

INTEGRATION OF INFORMAL SOLID WASTE COLLECTORS INTO MAINSTREAM

SOLID WASTE MANAGEMENT IN ADENTAN MUNICIPALITY

By

KNUST

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A Thesis submitted to the Department of Theoretical and Applied Biology

Kwame Nkrumah University of Science and Technology in partial

Fulfillment of the requirements for the award

of

MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

NOVEMBER, 2013

DECLARATION

I hereby declare that this thesis is my own work for the award of the Msc. Certificate. And that, to the best of my knowledge, it does not incorporate any material previously published by another person or material which has been accepted for the award of any other degree by the university or any other university

References made to any other work have been duly acknowledged.

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ABSTRACT

This thesis focuses on the role of the Informal Solid Waste Collectors in the collection and disposal of solid waste in Adentan Municipality. Management of waste in the Municipality by solid waste contractors is faced with numerous challenges resulting in their inability to collect large tonnes of waste for disposal daily. Rapid increase in the volume and types of solid and hazardous wastes as a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments. The main objective of the research is to study how Informal Solid Waste Collectors can be integrated into the mainstream solid waste management in the Adentan Municipality.

The study was conducted in the Adenta Municipality with Adenta as its capital. Adenta Municipal covers an area of 98.3 km² with a population density of 795.7/km² and population of 78,215 (2010 census). Adentan was chosen for the study because of its rapid urbanization and expansion. Qualitative and quantitative data were collected from the Municipal Assembly, households and informal solid waste collectors. The research gathered data from primary and secondary sources using field investigation, face to face interview and questionnaire administration.

Results obtained indicated that out of 55.38 metric tonnes of waste generated per day, 61.39% are collected for disposal by waste contractors, 9.93% by informal collectors and 29.07% are left uncollected. Solid waste management challenges include bad road network, lack of monitoring and supervision by the Assembly, lack of waste management by-laws and irregular service provision by formal waste contractors. The results also indicated that there are only 19 communal containers in the Municipality. Data gathered indicated that some Informal Waste Collectors had been in business for more than 10 years.

Apart from the immense contribution to environment cleanliness and prevention of diseases outbreak through collection and disposal of waste, Informal Solid Waste Collection has provided employment to significant number of youth who have turned out to be the bread-winners of their families. More income is earned by collectors as a result of lower fees charged for services rendered to households and businesses.

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DEDICATION

This research work is dedicated to Almighty God for His Grace. The work is also dedicated to my wife Rosemond Opoku Aboagyewaa and my little son Nana Kwame Agyarko-Agyem for their prayers, support and sacrifice which have made this work possible.

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ACKNOWLEDGMENTS

The opportunity given me to undertake this research has been exciting and at the same time, exacting. I deem it necessary to express my profound appreciation to the many people who in diverse ways contributed to the successful completion of this work.

First and foremost, I wish to acknowledge my sincere gratitude, my indebtedness to God, the Almighty for my successful achievements throughout my educational career and in the project work in particular. My thanks go to my dynamic and hardworking supervisor of the Department of Theoretical and Applied Biology, Dr. Philip Kweku Baidoo who did not only encourage me to write on the topic but also, supervised and guided me through without any charge.

My thanks again go to Richard Tetteh Bekai of Zoomlion Ghana Limited, Head Office who helped me nurse this work from the idea stage to the finished product. Although only my name appeared on the cover, credit for this work goes to many people including: Dr. Fei-Baffoe, Programme Coordinator, Msc. Environmental Science, Institute of Distance Learning, Kwame Nkrumah University of Science and Technology who encouraged me to put up this research.

TABLE OF CONTENTS

Content	Page
Title Page.....	i
Declaration.....	ii
Abstract.....	iii
Dedication.....	iv
Acknowledgements.....	v
Table of Contents.....	vi
List of Tables.....	vii
List of Figures.....	viii
List of Abbreviations.....	x

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study.....	1
1.2 Problem Statement.....	3
1.3 Aims and Objectives of the Study.....	5

CHAPTER TWO: LITERATURE REVIEW

Content	Page
2.1 Waste	6
2.2 Solid Waste.....	6
2.3 Sources and Types of Waste.....	6
2.4 Solid Waste Management.....	9
2.5 Solid Waste Management Process.....	10
2.5.1 Solid Waste Generation.....	10
2.5.2 Storage.....	10
2.5.3 Collection.....	11
2.5.4 Transfer and Transport.....	11
2.5.5 Processing and Recovery.....	11
2.5.6 Disposal.....	12
2.6 Early Practices of Solid Waste Management.....	12
2.7 Contemporary Methods of Managing Solid Waste.....	13
2.7.1 Source Reduction.....	13
2.7.2 Sanitary Landfill.....	13

Content	Page
2.7.3 Recycling.....	14
2.7.4 Incineration	15
2.7.5 Composting	16
2.8 Integrated Solid Waste Management.....	16
2.9 Problems of Managing Solid Waste.....	17
2.9.1 Technical.....	17
2.9.2 Financial.....	18
2.9.3 Institutional.....	18
2.10 Solid Waste Management in Ghana.....	19
2.11 Solid Waste Generation.....	20
2.12 Solid Waste Collection.....	21
2.13 Solid Waste Disposal.....	22
2.14 Problems of Solid Waste Management.....	23
2.8 Key Issues.....	24

CHAPTER THREE: MATERIALS AND METHODS

Content	Page
3.1 Research Designs.....	26
3.2 study Area.....	26
3.3 Sampling and Data Collection Methods/Procedures.....	28
3.4 Responds from the Households.....	28
3.5 Informal Solid Waste Collectors.....	28
3.6 Adentan Municipal Assembly.....	29
3.7 Field Survey	31
3.8. Data Sources.....	31
3.8.1 Qualitative Methods.....	31
3.8.2 Quantitative Methods.....	31
3.9 Data Analysis.....	32

CHAPTER FOUR: RESULTS

4.0 Field Survey	33
4.1 Zone of Residence.....	34

4.2 Disposal of Solid Waste by Households.....	34
Content	Page
4.3 Knowledge about Waste Management Companies Adentan Municipality.....	35
4.4 Household Subscription for Waste Collection by Formal Contractors.....	35
4.5 Frequency on Waste Collection by Waste Management Contractors.....	35
4.6 Informal Collectors Activities in the Zones.....	36
4.7 Operations of Informal Waste Collectors.....	37
4.8 Effectiveness of Services by Formal Companies in Adentan Municipality.....	37
4.9 Activities of Formal Solid Waste Contractors.....	38
4.10 Legalization of Informal Solid Waste Collection in Adentan Municipality.....	39
4.11 Solid Waste Management Challenges in Adentan Municipality.....	39
4.12 Measures to Improve Solid Waste Management in Adentan Municipality.....	40
4.13 Number of Zones, Names of Communities and Solid Waste Management Companies in Adentan Municipality.....	41
4.14 Solid Waste Containers in Adentan Municipality.....	42
4.15 Polluter Pays System in Adentan Municipality.....	43
4.16 Waste Generation, Collection and Disposal in Adentan Municipality.....	44

4.17 Number of Years in Solid Waste Business.....	47
Content	Page
4.18 Equipment Used by Informal Collectors.....	47
4.19 Ownership of Equipment Used for Operations.....	48
4.20 Disposal of Solid Waste Collected by Informal Collectors.....	49
4.21 Revenue Generated from Recovery Materials by Informal Collectors.....	49
4.22 Regularizing Activities of Informal Collectors in Adentan Municipality.....	50
4.23 Challenges of Informal Solid Waste Collection in Adenta Municipality.....	50

CHAPTER FIVE: DISCUSSION

5.1 Environmental Benefits of Informal Sector Integration.....	52
5.2 Legalization of Informal Solid Waste Collectors.....	53
5.3 Number of Zones, Names of Communities and Solid Waste Management Companies in Adenta Municipality.....	55
5.4 Communal Containers in Adentan Municipality.....	55
5.5 Polluter Pays System.....	56
5.6 Waste Generation, Collection and Disposal in Adenta Municipality.....	57
5.7 Permission from Adentan Municipal Assembly for Informal Waste Collection.....	59

Content	Page
5.8 Solid Waste Management Challenges in Adentan Municipality.....	60
5.9 Equipment Used By Informal Solid Waste Collectors.....	61
5.10 Disposal of Solid Waste Collected by Informal Solid Waste Collectors.....	62
5.11 Regularizing and Managing Activities of Informal Solid Waste Collectors in Adentan Municipality.....	62
5.12 Significance of Informal Solid Waste Collection.....	63
5.13 Economic benefits of Informal Sector Integration.....	64
CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS	
6.1: Conclusion	67
6.2 Recommendations	70
References.....	72
Appendix 1.....	78

LIST OF TABLES

Table	Page
Table 1: Typical Waste Generation Facilities, Activities, and Location associated with various Sources of Solid Waste.....	7
Table 2: Distribution of household respondents in the Zones.....	33
Table 3: Number of Zones, Names of Communities and Solid Waste Management Companies in Adenta Municipality.....	40
Table 4: Solid Waste Containers in Adentan Municipality.....	42
Table 5: Communal containers used for polluter pays system.....	43
Table 6: Solid waste generation in Adentan Municipality per day.....	45

LIST OF FIGURES

Figure	Page
Figure 1: Household Waste Disposal in Accra.....	22
Figure 2: Map showing Adentan Municipality.....	27
Figure 3: Percentage of Solid Waste Disposal by Households.....	34
Figure 4: Operations of Informal Solid Waste Collectors.....	37

Figure	Page
Figure 5: Activities of Formal Solid Waste Contractors in Adentan Municipality.....	38
Figure 6: Percentage of waste collection in Adenta Municipality.....	44
Figure 7: Numbers of years Informal Solid Waste Collectors have been in business.....	46
Figure 8: Percentage of equipment used by Informal Solid Waste Collectors.....	47

LIST OF PLATES

Plate	Page
Plate 1: Informal Solid Waste Collectors with their push carts.....	29



CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Solid waste is any material which comes from domestic, commercial, and industrial sources as a result of human activities. It has no value to people who possess it and is therefore described as useless. The problems associated with solid waste disposal can be traced back to the beginning of civilization, when humans gathered in communities. Solid waste generated at that time was not much enough such that it was easily contained by the natural environment. The industrial revolution that took place in Europe in the 19th century marked a turning point in waste management. It brought with it, the movement of people from rural areas to towns and cities in search for jobs. As population increased and villages grew into towns and cities, the amount of waste generated increased. Wastes were consequently dumped indiscriminately into water-bodies, empty lands and access roads (Priestly, 1968).

Solid waste management refers to source separation, storage, collection, transportation and final disposal in an environmentally sustainable manner. In the light of this, solid waste management is an important environmental health service and an integral part of basic urban services. This is because, the health implications of poor waste management can be very damaging to the people exposed to these insanitary conditions. Diseases such as cholera, typhoid, dysentery and malaria are all related to the practice of poor waste management. This can result in the loss of human resources needed for the development of a country.

Rapid increase in the volume and types of solid and hazardous wastes as a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments. It was estimated that in 2006 the total amount of Municipal Solid Waste (MSW) generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (Anomanyo, 2004). It was further estimated that between 2007 and 2011, global generation of municipal waste would rise by 37.3%, equivalent to roughly 8% increase per year (Anomanyo, 2004). The socioeconomic conditions prevalent in third world cities differ markedly from those in industrialized countries. Third world cities are experiencing rapid urbanization brought about by fast population growth, as well as high immigration rates.

Waste is a growing problem at global, regional and local levels. The continuous economic development and increasing living standards coupled with increasing demand for goods and services has resulted in increase in per capital waste generation. In most developing countries, the problem is compounded by rapid urbanization, introduction of environmentally unfriendly materials, changing consumption pattern, lack of political will, insufficient budgetary allocation and lack of dedicated workforce in the waste management sector (Anomanyo, 2004).

The physical characteristics of third world cities, their rapid expansion, and the lack of resources to provide them with the necessary infrastructure and urban services translate into an insufficient collection and disposal of the wastes generated. Most third world cities do not collect the totality of wastes they generate. Despite spending 30 to 50% of their operational budgets on waste management, third world cities only collect between 50 and 80% of the refuse generated (Kreith, 1994).

Low-income neighborhoods, slums, and squatter settlements constitute the areas where municipal collection of wastes often does not exist. Residents of areas without refuse collection

may resort to dumping their garbage in water bodies or simply burn it in their backyards. The improper disposal of solid waste constitutes a source of land, air and water pollution, and poses risks to human health.

Waste management has not been regarded as a national priority in Ghana despite being rated as one of the few countries in Africa which are at the fore front in waste management. The low emphasis on waste management has resulted in waste impacting negatively on the environment and on human health. The quest for a cleaner environment has introduced the modern systematic management approach of storage, collection, transportation and disposal of solid waste (Mensah and Larbi, 2005). Countries all over the world have laws that provide for the removal of solid waste by local authorities on specific days, accumulated waste from premises. The waste is normally placed into removal receptacles, polythene bags, baskets and plastic solid waste bins for easier removal.

1.2 PROBLEM STATEMENT

The physical characteristics of third world cities, their rapid expansion, and the lack of resources to provide them with the necessary infrastructure and urban services translate into an insufficient collection of the wastes generated, as well as their improper disposal on the streets and in municipal open dumps.

Although considerable efforts are being made by many Governments in tackling waste-related problems, there are still major gaps to be filled in this area. The World Bank estimates that in developing countries, it is common for municipalities to spend 20-50% of their available budget on solid waste management, even though 30-60 % of all the urban solid wastes remain

uncollected and less than 50 % of the population is served (Centre for Environment and Development, 2003). In middle income countries, collection costs 50-80 % of total budget. By 2030, Africa is expected to have an urban population of over 50 % growth rate (Kreith, 1994). The fear has been heightened by the changing dynamics of waste composition due partly to globalization and the peoples' changing consumption pattern. The increasing presence of non-biodegradable and hazardous waste types mean that safe collection, transportation and disposal of municipal solid wastes are critical for public health sustainability.

Solid waste management in cities and towns is one such responsibility of the municipalities. The municipalities are responsible for preparing comprehensive plans and implementation of such plans to provide a clean and healthy environment to the citizens. However, municipalities, in the current scenario, have been facing many challenges of planning, developing and managing the solid waste due to lack of technical know-how, human resource and scarce resources from state agencies. These challenges are compounded for numerous small and medium towns in Ghana including Adentan Municipality.

As a result of the inability of Municipal, Metropolitan and District Assemblies to properly handle solid waste management in Ghana due to various challenges, the Government of Ghana in 1998 introduced Public Private Partnership (PPP) which entrusted solid waste management in the hands of private companies.

It is estimated that the municipality averagely generates 55.3 metric tonnes of solid waste per day out of which only 61 % is collected and disposed by all the waste management companies operating in the municipality leaving 39 % uncollected a day (AdMA, 2013).

