018
				20.4	3	17.4	7.89251
				19.9	3	16.9	7.66571
				18.4	3	15.4	6.98532
				19.4	3	16.4	7.43891
				22	3	19	8.61826
				25.4	3	22.4	10.1605
				18	3	15	6.80389
				15.4	3	12.4	5.62455
				27.4	3	24.4	11.0677
				36	3	33	14.9685
				17	3	14	6.35029

				44.4	3	41.4	18.7787
				19	3	16	7.25748
				23	3	20	9.07185
				19.4	3	16.4	7.43891
				17	3	14	6.35029
				22	3	19	8.61826
				16.4	3	13.4	6.07814
				9.9	3	6.9	3.12979
				TOTAL			**347.633**
18-11-2011	METALS	4 WEEKS	3 DAYS	12.4	2.9	9.5	4.30913
				11	2.9	8.1	3.6741
				10.4	2.9	7.5	3.40194
				18.4	2.9	15.5	7.03068
				37.8	2.9	34.9	15.8304
				33	2.9	30.1	13.6531
				36.4	2.9	33.5	15.1953
				24	2.9	21.1	9.5708
				22	2.9	19.1	8.66361
				29	2.9	26.1	11.8388
				21	2.9	18.1	8.21002
				30	2.9	27.1	12.2924
				33.8	2.9	30.9	14.016
				19.8	2.9	16.9	7.66571
				49.9	2.9	47	21.3188
				22	2.9	19.1	8.66361
				36	2.9	33.1	15.0139

				34	2.9	31.1	14.1067
				TOTAL			**194.455**

ATONSU							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lbs.)**	**DIFF. IN WEIGHT(DIVERSION IN Kg)**
18-11-2011				4	1.8	2.2	0.997903
				4.4	1.8	2.6	1.17934
				3.8	1.8	2	0.907185
				22.8	1.8	21	9.52544
				15.8	1.8	14	6.350293
				17.4	1.8	15.6	7.076041
	PLASTIC			25.8	1.8	24	10.88622
	DENSE	1 WEEK	2 DAYS	12.4	1.8	10.6	4.808079

				14.4	1.8	12.6	5.715264
				12	1.8	10.2	4.626642
				21.8	1.8	20	9.071847
				12	1.8	10.2	4.626642
				21.8	1.8	20	9.071847
				15.8	1.8	14	6.350293
				85.4	22	63.4	28.75776
				13.4	1.8	11.6	5.261671
				3.2	1.8	1.4	0.635029
				22.4	1.8	20.6	9.344003
				1.8	0.4	1.4	0.635029
				TOTAL			**125.827**
18-11-2011	METALS	1 WEEK	2 DAYS	20.4	1.8	18.6	**8.43682**

18-11-2011	GLAS.BOTT LE	1 WEEK	2 DAYS	4	1.8	2.2	**0.9979**
18-11-2011	LEATHER	1 WEEK	2 DAYS	15.9	1.8	14.1	**6.39565**
18-11-2011	PLASTIC FILM	1 WEEK	2 DAYS	8.8	1.8	7	3.175147
18-11-2011		1 WEEK	2 DAYS	4	1.8	2.2	0.997903
18-11-2011		1 WEEK	2 DAYS	3.4	1.8	1.6	0.725748
				TOTAL			**4.8988**
18-11-2011	WOOD	1 WEEK	2 DAYS	21.4	1.8	19.6	8.89041
18-11-2011		1 WEEK	2 DAYS	24.8	1.8	23	10.43262
18-11-2011		1 WEEK	2 DAYS	67.8	1.8	66	29.9371
				TOTAL			**49.2601**

18-11-2011	OLD TYRES	1 WEEK	2 DAYS	39.4	1.8	37.6	17.05507
18-11-2011		1 WEEK	2 DAYS	35	1.8	33.2	15.05927
18-11-2011		1 WEEK	2 DAYS	30.8	1.8	29	13.15418
							45.2685
				TOTAL			
18-11-2011	FOAM	1 WEEK	2 DAYS	14.4	1.8	12.6	**5.71526**

