OPTIMIZATION OF MUNICIPAL SOLID WASTE MANAGEMENT IN MINNA METROPOLIS, NIGER STATE, NIGERIA

BY

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A DISSERTATION SUMMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS DEGREE IN ENVIRONMENTAL RESOURCE MANAGEMENT OF THE SCHOOL OF POST GRADUATE STUDIES OF NASARAWA STATE UNIVERSITY, KEFFI

Supervised by: Dr. Alikali

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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.

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GRACE AKUBO EJILE

CERTIFICATION

This dissertation "Optimization Of Municipal Solid Waste Management In Minna Metropolis, Niger State, Nigeria", meets the regulations governing the award of Master of Science degree, Faculty of Environmental Sciences of Nasarawa State University, Keffi.

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DEDICATION

This work is dedicated to the Almighty God for His wonderful love and mercies.

ACKNOWLEDGEMENT

I give thanks to Almighty God for His mercies, protection, providence, and granting me the grace, to complete this important stage of my life. Firstly I wish to acknowledge the contribution of all the authors that I have cited their woks in this work.

My profound gratitude and appreciation goes to the Almighty God for sustaining my life and sending his blessings and favour to me at all times. I wish to acknowledge with heart felt gratitude to the following people who has immensely contributed to my success on my academic pursuit my supervisor Dr. M. Alkali who despite his tight schedule ploughed through several preliminary versions of my text, making critical suggestions and persistence in ensuring that the work is successful. His expertise, invaluable guidance constant encouragement, affectionate. attitude, patience and healthy criticism contributed immensely to the success of this research work.

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To my husband, Mr. Amos Akubo who has always been a support system and our children Michelle, Sean anf Israel Akubo for all their prayers, to my siblings especially Arome who helped me with most of my assignment. To M.r Affi Jonah, thanks a million. To my late dad. I am forever grateful.

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DATA ANALYSIS AND DISCUSSION

ABSTRACT

Increasing population level, booming economy, rapid urbanization and the rise in community living standards have greatly accelerated the municipal solid waste generation rate in Minna metropolis. With about 0.22kg/person/day solid waste is generated and over 20 tons of wastes are dumped in dumping site daily. The main thrust of this study is to carry carryout the assessment of the current practices and commitment to sustainable municipal solid waste management (MSW) of Minna metropolis. The study approach involved the estimation of the quantity of municipal solid waste generated, evaluation of the segregation practices and distribution of structured questionnaires. A daily inventory of each district was carried out, followed by the evaluation of the status of waste management. The results shows that total estimate of municipal solid waste generated per week was 2,312.1kg. The waste comprises of paper waste which amounted to about 31.62% of the total waste, plastic waste which amounted to about 16.80% of the total waste, garbage waste which amounted to about 9.62% of the total waste, polythene waste which amounted to about 18.17% of the total waste and metal waste which amounted to about 23.79% of the total municipal solid waste generated in the metropolis. Also, Auto Cad land development software was used to extract the map of the entire metropolis showing the road network, location of waste bins, land uses and other valuable information's in a shape file. Consequently, in order to optimize the route for collection and transportation of MSW, and ensure cost effectiveness for waste management authority, total distances covered by the vehicles have been reduced from 196989.0m to 151791.1m, likewise the time will reduced from 1525.9min to 1153.1min respectively. Finally a workable solution was proffered for the waste management authority, in order to help in controlling waste generated, and further provide alternative means of revenue generation through the sales of recyclable materials.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The term Municipal solid wastes (MSW) is a composition of both organic and inorganic materials generated from series of human activities in industrial sites, domestic households, commercial centers and other institutional workshops. The presence of MSW in a society is a great problem if not well managed due to its ability to induce environmental degradation.(Suberu *et al.*, 2012). Municipal solid waste management (MSWM) is one of the critical environmental challenges of quick urban development that developing countries, including Iran, face(Shamshiry *et al.*, 2011). Management of waste encompasses a complex set of potential impacts on health, safety, and environment. It represents a "reverse" production process; the "product" is removal of surplus materials. Solid waste management becomes necessary and relevant for every government to provide for its residents. While service levels, environmental impacts and costs vary dramatically, solid waste management is arguably the most important municipal service and serves as a prerequisite for other municipal action. However, some wastes are not suitable for recycling. 'For the no recyclable fractions, an energy recovery method becomes essential because it can reduce the use of fossil fuels. At the same time, it can also minimize the environmental and health problems of waste disposal, unlike the land fill alternative' (Ryu, 2010).

Increasing population levels, booming economy, rapid urbanization and the rise in community living standards have greatly accelerated the municipal solid waste generation rate in developing countries(Guerrero *et al.*, 2012; Minghua *et al.*, 2009).Municipalities, usually responsible for waste management in the cities, have challenges to provide an effective and efficient system to the inhabitants. However, they often face problems beyond the ability of the municipal authority to tackle' mainly due to lack of organization, financial resources, complexity and system multi dimensionality (Guerrero *et al.*, 2012). Furthermore, globalization is accelerating by-products of an urban lifestyle, is growing even faster than the rate of urbanization. Thus, an increasing number of populations in urban cities cause an increase in the amount of municipal solid waste (MSW) generation. Therefore, operational efficiency of waste management depends upon the active participation of both the municipal agency and the citizen's participation in decision making, community awareness and social apathy for contributing in solutions (Henry *et al.*, 2006). Niger state, one of the states in Nigeria with a wider landmass, an attraction center for tourism, agricultural and commerce among other economic value (Maji, 2014). Minna, being the capital of Niger state has an estimated population to be 3,954,772 (population census 2006). Thus, the increasing number of population has resulted to an increase in the amount of municipal solid waste (MSW) generation. Owing to the structure of the society changes from agricultural with low-density and widespread population to urban, high-density population. Owing to this ever increasing waste, there is need to be balanced with the provision of adequate waste collection transportation system.

1.2 Statement of Problem

It has been observed that the existing municipal solid waste (MSW) management system in Minna metropolis is suffering from a lack of proper plan for an effective vehicle routes as well as collection station locations. The existing system is largely based on experience, which leads to high cost of spending by the state government. This problem leads to poor management and has made it necessary for continuous research aiming towards achieving an effective route optimization for municipal solid waste. Thus, this study is aimed at addressing this by employing the use of Geo informatics to ensure and provide good management system for Minna metropolis.

1.3 Aim and Objectives

The aim of this research work is to optimize the route for municipal solid waste management for Minna metropolis.

The specific objectives of this study therefore are TO:

i. Carry out an assessment of waste management system of minna metropolis.

ii. Optimize the route for waste collection and transportation using a hand held GPS

iii. Troffer a workable solution to the municipal solid waste management system of the city.

1.4.1 Research Questions

The following research questions are set to guide this study. They are as follow:

i. How can assessment of waste management system of minna metropolis be carried out.

ii. What Optimize the route for waste collection and transportation using a hand held GPS

iii. What troffer a workable solution to the municipal solid waste management system of the city.

1.5 Significance of the Study

The findings of this study will add more knowledge on the existing literature and will act as supportive insights for further research on the route optimization of municipal solid waste in Minna municipality. The study will help the Niger State Environmental Protection Agency (NISEPA), to have the road network map within their reach, rather than using the old method of mere assumptions for their vehicle routes. The study will also suggest measures for an effective utilization of recyclable materials in order to help the government to maximize its benefits. Lastly the study will help municipal authorities to be able to lessen high cost expenditure incurred in managing waste, and at the same time ease methods for waste disposal within the city of Minna.

1.6 Scope of the Study

The scope for this research work (route optimization of municipal solid waste) is mainly to be able to develop a route map of MSW for Minna metropolis, using a hand held Global Positioning System (GPS), and to proffer solutions to municipal solid waste management practice in Minna municipality. However this research work is not meant to analyze the potentialities for the renewable energy for municipal solid waste.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

This chapter is divided into two sections namely: overview of fundamental concepts for this research work and review of related literatures on waste management practices.

2.2 Conceptual Framework

2.2.1 Climate Variability Impact and Adaptation

This section presents characteristics of municipal solid waste (MSW), treatments and disposal options, various method of land filling, recycle methods etc.it also reviews the activities of NISEPA in collecting and disposing MSW from Minna town.

This research work is primarily motivated by the waste disposal problems been faced by Minna, the capital of Niger state.To collect waste, the Niger state environmental protection agency (NISEPA) has located about 600 stationary bunkers in the residential areas, whereby waste from the household are dropped into these bunkers by the inhabitants. Waste containers are unloaded virtually every day by fifteen trucks and about 39000kg of waste is been disposed of daily. The MSW compriseof assorted items such as plastics, metals, papers, bottles, food garbage etc. all this waste are dumped into the same bunker and finally taken to the dumping site located at Maikunkele landfill.This research work, aims to identify parameters which help to explain the present situation thereby preferring solution to waste management problems in Minna Niger state. Local governments assumed the responsibility of dealingwith urban refuse. Waste services were provided either directly by government orbyprivatescavengingcompanies(Lyeme, 2011).

Waste management is a particularly sensitive subject, since it affects the everyday life of the population. Nevertheless, efforts should be made to provide these systems with the best methods to improve their overall efficiency, thus reducing fuel consumption, pollutant emissions and costs. Waste management systems comprise many different areas and often deal with municipal solid waste (MSW) from the source to a final destination, which can be landfill, recycling stations or any other kind of waste treatment facility, depending on the waste disposal planning. A very important and cost-wise part of the process is the collection and transportation of MSW from containers to an intermediate or final depot. It is reasonable to consider that even small improvements in this area can lead to significant financial savings. Moreover, these procedures imply the existence of considerably high fuel consumption and pollutant emissions, since the activities involved are performed by heavy road vehicles. Thus, significant benefits can be derived from the optimization of MSW collection and transportation routes as well. The Geographical Information Systems (GIS) is a useful and resourceful tool providing treatment, handling and visualization of spatial data, and its application for the optimization of waste collection routes is referenced in many papers(Kalanatarifard & Yang, 2012). To optimize a vehicle circulation route the Vehicle Routing Problems (VRP) methodology can be applied.

2.2.2 Characteristics of Municipal Solid Waste

The term municipal solid waste MSW generally implies all the waste generated in a country with the exception of industrial process waste and agricultural solid waste(Consonni *et al.*, 2005).Three primary sources of (MSW) are classified as residential area, institutional and commercial waste (Tariq etal., 2007). And the sources of this waste are mainly residential, industrial, commercial and municipal services excluding treatment work. The compositions of the refuse must be known for local authorities to select the most economical collection techniques: to design and operate an efficient central incineration plant and to plan ahead for suitably sanitary landfill sites or design a composting plant, and to forecast the cost and efficiency of operation when choosing a particular method of disposal(Belgioruo *et al.*, 2003). Solid waste is a very general term which encompasses all waste materials except hazardous waste, liquid waste, and atmospheric emissions, although most solid waste regulations include hazardous waste within the definition of solid waste (Lyeme, 2011). Solid wastes are divided into three main categories: municipal, industrial, and agricultural. Municipal solid waste has several sources such as residential, commercial, institutional. construction and demolition. Industrial solid waste is defined as all solid waste generated from an industrial or manufacturing process and solid waste generated from non-manufacturing activities, such as service and commercial establishments.(Magutu & Onsongo, 2011). Industrial solid waste does not include office materials, restaurant and food preparation waste, discarded machinery, demolition debris, municipal solid waste combustor ash or household refuse. Agricultural waste includes all solid wastes resulting from the raising of crops or animals on land zoned agricultural by local requirements, including animal manures that are returned to the soils as fertilizer or soil conditions.(Programme, 2005)

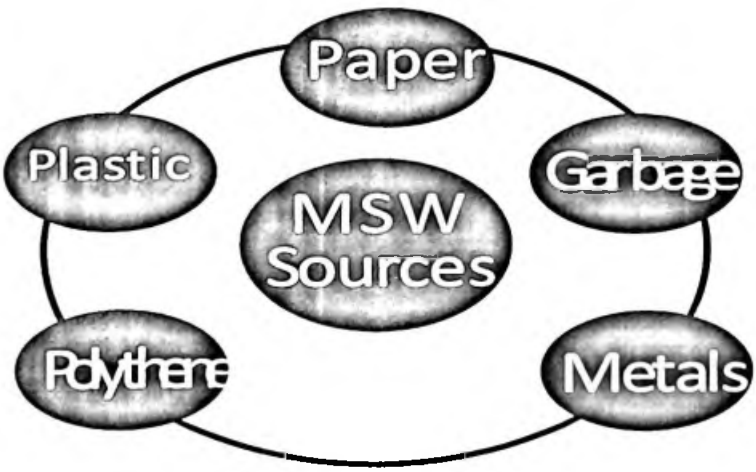

Figure 2.1: Sources of Municipal Solid Waste.