This has resulted in littering; heaping of waste and overflowing of skips with waste in the Adentan Municipality. The recent proliferation of polythene bags for packaging has seriously

aggravated the situation in the study area. This has made Adentan Municipality filthy and unattractive for habitation. This study seeks to determine contribution of the informal solid waste collectors to the collection and disposal of solid waste in Adentan Municipality and make recommendations for integration of the informal sector into mainstream solid waste management.

1.3 AIMS AND OBJECTIVE

The main objective of the research was to study how Informal Solid Waste Collectors can be integrated into the mainstream solid waste management in the Adentan Municipality.

The specific objectives were to:

1. assess the contribution and impact of Informal Solid Waste Collectors in solid waste management in Adentan Municipality
2. determine the major challenges facing Informal Solid Waste Collectors in the Municipality
3. assess the capacity of formal solid waste management companies in managing solid waste in Adentan Municipality
4. evaluate the operations of Formal Solid Waste Management Companies in Adentan Municipality

CHAPTER TWO

LITERATURE REVIEW

2.1 Waste

Waste is more easily recognized than defined. Something can become waste when it is no longer useful to the owner or when something is used and fails to fulfill its purpose. There are basically two types of wastes namely liquid and solid waste.

2.2 Solid Waste

Solid waste is any material that arises from human and animal activities that are normally discarded as useless or unwanted. Solid waste includes non-hazardous industrial, commercial and domestic waste such as household organic trash, street sweeping, institutional garbage and construction waste. (Zerbock, 2003)

2.3 Sources and Types of Solid Waste

Tchobanoglous *et al.* (1993) classified types of solid waste in relation to the sources and generation facilities, activities or locations associated with each type. This is presented in the Table1 below:

Table 1: Typical Waste Generation Facilities, Activities, and Location associated with various Sources of Solid Waste

SOURCE	TYPICAL LOCATION	TYPE OF SOLID WASTE
Residential	High rise apartments, single-family and multi-family dwellings, low-medium apartments	Food waste, rubbish, special waste, ashes
Industrial	Demolition, chemical plant, fabrication, construction, refinery, mining, light and heavy manufacturing	Special waste, rubbish, food waste, demolition and construction waste
Open areas	Street, playground, recreational areas, beach, vacant plot	Rubbish, special waste
Commercial/ Municipal	Restaurants, hotels, motels, repair shop, stores, office buildings, markets, auto repair shop	Ashes, special waste, demolition and construction, rubbish, food waste
Agricultural	Farms, feedlots, field and row crops, vineyard, orchards	Agricultural waste, spoiled food wastes, rubbish, hazardous waste
Treatment plant site	Waste water, industrial treatment processes	Treatment plant waste

Source: Tchobanoglous *et al.* (1993)

Furthermore, Tchobanoglous *et al.* (1993) explained the types of solid waste which include food waste, rubbish, ashes, residue and special waste as described below:

Food waste: Food wastes are animal, plant or vegetable residues resulting from handling, preparation, cooking and eating of foods. The most important characteristics of these wastes are their high putricibility and rapid decomposition features especially in warm weather (Tchobanoglous *et al.*, 1993).

Rubbish: Rubbish consists of combustible and non- combustible solid waste of households, institutions and commercial activities. This excludes food wastes or other decomposing materials. Typically, combustible rubbish consists of materials such as paper, cardboard, plastics, textiles, rubber, leather, wood, furniture, and garden trimmings. Non-combustible rubbish consists of glass, tin cans, aluminium cans, ferrous and other non-ferrous metals, and dirt (Tchobanoglous *et al.*, 1993).

Ashes and Residues: These are materials from the burning of wood, coal, coke and other combustible wastes for purposes of heating, cooking and disposing of combustible wastes. These are referred to as ashes and residues (Tchobanoglous *et al.*, 1993).

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

The Centre for Environment and Development (2003) has also classified types of solid waste based on origin (food waste, rubbish, ashes and residues, demolition and construction, agriculture waste), characteristics (biodegradable and non-biodegradable) and risk potential (hazardous waste). The Centre also enumerated sources of solid waste as residential, from shops, commercial establishments, hotels/restaurants/eating stalls and slaughter houses. This has

confirmed the sources and types of solid waste outlined by Tchobanoglous *et al.* (1993) and Centre for Environment and Development (2003).

2.4 Solid Waste Management

Various authors have different definition for Solid Waste Management. Kumah (2007) defines solid waste management as “the administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of waste”. However, Tchobanoglous *et al.* (1993) provided a more comprehensive definition of solid waste management. According to them, solid waste management is: “.....that discipline associated with the control of generation, storage, collection, transfer and transport, processing and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations and that is also responsive to public attitudes”.

Therefore, if solid waste management is to be accomplished in an efficient and orderly manner, the fundamental aspects and relationships involved must be identified and understood clearly.

The annual cost of solid waste management is projected to rise from the current \$205 billion to \$375 billion, according to World Bank Report (2012) on the state of municipal solid waste around the world. The report estimates that the amount of Municipal Solid Waste (MSW) will rise from the current 1.3 billion tonnes per year to 2.2 billion tonnes per year by 2025 with much of the increase coming from the fast and rapidly growing cities in developing countries. Giving projections, low income countries are expected to generate 213 million tonnes of solid waste a day with the population rising to 676 million by 2025. Lower middle income ones are also projected to generate 956 million tonnes of solid waste per day. Population growth in the

lower middle income countries has been predicted to reach 2.08 billion. Solid waste generation will hit 360 million tonnes per day by 2025 in upper middle income countries with expected population of 619 million (World Bank Report, 2012). Finally, waste generation in the high income nations will reach 686 million tonnes in a day by 2025. The challenges surrounding municipal solid waste are going to be enormous, on a scale of, if not greater than the challenges the world is currently experiencing with climate change according to the World Bank report (2012).

2.5 Solid Waste Management Processes

2.5.1 Waste Generation

Waste generation encompasses those activities in which materials are identified as no longer of value and are either thrown away or gathered together for disposal. According to United Nations Environmental Program (2009), in 2006 the total amount of Municipal Solid Waste (MSW) generated globally reached 2.02 billion tones, representing a 7 % annual increase since 2003

2.5.2 Storage

Transfer stations are places where solid waste is stored before it is collected and transferred to final disposal site. It could be stored in a skip or roll-on-roll-off containers or waste bins and not thrown away indiscriminately. Accordingly, storage is of primary importance because of the aesthetic consideration (Tchobanoglous *et al.*, 1977).

2.5.3 Collection

According to the United State Postal Services (USPS) (2000), in the city of Thimphu in Bhutan, the collection of solid waste from households and commercial set-ups was done in concrete receptacles placed at strategic points and conveyed by trucks/tractors. Accordingly, there were concrete bins and containers provided at various locations from where the waste was lifted for disposal.

2.5.4 Transfer and Transport

Transfer and transport involves hauling solid waste from one location to another called transfer stations or directly to final disposal sites, i.e. (1) the transfer of wastes from the smaller collection vehicle to the larger collection area and (2) the subsequent transport of the wastes, usually over long distances to the final disposal site (Kreith, 1994).

2.5.5 Processing and Recovery

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

2.5.6 Disposal

Disposal is the last fate of solid waste collected and transported directly to landfill sites. Modern technology involves the use of skip and roll-on-roll-off trucks to convey the waste to final disposal site. However, current trends using push cats, three wheel tricycles and many other low level logistics are employed to execute the exercise.

2.6 Early Practices of Solid Waste Management

According to Tchobanoglous *et al.* (1977), the most commonly recognized methods for the final disposal of solid wastes are:

- dumping on land, canyons and mining pits
- dumping in water
- ploughing into the soil
- feeding to hogs
- reduction and incineration

Burning of dumps is common in peri-urban and rural communities in Ghana and in many less developed countries. A study carried out by a team from Zoomlion Ghana Limited to undertake feasibility studies on implementation of various models of solid waste management in Niger showed that, the methods of solid waste disposal include dumping of waste in gutters, drains, by the roadside, unauthorized dumping sites and stream channels during raining season and burning of wastes on unapproved dumping sites during the dry season (Zoomlion, 2011). This confirmed that the practices of solid waste disposal in the 1950s still exist today.

2.7 Contemporary Methods of Managing Solid Waste

In the contemporary era, the methods of managing solid waste include source reduction, sanitary landfills, composting, recycling, and incineration).

2.7.1 Source Reduction

Source reduction entails any action that reduces the volume or toxicity of solid waste prior to its processing and disposal in incinerators or landfills (Denison and Ruston, 1990). This view was expressed by (Kreith, 1994) who indicated that source reduction focuses on reducing the volume and /or toxicity of waste generated. Source reduction includes the switch to reusable products and packaging, the most familiar example being returnable bottles.

Source separation and resource recovery is an important method in waste management. Wastes that are discharged may be of significant value in another setting, but of little or no value to the person who wants to dispose of it. According to Tsiboe and Marbel (2004), Austria, the Netherlands, and Denmark developed a waste management process to efficiently resolve the waste disposal problem by essentially educating the citizens to separate domestic solid waste into glass, paper and plastic thereby enabling easy collection and consequently reuse.

2.7.2 Sanitary Landfill

Sanitary land filling includes confining the waste, compacting and finally capping (covering with soil). It not only prevents burning of garbage but also helps in reclamation of land for valuable use (Centre for Environment and Development, 2003). The placement of solid waste in landfills is the oldest and definitely the most prevalent form of waste disposal (Zerbock, 2003). He further

argued that “landfills” are nothing more than open, sometimes controlled dumps. According to him the difference between landfills and dumps is the level of engineering, planning, and administration involved. Open dumps are characterized by the lack of engineering measures, no leachate management, no consideration of landfill gas management, and few, if any, operational measures such as registration of users, control of the number of “tipping fronts” or compaction of waste (Zerbock, 2003).

Furthermore, landfills are one form of waste management that nobody wants but everybody needs. There are simply no combinations of waste management techniques that do not require landfilling to make them work (Kreith, 1994). Of the basic management options of solid waste, landfills are the only management technique that is both necessary and sufficient. Some wastes are simply not recyclable, many recyclable wastes eventually reach a point where their intrinsic value is completely dissipated and can no longer be recovered and recycled.

2.7.3 Recycling

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

natural resource conservation, energy conservation, pollution prevention, and economic expansion and competitiveness. More importantly, a sizeable portion of what is thrown away contains valuable resources like metals, glass, paper, wood and plastic that can be reprocessed and used again as raw materials (USEPA, 1999).

Kreith (1994) also added that, recycling is the most positively perceived and doable of all the waste management options. Recycling returns raw materials to the market by separating reusable products from the rest of the municipal waste. The benefits of recycling are many. It saves precious finite resources, lessens the need for mining of virgin materials which lowers the environmental impact for mining and processing. For example, UK recycles only 11% of its household waste, Italy and Spain only 3 %, Netherlands 43 %, Denmark 29 %, and Austria 50 % respectively according to Institute of Waste Management (Tsiboe and Marbel, 2004).

2.7.4 Incineration

Incineration is controlled combustion process for burning combustible waste to gases, reducing it to a residue of non-combustible ingredients (Centre for Environment and Development, 2003). During incineration, moisture in the solid waste gets vapourized and the combustible portion gets oxidized and vaporized. Carbon dioxide, water vapour, ash and non-combustible residue are the end products of incineration. Incinerators have the capacity to reduce the volume of waste up to nine fold than any other methods (Kreith, 1994). According to him incineration can also recover useful energy either in the form of steam or electricity. The main constraints of incineration are high cost of operation, relatively high degree of sophistication needed to operate them safely and economically as well as the tendency to pollute the environment through emissions of carbon dioxide (Kreith, 1994).

2.7.5 Composting

Composting is the process of turning organic household waste into fertilizer through aerobic fermentation. This fertilizer can be used in lawns, parks, and gardens.

Composting process uses microorganisms to degrade the organic content of the waste. Aerobic composting proceeds at a higher rate and converts the heterogeneous organic waste materials into homogeneous and stable humus (Centre for Environment and Development, 2003). United Nations Environment Programme (UNEP) (2009) has also defined composting as a biological decomposition of biodegradable solid waste under controlled predominantly aerobic conditions to a state that is sufficiently stable for nuisance-free storage and handling and is satisfactorily matured for safe use in agriculture. According to Zerbock (2003), a low-technology approach to waste reduction is composting. He further stated that in developing countries, the average city's municipal waste stream is over 50 per cent organic material.

2.8 Integrated Solid Waste Management

Although considerable efforts are being made by many Governments in tackling waste-related problems, there are still major gaps to be filled in this area (UNEP, 2009). According to UNEP (2009), the World Bank estimates that in developing countries, it is common for municipalities to spend 20 to 50 % of their available budget on solid waste management (UNEP, 2009). If most of the waste could be diverted for material and resource recovery, then a substantial reduction in final volumes of waste could be achieved and the recovered material and resources could be utilized to generate revenue to fund waste management. Integrated Solid Waste Management (ISWM) system has been pilot-tested in few locations (Wuxi, PR China; Pune, India; Maseru, Lesotho) and has been well received by local authorities. It has been shown that with appropriate

segregation and recycling system, significant quantities of waste can be diverted from landfills and converted into resource (UNEP, 2009). Similarly, the United States Environmental Protection Agency (1999) has said that if a state or local government wants to plan for and implement ISWM, they have to consider hierarchy of methods which are, reduce, recycle, and incinerate/landfill.

2.9 Problems of Managing Solid Waste

According to Ogawa (2005), a typical solid waste management system in a developing country displays an array of problems, including low collection coverage and irregular collection services. The many challenges confronting solid waste management in developing countries including Ghana are considered as the bed rock for their inability to rid the streets, gutters and drains of solid waste. The lack of political will of various governments to implement proper solid waste technology in developing countries can also not be over-looked.

2.9.1 Technical Constraints

In most developing countries, there are inadequate human resources at both the national and local levels with technical expertise necessary for solid waste management planning and operation. Many officers in charge of solid waste management, particularly at the local level, have little or no technical background or training in engineering or management (Ogawa, 2005).

2.9.2 Financial Constraints

Ogawa (2005) intimated that, solid waste management is given a very low priority in developing countries. As a result, very limited funds are provided to the solid waste management sector by governments, and the levels of services required for protection of public health and the

environment are not attained. The problem is acute at the local government level where the local taxation system is inadequately developed and, therefore, the financial basis for public services, including solid waste management, is weak. The problem is more prevalent at the District and Municipal Assembly levels where the revenue generation system is inadequately developed which makes the financial basis for public services including solid waste management weak. This weak financial basis of the local governments can be supplemented by the collection of user service charges including pay as you dump system. However, users' ability to pay for the services is very limited due to high poverty level and their willingness to pay for the services which are irregular and ineffective.

2.9.3 Institutional Constraints

Several agencies at the national level are usually involved at least partially in solid waste management. There are often no clear roles or functions of the various national agencies defined in relation to solid waste management and also no single agency or committee designated to coordinate their projects and activities.

The lack of coordination among the relevant agencies often results in different agencies becoming the national counterpart to different external support agencies for different solid waste management collaborative projects without being aware of what other national agencies are doing. This leads to duplication of efforts, wasting of resources and unsustainability of overall solid waste management programmes. The lack of effective legislation for solid waste management, which is a norm in most developing countries, is partially responsible for the

roles/functions of the relevant national agencies not being clearly defined and the lack of coordination among them” (Ogawa, 2005).

