2

Status of Waste Management

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1. Introduction

Solid waste management problem appears to be the most prominent in urban cities and large towns across the world due to the huge quantity of solid waste generated from domestic and commercial activities. In most cities and large towns of the world, solid waste is not only heaped in huge quantities on refuse dumps but also thrown and made to lie around in piles in the street and in small illegal dump on any piece of unused land. Most third world countries have worst cases than industrialised countries which have the money, technical knowhow and public attitudes to control and manage their waste to some degree. This chapter presents a practical approach to the assessment of the Status of Solid waste management with application in Nigeria. The objectives of the chapter are discussed as follows:

1.1 Solid waste characterisation

Waste characterization is a waste stream analysis which involves a logical and systematic approach to obtaining and analyzing data on one or more waste streams or sub-streams. Waste characterization provides an estimate of solid waste quantity and composition. Two commonly use method of waste characterization are – material flow approach and site-specific study. However there is currently no agreed international standard for waste stream analysis or waste characterisation although many countries have national procedures for analyzing their waste. Waste characterization has been developed and discussed in this chapter.

1.2 Assessment of the solid waste chain

Waste management in all ramifications, is simply a planned system aimed at effectively controlling the production, storage, collection, transportation, processing and disposal of waste. Waste management is an important element of environmental protection. Its purpose is to provide hygienic, efficient and economic solid waste storage, collection, transportation and treatment or disposal of waste without polluting the atmosphere, soil or water system. The various steps involved in the management of solid waste from generation to the point of sanitary disposal are referred to as solid waste chain. It therefore means that the solid waste chain is the path trace by solid waste from generation to the final disposal point. The solid waste chain has been extensively discussed in this work

1.3 Assessment of the status of source segregation

The process of recovery is the main task in the Solid waste Management Mix that is sustainable. Waste sorting is a major part of sustainable solid waste management process because if the wastes are sorted correctly, about 30 - 50% of the work is done. The solid waste source sorting process has also been presented in this work.

1.4 Existing legislation for waste management

Various policy initiatives are required in alleviating the urban solid waste management problems. Policy initiative has been review as it applies in Nigeria

1.5 Review of the institutional and funding aspect of waste management

The institutional framework and funding are aspects of the most important requirements for improved solid waste management. The status of institutional framework and funding of solid waste management has been examined and presented with respect to Nigeria.
This presentation will not be meaningful without feasible suggestions of strategies for improved urban solid waste management system. Suggestions have therefore been presented in this work.

2. Definitions of waste

Waste is a term generally used to describe the materials we throw away. In the United state of America it includes objects the lay audience commonly calls garbage, refuse and trash (Davis and Masten, 2004). The oxford advance dictionary defined waste as unused materials or substance produced while making something. Another dictionary – the word net dictionary defined waste as any material unused and rejected as worthless or unwanted. Waste may also be defined simply as left-over, or already used items waiting for reuse or disposal (Audu, 2007). In addition another definition state thus, waste is any unwanted material intentionally thrown away for disposal (Hoornweg, 1999).
The problem with these definitions is that for any material to be a waste it must be thrown away for disposal. Not all wastes are thrown away for disposal. A lot of wastes are kept by the owner for sale which becomes useful raw materials to other persons. The dictionary meaning and other definitions stated above when carefully examined, rely too much on other terms (such as garbage, trash, refuse etc), which do not provide a means to determine whether a given particle, material or item is not a waste based on its composition and its instantaneous relationship to an owner, a generator, a recycler or a legal designation (Palmer, 1992).
As a follow-up to this, Palmer (1992) proposed the following prescriptive definition of waste which expressed in concise form the critical properties of waste which make it a subject of importance by presenting the instantaneous relationship to the owner. *"Waste is any object whose owner does not want to take responsibility for it".* (Palmer, 1992)
A careful examination of this definition will show that this definition is of the type, which depends on the relationship with an owner. Without an identified owner an object may not be considered in terms of waste. This definition shows that the first step in discussing waste is to locate and identify an owner. This implies that anything without an owner is a waste. If it is potentially valuable an owner will emerge Palmer (1992). However any object which acquires a new owner, who wishes to take responsibility for it, is not a waste, no matter what history.
Another definition states thus "waste is a material which has served its original intended use and sometime discarded." The problem with this kind of definition is that it is