Source: (Ibrahim, 2013)

2.2.3 Treatment and Disposal Options

Waste management is the collection, transport, processing, recycling or disposal, and monitoring of waste materials. Operations strategy can be viewed as part of a planning process that coordinates operational goals with those of the larger organization. Since the goals of the larger organization change over time, the operations structure must be designed to anticipate future needs. The operations capabilities of a firm can be viewed as a portfolio best suited to adapt to the changing product and service needs of a firm's customers (Magutu & Onsongo, 2011).

The costs for solid waste management are high especially for collection, transportation, treatment and disposal, which are largely borne by city councils. Methods of collection of waste are either door-to-door or using containers or communal bins. All medium and large cities have administrative structures for providing collection services but often, cities in developing countries use non-compaction trucks for daily collection, with a few cities using compaction trucks and hauling trucks. The most common municipal waste management practices include: recycling/recovery, composting, incineration and land filling/open dumping. The operations strategy is a very important tool in the solid waste management practices and processes (Magutu & Onsongo, 2011).

MSW may contain the following materials, which are considered recyclables: ferrous and non-ferrous metals, construction debris, scrap tires, paper/cardboard, plastics, textiles (including cloth and leather), glass, wood/timber, animal bones/feathers, waste oil and grease, cinders/ashes.In the treatment and management of waste, various methods have been adopted, however the following are the most widely methods in practice, these are:

2.2.4 Land Filling

There is no form of treatment that can entirely avoid the need for land as the final deposit. Treatment often enables a proportion of the wastes to be utilized in some way, but there are residues from all forms of treatment, thus sanitary land filling is usually necessary. Although on a reduced scale, whatever forms of treatment may be needed. Hence the basis of a good solid waste management system is the municipal solid waste (MSW) landfill. MSW landfills provide for the environmentally sound disposal of waste that cannot be reduced, recycled. composted, combusted, or processed in some other manner. A land filling is needed for disposing of residues from recycling, composting, combustion or other processing facilities and can be used if the alternative facilities break down. A properly designed MSW landfill includes provision for leach ate management and the possible collection of landfill gas and its potential use as an energy source (Ibrahim, 2013)

Sanitary landfill differs from ordinary dumping in that the materials are placed in a trench or other prepared areas and adequately compacted and covered with earth at the end of the working day. The procedure has been defined as a method of disposal wherein each day's accumulation of refuse is thoroughly compacted and covered. The term "modified sanitary landfill" has been applied to those operations where compaction and covering are accomplished once or twice each work. As opposed to other methods, sanitary landfills are designed to care for the complete disposal of all refuse produced, with the possible exception of bulky building wastes and the likes. For this reason, sanitary landfill capacities usually are designed for the total refuse produced. Where compacted refuse is placed in the fill to a depth of 2 meters, it is required that 1 ha of land per year will be required per 25.000 population(Lino *et al.*, 2010).

Prospective landfill sites should be evaluated with respect to type of soil available, drainage, prevailing winds, and availability of access roads, the underground water situation and the haul distance involved. Sandy loam is considered the most ideally suited landfill soil. although other soils can be utilized.

2.2.5 Sanitary Landfills

The sanitary landfill is one of the methods of disposing municipal solid waste, except that it is capital intensive as it requires sophisticated machines and equipment's among which are:

i. Bulldozers
ii. Excavator
iii. Roller
iv. Grader
v. Pay loader

In practicing the sanitary landfill, a large area of land is located in outskirt of the city. A big ditch is being dug with the aid of an excavator, the waste products are usually deposited into the ditch by the bulldozers and the roller is then use to compact the waste. This ditch may take a considerable long period before it is full, and when filled it is closed up and another site is located to dig a similar type. For any landfill that is properly managed and maintained, makes it easy for environmental problems to be controlled from problems associated with crude dumping- vermin, flies, and ground water pollution. The use of solid waste to reclaim landscape which has say resulted from mineral extraction is finding increasing interest in the waste and its deposit is in this instance seen to have social benefit.

2.2.6 Incinerator

This is another thermo-chemical conversion process for energy generation from waste either in the form of heat or electricity. In this method of energy extraction from municipal solid waste, no pre-treatment of the waste is required, and the whole mass of the waste is burn in incineration (Lee *et al.*, 2007). An incineration plant operates within a temperature range of 800 – 1000^{0}C. With an appropriate energy system connections heat and electricity can be generated from the incineration while waste is been subjected to combustion at a relatively high temperature(Ibrahim, 2013)

Well designed and properly operated incineration plants efficiently handle the disposal of combustible refuse. Bacterial and insects are destroyed in the process, and the noncombustible ashes, metal, etc. causes only minor sanitation problems if properly handled. An incinerator plant in Nashville, Tennessee, was completed in 1975 at a cost of $13 million to handle over half of the city's daily refuse of 700 tones and provide heat for the 32 buildings surrounding the facility (Modak *et al.*, 2010). The steam produced is used for either heat or an air conditioning plant. In Paris, a principal use of the steam produced from several central incinerators has been space-heating of over 100,000 dwelling units (Consonni *et al.*, 2005).The city is under laid with an elaborate steam-piping network to distribute the steams. Also, 200 million kilowatt hours of electricity are generated and sold to the public utility.

Most of the municipal solid waste incinerators are usually designed for burning papers or flammable materials which can easily be burn off with fire. Although attempts are being made to design incinerators that will burn waste products generally i.e. wastes that may contain even liquid or gaseous contents.

2.3 Review of Related Studies on Solid Waste Management

Otti (2011) In his work, a model for solid waste management in Anambra State used a deterministic model to determine which type of integrated solid waste management option or programmes will be suitable to minimized cost and maximized benefit (benefit cost ratio) over a long period of planning period. Consequently, the result of the model helped decision makers to finding the solution to environmental, economical, sanitary, technical and social goals, through the use of equipment, routine maintenance, personal and sundry. However the objectives of this work were not clearly outlined.

Shamshiry *et al.* (2011),used a response surface model (RSM) to establish the impact for optimization of solid waste management. The effects of three parameters such as fuel consumption, total workforce and volume of transport was investigated and numerical simulations were carried out.

Bhambulkar (2011), used a GIS network analyze approach to identify the best routing for municipal solid waste collection. Various loading spots were visited in Napur municipality to collect MSW that could not be collected by standing waste collection trucks, due to their large size in nature or their prohibitive obstacles. The network analyst was used to assess some of the obstacles such as close roads, due to natural or technical issues, e.g. fallen trees and car accidents in the study area and optimized solution were provided for that. The closest route for the waste collection was produced by using Arc Map Global Positioning System (GPS), thus with GIS technique optimum route was identified which was found to be cost effective and less time consuming when compared with the existing route.

Siddam *et al.* (2012),worked on Route Optimization for Solid Waste Management Using Geo-Informatics for collection and transportation of municipal solid waste of Chandrapur town. Using hand held GPS, the position of the entire dust bin in the city are collected and the data are converted into shape file. The roads were digitized from the road network map of the municipal corporation. Taking capacity of solid waste carrying vehicle into consideration, the routes are optimized for each trip of vehicle and total distance to be travelled was calculated for each trip. They finally compared the cost of solid waste disposal using this technique with the existing system of Municipal Corporation. From the analysis and results, it was concluded that the Geo-informatics technique gives better accuracy for route optimization and can be used as a decision support tool by municipal authorities for efficient management of the daily operations for transporting solid wastes, load balancing within vehicles, managing fuel consumption and generating work schedules for the workers and vehicles for overall cost minimization. However, a better accuracy would have been obtained in this work with the use of a hand held GPS to locate various positions of the waste bins.

Beijoco *et al.* (2012), presented a method for improving the collection and transportation system for glass waste in use by Armasul. The routes comprising the new system were optimized for time and distance, making recourse to the ESRI Arcgis® 9.3 Geographical Information Systems software, and values were estimated for travel time, total time, distance, pollutant emissions (CO, CO2, VOC, NOx and PM), taking into account the influence of dynamic load, and for the fuel consumption and costs. The estimated values for the new system showed that their benefits are quite substantial when compared to the presently existing system at Amarsul. The optimization for time, in particular, resulted in weekly average savings of 57% of the total cost, which correspond to over €11000 per year; the emissions were 62%.

Muhammad *et al.* (2013), carried out across sectional descriptive study for assessing the current practices of waste management system at FMC Bida. The approach of their study entails estimation of the quantity of healthcare waste generated, evaluation of the waste segregation practices and determination of the technical knowhow. The daily waste inventory of each ward and unit was carried out, followed by the evaluation of the status of the waste management practices. Final result shows that the total amount of healthcare waste generated per week was 1,554.05kg. All the healthcare waste generated in the center were finally disposed of finally in an offsite open pit and burnt. It was observed that the waste handling and management practice in FMC Bida was a commendable one, but unsustainable and therefore cannot be relied upon to protect human health and environment. However, the results obtained from this study were not back up with charts which will have aid better understanding of the concept.

Aremu (2013) In his work, established the application of simple and efficient ad in Microsoft solver add-in tool in Microsoft office excel 2010, software for in town optimization of solid waste collection. The results he obtained from the optimization of ten routes, revealed that two empirical routes had the same tour distance as the optimized tour and the remaining eight routes, the optimized process reduced tour distance by 2.04-19.27%, tour time by 0.33-22.80% and fuel consumption by 1.78-20.54%. However the trucks and the capacity of the municipal waste generated was not considered in the work.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study area

Minna Municipal comprises the following districts: Chanchaga, Sabon Gari, Bosso, Keteren Gwari, Zarumai, Sauka Kahuta, Maitumbi, Limawa, 'F'Layout, Up Hill, Tunga West, Tunga East and Kpakungu. Sub-districts that have the highest point of waste collection services are Kpakungu, Bosso, Maitumbi, Tunga West and Tunga East respectively(Sallah, 2015). The Limitation of the number of waste vehicles and existing waste collection routes cause waste hauling inefficiency. This thus causes the large pile of waste surrounding the neighborhood.

LAND USE MAP OF MINNA AND IT'S ENVIRONS

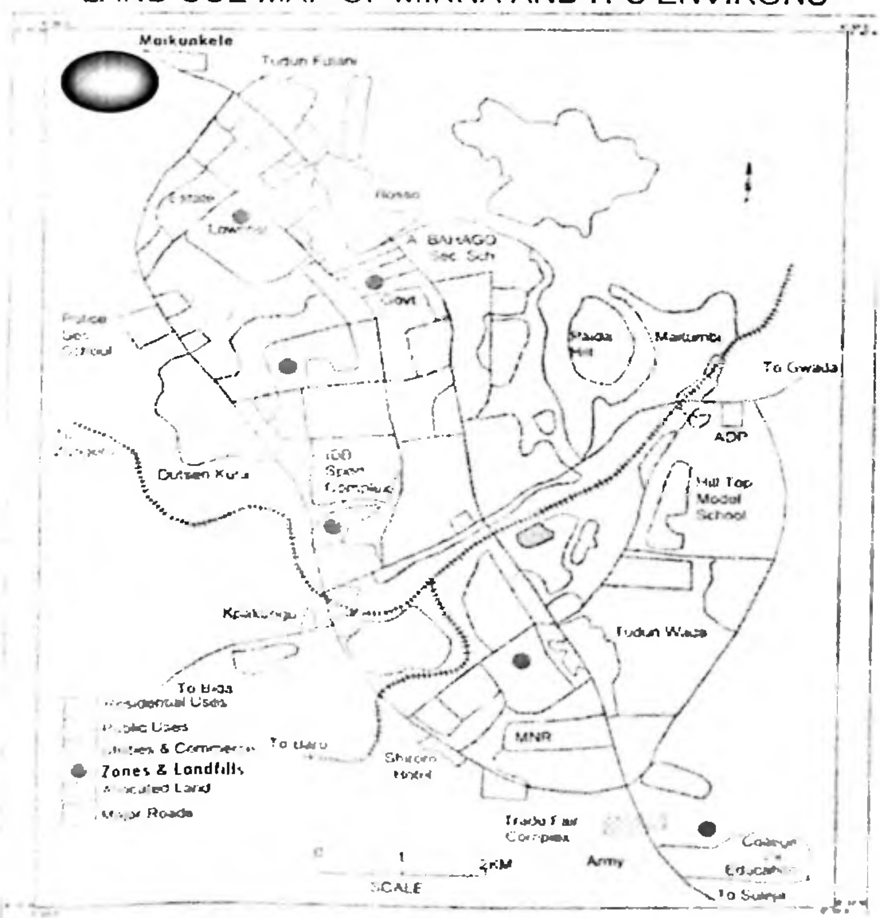

Figure 1.1: Map of Minna and its Environs

Source: (Niger State Government, 2000)

3.1.1 Vegetation and Agriculture

Minna possesses fertile land as a cherished asset and potentials are yet to be fully explored. The rich annual rainfall and the wide variety of mineral and agricultural resources all attest to the economic potential. Agriculture is the backbone of the economy of Niger state as nearly 70 per cent of the population depends either directly or indirectly on it for their livelihood. The state is one of the largest and most fertile agricultural lands in the country (Maji, 2014).