Zurbrugg (2009) further added that, solid waste collection schemes of cities in the developing world generally serve only a limited part of the urban population. The people remaining without waste collection services are usually the low-income population living in peri-urban areas. According to him, one of the main reasons is the lack of financial resources to cope with the increasing amount of generated waste produced by the rapid growing cities. Often inadequate fees charged and insufficient funds from a central municipal budget cannot finance adequate levels of service. He indicated that, apart from financial constraints that affect the availability or sustainability of a waste collection service; operational inefficiencies of solid waste services such as deficient management capacity of the institutions and inappropriate technologies affect effective waste management. Zurbrugg (2009) therefore points out the key challenges of waste management which include financial and institutional constraints.

2.10 Solid Waste Management in Ghana

Over the years, solid waste disposal in Ghana has become a major challenge to Municipal, Metropolitan and District Assemblies. As a result of urbanization and increasing densities, Metropolitan Assemblies find it difficult to deal with the large quantities of solid waste generated. This is due to the fact that people resort to indiscriminate dumping as the only means to managing their domestic solid waste thus resulting in littering and heaping of waste. The rural-urban drift has resulted in increased population density in the cities and the result is high generation of solid waste.

2.11 Solid Waste Generation

According to Mensah and Larbi (2005) based on an estimated population of 22 million and an average daily waste generation per capita of 0.45 kg, Ghana generates annually about 3.0 million tonnes of solid waste. Boateng and Nkrumah (2006) further added that, solid waste generated daily in Accra was between 1500-1800 tonnes. According to Anomanyo (2004), about 1800 tonnes of municipal solid wastes and estimated 0.5 kg per capital were generated per day in Accra. Anomanyo (2004) attributed this to the rate of population growth in the Metropolis at 3.5% per annum. Waste from domestic sources include, food waste, garden waste, sweepings, ash, packaging materials, textiles and electric and electronic waste with organic waste being the major component. These constituted about 65 % of total waste generated in Accra. According to Anomanyo (2004), the high proportion of food and plant waste was due to the fact that Ghana's economy largely depended on agricultural products for export and domestic consumption. AMA (2009) estimates waste generation to be about 2000 metric tonnes a day with per capita waste generation of 0.45 kg. According to KMA (2009), the current domestic waste generation in Kumasi was approximately between 1000 and 1500 tonnes a day. This was based on the projected population of 1,610,867.

2.12 Solid Waste Collection

There are basically three methods of household waste collection in Accra (Stephens *et al.*, 1994).

- Waste Management Department (WMD) “curbside” collection of waste through placement of waste collection trucks directly outside houses. This collection method was provided weekly in

the high-income residential areas like Roman Ridge, Airport and Cantonment by compactor trucks.

- WMD collection of waste through placement of communal containers at strategic locations in communities for households and businesses to dump. These were restricted to low-income areas like Nima and amounted to some 200 communal containers. Households that could not afford the house to house collection service took their waste to any of these 200 communal containers and from which the WMD collected the waste and disposed of it at the landfill site.
- Door-to-door collection services in middle-income areas like Labadi.

Solid waste collection in Accra and Kumasi has been carried out both on franchise and contract basis. On the franchise basis, a house-to-house collection has been done in high-income and middle-income areas and the contractors charge the households some fees with weekly or twice a week collection frequency. These areas are well-planned residential areas with access roads described as first and second class areas and include areas as Airport residential area and Cantonments. Each household has plastic containers with covers. These contractors then pay a tipping fee to the Accra Metropolitan Assembly (AMA) for the use of its dump site. On contract bases, waste contractors are paid by AMA to perform communal container collection. Approximately 75 % of the wastes generated are collected in these areas. Central communal skip collection occur in low income high population density and deprived residential areas such as James Town, Nima and other parts of Accra where houses are not well planned with poor or even no access roads (third class areas). Market places are also covered under this arrangement. Residents deposit their waste in such communal containers and the frequency of collection is at least once daily. Waste generators here do not pay user charges.

2.13 Solid Waste Disposal

According to Anomanyo (2004), waste disposal from households in AMA took different forms (Figure 1).

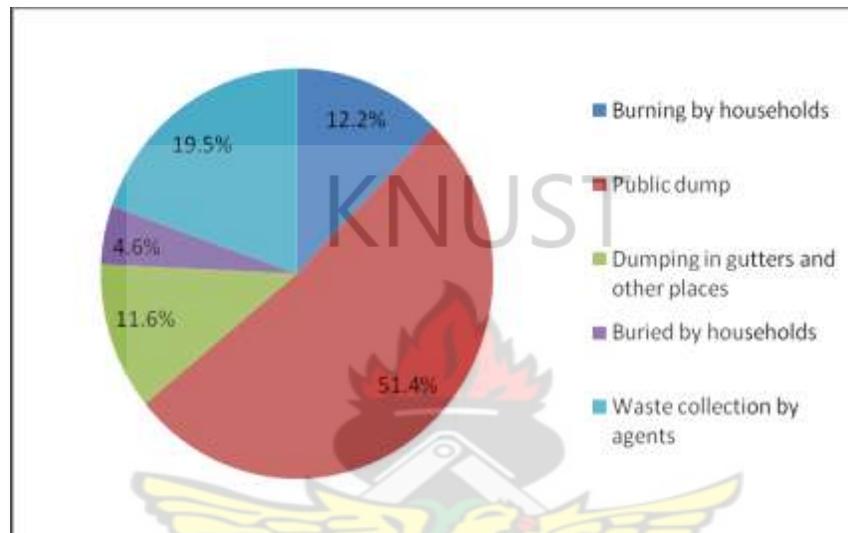


Figure 1: Solid Waste Disposal from Households in AMA

Source: Waste Disposal of Households in AMA, 2004.

It can thus be ascertained that out of the about 1800 tonnes of waste generated, only 19.5% was collected. Anomanyo (2004), further added that between 1991 and late 2001, the AMA's Municipal solid waste in the Accra Metropolis was deposited at Mallam, a suburb of Accra. Dumping at the Mallam site however was stopped in late 2001 as the dump capacity had been exceeded as well as objections from nearby residents. Waste dumping was henceforth shifted to Djanman which unfortunately could not last as it was filled to capacity in just three months. These abandoned sites were mountains of dumps. Since they were not landfill sites and there were no controls to their spread and emissions, the dump sites became of great concern as a

result of their threat to human health, leachate and landfill gas formation. The site had no engineered containment of leachate. AMA was only able to compact the waste to guarantee some level of proper dumping hence “this site was considered a controlled dump rather than a properly engineered landfill” (Anomanyo, 2004). He further added that since the formal systems of solid waste disposal could not cope with the ever-increasing volume of solid waste being generated in Accra, the public itself employs various means of waste disposal. Waste was thus disposed off indiscriminately especially in watercourses and drainage channels and also through burning.

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2.14 Problems of Solid Waste Management

In Ghana, Boadi and Kuitunen (2004) pointed out some of the problems affecting solid waste management. These include: weak institutional capacity and lack of resources, both human and capital. They also indicated that home collection of waste is limited to high and some middle income areas while the poor are left to contend with the problem on their own. This leads to indiscriminate disposal of waste in surface drains, canals and streams, creating insanitary and unsightly conditions in many parts of the city. Furthermore, Management Ministry of Local Government and Rural Development (MLGRD) (2004) summarized the challenges of solid waste management in Ghana as follows: poor planning for waste management programmes; inadequate equipment and operational funds to support waste management activities; inadequate sites and facilities for waste management operations; inadequate skills and capacity of waste management staff; and negative attitudes of the general public towards the environment in general.

2.15 Key Issues

The critical issues in solid waste management are collection and disposal. The main methods in disposing solid waste are: engineered sanitary landfills, composting, recycling, incineration and Integrated Solid Waste Management (ISWM). However, in Ghana landfills which are not engineered are mainly used for final waste disposal. There are two main modes of solid waste collection system in Ghana namely: door-to-door collection and communal container placement systems. The practice of unscrupulously disposing solid waste into gutters, drains and roadside among others is still in existence. Therefore, solid waste management should be the primary responsibility of all.

The use of informal solid waste collectors to augment the operations of formal solid waste management companies in many Latin American and Asian Cities has been in practice for a long period of time. The Informal Solid Waste Collectors use push carts, wheel burrows, woven baskets, “borla taxis”, and tricycles to enter into areas where large waste management trucks are unable to enter and collect waste for disposal. Waste collected in smaller quantities for disposal makes segregation and separation of recyclable material easier. This therefore makes scavenging for recyclable material simpler for industrial consumption. However, the industry has suffered set-backs ranging from repression, neglect, stimulation, discrimination and stigmatization

The review has also critically analyzed the high and effective economic and environmental impact in the living standard of people who engage in the activity and the sustainability of the environment respectively.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

The study focused on collection of data from household Residents, Informal Waste Collectors and Head of Adentan Municipal Waste Management through interviews and questionnaire administration.

3.2 Study Area

The study was conducted in the Adentan Municipality with Adenta as its capital. Adenta Municipal covers an area of 98.3 km² with a population density of 795.7/km² and population of 78,215 (2010 census). It shares boundaries with Ga East, Ledzokuku, Ashaiman and Tema Metropolitan Areas (Figure 2). Adentan Municipal has 45 communities and four electoral areas (AdMA, 2008). There are 20,478 households in Adentan Municipal. The Municipality has been divided into 6 zones. There are 6 main formal waste management contractors assigned to collect waste in the Adentan Municipality namely:

- Amanee Waste Management Company
- Honest Waste Management Company
- Jekora Ventures Company
- Jemoki
- Zoomlion Ghana Limited
- ESDOF

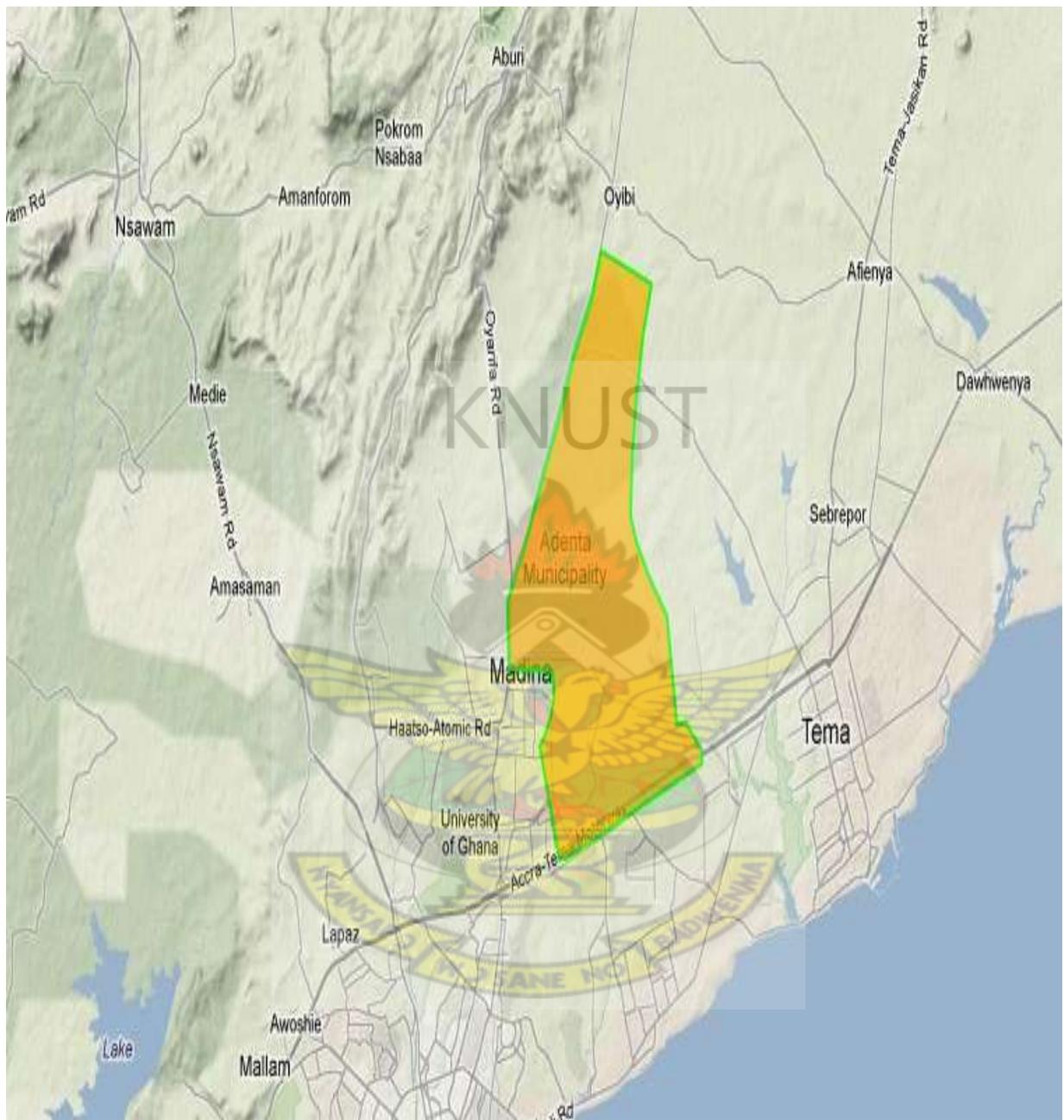


Figure 2: Map showing Adentan Municipality

3.3 Sampling and Data collection Methods/Procedures

A sample size of 56 made up of 40 households, 15 informal solid waste collectors and the Municipal Assembly Waste Management Officer were used for the study.

3.4 Respondents from households

The 40 households which were selected to provide responses to questionnaires and interviews were carefully done to cover all the zones in the Municipality in order to ensure fair representation of the Municipality.

Respondents from households were selected based on their literacy levels and knowledge of waste management issues. The sampling of 40 households for the distribution of questionnaire and interview administration was based on solid waste generation, operations of Formal Solid Waste Contractor and Informal Solid Waste Collectors in the 6 zones. 12 respondents were selected from Zone 1 which generated the highest volume of solid waste (18.10 tonnes) with (11) communities. However, 7 respondents were selected from zone 2 which generated (9.85 tonnes) of solid waste although the zone has the highest number of communities (12)

3.5 Informal Solid Waste Collectors

Face-to-face interviews and questionnaire administration were conducted to obtain information from informal solid waste collectors. The 15 Informal Solid Waste Collectors were selected across the 6 zones. This is because the Informal Collectors operate in all the zones without restriction to a particular zone (Plate 1).



Plate 1: Informal Solid Waste Collectors with their push carts in Zone 3

3.6 Adentan Municipal Assembly.

The Head of Waste Management Department in Adentan Municipality was contacted to provide information on behalf of the Municipal Assembly through questionnaire and an interview. The following questions were posed to the Head of the Municipal Solid Waste Management Department:

1. How many zones do you have in Adentan Municipality
2. What are the names of communities that form each zone?
3. How many formal waste contractors are assigned to collect waste?
4. What is the number of solid waste containers in Adentan Municipality?

