APPRAISAL OF MUNICIPAL SOLID WASTE MANAGEMENT IN BENIN CITY EDO STATE

BY

OMORUYI, EFE
PGD/CIVIL ENG/2008/037

DEPARTMENT OF CIVIL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

FEBRUARY, 2011.

APPRAISAL OF MUNICIPAL SOLID WASTE MANAGEMENT IN BENIN CITY EDO STATE

BY

OMORUYI, EFE
PGD/CIVIL ENG/2008/037

A THESIS SUBMITTED TO POSTGRADUATE SCHOOL IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF POST GRADUATE DIPLOMA (PGD) IN CIVIL ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

FEBRUARY, 2011

DECLARATION

I hereby declare that this research work **"Appraisal of Municipal solid waste Management in Benin City Edo State"** was wholly and solely written by me under the supervision of Engr. R.A ADESIJI. That, no part of this work has been wholly or partially presented before for any post degree elsewhere. Information obtained from published and unpublished works of others have been dully acknowledged.

OMORUYI, EFE

18/02/2011

DATE

CERTIFICATION

This is to certify that this project titled "**Appraisal of municipal solid waste management in Benin City Edo State"** was carried out by OMORUYI, EFE under the supervision of Engr. R, A ADESIJI and submitted to the Civil Engineering Department, federal University Technology, Minna in partial fulfillment the requirement for the award of postgraduates diploma degree in Civil Engine

..... 19-02-11

Engr. A. R.ADESIJI — Date
(Project supervisor)

....

Engr. Prof. O .D. JIMOH — Date
(Project supervisor)

....

Engr. Prof. S SADIKU — Date
Head of Department

....

Prof .Mrs. Zubairu — Date
Dean PGS

DEDICATION

I fully dedicate this work to my lovely daughter OSARUGUE OMORUYI and the entire member of OMORUYI family.

ACKNOWLEDGEMENTS

In due appreciation of the efforts of the contributors to the success of the project, I therefore express my sincere gratitude to Almighty God and I express my profound gratitude to my project supervisor Engr. Richard Adesiji for imparting into me the wisdom and knowledge and guidance in presenting this write up. I pray God to grant him long life and prosperity for giving me the best from his best in term of advices.

My appreciation also goes to my H.O.D Prof. Engr. S. Sadiku and to all my lecturers in the department; Dr. P. N. Ndoke, Dr. A. Amadi, Prof. Engr. Jimoh, Dr. T. Y. Tsado, Dr. Aguwa, Engr. A. Mustapha, Engr. O. James, Engr. Oritola, Engr. Adejumo, Dr. Auta, Engr. S kolo, and Mallam Sani who have laboured tirelessly to impact their God given knowledge both morally and educationally.

I owe my thanks to my lovely mother, Mrs. Comfort Omoruyi, my lovely brothers and sister for their morally and financially support through the program. My appreciation goes to my lovely wife for the love and care during the program. I am deeply indebted to the family of Mr. and Mrs. Ogbeifun, Engr. and Engr. (Mrs.) L. Gbadebo family whom also support me in the course of the program. I say thank you and Almighty God grants you and your family a long life and prosperity.

Lastly, my sincere gratitude goes to my course mates Gbadebo Lawrence, Pius Uduhiriuwa, Mrs Ebhodaghe Anthonia, Usman Monday, Al-min Adam, Yusuf Moh`d Habib, Vivian Atuegbu,

Funk Folarin, Ochigbo Clement, Usiobaifo Osayemwenre, Abiri Victor, and my lovely friends who directly and indirectly worked towards the success of this project, I say thank you and God bless you all.

ABSTRACT

For any clean environment, there must be the state of the art on municipal solid waste management system. The study was to appraise the present municipal solid waste management in Benin metropolis. Two structured questionnaires were administered in Benin metropolis, one for the residents and another for the municipal solid waste manager. From the results of questionnaires, it revealed that most residents were satisfied with the system waste manager using in collecting their solid waste. Municipal solid waste managers were not satisfied with the system Edo State environmental and waste management board adopted. Therefore, municipal solid waste management system in Edo State was not effective and efficient. From the finding, it was also showed that neither residents nor waste manager, and Edo state environmental and waste management board does not use an applied technology of managing municipal solid waste in the state.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study.

Modern society is becoming a waste society rather than a well-to-do society, the waste that people produce litters our streets and is not always in the bins.

Our environment is the total surrounding condition of where we live, for us to live comfortably in our environment we must make it healthy for all the living organisms that live within the environment.

One of the ways to make our environment comfortable for living is the proper management of waste we generate in the environment. Waste is any material that has lost value in the eyes of the first user. While solid waste may be define as the organic and inorganic materials, produced by households, commercial, institution, and industrial activities which have lost their values in the eyes of the first owner.

Municipal solid waste management is a major responsibility of local government. It is a complex task which requires appropriate organizational capacity and cooperation between numerous stakeholders in the private and public sectors. Although it is essential to public health and environmental protection, solid waste management in most cities of developing countries is highly unsatisfactory

Municipal solid waste is the waste collected by public authority from domestic, institution, commercial, yard waste, street sweeping and non hazardous from industry. Therefore, municipal

solid waste management is the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste from urban areas. Municipal solid waste management is the major responsibility of local government, typically, it consume between 50% and 80% of the municipal budget in developing country. The problems of municipal solid waste has become a live issue in our society in Benin metropolis, it is to be seen along street, road, market places. It also seen to be blocking drainage system of the City which result to flooding in the town during raining period and pose tremendous health hazard to public health.

There is no such a single technology that can solve the waste management problem fully. Therefore, it is important to integrate different waste management technology in a strategic way to achieve the sustainable waste management objectives. However, it is difficult to select a particular technology for sustainable waste management decision or policy making processes without knowing the different technologies and their impacts on the environment. Due to lack of information on impacts from certain technology, sometimes wrong decision has been made and which might arise in adverse and critical situation. Therefore, it is important to know different technology through comparative study for different options and that might be a guiding tool for decision making processes.

The functioning of Municipal Solid Waste Management system and the impact of related development activities depends on their adaptation to particular characteristics of the political, social, economic and environmental context of the respective city and country.

1.2 Aim and Objective of Project

The aim of the research work is to appraise the present municipal solid waste management effectiveness in Benin metropolis and propose effective municipal solid waste management, if the present management system is not effective.

The specific objectives of the research were the following:

1. To reduce the adverse environmental effects caused by indiscriminate disposal of solid waste.
2. To generate employment and income.
3. To promote the quality of the urban environment.
4. To identify the type of solid waste being generate in Benin metropolis.
5. To study the various method used for disposing municipal solid waste in Benin metropolis.
6. Examine and evaluate the main shortcomings and suggested improvements of the collection system and disposing method.

1.3 Justification of the Project

Benin metropolis often lack effective municipal solid waste management system which consequently result in solid waste see around the street, road drainage system and market places. This municipal solid waste blocks drainage system which results to flooding during raining period and posing serious health hazard to the environment. Municipal solid waste hill emitted gases such as carbon (IV) oxide and methane which causes global warming. Due to the fact that Benin City is more commercialized and industrialized , the amount of municipal solid waste generated will be increased, and a proper and effective management system should be adopted to manage the high rate of the municipal solid waste been generated from the activities. Base on this, there is need to examine the present system of municipal solid waste and proposed to Edo

CHAPTER TWO

LITERATURE REVIEW

2.0 SOLID WASTE

Solid waste may be defined as the organic and inorganic waste materials produced by households, commercial, institutional and industrial activities. Which have lost their value in the eyes of the first owner. (Ogwueleka, 2005)

Solid wastes are all wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. (Howards *et al* 1988)

2.1 TYPE OF SOLID WASTE

Waste can be classified as solid waste or liquid waste.

Solid wastes are in three categories

1. Municipal solid waste.
2. Industrial solid waste.
3. Hazardous solid waste.

2.1.1 MUNICPAL SOLID WASTE

Municipal solid waste is the waste collected by public authority from domestic, institution, commercial, yard waste, street sweeping and non hazardous from industry. Therefore, municipal solid waste management is the collection, transfer, treatment, recycling, resource recovery and disposal of solid waste from urban area. Municipal solid waste management is the major responsibility of local government, typically, it consume between 50% and 80% of the municipal budget in developing country.

2.1.2 INDUSTRIAL SOLID WASTES

These solid wastes arising from industrial activities and typically includes rubbish ashes demolition and construction waste special waste and hazardous (Ogwueleke, 2005)

2.1.3 HAZARDOUS SOLID WASTES

These are solid wastes that pose a substantial danger immediately or over a period of time to human, plant, and animal life, the hazardous solid waste may be corrosive, reactive, and toxic. Hazardous solid waste can be group in

(1) Radioactive substance

(2) Chemical substance

(3) Biological substance

(4) Flammable reactive or toxic substance. (Howards *et al* 1985)

2.2: CLASSIFICATION OF MUNICIPAL SOLID WASTE

Municipal solid waste can be classified according to material which comprising the municipal solid wastes.