KOTEI							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lbs.)**	**DIFF. IN WEIGHT DIVERSION Kg)**
25-11-2011	PLASTIC DENSE	1 WEEK	3 DAYS	46.8	17	29.8	13.51705263
				40.4	17	23.4	10.61406146
				37.6	17	20.6	9.344002822
				55	17	38	17.23651006
				34	17	17	7.71107029
				26	17	9	4.08233133
				TOTAL			**62.50503**
	METAL	1 WEEK		51	17	34	15.42214058
				63	17	46	20.86524902

				55	17	38	17.23651006
				48	17	31	14.06136347
				TOTAL			**67.58526**
	G/BOTTLE	1 WEEK		46.4	17	29.4	**13.33562**

AYIGYA							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER WITH CONTENTS (Lbs)**	**WEIGHT OFCONTAINER WITHOUT CONTENT(Lb)**	**WEIGHT (DIVERSION IN Lb)=(F-G)**	**WEIGHT (DIVERSION) (kg)**
25-11-2011	PLASTIC DENSE	1 WEEK	2 DAYS	15.9	0.8	15.1	6.84924479
				17.8	0.8	17	7.71107029
				11.9	0.8	11.1	5.03487531
				17.4	0.8	16.6	7.52963334
				17	0.8	16.2	7.34819639
				10.4	0.8	9.6	4.35448675
				10	0.8	9.2	4.1730498
				21.4	3	18.4	8.34609961
				15.4	3	12.4	5.62454539

				11	3	8	3.62873896
				TOTAL			**60.5999406**
	METAL	1 WEEK	2 DAYS	17.4	1	16.4	7.43891487
				20.8	1	19.8	8.98112893
				27.4	1	26.4	11.9748386
				15	1	14	6.35029318
							34.7451755
	FOAM	1 WEEK	2 DAYS	9.9	1	8.9	**4.03697209**
	LEATHER	1 WEEK	2 DAYS	11.9	1	10.9	**4.94415683**

AYIGYA-ZONGO							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF WEIG DIVE (Kg)**
25-11-2011	PLASTIC DENSE	1 WEEK		27	17	10	4.5359
				43	17	26	11.793
				45	17	28	12.700
				56	17	39	17.690
				43.4	17	26.4	11.974
				34	17	17	7.7110
				56	17	39	17.690
				33	17	16	7.2574
				37	17	20	9.0718
				39	17	22	9.9790
							110.40
	METALS	1 WEEK		67	17	50	**22.679**
	G/BOTTLE	1 WEEK		44	17	27	**12.240**

BOMSO							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIGHT (DIVERSION) (Kg)**
25-11-2011	PLASTIC DENSE	1 WEEK	3 DAYS	27	1.2	25.8	11.70268315
				18.3	1.2	17.1	7.756429527
				18	1.2	16.8	7.620351816
				15.7	1.2	14.5	6.577089365
				13.8	1.2	12.6	5.715263862
				23	1.2	21.8	9.888313666
				TOTAL			**49.26013**
	METAL	1 WEEK		43	1.2	41.8	18.96016107
				36.4	1.2	35.2	15.96645142
				13	1.2	11.8	5.352389966

				TOTAL			**40.279**
	WOOD	1 WEEK		50.4	0.8	49.6	22.49818155
				9.6	0.8	8.8	3.991612856
				TOTAL			**26.48979**
	G/BOTTLE	1 WEEK		25.2	1.2	24	10.88621688
				12	1.2	10.8	4.898797596
				TOTAL			**15.78501**
	CERAMIC	1 WEEK		44	0.8	43.2	19.59519038
				37.5	0.8	36.7	16.64683998
				TOTAL			**36.24203**
	LEATHER	1 WEEK		11.2	1.2	10	**4.535924**