Given the existence of abundant uncultivated arable land and its great agricultural and mineral resources, Niger state government has put in place incentives to woo potential investors to the state. These include the establishment of industrial estates and easy acquisition of land for development purposes. In addition to these, the existence in the state of three big hydroelectric power stations, also Niger state has adequate industrial power. Furthermore, the state capital is not only linked to all the local government headquarters, but the entire state is transverse with interregional roads linking the state from north to south as well as east to west (Maji, 2014).

Minna Municipal comprises the following districts: Chanchaga, Sabon Gari, Bosso, Keteren Gwari, Zarumai, Sauka Kahuta, Maitumbi, Limawa, 'F'Layout, Up Hill, Tunga West, Tunga East and Kpakungu. Sub-districts that have the highest point of waste collection services are Kpakungu, Bosso, Maitumbi, Tunga West and Tunga East respectively(Sallah, 2015). The Limitation of the number of waste vehicles and existing waste collection routes cause waste hauling inefficiency. This thus causes the large pile of waste surrounding the neighborhood.

3.2 Materials Used

The following materials will be used in the execution of this research work, they are:

- GIS software (AutoCAD land development)
- A hand held GPS

- A goggle map software
- A video camera
- Microsoft excel 2010
- SPSS software

3.3 Working principle of Global Positioning System (GPS)

The GPS is actually a constellation of 27-earth orbiting satellites (24 in operation and 3 extras in case one falls). The U.S military developed and implemented this satellite network as a military navigation system, but soon opened it up to everybody else. Each of this 3000-4000 solar satellites circles the globe at about 12,000 miles (19,3000km) making two complete rotations every day. The orbits are arranged so that at anytime, anywhere on earth there are at least 4 satellites visible in the earth. The GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the earth. Each satellite continuously transmits messages that include the time the message was transmitted and satellite position at the time of message transmission. Also, GPS receiver's job is to locate four or more of these satellites, figure out the distance to each and use this information to deduce its own location. This operation is based on a simple mathematical principle called trilateration. It should also be noted that the receiver uses the message it receives to determine the transit time of each message and compute the distance to each satellite using the speed of light. Each of this distances and satellites location define a sphere. The receiver is on the surface of each of this sphere, when the distance and the satellite locations are correct. These distances and satellites location are used to compute the location of the receiver using the navigation equation. This location is then displayed; perhaps the latitude and longitude information as well as elevation and altitudes may all be incorporated into the results obtained. Many GPS show derived information's such as directions, speed, east as well as the north coordinates calculated from position changes.

3.4 Methodology

Methodology used in this research paper is described stepwise as follows:

1. Information on the present waste management system in minna metropolis will be obtained from NISEPA, which include:
    - ❖ Present spending.
    - ❖ Truck type and capacity.
    - ❖ Quantity of solid waste production and number of inhabitants in minna city.
    - ❖ Total number of bunkers (solid waste containers within the metropolis).

- Data such as population density waste generated, Municipality boundary map, existing road map, storage bins and collection vehicle details were collected from Minna municipality for digitizing roads of city and locating the dustbin position according to its easting and northing.
- Geographical calculation software (Geo-Calc.) was used to convert the geographical coordinates to rectangular coordinates.
- The road map was collected from the departments of land and survey and was then scanned.
- Geo-referencing of the map was done using
- Digitizing of the municipality map and road network map was done using AutoCAD Land Development software.
- Road network map was exported in GIS
- Position easting and northing of solid waste bin location using hand held GPS were collected and data exported in GIS.

- AutoCAD land development software will be used to design the road network map for Minna MSW system, while GIS elements such as numerical pathways, demographic distributions, container distributions and the land fill will be integrated into the software.
- The optimized route for solid waste collection and disposal using AutoCAD land development was analyzed.
- A workable solution for municipal solid waste management system will be presented.

3.4.1 Methods of Data Collection from Niger State Environmental ProtectionAgency (NISEPA).

Data obtained from Niger State Environmental Protection Agency (NISEPA) include the following:

- The total number of districts and waste collection points.
- The location of the final dumping site where waste materials are finally deposited
- The types and quantity of waste containers used all over the metropolis
- The types of vehicles used for waste collection and disposal
- Their staff capacity and methods of waste management

3.4.2 Specification of Machineries.

Niger State Environmental Protection Agency (NISEPA) has a total of fifteen trucks, nine out of which are owned by NISEPA and eleven are been hired from other source. The following are the specifications on various types of machineries used in disposal of municipal waste products:

Table 3.1 Specification of Machineries

S/N	Type of vehicle	Quantity	No. of loading/day
1.	Volvo 614	5	2 Trips
2.	Tractor	2	2 Trips
3.	Ford	4	2 Trips
4.	Compactor	6	2 Trips
5.	Volvo 619	6	2 Trips
6.	Volvo 618	4	2 Trips
7.	Side loader	4	1 Trip

3.4.3 Method used for Executing the Research Work

A feasibility study for the study area was carried out during the first routing within the municipality. Subsequently, a hand held GPS (72H), was then used to record thirty three easting and northing coordinates within the 12 districts in Minna metropolis. The quantity of the waste bins as well as names for their locations was taken into consideration and computed together to form a database for the research work. These data obtained were then taken to the GIS laboratory at federal polytechnic Bida for the following operations:

- Scanning of the map
- Geo-referencing
- Digitizing of the exported map

- Plotting of the various points on the digitized map

Besides, different types of solid wastes generated within the 12 districts of Minna metropolis were segregated and weighed daily before evacuation by the NISEPA trucks to the dumping site, for a period of seven days. Thus, the quantity of different categories of waste such as plastic. papers, metals, polythene, food garbage were deduced by estimation.NISEPA management staffs were also interviewed to comprehend MSW management practices of the metropolis, main questions include; policy for waste management, allocation of funds for waste management, training of MSW handling staffs. The overall assessment of waste management practices for Minna metropolis was carried out based on the guidelines for the assessment level of sustainable waste management practice by Townend and Cheeseman. 2005 given in table 3.1 Based on the guidelines, MSW were grouped into five different categories in line with the characteristics described in Table 3.1 (Townend & Cheeseman, 2005)

3.5 Questionnaire Distribution

The questionnaire comprised of structured questions which were in form of a multiple choice type, a Likert scale format was used in which a respondent had to tick one of the boxes to show how much he/she agrees or disagrees with the question asked. A total number of eighty (80) structured questionnaires were distributed in the following districts Tunga, Bosso, London Street, Kpakungu, Out of the eighty (80) questionnaires randomly distributed to respondents, only sixty eight (68) were properly filled and returned which represent 85% of the total area.

Table 3.2: Questionnaire Administration

District Names	No. of questionnaire	No. of respondent	percentage (%)
Tunga	20	16	80%
Bosso	20	18	90%
London Street	20	14	70%
Kpakungu	20	20	100%
Total	80	68	85%

Table 3.3: Guidelines for the Assessment of Sustainable Waste Management Practices

Practice level	Operating performance	Characteristics.
Level 0	Operating in a totally unsustainable manner with reluctance to change.	No waste management strategy, only limited segregation of wastes, storage containers are unspecific with no colour coding and waste are likely to be dumped indiscriminately. In addition waste is transported in open trucks, limited re-use of materials and no recycling at the facility; waste treatment is limited to the simplest technologies such as crude incineration, while off-site disposal exist it will be mainly to a dumpsite or level I landfill with the attendant environmental hazards.
Level 1	Generally operating in an unsustainable manner, although there is some evidence of awareness and willingness to change.	Although having no specific waste management strategy, will have separate collection of segregated wastes In enclosed vehicles autoclave of infectious wastes and use of single cell incineration plant.
Level 2	Operating in a manner with some aspects that are considered sustainable and others that are considered unsustainable.	Waste management policy in place, segregation of waste and colour coding, specified waste storage containers, waste transported with enclosed compaction vehicles and separate vehicles for hazardous waste, some recycling at facility use of multi-

		chamber incinerator plants and alternative modem technologies to treat waste and disposal in level 2 land fill.
Level 3	Generally operating in accordance with sustainable development, but some aspects not ideal	Local waste management policy and strategy in place, full colour coding, dangerous waste are stored in UN approved containers and packing all waste in containers of approved standard and a dedicated waste handling facility. Re-use and recycling of materials, incineration of hazardous materials to EU directive emission standards plus use of alternative technology and offsite disposal at a level 3 landfill site.
Level 4	Operating in a way that displays all the characteristics normally associated with sustainable development	Waste management policy, full time waste manager, full segregation of materials, full colour coding, contracts with secondary raw material industries, storage in UN approved containers, waste is transported in enclosed compaction vehicles, basal convention applied to waste transport. Recycling of paper, glass, plastic metal, construction waste, food waste, textiles etc. incineration of hazardous materials to EU directive emission standards plus use of alternative technology, hazardous waste to strictly controlled landfill sites and off sites disposal to level 4 sanitary landfill.

3.4.3 Summary Chart ofthe Methodology

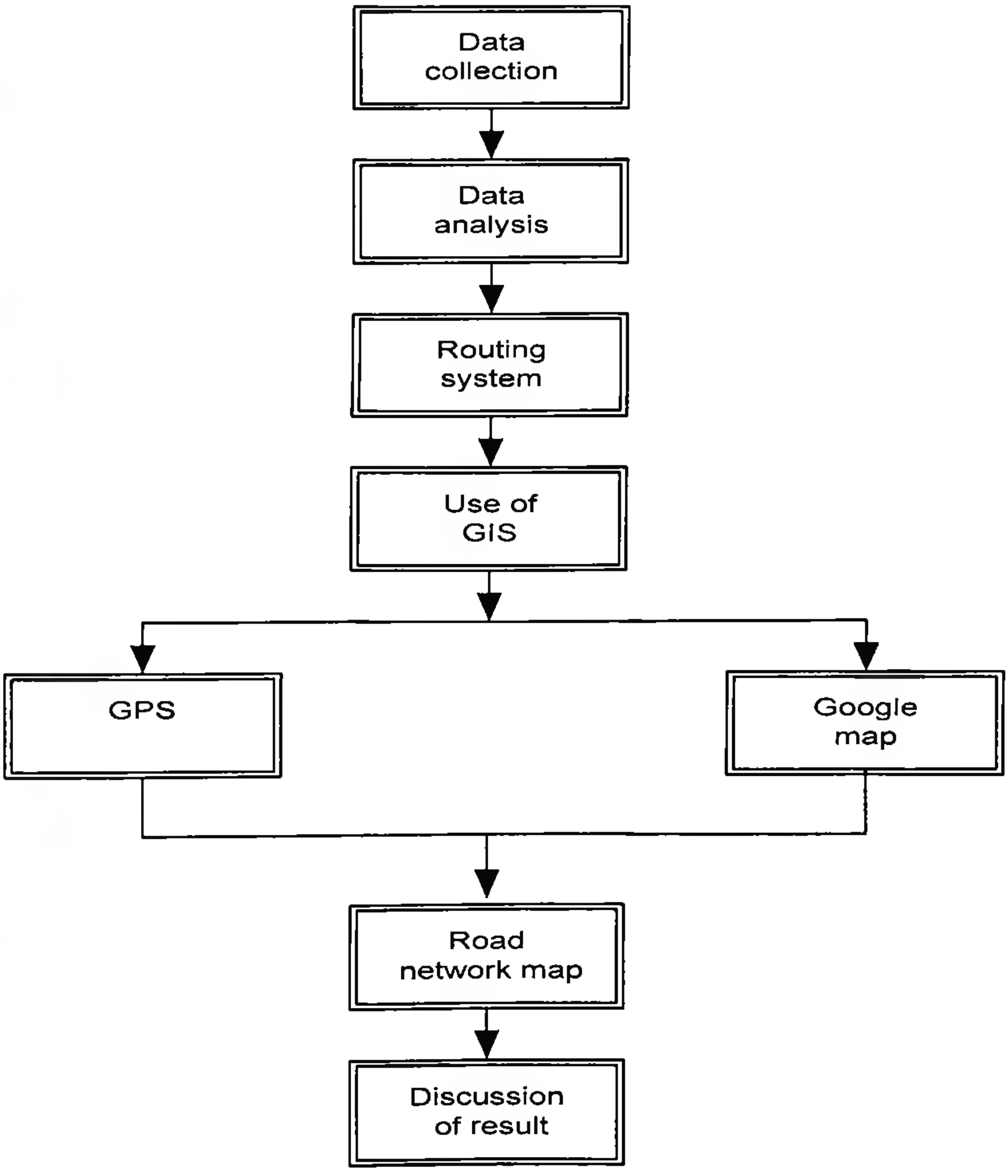

Figure 3.1: Methodology Chart

Table 3.4: Niger State Environmental Protection Agency (NISEPA) Routing Schedule List

NAME OF DISTRICT	DESCRIPTION
Chanchaga	City gate, Shango, Gidan Madara, T/Goro, Chanchaga
SABON GARI	Sabongari, Mobil R/About, Stadium Junction, Eid Ground, New Market, Saiko.
BOSSO	Bosso (Mypa Junction), Tudun Fulani, Bosso Estate Extension. Bosso Lowcost, Tudun Fulani.
KETEREN GWARI	Mobil Round About, Ketere Gwari, 123 Quarters, Kwangila, Oduoye Quarters.
ZARUMAI	Type 'B' and Zarumai Quarters, Panteka, Dusten Kuran Hausa, London Street, Okada Road.
SAUKA KAHUTA	City Gate Roundabout, Brighter, Sauka Kahuta, Barikin Saleh, Garima, Jonathan Palace, Kpakungu Bridge.
MAITUMBI	Maitumbi, Flamingo, El-Amin, 3 Arms Zone, M.I. Wushishi. Back of Galaxy International Schools and City Gate Roundabout.
LIMAWA	Obasanjo Shopping Compex, old Airport Quarters, Federal Secretariat, Limawa, Commissioner Quarters and GRA.
KPAKUNGU	Mawo Junction, Dusten Kura (Gwari), Fadikpe, Kpakungu and Nylkangbe.
'F' LAYOUT	Anguwan Daji, 'F' Layout, Tayi Village, Stadium Junction. Mypa Junction (Bosso), Anguwan Biri, Bosso East.

