CHARACTERIZATION AND QUANTIFICATION OF MUNICIPAL SOLID WASTE AS A MEASURE TOWARDS SUSTAINABLE WASTE MANAGEMENT IN GREATER KARU URBAN AREA, NASARAWA STATE NIGERIA

BY

IDIAT IDRIS SALAUDEEN

(NSU/PGD/ERM/0026/16/17)

(HND, Applied Chemistry)

FEDERAL POLYTECHNIC, NASARAWA

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF POSTGRADUATE DIPLOMA IN ENVIRONMENTAL RESOURCE MANAGEMENT OF THE SCHOOL OF POSTGRADUATE STUDIES OF NASARAWA STATE UNIVERSITY, KEFFI.

SUPERVISOR: DR. T. A. OGAH

DECLARATION

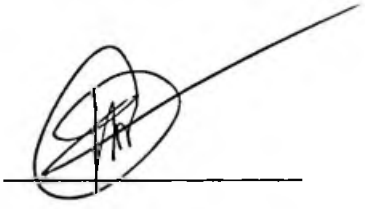
I hereby declare that this project has been written by me and it is a report of my research work. It has not been presented in any previous application for the award of Master of Science. All quotations are indicated and sources of information specifically acknowledged by means of references.

.....

IDIAT IDRIS SALAUDEEN

CERTIFICATION

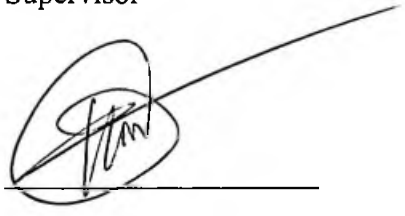
This project "Characterization and Quantification of Municipal Solid Waste as A Measure towards Sustainable Waste Management in Greater Karu Urban Area, Nasarawa State Nigeria" meets the regulations governing the award of Master of Science, Faculty of Social Sciences of Nasarawa State University, Keffi.



17/4/18

Dr. T. A. Ogah — Date

Supervisor



17/4/18

Dr. M.I. Nasiru — Date

Head of Department

_____ _____

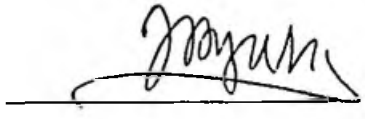
..... Date

Internal Examiner

_____ _____

..... Date

External Examiner



17/04/2018

Prof. S.A.S Aruwa — Date

Dean, School of Postgraduate Studies

DEDICATION

This project is dedicated to Almighty Allah for his grace that was sufficient to me throughout the course of this study.

ACKNOWLEDGEMENTS

I am also thankful to my supervisor, Dr. T. A. Ogah for his constructive criticism and guidance through the course of this project. I appreciate the head of Geography department, Prof Nasiru Idris all the staff of the department: Prof Sangari D., Prof Ayuba H.K., Prof Iwugo K.O, Prof. Marcus D., Prof. Aisha M., Prof Eziashi, Dr. T. Ogah, Dr A. Mahmud, Dr. J. Magaji, Dr. S. Ishaya, Dr. M. Alkali, Dr. A. Kadafa, Dr. Edicha, Dr. Abba, Dr. Bimbol, Mr. S. Kpalo, Mr. U. Lay, Mr A. Daniel, Mr. J. Kunda, Mr. Eyah, Mrs A. Salome, Mr C. Banky, Mr. Mukthar and Mrs Serah; for impacting me with knowledge during this programme.

I wish to express my profound appreciation to my parents for their prayers and words of encouragement. To my children, I am grateful for your understanding through the course of this programme. I also like to acknowledge my brothers and sisters for their care, my in-laws and my boss for their support, I will not forget to extend my gratitude to all my friends for their encouragement. To my loving and husband, I say a big thank you for your love and financial support through the course of my study. May Almighty Allah never forsake you all in your times of need.

ABSTRACT

Waste collection and disposal is a challenge for many metropolitan and municipal assemblies in Nigeria and the Greater Karu Urban Area is no exception. Currently, all the waste generated in Nyanya metropolis ends up at the final disposal sites without any recovery of the valuables in the waste. Waste separation efficiency and willingness to separate waste at source, the physical composition and the per capita waste generated per each household within the area were studied over a five week period. Questionnaire survey was carried out. The results show a solid waste composition of 60.01% biodegradables, 11.47% plastic, 7.35% paper and cardboard, 2.38% metals, 1.51% glass, 1.22% leather and rubber, 2.91% textiles, 8.04% inert materials and 4.98% miscellaneous materials. Over 80% of the waste had the potential for reuse (potentially recyclable) and of the usable material, 22.67% can be recycled and 63.64% for composting. The average per capita waste generated was 0.70 kg/ca/day. The data generated on the quantity and composition of the waste stream in the metropolis would play a positive role in solid waste management and help solid waste managers make informed decisions on waste management options. Hence, it was recommended that home composting facilities (with low or no cost to the household as only 46.24% of the respondents were willing to buy bin for composting) be established for households to encourage home composting within the community, and private firms should be involved for efficient and effective solid waste management in the area.

TABLE OF CONTENTS

		Page
Title Page		i
Declaration		ii
Certification		iii
Dedication		iv
Acknowledgement		v
Abstract		vi
Table of Contents		vii
List of Tables		x
List of figures		xi
CHAPTER ONE	**INTRODUCTION**	
1.1	Background to the Study	1
1.2	Statement of the Problem	2
1.3	Research Questions	3
1.4	Aim and Objectives	3
1.5	Significance of the Study	3
1.6	Scope and Limitation of the Study	3
CHAPTER TWO	**CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW**	
2.1	Introduction	4
2.2	Municipal Solid Waste	5
2.2.1	Sources and Types of Municipal Solid Waste	5
2.2.2	Characteristics of Municipal Solid Waste	6
2.3	Municipal Solid Waste Management (MSWM)	7
2.3.1	Municipal Waste Management Hierarchy	8
2.3.1.1	Reduction	8
2.3.1.2	Re-use	9
2.3.1.3	Recovery	9

2.3.1.4 Disposal 9
2.4 Quantity and Composition of Municipal Solid Waste 9
2.4.1 Quantity of Municipal Solid Waste 10
2.4.2 Composition of Municipal Solid Waste 12
2.5 Municipal Solid Waste Characterisation and Generation 13
2.5.1 Municipal Solid Waste Characterisation 13
2.5.2 Municipal solid waste Generation 14
2.6 Source Separation and Willingness to Separate Waste 14
2.7 Problem of Managing Municipal Solid Waste 15
2.8 Overview of Municipal Solid Waste Management in Nigeria 16
2.9 Municipal Solid Waste Transfer and Disposal in Nigeria 17
2.10 Private Sector Involvement in Waste Management 18

CHAPTER THREE THE STUDY AREA AND RESEARCH METHODOLOGY

3.1 The Study Area 20
1.1 Location and Extent 20
3.1.2 Climate 21
3.1.3 Soil and Vegetation 22
3.1.4 Relief and Drainage 22
3.1.5 Geology 23
3.1.6 Economic Activities 23
3.2 Research Methodology 23
3.2.1 Data Types and Sources 23
3.2.2 Reconnaissance Survey 23
3.2.3 Data Collection 24
3.2.3.1 Education of Households on the Survey 24
3.2.3.2 Distribution of Polythene Bags and Waste Bins 24
3.2.3.3 Collection of Waste from Households and Further Sorting 25
3.2.4 Sampling Technique 25
3.2.5 Data Analysis 26
3.2.5.1 Physical Composition of MSW Analysis 26
3.2.5.2 Separation Efficiency 26
3.2.5.3 Waste Quantification 27

3.2.5.4 Statistical Data Analysis 27

CHAPTER FOUR RESULTS AND DISCUSSIONS

4.1 Socioeconomic Characteristics of the Respondents 28

4.2 Physical Composition and Quantity of Household Waste 29

4.3 Separation Efficiency and Willingness to Separate Waste 32

4.3.1 Willingness of the People to participate in Waste Separation 35

4.4: Per Capita Waste Generation 37

CHAPTER FIVE SUMMARY, CONCLUSION AND RECOMENDATIONS

5.1 Summary of Findings 41

5.2 Conclusion 42

5.3 Recommendation 42

References 44

LIST OF TABLES

Table 2.1:	Sources and Types of Solid Waste	6
Table 3.1:	Number of households of the various classes	25
Table 4.1:	Distribution of Respondents by Socioeconomic characteristics	28
Table 4.2:	Composition of Municipal Solid Waste in Mararaba	29
Table 4.3:	Mean ± standard error of the Separation Efficiency of the various classes of Residents	32
Table 4.4:	General Knowledge on Waste and Waste Separation	35
Table 4.5:	Average per Capita Waste Generation by Class of Residential Area	37
Table 4.6	ANOVA Test for Differences in Per Capita Waste Generation of the Three Residential Classes	38
Table 4.7:	Relationship between Income Level and Per Capita Waste Generation	38
Table 4.8:	Relationship of Per Capita Daily Waste Generation to Households size	39

LIST OF FIGURES

Figure 2.1	Nasarawa State Showing Karu LGA	20
Figure 3.1	Karu LGA Sowing the Study Area (GKUA)	21
Figure 4.1:	Categorisation of Waste stream into Bio and Non-Bio	31
Figure 4.2:	Amount of Non-Bio in the Non-Biodegradable Polythene Bag	33
Figure 4.3:	The Amount of Bio in the Biodegradable Polythene Bag	33
Figure 4.4:	The Amount of Bio in Non-Biodegradable Polythene Bag	34
Figure 4.5:	Amount of Non-Bio in Biodegradable Polythene Bag	34

LIST OF APPENDICES

Appendix 1: Research Questionnaire 51

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Solid Waste generation within households, markets and communities is as a result of human activities (Zurbrugg, 2002; Gawaikar and Deshpande, 2006 and Ejaro and Jiya, 2013). These human activities which directly or indirectly produce waste could be agricultural, commercial, or domestic. These sources of waste are highly heterogeneous and are made up of important waste streams such as plastics, yard waste, food waste, papers, metals, glass, textiles, leather and other miscellaneous materials.

Waste management being a major environmental and health challenge around the world today is more pronounced in developing countries (Ejaro and Jiya, 2013). Identification of these valuables in the solid waste stream and their quantities has called for the development of important recovery and recycling technologies and designs for treatment to extract the exact economic benefit of these materials (Pichtel, 2005; Gawaikar and Deshpande, 2006; Ahmad and Jehad, 2012). In most developing economies, biodegradables are the highest fraction; hence the strategic development of bioconversion processes to reduce the quantities of the generated waste and consequent benefit over mere disposal. Biogas and compost production from such a renewable source offers an advantage because of its continual and sustainable supply provided their production cost are minimized.

Greater Karu Urban Area (GKUA) and other African cities generate 80% organic waste, 10% plastic, glass and metal waste and less than 1% paper waste per day (Omole and Alakinde 2013). However, most of these wastes is not properly collected and disposed of in a safe and healthy manner. This situation is not limited to Accra and may be applicable to all the major cities in Ghana. The Takoradi Sub-Metro (TSM) like Accra has a major waste management and disposal problem which may be attributed to lack of understanding of the waste management system.

Although many cities the world over use 20-50 percent of their budget in solid waste management, only 20-80 percent of the waste they produce is collected (Achankeng, 2003). The uncollected or illegally dumped waste constitutes danger to human health and is a recipe for environmental degradation. Not only are the quantities but also the variety of waste is increasing as consumption habits are fuelled by globalisation (Achankeng, 2003).

The various classes of residential areas often have varying waste management challenges; first class residential areas enjoy a door- to -door waste collection, while the second and third class

residential areas sometimes have door –to- door service, but the majority of the areas are under the "pay- as- you- dump" service where community bins are provided. However, there are other third class residential areas which do not have any of these services. Wastes from these less-privileged areas are mostly dumped indiscriminately in open places.

This research therefore aimed at generating data on the waste produced in the GKUA and its composition by quantifying and characterizing it to inform decisions on waste management project planning.

1.2 Problem Statement

The Federal Government of Nigeria establishments were relocated to Abuja, the Federal Capital Territory (F.C.T) in the 1990s and today rapid expansion has exceeded the anticipated master plan (Iman *et al.,* 2008), with resultant evolution of suburbs which are characterized by unplanned growth in property resulting from absence of development control. GKUA in the western zone of Nasarawa state began to swell with uncontrolled influx of people as early as in the mid-90s barely five years after the seat of government officially moved from Lagos to Abuja. Construction activities which broke ground in Abuja with the expansion of government and private businesses heighten demand for affordable accommodation by construction workers and other low income working class people. GKUA with proximity to Abuja became the destination (Hir, 2012). This suburb continued to experience a growth at geometric rate, but the then old Plateau state and the current Nasarawa State government failed to come up with an immediate project to effectively address what soon became, but dirty environment to Abuja.

In line with foregoing, municipal solid waste (MSW) generation has increased significantly within the GKUA. A World Bank Assisted Project called Supreme with Karu Local Government Area Council undertakes the cleansing and waste management exercise of the study area in order to keep the cities clean and to enhance public health and safety. Evaluation of the resource requirement for collection, transportation, processing and disposal as well as equipment for waste management requires a correct assessment of the quantity of waste generated per capita per day from direct residential areas and the characteristics of waste generated (Gawaikar and Deshpande, 2006). However, in GKUA there is no data on waste generation and composition thus making planning difficult. All the mixed waste ends up in the landfill sites without recovering or recycling any of the poisonous and valuable materials in them (Butu et al, 2013). Thus, source specific quantification and characterisation of the household waste is very much required to assess the quality and quantity of waste generated which will allow correct

assessment of waste load and make it easier for proper planning of solid waste management in the area.

1.3 Research Questions

i. What is the socioeconomic status of the respondents
ii. What is the physical composition of household waste within the GKUA?
iii. How is the separation efficiency and willingness of the people to separate waste?
iv. What is the per capita and quantity of the waste generation in GKUA?

1.4 Aim and Objective

The aim of the study was to characterise and quantify household waste for proper management of waste in the GKUA and to help make informed decisions on project planning for diversion of this waste from the final disposal sites. The specific objectives are:

i. Assess the socioeconomic status of the respondents
ii. Determine the physical composition and quantity of household waste within the GKUA
iii. Assess the separation efficiency and willingness of the people to separate waste
iv. Determine the per capita waste generation and its relationship with income and household size in GKUA

1.5 Significance of the Study

The characterization and quantification of household waste in GKUA would bring together data on the generation rate and the composition of waste in the area. This will help the waste management authorities in the area to operate an efficient waste management system. An efficient solid waste management system for GKUA will serve as a model for municipal waste management for the other urban centres in Nasarawa State as well as other cities in Nigeria since the problems of waste management is similar and prevalent through Nigeria.