KENTINKRONO							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lbs.)**	**DIFF. IN WEIGHT DIVERSION (Kg)**
25-11-2011	PLASTIC DENSE	1 WEEK	3 DAYS	46	17	29	13.15417873
				52	17	35	15.87573295
				49	17	32	14.51495584
				54	17	37	16.78291769
				TOTAL			**60.32779**
	METAL	1 WEEK		54.4	17	37.4	16.96435464
				51	17	34	15.42214058
				40.2	17	23.2	10.52334298
				34	17	17	7.71107029
				TOTAL			**50.62091**
	G/BOTTLE	1 WEEK		59.7	17	42.7	**19.36839**
	LEATHER	1 WEEK		8.8	0.5	8.3	**3.764817**

ATONSU							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lbs.)**	**DIFF. IN WEGIHT DIVERSION (Kg)**
25-11-2011	PLASTIC DENSE	1 WEEK	2 DAYS	38.6	17	21.6	9.797595192
				37	17	20	9.0718474
				29.7	17	12.7	5.760623099
				30	17	13	5.89670081
				TOTAL			**30.52677**
	METAL	1 WEEK		50.8	17	33.8	15.33142211
				43	17	26	11.79340162
				27.6	17	10.6	4.808079122
				TOTAL			**31.9329**
	FOAM	1 WEEK		9.1	1.4	7.7	**3.492661**
	WOOD	1 WEEK		13.2	1.4	11.8	**5.35239**
	LEATHER	1 WEEK		3.8	1.4	2.4	**1.088622**

GYENYASE							
DATE OF MEASUREMENT	SOLID WASTE FRACTION	PERIOD OF ACCUMULATION	FREQUENCY OF COLLECTION	WEIGHT OF CONTAINER & CONTENT	WEIGHT OF CONTAINER	DIFF. IN WEIGHT(lb)	DIFF. IN WEGIHT DIVERSION (Kg)
25-11-2011	PLASTIC DENSE	1 WEEK	3 DAYS	10.1	1	9.1	4.127690567
				11	1	10	4.5359237
				10	1	9	4.08233133
				12	1	11	4.98951607
				13	1	12	5.44310844
				9	1	8	3.62873896
				10	1	9	4.08233133
				TOTAL			**30.88964**
	METALS	1 WEEK		13	1	12	5.44310844
				15.2	1	14.2	6.441011654
				14.8	1	13.8	6.259574706
				16.3	1	15.3	6.939963261
				TOTAL			**25.08366**

KOTEI							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIHT(DIVERSION Kg)**
21-12-2011	PLASTIC DENSE	1 WEEK		17.5	2.4	15.1	6.84924479
				17	2.4	14.6	6.6224486
				20.4	2.4	18	8.16466266
				18.5	2.4	16.1	7.30283716
				14.3	2.4	11.9	5.3977492
				13	2.4	10.6	4.80807912
				14	2.4	11.6	5.26167149
				15.6	2.4	13.2	5.98741928
				18	2.4	15.6	7.07604097
				17.7	2.4	15.3	6.93996326

				13.3	2.4	10.9	4.94415683
				16.9	2.4	14.5	6.57708937
				15	2.4	12.6	5.71526386
				17.6	2.4	15.2	6.89460402
				18.8	2.4	16.4	7.43891487
					TOTAL		**95.980145**
21-12-2011	METALS	1 WEEK		19.8	1.8	18	8.16466266
				18.6	1.8	16.8	7.62035182
				17.5	1.8	15.7	7.12140021
				19	1.8	17.2	7.80178876
				17.5	1.8	15.7	7.12140021
				16.8	1.8	15	6.80388555
				15	1.8	13.2	5.98741928
				16.7	1.8	14.9	6.75852631

				14.6	1.8	12.8	5.80598234
				13.5	1.8	11.7	5.30703073
				12.8	1.8	11	4.98951607
					TOTAL		**73.481964**
21-12-2011	G/BOTTLE	1 WEEK		43.4	1.8	41.6	**18.8694426**
21-12-2011	CERAMIC	1 WEEK		56.6	1	55.6	**25.2197358**
21-12-2011	LEATHER	1 WEEK		18	1.8	16.2	**7.4396394**