	UP HILL	David Mark Road, El-Amin, IBB Road, Paiko Road, NTA, NISEPA, Pension Board, Pot Round About, Mobile Police Base, Railway Station, Morris Fertilizer.
	TUNGA WEST	Entire Tunga 'B'
	TUNGA EAST	Entire Tunga 'A'

(**Source**: Sallah, 2015)

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.0 RESULTS AND DISCUSSIONS

4.1 RESULTS

The results of municipal solid waste assessment for Minna metropolis are presented in table 4.1 - 4.5 respectively, while responses received from the questionnaires distributed are also presented in table 4.7.1 - 4.7.8

Table 4.1: Paper waste (Segregated)

Generation Units	Quantity of waste in kg/day							Estimated Weekly Weight (kg)	Average Daily Weight (kg)
	1	2	3	4	5	6	7		
Chanchaga	10.0	12.0	5.5	12.0	14.0	8.0	5.0	66.5	9.50
Sabon gari	8.0	7.0	4.0	14.0	15.0	6.0	7.0	61.0	8.71
Bosso	12.0	9.0	13.0	11.0	12.0	10.0	6.5	73.5	10.50
Keterengwari	11.0	5.0	8.5	10.0	8.0	11.0	5.5	59.0	8.43
Zarumai	14.0	9.0	10.0	9.0	9.0	7.0	2.0	60.0	8.57
Sauka kahuta	11.5	10.0	8.0	6.0	12.0	10.0	7.0	64.5	9.21
Maitumbi	10.0	16.0	8.0	8.0	10.0	7.0	6.0	65.0	9.29
Limawa	11.0	5.0	7.0	6.0	7.0	9.0	7.5	52.5	7.50
Kpakungu	7.0	8.0	9.0	7.0	5.0	7.0	4.5	47.5	6.79
F-layout	8.0	9.0	10.5	10.0	8.0	8.0	5.0	58.5	8.36
Up hill	9.0	6.0	15.0	11.0	9.0	6.0	6.0	62.0	8.86
Tunga	6.0	7.0	12.5	14.0	10.0	5.0	7.0	61.5	8.79
Total	117.5	103.0	111.0	118.0	119.0	94.0	69.0	731.5	104.50

From Table 4.1, the estimated weekly waste generation for paper is 731.5kg and average daily waste generation is 104.50kg. High waste generation comes from day 5, 4 and 1 on daily basis, likewise from Bosso, Chanchaga and Maitumbi. Wastes generated on these days are high because they are week days and those areas are mostly dominated by students as such there are more tendencies for littering of papers and other related waste.

Table 4.2:Plastic Waste (Segregated)

Generation Units	Quantity of waste in kg/day							Estimated Weekly Weight (kg)	Average Daily Weight (kg)
	1	2	3	4	5	6	7		
Chanchaga	4.5	5.0	6.0	5.0	7.0	3.0	4.0	34.5	4.93
Sabon gari	8.0	7.0	4.0	3.5	5.0	4.5	3.0	35.0	5.00
Bosso	5.0	3.5	5.0	6.0	5.5	3.0	4.0	32.0	4.57
Keterengwari	4.0	5.0	4.5	5.0	8.0	4.5	4.0	35.0	5.00
Zarumai	4.0	5.0	5.0	6.5	4.5	4.0	3.0	32.0	4.57
Sauka kahuta	5.5	3.0	4.0	6.0	2.0	4.0	7.0	31.5	4.50
Maitumbi	5.0	6.5	8.0	3.0	6.0	4.0	2.5	35.0	5.00
Limawa	6.0	5.0	3.0	6.0	4.0	2.0	2.5	28.5	4.07
Kpakungu	7.0	5.5	6.0	5.0	4.0	3.0	2.0	32.5	4.64
F-layout	4.0	5.0	2.0	6.0	3.5	6.0	5.0	31.5	4.50
Up hill	5.0	6.0	4.5	3.0	4.0	2.5	3.0	28.0	4.00
Tunga	3.5	6.0	4.0	7.5	5.0	4.5	2.5	33.0	4.71
Total	61.5	62.5	56.0	62.5	58.5	45.0	42.5	388.5	55.50

Table 4.2 shows that the estimated weekly waste for the plastic is 388.5kg and average daily waste generation is 55.50kg. High waste generation comes from day 4, 2 and 1 on daily basis and from Keterengwari, Sabon gari and Chanchaga respectively.

Table 4.3: Garbage Waste (Segregated)

Generation Units	Quantity of waste in kg/day							Estimated Weekly Weight (kg)	Average Daily Weight (kg)
	1	2	3	4	5	6	7		
Chanchaga	3.0	2.0	2.5	3.0	1.0	1.0	1.5	14.0	2.00
Sabon gari	2.0	3.0	4.0	3.0	3.0	4.0	3.0	22.0	3.14
Bosso	3.5	1.0	2.0	3.5	3.0	1.5	2.0	16.5	2.36
Keterengwari	3.0	4.0	3.5	4.0	3.0	2.0	1.0	20.5	2.93
Zarumai	4.0	1.5	3.0	2.0	4.0	3.0	2.0	19.5	2.79
Sauka kahuta	2.0	4.0	3.0	1.5	3.0	2.5	1.0	17.0	2.43
Maitumbi	2.0	3.0	4.0	4.0	3.0	1.5	2.0	19.5	2.79
Limawa	3.5	4.0	5.0	2.5	2.0	3.0	1.0	21.0	3.00
Kpakungu	4.0	1.0	3.0	2.5	3.0	1.0	2.5	17.0	2.43
F-layout	4.0	3.0	2.0	2.5	3.5	2.0	1.5	18.5	2.64
Up hill	2.0	2.5	1.0	3.0	4.0	2.0	1.5	16.0	2.29
Tunga	3.5	4.0	3.0	3.5	3.0	2.0	2.0	21.0	3.00
Total	36.5	33.0	36.0	35.0	35.5	25.5	21.0	222.5	31.79

It is shown in table 4.3 that the estimated weekly waste generation for food garbage is 222.5kg and average daily generation is 31.79kg. Similarly, high waste generations comes from Sabon gari Tunga and Limawa respectively, this shows there is large population in this districts.

Table 4.4:Polythene waste (Segregated)

Generation Units	Quantity of waste in kg/day							Estimated Weekly Weight (kg)	Average Daily Weight (kg)
	1	2	3	4	5	6	7		
Chanchaga	4.0	5.5	6.0	3.5	4.5	4.0	3.0	30.5	4.36
Sabon gari	8.0	7.0	7.0	6.0	12.0	2.5	3.0	45.5	6.50
Bosso	6.0	4.0	6.0	9.0	5.0	5.5	5.0	40.5	5.79
Keterengwari	7.5	5.0	9.0	3.5	8.0	6.5	4.0	43.5	6.21
Zarumai	4.0	7.0	4.0	5.5	4.5	7.0	2.0	34.0	4.86
Sauka kahuta	2.5	3.0	4.0	3.5	2.5	2.0	2.5	20.0	2.86
Maitumbi	4.5	8.0	8.0	2.5	5.0	7.0	6.0	41.0	5.86
Limawa	3.5	5.0	7.0	6.0	7.0	5.5	4.0	38.0	5.43
Kpakungu	4.5	5.0	3.0	7.0	3.5	2.5	4.0	29.5	4.21
F-layout	4.5	4.5	7.0	4.0	8.0	6.5	5.0	39.5	5.64
Up hill	5.0	6.0	3.5	6.5	3.5	5.0	2.5	32.0	4.57
Tunga	3.0	4.0	2.5	6.0	3.0	4.0	3.5	26.0	3.71
Total	57.0	64.0	67.0	63.0	66.5	58.0	44.5	420.0	60.00

Table 4.4 also shows that the estimated weekly generation for the polythene is 420.0kg and average daily generation is 60.00kg. Also, high waste generation comes from Sabon gari, Keterengwari and Maitumbi respectively.

Table 4.5: Metal Waste (Segregated)

Generation Units	Quantity of Waste in kg/day							Estimated Weekly Weight (kg)	Average Daily Weight (kg)
	1	2	3	4	5	6	7		
Chanchaga	8.5	7.0	10.5	8.5	6.5	5.0	7.0	53.0	7.57
Sabon gari	6.0	8.5	6.5	8.0	12.5	5.5	5.5	52.5	7.50
Bosso	9.0	7.5	8.0	6.0	4.0	3.5	4.0	42.0	6.00
Keterengwari	6.5	8.5	4.5	6.0	6.0	5.0	6.5	43.0	6.14
Zarumai	6.0	9.0	11.5	5.0	6.0	5.0	5.0	47.5	6.79
Sauka kahuta	5.5	8.0	6.5	6.0	7.0	3.0	6.0	42.0	6.00
Maitumbi	6.0	9.0	7.5	8.0	6.5	5.0	6.5	48.5	6.93
Limawa	9.5	5.0	6.0	5.0	7.0	4.5	5.5	42.5	6.07
Kpakungu	4.5	6.0	8.5	8.5	5.0	3.0	6.0	41.5	5.93
F-layout	5.5	8.0	6.0	7.5	6.0	5.0	4.5	42.5	6.07
Up hill	6.5	6.5	10.0	5.0	14.0	3.5	4.0	49.5	7.07
Tunga	7.5	5.0	6.5	8.0	5.0	9.5	4.0	45.5	6.50
Total	81.0	88.0	92.0	81.5	85.5	57.5	64.5	550.0	78.57

Table 4.5 gives the estimated weekly waste generation for metals to be 550.0kg and average daily generations to be 78.57kg. Highest waste generations for the metal wastes come from Chanchaga, Sabon gari and Uphill respectively.

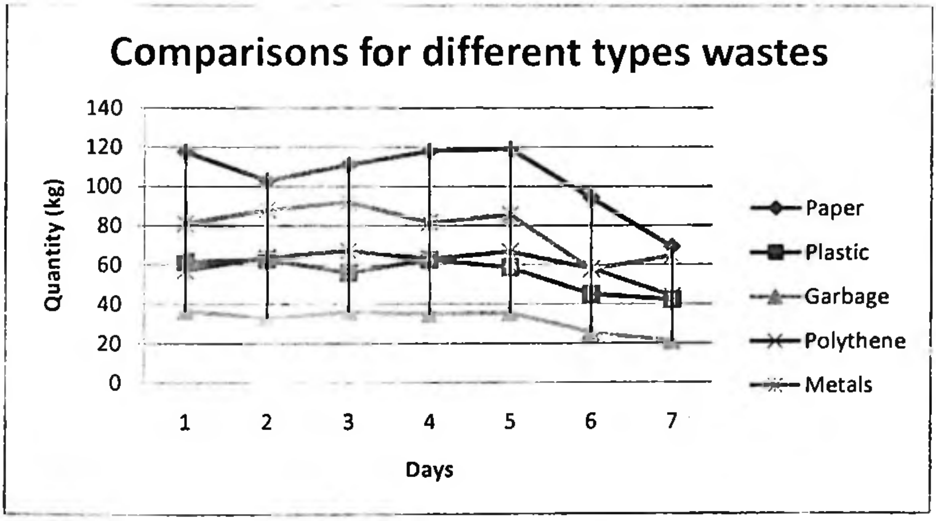

Figure 4.1: Comparison of various components sorted out during the study period.

The figure 4.1 shows the comparison of various waste components sorted out during the study period. The highest amount sorted per day is paper waste, followed by metal waste. while the lowest amount of the generated waste is garbage (food remnants) waste which has less than 40kg per day.