1.6 Scope and Limitation of the Study

This study covers the Greater Karu Urban Areas which include several settlements. However, the study was limited to three settlements namely: Abacha Road in Mararaba, Veronica Estate in New-Nyanya and Jogodo in New-Karu. Data for the study was obtained from household waste generated for a period of five weeks. The study explored the socioeconomic status of the study area residents, the composition of household wastes generated by the three categories of selected settlements, separation efficiency and willingness to separate waste by the residents as well as their per capita waste generation.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

Rapidly growing populations, rapid economic growth and rise in community living standards have accelerated the generation rate of Municipal Solid Waste (MSW) causing its management to be a major worldwide challenge (Aguilar-Virgen *et al.*, 2010; Al-khatib *et al.*, 2010; Nabegu, 2010 and Fakare *et al.*, 2012). Particularly in urban cities of developing countries like Ghana, MSW management (MSWM) is a highly neglected area. Fakare *et al.* (2012), showed that the rate of change in domestic waste quantification and composition in developed and developing countries is outstanding. Generally the greater the economic prosperity and higher percentage of urban population the greater the amount of solid waste generated.

A walk through the streets of towns and cities in the urban areas of Nigeria show a clear breakdown in the waste management situation in the country. A study by Fakare *et al.* (2012) showed that the problem of waste generation, handling and disposal have reached a disturbing level in Nigerian urban centers and in most cities in Nigeria; waste management issues have become a glaring challenge. In recent years, there has been a phenomenal increase in the volume of wastes generated daily in Nigeria. About 83% of the population dump their refuse in either authorised or unauthorised sites in their neighbourhood, and weak capacity to handle solid waste creates unsanitary conditions (Freduah, 2004). Waste is inseparable from man, he stores up, uses, and disposes of materials and the waste produced by modern civilization is directly related to the living standard, socio- economic and cultural attributes of that particular environment Fakare *et al.* (2012). There is therefore the need for an efficient waste management strategy to be adopted to help improve the poor handling of waste.

Data pertaining to MSW vary greatly among waste studies. Usually waste management decisions are based on household waste, which constitutes a small portion of the total waste stream. Industries and commercial activity hide the information to avoid statutory obligations (Anon, 2005). The valuable materials in the waste stream can be recycled and reused therefore minimising the amount of waste that ends up at the final disposal sites. However due to the heterogeneous nature, it is very difficult (if not almost impossible) to make projections as those for recycling and reuse (Kui, 2007; Walling *et al.*, 2004).This view expressed by Kui (2007) and Walling *et al.* (2004), is relevant to this research because the waste produced by the people of GKUA is mixed without any form of separation. Al-Khatib *et al.* (2010) noted that the composition of solid waste is an important issue in waste management and ends up affecting the

density of the waste, the proposed methodology of disposal and is necessary for examining reuse, reduction and recycle of waste. Oumarou *et al.* (2012) therefore believes a comprehensive characterisation of MSW is crucial to the long term efficient and economical planning for solid waste management.

Identification of waste composition is crucial for the selection of the most appropriate technology for treatment, taking essential health precautions and space needed for the treatment facilities (Nabegu, 2010). Despite this acknowledgment, there has been no study on the analysis of municipal waste composition in GKUA even though a lot of work on waste management has been done on municipal waste management. This study attempts to fill this gap by providing data on the composition, and sources of municipal waste in Mararaba communities of the GKUA for the purpose of understanding the type of waste generated to help in proper waste management.

2.2 Municipal Solid Waste

Waste is more easily recognised than defined. Something can become waste when it is no longer useful to the owner or it is used and fails to fulfill its purpose (Freduah, 2004). Municipal waste is defined by Hogan *et al.* (2006) as household waste as well as commercial and other waste which because of its nature and composition are similar to household waste. Household waste is waste produced within a building or self-contained part of a building used for the purpose of living or residential accommodation. Municipal waste may therefore be considered to be coming from three different sources: household, commercial and other waste but this research would be devoted to household waste because municipal waste analysis is better carried out using household waste. MSW includes durable goods, non-durable goods, containers and packaging wastes, food wastes and yard trimmings, and miscellaneous inorganic wastes. This information is of great importance to the research in helping categorise the waste into the right components. Thus municipal waste is an accumulation of rejects from households, markets, traders, shops and other commercial activities in the areas (Bichi and Amatobi, 2013).

2.2.1 Sources and Types of Municipal Solid Waste

The knowledge of the sources and types of waste in an area is required in order to design and operate appropriate solid waste management systems (Oyelola and Babatunde, 2008). Fundamental understanding of the sources and types of solid wastes is key in evaluating the composition and generation rates of MSW sources in a community area related to many aspects of residential units. Classified of types of solid waste in relation to the sources and generation facilities, activities, or locations where wastes are generated associated with each type which is

presented in table 1. Types of solid waste based on origin (food waste, rubbish, ashes and residues, demolition and construction, agriculture waste), based on characteristics (biodegradable and non-biodegradable), based on the risk potential (hazardous waste) is the classification of (Puopiel, 2010). And also sources of solid waste as residential, waste from shops, commercials establishment, hotels/restaurants/eating stalls, slaughter houses and others.

Table 2.1: Sources and Types of Solid Waste

Sources	Typical facilities, activities, or locations where wastes are generated	Types of solid wastes
Residential	Single family and multifamily detached dwellings low-medium and high-rise apartments, etc	Food waste, paper, cardboard, plastics, textiles, leather, yard wastes, wood glass tin cans, aluminum, other metals ashes, street leaves, special wastes, household hazardous waste.
Commercial	Stores, restaurants markets, offices building, hotels, motel, print shops service, stations auto repair shops, etc.	Paper, cardboard, plastics, wood, food, waste, glass, metals, special wastes, hazardous wastes, etc
Institutional	Schools, hospitals, prisons, governmental centers	As above in Commercial
Municipal services	street cleaning, landscaping, catch basin cleaning, parks and beaches, other recreational area	Special wastes, rubbish, street sweepings, landscape and tree trimmings, catch basin debris, general wastes from parks, beaches, and recreational areas.

Source: Omole and Akinde 2013

2.2.2 Characteristics of Municipal Solid Waste

The characteristics and quantity of the solid waste generated in a region is not only a function of the living standard and lifestyle of the region's inhabitants, but also of the abundance and type of the region's natural resources (Anon, 2005). To ensure the amount of waste that ends up at the final disposal site is minimum, and to determine the most sustainable waste management strategy, it is first necessary to identify the nature and composition of the city's urban waste (Gomez *et al.*, 2009).

2.3 Municipal Solid Waste Management (MSWM)

In developing countries, solid waste management is faced with challenges including low collection coverage and irregular collection coverage and irregular collection services, insufficient refuse dumps as well as crude open dump sites, burning without air and water pollution control the breeding of flies and vermin and the handling and control of informal waste picking or scavenging activities (Ejaro and Jiya, 2013). This is very pertinent in Ghana and Takoradi in particular where waste management services are largely inefficient and ineffective. According to Freduah (2004) one third to one-half of solid waste generated within most of these cities in low- and middle- income countries, of which Ghana is no exception, are not collected.

Generation and composition of solid waste is key in planning for the long term solid waste management in an efficient and economical manner (Aguilar-Virgen *et al.,* 2010). Such management includes the selection and operation of equipment for the treatment and handling of waste, and the types of disposal facilities that will allow for energy generation and resource recovery. This explanation is very relevant to the research as there is no known data on the generation and composition of solid waste available at the GKUA.

MSW composition studies are essential to proper management of waste for a variety of reasons including a need to estimate potential materials recovery, to identify sources of component generation, to facilitate design of processing equipment, to estimate physical, chemical, and thermal properties of the wastes, and to maintain compliance with regulations (Ahmad and Jehad, 2012; Fakare *et al.*, 2012). Waste management is an important element of environmental protection. Proper characterization of MSW is fundamental for the planning of municipal waste management services (Oyelola and Babatunde, 2008). Both planning and design of municipal waste management (MWM) systems require accurate prediction of solid waste generation (Dyson and Chang, 2005).

If solid waste management is to be accomplished in an efficient and orderly approach, the fundamental aspects and relationships involved must be identified and understood clearly (Puopiel, 2010). Fakare *et al* (2012) describe MSWM as activities that deal with waste before and after it is produced, including its minnimisation, transfer, storage, separation, recovery, recycling and final disposal. MSWM refers to the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste in urban areas (Schubeler *et al.,* 1996). MSWM incorporates the following: source separation, minimisation, collection, transfer, treatment, recovery, recycling and final disposal in an environmentally sustainable manner.

2.3.1 Municipal Waste Management Hierarchy

Waste Management Hierarchy (WMH) is a widespread element of national and regional policy and is often considered the most fundamental basis of modern MSWM practice. The hierarchy ranks waste management operations according to their environmental or energy benefits (Anon, 2005). Africa has concluded that the most sustainable way to manage waste in the majority of urban communities, like the GKUA, is to use the municipal solid waste hierarchy. It will require limited capital investment in comparison to complex and expensive waste treatment and landfill disposal systems which are typically used in developed countries. It will also require less technology and complexity (sustainable). The hierarchy is a useful policy tool for conserving resources, for dealing with landfill shortages, for minimising air and water pollution, and for protecting public health and safety (Anon, 2005).

2.3.1.1 Reduction

Waste reduction is made up of all waste management methods – source reduction, recycling, and composting – that result in reduction of waste going to a landfill or combustion facility (Post, 2007). As part of the aims of this research, reducing the amount of waste that ends up in the final disposal site to efficiently manage the waste being generated and the logical starting point for the proper management of solid waste is to reduce the amounts of waste that must be managed (Hogan *et al.*, 2006) . Thus, the reduced waste quantities do not have to be collected or otherwise managed. The reduction of waste is a primary element of solid waste management hierarchies. A good number of economically developing countries have solid waste management hierarchies that list reduction of waste as the highest priority among the generic methods to manage solid waste.

A current trend for minimising the amount of waste destined for final disposal is prompted, in large part, by the rapid diminishing of available landfill capacity (Hogan *et al.*, 2006). The view expressed by Hogan *et al.* (2006), is very relevant to the current research as the current tipping site in the Takoradi sub metro has almost reached its full capacity and therefore a new site for final disposal is sought.

From the definition above the three components of waste reduction are recycling, composting, and source reduction. Significant waste reduction could be accomplished through source reduction with increased backyard composting (Post, 2007). This suggestion is significant to the research as composting would result in diverting greater quantities of waste from the final disposal site since more than 50% of waste generated in developing countries in Africa like Ghana is organic (Mancini et *al.*, 2007).

2.3.1.2 Re-use

Achankeng (2003), has shown that there are a few formal systems of material recovery in Africa; however, there is a wide reuse of plastics, bottles, paper, cardboard, cans for domestic purposes. The practice is highly common among the poor in the city.

2.3.1.3 Recovery

The element of processing and recovery includes all the technology, equipment, and facilities used both to improve the efficiency of other functional elements and to recover usable materials, conversion products or energy from solid wastes (Puopiel, 2010). Some of the wastes are recovered through recycling and composting, and others converted into energy in the form of electricity, energy pellets or steam (Chowdhury, 2009). Recycling can divert a major portion of the waste stream from disposal site and recycling should be a fundamental part of the integrated solid waste management. Reuse and recovery of the inorganic components of the waste stream is an important aspect of waste management but special attention is given to organic (biodegradable) residues because in majority of developing countries, these residues constitute at least 50% of the waste (by weight). Many authors and researchers suggest compositing could be a very viable recovery alternative (Achankeng, 2003).

The resource recovery aspect regarding the biodegradable component is in threefold: used in agriculture as a soil amendment through composting, its energy content can be recovered and the organic content can be hydrolysed (Anon, 2005).

2.3.1.4 Disposal

The disposal site is the final ending place of all municipal solid wastes whether they are residential or any other wastes collected.

2.4 Quantity and Composition of Municipal Solid Waste

The composition of waste varies according to changes in consumer patterns and economic growth rates and depends upon standard of living, season of the year, day of the week, population habits and the geographical site of human settlement (Aguilar- Virgen *et al.,* 2010). This makes managing solid waste one of the most essential services. Managing waste is unsuccessful due to rapid urbanization together with changes in the waste quantity and composition which makes it difficult to adopt for waste management system which may be successful at other places. Thus data on waste characterization cannot be used to make decision for any different location. It is therefore necessary to quantify and characterize the MSW of the GKUA which is the subject of present investigation.

The importance of the knowledge on quantity and composition survey on waste has an essential role in determining the dimensions of the key elements in solid waste management. These elements include method and crew size, type of storage, method of disposal, and type and frequency of collection, degree of resource recovery. The determinations help in the evaluation of present conditions, as well as predicting future trends of waste. One of the factors that contribute to the poor management of solid waste is the lack of consistent data on the composition and quantity of solid waste being produced. In order to implement an effective solid waste management program, quantitative data on the composition of waste being generated must be obtained (Ejaro and Jiya, 2013).

A community needs to know how much solid waste is being generated and how fast the waste is generated so the current and future needs in budgeting, disposal facilities operation and processing can be assessed. The data on the characteristics can be used in designing processing equipment and disposal facilities. In the case of composting, information on the biodegradable fraction of the solid waste becomes important (Guangyu, 1999).

2.4.1 Quantity of Municipal Solid Waste

There are several methods available for determining the quantity of wastes that require disposal (Anon, 2005); however, accuracy of the results depends on the method followed. These methods include weighing each vehicle and its load of wastes as it enters the disposal site (the approach involves the use of a weighing scale sufficiently large to accommodate vehicles of all sizes), weighing few randomly selected incoming vehicles is an alternative and the third and final method which is the least accurate involves the collection of the following data: 1) average density of waste, 2) number of loads collected per day, and 3) average volume per load. A number of methods have been used to approximate the volume of waste generated in a given locality. These are the specific weight method, specific refuse volume and bulk density and of the three, the specific weight method gives the most reliable information on amounts of waste that can be obtained.

Waste characteristics and per capita generation rates are two important parameters in designing any effective solid waste management program. Cost of collection, treatment and disposal are rising year by year and often represent a high proportion of municipal budget therefore knowledge of these parameters help in improving the operations. These rises are as a result of the significant and disturbing changes in the characteristics and composition of wastes (Gilbertson, 1969). Normally developed countries produce more solid waste per capita (0.7 –

1.8 kg/d) compared to middle income (0.5 – 0.9 kg/d) and low income countries (0.3 – 0.6 kg/d) (Anon, 1999).

All communities, people produce domestic waste and urbanization and industrial development has rapidly increased the range and diversity, as well as quantity of wastes that require collection and disposal (Rushbrook and Pugh, 1999). In order to plan the development of a waste management facility therefore, the waste manager requires information about the quantities and types of waste that are generated within and around the municipality which may be included in the waste management plan and in addition, probable increases in quantities of each waste stream should be estimated in order to plan for future provision of facilities.

Population growth is one of the major causes of increase in solid waste volume in many cities and higher living standard results in higher solid waste generation rate and change in waste characteristics (Hoornweg *et al.*, 1999). It is a serious problem in cities of developing countries, where about 0.76 million tons or approximately 2.7 million cubic meters of municipal solid waste is produced per day. The presence of degradable organic compounds, moisture contents, particle size and composition, density and compressibility are some of the solid waste properties playing major role in degradation rate in dumpsites.