5. What is the number of solid waste containers used for Polluter Pays System in Adentan Municipality
6. What is the average quantity of waste generated in a day in the municipality?
7. What is the average quantity of waste generated in each zone?
8. What is the amount of waste collected for disposal in each zone by contractors per day? Are all waste generated collected by waste management contractors?
9. If yes, what percentage of total waste is collected by the formal waste management contractors?
10. If No, what accounts for the difference?
11. How is the rest of the waste catered for?
12. Would you say waste collection by formal companies in your municipality is effective and efficient? Yes No
13. If No, what is the cause of this inefficiency?
14. Does the Municipal Assembly allow informal waste collection (truck pushers and motor-tricycles) to operate in the area? Yes No
15. Are there any measures in place to regulate their activities? Yes No
16. Of what significance are their activities towards waste collection? Yes No
17. Are there any challenges that they face?
18. If yes what are the challenges?
19. Do you think the Municipal Assembly is willing to allow for integration of the informal solid waste collectors into general solid waste collection/management system?

3.7 Field Survey

Data to establish the average tonnes of waste collected by the Informal Collectors for disposal was obtained through daily visit to Abokobi final disposal site for 7 days from Monday to Sunday. The number of trips to the site to dispose of waste was recorded each day within the 7 days. The exercise was carried out from morning, 6: 00 am to 6:00 pm daily

3.8 Data Sources

Quantitative and Qualitative methods were applied during the study. These included questionnaires and interviews.

3.8.1 Quantitative Methods

Through the conduction of surveys using the medium of questionnaire administration, secondary data were collected from the households and workers of the Informal Solid Waste Collection.

3.8.2 Qualitative methods

Structured questionnaire was used as one of the data collection methods to obtain primary data from the head of waste management at the Municipal Assembly through an interview regarding the operations of Informal Solid Waste Collection and solid waste management in Adentan Municipality. The questionnaire was structured for both open-ended and close-ended questions where the Municipal Official provided answers and responses respectively.

3.9 Data Analysis

Statistical data obtained after interview and questionnaire administrations were processed and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS 16.0.2, 2008) into statistical tables, figures, charts and percentages for interpretation, discussion and establish the level of significance between the following:

- The volume of solid waste generated and the volume of waste collected for disposal in the 6 zones per day
- The volume of solid waste generated and the volume of solid waste collected for disposal in the Adentan Municipality per week
- The volume of waste generated and the volume of waste uncollected for disposal in the Municipality per day
- The operations of Formal Solid Waste Contractors and Informal Solid Waste Collectors in Adentan Municipality
- Volumes of solid waste generated and collected for disposal by Formal Solid Waste Contractors and Informal Solid Waste Collectors in Adentan Municipality per day

CHAPTER FOUR

RESULTS

4.0 Field Survey

Numbers of trips for disposal and average tonnes of solid waste per day were calculated.

Table 2: Average waste collected for disposal by Informal Solid Waste Collectors daily

DAYS	NO. OF TRIPS / "B" TAXI / DAY	TONNES / DAY
1	5	7
2	4	5.6
3	4	5.4
4	4	5.4
5	3	5.6
6	4	5.4
7	3	4.2
AVERAGE TONNES / DAY		5.5

"B" Taxi= "Borla" Taxi

$$\text{Density}(D) = \text{Mass}(M) / \text{Volume}(V) \quad (\text{I})$$

$$\text{Density} = 500\text{kg/m}^3 \quad (\text{II})$$

$$\text{Volume} = 2.8\text{m}^3 \quad (\text{III})$$

$$\text{Mass} = \text{Density} * \text{Volume} \quad (\text{IV})$$

$$500\text{kg/m}^3 * 2.8\text{m}^3 \quad (\text{V})$$

$$1400\text{kg/m}^3 / 1000 \quad (\text{VI})$$

$$\text{Mass} = 1.4 \text{ tonnes} \quad (\text{VII})$$

4.1 Zone of Residence

Household respondents were selected from the 6 zones in the Municipality during the interview and questionnaire administration. The distribution patterns were mainly informed by volumes of solid waste generated in each zone per day (Table 2).

SAMPLING RESPONDENTS FROM HOUSEHOLDS IN 6 ZONES

Table 2: Distribution of Household respondents in the Zones

S/N	ZONES	NUMBER OF HOUSEHOLD RESPONDENTS	WASTE GENERATION/DAY/mt
1	1	12	18.10
2	2	7	9.85
3	3	6	8.60
4	4	6	8.49
5	5	6	8.01
6	6	3	2.33
	TOTAL	40	55.38

4.2 Disposal of Solid Waste by Households in the Adentan Municipality

Sixty Five percent (65%) of the respondents have signed up for the services of Waste Management Contractors whilst 35% dispose of waste through informal collectors and on the street. 7 respondents representing 17.5% of the households that are not serviced by Waste

Contractors receive services from Informal Collectors, 4 respondents (10.01%) dump waste on the street and gutters whilst 3 representing 7.49% dispose of waste into communal containers (Figure 3).

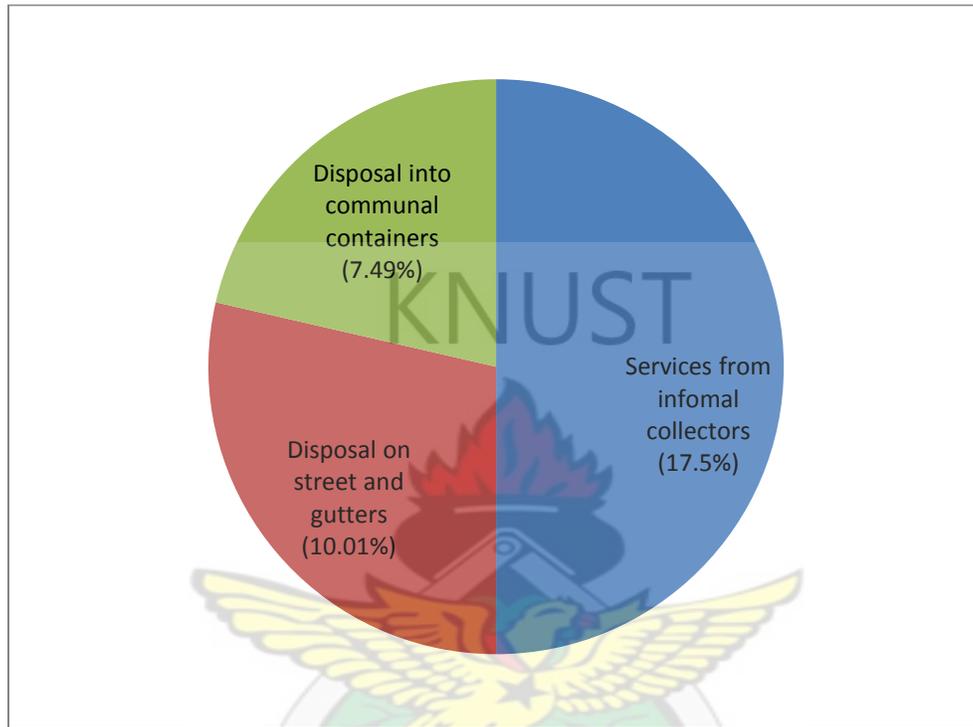


Figure 3: Percentage of Solid Waste Disposal by Households, 2013

4.3 Knowledge about Waste Management Companies in Adenta Municipality

Out of the 40 sampled household respondents, 70% knew the names of waste management contractors responsible for solid waste collection and disposal in the Municipality whilst 30% had no knowledge about Waste Contractors approved/licensed by the Assembly.

4.4 Households Subscription for Waste Collection by Formal Contractors

Sixty Five percent (65%) of household respondents have subscribed to the services of Formal Solid Waste Companies whilst 35% have not signed up for waste collection by the companies that operate in the respective zones. Thus, this percentage of household either employs the services of Informal Waste Collectors or dumps their waste at unapproved sites.

4.5 Frequency on Waste Collection by Waste Management Contractors

According to Head of Municipal Solid Waste, Waste Management Contractors are supposed to provide Door to Door waste collection services to all the homes in their respective zones twice in a week or once a week depending on the size of household and waste generated. However, 17.5% household respondents indicated that waste collection was done once a week, 15% received twice a week service whilst 67.5% indicated that waste collection from homes was done at any time the waste collectors deemed fit. Uncollected wastes generated due to irregular service by contractors are kept on the ground around the waste bin for collection.

4.6 Informal Solid Waste Collectors Activities in the Zones

Response from the 40 households sampled in the 6 zones indicated that 94% of the respondents saw Informal Collectors with push carts moving to homes, markets, businesses and shops to collect solid waste for disposal whilst 6% respondents have not sighted any Informal Collectors in the 6 zones.

4.7 Operations of Informal Waste Collectors in Adentan Municipality

On the operations of Informal Collectors, 25% prefer the services of Informal Collectors because of inexpensive services whilst 45% preferred their services because they are always available to provide services. On the other hand, 20% and 10% indicated their non-preference for Informal Collectors operations due to lack of expertise and the use of inappropriate equipment for solid waste collection compared to Formal Collectors respectively (Fig. 4).

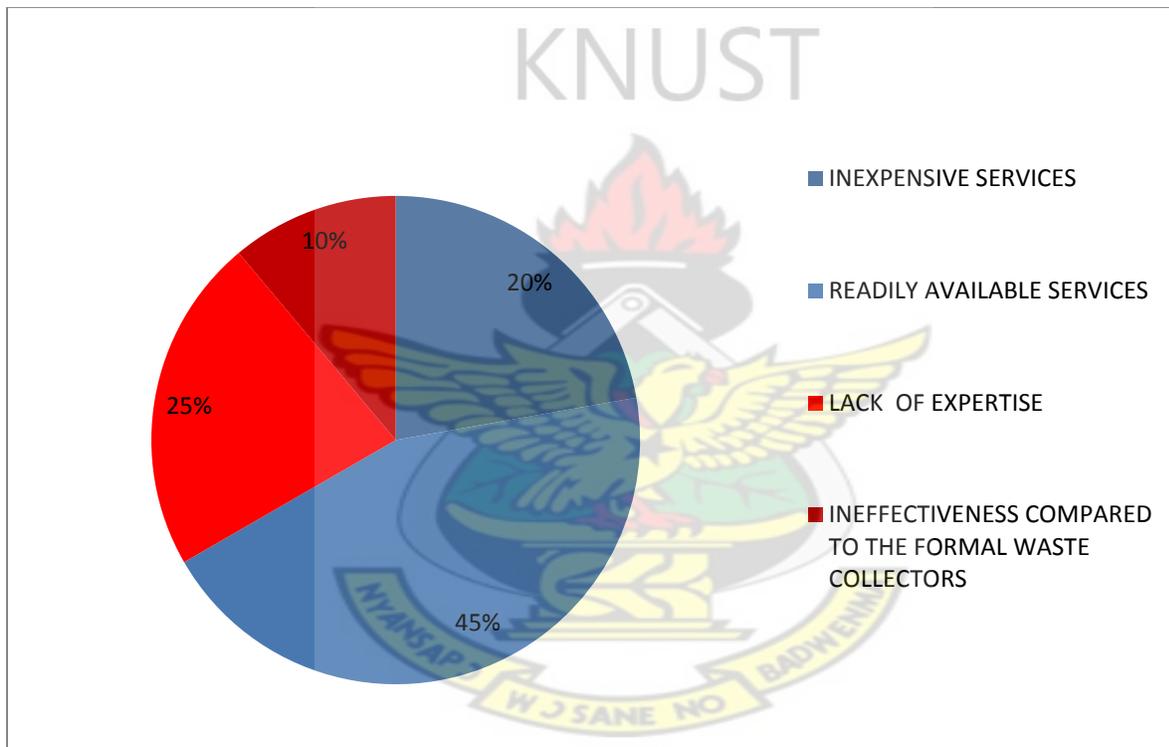


Fig. 4: Operations of Informal Solid Waste Collectors, 2013

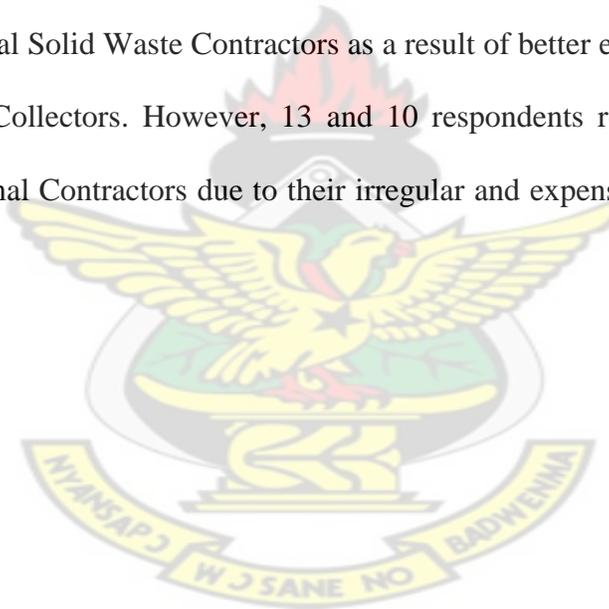
4.8 Effectiveness of Services by Formal Companies in Adentan Municipality

The services provided by Formal Solid Waste Companies in the Municipality do not meet the expectations of 67% of the sampled household respondents in terms of effectiveness and

efficiency whilst 33% believed that Formal Companies are providing effective and efficient services to households and clients in general.

4.9 Activities of Formal Solid Waste Contractors

The 40 household respondents provided varying answers to the operations of Solid Waste Contractors in the Municipality. 7 respondents representing (17.5%) preferred the activities of Formal Contractors because they have approval/license from Municipal Assembly to operate, 5 respondents (12.5%) did not prefer their activities due to lack of adequate personnel with requisite experience and expertise in Solid Waste Management whilst 5 respondents representing (12.5%) preferred Formal Solid Waste Contractors as a result of better equipment compared with Informal Solid Waste Collectors. However, 13 and 10 respondents representing (32.5%) and (25%) did not like Formal Contractors due to their irregular and expensive services respectively (Fig. 5).