Table 4.6:Current Municipal Solid Waste (MSW) Management situation at Minna Metropolis

MSW Management Criteria/Descriptors	Description of Existing Practice

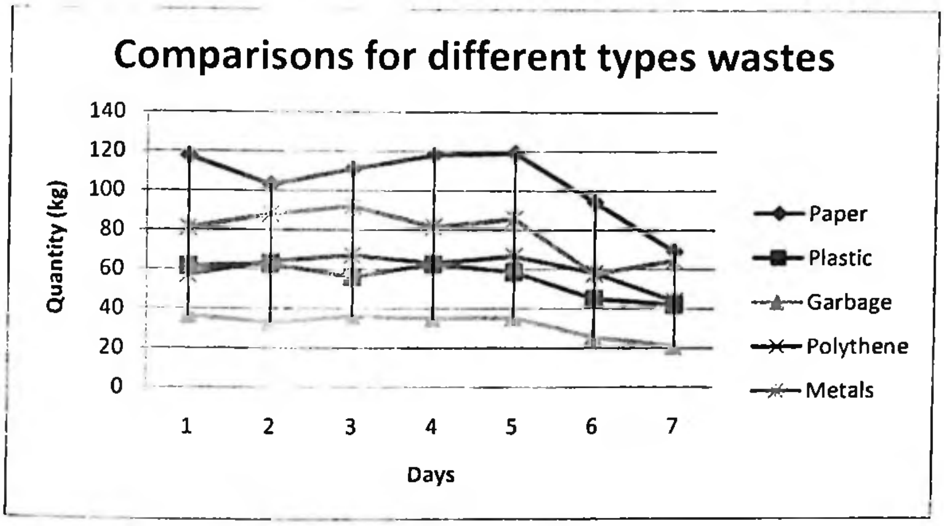

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Table 4.6:Current Municipal Solid Waste (MSW) Management situation at Minna Metropolis

MSW Management Criteria/Descriptors	Description of Existing Practice

General Management Strategy	
Any form of MSW management policy or strategy	Yes
Special budget for waste management	Yes
Operative staff for waste management	Yes, but few
Training on waste management	Partial
Personal protective equipment for waste management staff	Yes
Waste Collection and Segregation	
Types of receptacle/storage container (uniform or specific, varying types, sizes)	Uniform waste containers
Colour coding of receptacles	No
Number/adequacy of waste receptacles	Not adequate
Are waste materials segregated before dumping or dump collectively into a single container?	No, they are dumped collectively without separation
Is segregation regulated or controlled?	No
Waste Recycling	
Is there any form of recycling?	No
Which type of waste is recycled?	None
Will you welcome the idea of recyclable programme if implemented?	Yes
Waste Storage/disposal	
Any purposely built waste treatment facility?	No

Are waste dumped into storage containers such as receptacles and bunkers?	Yes
Open waste dumping practiced when receptacles are not provided	Partial
Types of Waste managed by NISEPA	
Solid waste such as plastic, paper, polythene etc.	Yes
Liquid waste such as sewage evacuation	Yes
Industrial waste	No
Offsite Disposal	
How is waste transported	Closed
Open or enclosed compaction vehicle?	Both
Waste disposal contracted out?	No
Where is the final destination of waste materials?	Open land fill.

Table 4.6 presents key findings on current situation of municipal solid waste (MSW) management practice for Minna metropolis. In this study it was found out that Minna metropolis has a sanitation unit called Niger State Environmental Protection Agency with the acronym (NISEPA). This body, being the only organization approved by the Niger state government is in charge of managing the solid waste generated within Minna metropolis. NISEPA is an organized body which has its management manual and policies for ensuring

effective waste management exercise within the metropolis of Minna as indicated in Table 3.3. Besides, the state government allocates special budget for effective waste management, in spite of the allocations provided by the state government they are no enough storage containers for collection of waste generated.

It was observed that wastes are collected in uniform receptacles, with no colour coding to indicate the type of waste to be deposited in the respective containers. Also waste materials are not being segregated before dumping but rather they are dump collectively into a single container, with no any effort that may encourage recycling of some of the waste materials such as plastics. However, the general public admitted that they are willing to welcome any idea of recyclable program in case if implemented.

The solid waste are collected from various districts within the metropolis on a daily basis where they are now been transported in closed vehicle to the opened dumped site located at Maikunkele, where they are burned in open fire. Scavengers who are lucky enough may pick up some valuable waste materials deposited at the landfill before the actual burning. During the burning process, air pollutants are released into the atmosphere causing respiratory illness to nearby population and emission of greenhouse gases dioxins to the atmosphere. In the light of the above, Minna metropolis has level 2 sustainable waste management practices in line with guidelines provided by Townend and Cheeseman, 2005.

Table 4.7.1: Waste management policy is fully implemented

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	26	38.2	38.2	38.2
	Agree	19	27.9	27.9	66.2
	Undecided	5	7.4	7.4	73.5
	Disagree	13	19.1	19.1	92.6
	Strongly Disagree	5	7.4	7.4	100.0
	Total	68	100.0	100.0	

Table 4.7.2: Receptacles are provided in large quantity all over minna city

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	5	7.4	7.4	7.4
	Agree	19	27.9	27.9	35.3
	Undecided	7	10.3	10.3	45.6
	Disagree	21	30.9	30.9	76.5
	Strongly Disagree	16	23.5	23.5	100.0
	Total	68	100.0	100.0	

Table 4.7.3: Waste materials are segregated before dumping into receptacles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	2	2.9	2.9	2.9
	Agree	5	7.4	7.4	10.3
	Undecided	4	5.9	5.9	16.2
	Disagree	11	16.2	16.2	32.4
	Strongly Disagree	46	67.6	67.6	100.0
	Total	68	100.0	100.0	

Table 4.7.4: Wastes are dumped into a single container without sorting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	33	48.5	48.5	48.5
	Agree	23	33.8	33.8	82.4
	Undecided	3	4.4	4.4	86.8
	Disagree	5	7.4	7.4	94.1
	Strongly Disagree	4	5.9	5.9	100.0
	Total	68	100.0	100.0	

Table 4.7.5: Segregation of waste is regulated by NISEPA authority

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	7	10.3	10.3	10.3
	Agree	6	8.8	8.8	19.1
	Undecided	15	22.1	22.1	41.2
	Disagree	22	32.4	32.4	73.5
	Strongly Disagree	18	26.5	26.5	100.0

Total	68	100.0	100.0	

Table 4.7.6: A well planned recyclable program may be welcome by the public if implemented

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	29	42.6	42.6	42.6
	Agree	19	27.9	27.9	70.6
	Undecided	10	14.7	14.7	85.3
	Disagree	3	4.4	4.4	89.7
	Strongly Disagree	7	10.3	10.3	100.0
	Total	68	100.0	100.0	

Table 4.7.7: Separating waste materials into three compartment will be a good idea to help in recycling program

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	28	41.2	41.2	41.2

Agree	16	23.5	23.5	64.7
Undecided	8	11.8	11.8	76.5
Disagree	11	16.2	16.2	92.6
Strongly Disagree	5	7.4	7.4	100.0
Total	68	100.0	100.0	

Table 4.7.8: Waste materials generated are taken to the final dumping site by NISEPA trucks

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	16	23.5	23.5	23.5
	Agree	22	32.4	32.4	55.9
	Undecided	14	20.6	20.6	76.5
	Disagree	7	10.3	10.3	86.8
	Strongly Disagree	9	13.2	13.2	100.0
	Total	68	100.0	100.0	

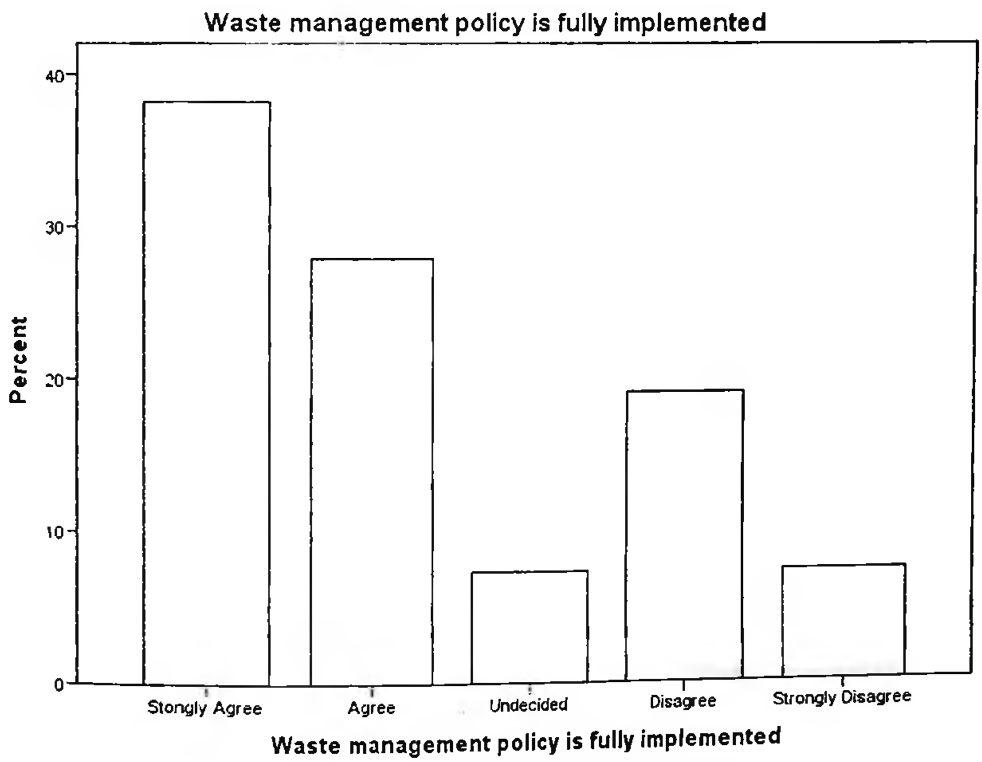


Figure 4.2

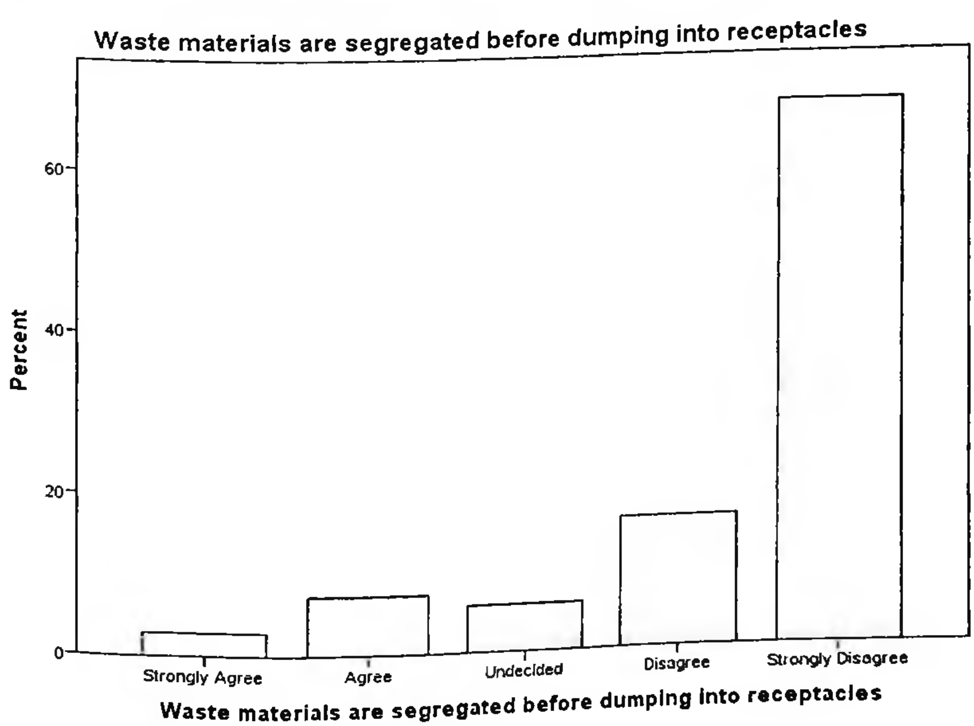
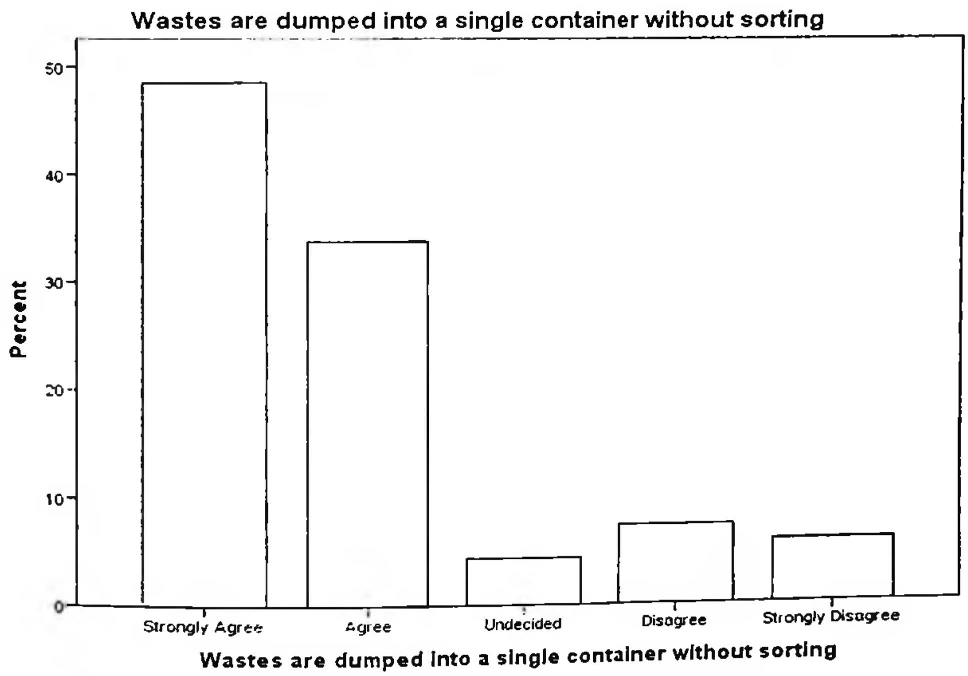