unforgiving. Any material which once had another use is now a waste no matter that it is brand new, clean and valuable, much less perfectly recyclable if given a little attention.
Waste is also seen as "any material which the holder discards, is obliged to discard or intends to discard". It has an objective element in the sense that a material becomes waste by virtue of a circumstance which is outside the control of the owner or holder of the material; namely the fact of abandoning the material or the fact that there are provisions which determine that certain material is to be classified as waste. (Melissa, 2005)
The USEPA, regulatory definition is broader in scope. It defines solid waste thus "solid waste include any discarded item, things destined for reuse, recycling, or reclamation, sludge and hazardous waste. The regulatory definition specifically excludes radioactive waste and in situ mining waste (Davis and Masten, 2004).

2.1 Proposed definition

Having examined the definition given by various authors as shown above it became clear that they are not all encompassing hence there is need to propose a definition that can define waste more broadly as follows: "Any object that may or may not have served its intended use and the owner is not ready to continue to take responsibility for ownership and or continuing to keep it and he or she is ready to discard it if possible is a waste".
Waste may be asset or a liability depending on the management system applied on it. To the developed countries wastes are asset because they have the technology and public attitude that help the nations to reverse the state of their waste which make it become assets instead of liability. Take for example, the recycling of waste paper save trees use for making fresh pulps.
In this chapter the status of municipal solid waste management has been discussed with a case study in developing country - Nigeria. The study covered the nature and quantities of municipal waste generated, the availability of technology for handling and processing, the degree of industrialisation in terms of extent of mechanisation and availability of technological resources, perception and attitude to solid waste management.

3. Municipal solid waste

Municipal solid waste (MSW) is defined Cointreau (1982) as non-air and sewage emissions created within and disposed of by a municipality, including household garbage, commercial refuse, construction and demolition debris, dead animals, and abandoned vehicles. Municipal solid waste is generally made up of paper, vegetable matter, plastics, metals, textiles, rubber, and glass (USEPA 2002). Municipal solid waste disposal is a major concern in developing countries across the world, as high poverty, population growth, and high urbanization rates combine with ineffectual and under-funded governments hampers efficient management of wastes (Doan 1998, Cointreau 1982). In most cities and large towns of developing countries, solid waste is not only heaped in huge quantities on refuse dumps but also thrown and made to lie around in piles in the street and in small illegal dump on any piece of unused land. Most third world countries have worst cases than industrialised countries which have the money and technical know now and public attitudes to control and manage their waste to some degree.

3.1 Characterisation of municipal solid waste (MSW)

Municipal solid waste characterization is a waste stream analysis which involves a logical and systematic approach to obtaining and analyzing data on one or more waste streams or

sub-streams. The analysis usually provides - the composition of the waste stream and an estimate of the quantity of the waste stream (EPA Ireland, 1996). There is currently no agreed international standard for waste stream analysis or waste characterization although many countries have national procedures (EPA, Ireland, 1996). However there are two basic approaches to estimating quantities of municipal solid waste - Site-Specific Study and material flow approach (USEPA, 2006).

3.2 Site-specific study

This method involves sampling, sorting, and weighing the individual components of the waste stream. The method is useful in defining a local waste stream. The site-specific study requires a large numbers of samples to be taken over several seasons. Large sample ensure that the results are not skewed and misleading. This method is best applied in the characterization of a solid waste stream that has components such as food and yard trimmings. A study that involves the use of site-specific study is usually preceded by survey. Solid waste survey is a statistical study of a sample population which involves asking questions about age, income, opinions, size of family, and other aspects of people's lives with respect to solid waste. Usually survey research method is employed when research is to be carried out in a large population. Random sampling method is commonly used to observe and collect data from the population. The sample size required for a survey partly depends on the statistical quality needed for the survey findings; this, in turn, relates to how the results will be used (Haruna, 2004, Scheuren, 2004). Two methods commonly applied in Surveys research are the questionnaire and interview methods. Questionnaires are usually paper-and-pencil instruments that the respondent completes. Interviews are completed by the interviewer based on what the respondent says. Sometimes, it's hard to tell the difference between a questionnaire and an interview. The procedure for MSW Characterization using site-specific study is discussed in the following sections.