For high degree of accuracy sampling must be done at the generation source where a modest program in which special sampling areas are selected and defined. In setting up areas, care is taken all socioeconomic groups are represented. The sub metro was stratified into first, second and third class residents so as to be representation of the whole sub metro. Each participating household in the sampling area was provided with a container of some sort, a plastic bag, in which the day's output of wastes is placed. The per capita generation and total waste generation can then be determined through the sampling which is sufficiently accurate to meet most needs, whether they are for facility and equipment design or for waste management planning. Both planning and design of municipal waste management systems require accurate prediction of solid waste generation and the lack of complete historical records of solid waste quantity and quality due to insufficient budget and unavailable managing capacity has resulted in a situation that makes the long-term system planning and /or short-term expansion programs intangible (Dyson and Chang, 2005).

Globally, the per capita amounts of municipal solid waste generated on a daily basis varies significantly and going to say economic standing is one primary determinant of how much solid waste a city produces (Zurbrugg, 2002). Estimates of MSW quantities are usually based on the amount of waste generated per person per day, kg/person and that in general weight is used for

measurement of solid waste quantities. Also, in municipal environmental management, it is very important to be able to predict the amount of solid wastes generated. This information is needed not only to make environmental standards and assess environmental impacts of the wastes, but also to evaluate the potential quantities of solid waste generated and collected which are of critical importance in selecting specific equipment and in designing waste collection routes, materials recovery facilities and disposal facilities. The data can also be used for budget preparation and operation optimization as well as provide essential foundation for environmental economy programs and can greatly influence final environmental management target and strategy.

2.4.2 Composition of Municipal Solid Waste

Waste composition analyses are widely used in order to investigate the waste generated in a specific area, and also to evaluate and compare different waste collection systems. In order to make evaluations and comparisons relevant and just, evidence-based knowledge of the investigated system is required. It is also necessary to ensure that samples used for the waste composition analyses are representative of the population as a whole (Bernstad *et al.*, 2012).

Full knowledge of the composition of the wastes is an essential element in: 1) the selection of the type of storage and transport most appropriate to a given situation, 2) the determination of the potential for resource recovery, 3) the choice of an appropriate method of disposal, and 4) the determination of the environmental impact exerted by the wastes if they are improperly managed (Anon, 2005). Composition is tending to vary and becoming an important factor which determines further process and end-pipe treatment and the composition determines different waste management processes. Some waste management systems are flexible and can be applied to treat solid waste with any composition mixed or not. No pretreatment reduces the income from recyclable materials. Pre-treatment is crucial (by separating into the various compositions hence the recyclable materials are identified and separated), in recovering potential valuable products to be reused for the market (Kui, 2007). Therefore to get most from waste stream and decrease the chances of residuals from ending up in the landfill, there is the need to know what is in the waste by carrying out proper and efficient separation at source of generation. One of the most accurate approaches for characterising waste composition consists of collecting waste at its generation source and directly sorting it out into types of materials (Bernache-Perez *et al.*, 2001).

Oyelola and Babatunde (2008), say the main constituents of solid wastes are similar throughout the world but the proportions vary widely from country to country and even within a city,

because the variations are very much related to income level. Waste generated in developing countries contains large percentage of organic materials, more often than not three times higher than that of industrialized countries (Oyelola and Babatunde, 2008). The waste is also more dense and humid, due to the prevalent consumption of fresh fruits and vegetables, as well as unpackaged food. However, first world residents consume more processed food and packaged in cans, bottles, jars and plastic containers than those in the developing world. As a result, waste generated in the former contains more packaging materials than in that of the latter.

Although countries sometimes use different categories for the physical characterization of solid waste, the high content of biodegradable matter and inert material, results in high waste density (weight to volume ratio) and high moisture content (Zurbrugg, 2002). These physical characteristics significantly influence the feasibility of certain treatment options. Vehicles and systems working well with low- density wastes such as in industrialized countries will not be suitable or reliable under such conditions. In addition to the added weight, abrasiveness of the inert material such as sand and stones, and the corrosiveness caused by the high water content, may cause fast deterioration of equipment.

2.5 Municipal Solid Waste Characterisation and Generation

Waste characteristics are essential data for waste disposal facilities planning and waste management policy formulation (Chung and Poon, 2001). TSM lacks data on quantity of waste generated and their characteristics which are some of the factors that contribute to the poor management of solid waste and in order to implement efficient and sustainable waste management program, quantitative data on the composition of the waste being generated within the sub metro must be obtained. The amount of waste generated by majority of Municipal Corporations / Councils are not weighed but the quantities are estimated on the basis of number of trips of trucks which carry the waste to disposal site (Gawaikar and Deshpande, 2006) and this is not different from the situation in the TSM. The amount of waste that does not get to the disposal site is therefore not accounted for. Specific source quantification and characterization is significant to achieve the aim of the investigation therefore waste for the study was taken directly from the households.

2.5.1 Municipal Solid Waste Characterisation

Developed countries utilize various methods for waste management which give way to renewable energy forms and the emergence of new products such as compost (Topanou *et al*, 2011). In these countries, considerable investment is made to recycle waste for the benefit of agriculture; on the other hand, waste management in developing countries remains an additional

weakness which continues to hinder their emergence. Insufficient studies focused on waste characterisation in waste management planning in African cities hinder the decision-making in regards to adapting waste management as a tool of environmental protection. Waste characterisation is identified as one of the factors influencing sustainable recycling collection in developing countries (Troschinetz, 2005).

2.5.2 Municipal solid waste Generation

Waste generation are those activities that encompasses materials which are identified as no longer being of value and are either thrown away or gathered together for disposal (Momoh and Oladebeye, 2010). In 2006 the total amount of MSW generated reached 2.02 billion tones globally, that is, a 7 per cent annual increase since 2003 (Anon, 2009). It is estimated that between 2007 and 2011, municipal waste will rise globally by 37.3 per cent, corresponding to roughly 8 per cent increase per year (Anon, 2009). It is accepted that Solid waste generation is increasing at a faster rate globally as indicated by Anon, (2009); Mensah and Larbi (2005).

2.6 Source Separation and Willingness to Separate Waste

Source separation of solid waste is the setting aside compostable and recyclable material from the waste stream before they are collected with other MSW, to make possible reuse, recycling and composting (Anon 2005). This practice does not exist in the solid waste management practice of most developing countries like Nigeria but has long been practiced in developed countries.

Source separation of MSW into various components is an important option towards achieving a sustainable and integrated sole waste management system in Nigeria and GKUA in particular. It is better to separate recyclable materials at source rather than mixed waste recovery as cleaner and higher quality materials are produced through source separation (Anarfi, 2013). Source separated materials readily make available the necessary raw materials for recycling and composting plants. Relatively small portions of solid waste in additions to the inevitable by-products of composting and recycling will end up in landfills. Separation of organic waste from the MSW stream represents an opportunity to reduce the quantity of waste entering landfills in developing countries by more than 50% by weight (Oduro-Appiah and Aggrey, 2013). Source separation increases the value of MSW and prolongs the lifespan of landfills.

Introduction of source separation of waste as part of integrated solid waste management would thus require knowledge on the extent and category of separation in addition to the willingness and ability of the masses to effectively carry out the separation process. This will help develop

alternative waste management strategies that will help diverse the waste that will end up in landfills.

In a study by Oduro-Appiah and Aggrey (2013), 75.3% of households would separate their waste only if they are given free bins, 72.3% were willing to separate their waste if the waste collection fee will be reduced and only 21.9% were willing to separate their waste with no incentive. Asase and Oduro-Kwarteng (2010) reported that over 70% of households were willing to separate waste so far as motivations such as free bins were in place.

2.7 Problem of Managing Municipal Solid Waste

Some of the challenges facing solid waste management in developing countries (and for that matter Nigeria) includes: collection and disposal, low collection coverage and irregular collection services, inadequate funds to support waste management, inadequate equipment to support waste storage, crude open dumping and burning without air and water pollution control (Puopiel, 2010).

The "blind technology transfer" of machinery from developed countries to developing countries contributes to the problems of managing MSW (Nabegu 2010) and its subsequent failure has brought attention to the need for appropriate technology to suit the conditions in developing countries in terms of type of waste, composition, quantity of waste etc. Therefore the lack of data on the type of waste, its composition and the quantity pose a challenge to the selection of the right technology for treatment. Identification of waste composition is thus, critical for the selection of the most suitable technology for treatment, taking vital health precautions and space needed for the treatment facilities (Nabegu 2010).

Waste characterization is the prerequisite for developing management strategies and/or for maintaining up to date data. The lack of data is due to the very high cost of the methodologies coming from developed countries, and on their inappropriate transfer to less developed countries. These two aspects prevent effective and sustainable waste management in developing countries (Topanou *et al,* 2011)

The main problem facing Ghana in managing waste is the lack of suitable sites for disposal of solid waste (Freduah, 2004). Reduction of the amount of waste that ends up at the final disposal site will help improve the waste management as the valuable materials will be recycled due to natural population increase and rural-urban migration. This is an undeniable fact, because the oil find in the region has increased the number of people migrating into the GKUA for various economic reasons which in turn increased the amount of waste being generated. A typical solid waste management system in a developing country shows a range of problems, including low

collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control (Puopiel, 2010).

2.8 Overview of Municipal Solid Waste Management in Nigeria

Studies have been carried out on aspects of solid waste management in Nigeria. Though few were carried out on a national scale, findings from most of the studies could be applied in the other regions.

A few of the studies with cross regional or national significance are reviewed below: Adelagan (2004), traced the history of environmental policy and legislation in Nigeria to the earliest days of colonial rule around the early 1900s and posits that the formative years of environmental legislation and management in Nigeria has all along been characterized by absence of clearly laid out objectives and strategies to achieve stated objectives efficiently. Adelagan (2004) contended that there are no clearly formulated policies in Nigeria aimed at co-ordinating and addressing the harmful consequences of industrial development on the environment. The study maintains further that where legislation exists in the country, their enforcement had often been carried out rather poorly.

While it is agreed that existing environmental legislation in the country are poorly enforced, asserting that there is no body of legislation and policies, on which management of environmental concerns may be based, amounts to an over statement. This is because several other studies on the subject agree that inefficiencies in solid waste management in Nigeria cannot be blamed solely on absence of policy and effective legal frameworks (Olowomeye, 1991; Agunwamba, 1998; Walling *et al.*, 2004).

Walling *et al.*, (2004), is one of the few studies on the subject with a national perspective. The study reviews several governmental initiatives at effective and efficient management of MSW in the country, such as FEPA and VISION 2010, and conclude like, Adelagan (2004), that the Federal government currently has very little control over environmental regulation throughout the country. The study maintains further that though Local Governments were intended to fund solid waste management, most have shirked this responsibility as a result of resource inadequacies and endemic corruption in the system. The study sums up the major drivers of the MSW problem in Nigeria as poverty, population growth rate, rapid urbanization and under funding of state agencies.

Other key literature on the subject from the 1990s to early 2000 such as Olowomeye (1991), Agunwamba (1998; 2003), (Onibokun and Kumuyi (1999) in Adama (2007)) as well as Edoho and Dibie (2000) dwelt extensively on the structure and relationships between various state

agencies saddled with waste management responsibility and highlights areas of successes and major barriers militating against their efforts at sustainable management of MSW in the country.

While Olowomeye (1991) is of the opinion that many important structures required for the efficient management of MSW in the country are still missing from the Federal through to the local government levels, Agunwamba, Onibokun and Kumuyi argued that current operational difficulties in municipal waste management in the country are reflective of the general state of infrastructural and economic decay in Nigeria. To this extent they argue that any effective solution must be such that take into cognisance the overall economic position of the country. In this respect, they advocate that Government must begin to adopt integrated MSW management solutions that are private sector driven as they have greater potential for long term desirable environmental and economic improvements.

More recent studies on the subject have concentrated on the analysis of the "composition" of MSW in Nigeria, designing local management solutions for its management and situating MSW as an important resource with enormous economic potentials. Igoni (2007), analysed the composition of waste samples from Port Harcourt which is representative of other southern Nigerian cities. This analysis showed that the samples contained 66.6% of volatile solids, 13.5% fixed solids 19.1% liquids and 0.8% other components. This study showed that samples had a carbon: nitrogen ratio of 27:1. These results indicate that samples are ideal for composting as well as having a reasonable potential for energy recovery. The author points out that Port Harcourt, just like most cities in Nigeria, has no engineered landfills. As such, solid waste are most often disposed by burial or simply dumped in open dumps and water bodies.

Similar studies have been undertaken by John *et al.* (2006) for Uyo in South Eastern Nigeria, Kofoworola (2007), for Lagos, South Western Nigeria and for Makurdi, North Central Nigeria by Sha'Ato*et al.* (2007). From their study Sha'Ato*et al.* (2007) showed that approximately 82% of the MSW waste stream from Makurdi comes from households.

2.9 Municipal Solid Waste Transfer and Disposal in Nigeria

There is need to transfer all waste generated from either households or communal facilities in a safe and efficient manner to recycling facilities or final disposal site. Efficient transfer of waste in Nigeria is however difficult due to the peculiarcharacteristics of tropical waste streams, terrain and other barriers (Olowomeye, 1991).

In most parts of the country, waste transfer is still carried out haphazardly with wheel barrows, carts, open trucks, lorries, tippers and more recently by compactor trucks (Olowomeye, 1991; Afon, 2007; Coker *et al.*, 2009). As the most common means of transporting waste are open

trucks and Lorries, it is not uncommon to see street littered with waste dropping from vehicles in transit.

There is need to properly dispose of all collected waste in a safe and sustainable manner so as to avoid any negative environmental and health impacts. Various methods of waste management have evolved over the years such as burning, open dumping, landfilling, composting, incineration, disposal into the sea, pyrolysis, recycling etc (Ezeah, 2006). In the study "Recovery and recycling practises in municipal solid waste management in Lagos, Nigeria", Kofoworola (2007), noted that "the inhabitants of Lagos dump their waste at any location that suits them because there are no defined waste disposal points in the City".

This situation best mirrors the state of waste disposal in Nigeria. Open dumping and burning are still the most prevalent waste disposal methods in the country (Walling *et al.*, 2004). The very few landfills that exist in the country are neither engineered nor secured; as a result waste dumped at such dump sites eventually find their way back to block access ways, drainages, farmlands and water bodies (Olowomeye, 1991; Chokor, 1993;Adelagan, 2004).

2.10 Private Sector Involvement in Waste Management

In many cities of Asia, deficiencies in the provision of waste services are the result of inadequate financial resources, lacking management, and technical skills of municipalities and government authorities to deal with the rapid growth in demand for service. Although budgets are limited, the willingness to pay for well rendered services is high thus giving an opportunity for appropriate approaches (Zurbrugg, 2002). Solid waste collection in developing countries especially in Africa is a real challenge to the public sector. Given the level of investment the running cost of solid waste management and the competing priorities (water, health, education, road and energy) of national governments the public sector alone could not deliver the solid waste services. The private sector is partnering with the public sector to give the needed resources for the solid waste service delivery (Oduro-Kwarteng, 2011). Pressures on government to reduce taxes, while increasing and improving levels of service are leading to an exploration of privatisation as an option for waste management functions.