Figure 4.3



Wastes are dumped into a single container without sorting
Percent
50
40
30
20
10
0
Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree
Wastes are dumped into a single container without sorting

Figure 4.4

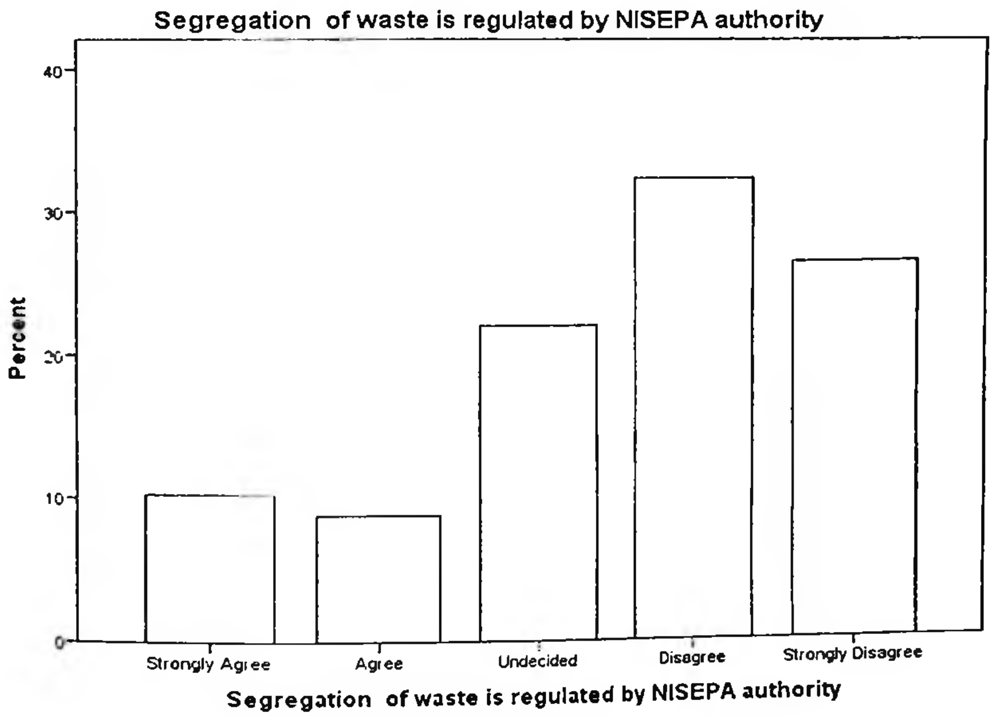

Segregation of waste is regulated by NISEPA authority
40
30
20
10
0
Percent
Strongly Agree
Agree
Undecided
Disagree
Strongly Disagree
Segregation of waste is regulated by NISEPA authority

Figure 4.5

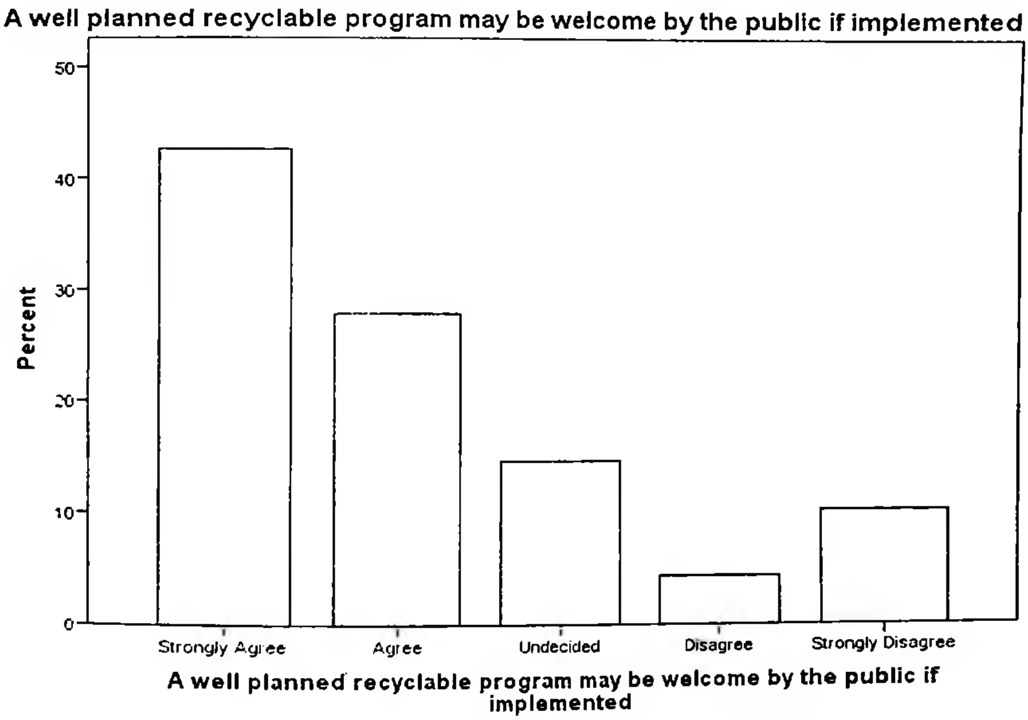


Figure 4.6

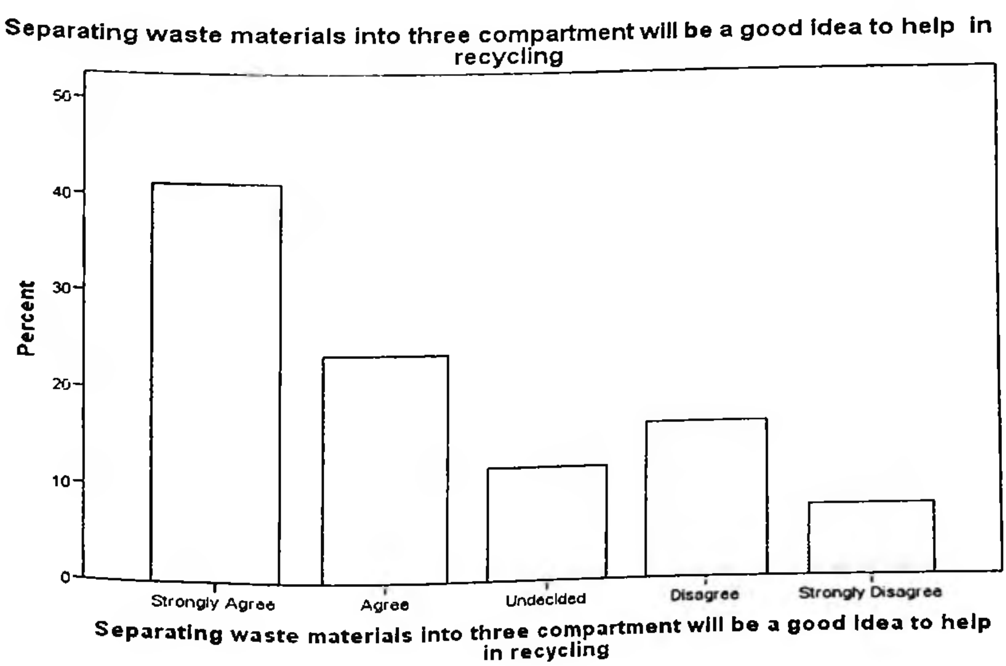


Figure 4.7

4.2 Generation of a Data Base for the Study Area

All data such as district names, quantity of receptacles as well as the easting and northing coordinates were been collected with the use of a hand held GPS and finally converted into a shape file as will be shown later. The vehicle routing was performed with the aid of some of the NISEPA staff to help in locating the positioning of various waste bins that are placed all over the metropolis. Also a visit was made to dumping site located at Maikunkele were all the refuse were been finally dumped without any effort made for management of these waste. This is because all types of generated waste such as bottles, papers, plastic, metals etc. are all been deposited into one single container before been finally transported to the final dumping site by the NISEPA officials.

Table 4.8: Data Base for the Study Area

	DISTRICT NAMES	NO. OF BINS	CO-ORDINATES E	CO-ORDINATES N
1	TUNGA B	200	231315	1061710
2	CHANCHAGA	40	234482	1055495
3	SHANGO	19	233822	1058527
4	M.I.WUSHISHI	100	233852	1061965
5	NEW SECRETARIAT	10	233039	1060185
6	TUNGA TOP MEDICAL	15	232414	1061694
7	NISEPA OFFICE	10	231769	1062673
8	DAVID MARK ROAD	50	233192	1065373
9	SABON GARI	20	231770	1064626
10	BOSSO	100	229057	1068084
11	BAHAGO ROAD	30	230151	1066695
12	F-LAYOUT	69	230606	1065286
13	FIRST BANK TUNGA	11	231441	1063009
14	GURARA	10	228142	1061655
15	NNPC MEGA STATION	20	232305	1059764
16	SECRETARIAT JUNCTION	25	229769	1063132
17	123-QUARTERS	80	229752	1063782
18	KURE MARKET	60	229871	1063782
19	DARU SALAAM	20	229978	1060912

20	SHIRORO JUNCTION	30	230229	1060746
21	NITECO ROAD	60	231275	1061466
22	ODOUYE QUARTERS	14	228907	1063396
23	DUSTEN KURA GWARI	10	228061	1065313
24	LONDON STREET	45	228399	1065781
25	DUSTEN KURA HAUSA	15	228288	1066300
26	BOSSO ESTATE	65	227670	1067766
27	TUDUN FULANI	23	228055	1069099
28	MAIKUNKELE	40	227088	1069596
29	HANDICAPPED SCHOOL	8	226629	1067272
30	BARIKIN SALEH	30	228626	1064581
31	LIMAWA	22	229027	1062475
32	GENERAL HOSPITAL	20	230580	1063361
33	KPAKUNGU	50	228113	1061631
Total		1321		