TABLE 2.0: Solid waste component

Component	Description
Food waste	The animal, fruit or vegetable residues also called garbage resulting from the handling, preparation, cooking and eating of foods, Because food waste are putrescible they will decompose rapidly, especially in warm weather.
Rubbish	Combustible and non combustible solid waste, excluding food waste or other putrescible material. Typically combustible rubbish consist of material such as paper, cardboard, plastic, textile, rubber leather, wood furniture and garden trimmings, Noncombustible rubbish consist of items such a glass, tin can, aluminum can, ferrous and nonferrous metals, dirt and construction waste (Howard peavey et al 1985)
Ashe and Residues	Materials remaining from the burning of wood, coal, coke and other. Combustible waste. Residues from power plant normally are included in this categories, Ashe and residue are normally compose of fine powdery material, cinder, clinker and small amount of burned and partially burned material.
Demolition and construction waste	Waste from razed building and other structure are classified as demolition waste. Wastes from the construction, remodeling and repairing of residential, commercial and industrial building and similar structure are classified as construction waste. These waste may include dirt stones, concrete, brick, plaster lumber shingles and plumbing, heating and electrical parts.
Special waste	Waste such as street sweepings roadside litter, catch-basin debris, dead animals and abandoned vehicles are classified as special waste
Treatment plant waste.	The solid and semi-solid waste from water, wastewater, and industrial waste treatment facility are included in this classification.

2.3: SOLID WASTES GENERATION

Production of unwanted solid or solid materials resulted from human and animal activities (ogwueleka, 2005)

2.4: WASTE HANDLING AND SEPARATION, STORAGE AND PROCESSING AT THE SOURCE: - this involve s handily and separation until they are placed in storage container for collection.

2.5: COLLECTION

Collection operation involves removing wastes from generation districts and haul to disposed site. Haul operation involves total normal trip time from generation sources to disposal.

2.6: SEPARATION AND PROCESSING AND TRANSFORMATION OF SOLID WASTES

Separation and processing involve recovery of separation materials through size reduction, separation of ferrous metals using magnets, volume reduction by compaction and combustion.

2.7: TRANSFER AND TRANSPORTATION

Transfer and transport involves the transfer of wastes from the smaller collection vehicle to the larger transport equipment and transport of the wastes over long distance.

2.8: DISPOSAL

This is the disposing of municipal solid waste by land filling and spreading, and dump site.

2.9: INTERRELATIONSHIPS BETWEEN THE FUNCTIONAL ELEMENTS IN SOLID WASTES MANAGEMENT SYSTEM

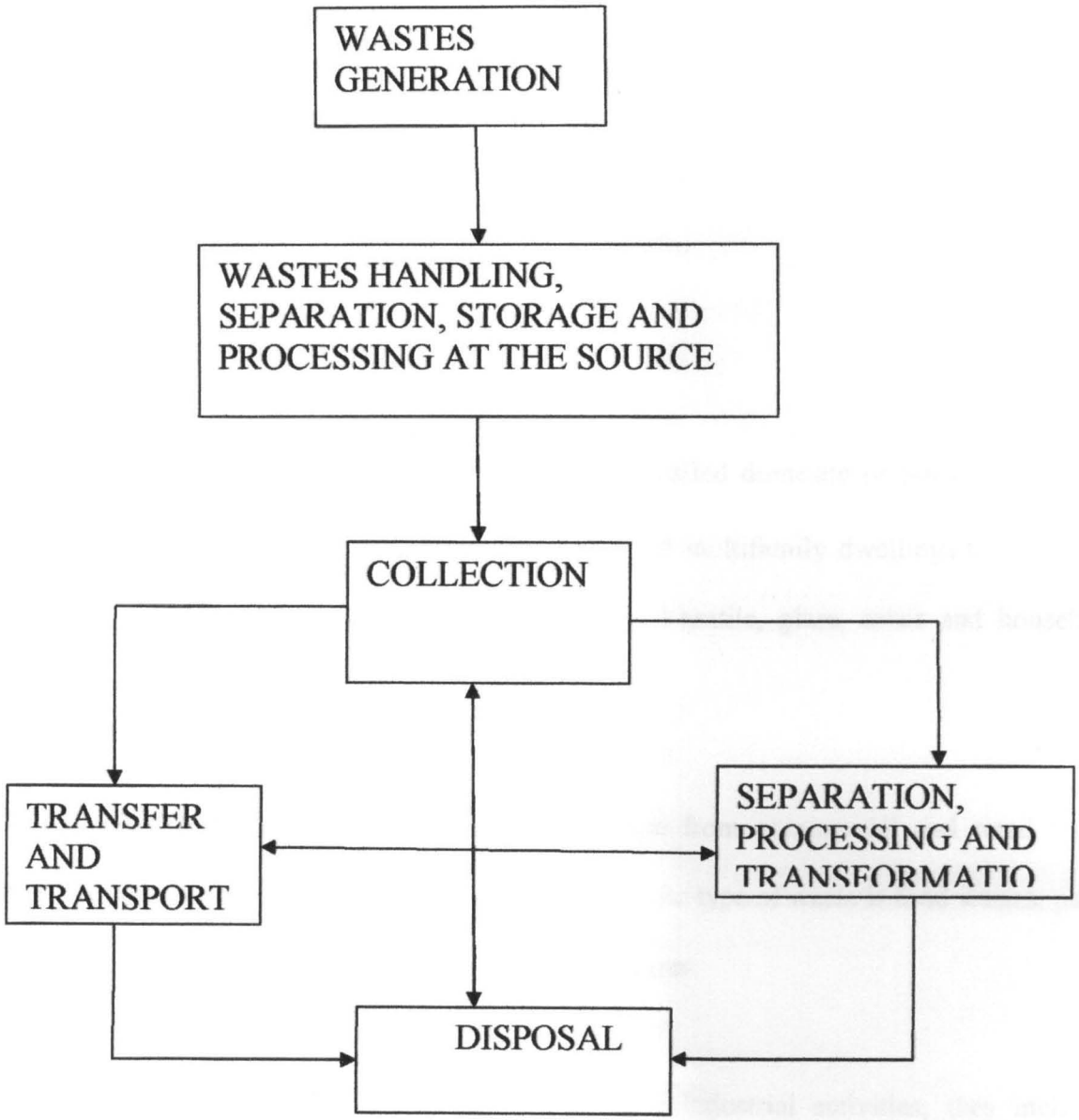

Fig: 2.0: interrelationships between the functional elements in solid wastes management system (Howard at al, 1985)

2.13: CHEMICAL AND ENERGY PROPERTIES OF MUNICIPAL SOLID WASTE

There are several possible recycle, reuse and transformation technologies, one of the first steps in indentifying the most suitable treatment technologies is to determine its chemical properties. These are

1, Proximate Analysis

2, Ultimate Analysis

3, Fusing Point Of Ash

4, Energy

2.13.1: PROXIMATE ANALYSIS:-

1, Moisture (loss at 105° c for 1 hour)

2, Volatile matter (additional loss on ignition at 950°c)

3, Ash (residue after burning)

4, Fixed carbon (remainder)

2.13.2: ULTIMATE ANALYSIS:-

The most important element in waste energy transformation are carbon C, Hydrogen H, Oxygen O, Nitrogen N, Ash A. it is to characterizes the chemical composition of the organic matter in municipal solid waste and define the proper mix of waste material to achieve C/N ration for biological conversion processes.

2.13.3: FUSING POINT OF ASH: - The fusing point ash is defined as that temperature at which the ash resulting from burning of waste will form a solid (clinker) by fusion and agglomeration. (Agunwamba at al, 2003)

2.13.4: ENERGY CONTENT:-

The energy content of municipal solid waste can be determine by

1. Using a full scale boiler as a calorimeter
2. By a laboratory bomb calorimeter
3. By calculation, if the element composition is known

Energy content of municipal solid waste can be determined from the Dulong Equation.

$Hawf = 337C+1419(H_2 - 0.125O_2)+93S+23N$

Where, Hawf = Higher heat value i.e from ash and waste free water.

C, H, O_2, S and N are the percentage by weight of each element. (Howard peavey el at 1985)

2. 14: BIOLOGICAL PROPERTIES OF MUNICIPAL SOLID WASTE

Biological properties of municipal solid waste are important due to the technology of aerobic and anaerobic digestion to transfer waste into energy and beneficial end-product. Biodegradation can be aerobic or anaerobic.

Anaerobic composting is the biological decomposition of food waste with end-products of methane (biogas), carbon and others gases.

$BF = 0.85 - 0.028LC$

Where, BF =biodegradation fraction on a volatile solid base.

LC = lignin content of volatile percentage of dry weight

2.17: CAUSES OF ERRORS IN ESTIMATING MUNICIPAL SOLID WASTE TONNAGE

Municipal solid wastes do not get to disposal site due to one of the following:

1. Salvage by servants
2. Salvage solid by householders
3. Salvage by scavenger (waste picker)
4. Loss disposed of by authorized mean. (Agunwamba at al, 2003)

2.18: COLLECTION SYSTEM

This comprise household and neighborhood (primary) waste containers, primary and secondary collection vehicles and equipment, and organization and equipping of collection workers including the provision of protective clothing collection operation involves removing municipal solid waste from generation district and have to disposal site. Collection is major component of the municipal solid waste management system. A proper collection system design and management can reduce the cost of municipal solid waste management system significantly.

2.19: HAULED CONTAINER SYSTEM

The containers used for the storage of municipal solid waste are hauled to the disposal site for emptied and returned to their original location or some other location.

Hauled container systems are suited for the removal of waste from where rate of generation is high.

Type of hauled container systems

1. Hoist truck

2.10: SOURCE OF MUNICIPAL SOLID WASTE.

1. Residential
2. Commercial
3. Institutional
4. Construction and demolition
5. Treatment plant sites
6. Municipal services
7. Agricultural and
8. Industrial

2.10.1 RESIDENTIAL SOURCE: - this can also be called domestic or household source. There are waste generated from private houses, single and multifamily dwellings this types of wastes are food wastes, paper, cardboard, plastics, metal textile, glass, ashes and household hazardous wastes.(Ogwueleke,2002)

2.10.2: COMMERCIAL SOURCE: - wastes generated from commercial and retail trader activities like restaurant, metals, market, repair Shop e.t.c. the type of waste is food wastes, paper cardboard, plastic, textiles, glass, ashes, and hazardous wastes.