Privatization can take various forms. A government can award a contract to a private firm for specified MSWM services; it can contract with a private firm to construct a waste management facility, which the firm may subsequently own or operate; it can license a private firm to carry out MSWM activities and recover its costs directly from those served; or it can allow qualified firms to participate in open competition. Informal waste recovery and scavenging may be rendered more productive through support measures and appropriate technical design of the

waste management systems. Public sector involvement in waste recovery and/or leasing of waste recovery rights to private sector enterprise may be considered (Adu-Boahen, 2012).

CHAPTER THREE

THE STUDY AREA AND RESEARCH METHODOLOGY

3.1 The Study Area

3.1.1 Location and Extent

The study area is Greater Karu Urban Area (GKUA) located in the western zone of Nasarawa state and suburb of the Federal Capital Territory (FCT) Abuja, the Nigeria Capital. The focus area spans from Mararaba, Ado, New Nyanya and Masaka. It is located between latitude 8 59' 46'' N and 9 25' 00" N of the Equator and longitude 7 34' 32'' E and 8 00'00" E of the Meridian. GKUA is bordered by Keffi and Kokona LGAs in the east, FCT to the west, Kaduna state to the north and Nasarawa LGA to the south. It has approximately area of 2,640 km^2 (NPC 2006).

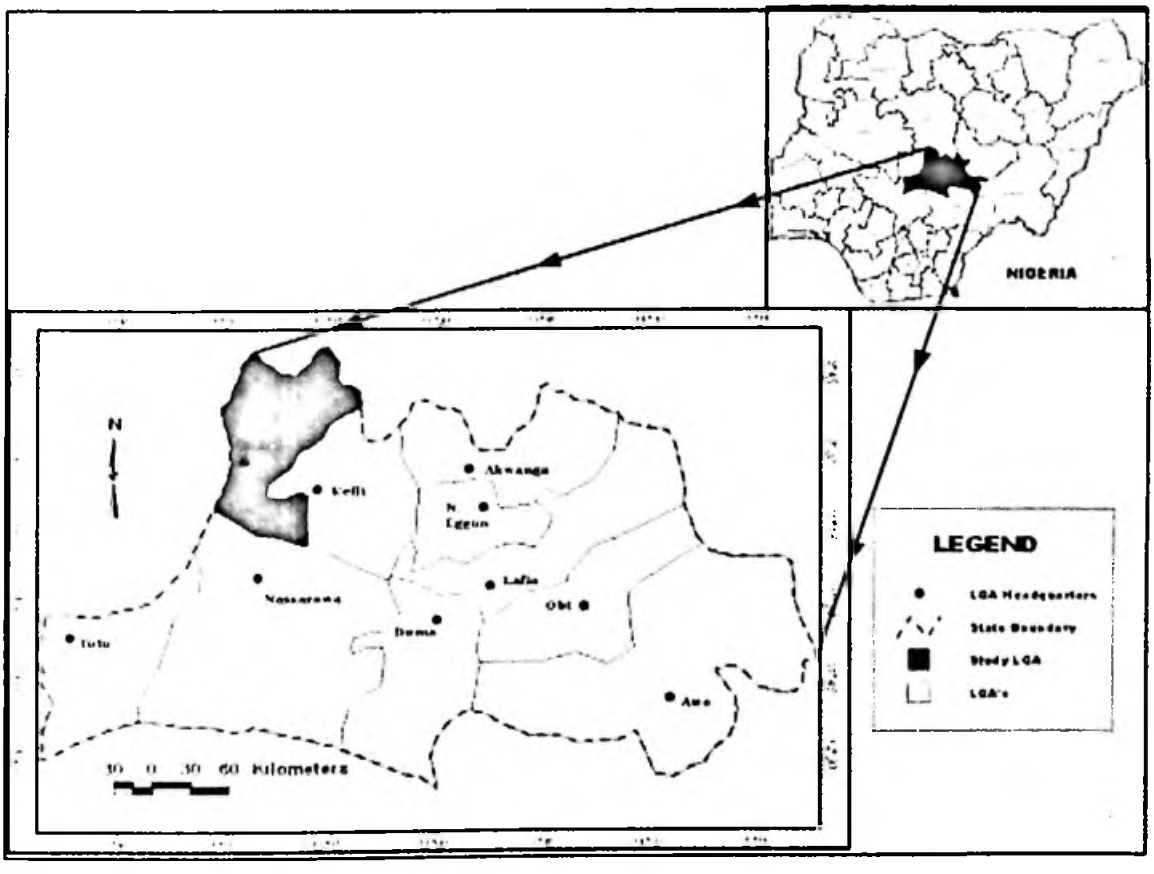


Figure3.1: Nasarawa State Showing Karu LGA

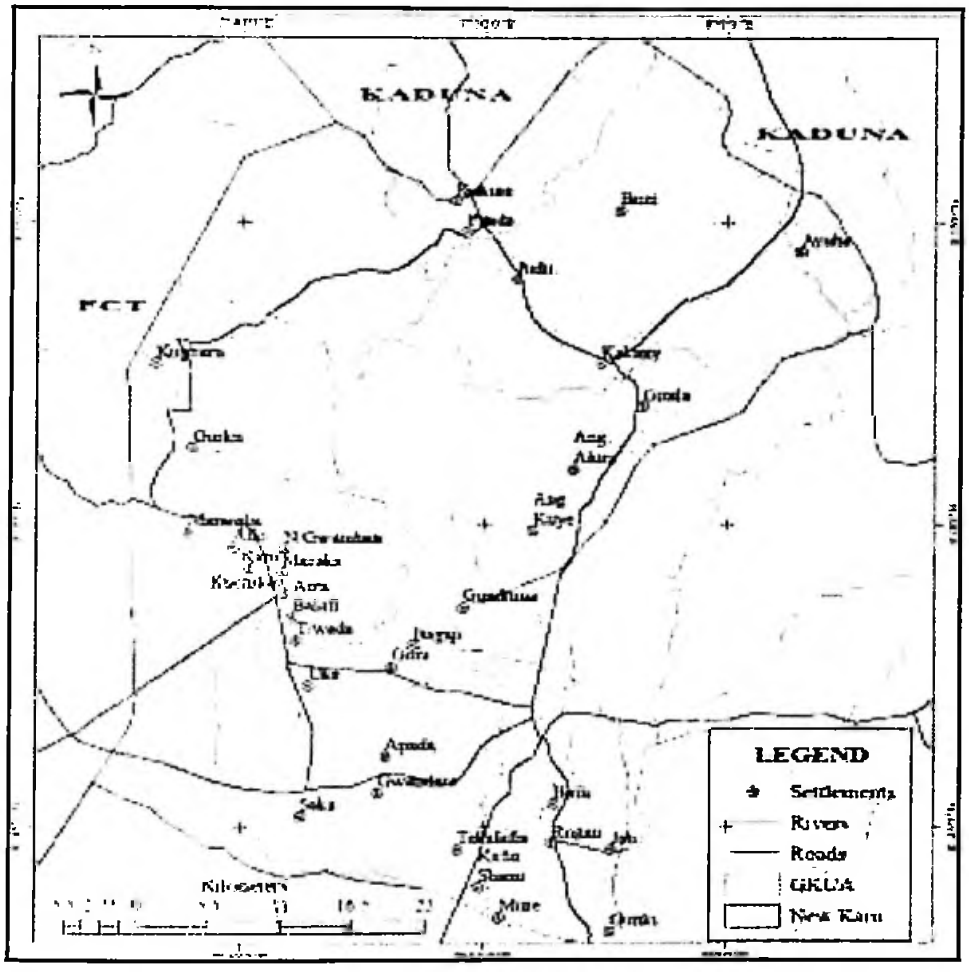


Figure 3.2: Karu LGA Sowing the Study Area (GKUA)

3.1.2 Climate

GKUA area has climate that correlate with that of savanna belt. It is under the influence of inter-tropical convergence zone (ITCZ). The area has a distinct wet and try season. The wet season start from about the beginning of May and ends in October and the try season is experienced between November and April. Annual rainfall ranges from about 1100mm to about 200mm. About 90% of the rain falls between May and September. The rain comes in thunder storms of high intensity particularly the beginning and towards and towards the end of the rainy season. The temperature is generally high during the day particularly between the months of March and April. The mean monthly temperature is in the range of 20 c to 34 c with the hottest month being March and April and the coolest month being December and January (Binbol, 2007).

Sunshine as one of the weather element is closely associated with other elements like cloudiness radiation, evaporation amongst others. There annual variations which are not as pronounced as the spatial or seasonal variations. Between November and April, the mean sunshine hour is about 250 hours in the southern part of the study area to over 275 hours in the northern part of

the study area. There is occurrence of a sharp drop in the months of May to September, an average monthly sunshine hours occur in the month of August due to almost continues total cover of the sky by clouds (Bindol, 2007).

3.1.3 Soila and Vegetation

The soil formation in GKUA is a product of the interaction of myriad of factors such as rock types, local climate, organic matter (plants and animals), topography and time. Complex relationship exist between the soil types and the forming processes; this is because most parts of the L.G.A have undergone series of climatic and vegetative shifts (Samalia Ezeaku, 2007). The major soils units of the area as observed by Lyam (2000) belong to the category of tropical ferruginous soils are derived mainly from the basement complex formation and older sedimentary rocks typically of the savannah belt of Nigeria. It has a high content (0.02-2.00mm in diameter). The soil has high bulk density which makes it resistant to erosion processes. The soil has high infiltration capacity and high water holding capacity (Samalia and Ezeaku, 2007).

The vegetation on the hilly parts of the area are composed mainly of grasses and isolated trees. Tres of economic value including locust beans, shea butter, Neam, Mango, Citrus and Banana are scattered across the area, particularly in the lowland area and the southern part of the study area. The forest is evergreen with some elements of deciduous. The dominant woody species in the study area are those also found in the southern Guinea Savanna of the state. These include, Tarmarindus indica amongst many others. Species of grasses that occur in Northern Guinea are very similar to the southern Guinea with more grassland and woody shrubs than trees. The abundant grass species here are the Penisetum, Andropogon, Monocymbium ceressiforme, Hyparrhernia, Bracharia and Aristida among others (Aboki et al, 2007).

3.1.4 Relief and Drainage

The area lies between 300-100meter above the sea level except the hilly areas of kajari and Gitata whose elevation reached 2154 meter in kajari and 2760meter in Gitata respectively. The Uke River is another major river in the state that flows through the Northwestern corner of Karu hills to the Southwest Kugwaru forest. The river takes it source from North-central Highlands and flows through towns like Panda and Nasarawa Benue east of Umaish.Its major tributaries are rivers Ado,Obi and Antau (Samaila and Bimbol,2007).

3.1.5 Geology

The geology of the study area is made up basement complex rocks cover about 70% of the total superficial area of the state while the remaining 40% is made up of sedimentary rocks of the middle Benue trough. The younger granite intrude the basement complex and therefore do not occupy any separate land mass of their own. Of the basement complex migmatite, gneisses along with the older granites accounts for about 70% while rocks of the schistose lithology and other metasedimentary series [schist,quartzite,marble,ironstone] (Obaje et al, 2007).

3.1.6 Economic Activities

Trade and farming are the major economic activities in GKUA. Crops are grown primarily for consumption and trade. Some people engage in weaving of mats and blacksmithing. Nomads (Fulani) supply cattle (Beef) and milk is sold in the area. Apprentices such as in tailoring and automobile mechanic are also common among youths. Recently, apart from agriculture logging is the leading economic activity that is carried out in the study area, and most of the participants are youths. From field observation and inquired made, about 60% of youths that are not schooling have already take up logging to be their major occupation.

3.2 Research Methodology

3.2.1 Data Types and Sources

Data used for the study were from both primary and secondary sources. Among the data that were primarily obtained are: the different categories of waste generated by the sampled households in the study area; household income level; the household size; knowledge on waste collection and willingness to cultivate the habit of waste separation for efficient collection and disposal.

In addition, Secondary data were obtained from published and unpublished works, such as journals, magazines, newspaper, and text books.

3.2.2 Reconnaissance Survey

The reconnaissance survey involved visiting randomly selected households to inform occupants about the survey work and to communicate the importance of the respondent's participation and how the respondents will be involved. The field survey was to help receive feedback on their willingness to participate in the programme. Participants were assured of the confidentiality of their responses. The suitability of the study area households as points for sorting at source was also assessed.

3.2.3 Data Collection

Administration of questionnaires and direct field measurements were the two approaches adopted in obtaining data relevant for the study. A well-structured questionnaire was developed and administered randomly to sample households for collection of relevant data relating to the research work. The household waste characterization survey questionnaire looked at solid waste management and the minimisation of waste through recycling at the household level. Also information about each respondent, the household socioeconomic status, household waste disposal methods, knowledge on waste separation, knowledge on waste management and knowledge on recycling were sought for in the questionnaire. The content of the questionnaire was based on five of the twelve factors influencing sustainable recycling of municipal solid waste in developing countries identified by Troschinetz (2005). The factors were waste collection and segregation, household economics, household education, local recycled-material market and MSWM administration.

Data were also collected through observations and direct field data collection using a sheet to record waste weighed after sorting into various components. The collected waste materials were filled in polythene bags and weighed using a weighing balance equipment.

3.2.3.1 Education of Households on the Survey

The randomly selected households were educated on sorting and separation of waste. This was done on one-on –one basis after the questionnaire administration and for a period of two weeks. During the period, a one way separation method was explained to them as to which materials were to be sorted into which colour of polythene bags that were provided. Also, the importance of the survey was explained to the respondents to encourage their full participation. Households were also allowed to ask questions and they were also tested for their understanding on the sorting and separation activities by asking them questions.

3.2.3.2 Distribution of Polythene Bags and Waste Bins

Two polythene bags were supplied to each of the randomly sampled households for the separation of their solid waste. Each household was given a blue polythene bag for biodegradables (BIO) and a black polythene bag for non-biodegradables (NON-BIO). In the case of the third class residents, a waste bin each was distributed to them to keep the polythene in since they did not have proper waste bins.

3.2.3.3 Collection of Waste from Households and Further Sorting

Waste from the households was collected three (3) times in a week (Mondays, Wednesday and Fridays) over a period of five (5) weeks. The waste was sorted and separated in the two polythene bags. Biodegradables (food, yard and wood waste) was sorted into the blue polythene bag while the non-degradable waste (plastics, paper and cardboard, metal, glass, leather and rubber, inert and all other waste) was sorted into the black polythene bag. Further sorting and separation was carried out into various physical components and weighed and recorded.