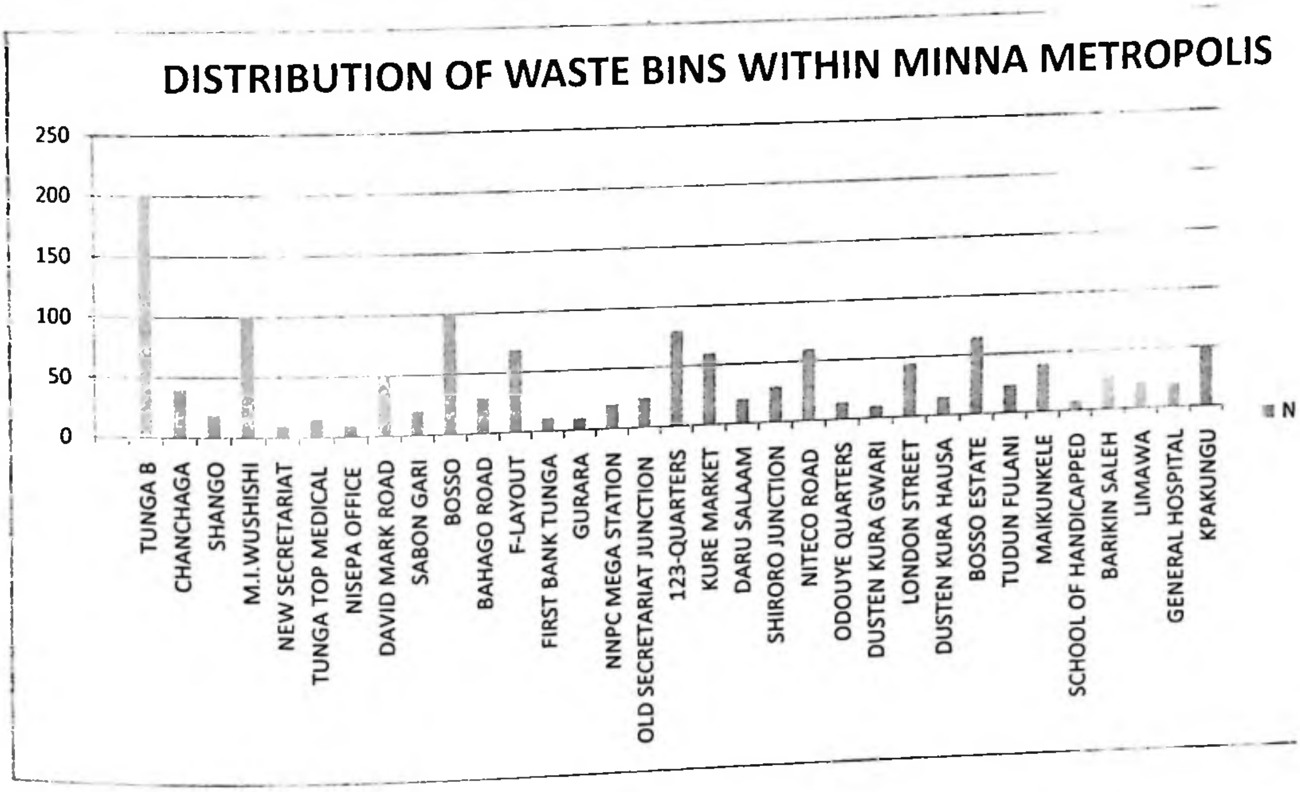
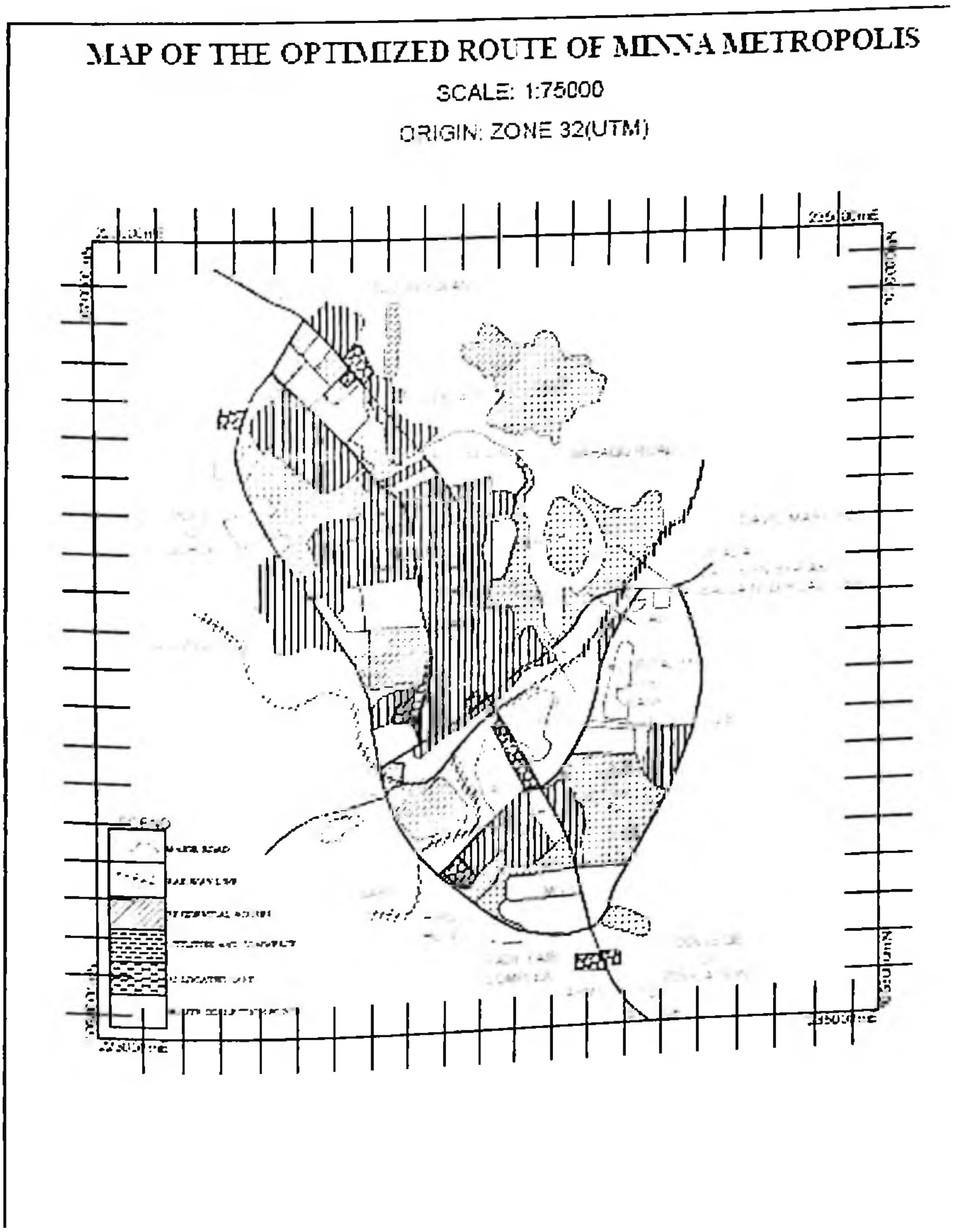


Figure 4.8 Waste Bin Distributions in Minna Metropolis

Figure 4.8 shows the allocation of waste bins to various districts within the metropolis of Minna. Tunga B has the highest number of waste bin, which is about 200 waste bins distributed within the district of Tunga. Perhaps, this may be due to the presence of high income earners and well planned structures in the area. The next districts with higher number of waste bin are Bosso and M.I. Wushishi. Gurara and school of handicapped have relatively the lowest distribution of waste bin; this is because they are far away from the main metropolis.

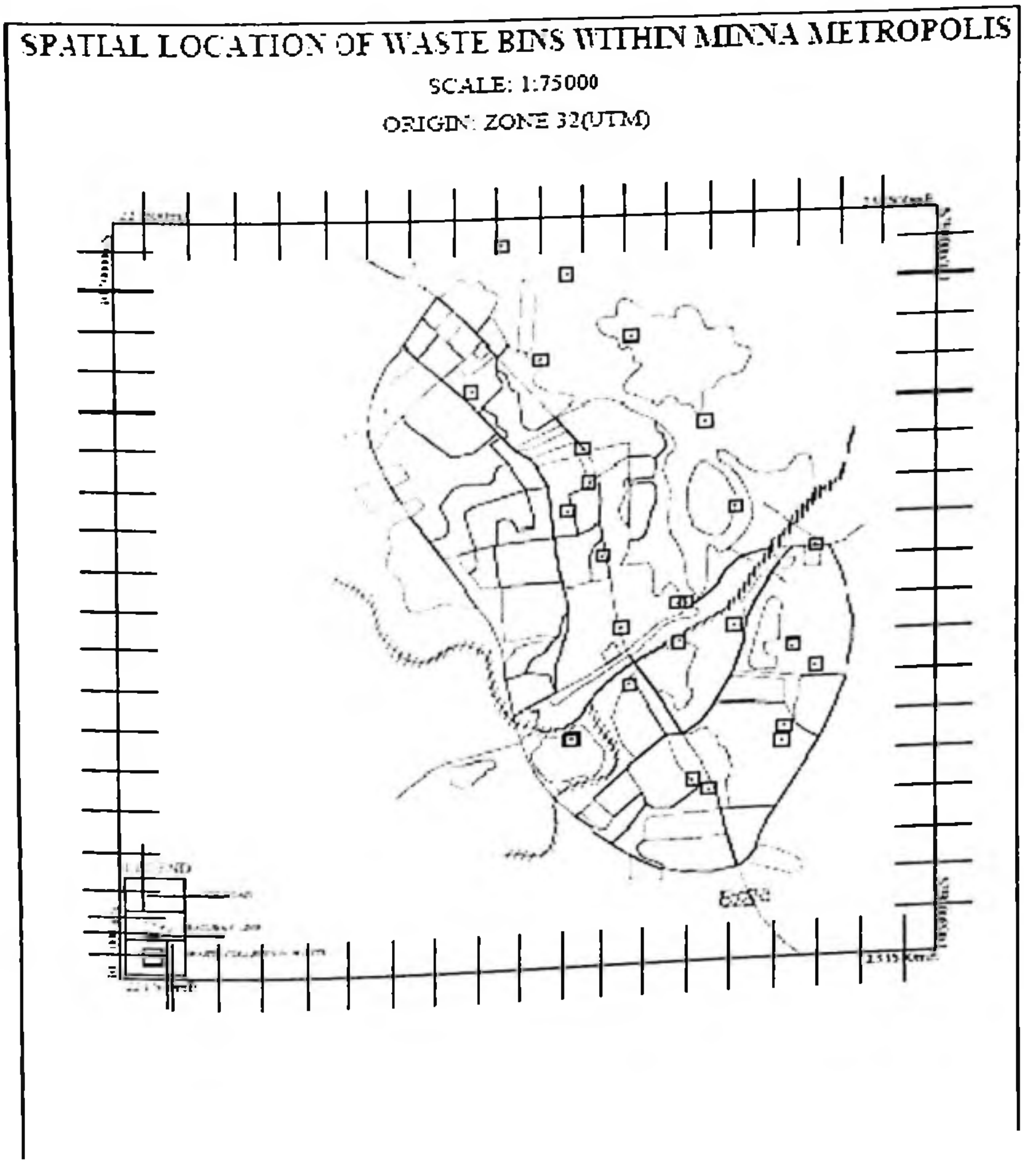


Source: Research Result

Figure 4.9.1 Map of optimized route for Minna Metropolis

From the map of the study area shown above, the easting and northing coordinates for solid waste collection bins locations were collected for the entire metropolis using a hand heldGPS.

With the data obtained, a data base was generated and the information's in the database were converted into a shape file as shown in figure 4.9.1 above. Also, from the network dataset generated, routes were optimized from the solid waste storage bins to disposal site (dumping site) for all the 12 districts in the study area using an analyst tool of GIS (AutoCAD land Development). The correspondingdistrict distances and durations were generated as shown in Table 4.9.



Source: Research Results

Figure 4.9.2 spatial locations of collection points in the study area

The figure 4.4 above shows the spatial distribution of service points (waste bins locations, existing routes) in the studied routes within Minna metropolis.

Table 4.9: Distances and Durations for various collection points

District Names	Distance to be travelled from source to dumping site(m)	Time (min)
Tunga B	8947.4	64.4
Eastern Bypass	6828.0	49.2
Gurara	8357.0	60.2
City Gate	9144.8	65.9
Shiroro Hotel	11087.0	79.9
Zenith Bank	9792.5	70.5
David mark road	8357.0	60.2
College of Education	7422.4	89.3
Bosso	12391.3	53.5
Bahago Road	2482.6	37.9
F-layout	4218.7	30.4
First Bank Tunga	5505.3	39.7
Gurara	7895.4	56.9
Army Barrack	8030.7	57.8
Old Secretariat	11534.4	83.1
Kure Market	7037.6	50.7
Shiroro Junction	6423.9	46.3
Niteco Road	9390.9	67.6
Odouye Quarters	9144.8	65.9
Police Sec. Schools	6464.6	46.6

london Street	4411.0	31.8
Dusten kura hausa	4035.5	39.1
Bosso Estate	3470.7	32.0
Tudun fulani	1387.0	30.0
Lowcost	1087.2	27.8
Barikin Saleh	2368.9	47.1
Limawa	5245.5	37.8
General Hospital	7380.3	53.2
Kpakungu	7146.3	51.5
Total	196989.0	1525.9

Table 4.9 gives the total distances for collection and transportation of municipal solid waste in the metropolis to be 196989.0m and the total duration that will enable the vehicles to collect MSW from various collection points to the final dumping site to be 1525.9min.