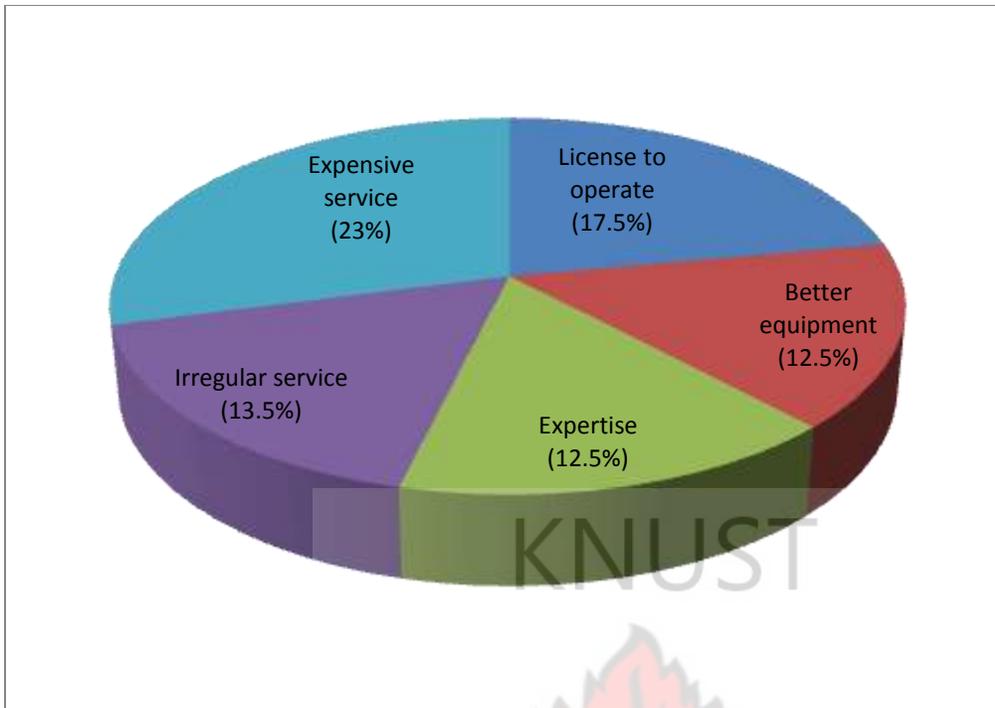


Fig. 5: Activities of Formal Solid Waste Contractors in Adentan Municipality, 2013

4.10 Legalization of Informal Solid Waste Collection in Adentan Municipality

The Assembly does not have any by-laws to regulate and support activities of the Informal Solid Waste Collectors. They therefore operate in free-range without any monitoring and supervision by the Municipal Assembly. Seventy Five (75%) of the household respondents agreed to the enactment of by-laws to regulate the activities of Informal Collectors whilst Twenty Five (25%) disagreed.

4.11 Solid Waste Management Challenges in Adentan Municipality

Residents of Adentan Municipality attributed poor Solid Waste Management in the Municipality to the following reasons:

- Lack of monitoring and supervision by the Municipal Assembly (90%).
- Irregular service provision by Formal Contractors (92.5%).
- Lack of requisite equipment (72.5%).
- Poor road network (85%).
- Lack of by-laws to regulate solid waste management (57.5%).
- Attitude of the public on Solid Waste Management (25%).

The percentages were generated through the data sampled from the household's questionnaire administration

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4.12 Measures to Improve Solid Waste Management in Adentan Municipality

- Seventy Five percent (75%) believe that regularization of the Informal Collector's operations will augment the Formal Solid Waste Companies in the collection and disposal of solid waste generated in the Municipality
- Requisite logistics and equipment should be used by the Formal Solid Waste Companies to ensure effective and efficient service according to (84%) of the respondents
- The road network in the Municipality should be improved according to (79%) of respondents to ensure accessibility to households and businesses by Formal Waste Companies trucks for prompt and quick delivery of services
- Sixty Two percent (62%) of the respondents agree on the need for education of the public on waste management practices

4.13 Number of Zones, Names of Communities and Solid Waste Management Companies in Adentan Municipality

The Solid Waste Contractors have been allocated zones to provide solid waste management services in the Municipality. The services are mainly door-door collection and disposal of solid waste from households, individuals, businesses and others for disposal. Compactor Trucks are used by Contractors for operations. However, due to lack of equipment, some Contractors use Tipper Trucks, Pick-Ups and Tractors for solid waste collection and disposal. There are 6 zones in the Municipality (Table 3).

NAMES OF FORMAL SOLID WASTE CONTRACTORS, OPERATIONAL ZONE AND COMMUNITIES THAT FORM THE ZONES, 2013

Table 3: Number of Zones, Names of Communities and Solid Waste Management Companies in Adentan Municipality

ZONE	CONTRACTOR	AREA	COMMUNITIES
1	ZOOM DOMESTIC	1	Joggis, Trassaco
		4	Frafraha, Commandos
		6	New Legon, Foster Home
		15	Otano, Salem Estates, Zoomlion HQ
		9	Maledzor, Amrahia
2	JAMOKY B	5	Mother Love, Mantey Farms, Owusu Ansah
		10	Lake Side, Old Botwe, Housing Down, New Adenta
		14	Little Rose, Nanakrom, Obodankari, New Nmai Dzor, University Farms
	M&D ENERGY	3	Manmomo, Ritz Junction, Aviation

3	SOURCE/ZOOM ALLIANCE		Area
		12	SSNIT Flat, National Lotteries
4	HONEST WASTE	7	Left Ashiyie, Left Amanfro, Ampomah Village
		8	Right Asheyie, Fulani, Right Amanfro
		16	Right Adjiringanor, Tessa
5	AMANEE WASTE	11	Dzornaman, Bendjin, Dzen Ayor, Ogbojo, Otinshie
		13	New Botwe, Sraha, 3 rd Gate, Arapajay
6	JEKORA VENTURES	2	Stat Housing, Approtech

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4.14 Solid Waste Containers in Adentan Municipality

The Municipal Assembly has engaged Zoomlion Ghana Limited in a programme called Sanitation Improvement Package (SIP). Zoomlion is required to provide communal containers at strategic locations in the Municipality. This is done to prevent dumping on the ground and unapproved dumping locations by households, individuals and businesses. Skip Trucks and Roll-On-Roll-Off trucks are used for lifting containers. 19 communal containers made up of 2 Roll-On-Roll-Off (23m³) and 17 Skip (12m³) have been placed at different locations in the Municipality (Table 4).

**LOCATION OF SKIP AND ROLL-ON-ROLL-OFF CONTAINERS IN ADENTAN
MUCIPALITY, 2013**

Table 4: Solid Waste Containers in Adentan Municipality

A/N	LOCATION	N0.	TYPE	SIZE
1	Amrahia on Akatamanso Road	1	Skip	12m ³
2	Ashiyie on Road to Koose Zonal Council	1	Skip	12m ³
3	Maledzor near Chief's Palace	1	Skip	12m ³
4	Adenta Village near Catholic School	1	Skip	12m ³
5	Adenta Housing Down	1		23m ³
6	Aviation Land Opposite Baba Yara	2	Skip	12m ³
7	Aviation Land on De-youngsters Road	1	Skip	12m ³
8	Lotto Kiosk near Vineyard Church	1	Skip	12m ³
9	3 rd Gate near Big Drain	1	Skip	12m ³
10	Botwe Old Town near Chief's Palace	1	Roll/Off	23m ³
11	School Junction near Nii Sowah Din Memorial School	1	Skip	12m ³
12	Ogbojo near Market	1	Skip	12m ³
13	Ogbojo near Cemetary	1	Skip	12m ³
14	Adjiringanor near Cemetary and Public Toilet	2	Skip	12m ³
15	Otano near Public Toilet and Behel School	1	Skip	12m ³

4.15 Polluter Pays System in Adentan Municipality

Out of 19 communal containers in the Municipality, 9 containers which represent 47.36% are used for Pay as you dump system. Individuals, households and businesses pay a fee before dumping into the containers. Informal Solid Waste Collectors pay between GH¢4.00 and GH¢8.00 before dumping waste into the containers whilst households pay between GH¢1.00 and GH¢3.00 per dump (Table 5).

COMMUNAL CONTAINERS USED FOR POLLUTER PAYS SYSTEM IN ADENTAN MUNICIPALITY, 2013

Table 5: Communal containers used for polluter pays system

A/N	LOCATION	NO.	TYPE	SIZE
1	Amrahia on Akatamanso Road	1	Skip	12m ³
2	Adenta Village near Catholic School	1	Skip	12m ³
3	Adenta Housing Down	1		23m ³
4	Aviation Land Opposite Baba Yara	2	Skip	12m ³
5	3 rd Gate near Big Drain	1	Skip	12m ³
6	School Junction near Nii Sowah Din Memorial School	1	Skip	12m ³
7	Ogbojo near Market	1	Skip	12m ³
8	Ogbojo near Cemetary	1	Skip	12m ³
9	Adjiringanor near Cemetary and Public Toilet	2	Skip	12m ³

4.16 Waste Generation, Collection and Disposal in Adentan Municipality

The average quantity of waste generated in a day in the municipality is 55.38 metric tonnes. Out of this quantity, only 34.09 metric tonnes (61.39 %) are collected by the waste management companies, 5.5 metric tonnes (9.93%) by Informal Solid Waste Collectors whilst 16.1 metric tonnes (29.07%) are left uncollected (Fig.6).

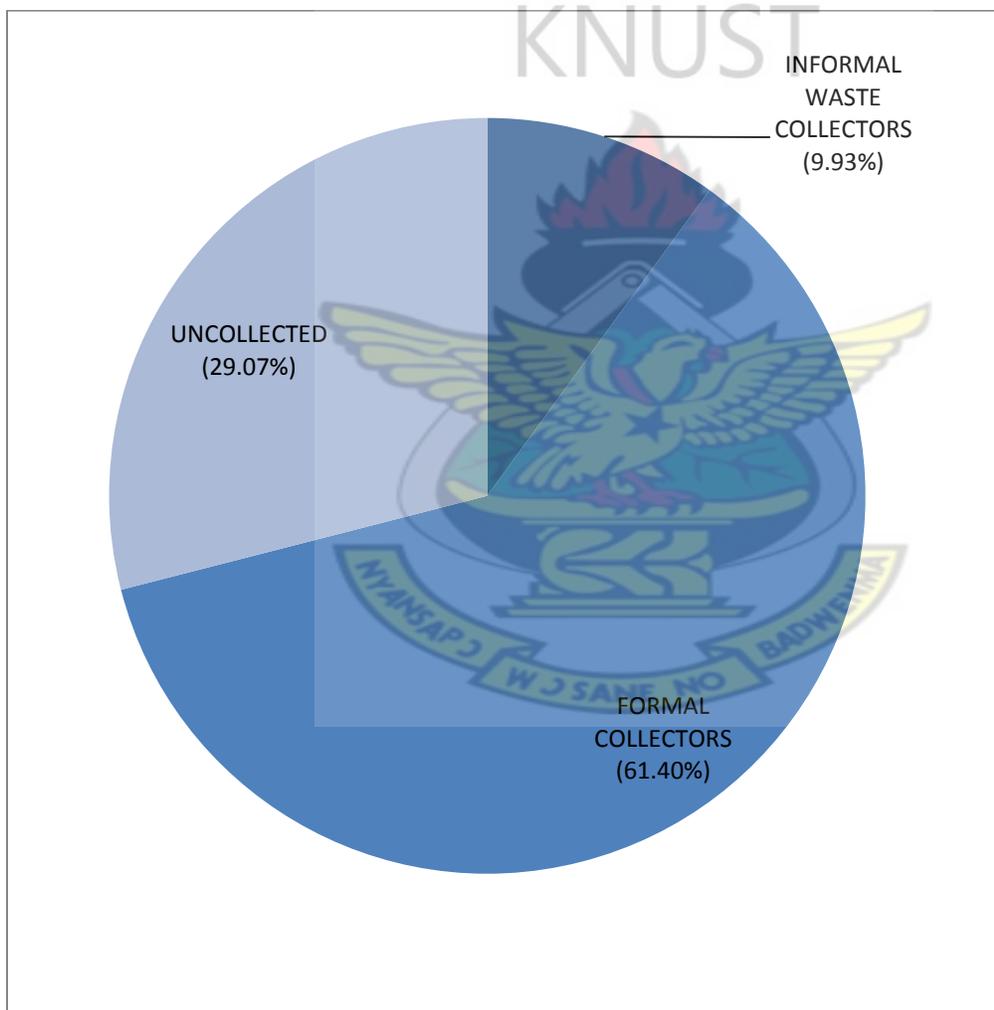


Fig 6: Percentage of waste collection in Adentan Municipality, 20

SOLID WASTE GENERATION IN ADENTAN MUNICIPALITY PER DAY, 2013

Adentan Municipality generates a total of 55.38 metric tonnes of solid waste in a day (AdMA, 2013) (Table 6).

Table 6: Solid waste generation in Adentan Municipality per day

S/N	Contractor	Zone	Communities	Waste Generated/ Day/ metric tonne
1	ZOOM DOMESTIC	1	Joggis, Trassaco	2.27
		4	Frafraha, Commandos	4.35
		6	New Legon, Foster Home	3.40
		15	Otano, Salem Estates, Zoomlion HQ	4.13
		9	Maledzor, Amrahia	3.95
			TOTAL	18.10
2	JAMOKY B	5	Mother Love, Mantey Farms, Owusu Ansah	1.93
		10	Lake Side, Old Botwe, Housing Down, New Adenta	4.04
		14	Little Rose, Nanakrom, Obodankari, New Nmai Dzor, University Farms	3.88
			TOTAL	9.85
3	M&D ENERGY SOURCE/ZOOM ALLIANCE	3	Manmomo, Ritz Junction, Aviation Area	3.34
		12	SSNIT Flat, National Lotteries	5.26
			TOTAL	8.60
4	HONEST WASTE	7	Left Ashiyie, Left Amanfro, Ampomah Village	2.85
		8	Right Asheyyie, Fulani, Right Amanfro	2.94
		16	Right Adjiringanor, Tessa	2.70
			TOTAL	8.49
5	AMANEE WASTE	11	Dzornaman, Bendjin, Dzen Ayor, Ogbojo, Otinshie	4.39
		13	New Botwe, Sraha, 3 rd Gate, Arapajay	3.62
			TOTAL	8.01
6	JEKORA	2	Stat Housing, Approtech	2.33
			TOTAL	2.33
	TOTAL WASTE GENERATION			55.38

Source: AdMA, 2013

4.17 Number of years in Solid Waste Business

Data gathered indicated that some Informal Waste Collectors had been in business for more than 10 years. The average number of years informal waste collectors had been in business was 6 years. The least number of years recorded was 1 year, 7 Months whilst the longest period recorded was 13 years (Fig. 7).