AYIGYA							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIGHT (DIVERSION)(Kg)**
21-12-2011	PLASTIC DENSE	1 WEEK		43.6	17	26.6	12.065557
				66.4	17	49.4	22.4074631
				50.5	17	33.5	15.1953444
				55	17	38	17.2365101
				48	17	31	14.0613635
				64	17	47	21.3188414
				35.4	17	18.4	8.34609961
					TOTAL		**110.63118**
21-12-2011	METALS	1 WEEK		34	17	17	7.71107029
				47.4	17	30.4	13.789208
				33.6	17	16.6	7.52963334
					TOTAL		**29.029912**
	LEATHER	1 WEEK		24	17	7	**3.17514659**

AYIGYA ZONGO							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIHT(DIVERSION(Kg)**
21-12-2011	PLASTIC DENSE	1 WEEK	3 DAYS	55	17	38	17.2365101
				58	17	41	18.5972872
				50	17	33	14.9685482
				45	17	28	12.7005864
				50	17	33	14.9685482
				53	17	36	16.3293253
				38.4	17	21.4	9.70687672
				49	17	32	14.5149558
				60	17	43	19.5044719
				39	17	22	9.97903214
					TOTAL		**148.50614**

21-12-2011	METALS	1 WEEK		60.6	17	43.6	19.7766273
				70	17	53	24.0403956
				77.7	17	60.7	27.5330569
				66	17	49	22.2260261
				49	17	32	14.5149558
					TOTAL		**108.09106**
21-12-2011	BOTTLES	1 WEEK		101	17	84	**38.1017591**
	LEATHER	1 WEEK		11.4	0.8	10.6	**4.80807912**

BOMSO							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIHT(DIVERSION (Kg)**
21-12-2011	PLASTIC DENSE	1 WEEK		17.4	3	14.4	6.53173013
				16.5	3	13.5	6.123497
				19	3	16	7.25747792
				18	3	15	6.80388555
				18.6	3	15.6	7.07604097
				20	3	17	7.71107029
				15.8	3	12.8	5.80598234
				14.5	3	11.5	5.21631226
				21	3	18	8.16466266
				14	3	11	4.98951607
				17	3	14	6.35029318
					TOTAL		**72.030468**

21-12-2011	METALS	1 WEEK		15.5	2.1	13.4	6.07813776
				14.4	2.1	12.3	5.57918615
				16	2.1	13.9	6.30493394
				14	2.1	11.9	5.3977492
					TOTAL		**23.360007**
21-12-2011	CERAMIC	1 WEEK		53.4	0.8	52.6	23.8589587
				30.4	0.8	29.6	13.4263342
					TOTAL		**37.285293**
21-12-2011	WOOD	1 WEEK		23.4	0.8	22.6	10.2511876
				13	0.8	12.2	5.53382691
					TOTAL		**15.7850145**
21-12-2011	LEATHER	1 WEEK		14	0.8	13.2	**5.98741928**

KENTINKRONO							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIHT(DIVERSION (Kg)**
21-12-2011	PLASTIC DENSE	1 WEEK		14.2	3	11.2	5.08023454
				13.8	3	10.8	4.8987976
				18	3	15	6.80388555
				19.4	3	16.4	7.43891487
				17.5	3	14.5	6.57708937
				22.2	3	19.2	8.7089735
				14.6	3	11.6	5.26167149
				26	3	23	10.4326245
					TOTAL		**55.202191**
21-12-2011	METALS	1 WEEK		17.8	3	14.8	6.71316708
				21	3	18	8.16466266
				19.4	3	16.4	7.43891487
				20	3	17	7.71107029
					TOTAL		**30.027815**
	LEATHER	1 WEEK		9	3	6	**2.72155422**