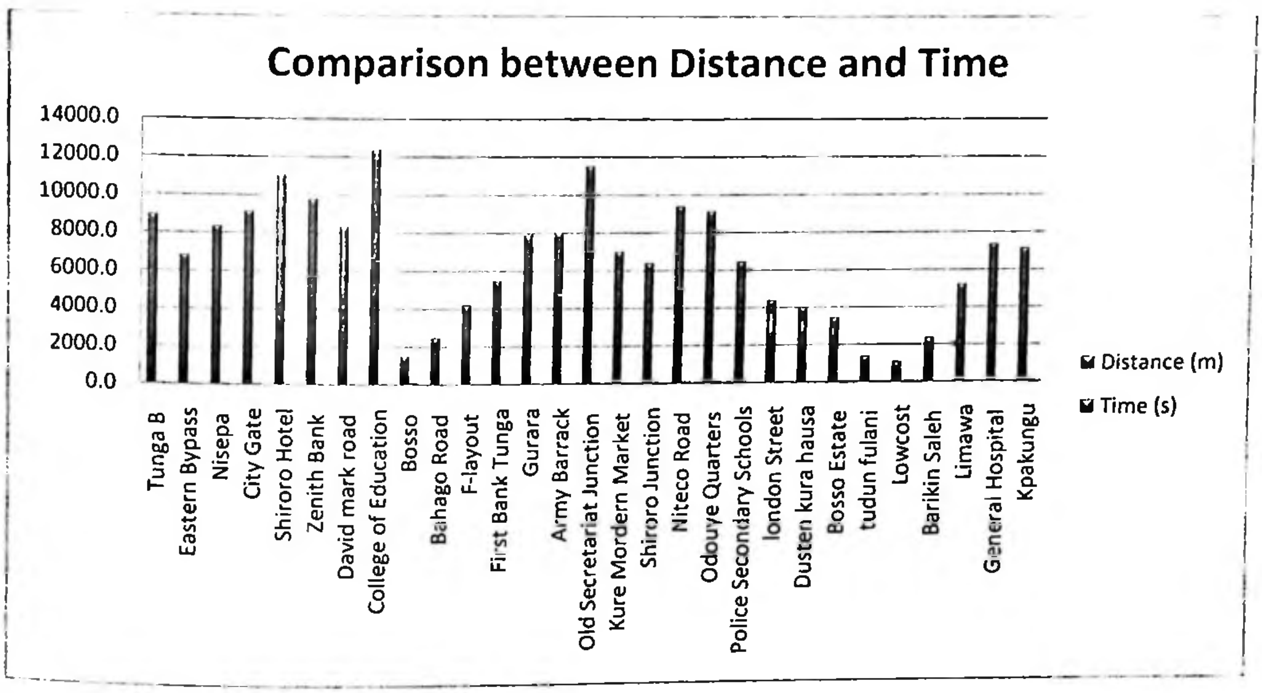


Figure 4.9.3: Comparison Between Distance Travelled and Time to the Land fill

From the figure above, the corresponding distances and time that will be required by NISEPA trucks to get to the final dumping for all the districts are represented in a chart as shown in figure 4.9.3

In order to ensure optimum waste collection vehicle route in terms of collection and distances, a feasibility study was done, and it was observed that NISEPA Authority do not carry out proper allocation of waste collection trucks that will enable frequent disposal of accumulated waste from various generating point to the final dumping site. From the usual practice, a single truck is assigned to each collection point. But, because of Poor management such as lack of regular service and maintenance some of these vehicles from time to time developfaults. These faulty trucks will end up not collecting refuse from the allocated areas within the municipality. Uncollected wastes accumulate at roadsides which become public nuisance, these wastes are occasionally burned by residents, or are disposed of in illegal dumps which blight neighborhoods and harm public health. In order to curb this menace, waste generating points that are in close proximity were merged together for collection and disposal considering the capacity of the automobile used for the waste collection. Table 4.10 gives the description of the optimized routes.

Table 4.10: Description of route optimized and vehicles required for Disposal

S/N	Districts names merged	Distance to be travelled from source to dumping site(m)	Time (min)	Type of Vehicle to be used
1	Bosso Estate, Bypass	3470.7	32.0	Compactor
2	Bosso, Bahago Road, F-layout	12391.3	53.5	Compactor
3	Dusten Kura, PSS.	4035.3	39.1	Compactor
4	David mark road, Niteco	8357.0	60.2	Compactor
5	Barikin Saleh, Limawa	2368.9	47.2	Compactor
6	Kpakungu, Gurara	7146.3	51.5	Volvo 619
7	C.O.E, Army Barrack	7422.4	89.3	Compactor
Total		45191.9	372.8	

The table above shows the description of routes optimized as well as the types of vehicles that will be used for collection and disposal of MSW, within the various districts. Closest district were merged together as one, and higher capacity vehicle were henceforth assign to them. To this, fifteen different routes, as well as collection vehicles were merged to become seven. Similarly total distances, as well as durations that will enable municipal solid waste management trucks to travel from various districts for collection to the final dumping site will now be reduced to 151797.1m and 1153.1min respectively.

4.3 Development of a Recyclable Programme.

Since no measures have been put in place to recycle useful waste materials such as plastics and metals by the NISEPA, a well-run recycling program can divert a significant percentage of municipal waste from disposal and can help to control waste management cost by generating government revenue through the sale of recyclable materials. This could come in form of a voluntary program that will encourage separation of recyclable materials such as: paper (newspaper, cardboard, mixed paper, etc.), glass (amber, green, and/or flint), cans (aluminum, ferrous metals and nonferrous metals, bimetal), and plastics (PET, HDPE, PS, PVC, PP, LDPE, etc.), as well as other items.

This program will require the participation of residents to separate recyclable materials into one or more fractions for collection purposes. Many developed countries have succeeded by recovering huge amount of recyclable materials with the implementation of this ambitious program.

In the light of the above, the NISEPA authority could device another way of repositioning waste storage containers, in such a way that each container be labeled the category of waste that should be dumped into it. This will thereby enable the recovery of most recyclable materials such as plastics and metals, thereby turning waste into wealth. The diagram below shows a schematic representation for repositioning the solid waste receptacles at each of the collection point within the metropolis.

Figure 4.10: Solid Waste Receptacles

Figure 4.10 shows a simple guide on repositioning waste bins by employing three separate large containers[One for plastic wastes (container on right), one for metal wastes (container in center), and the last one for other wastes (container on right)];

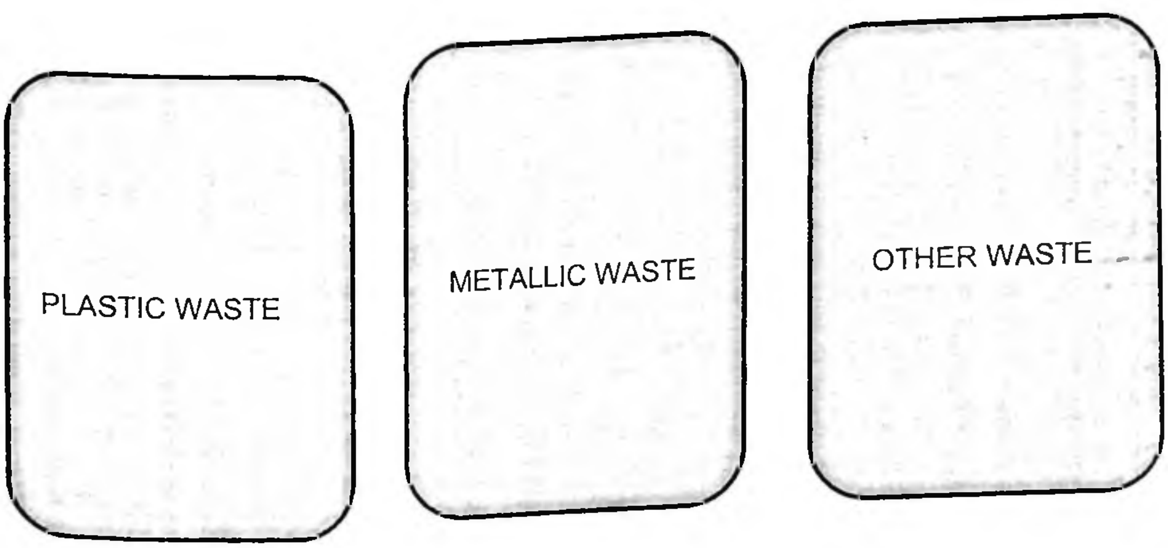


Figure 4.11 Alternative way for Re-positioningReceptacles

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

From the results and discussion of this study, the following conclusions can be drawn:

The total amount of municipal solid waste (MSW) generated in Minna metropolis is 2312.1kg per week. The waste comprises of paper waste which amounted to about 31.62% of the total waste, plastic waste which amounted to about 16.80% of the total waste, garbage waste which amounted to about 9.62% of the total waste, polythene waste which amounted to about 18.17% of the total waste and metal waste which amounted to about 23.79% of the total municipal solid waste.

Also, the total distance and time for collection and transportation of municipal solid waste (MSW) for Minna metropolis have been reduced from 196989.0m to 151791.1m and 1525.9min to 1153.1min respectively.

Finally, a recyclable programthat will enable sorting out of municipal solid waste (MSW) into three different compartments has been developed. This idea, will be more effective, and will further provide alternative source of revenue generation for the state government besides other benefits.

5.2 RECOMENDATIONS

Based on the findings in this research work, the following recommendations are hereby put forward:

1. Government should create law enforcement agencies to ensure proper sorting of municipal solid waste into separate containing vessels within the municipality.
2. The state government should establish stable financing and ensure funds are used appropriately.

3. There is need to design, develop and implement privatization schemes after weighing the potential costs and benefits.
4. There is need for proper sensitization on the importance of having waste sorted into different containers to help in facilitating recycling process so as to serve as an alternative means for revenue generation to the government.
5. Finally the concept of waste-to wealth is very new to most of the Sub Saharan African countries especially Nigeria. To this regard there is need for proper orientation of the general public.

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APPENDIX A

AHMADU BELLO UNIVERSITY ZARIA

MECHANICAL ENGINEERING DEPARTMENT

QUESTIONNAIRE FOR MASTERS IN ENGINEERING MANAGEMENT

(RESEARCH WORK)

TOPIC:

ROUTE OPTIMIZATION OF MUNICIPAL SOLID WASTE

(A CASE STUDY OF MINNA METROPOLIS)

SECTION A

INSTRUCTION: PLEASE FILL AS APPROPRIATE

Dear respondent

I am a master's student from the above institution, conducting a research work on "Route Optimization of Municipal Solid Waste Management".

In the light of the above, the researcher solicits for your support and cooperation by responding adequately to the questions contained in this questionnaire.

Thank you for your Cooperation.

1. What is your gender? Male ☐ female ☐
2. What is your occupation? Civil servant ☐ student ☐ Entrepreneur ☐ house wife ☐
3. What age group do you belong? Adolescent ☐ adult ☐ old age ☐
4. What is your educational qualification? Secondary cert ☐ Graduate ☐ Post Graduate ☐

SECTION B

INSTRUCTION: Please tick one box for each statement below to show how much you agree or disagree with it.

S/N	Research Questions	Strongly	Agree	Undecided	Disagree	Strongly

		Agree				Disagree
1.	Waste management policy is fully implemented					
2.	There are special budget for waste management in Minna					
3.	There are enough staff in charge waste management					
4.	Waste management staffs usually undergo special training					
5.	There is provision of protective equipment's for the staffs					
6.	Storage containers are uniform and mostly of the same sizes					
7.	Receptacles are provided in large quantity all over Minna city					
8.	Waste materials are segregated before dumping into receptacles					
9.	Wastes are dumped into a single container without sorting					
10.	Segregation of waste is					

	regulated by NISEPA authority					
11.	Plastic and metal waste are usually being recycled by NISEPA					
12.	A well planned recyclable program may be welcome by the public if implemented					
13.	Separating waste materials into three compartment will be a good idea to help in recycling					
14.	Open waste dumping is practiced in most areas where receptacles are not provided					
15.	Waste materials managed by NISEPA include: paper, plastic, polythene, metals etc.					
16.	Waste materials generated are taken to the final dumping site by NISEPA trucks					
17.	Solid waste is transported with enclosed compaction vehicles.					

APPENDIX B

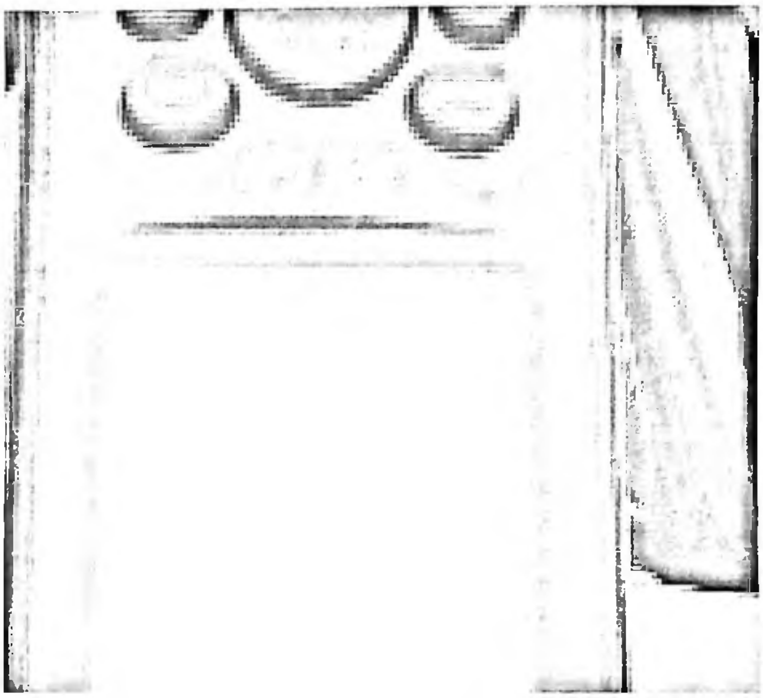

Plate A1: A Hand Held Global Positioning System (GPS)