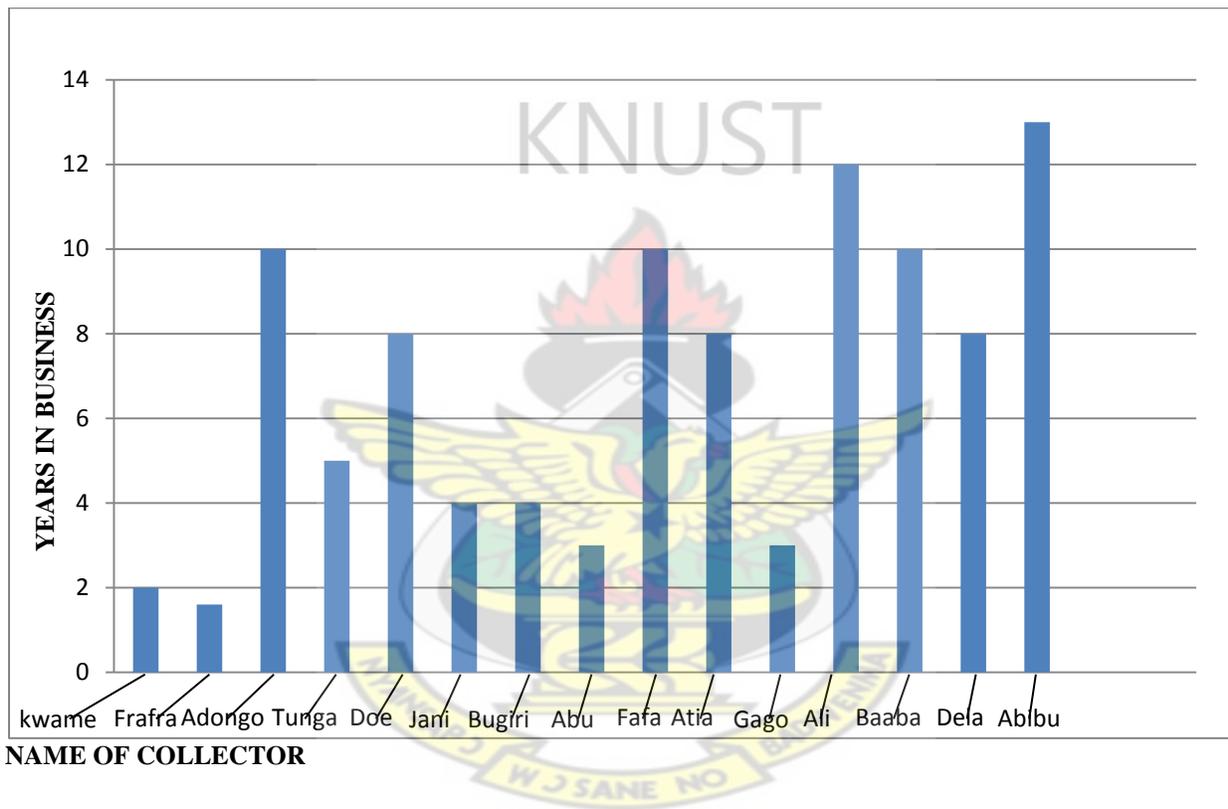


Fig. 7: Numbers of years Informal Solid Waste Collectors have been in business

4.18 Equipment Used By Informal Solid Waste Collectors

Based on 15 Informal Solid Waste Collectors that responded to the questionnaire, 53.3% used wheel burrow for solid waste collection and disposal, 20% used push cart whilst 13.3% operated

with woven basket. Information gathered from the sampled Informal Collectors indicated that both motor-tricycle and “borla taxi” formed 6.7% of the equipment used for their operations (Fig. 8).

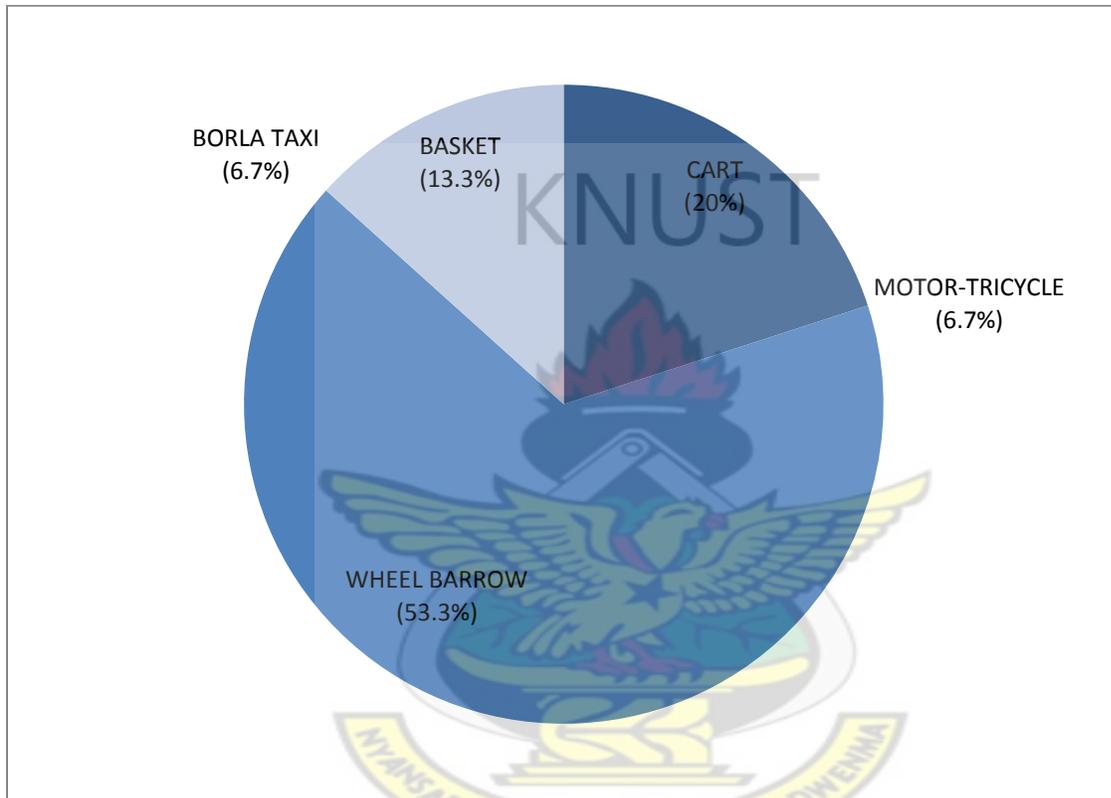


Fig. 8: Percentage of equipment used by Informal Solid Waste Collectors, 2013

4.19 Ownership of Equipment Used for Operations

Majority of the sampled Informal Collectors representing 62% own the woven baskets, push carts and wheel burrows used for solid waste collection whilst 24.6% rent the equipment. 13.4% of the respondents that operate the motor-tricycles and “borla taxis” are employed by individual companies.

4.20 Disposal of Solid Waste Collected by Informal Solid Waste Collectors

From information provided by the 15 Informal Collectors that responded to the questionnaire, 60% of them dispose of collected waste at unapproved disposal sites, 26.7% dispose them into communal containers placed at specific locations in the Municipality while 13.3% dispose of collected solid waste at approved final disposal sites.

4.21 Revenue Generated from Recovery Materials by Informal Waste Collectors

Informal Waste collectors collect all kinds of waste due to lack of waste separation in the Municipality. They are involved in scavenging for items which are sold for additional income. Most of the recovered items consist of plastics, scrap metals and cardboard materials that could be reused. Recycling companies and scrap metal dealers are the major groups that buy recovered materials. Based on the weight of recovered material, the informal waste collectors make between GH¢5.00 and GH¢10.00 from selling plastics and cardboards and between GH¢15.00 and GH¢ 20.00 from the sale of scrap metals. Sale of the recovered items is one of the main source of income apart from what the informal collectors charge for the solid waste collection services.

4.22 Regularizing Activities of Informal Solid Waste Collectors in Adentan Municipality

On the idea of regularizing the activities of Informal Waste Collectors, 82% informal respondents prefer regularization and legalization of their operations by the Adentan Municipal

Assembly, whilst 13% prefer to collect waste for disposal in the Municipality without approval by the Assembly. However, 5% of the respondents were undecided.

4.23 Challenges of Informal Waste Collection

The following are the major challenges that hampered the activities of Informal Solid Waste Collectors:

- Nine (9) respondents which represented (60%) indicated that lack of access to funds affect their ability to purchase the appropriate Personal Protective Equipment (PPEs) for operations.
- Stigmatization by the general public is affecting the activities of the informal collectors according to 14 respondents of the sampled Informal Solid Waste Collectors (93.33%).
- The high amount of fees charged at approved final disposal and communal container sites based on (73.33%) of respondents is one of the major factors that account for dumping at unapproved locations by Informal Collectors
- (86.66%) respondents indicated that lack of requisite equipment and logistics are affecting effective operations at the informal sector
- Lack of regulatory body to monitor and supervise activities have a toll on efficient delivery, support from the Municipal Assembly and the society according to (73.33%) of the sampled Informal Collectors
- Lack of periodic capacity building trainings and workshops on effective and efficient ways of managing solid waste affects operations as indicated by (86.66%) respondents

CHAPTER FIVE

DISCUSSION

5.1 Environmental Benefits of Informal Sector Integration

Fifty percent (50%) of the household respondents that dispose of waste by themselves are serviced by Informal Collectors. The high percentage indicates that the Informal sector plays a key role in the collection and disposal of solid waste in the Municipality. 5.5 metric tonnes of solid waste are collected daily by the Informal Collectors which reduces volumes of waste that find themselves into gutters, drains and on the ground. This activity helps keep the environment clean and prevent diseases outbreak. Scavenging activities by the informal collectors results in collection of recyclable materials which ensures sustainable environment.

The informal sector achieves high recovery rates (up to 80%) because the ability to recycle is vital for the livelihoods of the people involved. Consequently a huge variety of recyclables is segregated and can be further processed in accordance with new demands and technological advancements in the recycling industries. By making recycling and composting possible, the informal sector thus also contributes to the reduction of greenhouse gases. There is a simulation for Cairo that assumes that an integration of informal valorization activities and systematic extension could significantly reduce the greenhouse gas emissions from the waste sector in the city.

On the other hand, one should not ignore negative environmental impacts by informal recovery activities. When sorting out recyclable waste in the streets or at waste transfer station, some informal workers contribute to scattering waste that might cause environmental pollution.

Informal recycling activities do often not respect environmental standards and also might contribute to pollution. By integrating, organizing and training informal workers on the negative effects of these practices, these practices can be better controlled and reduced (CID Consulting, Cairo 2008).

5.2 Legalization of Informal Solid Waste Collectors

A large percentage of respondents advocated for legalization of Informal Solid Waste Collectors operations in the Municipality. The call was mainly due to availability of service and the small amount of money they charge. Legalizing operations of Informal Solid Waste Collectors will provide an opportunity for the acceptance of informal collector's activities by society to avert the stigmatization and discrimination. Legalization will also enable the Informal Collectors to form organizations which will help in accessing financial assistance from banks, financial institutions, support from Government, Non-Governmental Organizations and International Agencies. Finally, the respondents agreed to regularization of the operations to enable Municipal Assembly provide support, supervise, monitor and evaluate the activities of the Informal Solid Waste Collectors. However, 25% respondents were against legalization of informal waste collectors mainly due to lack of skills, knowledge and expertise in solid waste management and the use of miniature equipment for their operations.

Legal protection measures for waste pickers (identity cards, land property rights etc.) facilitate the organization and professionalization of waste pickers' activities. The adaptation of laws, orders, regulations and by-laws at federal, state and municipal levels to the requirements of a successful integration process paves the way for further developments. The Project for the Empowerment of Waste pickers of the Women's University in Pune in Western India had first

issued identity cards to informal collectors and promoted source segregation of waste and door-to-door collection by waste pickers. Following these developments, the state of Maharashtra passed state orders to municipalities, directing them to issue identity cards to waste pickers, to allot the work of collecting waste from homes, shops, market places and organizations (Gerdes and Gunsilius, 2010).

Political will to integrate the informal sector is one of the major factors defining the level of integration being reached. It is both a matter of national policy of respective laws and regulations and underlying attitudes towards informal sector activities in general. It is also determined by the willingness and creativity of local decision makers, using the space within existing regulations to create initiatives with the informal sector. In Brazil, after an initial period of mutual mistrust and conflict, various functioning models of cooperation and partnership between waste picker organizations and formal authorities have evolved. This has resulted in the formation of municipal recycling scheme partnerships between many waste pickers' organizations and local governments. Relations are regulated with specifically designed contracts, covenants and arrangements according to local circumstances. The establishment of direct contracts between informal sector organizations and local governments in Brazil has been facilitated by a general trend towards re-democratizing local governments and the clear commitment of state institutions to act as catalysts for social development (Dias and Fábio, 2008).

5.3 Number of Zones, Names of Communities and Solid Waste Management Companies in Adentan Municipality

Zone 1, according to the results, generates the highest volume of solid waste among the 6 zones (18.10 tonnes). Although zone 2 has larger number of communities (12) compared to zone 1 (11 communities), waste generated per day was 9.85 tonnes. This therefore informed the distribution pattern of respondents in the 6 zones based on volume of solid waste generation rather than number of communities that form the zones. According to the results obtained, waste management companies have not provided households with solid waste bins for the door-door services. Households therefore put waste in materials such as sacks, woven baskets, plastic buckets and more seriously, on the ground. This has been identified as the major contributing factor to indiscriminate dumping at unapproved sites.

5.4 Communal Containers in Adentan Municipality

According to the results obtained, out of the 45 communities in the Municipality, only 15 (33.33%) have been allocated with communal containers. Provision of inadequate communal containers in the zones has been identified as a major contributor to dumping of waste at unapproved locations in the municipality. Data collected also indicated that out of the 19 communal containers, 17 are Skip Containers whilst 2 are Roll-On-Roll-Off. Apart from the fact that the numbers of the Skip Containers in the zones were inadequate, the containers become full earlier due to their small size (12 m³) compared to the Roll-On-Roll-Off (23 m³). This results in frequent spillages of solid waste on the ground.

In Tamale Municipality (TMA), the skip ratio to the population in the low class residential areas was 1:9378 as opposed to the acceptable standard of 1:700. This means that the average population a skip served was 13 times greater than the standard maximum population a skip was supposed to have served. This explained why 40.5 per cent of the respondents resort to dumping waste at roadside, dump sites, open spaces, nearby gutter, backyard or burning as means to deal with their domestic waste in the Metropolis. In effect skips were seen overflowing with waste (Puopel, 2010).

According to Oteng-Ababio (2010), 10% and 20% of respondents from low-income areas in Accra and Tema travel within 50 meters radius to waste container sites to dispose of their waste. In Kumasi, 50% of residents in Aboabo (low-income area) travel over 150 meters to access refuse receptacle. This has a negative impact on solid waste disposal as most residents have the tendency of finding other convenient places to dispose of their waste.

5.5 Polluter Pays System

The major factor identified as to the 29.07% uncollected solid waste in the municipality is the pay as you dump principle. The Assembly Members in the various zones have placed staff of the Assembly at the 9 container sites to collect fees as part of Internally Generated Fund (IGF) processes. Lack of education on waste management on the part of the Assembly to residents and fees charged at communal container sites cause households, businesses, individuals and Informal Solid Waste Collectors to dump at unapproved dump sites. Whilst the total number of Skip Communal Containers (17) is inadequate to contain the volumes of solid waste in the zones, only 8 containers (47.05%) are allocated for free dumping.