2.10.3: INDUSTRIAL SOURCE: – wastes result from industrial activities; they included wastes from chemical plant, fabrication refineries and industries.

2.10.4: CONSTRUCTION AND DEMOLITION SOURCE: - waste from construction site, they include timber, solid concrete, glass, vegetation, and wastes from repairing of building and others structures are also included as wastes from constructor and domestic source.

2.10.5: INSTITUTION WASTE:-Institutions are wastes from schools, non-pathogenic wastes from hospital, prisons government centre e.t.c.

2.10.6: AGRICULTURAL WASTE:-Wastes and residues resulting from diverse agricultural activities such as plant and harvesting of row and the operation of feedlots are collectively called agricultural wastes.

2.10.7: TREATMENT PLANT SITE

The resident resulting from treatment plant site which non-pathogenic or hazardous, are called treatment plant sites wastes.

2.11: COMPOSITION OF MUNICIPAL SOLID WASTE

Composition is used to describe components that make up a municipal solid waste stream and their relative distribution. It is also reflect the proposed treatment method to be applied.

Composition of municipal solid waste could be used by engineers to determine the type, location of facilities, the transportation route from the district to disposal site, personnel needs, waste handling equipment requirement and also to judge whether land filling is the best disposal option or whether some form of the pre-treatment of a particular waste will be need. Waste composition varies from socio-Economic groups within a country and country to country.

Composition of municipal solid waste can group into organic and inorganic.

Organic solid waste comprise of food putrescible, paper and cardboard, plastics, clothing and fabric, yard waste and wood.

Inorganic solid waste includes metal, glass, dirt, ash, e.t.c. (Ogwueleka, 2002 and 2004)

2.12 PROPERTIES OF MUNICIPAL SOLID WASTE.

Information on the properties municipal solid waste in important in evaluative alternative equipment needs, system and management programs and plans, especially with respect to the implementation of disposal and resource and energy recovery option (Howard peavey el at 1985)

2.12.1 PHYSICAL PROPERTIES OF MUNICIPAL SOLID WASTES

Particle size and size distribution: - The size of the component materials in solid waste is importance in the recovery of materials, especially with mechanical means such as trammel screens and magnetic separators. Particle size distribution can be obtained by sieve analysis.

Sc= l

$$Sc = \frac{l+w}{2}$$ l =Length (mm), w= width (mm)

$$Sc = \frac{l+w+h}{3}$$ h = height (mm)

$$Sc = (l*w)^{0.5}$$

$$Sc = (l*w*h)^{1/3}$$

Where Sc = size of component (Ogwueleka, 2004)

Moisture content: - Moisture content of solid wastes is usually expressed as the mass of moisture per unit mass of wet or dry material. In the wet-mass method sample of measurement, the moisture in a sample is expressed as percentage of the wet of the material. In dry mass method, it is expressed as a percentage of the dry mass of the material.

Equation for determining the wet-mass moisture content

Moisture Content (%) $= (a - b/a) * 100$

Where a= initial mass of sample as delivered kg

b= mass of sample dry at 105° C, Kg

To obtain the dry mass the solids waste material is dries in an oven at 77°C for 24 hours. Temperature and time is used to dehydrate the material completely and to limit the vapourisation of volatile material

Density: - The density of municipal solid waste is estimated by dividing the mean weight of waste by the volume of the waste. Density of solid waste varies with its composition of moisture content, degree of compaction, geographical location, and season of the year and length of time in storage

Density (Kgm^{-3}) = Mass (Kg)/Volume (m^3)

Hydraulic conductivity of municipal solid waste:- In landfills, the sludge tend to resist the movement of water down through them due to low hydraulic conductivity by virtue of very moisture content. Instead, rainfall is converted into surface run-off and the sludge material is transported overland to surface streams.

$K = cd^2 \gamma/\mu = k \gamma/\mu$,

Where K =coefficient of permeability

C =dimensionless constant of shape factor

D = average size of pore

γ = specific weight of water

μ =dynamic viscosity of water

k =intrinsic permeability

Cd^2 is known as intrinsic permeability. It depends on the properties of the solid material, including pore size distribution, specific surface and porosity. (Howard peavey el at 1985)

2. Tilt – frame container

3. Trash – traitor

2.20: STATIONARY CONTAINER SYSTEM

In this system, containers used for the storage of wastes remain at the point of generation except when they are moved to be curb or other location to be empted. There are two main type

(1) System in which manually loaded collection vehicles are used.

(2) System in which mechanically loaded collection vehicle are used

At site time per trip, s = 0.07 h/htrip

Off-route factor, w = 0.15

Haul time, h = 0.73 h/trip

Length of workday, H = 8 h/d

Time required to unload waste container at collection point = u

Time required to pickup loaded container = m

Time required to drive between container locations = dl

Pickup time per trip = m + u + dl = 0.21 h/trip

2.21: SUITABILITY OF HAULED CONTAINER SYSTEM

The use of hauled container system is highly dependent on local culture, tradition and altitude toward solid waste management. The use of the hauled system encourages illegal dumping in Nigeria because the container would be far from the residents or householder. In addition, residual and scattered solid waste around the container emit foul odour which discourage resident from using the container properly. Vandalism by animal and scavenger is likely to take place at the collection points. The obvious result is the spreads of the waste all over the area with

the waste collection cost would be reduced. Vandalism by animals and unauthorized recycles is likely to take place at collection points. The obvious result is the spreading of the wastes all over the areas with resultant disruption of the whole solid waste management system.

(Agunwamba at al, 2003)

2.23: COLLECTIONS ROUTES

The collection routes will be routes that minimize the overall travel distance and collection duration. Each vehicle starts from the garage, drives through a subset of collection points, and returns to its origin. The route should be continues and non repetitive as much as practicable and areas that are prone to traffic congestion should be collected as early in the morning as possible. Designing the household refuse vehicle routes is usually achieved by breaking down the city into districts.

2.24: COLLECTIONS POINTS

The collection point affects some collection system components such as crew size and storage, which ultimately controls the cost of collection. The collection points depend on locality. It is necessary to provide facilities at the point of generation, for storage of municipal solid wastes until they are collected. The type of storage used depends on the collection facility, which may be:-

1. Door step collection
2. Regular curb collection
3. Civil amenity drop off
4. Community recycle bins
5. Vacuums trucks.

2.25: TYPE OF CONTAINER FOR MUNICIPAL SOLID WASTE

1. Bags a-a plastic or paper
2. Wheeled bins
3. Skip containers
4. Containers compacting
5. Community bins

2.26: COMMUNAL BINS

If the collection vehicle stops frequently, every 50m or so, fuel consumption increases. When a truck is used as a collection vehicle, the use of communal containers may be advisable. The containers are placed 100-200m apart. The use of communal bins is highly dependent on local culture, tradition, and attitudes towards waste. Communal bins may be fixed on the ground (stationary) or may be movable (hauled). Movable bins are provided with hoists and tails compatible with lifting mechanism of collection vehicles and such containers have capacities of 1-4m^3. The major disadvantage of communal bins is the lack of maintenance and upgrading. The residuals and scattered solid wastes emit foul odours, which discourage residents from using the containers properly. Fixed communal containers have higher rates of failure and their use is not advisable.

2.27: COLLECTION VEHICLE

Solid waste collection vehicle means a heavy-duty vehicle used for the purpose of collecting solid waste or recyclable materials from residential or commercial establishment. A solid waste

collection vehicle is a vehicle having the capacity to collect solid waste using, manual or automated, front, side or loaders and generally operates on fixed routes. Collection vehicle for municipal solid waste are distinguished by their size, load they can carry and how much compaction of refuse they can accomplish. Trucks designed for residential refuse services are usually rear loaded or side loaded. Rear loaded. Rear loaded trucks accommodate large, bulky items and they tend to be able to provide greater refuse compaction while side loaded trucks tend to cost less and are often more appropriate in densely populated areas where collection takes place on one side of the street at a time. A range of sides for either type of collection truck is available, from roughly 5 to $30m^3$.

2.28: TYPE OF VEHICLES USED FOR TRANSPORTING MUNICIPAL SOLID WASTE

1. Open top trucks
2. Refuse truck taking primary bagged waste
3. Single compartment trucks taking wheel bins.
4. Skip truck taking skip loads
5. Truck taking container loads either closed or operated, topped.
6. Vacuum truck
7. Per loaded truck. (Medina, 1997)

the concomitant of public health and aggravation of solid waste collection. In selection of appropriate waste collection system, it is necessary to into account the economic, technical and sociological aspects as well as paying attention to the peculiar environmental problems and the requirement for community participation. (Agunwamba at al, 2003)

2.22: MUNICIPAL SOLID WASTE COLLECTION METHODS

(1) Block Collection System

Block system involves collection truck moving from street (are or link) to street and stopping periodically for the households to drop their wastes into the collection trucks. The households need to be informed of the collection schedule in terms of day, time of the day, and collection points. The collection schedule and frequency have to be adhered to for the efficiency of the system. This method is practiced in areas with good road conditions and networks, like in Abuja. Nigeria. Block collection system eliminates the need for intermediate storage containers and door-to-door collection system. (Ogwueleka, 2005)

(2) Communal System

Alternative methods of collection involve communal skips or collection sites. This method requires the delivery of wastes by the householder at a storage confiner. The storage confiners are strategically located in the area.