3.2.4 Sampling Technique

Purposive and random sampling techniques were utilized in the study. Purposive sampling was used in the selection three different settlements from the study area. The selection was based on basic socioeconomic classes (first, second and third class residential areas) as defined by the district directorate of housing and planning. Hence, Abacha Road, Veronica Estate and Jogodo settlements in Mararaba, New-Nyanaya and New-Karu respectively were selected accordingly for the classes. The first class residential areas are made up of single detached houses out-side the city centre with gardens/lawns and usually have quiet neighbourhood. Second class residential areas are made up of high rise buildings or multiple occupancy properties with no gardens/lawns and are characterised by mixed residential properties like semi-detached flats and multi-family properties. The communities in third class residential areas are unplanned and have many squatters. Low income families dominate and they are normally condensed, overcrowded and noisy. The crime rate is high.

The target groups for the questionnaire were heads of household, particularly women in the sample households because they are the persons often in charge of cleaning, gathering and final disposal of household waste in the home. Following the procedure outlined by Nordtest (1995), household numbers of 50- 250 would be representative enough to undertake the survey. The household sampled as a function of the population size in each of the stratified class is as listed in Table 3.1.

Table 3.1: Number of households of the various classes

SN	CLASS OF RESIDENTIAL AREA	SAMPLE SIZE
1	Abacha Road	28
2	Veronica Estate	34
3	Jogodo	31

Source: Author's design 2017

The sampling of households was carried out randomly. At first, each residential class area was mapped into blocks using pathways, and the house numbering were used for raffle selection of the houses from which respondents were drawn for questionnaire administration. In the case of the third class residential area where house numbering is not adequately done, the house in the area were numbered and the numbers were used for the draw. In the case of multiple occupancy for the second and third class residential areas, another draw was design for the households occupying a selected house in order to determine which should be finally selected for the survey.

3.2.5 Data Analysis

3.2.5.1 Physical Composition of MSW Analysis

MSW from the households were segregated into the following compositions and analysed by weight as well as the percentage composition described by the ASTM (2003) method. By modification the following were adopted:

Blue polythene bags for Biodegradables

- Food waste, yard waste and wood

Black polythene bags for non-biodegradables, except paper

- Plastics (PET, HDPE, PVC, LDPE, PP, PS and Pure water sachet)
- Metals
- Papers (packaging/cardboard/office print/sheet/newsprint and tis- sue/diaper)
- Leather and Rubber
- Textiles
- Inert (sand, ceramic, rock, ash)
- Miscellaneous (other materials which could not fit in the above).

$$\text{Composition of separated waste} = \frac{\text{Weight of separated waste}}{\text{The total mixed weight sampled}}$$

3.2.5.2 Separation Efficiency

The efficiency of the separation was assessed by the weight of sorted waste in the designated polythene bag provided as a percentage over the total weight of waste in the same bin.

Example:

$$\text{Separation efficiency of BIO} = \frac{\text{Weight of BIO in blue polythene bag}}{\text{Total weight of all waste separated into blue bag}}$$

The administered questionnaire helped to determine the preparedness of the participants to separate their waste at any given period. This was compared with how best the separation was done and attributions to the level of separation achieved were assigned considering the background of the household.

3.2.5.3 Waste Quantification

The per capita generation of the waste and the total waste generation were deduced from the waste components separated. The separated wastes were collected, weighed and recorded. The waste were then sorted again and separated into various components and reweighed. The per capita generation was determined as per the mixed and also the separated components using the formula:

$$\text{Per capita waste generation} = \frac{\text{Weight of MSW generated at the household}}{\text{Total number of persons in the household x total generation days}}$$

The total Generation rate was obtained by multiplying the per capita generation by the total population in the sampled households.

3.2.5.4 Statistical Data Analysis

The statistical package for Social Sciences (SPSS) 17 for Windows and Microsoft Excel were used to analyse the data obtained. SPSS was used to establish if any correlations exist between income levels, household size of the three socioeconomic classes and the per capita generation. One way ANOVA was used to test for significant difference between the three classes. The mean value in relation to the standard error of the separation effectiveness of the waste in the three classes was determined using the SPSS. The significance was at $p=0.05$ (95% confidence level).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socioeconomic Characteristics of the Respondents

Table 4.1: Distribution of Respondents by Socioeconomic characteristics

ITEM	NUMBER OF RESPONDENTS	PERCENTAGE (%)
Gender		
Male	32	34.41
female	61	65.59
Age		
15 - 24	4	4.30
25 - 34	14	15.05
35 - 44	38	40.86
45 - 54	25	26.88
≥55	12	12.90
Household Size		
1 – 5	47	50.54
6 – 10	32	34.41
11 – 15	10	10.75
>15	4	4.30
Educational Level		
Tertiary	30	32.26
Secondary	35	37.63
Primary	19	20.43
No Formal Education	9	9.68
Employment Status,		
Abacha Road	17	60.71
Informal	8	28.57
Unemployed	3	10.71
Veronica Estate		
Formal	12	35.29

Informal	16	47.06
Unemployed	6	17.65
Jogodo		
Formal	8	25.81
Informal	18	58.06
Unemployed	5	16.13

Source: Field Survey 2017

Table 4.1 shows the surveyed socioeconomic characteristics of the respondents. The survey reveals that of the 93 respondents, 66% were females and 34% males. Majority of the respondents representing 40.86% fell within the 35 – 44 years age bracket, followed by those within the ages of 45 – 54 years (26.88%), 25 – 34 years (1505%). Those whose ages were either equal or greater than 55 years and between 15 and 24 had the least representations with 12.9% and 4.3% respectively. In terms of household size, 50.45% of the respondents had a household size between 1 and 5, the household size of 6 – 10 accounted for 34.41% of the respondents, 10.75% and 4.3% had household sizes of 11 – 15 and >15 respectively. A good number of the respondents (30) representing 32. 26% have attained tertiary education in the study area, 37.63%, 20.43% and 9.48% have attained secondary, primary and no formal education respectively. The employment status of the respondents revealed that 37 of the respondents were formally employed. Out of these, 60.71% were from the first class residential area, 35.29% from the second class and 25.81% from the third class area. Out of the 42 respondents who had informal employment, 28.57% were from the first class residential area while 47.06% and 58.06% were from the second and third class residential areas respectively. Unemployed respondents were 15.05 out of which 10.71%, 17.65% and 16.13% were from the first, second and third class residential areas respectively.

4.2 Physical Composition and Quantity of Household Waste

Table 4.2: Composition of Municipal Solid Waste in Mararaba

PHYSICAL COMPOSITION OF WASTE	CLASS RESIDENTIAL SETTLEMENTS					
	Abacha Road		Veronica Estate		Jogodi	
BIODEGRADABLES	**Wt kg**	**Wt %**	**Wt kg**	**Wt %**	**Wt kg**	**Wt %**
Food Waste	1799.77	*42.47*	2255.93	*60.76*	1376.15	*36.62*
Yard Waste	1109.29	*26.18*	44.3	*1.19*	317.5	*8.45*
Wood	97.8	*2.31*	34.9	*0.94*	42.1	*1.12*
	3006.86	*70.95*	2335.13	*62.89*	1735.75	*46.19*
NON-BIODEGRADABLE						
Paper and Cardboard						
News/Office Print/ Cardboard	152.7	*3.6*	167.56	*4.52*	93.8	*2.49*

Tissue Paper/Diaper	217.9	*5.14*	141.3	*3.81*	93.5	*2.49*
	370.6	*8.74*	**308.86**	*8.32*	**187.3**	*4.98*
Plastics						
Plastic Film/LDPE	146.4	*3.45*	249.02	*6.71*	219.6	*5.84*
Polyethylene Terephthalate	85.7	*2.02*	50.91	*1.37*	29.9	*0.8*
High Density Polyethylene	45.5	*1.07*	36.2	*0.97*	24.5	*0.65*
Pure water sachet	54.65	*1.29*	125.31	*3.38*	65.5	*1.74*
Polypropylene	33.5	*0.79*	28.51	*0.77*	17.7	*0.47*
Polystyrene	32.95	*0.78*	15.32	*0.41*	4.2	*0.11*
Polyvinyl Chroride	11.1	*0.26*	6.7	*0.18*	8.8	*0.23*
Other Plastics	13.5	*0.32*	20.6	*0.55*	8.91	*0.24*
	423.3	*9.99*	**532.58**	*14.34*	**379.11**	*10.09*
Metal	**132.9**	*3.14*	**93.25**	*2.51*	**55.6**	*1.48*
Glass	**116.4**	*2.75*	**45.7**	*1.23*	**20.6**	*0.55*
leather and Rubber	**27.1**	*0.64*	**83**	*2.24*	**29.8**	*0.79*
Textiles	**79.8**	*1.88*	**181.22**	*4.88*	**73.6**	*1.96*
Inert	**33.2**	*0.78*	**55.5**	*1.49*	**820.8**	*21.84*
Miscellaneous	**46.7**	*1.1*	**68.3**	*1.84*	**450.7**	*11.99*
TOTAL	**4237.96**	*100*	**3712.94**	*100*	**3757.46**	*100*

Source: Field Data Analysis 2017

Table 4.2 shows the physical composition by weight of the waste stream obtained in the study area over the entire survey period. The waste stream from the Abacha Road had 70.95% biodegradable waste, 8.74% paper and cardboard, 9.99% plastics, 3.14% metals, 2.75% glass, 0.64% leather and rubber, 1.88% textile, 0.78% inert and 1.10% miscellaneous. Veronica Estate had 62.89% biodegradable waste, 8.32% paper and cardboard, 14.34% plastics, 2.51% metals, 1.23% glass, 2.24% leather and rubber, 4.88% Textile, 1.49% inert and 1.84% Miscellaneous. Adakope has 46.19% biodegradable waste, 4.98% paper and cardboard, 10.09% plastics, 1.48% metals, 0.55% glass, 0.79% leather and rubber, 1.96% textile, 21.84% inert and 11.99% miscellaneous.

The percentage composition of biodegradables were highest for all three areas. Leather and rubber had the lowest composition for Abacha Road while glass had the lowest by weight for both Veronica Estate and Jogodo. The figures shown in the table are averages of all the samples taken. Averagely the study area has 60.01% biodegradables, 11.47% plastic, 7.35% paper and cardboard, 2.38% metals, 1.51% glass, 1.22% leather and rubber, 2.91% textiles, 8.04% inert materials and 4.98% miscellaneous materials.

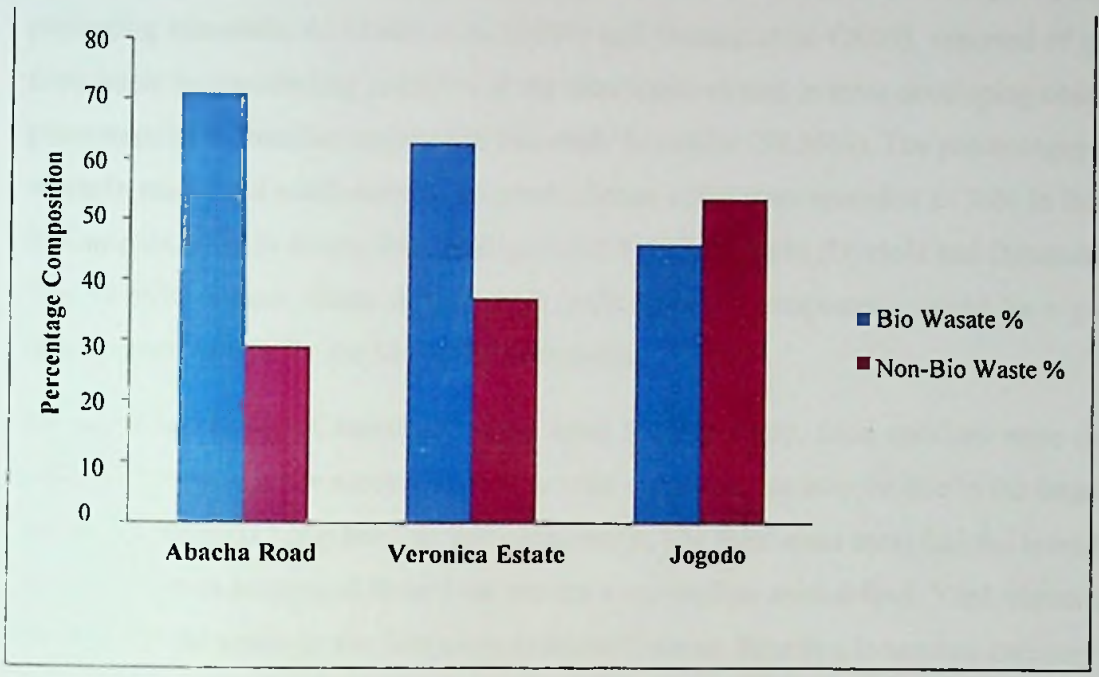


Figure 4.1: Categorisation of Waste stream into Bio and Non-Bio

A total waste load of 11,708.36 kg was weighed, out of which 3757.46 kg belonged to the low socioeconomic status, 3712.94 kg to the medium status and 4237.96 kg to the high status (Table 4.2). It can be seen that biodegradable waste generated by the three classes decreased steadily and the non-biodegradable waste increased steadily from the first to the third class. One-way ANOVA test indicates that there is no significant difference in the quantity of waste generated among the three residential classes (Appendix). The ANOVA produce a test statistic of 0.05 and a p-value of 0.96 which is greater than any significance level.

Of the three socioeconomic groupings; biodegradables (food, yard and wood waste) accounted for more than half of the total except for the third class area which has high amount of Inert and miscellaneous materials (Table 4.2) accounting for the high amount of non-biodegradable waste generated compared to the other residential areas.

The first and second classes had their waste stream made up of more biodegradables than non-biodegradables (Fig. 4.1). The independent t-test for Abacha Road, Veronica Estate and Jogodo residential classes between Bio waste and Non- bio waste shows that, there is a significant difference between the two groups of waste generated by the various classes.

Results from the study show that food residues were on average the most abundant (58.56% putrescible; food and yard) waste in all the three classes of residential areas. This is also the case in many developing countries where buying of unprocessed food to be cooked at home

leading to a lower representation of food waste in household waste but a higher percentage of packaging materials. Al-khatib *et al.* (2010) and Gomez *et al.* (2009), reported of garden and food waste as contributing to 65.1% of the total waste stream in most developing countries. The percentage of putrescible reported in this study is similar (58.56%). The percentages of organic waste in municipal solid waste in selected African cities were recorded as 56% in Ibadan, 75% in Kampala, 85% in Accra, 94% in Kigali and 51% in Nairobi (Oyelola and Babatunde, 2008). The 58.56% organic waste in this study indicates that composting would be a good waste management option for the Mararaba metropolis.

Of the three classes of residential areas used for this study, food residues were the highest volumes of waste in the second socioeconomic class and this may be due to the large numbers of local restaurants " hop bars" in that community. The third class areas had the lowest volumes of food residues as most of these food wastes were used as animal feed. Yard trimming formed the bulk of the waste in the first class residential areas. Textiles, is another category of waste that stands out as it formed only 1.88% of the total waste generated within the high socioeconomic status area. This should have been higher considering their high purchasing power and the ever-changing fashion trends within such communities. However, this may be because they give out most of their unwanted clothes to their domestic workers before discarding the rest.