The users of communal collection system were not charged user fees prior to 2008 as all service costs were borne by Assemblies. The pay as you dump for communal collection has been introduced in some parts of Accra, Kumasi, Takoradi, and Tema with the exception of Tamale. The policy was approved by the Assembly and by-law passed in Kumasi. In Accra, it was termed as 'illegal' by the head of Waste Management Department since there was no legal approval, whereas in Takoradi it was approved and the Assemblymen tasked to collect the revenue but did not account for monies collected. The revenue from the pay as you dump for solid waste collection in Accra and Takoradi did not go to the Assemblies or the companies as the case of Kumasi. Despite its challenges, the policy has proven to have potential for cost recovery in low income communities in a developing country. Under the policy user charging arrangements, communal system users pay 10 to 20 Ghana Pesewas per head load of solid waste dumped into communal container. This user charging arrangement has become necessary to help reduce cost of waste collection in the cities. This is intended to supplement the Assembly's subsidy for solid waste collection. The low income residents who contribute the large quantities of waste in the cities could pay through pay as you dump for improving solid waste collection (Oduro-Kwarteng, 2011).

The pay-as-you dump policy is practiced in United State of America, parts of Europe and now a mechanism that promotes solid waste source reduction, recycling, and diversion from landfill (Skumatz, 2002).

5.6 Waste Generation, Collection and Disposal in Adenta Municipality

The formal waste contractors in the Municipality responsible for collection and disposal of total solid waste generated are able to collect only 61.39% whilst 38.61% are left uncollected

according to results obtained. This is attributed mainly to lack of monitoring and supervision of the formal contractors by the Municipal Assembly, inadequate equipment and logistics, lack of experienced personnel and poor road network which made it virtually impossible to access every individual household, markets, shops and store within the Municipality. Daily waste generation varies from zone to zone. The number of communities in zone 1(11) is smaller than zone 2 (12). However, waste generation per day is 8.25 metric tonnes greater than the latter. Informal solid waste collectors play a significant role in the collection and disposal of 9.93% of the waste generated. The smaller nature of equipment used for operations enable the informal collectors to access every home, markets, shops and stores. Due to lack of appropriate by-laws and the enforcement of existing ones which are considered as inadequate by the authorities of Adentan Municipality, individuals dispose of solid waste at unapproved areas, gutters and on the street.

Despite the private sector involvement in solid waste management in developing countries in the past two decades, there are still problems with solid waste management services. The problems in cities have become burdensome despite efforts being made by city authorities and governments (Onibokun and Kumuyi, 1999). The problems of solid waste such as inadequate service coverage, irregular waste collection, waste spill over from bins and storage containers, and lax attitude of people towards indiscriminate disposal on unauthorized places and waste littering are common in developing countries (Zurbrugg, 1999). These problems eventually lead to public health impact, aesthetic nuisance, and environmental pollution. Because of the insufficient service coverage, the uncollected solid waste by the public sector or its agent is often dumped into drains, rivers and surrounding areas. These practices lead to considerable environmental pollution and degradation, and pose serious health risk to the population. The impact of uncollected waste within cities in developing countries is enormous. Cities are faced

with urban environmental health issues related to solid waste management (UN-HABITAT, 1996).

According to AMA, (2009), Oteng-Ababio, (2010a) and Huober, (2010) solid waste collection rate by contractors in Accra were 70% and 80% respectively. The remaining 20-30% uncollected is dumped indiscriminately. Low income areas such as Adentan Municipality are expected to experience improved sanitation, however, the opposite pertains.

5.7 Permission from Adentan Municipal Assembly for Informal Waste Collection

Data obtained from the Head of Waste Management Department indicates that Informal waste collectors in the Municipality do not have any permit to operate. As a result, their operation is considered as illegal. Solid waste management is considered as a cost intensive activity and therefore requires substantial amount of capital to obtain requisite logistics and equipment for operations. However, workers in the informal sector are poor and therefore use inappropriate equipment for waste collection and disposal. This is one of the reasons why the Assembly is unwilling to give permission to the collectors. Almost all the workers in the informal sector are illiterate. The Municipal Assembly believes that it will be difficult to train the workers to acquire requisite skills and knowledge in solid waste management considering the hazards and risks associated with it.

5.8 Solid Waste Management Challenges in Adentan Municipality

Adentan Municipal Assembly assigns Waste Contractors to the various zones. The Assembly has the sole authority to review, renew and terminate existing contracts of non-performing contractors. However, lack of effective supervision mainly due to staff capacity and logistics affects proper monitoring and supervision to ensure value for money operations by the contractors according to 90% of household respondents. Irregular collection of solid waste by formal contractors has resulted in spill-over of waste at communal container sites and around the containers which households and businesses use to keep waste. They are therefore compelled to engage in indiscriminate disposal. Irregular services are caused mainly by bad nature of equipment and logistics which results in frequent breakdown and inability to sustain approved routine and time schedule for waste collection by solid waste companies.

The poor nature of road network in Adentan Municipality prevents waste management companies to use equipment such as compactor to provide door to door services to many households. There are no solid waste management by-laws in Adentan Municipality. Individual households dispose of waste on the ground, into gutters and unapproved dump site without prosecution. Again there are no by-laws to regularize Informal Solid Waste Collection to augment operations of Formal Waste Management Companies. Finally, 25% respondents indicated that lack of public education on solid waste management is a challenge and contributes to indiscriminate disposal of waste by households, individuals and businesses.

Most high density low income areas where about 60% of the city's waste is generated are poorly accessible by road. This makes the removal of accumulated waste using motorized vehicles difficult, hence the use of the container system, which is also fraught with many problems. For

example, the fact that some residents have to travel long distances to access waste receptacles encourages indiscriminate littering. Furthermore, inadequate funding and poor cost recovery capabilities have resulted in acute financial problems for the authorities. The situation has been aggravated in Accra and Kumasi where the container system, which caters for almost 60% of total waste collection, is fee free, thus putting severe financial constraints on the authorities which invariably affects service delivery. The inability of the assemblies to enforce their own by-laws also impacts negatively on Solid Waste Management (Oteng-Ababio, 2011).

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5.9 Equipment Used By Informal Solid Waste Collectors

A large number of the Informal Waste Collectors indicated that they use simple equipment such as wheel burrows, woven baskets and push carts. Wheel burrow recorded high percentage in the equipment which is used for operations while “Borla Taxi” and Motor-Tricycle recorded the least. The low percentage for motor-tricycles and “borla taxis” is attributed to high cost of the equipment. However, “Borla Taxi” and Motor-Tricycle are identified as the requisite equipment for the provision of effective and efficient service in the informal sector.

The continuous use of miniature equipment by the informal collectors hampers delivery of effective and efficient services to clients and prevents expansion of business to cater for the large volume of waste generated in the Municipality which is not collected by Formal Waste Contractors for disposal.

5.10 Disposal of Solid Waste Collected by Informal Solid Waste Collectors

Lack of equipment and logistics for operations have a great impact on revenue generation by informal collectors. This therefore makes it almost impossible to many informal solid waste collectors to pay the high disposal fees charged at approved final disposal dump sites and result to disposal at unapproved areas in the Municipality. Waste disposal at approved final disposal sites and communal containers attract fees of between GH¢5.00 and GH¢10.00 and GH¢4.00 and GH¢8.00 respectively. Whilst 13.3% dispose of waste at approved final disposal sites, 60% of the respondents dispose of waste at unapproved dump sites as a result of the fees. Again, lack of supervision, monitoring and evaluation of the activities of informal solid waste collectors by Adentan Municipal Assembly also contribute to the solid waste disposal at unapproved sites by Informal Solid Waste Collectors.

5.11 Regularizing and Managing Activities of Informal Solid Waste Collectors in Adentan Municipality

A large percentage of sampled informal solid waste collectors advocate for the regularization and legalization of the informal solid waste collection in the Adentan Municipality according to the result. This will reduce the incidence of stigmatization and lack of recognition by the public and society. It will also help the collectors to form unions in order to be able to access financial assistance from banks and financial institutions to acquire requisite equipment for effective and efficient operations.

From the results obtained, regularization and legalization will make the sector attractive and result in more people joining the collection and disposal of solid waste to augment the activities

of the Formal Sector in the Adentan Municipality. The results also indicate that the Informal Collectors will be able to access workshops and capacity building trainings on solid waste management to boost their operations.

13% of the respondents do not prefer regularization of the informal sector due to payment of taxes and revenue to the Municipal Assembly. Again, regularization will cause more people to join and result in high competition for clients. The results obtained show that some respondents did not like legalization of the informal sector for the reason that it may result in allocation of specific areas for collectors to operate which will prevent working in all the 6 zones as currently been practiced.

Finally, according to the 5% undecided respondents, nothing will change if the activities of informal solid waste collectors are regularized and legalized. The entrepreneurial capacities of informal sector workers and organizations are an important factor in the sustainability of informal sector intervention. Activities supporting informal sector integration include facilitating credit, skills development and improvements in managerial know-how and marketing to enhance the competitiveness of labour-intensive small-scale activities.

5.12 Significance of Informal Solid Waste Collection

The significance of informal sector in solid waste collection and disposal cannot be overlooked. Taking into consideration the bad nature of equipment and logistics used for operations and the small number of workers in the sector, it is overwhelming to note that the informal solid waste collectors accounts for 5.5 metric tonnes of waste collected and disposed daily in Adentan Municipality. Again, it is significant to note from the results that out of 35% respondents that

undertake self disposal of solid waste generated, 17.5% receive services from the informal solid waste collectors. A total percentage of 70% of household respondents prefer the services of the informal collectors mainly due to their readiness and availability to provide service and lower fees charged for collection and disposal.

There is no initiative that is drawn by the government to incorporate the informal system in to the formal waste management scheme. In general, it can be stressed that the government and more specifically, Accra Metropolitan Assembly (AMA) has no clear understanding or knowledge of the activities of the informal waste management system. The Assembly had articulated an integrated waste management strategy that incorporated medium and long term plans that will be in to effect up to 2017. In the document, there is a mention for the need of new innovations for the separation, recycling and energy production from waste. `Upgrading the existing informal activities through integration into the formal sector will be looked at very seriously in view of the potential for job creation at the grassroots level (AMA, 2010b). However, the strategy does not have a detailed and articulated plan regarding how to integrate or incorporate the activities in to the formal system.

5.13 Economic benefits of Informal Sector Integration

According to the Head of Solid Waste Management Department, the Assembly is willing to allow integration of the collectors into mainstream solid waste management mainly due to the huge impact of the sector in solid waste collection and disposal. Again in the quest to increase tax net, the Assembly is working towards integration of the sector into mainstream formal collection to increase revenue generation.

The Head of the Solid Waste Management Department at the Assembly believes that integration will ensure total control and supervision of solid waste management in the Municipality so that the Assembly will always obtain accurate data on solid waste management in Adentan Municipality. Given license to the Informal Collectors to operate will bring about competition among the formal and informal sectors which will ensure delivery of efficient and effective services to clients and overall improvement in solid waste management in Adentan Municipality.

Although informal sector activities very often take place outside official and formal channels, unlicensed and untaxed, they nevertheless contribute significantly to the national economy. Scrap collectors add value to waste by collecting and transforming it into tradable commodities. New enterprises are formed, trading networks evolve, capital accumulation and investments take place and savings are made in terms of raw materials, transport and energy. Furthermore, additional employment is generated through informal sector integration and gives income opportunities to disadvantaged social groups. The informal waste management operations achieve a net benefit while formal waste management operations have a net cost. This is partly due to the fact that the informal sector works primarily in waste valorization, whereas the formal sector primarily works in waste management services (collection and disposal). But it is also due to the fact that the informal sector is, much more than formal actors oriented on the productive use of waste materials in order to be self-financing (GTZ/ Skat/ WASTE (forthcoming), 2010).

According to the sampled respondents, discrimination and stigmatization by the public, neglect by Municipal Assembly and collusion with Formal Contractors are among the highest challenges which workers of informal solid waste collection faces. Workers in the sector are branded as outcast and thieves in society. The use of requisite equipment and logistics are also observed to be other challenges that confront the sector. Workers are unable to purchase equipments such as

“borla taxies” and therefore result to miniature equipment including wheel burrows for collection and disposal of waste. Coincidentally, high fees charged at approved final disposal sites and communal containers and lack of regulatory body to supervise and monitor the informal sector recorded the same percentages whilst lack of funds to purchase the required Personal Protective Equipment recorded the least percentage.

Scavenging and informal collection in many developing countries are seen as inhuman, a symbol of backwardness, and a source of embarrassment and shame for the city or country. Based on this, scavenging and informal collection have been declared illegal and punished in many Third World cities such as in several Colombian, Indian, and Philippine localities (Furedy, 1984c; Keyes, 1974). Restrictions and a hostile attitude towards scavengers and informal collection typify repressive policies.

In other cases, authorities simply ignore scavengers and informal collection and their operations leaving them alone without persecuting or helping them. African cities such as Dakar, Senegal, Bamako, Mali, and Cotonou, Benin, illustrate the policy of neglect towards scavengers and informal collection (Waas and Diop, 1990; Diallo and Coulibaly, 1990; Tonon, 1990). Indifference towards scavengers and informal collection and their activities characterizes a policy of neglect.

CHAPTER SIX:

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

The informal Solid Waste Collectors uses equipment made up of push trucks, woven baskets, “borla taxies”, tricycles and others to collect solid waste from households, market centers, shops and businesses for disposal. Residents prefer their operations to formal contractors due to lower fees charged for services. Due to the smaller nature of their equipment, the Informal Collectors are able to move to all areas where trucks (compactors, skip and roll-on-roll-off trucks) used by the solid waste contractors are not able to access to collect waste for disposal.

Informal collectors often simply dump waste collected illegally at unapproved dump sites which pose risks to human health and the environment. Dumping the collected waste at these locations is attributed to location of approved dump sites or landfills which tend to be at a considerable distance from residential areas, inadequate communal containers and fees charged at landfill and communal container sites before dumping. Informal Collectors are involved in waste segregation at both collection point and final dump sites to collect recyclable materials to sell for additional income.

The sector has provided employment to significant number of youth who have turned out to be the bread-winners of their families. More income is earned by collectors as a result of lower fees charged for services rendered to households and businesses. The lower fees attract more clients for the services of the Informal Collectors thereby increasing their income earnings. Although the informal sector activities take place outside official and formal channels of the Adentan Municipal Assembly, unlicensed and untaxed, they nevertheless contribute significantly to the national economy.

During the collection and selling of recyclable materials for income, new enterprises are formed, trading networks evolve, capital accumulation and investments take place and savings are made in terms of raw materials, transport and energy. These factors contribute to economic growth of the Municipality and the nation as a whole.

5.5 metric tonnes of solid waste generated in a day in the Municipality is collected for disposal by the sector regardless of the following hindering factors: inappropriate equipment, lack of logistics, small workforce and lack of experience and skills in solid waste management. This activities results in reduction in the waste generated and uncollected by the formal companies on the streets, gutters, drains thereby improving hygiene and sanitation and prevent disease outbreak. The informal sector has made recycling and composting possible through the segregation and collection of recyclable material for sale to the manufacturing companies and contributes to the reduction of greenhouse gases.

The Informal Sector is faced with huge challenge in obtaining funds to acquire the requisite equipment and logistics for efficient and effective operations in solid waste collection and disposal. Workers in the sector are unable to access financial assistance from the banks and financial institutions to purchase Personal Protective Equipment (PPE) and other logistics including rakes, long brooms, waste pickers and others to provide efficient services to the public. Lack of recognition by the Municipal Assembly has also resulted in the inability of the sector to access funds made available to the public and organizations from the World Bank, Non-Governmental Organizations (NGOs) and the State through the Ministry of Local Government for waste management.