This collection methods is practiced in areas, where houses are not properly planned, arranged and with poor road conditions and network. This method eliminates the need of moving from house to house, which is a tedious, exhaustive and time-consuming process. This means less time would be spent at each waste collection point and crew size would be reduced as well. Generally,

TABLE 2.1: Storage Containers for Municipal Solid Waste

Type of container	Container size (m)`	Volume (L)	House-hold	Commercial
Bag				
Plastic	1 x 0.9	110 and 160		
Paper	1 x 0.9	110 and 160		
Bags in bin holder	1 x 0.9	110 and 160		
Wheeled bins	1 x 0.54 x 0.48	120		
	1.1x0.61 x 0.55	190		
	1.1x0.72x0.58	240		
	1.1x0.79 x0.77	390		
Multi household	-1.5 x 2 x 1.2	600-1100		
Wheeled bins	-2 x 2 x 1.5	-3000		
Community bin				
Glass/metals				
Skips	1.2 x 1.2 x 1.2	1700		
Mini	1.1 x 3 x 1.8	6000		
Maxi	1.8 x 4.5 x 1.8	14,500		
Jumbo	2.4 x 3.6 x 6	10,000		
Containers		25,000		
		40,000		
Compacting				
Vacuum truck				

2. Reduction in trafficking of smaller vehicle at the treatment or disposal site

3. Reduction in refuse crew cost due to waiting time for vehicles in transit.

Factor To Be Consider When Introducing Transfer Station:

1. Distance between disposal site and collection area.

2. Hauling cost for small and large trucks

3. Cost of transferring the municipal solid waste from small to large trucks.

Factors affecting the selection of transfer station for a community.

1. Types of waste received

2. Site topography and access

3. Types of collection vehicles using the facility

4. Required capacity and amount of waste storage desired.

5. Processes required recovering material from wastes.

6. Types of transfer vehicle that can be accommodated at the disposal facility

7. Local collection system

2.31: TYPES OF TRANSFER STATION

- **Small to medium stations.** Small to medium transfer stations are direct discharge stations that provide no intermediate waste storage area. The capacities are generally small (less that 100 tonnes/day).
- **Large transfer station.** These are designed for heavy commercial use by private and municipal collection vehicles. The collection vehicle travel to the dumping area and empty waste into a waiting trailer, a pit or a platform unloading, the collection vehicle leaves the site.

- **Direct discharge non compaction station.** In these stations waste is dumped directly from collection vehicle into waiting transfer trailers. A stationary crane with a bucket is often used to distribute the waste in the trailer. After loading, a cover or tarpaulin is placed over the trailer top.
- **Compaction transfer station.** Compaction transfer stations use mechanical equipment to increase the density of wastes before they are transferred.

2.32: FACTOR TO BE CONSIDERED IN DETERMINING THE APPROPRIATE SIZE OF A TRANSFER FACILITY

1. Transfer trailer capacity
2. Hours of station operation,
3. Time required unloading collection vehicles
4. Capacity of collection vehicles using the facility
5. Desired number of days of storage space on tipping floor.
6. Number of vehicles that will use the station and their expected days and hours of arrival.
7. Waste sorting or processing to be accomplished at the facility.
8. Availability of transfer trailers waiting for loading.

2.33: TRANSFER STATION CAPACITY CAN BE DETERMINED USING THE FOLLOWING FORMULAE

(i) Pit Station:-Based on rate at which wastes can be unloaded from collection vehicles.

$$C = Pca * (l/w) * (60 * Hw/Tc) * F$$

Based on rate at which transfer trailers are loaded.

$$C = (pt * N * 60 * Ht)(Tt + B$$

(ii) Direct Dump Stations:-

$$C = (Nn * Pt * F * Hw)/(Pt / Pc * Tc) + B)$$

Where, C = Station capacity (tones/day)

P_c = Collection vehicle payload (tones)

L = Total length of dumping space (feet)

W = Width of each dumping space (feet)

H_w = Hours per day that waste is delivered

T_c = Time to unload each collection vehicle (minutes)

F = Peaking factor (ratio of the number of collection vehicle received during an average 30-minut period to the number received during a peak 30-minute period)

P_t = Transfer trailer payload (tones)

N = Number of transfer trailers loading simultaneously

H_t = Hours per day used to load trailers (minutes)

B = Time to remove and replace each loaded trailer (minutes)

T_t = Time to load each transfer trailer (minutes)

N_0 = Number of hoppers

L_m = Length of each hoppers (feet)

L_p = Length of push pit (feet)

N_p = Number of push pits

B_e Total cycle time for clearing each push pit and compacting waste into trailer.

2.34 LOCATION OF TRANSFER STATION

1. Transfer station should be located to minimize transportation costs.
2. The transfer station should be as near as possible to the centre of the individual municipal solid waste production areas to be served.
3. It should be within easy access of major arterial highway routes as well as near secondary or supplemental means of transportation.
4. It should be located where there will be a minimum of public and environmental objective to the transfer operation
5. It should be locate where construction and operation will be most economical.
   (Howard peavey at al 1985)

2.35: MUNICIPAL SOLID WASTE SEPARATION

Separation can be either at source of generation (household) or at the transfer station or at final destination. The wastes that are desirably separated at source are:-

1. Food waste household source separation
2. Paper and cardboard – household source separation.
3. Plastic – household source separation

2.36: TYPES OF SEPARATION

1. Mechanical separation/sorting
2. Magnetic separation
3. Vibrating screening
4. Air screening; are screening and ballistic screens are used to separate light from weary material. (Howard peavey el at 1985)

2.37: TECHNOLOGIES OF TREATMENT OF MUNICIPAL SOLID WASTE

1. Waste immunization
2. Reuse and recycling
3. Biological treatment
4. Thermal treatment
5. Land filling. (Chang and Wang1994)

2.37.1 Municipal Solid Waste Minimization:-

Waste minimization means reducing the amount of waste that is generated at source. Waste minimization is considered by many to be the most important management technique to be applied to solid waste. Minimizing the quantities of wastes actually produced during a particular process requires a very specific knowledge of that process. Since commercial and household wastes make up a very significant percentage of total waste generation; it is apparent that homes and offices can have an input on overall volumes and that the biggest contribution to reducing waste must come from homes, offices, schools, institutions, hospitals and hotels.

2.37.2 Biological Municipal Solid Waste Treatment:-

At least three option exist for biological municipal solid waste treatment

1. Aerobic or compositing
2. Anaerobic or biogas
3. Combined anaerobic and aerobic

Aerobic or compositing is the process where microorganism is an oxygen environment, decompose the organic waste.

2.29: FACTOR IN FLUENCY THE SELECTION OF VEHICLE TO BE USE IN TRANSPORTATION OF MUNICIPAL SOLID WASTE

1. Street width
2. Traffic volume
3. Crew size
4. Viability of a transfer station
5. Viability of a transfer patterns
6. Local costs for equipment procurement
7. Solid nest for generator and composition
8. Maintenance (Labour, fuel. Lubrication) .

Therefore, municipal solid waste can be transported to three difference alternatives.

1. Directly to land fill
2. Directly to transfer station and then to terminal facilities
3. Directs transportation to processing facilities where the wastes are burned, recycled or composted with the residues being delivered to landfill directly through transfer station.
4. Directly to dump site. (Chang and Wang1994)

2.30: TRANSFER SYSTEM

Transfer station is a centralized facility where waste is unloaded from smaller collection vehicle and reloaded into large vehicles for transport to a disposal or processing site.

Objective of using transfer station

1. Reduction in transport cost

2.38.2 Ocean Disposal: - Ship and other vessels are used in depositing waste into seas. Most of it ends up in open dumps and wetlands, contaminating surface and ground water and posing major health hazards.

2.38.3 Animal Feeding:-The garbage component of the waste is used in feeding animals such a hogs

2.38.4 Sanitary Landfill: - Sanitary landfill is a method of disposal of solid waste on land. Wastes are discharged, spread, and compacted in a series of cells that can be covered daily with soil or other inert material to avoid health risks or environmental hazards. The American Society of Civil Engineers defines a sanitary landfill as "a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation or at such more frequent intervals as may be necessary." (USEPA, November 1989, p. 108)

Modern landfill practices include monitoring programs for incoming waste, for gas, for Leachate etc. to control pollution of the surrounding environments, particularly groundwater, surface water and air. Sanitary landfills are the only land disposal option that enables control and effective mitigation of

1. Potential surface and groundwater contamination;
2. Health and physical threats to waste pickers and sanitation
3. Workers and
4. Methane emissions.

2.39: LAND FILLING METHODS

1. Excavated Cell/Trench Method

This method is ideally suited to area where the water table is not near the surface and an adequate depth of cover material is available at the site. The soil excavated from the site is used for daily and final cover. Cells are excavated to depths of 1 to 3m with side slope of 2:1 or 3:1 (3 horizontal). The length and width depends on the loading rates and rainfall intensities. (Ogwueleka, 2005)

2. Area Method

Area method is used when the terrain is unsuitable for the excavation of trench in which to place the municipal solid waste. This value is achievable with either natural clay liners or synthetic lines. The filling operation usually is started by building an earthen levee against which waste are placed in their layer and contacted. Each layer is compacted as the filling progresses until the thickness of the compacted waste reaches a height varying from 2 to 3m. At that time and at the end of each day's operation a 150 to 300mm layer of cover material is place over the completed fill. The cover material must be hauled is by truck or earth moving equipment from adjacent land or from borrow pit areas. (Howard peavey el at 1985)

3. Canyon/Depression Method

Father naturally depression or manmade depression. Mining quarries and dry valleys are commonly used. The techniques to place and compact solid wastes in canyon/depression sites are dependent on site geometry, the access to the site, the type of Leachate and gas control facilities to be used, the hydrology and geology of the site, and type of the cover material. (Crawford and Smith, 1985)

2.40: FACTOR THAT MUST BE CONSIDERED IN SITTING A NEW LANDFILL

Haul Distance: - The haul distance affects the operating cost of sanitary landfill. A minimum distance of 250m from public area must be maintained

Location restrictions: - Location restrictions refer to where landfills can be located. Restrictions new apply with respect to sitting landfills in highly populated areas, rich natural habitats in wetlands, in floodplains and in unstable area.