4.3 Separation Efficiency and Willingness to Separate Waste

Table 4.3: Mean ± standard error of the Separation Efficiency of the various classes of Residents

SEPERATION EFFICIENCY (MEAN ± SE) Class of Residents	WK 1	WK 2	WK 3	WK 4	WK 5
BIO					
1st C lass	6.82±0.6	6.87±0.6	6.81±0.6	6.47±0.6	5.44±0.6
2nd Class	4.21±0.2	4.32±0.3	4.12±0.2	4.07±0.2	3.95±0.3
3rd Class	3.10±0.2	2.67±0.2	2.95±0.2	2.74±0.2	4.09±0.4
NON-BIO					
1st C lass	1.04±0.4	1.70±0.2	0.60±0.1	1.03±0.2	0.66±0.1
2nd Class	3.20±0.6	2.00±0.5	0.80±0.3	1.74±0.4	1.50±0.3
3rd Class	3.13±0.4	2.43±0.4	0.80±0.2	0.34±0.1	4.37±0.2

Field Data Analysis 2017

Table 4.3 shows the mean values of how well the various classes of residents separated (separation efficiency) waste into the right polythene bags provided for the survey. From the table, the heading " bio" represents amount of biodegradable waste in the right polythene bag

Table 4.3 shows the mean values of how well the various classes of residents separated (separation efficiency) waste into the right polythene bags provided for the survey. From the table, the heading " bio" represents amount of biodegradable waste in the right polythene bag given the selected households and the heading "Non- bio" represents the amount of waste in the right polythene bag that is, the polythene bag that is to contain only non-biodegradables waste.

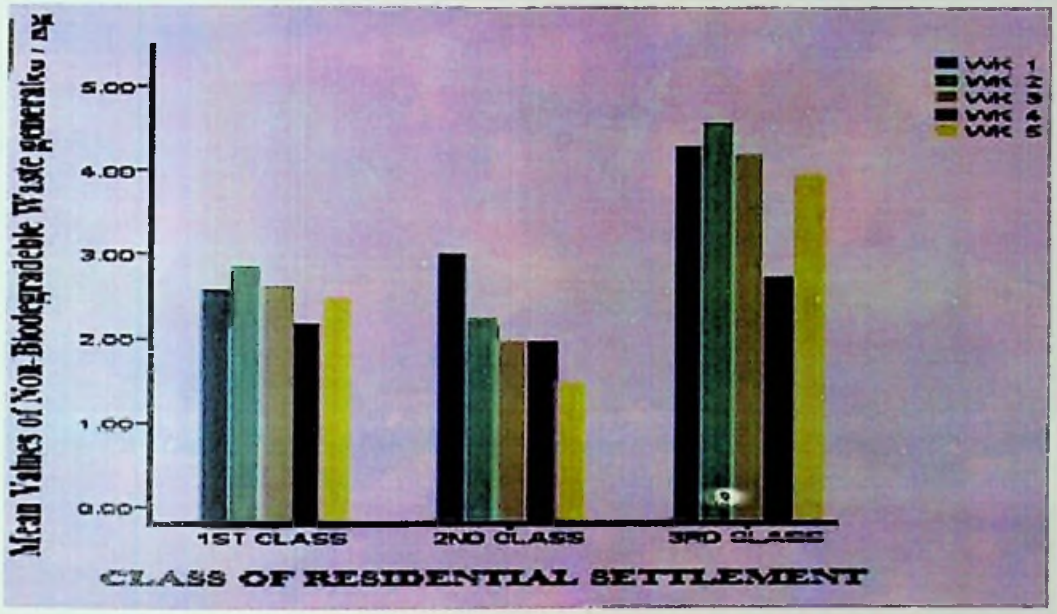


Figure 4.2: Amount of Non-Bio in the Non-Biodegradable Polythene Bag

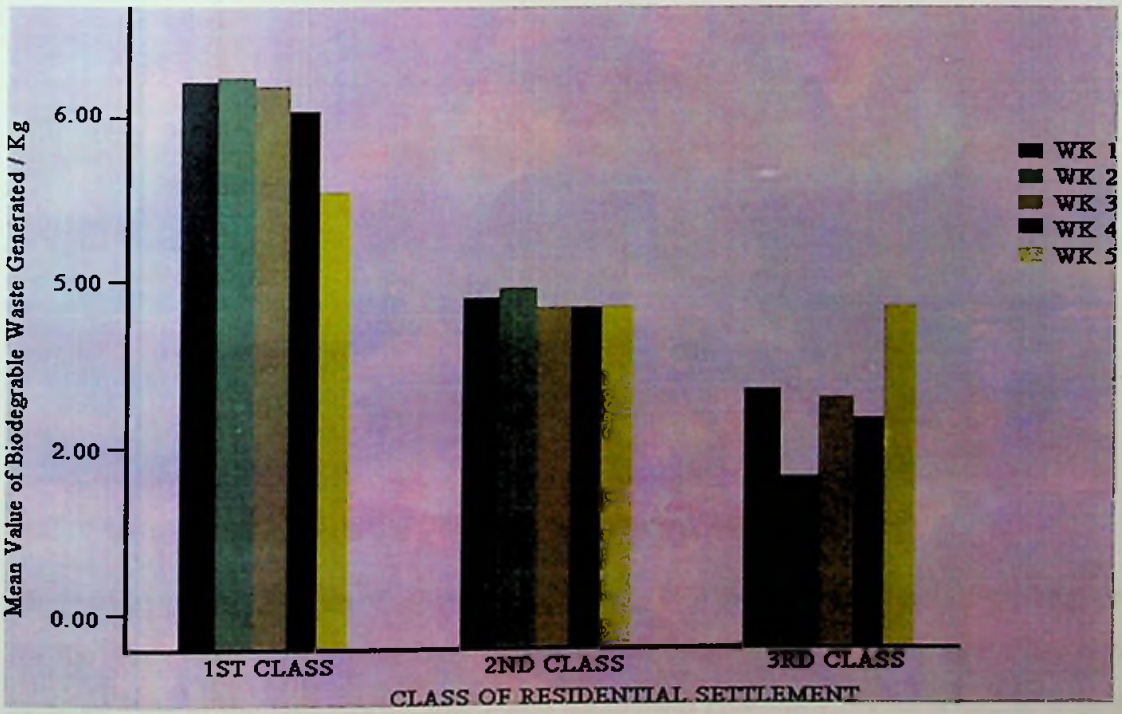


Figure 4.3: The Amount of Bio in the Biodegradable Polythene Bag

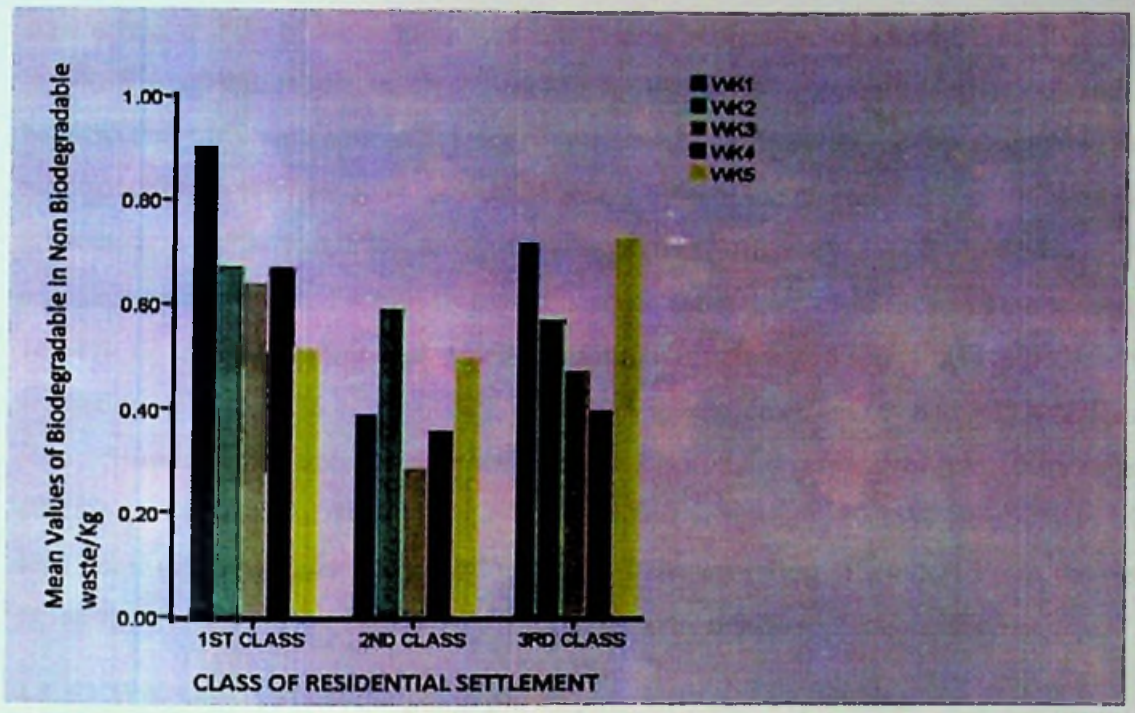


Figure 4.4: The Amount of Bio in Non-Biodegradable Polythene Bag

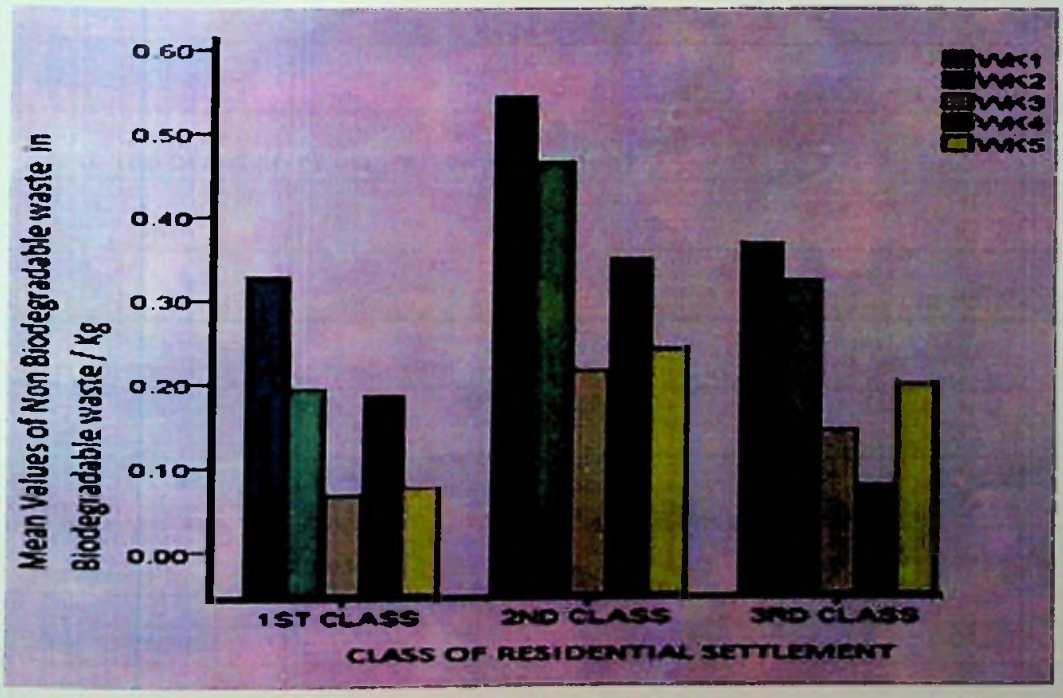


Figure 4.5: Amount of Non-Bio in Biodegradable Polythene Bag

There were various degrees of separation efficiency into the designated polythene bags provided for the study. In the polythene bag designated for biodegradable in the first class residential area, 18.57% of the respondents had 100% separation efficiency, 79.29% had 80% to 99.99% separation efficiency and 1.76% had 50% to 79.99% separation efficiency. However, in the second class, 6.50% of the respondents had 100% separation efficiency, 83.53% had 80% to 99.99% separation efficiency and 9.64% had 50% to 79.99% separation efficiency. In the third

class areas, 14.77% of the respondents had 100% separation efficiency, 76.13% had 80% to 99.99% separation efficiency, 7.10% had 50% to 79.99% separation efficiency and 1.94% had less than 50% separation efficiency. For the waste in the polythene bag designated for non-biodegradable in the first class residential area, 4.50% of the respondent had 100% separation efficiency, 51.43% had 80% to 99.99% separation efficiency, 39.29% had 50% to 79.99% separation efficiency and 4.28% had less than 50% separation efficiency. In the second class, 16.47% of the respondent had 100% separation efficiency, 53.53% had 80% to 99.99% separation efficiency, 26.47% had 50% to 79.99% separation efficiency and 3.53% had less than 50% separation efficiency. In the third class, 3.23% of the respondent had 100% separation efficiency, 74.84% had 80% to 99.99% separation efficiency, 19.35% had 50% to 79.99% separation efficiency and 2.58% had less than 50% separation efficiency. From the result, it shows that less than 5% of the respondents had less than 50% separation efficiency.

4.3.1 Willingness of the People to participate in Waste Separation

Table 4.4: General Knowledge on Waste and Waste Separation

Item	Number of Respondent	Percentage %
Have you heard of, or seen waste separation?		
Yes	57	61.29
No	36	38.71
Are you willing to separate your waste?		
Yes	67	72.04
No	26	27.96
Have you heard of, or seen waste recycling?		
Yes	86	92.47
No	7	7.53
If recycling centre is established would you send waste for recycling?		
Yes	72	77.42
No	21	22.58
Would you accept concept of home composting?		
Yes	69	74.19

No	24	25.81
Would you buy an extra bin for home composting?		
Yes	43	46.24
No	50	53.76

Source: Field Survey 2017

Source separation programs need high participation rate of the people and a guaranteed participation is difficult to measure since what people say they will do and what they actually do may not be the same. The willingness to separate waste at source may not reflect in the actual separation of the waste at source. The willingness of households to separate waste at source on average was 71.4%, 79.4% and 64.5% for first, second and third class areas respectively. This is consistent with research by Anarfi (2013), who recorded 73.3% and 86.7% for the low and middle income groups, respectively. It is also consistent with work by Asase and Oduro-Kwarteng (2010), who reported that over 70% of respondents in their study area were willing to separate their household waste at source. The results from other researchers have also confirmed the high willingness to separate household waste in Nigeria (Asase and Oduro-Kwarteng, 2010). Respondents from the third class had the lowest response in terms of willingness to separate waste at source and the explanation may be because they did not believe initially the collection and disposal of their waste from their residence will totally come at no cost to them.

The separation efficiency achieved for separating waste at source for the study was 95.70%, 90.86% and 91.32% for the first, second and third class respectively for the polythene bag designated for biodegradable while that for the non-biodegradables was 79.76%, 84.65% and 85.85%. This indicates that the numbers of households who were willing to separate at source and those who actually participated in the source separation were different. The willingness was much lower than what was actually separated at source. The high percentage of people achieving a good separation was probably due to the explanation given to them on the benefits of source separation to the existing solid waste management system in the area. The level of separation efficiency achieved by the third class residents considering their prior knowledge of separation (41.9%) and their willingness to separate waste (64.5%) may be because they have problems with managing their waste especially disposal. The much lower separation efficiency achieved in the bag designated for non-biodegradable may be because some amount of food waste was left in the packaging.