Workers in the Informal Solid Collection Sector are branded by the public as outcast, vagabond, criminals and thieves. The workers are mostly prevented from entry into many households and

businesses because they are considered by many in the public as thieves or spies for armed robbers. Many do not sit by them in public transports and eating joints in the Municipality. All these are happening without taking into consideration by the public, the impact and contribution of the workers in the sector to solid waste management in the Adentan Municipality.

The Assembly has not given license to the informal sector to operate. Activities of the sector are therefore considered as illegal. This has contributed immensely to the exuberant fees charged workers during disposal of waste at the final landfill and communal container sites because of lack of control and supervision of the sector by the Assembly. Lack of recognition by both the Assembly has affected the opportunity of the sector to access many benefits including financial assistance from Central Government, Non-Governmental Organizations, banks and financial institutions. It has also affected the workers in the sector from accessing capacity building workshops and trainings on effective and efficient ways of managing solid waste provided by many organizations including the World Bank.

Solid waste management companies operating in the Municipality have been assigned specific zones to collect and dispose of solid waste. Zoomlion Ghana Limited is operating Sanitation Improvement Package (SIP) program which involves placement of Skip and Roll-On-Roll-Off communal containers at strategic locations in the Municipality. Out of 45 communities which form the 16 areas and 6 zones, 17 Skip and 2 Roll-On-Roll-off containers are used for communal waste collection. Inadequate number of containers contributes to indiscriminate waste disposal in the Municipality. Only Zoom Alliance out of the 6 contractors has provided solid waste bins to some of the households within its operational zone. Lack of resources has resulted in the use of tipper trucks, pick-ups and other inappropriate equipment for waste collection by companies.

6.2 RECOMMENDATIONS

The Adentan Municipal Assembly is recommended to enact by-laws which will regularize and integrate the informal sector into mainstream solid waste collection based on the following benefits according to the research:

- it will lead to issuance of license to informal collectors to operate. This will bring about recognition of the informal collectors by the public and society and destroy the stigmatization syndrome.
- it will enable the informal sector to access financial assistance as a result of recognition by banks and financial institutions. This will ensure sustainability of the sector through the acquisition of requisite equipment and logistics and contribute effectively to the collection and disposal of solid waste in Adentan Municipality.
- the informal sector will be able to access capacity building workshops, trainings and financial support from Donor Communities and Central Government for waste management
- it will results in revenue generation by the Assembly through collection of taxes from workers in the informal sector
- it will ensure effective supervision, monitoring and evaluation of the activities of the sector to maximize efficient operations
- it will guarantee accurate data on waste management in Municipality
- activities to support the informal sector through management by the Assembly which include facilitating credit, skills development, improvements in managerial know-how and marketing of recyclable materials to enhance the competitiveness of the sector and make it lucrative will be guaranteed.

The study was able to achieve the objectives outlined. However, I will recommend further studies into the impact of “Polluter-Pays System” on solid waste management in Adentan Municipality.

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REFERENCES

Accra Metropolitan Assembly (AMA) (2009). *Itergrated Solid Waste Management Strategy*.

Hifad SIPU-Colan Consultants. *Urban Environmental Sanitation Project*, Accra, Ghana.

Adentan Municipal Assembly (AdMA) (2008). *Geographical Location of Adentan Municipality*.

Adentan Municipal Assembly (AdMA) (2013). *Solid Waste Generation, Collection and Disposal in Adentan Municipality*.

Accra Metropolitan Assembly AMA (2010b). *Accra Metropolitan Assembly Integrated Solid Waste Management Strategy*.

Accra: Accra Metropolitan Assembly.

Anomanyo, D.E (2004). *Integration of Municipal Solid Waste Management in Accra, Ghana:*

Biofactor treatment technology as an integral part of the management process.

Presented to Lund University, Sweden.

Baamlak Tesfaye, G. (2012). *The Cycle of Solid Waste: A Case Study on the Informal Plastic and Metal Recovery System in Accra.*

Beukerung, P.V., Sehker, M., Gerlagh, R. and Kumar V. (1999). *Analysing Urban Waste in Developing Countries: a perspective on Bangalore, India. Working Paper No.24.*

Boadi K.O and Kuitunen, M. (2004). *Municipal Solid Waste Management in the Accra Metropolitan Area in the Environmentalist Journal. Volume 23, No.3.*

Boateng, C. and Nkrumah, D. (2006). *Managing Waste! The Attitudinal Change. Daily Graphic,*

- Centre for Environment and Development (2003). Study of the Attitude and Perception of Community towards Solid Waste Management. A case study of Thiruvananthapuram city-Phase II. Submitted to Kerala Research Programme on Local Level Development.
- CID Consulting, Cairo (2008). The Informal Sector in Waste Recycling in Egypt, commissioned by GTZ, Eschborn.
- Denison, R.A. and Ruston, J. (1990). Recycling and Incineration. Island Press, Washington D.C.
- Environmental Protection Agency (2002). Ghana's State of the Environment Report
- EPA, MES, MLGRD, (2002) Ghana Landfill Guidelines: Best Practice Environmental Guidelines. Accra, Ghana.
- Dias and Fábio (2008). Integration of the Informal Recycling Sector in Solid Waste Management in Brazil.
- Diallo, S. and Coulibaly, Y. (1990). "Les Déchets Urbains en Milieu Démuni a Bamako." *Environnement Africain*.
- Felix P. (2010). Solid Waste Management in Ghana: The Case of Tamale Metropolitan Area.
- Furedy (1984c). "Survival Strategies of the Urban Poor- Scavenging and Recuperation in Calcutta." *GeoJournal*.
- Gerdes, P. E. G. (2010). The Waste Experts. Enabling Conditions for Informal Sector Integration in Solid Waste Management. Lessons learned from Brazil, Egypt and India, Eschborn.

GTZ/ Skat/ WASTE (forthcoming) (2010). Economic Aspects of the Informal Sector in Solid Waste and Recycling.

Huober, A. L. (2010). Moving Towards Sustainable Solid Waste Management in Accra: Bridging the Formal-Informal Divide. Desertation, Amherst College.

Institut für Energie und Umweltfors (IFEU) (2009). SWM GHG Calculator. Tool for Calculating Greenhouse Gases (GHG in Solid Waste Management (SWM), commissioned by KfW, Frankfurt.

Kumasi Metropolitan Assembly (KMA) (2006). [www. Ghanadistricts.com](http://www.Ghanadistricts.com). Accessed on 12th June, 2010.

Keyes, W. (1974). Manila Scavengers, the Struggle for Urban Survival. Manila, Philippines: Ateneo de Manila University.

Kreith, F. (1994). Handbook of Solid Waste Management. McGraw Hill, USA.

Kumah, A.M. (2007). The Situation of Solid Waste in Ghana. Accra, Ghana.

Mensah, A. and Larbi, E. (2005). Solid waste disposal in Ghana. www.trend.wastsan.net

Accessed on 24th April, 2009

Ministry of Local Government and Rural Development (MLGRD) (2010a). Environmental Health and Sanitation Directorate. National Environmental Strategy and Action Plan (NESSAP) 2010-2015. Government of Ghana.

Ministry of Local Government and Rural Development (MLGRD) (2010b). Environmental Sanitation Policy 2009 (Revised 2010). Government of Ghana.

Momoh, J.J. and Oladebeye, D.H. (2010). Assessment of Awareness of Attitude and Willingness of People to Participate in Household Solid Waste Recycling Programme in Ado-Eketi, Nigeria, in the *Journal of Applied Sciences in Environmental Sanitation*. Jakarta, Indonesia.

Ministry of Local Government and Rural Development (MLGRD) (2009). National Report for Ghana Waste Management 2009. [18www.un.org/National Reports/ghana](http://www.un.org/NationalReports/ghana)). Accessed on 12th October, 2009. Section of the United Nations Commission on Sustainable Development.

MLGRD (2004). Sanitation Country Profile Ghana (2004). (www.un.org/esta/agenda21.../ghana/sanitationGHANA04.pdf). Accessed on 12th October, 2009 USPS (2000).

Ogawa, H. (2005). Sustainable Solid Waste Management in Develop Countries. (www.gdrc.org). Accessed on 30th January, 2010.

O. and K. (1999). Governance and Waste Management in Africa: In Adepoju G. and Onibokun (ed). *Managing the monster urban waste and governance in Africa*.

Oteng-Ababio, M. (2011). Governance Crisis or Attitudinal Challenges? Generation, Collection, Storage and Transportation of Solid Waste in Ghana.

Oteng-Ababio, M. (2010a). Private Sector Involvement in Solid Waste Management in Greater Accra Metropolitan Area. *Waste Management & Research*, Vol. 28, No. 4, pp. 322-329.

- Oduro-Kwarteng, S. (2012). Private sector involvement in urban solid waste collection.
- Oteng-Ababio, M. (2010). Governance Crises or Attitudinal Challenge? Generation, Collection, Storage and Transportation of Solid Waste in Ghana.
- Oduro-Kwarteng, S. (2011). Private Sector Involvement in Urban Solid Waste Collection.
- Oduro-Kwarteng, S. Awuah E., and Kotoka P., (2006). Solid waste management practices in Kumasi, Ghana: public concerns and attitude towards disposal and cost recovery Solid Waste Management Plan for Thimphu City, Bhutan, Draft version, April 2000 .Bhutan: Urban Sector Programme Support Secretariat.
- Priestly, J.J. (1968). Civilization, Water and Waste, Chemistry and Industry, March 23
- Solid Waste Management Plan for Thimphu City, Bhutan, Draft version, April 2000
- Bhutan: Urban Sector Programme Support Secretariat.
- Skumatz L. (2002). Variable-Rate or Pay-as-you-throw Waste Management, Reason Foundation
- Stephens *et al.* (194). Solid Waste Management in Accra.
- Tchobanoglous, G., Theisen, H. and Eliason, R. (1977). Solid Wastes: Engineering Principles and Management issues. McGraw-Hill Publishing Company, USA.
- Tonon, F., 1990. "Gestion des Ordures Ménagères `a Cotonou." *Environnement Africain*. No. 29-30. Vol. VIII, 1-2, pp. 79-92.
- Tchobanoglous, G., Theisen, H. and Vigil, S. (1993). Integrated Solid Waste: Engineering principles and management issues. McGraw-Hill Publishing company, USA.
- Tsiboe, I. A. and Marbel, E. (2004). A Look at Urban Waste Disposal Problems in Accra.

Roskilde University, Denmark.

United States Environmental Protection Agency (USEPA) (1999). State and Local Solutions to Solid Waste Management Problems. (<http://www.epa.gov>). Accessed on 18th July, 2009.

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

United Nations Habitat (1996). An Urbanizing World, Global Report on Human Settlements 1996. New York, United Nations Centre for Human Settlements (HABITAT).

United State Post Services (USPS) (2000). Solid Waste Management Plan for Thimphu City, Bhutan, Draft version, April 2000 .Bhutan: Urban Sector Programme Support Secretariat.

Waas, E. and Diop, O. (1990). “Economie Populaire du Recyclage des Déchets `a Dakar.” *Environment Africain*.

World Bank report (2012). State of municipal solid waste around the world.

Zerbock, O. (2003). Urban Solid Waste Management: Waste Reduction in Developing Nations. (www.cee.mtu.edu). Accessed on 18th July, 2009.

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

Accessed on 18th July, 2009.

Zurbrugg, C. (1999). Solid Waste Management in Developing Countries. SANDEC / EAWAG.

Zoomlion Ghana Limited (2011). Feasibilities studies for implementation of Solid Waste Management Models in Dakar

APPENDIX 1

QUESTIONNAIRE FOR INTEGRATION OF INFORMAL SOLID WASTE COLLECTORS INTO MAINSTREAM FORMAL SOLID WASTE MANAGEMENT SYSTEMS IN ADENTAN MUNICIPALITY

RESIDENTS OF ADENTAN MUNICIPALITY

1. Which zone do you reside?
2. How do you dispose off your waste? a. Waste mgt. Company b. Self c. Informal waste collector
3. Do you know the waste Management Company responsible to collect waste in your area?
Yes No
If yes, what is the name of the company?
If No, what other means of waste collection is available.....
4. Have you signed up with Formal Waste Contractors for waste collection? Yes No
If yes, which company?
If No, why
5. What is the frequency of waste collection? a. Once a wk b. Twice a wk c. Any other
6. Are they regular? Yes/No.
If no how do you manage the excess waste?
7. Do you observe activities of informal waste collectors in your zone? Yes No
8. How would you rate the activities of Informal Collectors?
.....

9. Would you say waste collection by Formal Companies in Adentan Municipality is effective and efficient? Yes No .

If No, what is the cause of this inefficiency?

10. Do you think that the operations of Informal Collectors should be legalized in the Municipality? Yes No

If No, why?

If Yes, why?

11. How would you rate the activities of Formal Companies in Adentan Municipality

.....
.....

12. In your opinion what are the lapses/challenges in solid waste management in Adentan Municipality.

.....
.....
.....

13. What do you suggest should be done to improve solid waste management in Adentan Municipality

.....
.....
.....

MUNICIPAL WASTE MANAGEMENT OFFICER

14. How many zones do you have in Adentan Municipality?

15. What are the names of communities that form each zone?

16. How many formal waste contractors are assigned to collect waste?

17. What is the number of solid waste containers in Adentan Municipality?

18. What is the number of solid waste containers used for Polluter Pays System in Adentan Municipality?

19. What is the average quantity of waste generated in a day in the municipality?
.....

20. What is the average quantity of waste generated in each zone?

21. What is the amount of waste collected for disposal in each zone by contractors per day?
.....

22. Are all waste generated collected by waste management contractors? Yes No

23. If No, what accounts for the difference?

24. How is the rest of the waste catered for?

25. Does the Municipal Assembly permit informal waste collection (truck pushers and motor-tricycles) in Adentan? Yes No

If yes which areas and why?

If No, why?

26. Are there any measures in place to regularize activities of Informal Collectors? Yes No

If yes, state.....

27. Of what significance are their activities towards waste collection?

.....
.....

28. Are there any challenges that they face? Yes No

If yes what are the challenges?

29. Do you think the Municipal Assembly is willing to allow for integration of the informal solid waste collectors into general solid waste collection/management system? Yes No

If Yes why?

If No why?

INFORMAL WASTE COLLECTORS

30. For how long have you been working

31. What do you use to collect waste a. Truck b. Moto-Tricycle c. Wheel Barrow
d. Bola Taxi e. Any other.....

32. Do you own it? Yes No

If yes, how were you able to afford it?

33. Where do you disposal of the waste collected?

34. Do you collect recovery materials? Yes No

35. Where do you send them?

36. How much do you get from these materials?

37. Are you managed by the Municipal Assembly? Yes No

38. Would you want your activities to be regularized? Yes No

If No why?

If Yes how?

39. Do you face any challenges in doing your work? Yes No

40. If yes how?

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