Available land area:-The site should have enough space to last at least for 10 years.

Site access: - The site should be easily reached by trucks via streets or highways.

Geologic and hydro geological conditions: - The hydro geological properties of the site must be satisfactory. The bottom soil should be impermeable to prevent contamination of groundwater source.

Climatology conditions: - Wind strength and wind patterns must be considered to avoid blowing or flying debris.

Soil conditions and topography: - Suitable cover material should be available on or close to the site and topography should be such that the earthwork for site preparation and landfill operation are minimize

Local environmental conditions,

Potential ultimate used for the completed site. (Davis and Cornwall 1991)

2.41: SELECTION OF A SANITARY LANDFILL SITE

Barring any political or social constraints the site recommended should be the one with the lowest cost (trucking plus disposal)

Table2.2: Landfill Operations and Processes

Criterion	Recommended	Recommended with Restrictions	Not Recommended
Useful life	More than 10 years	10 years	
Zoning environmental	Areas without environmental Zoning restrictions	Areas without environmental Zoning restrictions	Environment conservation or related areas
Zoning-urban	Low growth rate	Intermediate growth rate a	High growth rate
Population density	Low	Medium	High
Land use	Undeveloped or public land	Undeveloped or public land	Highly developed
Land value	Low	Medium	High
Acceptance by the community and environmental NGOs Distance from watercourses	Good	Fair	Opposed
		Less than 200 meters, with approval of responsible environmental authority	With Less than 200 meters, with approval of responsible environmental authority

(Ogwueleka, 2005)

2.42: LANDFILL OPERATIONS AND PROCESS

- Landfill design
  - Foundation design
  - Liner design
  - Leachate collection and gas collection
  - Drainage design
  - Filling design
  - Runoff collection etc
  - Closure design
- Landfill operations
  - Waste inventory loads types etc
  - Cell layout
  - Cells for hazardous waste
  - Cells for non-hazardous waste
- Biochemical reactions in landfill
  - Biological decay rates
  - Slowly biodegradable
  - Rapidly biodegradable
  - Non-biodegradable
- Leachate management
  - Collection
  - Treatment
  - Monitoring

- Reuse

- Landfill gas management
  - Monitoring
  - Collection
  - Flaring or using
  - Quantity and quality
- Environmental monitoring
  - Air quality and odour monitoring
  - CH_4, H_2S, VOCs etc.
  - Groundwater monitoring
  - Pests and litter
  - Traffic

2.43: TYPES OF LANDFILL

1. Altercate and disparage site
2. Containment sites

2.43.1 Attenuate and Disperse Site: - This is the mechanisms were dilution and dispersion through pores and micro-fissures into the underlying situated zones. It was not possible to monitor or track the leached pollutants, and in some area Leachate transport was too quick causing poorly diluted Leachate to reaches surface water and ground water.

This type of site is now unacceptable and does not meet the European Union (EU) directive requirement.

2.43.2 Containment Site:-This is where the waste its Leachate and gas are isolated from the surrounding environment. The containment is achieved by either natural clay bathos uner or synthetic liners. Facilities for Leachate and gas collection and removal are installed and regular monitoring is possible.

2.44 LANDFILL GAS

Gases found in landfill include air, ammonia carbon (IV) oxide, carbon (II) oxide, hydrogen, hydrogen surphide, methane, nitrogen and oxygen.Carbon (IV) oxide and methane are the principal gases produced from the anaerobic decomposition of the organic municipal solid waste comports. Methane gas production is a potential problem associated with municipal solid waste deposited in landfill sites in two ways.

First, it presents acute problems as a free and explosion hazard in the immediate vicinity of a sanitary landfill. Secondly, the increasing concentration of methane a direct contribution to the atmospheric green house effect because each incremental molecule of methane is about 20 time more effective then each additional molecule of carbon (iv) oxide.

2.45 LEACHATE IN LANDFILLS

Leachate may be defined as liquid that has percolated through municipal solid waste and has extracted dissolved or suspended material from it in most landfills, the liquid portion of the Leachate is composed of the liquid produced from the decomposition of the waste and liquid that has entered the landfill from external sources such as surface drainage, rainfall, ground water and water from underground spring.

CHAPTER THREE

MATERIALS AND METHODS

3.0 MATERIALS

3.0.1 Benin City Map

Benin City is the capital of Edo state of Nigeria, in West African region; it is located on latitude 6.33°, longitude 5.63° of the equator.

Benin City is highly concentration of commercial and industrial activities in the state, with population of 1,125,058. There are movement of people from the rural and suburbs into the city, therefore, it has high rate of municipal solid waste in the Edo state. Benin City map is show in appendix.

3.0.2 The Existing Zones of Municipal Solid Waste Management in Benin Metropolis

Benin City has 121 zones for municipal solid wastes disposal system in Benin metropolis but only 68 of the zones are manage by accredited waste managers and enforcement officers of Edo State Environmental and Waste Management Board. Each zone is made up of about 1,200 houses/ facilities. The house/facility in each zone is registered and tagged.

3.1.3 Bench Marks for Waste Manager for Various Zones

1. Completion of registration of at least 100% of the allocated zone(s)
2. Picking of waste/refuse from every house/facility once every week.
3. Functional compactor truck per economically viable and territorially manageable zone
4. An established office in the allocated zones.
5. Comprehensive documentation of all activities of the waste managers in their waste/refuse collection efforts using the waste manager record books.
6. Clearing and carting away of all inherited dumps in the zones.

7. Eliminating of all non-accredited waste managers and cart boys due to the dominant presence of the accredited waste managers
8. Quick discovery of illegal waste managers and cart boys.
9. An aggressive mass enlighten and advocacy to sensitize the people on the new focus and direction of government on the integrated waste management campaign.
10. The setting up of a functional neighbourhood environmental sanitation committee in the various zone(s).
11. The daily patronage of the approved dumpsite(s) and signing the dump site service roaster
12. Put in place a network to arrest and take to the Board or police station any non-accredited waste collector/mover..
13. Ensuring that your zone(s) are not Sub-let to a second or third party
14. Open an account with Skye bank for the proper billing of your zone.(s)
15. Reporting all incidences on daily or weekly basis of developments and happening in your zones
16. Put in place an arrangement for effective waste collection and reduction peculiar to the zones.

3.0.4 Activities and Function of the Enforcement Team

1. Ensuring that waste manager collect waste in bags from energy house/facilities in the zone at least once every week ensure that zone are demarcated into six work zone.
2. Ensuring the active participation of everyone in the zone in the new program by carrying out serious advocacy and outreach in the zone

Leachate impact can be controlled only with lined landfill install collection systems to retrieve Leachate from the bottom of the landfill.

2.46 SITTING LANDFILL

Sitting is possibly the most difficult stage in landfill development.

1. Carryout an environmental impact assessment that addresses all sitting criteria.
2. Organize full community-involvement this is especially important given the greater expense and often greater size of sanitary landfill.

Due to potential negative impact and conflicting interests, the location of the landfill is a significant element in the general process of its planning design and construction. As landfill always have some impact on their surrounding it is not possible to find a perfect site. The interest to take into account includes:

1. Ecological and biological condition
2. Geological and hydrogeological condition
3. Existing and potential water supply sources.

- Ground water
- Surface waste
- Other water recipient

4. Historical and archaeological
5. Recreational
6. Other planning e.g. Agriculture, town and industrial development. These interest need to be balanced with infrastructure requirement.
7. Access possibilities (Crawford and Smith,1985)

3. Serving of violation abatement notices to non complying owner or occupiers
4. Participating in the sanitary inspection of houses/facilities in the zone in close collaboration with the enforcement and compliance monitoring team.
5. Ensuring that all environment standards and guideline as well as regulation are complied with.
6. Educating the people on their responsibilities to the new integrated waste management program and what they should do to make it work.
7. Identify and report all illegal, notorious inherited dump site to the Board with precise description of location and volume.
8. Ensuring that waste silt gutters/drains are cleaned, cleared and carted always by owners/occupiers of all houses/facilities adjacent such drain
9. Ensuring that government right of way/road set back are free of litters of any form of waste at all time.
10. Arrest, detain, and prepare for prosecution any unaccredited or illegal waste manager found in any zone.
11. Report the preserve of NDDC donated refuse bin in their zone of posting
12. Registration and enumeration of house/facilities that were not captured in the initial exercise.
13. Any other duties/responsibilities that may be given to their from time to time.

3.0.5 Questionnaire

Two questionnaires were prepared, one of the questionnaire was administered to the residents in (municipal solid waste generator) in a zone, while the other is to be administer to the municipal solid waste manager in Benin metropolis. Questionnaire sample is on appendix.

3.1 METHODS

3.1.1 Method research

Benin metropolis is divided into two study areas, (district). Questionnaires will be administered to the areas. The first area is 2 kilometer from the point of reference which assumed as the centre of the city (Ring road) while the second area is 5 kilometer. The first area is the centre of most commercial activities is carried out in Benin metropolis. The areas under study are show in appendixiii.