ATONSU							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIHT(DIVERSION (Kg)**
21-12-2011	PLASTIC DENSE	1 WEEK		13.8	1.2	12.6	5.71526386
				15.4	1.2	14.2	6.44101165
				12	1.2	10.8	4.8987976
				17.5	1.2	16.3	7.39355563
				16	1.2	14.8	6.71316708
				14	1.2	12.8	5.80598234
				18	1.2	16.8	7.62035182
				14.6	1.2	13.4	6.07813776
				16.4	1.2	15.2	6.89460402
				12.8	1.2	11.6	5.26167149
				15.5	1.2	14.3	6.48637089
				11.7	1.2	10.5	4.76271989

					TOTAL		**74.071634**
21-12-2011	METALS	1 WEEK		15.4	1.2	14.2	6.44101165
				19.2	1.2	18	8.16466266
				17.6	1.2	16.4	7.43891487
				18.6	1.2	17.4	7.89250724
				15.3	1.2	14.1	6.39565242
				13	1.2	11.8	5.35238997
				16	1.2	14.8	6.71316708
				21	1.2	19.8	8.98112893
				17.4	1.2	16.2	7.34819639
				16.4	1.2	15.2	6.89460402
				12.5	1.2	11.3	5.12559378
				11.4	1.2	10.2	4.62664217
					TOTAL		**81.374471**
21-12-2011	G/BOTTLE	1 WEEK		33.4	1.2	32.2	14.6056743
				11.3	1.2	10.1	4.58128294
					TOTAL		**19.1869573**

GYENYASE							
DATE OF MEASUREMENT	**SOLID WASTE FRACTION**	**PERIOD OF ACCUMULATION**	**FREQUENCY OF COLLECTION**	**WEIGHT OF CONTAINER & CONTENT**	**WEIGHT OF CONTAINER**	**DIFF. IN WEIGHT(lb)**	**DIFF. IN WEIHT(DIVERSION (Kg)**
21-12-2011	PLASTIC DENSE	1 WEEK		15.2	1	14.2	6.44101165
				13.6	1	12.6	5.71526386
				17	1	16	7.25747792
				17.4	1	16.4	7.43891487
				13.4	1	12.4	5.62454539
				12.4	1	11.4	5.17095302
				16	1	15	6.80388555
					TOTAL		**44.452052**
21-12-2011	METALS	1 WEEK		18.8	1	17.8	8.07394419
				19	1	18	8.16466266
				16.5	1	15.5	7.03068174
				16	1	15	6.80388555
					TOTAL		**30.073174**
21-12-2011	WOOD	1 WEEK		40.1	0.4	39.7	18.0076171
				33	0.4	32.6	14.7871113
					TOTAL		**32.7947284**

Appendix C: summary of land fill disposal data

Table C 1: 2007 Disposal data from Dompoase Land fill for six communities

COMMUNITY						
MONTH	KOTEI	BOMSO	AYIGYA	KKRONO	GYENYASE	ATONSU
JAN	182.9				168.82	
FEB	199.48		588.46	182.58	137.16	412.49
MAR	240.99		552.06	210.04	137.14	394.98
APR	151.6		161.32	22.42	97.48	177.5
MAY	147.28		405.48	151.6	102.52	278.16
JUN	81.88		148.26	24.7	89.04	423.22
JUL			315.76	293.298		616.26
AUG	172.94		350.18	405.56	99.58	535.28
SEP	186.71		192.73	298.76	77.64	415.6
OCT	190.32		259.65	3.9	119.6	189.04
NOV	193.13		180.76	10.42	125.1	51.44
DEC	241.36		364.86		127.72	699.7

Table C2: 2008 disposal data from Dompoase land fill for six communities

COMMUNITY						
MONTH	KOTEI	BOMSO	AYIGYA	KKRONO	GYENYASE	ATONSU
JAN	232.99	84.75	233.79		14.12	125.49
FEB	267.14	195.1	251.64		55.13	93.48
MAR	219.91	194.22	256.54		65.37	405.98
APR	120.93	199	76.33		104.27	150.34
MAY	41.03	57.84	112.14		102.88	172.71
JUN	94.93	154.46	193.17	95.27	88.18	270.82
JUL	131.56	225.15	189.43	120.94	93.78	262.64
AUG	216	187.42	212.7	108.44	110.48	258.45
SEP	170.6	196.74	228.18	124.8	83.34	251.64
OCT	196.4	217.1	217.7	133.62	108.54	297.14
NOV	152.64	189.71	242.32	120.62	92.04	253.92
DEC	172	230.94	215.46	94.28	114.9	258.48