3.2.1 Selection of a representative sample

Selecting a representative Sample is one of the most difficult tasks associated with waste stream analysis (EPA, Ireland, 1996). It is of critical importance that a sample be collected that is representative of the waste management unit under study. The first step in good sample design is to ensure that the specification of the target population is as clear and complete as possible to ensure that all elements within the population are represented. Several sampling techniques exist - Cluster sampling, Multi-stage sampling, Quota sampling, Simple random sampling, Stratified sampling, Systematic sampling etc. As you can see listed above there are many methods available for use with varying degrees of complexity. Certain methods suit circumstances better than others.

3.2.2 Sampling

The most convenient way to select a representative sample is to use the social class grouping. The population is group into three major social classes – Upper social class, Middle social class and Lower social class (Lindsey and Beach, 2000). The forth is the Underclass.

The upper social class consists less than 5 percent of the population and is group into two sub-classes: upper-upper and lower-upper social classes. The middle social class is also broken into three sub-classes - upper-middle, average or middle-middle and lower middle class. The membership of the sub-class is determined by educational background and earning.

In Nigeria it is assumed that over 70% belong to the lower social class. This class is made up of those who barely half manage to complete secondary school and less than about 25% are able to get university education (macionis, 2002). They own their houses in least desirable neighborhood. Society segregates the lower social class especially when no education at all.
The forth is the Underclass. Very little percentage of the population is locked up in this class. The members of this group lack employable skill and have little or no experience in the job market. Unless given extensive training, they are virtually unemployable. Sociologists disagree about what to call this class. Some use the term "Underclass". In America some argue that this word is stigmatizing, a real concern given the negative classist attitude of most Americans (Lindsey and Beach, 2000)

3.2.3 Sample size

The size of sample to be taken is dependent on the number of solid waste generation units in the sampling area. The following procedure may be employed in selecting the sample size.
A breakdown of social class groups in the sampling area is obtained from the census figures. The number of sampling units (households for domestic waste) to be surveyed is determined. The minimum number of sampling units is 50 per 500 households. For domestic waste this will result in a sample of approximately 1,000 kg, assuming a waste generation rate of 20 kg /household/ week (EPA, 1996). For practical purposes, the weight of the sample for a single survey should be kept below about 5,000 kg, which is roughly equivalent to the waste collected from about 250 households. The recommended range for a survey therefore, is, roughly, 50 – 250 households. However in larger areas, where the sample size will be greater than 250 households, it is recommended that a survey be split into several sub-surveys.

3.2.4 Sample collection

In Nigeria and in most other industrialized countries such as United States, solid waste collection is by trucks fig 1. The trucks are usually parkers, tippers and trucks that carry hydraulic rams to compact the waste to reduce its volume and thus can carry larger quantity. The sample should be collected from the selected sampling units on the same day as normal collection.
The vehicle are weighed prior to and after sample collection so that the total weight of the collected sample can be obtained by determining the deference between the weight of the collection vehicle before and after collection of the waste. Occupants of households and operators of firms chosen for the survey should not be informed about the survey so that any bias that may be created by a temporary change in habits can be eliminated. However in developing countries the people show indifference to solid waste issues and as such the approach above is often not easily applicable. The weight of the total sample should be obtained before sorting and the number of sampling units (households or firms) included in the survey recorded so that the average weight of waste per household per week can be determined.

3.2.5 Sample analysis

The samples are then sorted into the types and classes of solid waste and the weight of each type and class determined and recorded. The moisture content and the bulk density of the sample should be measured. This information will help comparison of results of different surveys as large fluctuations in either moisture content or bulk density will normally reflect a significant difference in waste composition.

Fig. 1. Solid waste collection vehicles with hydraulic ram

3.2.6 Safe disposal of sampled waste

After the analysis arrangements should be made for appropriate and safe disposal of the waste to an authorised site having completed a waste composition survey.