In first district, twenty (20) zones will be administered with questionnaire, in each zone, 20 household were interviewed and also ten (10) municipal solid waste managers will also be interviewed. For the second district, which is 5 kilometer from Ring road, fifteen (15) zones will be administered with questionnaires, in each zone, fifteen (15) household will be interview and fifteen (15) municipal solid waste managers will also be interview.

3.1.2 Reconnaissance survey

An extensive personal observation was undertaken with a view to make inventory of existing conditions and assembly of background data of the solid waste disposal facility. There include assessment of physical environment condition relating to waste management system, and general environment sanitation. It also involves the familiarization tour in the study area to see what is on ground so as to get first hand information and to get acquainted with the selected districts.

This is done by taking picture of the various dump sites, streets littered with refuse and knowing the composition of waste in the area.

3.1.3 Use of Questionnaires

Questionnaire method was used where question related to the subject matter of study were structure on paper and administer on various stake holder which elicited most of the information use for this study. The questionnaires were distributed to residents and waste manager of the various district or zone who are one way or the other involved in municipal solid waste management. A total of 1000 questionnaires were distributed to the first district (district 1 or zone 1), 930 questionnaires were filled and returned, while 70 were not returned for the reason not know to researcher. In the second district (district 2 or zone 2), a total of 700 questionnaires were distributed, 680 were filled and returned out of the 700. For the municipal solid waste manager, a total of 25 questionnaires were distributed in the both districts and 20 were filled and returned. The information obtained from the returned questionnaire was analyzed and present in chapter four. Therefore, the sampling size for first district and second was 930 and 680 while that waste manager is 20.

3.1.4 Interview method

Some information that was not obtained through questionnaire method, the interview method of data collection was adopted to get such information. Residents were contacted on individual, group and organizational basic and interview of various aspects of municipal solid waste management, such as the institution and legal frame work of municipal solid waste management, the implementation of strategies,

achievement, obstacle and constraint faced as well as suggested way of ensuring a sustainable system of waste management.

3.1.5 Observation Method

Considering the needed for an articulated study, the researcher fined it absolutely necessary to carryout personal observation in order to have first hand information and knowledge about municipal solid waste management. Therefore, visits to the state dump site to assess the manner of used and maintenance of such facilities in some part of Benin metropolis was carry out. Some individual houses were visited where the volume and characteristic of solid waste as well the type of waste bin in use were studied. Relevant site photographs were snapped for articulated study

3.1.6 Statistical Techniques

The statistical techniques used were total average and percentage range. These were adopted in order to link the hypothesis drawn in chapter one. As the result, there were provisions for number of table which were discussed and interpreted

Fig 3.2: Scavenger at the dump site

Fig 3.3: Operating Dump site with worker separating waste

Fig 3.6: Newly acquired street storage for solid waste bin

Fig 3.7: Newly punches wheel bin for state environment and waste management board

Fig3.0: The researcher at dump site

Fig 3.1: Abandon dump site

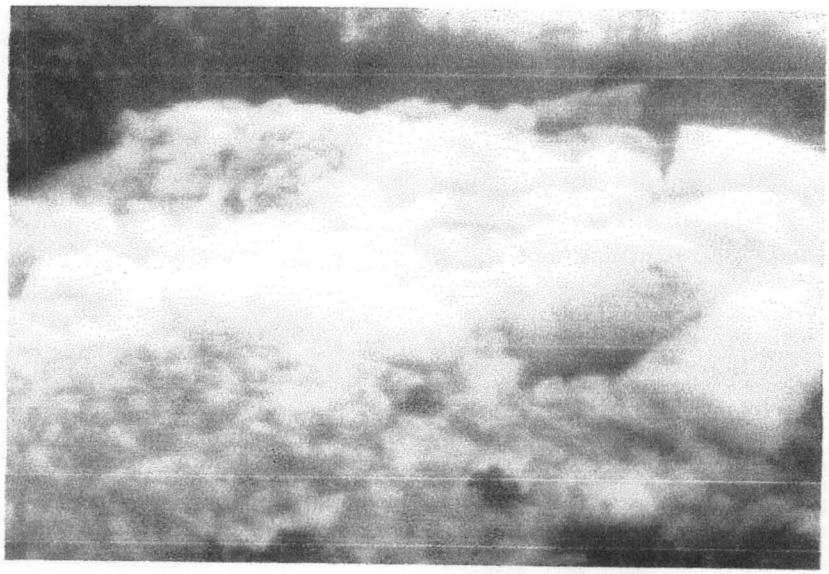

Fig 3.4: Separated plastic waste at dump site

Fig 3.5: Skit truck unloading solid waste

Fig 3.8: Newly punches compactor truck for state environmental and waste management board

CHAPTER FOUR

4.0 **RESULTS**

Table 4.0: **Percentage of household type distribution in each district**

Household Types	District 1	District 2
Residential	61.29%	60.31%
Commercial	25.81%	17.92%
Institution	12.90%	21.72%
Total No of Respondent	930	680

Table 4.1: **The percentage of solid waste generated in each district**

Solid waste generated	District 1	District 2
Food material	54.05%	50.73%
Paper	21.62%	22.93%
Metal	5.32%	10.0%
Glass	5.5%	4.38%
Cloths/fabric	7.39%	3.76%
Plastic	4.05%	6.25%
Others	2.7%	1.77%

Table 4.2: **Type of container for storing solid waste**

Storage type	District 1	District 2
Plastic waste bin	39.78%	47.21%
Plastic bag	14.52%	11.62%
Sack bag	30.11%	27.50%
Wheel bin	10.21%	10.39%
Others	5.33%	3.09%
No. of respondent	930	680

Table 4.3: **Percentage of separation of solid waste**

Separation	District 1	District 2
Percentage of waste separated	29.03%	35.29%
Percentage of waste not separated	70.97%	64.71%
No. of Respondent	930	680

Table 4.4: **Percentage of resident that treat solid waste**

Treatment	District 1	District 2
% of waste treated	16.13%	14.41%
% of waste not treated	83.87%	85.59%
No. of respondent	930	680

Table 4.5: **Methods used for treatment of solid waste (%)**

Method of treatment	District1	District2
Physical	60%	100%
Chemical	40%	-
Biological	-	-
No of respondent	180	150

Table 4.6: **Methods of disposal of solid waste (%)**

Method of disposal	District 1	District 2
Waste manager	83.87%	79.56%
Individual	16.13%	20.44%
No. of Respondent	930	680

Table 4.7: **Number of time waste manager collected waste in a month (%)**

Time for collection	District 1	District 2
Once a week	20.27%	33.10%
Once a month	33.10%	18.62%
Twice a week	12.11%	10.52%
Twice a month	35.87%	37.76%
No. of respondent	750	580

Table 4.8: **Percentage of resident satisfied with the number of time waste manager collect their solid waste for disposing.**

Satisfaction	District 1	District 2
% of resident satisfied	66.67%	57.83%
% of resident not satisfied	33.33%	42.17%
No. of Respondent	810	600

Table4.9: **Number of time the resent want the waste manager to collect and dispose their waste (%)**

No. of Times	District 1	District 1
Daily	21.85%	15.81%
Two days	-	15.81%
Three days	23.33%	23.72%
Four days		
No. of Respondent	270	250

Table 4.10: **Residents that were satisfied with the system waste manager used in disposing their waste (%)**

Satisfaction	District 1	District 2
Satisfied	73.08%	60.30%
No Satisfied	26.92%	39.50%
No. of Respondent	780	600

Table 4.11: **Method used by waste manager in collecting waste from each district**

Method used	No. of Respondent	% of respondent
Block collection system	24	66.67
Communal collection system	12	33.33
Total	36	100

Table 4.12: **Type of vehicle used by waste manager for waste collection and disposal**

Vehicle type	No. of Respondent	Percentage (%)
Rear load truck	-	-
Side load truck	-	-
Pay loader and open tipper truck	-	-
Compactor truck	20	100
Total	20	100

Table 4.13: **Ownership of vehicle**

Ownership of vehicle	No. of Respondent	Percentage (%)
Private	20	100
Government	-	-
Total	20	100

Table 4.14: **Cost of maintenance of vehicle**

Maintenance cost	No. of Respondent	Percentage (%)
High	20	100
Medium	-	-
Low	-	-
Total	20	100

Table 4.15: **Access roads to all collection points in the district all year round**

Access road	No. of Respondent	Percentage (%)
Access road	-	-
No access road	20	100
Total	20	100

Table 4.16: **Time takes to collect solid waste from their route in a day**

Time	No of Respondent	Percentage (%)
1 – 2 hours	-	-
4 – 6 hours	4	20
6 – 8 hours	8	40
Above 8 hours	8	40
Total	20	100

Table 4.17: **Day taken to collect district per week**

Day	No. of Respondent	Percentage (%)
A day	-	-
2 – 3 days	-	-
3 – 4 days	-	-
4 – 5 days	-	-
5 – 6 days	20	100
Total	20	100

Table 4.18: **Type of disposal site being operated**

Type of disposal site	No. of Respondent	Percentage (%)
Open dump	20	100
Sanitary landfill	-	-
Transfer station	-	-
Recycling centre	-	-
Total	20	100

Table 4.19: **Ownership of the disposal site**

Ownership	No. of Respondent	Percentage (%)
Private	-	-
Government	20	100
Total	20	100

Table 4.24: **Area to be improved upon by the government**

Area to be improved	No. of Respondent	Percentage (%)
Financing	15	34.09
Provision of equipment and facility	5	11.36
Zone size	2	5.26
Policy making and Implementation	9	20.45
Others	13	29.55
Total	44	100

Table 4.20: **Community around the disposal site**

Community	No. of respondent	Percentage (%)
Yes	12	60
No	8	40
Total	20	100

Table 4.21: **Distance of disposal site to the collection district**

Distance	No. of Respondent	Percentage (%)
0 – 5km	-	-
5 – 10km	4	20
10 – 20km	4	20
20 – 30km	8	40
30km and above	4	20
Total	20	100

Table 4.24: **Area to be improved upon by the government**

Area to be improved	No. of Respondent	Percentage (%)
Financing	15	34.09
Provision of equipment and facility	5	11.36
Zone size	2	5.26
Policy making and Implementation	9	20.45
Others	13	29.55
Total	44	100

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.0 DISCUSSION OF RESULT

From the Table 4.0 showed that, in District 1, total number of respondent was 930, this meant that 61.29% and 25.81% were residential and commercial household type, while institution household was 12.90%. For District 2, residential was 60.31%, commercial 17.92% while 21.72% was for institution household type and the total respondent was 640.