Table C3: 2009 disposal data from Dompoase land fill from six communities

COMMUNITY						
MONTH	KOTEI	BOMSO	AYIGYA	KKRONO	GYENYASE	ATONSU
JAN	154.86	202.58	205.4	114.16	94.94	261.37
FEB	150.08	204.12	201.78	102.34		
MAR	212.07	218.8	205.27	117.2	93.06	276.37
APR	159.26	196.32	191.54	127.18	123.76	290.42
MAY	195.36	210.64	226.14	117.74	93.82	276.1
JUN	161.48	183.22	184.14	124.64	72.32	212.3
JUL	153.24	163.42	172.78	119.94		
AUG	183.42	189.54	189.1	119.94	71.76	202.22
SEP	172.24	212.78	191.3	117.72	85.34	231.82
OCT	152.88	228.18	210.86	128.62	54.74	206.18
NOV	171.66	175.74	203.88	107.32	72.72	240.6
DEC	186.4	227.92	418.64	117.24	64.18	301.24

Table C4: 2010 disposal data from Dompoase land fill from communities

COMMUNITY						
MONTH	KOTEI	BOMSO	AYIGYA	KKRONO	GYENYASE	ATONSU
JAN	160.66	150.56	285.92	132.06		
FEB	164.28	173.74	202.86	129.05		
MAR	212.54	257.44	260.88	140.22	76.94	325.4
APR	193.18	227.06	270.52	128.8		
MAY	205.96	232.78	287.48	141.66	95.6	397.02
JUN	217.98	221.02		139.32	80.74	326.54
JUL	221.44	217.68	422.14	151.7	84.7	313.82
AUG	168.68	188.2	282.4	178.22		
SEP	204.34	199.82	245.16	149.08	59.54	157
OCT	202.06	208.1	329.42	134.06	83.56	258.16
NOV	216.7	212.78	360.76	115.08	92.1	317.3
DEC	168.3	251.12	221.8	105.88	119.8	262.68

Appendix D: summary of average disposal in tons

Table D 1: Yearly average disposal tonnage of six communities

Location	**2007 Disposal**			**2008 Disposal**		
	Yearly Total (tons)	**Monthly Average (tons)**	**Yearly Average Total(tons)**	**Yearly Total (tons)**	**Monthly Average (tons)**	**Yearly Average Total(tons)**
Kotei	1988.59	180.7809	2169.371	2016.13	168.0108	2016.13
Ayigya	3579.52	325.4109	3904.931	3519.52	293.2933	3519.52
Kentinkrono	1603.278	160.3278	1923.934	797.97	113.9957	1367.949
Gyenyase	1281.8	116.5273	1398.327	1033.03	86.08583	1033.03
Atonsu	4193.67	381.2427	4574.913	2801.09	233.4242	2801.09
Bomso				2132.43	177.7025	2132.43

Location	2009 Disposal			2010 Disposal		
	Yearly Total (tons)	Monthly Average (tons)	Yearly Total(tons) (Average)	Yearly Total (tons)	Monthly Average (tons)	Yearly Total(tons) (Average)
	2052.05	171.0042	2052.05	2336.12	194.6767	2336.12
Kotei	2600.83	216.7358	2600.83	3586.1	298.8417	3586.1
Ayigya	1414.04	117.8367	1414.04	1645.13	137.0942	1645.13
Kentinkrono	826.64	82.664	991.968	692.98	86.6225	1039.47
Gyenyase	2498.62	249.862	2998.344	2357.92	294.74	3536.88
Atonsu	2413.26	201.105	2413.26	2540.3	211.6917	2540.3
Bomso						

Appendix E: Pictures of quantitative field measurements

Plate 2: Plastic fraction to be measured

Plate 3: metal fraction to be measured