The results from the questionnaire and field survey suggest that a culture of waste segregation does not exist in the study area. However, there were a high number of residents (72.04%) who were willing to separate their waste. This indicates a desire for access to other disposal options in the community, like recycling (77.42% of respondents are willing to send waste for recycling) and composting (74.19% of respondents are willing to accept the concept of home composting).

4.4: Per Capita Waste Generation

Table 4.5: Average per Capita Waste Generation by Class of Residential Area

SN	SIZE	Abacha Road	SIZE	Veronica Estate	SIZE	Jogoda
		Average		Average		Average
1	6	1.12	7	0.38	9	0.56
2	6	1.14	3	0.82	6	0.82
3	4	0.97	6	0.54	6	0.74
4	6	0.71	5	0.54	10	0.26
5	3	1.02	3	0.9	10	0.26
6	5	0.60	5	0.5	5	0.62
7	6	0.75	9	0.34	6	0.4
8	5	1.33	10	0.14	4	0.82
9	8	0.38	4	1.08	3	1.12
10	4	1.29	5	0.8	4	0.78
11	8	0.39	3	1.1	5	0.74
12	6	0.80	8	0.32	5	0.58
13	7	0.53	4	0.68	4	0.68
14	6	0.73	4	0.78	2	1.44
15	8	0.63	6	0.58	8	0.48
16	14	0.21	5	0.76	5	0.68
17	9	0.61	11	0.26	6	0.36
18	9	0.39	4	0.84	4	0.56
19	6	0.84	4	0.78	3	0.94
20	5	0.60	5	0.74	6	0.58
21	5	0.61	5	0.56	5	1.02
22	4	1.19	2	1.48	4	0.86
23	4	0.88	6	0.74	6	0.56
24	6	0.52	4	0.76	8	0.56
25	7	0.46	8	0.34	2	2.1
26	7	0.86	5	0.48	6	0.52
27	5	1.35	2	1.36	12	0.36
28	9	0.74	6	0.58	7	
29		0.38	9	0.64	6	
30		0.68	5	0.22	16	
31		0.74	4	0.64	6	
32		0.36	10			
33		0.3	15			
34		0.74	4			
Average		**0.76**		**0.66**		**0.69**

Source: Field Data Analysis 2017

The total daily per capita generation rates show the first class areas having a higher rate of 0.76 compared to the second and third class which had generation rates of 0.66 and 0.69 respectively. The average for the three classes was 0.70, which is similar to the per capita generation of 0.75 kg/ca for metropolitan and municipal areas (Anon, 2010). This is above the estimated national average of 0.5 kg per capita per day (Mensah and Larbi, 2005). This result is in line with global trends for developing countries which also indicate an increase in MSW generation rate with improving economic conditions (Gomez *et al.,* 2009). In the city of Kitwe, Zambia, the daily per capita generation in the year 2003 for low, medium and high income areas was 0.40, 0.60 and 0.68 kg per day respectively but our present study was 0.69, 0.66 and 0.76 for low, medium and high income areas respectively. Developed countries normally produce more solid waste per capita (0.7 – 1.8 kg/d) compared to middle income or developing countries (0.5 – 0.9 kg/d). Nigeria and for that matter GKUA falls in the middle income category. This rate is much lower than those reported for some developed or high income countries like the US (1.98 kg), Canada (1.64 kg), Japan (1.22 kg) and Germany (1.15 kg), but slightly higher than those found in developing economies like India (0.41 kg) and Yemen (0.45 kg). The ANOVA test of per capita waste generation rate among the three classes indicates that, there is significant difference among the three classes of per capita waste generated over the period. The ANOVA test produced an F-statistic of 0.05 and p-value 0.96, which means that the differences between the classes are significant at 5% significance level.

Table 4.6 ANOVA Test for Differences in Per Capita Waste Generation of the Three Residential Classes

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	12599.69	2	6299.84	0.05	0.96	3.14
Within Groups	8669101.64	63	137604.79			
Total	8681701.33	65				

Table 4.7: Relationship between Income Level and Per Capita Waste Generation

AVERAGE WASTE PER CAPITA	1ST CLS INC	2ND CLS INC	3RD CLS INC
1ST CLS AVR	-0.0082	*	*
2ND CLS AVR	*	-0.1838	*
3RD CLS AVR	*	*	-0.0177

****. Correlation is significant at the 0.01 level (2-tailed).**

The results show that the higher the income level the lower the per capita generation of waste per weight generated. However, the correlation variables can be considered as a weak effect therefore no or negligible relationship or a non-significant correlation exist between the income level and per capita waste generation.

This data confirms that, in general, a direct correlation exists between the economic status of a country and its HSW generation rate in urban areas (Bernache-Perez *et al.*, 2001). In this study, the per capita waste generation was negatively correlated with income levels, that is, as income levels rise, the amount of waste generated reduces (Aisa, 2013). This is because most households purchase cheap inferior items that do not last and have to be discarded in a relatively shorter time. If the income levels are high, people tend to buy quality and durable products that last long. It might also have happened due to number of households, getting food items from outside and reusing some types of waste. Most of the people living in the study area especially those in the first class are government servants/ employees in private company or NGO/ labours/ students. These people have their breakfast/lunch outside the home. This activity reduces waste generation in their homes, therefore reducing waste generation.

Table 4.8: Relationship of Per Capita Daily Waste Generation to Households size

Average Waste per capita	1st Class Hse size	2nd Class Hse size	3rd Class Hse size
1st Class AVR	-0.711	*	*
2nd Class AVR	*	-0.825	*
3rd Class AVR	*	*	-0.706

Table 4.8 shows there is a strong negative relationship between household size and per capita generation of waste in the area. This means that as household size increase the per capita (kg/day) waste generation decreases. Jenkins (1993), Qdais *et al.* (1997), Bolaane and Ali, (2004) and Ojeda-Benitez *et al.* (2008), have shown that as the number of household members increases, waste generation per capita decreases. Thus, the larger the household size, the smaller the daily per capita waste generation. The reason for this may be attributed to households' social and economic activities. In the household survey it was observed that, waste from business activities taking place at households were mixed with the waste produced from domestic activities. Per capita daily waste generation may not be dependent on household's size as there were variations in household size during the study period. Relatives and friends moved in and out during the study period, owning to October and November which are preparatory months

for Christmas festivities. Furthermore, increased population increases demand and minizes wastage.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary of Findings

This study characterized and quantified municipal solid waste generation in Mararaba metropolis of the GKUA, Nasarawa State. Two three classes of residential areas based on socioeconomic status were purposively selected and used for the study. A total of 93 households were sampled from the three residential areas and educated on the purpose of the study as well as the need for participation. Waste generated by the households were collected and sorted with heir help for a period of five weeks and the data were used for further analysis.

The study found that the household generated waste in the study area include biodegradables (food, yard and wood wastes) and non-biodegradables (paper and cardboards, plastics, metals, glass, leather and rubber, textiles, inert and miscellaneous wastes). The percentage composition of biodegradables were highest for all three areas and Leather and rubber had the lowest composition for Abacha Road while glass had the lowest by weight for both Veronica Estate and Jogodo. The third class residential area had high amount of Inert and miscellaneous materials, while the first and second classes had their waste stream made up of more biodegradables than non-biodegradables.

The separation efficiency achieved for separating waste at source for the study was 95.70%, 90.86% and 91.32% for the first, second and third class respectively for the polythene bag designated for biodegradable while that for the non-biodegradables was 79.76%, 84.65% and 85.85%. Much lower separation efficiency was achieved in the bag designated for non-biodegradable than that for biodegradables. There were a high number of residents (72.04%) who were willing to separate their waste and this indicated a desire for access to other disposal options in the community, like recycling (77.42% of respondents are willing to send waste for recycling) and composting (74.19% of respondents are willing to accept the concept of home composting).

The average daily per capita waste generation for the three residential areas was 0.70. The total daily per capita generation rates show the first class areas having a higher rate of 0.76 compared to the second and third class which had a generation rate of 0.66 and 0.69. There was no statistically significant difference between the average daily per capita wastes generated by each of the three areas. A week negative correlation exist between daily per capita waste generation in the areas while a strong negative correlation exist between household size and daily per capita waste generation.

5.2 Conclusion

Household waste within the Mararaba Metropolis of GKUA were mainly food, yard waste, wood, paper and cardboard, plastics, glass, textiles, Leather and rubber and metals. Biodegradables from all the three socioeconomic groups were over 60% and plastics 11.74%.

Solid waste within the study area had an average recyclable and compostable content of 81.65%. Only 18.35% of the waste may end up at the final disposal site if appropriate recycling and composting measures are instituted. Waste separation was not being practiced in the metropolis. There was a general willingness among the inhabitants of the metropolis to separate waste at source. The average per capita waste generation for Mararaba was 0.70 kg/ca/day, at all the three socio-economic levels with the highest waste generation being in households in first class residential areas.

5.3 Recommendation

i. Education of people in Mararaba metropolis on the need to separate waste through public enlightenment and awareness in the media (radio, television and newspaper since most of the respondents had heard about separation through these media), schools, churches, mosques, community associations, traders and transporters unions and use of traditional rulers should be carried out by the Karu Local Government Area Authorities.

ii. It is recommended that home composting facilities (with low or no cost to the household as only 46.24% of the respondents were willing to buy bin for composting) be established for households to encourage home composting within the community, and private firms should be involved for efficient and effective solid waste management in the area.

iii. With the purpose of improving the current waste management system and having the information presented here regarding the composition of household solid waste (HSW) and municipal solid waste (MSW), it is recommended to conduct an analysis and assessment of the potential treatment options for the non-biodegradable in the waste stream of Mararaba metropolis of GKUA, with a market oriented approach.

iv. Efforts should be devoted to obtain better estimates of the generation rates and composition of non-household waste (they do end up in the landfills as well and have valuable materials). In this study, an adequate and statistically valid characterization of HSW was made. However, the other sources contributing to MSW were not examined. Further studies particularly focusing on these aspects might be worthwhile to possibly increase the amount of recyclables.

v. To enhance the sustainability of SWM, it is recommended that public aware- ness, funding, expertise; equipment and facilities as well as other provisions that are currently lacking or inappropriate must be provided. Furthermore, since the envisaged SWM practices call for some behavioral changes, there is a need for community participation on related issues.

REFERENCES

Achankeng, E. (2003). "Globalisation, Urbanization and Municipal Solid Waste Management in Africa", *Proceedings of the Conference of African Studies Association of Australasia and the Pacific - African on a Global Stage,* University of Adelaide, Adelaide, Australia, pp. 1-22.

Adams, A. (2011). *Sekondi-Takoradi Metro Assembly in Focus*, Ghanaian Chronicle, Accra, Ghana.

Addo, E.A. (2009). "Economic Analysis of Household Source Separation of Solid Waste: The case of Kumasi Metropolis of the Ashanti region of Ghana", *Unpublished MSc. Thesis Report,* Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 110 pp.

Adu- oahen, A. (2012). "Management of the Kojorom Final Waste Disposal Site by the Secondi-Takoradi Metropolitan Assembly" *Unpublished MSc. thesis Report,* Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 99pp.

Aguilar-Virgen, Q., Armijo-de Vega, C., Taboada-Gonzalez, P. A. and Ojeda-enitez, S. (2010). "Municipal Solid Waste Generation and haracterization in Ensenada, Mexico" *Open Waste Management Journal*, 3:140-145.

Ahmad, A. and Jehad, H. (2012). "Municipal Solid Waste omposition Determination Supporting the Integrated Solid Waste Management in Gaza Strip", *International Journal Environmental Science and Development,* 3(2): 172-176.

Aisa, S. O. (2013) "characterization of household waste in Kinondoni Municipality, Dar Essalaam" *Academic Journal of Interdisplinary Studies,* 2(13): 35-46pp.

Al-khatib, I. A., Monou, M., Abdul Salam F., Abu, Z., Shaheen, H. Q. and Kassinos, D. (2010). "Solid Waste haracterization, Quantification and Management Practises in Developing Countries, A case study: Nablus District – Palestine". *Journal of Environmental Management*, 9: 1131-1138.

Anarfi, K.P. (2013). *"Source Separation, Characterization and Recycling Potential of Household Solid Waste. A case study of Kumasi, Ghana", Unpublished MSc. thesis Report,* Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 121 pp

Anomanyo, E. D. (2004). "Integration of Municipal Solid Waste Management in Accra (Ghana): Bioreactor Treatment Technology as an Integral Part of the Management Process" *Unpublished MSc. Thesis Report*, Lund University, Lund, Sweden, 48 pp.

Anon (1999). "Effective Solid Waste Management With The Participation of Waste Producers, Report from Calcutta UNDP-World Bank Water and Sanitation programme and Seventh Meeting of The Urban Think Tank".

Anon (2009). "Developing Integrated Solid Waste Management Plan Training Manual", *Vol. 2. Assessment of Current Waste Management System and Gaps Therein*, Osaka/Shiga, Japan.

Anon (2010). "National Environmental Sanitation Strategy and Action Plan NESSAP: Materials in Transition MINT", *Ghana, Ministry of Local Government and Rural Development*, Accra, Ghana, 142pp.

Anon (2011). "Ghana: The New Land of Opportunity for Oil and Gas Investment: Overview of the Potential for Ghanaian Oil and Gas Investors "http://maritimehubafrica.com/uploads/news_attachment/Report_Ghana_Oil_Opportunities.pdf., Accra, Ghana, 4pp. Accessed: March 15, 2014.

Anon (2012a). "Sekondi-Takoradi itizen"s Report ard 2012", *CHF International and Sekondi-Takoradi Metropolitan Assembly (STMA)*, 55pp.

Anon (2012b). "The omposite udget of the Sekondi-Takoradi Metropolitan Assembly for the 2012 Fiscal Year", www.ghanadistricts.com. Accessed: March 15, 2014.

Anon (2012c). "2010 Population and Housing ensus", *Ghana Statistical Service*, Sakoa Press Limited, Accra, Ghana, 117pp.

Anon, (2005). "Solid Waste Management", *Cal Recovery Inc.*, Vol. 1, California, U.S.A, 49pp.

Ariola, M. M. (2006). *Principles and Methods of Research 1st ed.*, Rex Bookstore Inc., 282pp.

Aryee, D., Zakari, A. and Owusu, H. (2014). "The Sekondi-Takoradi Metropolitan Assembly", www.mile.org.za/. Accessed: March 15, 2014.

Asase, M. A. D. and Oduro-Kwarteng, S. (2010). "Source Separation Efficiency and Level of compliance by Households Participating in Pilot Project in Kumasi".