From table 4.1, it is showed that district 1 had 54.05% and district had 250.75% of food materials as solid waste generated; which indicated that half solid waste generated was food materials. Paper, metal, glass, clothes/fabrics and plastic had 21.65%, 5.32%, 7.39% and 4.05% respectively. Others have 2.07% for district 1. In district 2, paper was 22.93%, metal is 10.0%, glass was 4.38%, clothes/fabrics were 3.96% plastic was 6.25% while others were 1.77%.

Observation;

In district 1, there were more residential household, but there were few institutions and commercial household was more than the institution household. The type of solid waste generated was distributed across the type of household, food materials takes higher percentage with respect to the high percentage of the residential household. While commercial and institution household share 45.95% of the remaining solid waste generated. District 2; also have the same pattern of solid waste generated. But, there were more institutions household than in district 1, and have almost the same residential household and food material waste type. 50.73% of the total solid waste generated was for food material while 49.27% was paper, metal, glass, clothes/fabric, plastics and others.

The table4.2 showed that in district 1, out of 960 respondents, 39.78% store their solid waste in plastic bin, while 14.52%, 30.11% and 10.21% store solid waste in plastic bags, sack bags, and wheel bin, 5.38% store their solid waste in others. In district 2, 47.21%, 11.62% and 10.59% stored solid waste in plastic waste bin, plastic bags, sack bags and wheel bin respectively while 3.09% store their waste in others.

Table 4.3 showed that in both districts, high number of resident does not separate their solid waste generated, only few ones do separate their solid waste generated.

Table 4.4 it showed that only few residents treated their waste in both districts which was 16.13% in district 1 and 14.4% in district 2, out of 930 and 680 respondents respectively. Also 83.87% and 85.59% do not treated their solid waste in district 1 and district 2.

The table 4.5 showed that none of the resident treated their solid waste biologically in both districts. In district 1, 60% treated their solid waste physically and 40% treated chemically, while district 2, only chemical treatment is used.

Observation;

Tables 4.2, 4.3, 4.4 and 4.5, it was revealed that both districts, the resident used most plastic waste bin and sack bag to stored their waste and they did not separated their waste, the percentage of resident that separated waste in the two district was very low compared to the total number of respondents. Since the percentage that separated their solid waste is low, therefore, the percentage that treated their solid waste were also low, because before you treated, you have to separated the solid waste into different components. Table 4.5; revealed that out of 150 resident that treated their solid waste in both districts, physical and chemical method are commonly used, while biological method were not used.

dispose their waste every four days, 23.72% prefer every three days, while15.81% of the resident wanted their waste to be dispose every two days or daily.

Observation;

It was observed from Table 4.8, more than half of the respondent in both district are satisfied with number of times waste manager dispose their waste. In Table 4.9, more respondents preferred every four days for waste manager to dispose their waste in district 1 but in district 2, the percentage of respondents that wanted their waste to be disposed every two days have the same percentage of respondent.

From Table 4.10, it showed that 73.08% of respondents were satisfied with method which the waste manager adopted in managing their waste, while 26.92% of respondent were not satisfied with the method used by waste manager in district 1. In district 2, 39.50% are not satisfied with the method use in managing their wastes while 60.50% were satisfied with the system waste manager adopted.

Observation;

From table 4.10; it is revealed that in both districts, the respondents were satisfied with the system waste manager used in disposing their waste.

From the table 4.11; it showed that 66.67% of the waste manager used block collection system while 33.33% adopted communal system for collecting solid waste for disposal.

The table4.12; showed that the entire waste manager used compactor truck.

Table 4.13; showed that the ownership of vehicle is 100% privates.

Observation;

Table 4.22: **Rate of payment by household**

Rate	No. of Respondent	Percentage (%)
Flat rate	4	20
Per volume of waste	-	-
Household type	16	80
Total	20	100

Table 4.23: **Satisfy with the system adopted by government**

Satisfied	No. of Respondent	percentage (%)
Satisfied	-	-
Not satisfied	20	100
Total	20	100

From Table 4.22, 20% of the respondent charge flat rate, while 80% charge household type. None of these wastes manager charge per volume waste collected and disposal.

Observation;

It was revealed that almost all the waste manager rates their payment by the household type.

All waste managers are not satisfied with the system adopted by the government in managing solid waste in the state.

From the table4.24; it indicated that 34.09% (15) want improvement in financing the solid waste management system, 11.36% (5) wanted provision of equipment and facility, 4.56% had problem of zone size and they needed improvement on that area. Policy making and implementation and others were 20.45% and 29.55% respectively

Observation;

From the table 4.23 and 4.24; it was reveals that the entire solid waste managers are not satisfied with the system which state solid waste management board is operating. Therefore, they needed improvement in area of financing, policy making and implementation, provision of equipment and facility, zone size and other areas.

5.1 CONCLUSION

The aim of the research work is to appraise the present system of municipal solid waste management in Benin City, the capital city of Edo State. From the result of the study reveals that, high percentage of resident (respondent) were satisfied with the system the waste manager adopted in managing their solid waste. The study also showed that resident (respondent) were not aware of the best way of managing waste ranging from storage, to separation, for easy

management of solid waste. Also the solid waste managers were not satisfied with the system which Edo State Environmental and Waste Management Board used in managing solid waste in Benin metropolis. The study result shows that the problems range from financing, provision of equipment and facilities, policy making and implementation to zone size. In general, research work showed that the municipal solid waste management system in the state was not effective, it lacked the basic modern technology of managing solid waste to reduce the adverse effect on the environment.

5.2 RECOMMENDATION

Municipal solid waste problems are storage, separation, collecting, transportation, finance and disposing system, the most pressing environmental problems being faced by urban dwellers, Urban manager are urban planners, with increase in movement of people from rural to urban, and the solid waste generation increase also. Therefore, there is need for the collection of the solid waste to reduce the adverse effect on the environment.

However, the following recommendations are given based on findings from the research work.

(1) Public enlightenment campaign: This must be the first stage, if Edo State environmental and waste management board wants to achieve any of their problem or policy on municipal solid waste management. This can be done through mass media, distribution of information hand bills, stickers, posters etc. community forum should be organized to discuss the nature and monitory of solid waste disposal sites.

(2) All the three tiers of government, that is federal, state and local government, should recognize effective municipal solid waste management as major problem and allocate

appropriate and adequate resources to efficiently and effectively manage the municipal solid waste in the state.

(3) Training of environmental personnel, e.g. sanitary inspector, community health supervisor that will inspect house of on their sanitary state weekly and monitoring the solid waste manager.

(4) The Edo State environmental and waste management board should encourage the resident to separate their municipal solid waste in organic and inorganic waste.

(5) The State should establish recycling of solid waste centre which will create employment.

(6) The board should provide solid waste storage container in road and street and strategic location to reduce solid waste lottery in the street or road, which may later find it way in the drainage and cause blockage which result to urban flooding during rainfall.

(7) Task force should be backed up legally and financial backing to be able to force out the illegal waste manager (carte boys) and ensure the resident pay their correct levy for waste manager for collecting and disposing their waste.

(8) The Edo State Environmental and Waste Management Board should reduce or subsidize the charges for the resident, whom separate solid waste property and pay them some amount for bringing the separate waste into solid waste recycling centre, which will keep the solid waste recycling centre more active.

(9) The State government should make all roads accessible all year round for the waste manages to access all the routes in their district.

(10) The State government should provide more compactor truck and spare parts of low maintenance and operation cost for the waste managers to enable them to be more efficiently and effectively used

(11) The State government should discourage resident not to live around disposal site, they should give 3 – 5km distance away from the disposal site.

(12) The State environmental and waste management board should create transfer station within (zones) districts to reduce of cost of transportation and traffic on highways to the dump site. Also it gives room or chances for separation and provides more income for the operator of the transfer station.

(13) State government should adopt sanitary landfill system for disposing the municipal solid wastes. Since, sanitary land filling is the best method of disposing municipal solid waste without causing nuisances or hazards to public health or safety.

REFERENCES

Agunwamba, J .C, Egbuniwe N. and Ogwueleka T.C (2003). Least cost management of solid waste collection journal of solid waste technology and management vol 29,No3 pp150-170

Conwell D.A (1985), Introduction to environmental Engineering. P.W.S publisher Boston Massachusetts

Chang N.B and Wang S.F (1994), A location for the site selection of solid waste management system. Journal of environmental Engineering, ASCE Vol, 122, No7 pp640-660.

Crawford J.F and Smith P.G (1985), Landfill Technology, Butterworths Oxfor
Davis M.I and Cornwall D. A (1991), Introduction to environmental Engineering, McGraw Hill New York.

Howard S., Peavy,Donald R. Rowe and George Tchobanoglous (1985), Environmental Engineering. McGraw Hill Book Company

www.mdpi.com/journal/sustainability(2010), Domestic Separation and Collection of municipal solid waste; Opinion and Awareness of citizens and workers

Ogwueleka T.C (2003), Analysis of Urban solid waste in Nsukka, Nigeria, Journal of solid waste technology and management. Vol29, No4 pp156-159

Oguweleka T.C (2005), Introduction to Environmental Engineering, our savior press LTD
United State Environmental Protection Agency,(USEPA November 1989 p108) Environmental Management Protection.

Wikipedia Encyclopedia (2010), www Wikipedia.org

APPENDIX i

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

SCHOOL OF POSTGRADUATED STUDIES

FEDERAL UNIVESIRTY OF TECHNOLOGY MINNA, NIGER STATE

QUESTIONNAIRE ON MUNICIPAL SOLID WASTE COLLECTION AND DISPOSAL IN BENIN METROPOLIS

Dear Respondent,

The information collected shall be treated confidential for the purpose of the research work only.

Thanks.

OMORUYI EFE.

INSTRUCTION: PLEASED, TICK AS APPROPRIATE

1. YOUR COMPANY NAMES.....
2. YOUR COMPANY ADDRESS.....;.
3. YOUR ZONE(S) AREA YOU MANAGE.....;.
4. WHAT METHOD YOU USE FOR COLLECTION OF WASTE IN FOLLOWING PREMISES?

   (A) BLOCK COLLECTION SYSTEM. (B) COMMUNAL COLLECTION SYSTEM.

   1. RESIDENTIAL WASTE.....,
   2. INSTITUTION WASTE.....,
   3. COMMERCIAL WASTE.....,
   4. STREET AND OTHER WASTE.....,

4. WHAT TYPE OF VEHICLE DOES YOUR COMPANY USE FOR COLLECTION AND DISPOSING OF WASTE? 1. REAR LOAD TRUCK..... 2. SIDE LOAD TRUCK....., 3. SKIP TRUCK..... 4. PAY LOADER AND OPEN TIPPER TRUCK.....,

   5. SMALL TRUK AND OTHER..... 6. COMPACTOR TRUCK.....

5. WHO IS THE OWNERSHIP OF THE VEHICLE?

   PRIVATE.....; GOVERNMENT.....;

6. IF PRIVATE, WHAT IS THE COST OF MAINTIANCE?
   HIGH..... MEDIUM.....; LOW.....;
7. DOES ALL YOUR ZONE HAVE GOOD ACCESS ROAD TO COLLECTION POINT ALL YEAR ROUND? YES.....; NO.....;
8. HOW LONG DOES IT TAKE YOU TO COLLECT YOUR ROUT IN A DAY?
   2-4 HRS.....; 4-6HRS.....; 6-8 HRS.....;
9. HOW MANY DAY DOES IT TAKE TO COLLECT YOUR ZONE PER WEEK
   A DAY....; 2-3 DAYS...; 3-4 DAYS.....; 4-5 DAYS.....;5-6 DAYS
10. HOW MANY WEEKS DOES IT TAKE TO COLLECT YOUR ZONE
    A WEEK.....; TWO WEEKS.....; THREE WEEKS..... FOUR WEEKS....
11. WHERE DO YOU DISPOSE YOUR WASTE?
    RECYCLING CENTRE .....; DUMP SITE.....; TRANSFERS STATION.....
12. IF DISPOSAL SITE, WHICH TYPE OF DISPOSAL SITE DO YOU OPERATE?
    OPEN DUMP.....; SANITARY LANDFILL.....;
13. WHO OWN THE DISPOSAL SITE?
    PRAVITE.....; GOVERNMENT.....;
14. IS THERE ANY COMMUNITY AROUND THE DISPOSAL SITE?
    YES.....; NO.....;
15. HOW FAR IS THE DISPOSAL SITE FROM YOUR COLLECTION ZONE?
    0-5 KM.....; 5-10 KM.....; 10-20 KM.....; 20-30 KM.....; 30 KM AND ADOVE
16. HOW DO YOU RATE THE AMOUNT PAY BY EACH HOUSE HOLD?
    FLAT RATE..... PER VOLUME OF WASTE....., TYPE OF HOUSEHOLD.....
17. ARE YOU SATISFIED WITH THE SYSTEM ADOPTED BY GOVERNMENT FOR MUNICIPAL SOLID WASTE MANAGEMENT IN THE STATE?
    YES..... NO.....;
18. IF NO, WHICH AREA DO YOU WANT THE GOVERNMENT TO IMPROVE?
    FINANCING.....; PROVISION EQUIPMENT AND FACILITY.....; ZONE SIZE.....
    POLICY MAKING AND IMPLEMENTATION .....;

SPECIFY.....

.....

THANKS FOR YOUR CO-OPERATION.

APPENDIX ii

DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

SCHOOL OF POSTGRADUATED STUDIES

FEDERAL UNIVESIRTY OF TECHNOLOGY MINNA, NIGER STATE

QUESTIONNAIRE ON MUNICIPAL SOLID WASTE GENERATOR (RESIDENT) IN BENIN METROPOLIS

Dear Respondent,

The information collected shall be treated confidential for the purpose of the research work only.

Thanks.

OMORUYI EFE.

INSTRUCTIONS: PLEASED, TICK AS APPROPRIATE.

1. ZONE.....
2. HOUSEHOLD LOCATION.....
3. HOUSEHOLD TYPE; RESIDENTIAL.....COMMERCIAL..... INSTITUTION.....

(1) RESIDENTIAL

(a) BUNGALOW: 2 BED ROOM....., 3 BED ROOM WITH B/Q....., 4 BED ROOM WITH B/Q.....,

(b) FLAT: 1 BED ROOM....., 2 BED ROOM.....,3 BED ROOM.....,

(c) PASSSAGE HOUSE (FACE TO FACE) 4 ROOMS.....; 6 ROOMS .....;8 ROOMS.....; 12 ROOMS.....;

(d) DUPLEX AND OTHERS.....,

(2) COMMERCIAL. (A). BUSINESS CENTRE..... (B). RESTURANT.....,

(C) HOTEL.....,

(D.) SHOPPING COMPLEX....., (E.) WORKSHOP....., (F) MARKET.....,(G) OTHERS SPECIFY.....,

(3) INSTITUTION. (A). SCHOOL....., (B).GOVERNMENT OFFICES.....

(C) HOPITAL.....,

4. WHAT TYPE OF SOLID WASTES DO YOU GENERATE?

(1).FOOD MATERIALS……; (2) PAPER…... (3) CLOTHES/ FABRIC…... (4) PLASTIC……; (5) METAL……; (6) GLASS……; (7) LEATHER……; (8) TIN CAN……. ;(9) OTHER……;

5. WHICH CANTIENER DO YOU USED TO STORE YOUR WASTE?

(A). PLASTIC WASTE BIN…… (B) PLASTIC BAGS……

(C). SACK BAGS…….. (D) WHEEL BIN …… (E) OTHRS……;

6. DO YOU SORT YOUR WASTE INTO DIFFERENT COMPONENT BEFORE DISPOSING? YES……, NO…….

7. IF YES, WHAT COMPONENT?

PLASTIC……; METAL……; FOOD MARERIAL……; CLOTHES/FABRIC……; GLASS……; OTHERS……..;

8. DO YOU TREAT YOUR WASTE BEFORE DISPOSAL? YES……; NO…….

9. IF YES, HOW DO YOU TREAT YOUR WASTE? PHYSICAL……; CHEMICAL…... BIOLOGICAL…….

10. HOW DO YOU DISPOSE YOUR WASTE?

(A) BY WASTE MANAGER…… (B) BY YOUSELF……;

11. IF BY YOUSELF, WHERE DO YOU DISPOSE IT?

(A) APPROVED DISPOSAL SITE …… ;(B) COLLECTION CENTRE……..;

12, IF BY WASTE MANAGER, HOW MANY TIMES DO WASTE MANAGER COLLECTS YOUR WASTES?

ONCE A WEEK…... ONCE A MONTH……TOWICE AWEEK……. TOWICE AMONTH

13. ARE YOU SATIFIED WITH THE NUMBER OF TIME THE WASTE MANAGER COLLECTS YOUR WASTE? YES…., NO……;

14. IF NO, HOW MANY TIME DO YOU WANT YOUR WASTE MANAGER TO COLLECT YOUR WASTE? DAILY……. TWO DAYS…….. THREE DAY…….. FOUR DAY……..

15. DO YOU PAY FOR THE COLLECTION OF WASTE? YES……; NO……..;

16. IF YES, DAILY.....; WEEKLY.....; MONTHLY.....;

17. DO YOU PAY BEFORE THE COLLECTION?

YES.....; NO.....; IF YES, BANK..... . WASTE MANAGER OFFICE.....

AT THE COLLECTING POINT.....

18. ARE YOU SATISFIED WITH THE SYSTEM YOUR WASTE MANAGER USE IN

COLLECTING YOUR WASTE? YES.....; NO.....;

19. WHAT AREA DO YOU WANT THEM TO IMPROVE THEIR

SERVICES.....

YOUR NAME.....;

THANK FOR YOUR CO-OPERATION

APPENDIX iii

MAP OF BENIN CITY;