ASTMD (2003). "Standard Test Method for Determination of the omposition of Unprocessed Municipal Solid Waste", *American Society for Testing and Materials International*, USA, 6pp.

Bernache-Perez, G., Sanchez-Colon, S., Garmendia, A. M., Davila-Villareal, A. and Sanchez-Salazar, M. E. (2001), "Solid Waste haracterisation Study in the Guadalajara Metropolitan Zone, Mexico", *Waste Management Research*, 19(5): 413-424.

Ernstad, A., Jes la our, J. and Aspegren, H. (2012), "Local Strategies for Efficient Management of Solid Household Waste – The Full-Scale Augustenbong Experiment", *wmr.sagepub.com*, pp. 200-212.Accessed: October 29, 2013.

Ichi, M.H. and Amatobi, D.A. (2013), " haracterisation of Household Solid Wastes Generated in Sabon-Gari Area of Kano in Northern Nigeria", *American Journal of Research Communication,* 1(4): 165-171.

Bolaane, B. and Ali, M. (2004), "Sampling Household Waste at Source: Lessons Learnt in Gaborone", *Waste Management and Research Journal,* 142-148.

Ryant, I. M., Armah, F.A. and Pappoe, A. N. M. (2010), "Source Specific Quantification and Characterization of Solid Waste along a Sandy Beach in apeoast, Ghana". *Theoretical and Empirical Researches in Urban Management*, 8(17): 49-63.

Howdhury, M. (2009), "Searching Quality Data for Municipal Solid Waste Planning" *Waste Management Research*, 29: 2240-2247.

Chung S. and Poon, C., (2001), "haracterization of Municipal Solid Waste and its Recyclable ontents of Guangzhou", *Waste Management Research*, 19: 473- 485.

Dauda, M. and Osita, O.O. (2003), "Solid Waste Management and Reuse in Maiduguri, Nigeria". *In Proc. 29th WEDC International Conference*, Abuja, Nigeria, pp. 20-23.

Dyson and hang, N, (2005), "Forecasting Municipal Solid Waste Generation in a Fast-Growing Urban Area with System Dynamics Modelling". *Waste Management Journal*, 25: 669-679.

Ejaro, S.P. and Jiya, S. N. (2013), "Source Specific Quantification haracterization and Management of Solid Waste in Lapai, Nigeria State, Nigeria", *Ethiopian Journal Environmental Studies and Management*, 6(5): 561-569.

European ommission (2004), "Methodology for the Analysis of Solid Waste (SWA-Tool) Project", SWA-Tool Consortium, *www.wastesolutions.org.*Accessed: March 25, 2014.

Fakere, A. A., Fadairo, G. and Olusegun, O. (2012), "Domestic Waste Management and Urban Residential Environment: Focus on Akure, Nigeria", *International Journal of Engineering and Technology*, 2(5): 878-887.

Felder, M. A., Petrell, R. J. and Duff, S. J. (2001),"A Solid Waste Audit and Directions for Waste Reduction at the University of British Columbia, anada", *Waste Management Research*, 19(4): 354-365.

Freduah, G. (2004), "Problems of Solid Waste Management in Nima, Accra", *Unpublished BSc. Project Report*, University of Ghana, Legon.

Gawaikar, V. and. Deshpande,V.P. (2006), "Source Specific Quantification and Characterisation of Municipal Solid Waste – a Review", *Solid Waste Management Division, National Environmental Engineering Research Institute (NEERI)*, Nagpur, India, 86: 33-38.

Gilbertson, W.E, (1969), "Present and Future Trends in Municipal Disposal of Solid Waste", in hap. 1 of Problems in ommunity Waste Management, World Health Organisation Public Health Papers No. 38, pp. 9-20.

Gomez, G., Meneses, M., allinas, L. and astells, F. (2009), "Seasonal Characterization of Municipal Solid Waste (MSW) in the ity of hihuahua", *International Journal of Waste Management*, 29(9): 2018-2024 pp.

Guangyu, Y. (1999), "Amounts and composition of Municipal solid wastes, Point sources of pollution: local effects and its control", *Encyclopaedia of Life Support Systems (EOLSS),* pp. 1-8.

Hogan, A., unningham, D. and Finn, J. (2006), " haracterisation of Non-Household Municipal Waste in Ireland and the Development of an Approach to Tracking Municipal Waste omposition", *Final Report Prepared for the Environmental Protection Agency Environmental*, RTDI programme, Clean technology, Ireland, 129pp.

Hoornweg, D., Thomas, L. and Verma, K. (1999), "What a Waste: Solid Waste Management in Asia", *Urban Development Sector Unit*, East Asia and Pacific Region, Washington D.C., USA.

Jenkins R. R. (1993), *the Economics of Solid Waste Reduction: The Impact of Users' Fees*, Edward Elgar Publishing Limited, Brookfield, Michigan, U.S.A.

Kazimbaya-Senkwe, and Mwale, A. H. (2001), "Solid Waste in Kitwe; Solid Waste Characterization Study for the City of Kitwe, Zambia: Phase 1", *His Sinpa Papers Sinpa Number 28/2001 Zambia,* SinpaProgramme, Institute for Housing and Urban Development Studies, Rotterdam, Netherlands in cooperation with Copperbelt University, Kitwe, Zambia, 57pp.

Kui, L. (2007), "Study of Influence Factors in Municipal Solid Waste Management Decision-making", *Unpublished MSc. Thesis Report*, Industrial Ecology, Royal Institute of Technology, Stockholm, Sweden, pp. 1-43.

Lopez Zavala, M. A. and Funamizu, N. (2005), "Effect of moisture content on the composting process in a biotoilet system", *Compost science and utilization*, 13(3): 208-216.

Mancini, S. D., Nogueira, A. R., Kagohara, D. A., Schwartzman, J. A. S. and de Mattos, T. (2007), " Recycling Potential of Urban Solid Waste Destined for Sanitary Landfills: The ase of Indaiatuba, SP, razil", *Waste Management Research*, 25: 517-523.

Mensah, A. and Larbi, E. (2005), "Solid Waste Disposal in Ghana" Well Fact sheet- Regional Annex, http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/RSA%20Solid%20waste.htm. Accessed: March 25, 2014.

Momoh, J. J. and Oladebeye, D. H. (2010), "Assessment of Awareness, Attitude and Willingness of People to Participate in Household Solid Waste Recycling Programme at Ado-Ekiti, Nigeria" *Journal Of Applied Sciences In Environmental Sanitation*, 5(1): 93-105.

Nabegu, A., (2010), "An analysis of Municipal Solid Waste in Kano Metropolis, Nigeria", *Journal of Human Ecology*, 31(2): 111-119.

Nordtest Environment 001 (1995), "Solid Waste, Municipal: Sampling and haracterisation", www.nordtest.org. Accessed: March 25, 2014.

Oduro-Appiah, K. and Aggrey, B.E. (2013), *"Determinants of Source Separation of Municipal and Solid Waste in Developing Countries: The Case of Ghana", Journal of Sustainable Development in Africa,* 15(3): 47-60.

Oduro-Kwarteng, S. (2011), "Private Sector Involvement in Urban Solid Waste collection: Performance, apacity and Regulation in five ities in Ghana" *Unpublished PhD. Thesis Report,* CRC Press, Belkema, Rotterdam, Netherlands, 378pp.

Ojeda-Benitez, S.G., Lozano-Olvera, R., Adalberto, M. and Armijo de Vega, C. (2008), "Mathematical Modeling to Predict Residential Solid waste Generation", *Journal of Waste Management*, pp. 7-13.

Oumarou, M. B., Dauda, M., Abdulrahim, A.T. and Abubakar. A.B. (2012), "Characterization and Generation of Municipal Solid Waste inNorth Central Nigeria", *International Journal of Modern Engineering Research (IJMER)*, 2(5): 3669-3672.

Oyelola, O. T. and abatunde, A.I. (2008), "haracterization of Domestic and Market Solid Wastes at Sources in Lagos Metropolis, Lagos, Nigeria", *African Journal of Environmental Science and Technology*, 3(12): 430-437.

Pitchel, J. (2005), "Waste Management Principles: Municipal Hazardous, Special Waste", *CRC Press*, Boca Raton, Florida.

Planitz, E. and Kuzu, D, (2014), "Oil Production and its Impact on the Livelihood of Communities in Ghana", *Draft Report of Study – Preliminary Results,* Ghana, 78pp.

Post, L. J. (2007), "Solid Waste Management in Jamaica: An Investigation into Waste Reduction Strategies", *Unpublished MSc. Thesis Report,* Michigan Technological University, 177pp.

Puopiel, F. (2010), "Solid Waste Management in Ghana: the ase of Tamale Metropolitan Area", *Unpublished MSc. Thesis Report*, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 93pp.

Qdais, A., Hamoda, M. F. and Newham, J. (1997), "Analysis of Residential Solid Waste at Generation Sites", *Waste Management and Research Journal,* 15: 395-406.

Quayson, F. A. (2012), "Oil ity? The Role of Sekondi-Takoradi in Ghana"s Emerging Oil Industry", *Unpublished MPhil. Thesis Report*, Norwegian University of Science and Technology, Trondheim, Norway, 132pp.

Rushbrook, P. and Pugh, M. (1999), "Solid Waste Landfills in Middle-and Lower- Income ountries", *Urban Development Division Waste Management*, the World Bank, Washington, USA.

Schubeler, P., Wehrle, K. and hristen, J. (1996), " onceptual Framework for Municipal Solid Waste Management in Low-Income countries", *SKAT UNDP/UNCHS (Habitat)/World Bank/SDC Collaborative Programme on Municipal Solid Waste Management in Low-Income Countries. Urban Management and Infrastructure*, pp. 9-55.

Tia, S. (2012), "Assessment of the Performance of Public and Private Municipal Solid Waste ollection Institutions in the Tamale Metropolis" *Unpublished MSc. Thesis Report*, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 92pp.

Topanou, N., Domeizel, M., Fatombi, J., Vosse, G. R. and Aminou, T. (2011) "haracterization of Household Solid Waste in the Town of Abomey-Calaviinenin" *Journal of Environmental Protection*, 2: 692-699.

Troschinetz, A. M. (2005) "Twelve Factors Influencing Sustainable Recycling of Municipal Solid Waste in developing countries", *Unpublished MSc. Thesis Report*, Michigan Technological University, Michigan, U.S.A., 139pp.

Wallling, E., Walston, A., Warren, E., Warshay, B. and Wilhelm, E. (2004), *Municipal Solid Waste Management in Developing Countries: Nigeria, a Case Study*,Nigeria, 16pp.

Zurbrugg, (2002), "Urban Solid Waste Management in Low-Income Countries of Asia. How to ope with the risis", *Scientific Committee on Problems of the Environment (SCOPE) Urban Solid Waste Management Review Session*, Durban, South Africa, pp. 1-13pp.

Omloe F.K. and M.K. Alakinde (2013). Managing the unwanted materials: The agony of solid waste management in Ibadan, Nigeria. *International Journal of Education and Research*

1(4):1-12.

APPENDIX 1

HOUSEHOLD WASTE CHARACTERIZATION SURVEY

PART ONE: ABOUT YOURSELF

Area Name …….. Location……

Name of Respondent……..

Age group

15 - 24yrs [ ] 25 - 34yrs [ ] 35 - 44yrs [ ]

45 - 54yrs [ ] ≥55yrs [ ]

GenderMale [ ] Female [ ]

What is your highest level of education? ……

What is your Occupation? ……

Marital Status Single [ ] Married [ ] Status in the household

Father/Mother [ ] Other [ ] (Specify)……..

PART TWO: ABOUT YOUR HOUSEHOLD

Which of the following best describe your home?

Single Family Detached [ ] Duplex or Townhouse [ ] Multifamily Unit/ Compound House [ ] Storey building [ ]

How many people live in your house? ……..

How many households are in your house? ……

How much is your household's average monthly expenditure?

Less than N10000 [ ] N10000 - 20000 [ ] N20000 - 50000 [ ]

50000-100000 [ ] Above 100000 [ ]

PART THREE: HOUSEHOLD WASTE DISPOSAL

How do you dispose your household wastes?

Buried [ ] Burned [ ] Individual Bin (House to house Collection) [ ] Communal dumpsite [ ]

How many refuse bins do you have in your household?

One [ ] Two [ ] Three [ ] Four [ ] Five [ ]

How often is your bin lifted?

Once a week [ ] Twice a week [ ] Thrice a week [ ] Which Company services your household?

Zoomlion [ ] Informal Waste Collectors [ ] others (specify) .....

Do you sell or give out items to itinerant buyers? Yes [ ]No [ ] If Yes specify the items .....

PART 4: KNOWLEDGE ON WASTE SEPARATION

Have you ever heard or seen waste separation activities? Yes [ ] No [ ] If Yes, from where:

Foreign Countries [ ] Other parts of Nigeria/Different communities [ ] In movies [ ] Television news [ ] Radio [ ] Newspapers [ ] Magazines [ ]

Others (specify) .....

Are you willing to separate your waste on daily basis, even after this exercise? Yes [ ] No [ ] If No why .....

If yes what will be your driving force:

When motivated [ ] Clean Environment [ ] Resource [ ] Best practice and example from other

Countries for recycling [ ] others (specify) .....

PART 5: KNOWLEDGE ON RECYCLING

Have you heard or read anything about recycling of waste materials? Yes [ ] No [ ]

If Yes from which source?

Television [ ] Radio [ ] Magazines/Newsletters [ ] Newspaper [ ] Billboards [ ]

Others (specify) .....

Do you know any company engaged in recycling of waste? Yes [ ]No [ ]

If Yes, name any .....

Do you recycle any of the following materials?

Newspapers [ ] other papers and Cardboards [ ] Glass [ ] Metal & Cans [ ] Plastics [ ]

Leaves/Food waste/ Yard waste [ ] others (specify) .....

If you do recycle, what is the principal reason for your action?

Concern for the environment [ ] Concern about the availability of landfill space [ ] My children encourage me to recycle [ ] Get paid for recycling material [ ] Others (specify).....

If you do not recycle what would be your principal reason?

Inconvenience [ ] Believes there are better ways to handle my waste /garbage [ ] believes It's the responsibility of government/ Waste management company [ ] Do not have the necessary facilities and skills to recycle [ ]

Others (specify) .....

If you do recycle, how long have you been recycling?

Less than 1 year [ ] 1-2 yrs [ ] 3-5 yrs [ ] more than 5 yrs [ ]

Do you think residents should be required by law to recycle, or should be voluntary? By Law [ ] Voluntary [ ] Not Sure [ ]

If a recycling centre is established at your neighbourhood, would you be willing to bring materials for recycling? Yes [ ] No [ ]

If No why .....

If Yes explain .....

Are you willing to buy two household waste plastic bags? (One waste plastic bag for recyclables and one for non-recyclables) Yes [ ] No [ ]

If No why .....

How long will you be willing to spend to drive (one way) to a recycling centre?

Less than 10 min [ ] 10 min [ ] 11-15 min [ ] 16-20 min [ ] More than 20 min [ ] should not be my responsibility [ ]

Others (specify) .....