3.3 Materials flow approach

In the material flow methodology production data (by weight) are collected for the materials and products in the waste stream. Waste generation data is obtained from the data collected by making specific adjustments to the production data for each material and product category. Adjustments are made for imports and exports and materials diverted from the municipal solid waste (MSW) stream (e.g., for building materials made of plastic and paperboard). Adjustments are also considered for the life spans of various products. One major disadvantage is that the materials flows methodology requires additional sampling study to determine food wastes, yard trimmings and a small amount of

miscellaneous inorganic wastes. This method is widely used in the United States of America (USEPA, 2006).

4. The solid waste chain

Waste management in all ramifications is simply a planned system aimed at effectively controlling the production, storage, collection, transportation, processing and disposal of waste. Waste management is an important element of environmental protection. Its purpose is to provide hygienic, efficient and economic solid waste storage, collection, transportation and treatment or disposal of waste without polluting the atmosphere, soil or water system. The path trace by solid waste in the management of solid waste from generation to the point of disposal is referred to as solid waste chain. The solid waste management is a complex process, involving multiple steps (solid waste chain) shown in fig. 1.

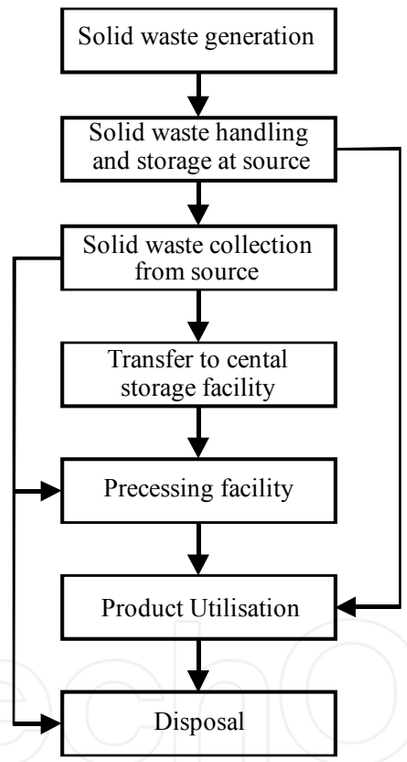

Fig. 1. The solid waste Chain

As indicated in fig.1, the first step in the solid waste chain is the generation of solid waste. Once a material no longer has value to the owner, and owner does not want to take responsibility for it, it is considered to be a waste (Palmer, 1992). The generation of waste varies by country, socioeconomic status and as a result of many other practices (Davis, eta al 2004). Once solid waste is generated, it must be handled properly and stored at source for collection by solid waste disposal agents. The processing and handling may include sorting or segregation, washing and storage so as to ensure recycling of some portion of the waste. Other steps included in the solid waste chain are collection, transfer to central storage facility, final processing facility, product utilization and disposal.

5. Solid waste source segregation

There are four common methods of solid waste Disposal – Landfill, incineration, composting and anaerobic digestion and Recycling (Rao, 2006, Audu, 2007). Incineration, composting and anaerobic digestion are volume reducing technologies; however, residues from these methods must be land filled (Seo et.al 2004). Recycling is one of the waste management techniques that can ensure sustainability of any solid waste management strategy. Recycling is a waste minimization strategy which can be used to divert or prevent discarded material from the waste stream. It consists of a series of activities that are preceded by waste segregation/sorting, processing and manufacturing into new products. Recycling is one of the solid waste management that can ensure sustainability of solid waste management as it converts the waste from liability to asset.

In most large towns and cities in Nigeria solid wastes including medical waste are commingled and disposed at the solid waste dump site. Thereafter open air incineration without pollution control is carried out on the waste. This is not sustainable as it does not bring financial return at the end point of the waste. If a sustainable solid waste management must be realized recycling which ensure financial returns at the end point of the waste must be included in the waste management designed. The first step in solid waste management which will include recycling is segregation/sorting. If solid waste is sorted about 30% of the work is done (Chidubem, 2008). Several methods of sorting solid waste exist.

6. Solid waste management policies and institutional framework

In order to handle growing volumes of wastes generated in a country, proper policies need to be enacted and implemented. These policies are formulated based on the provision of the constitution. A country's constitution is the most important legal document from which all laws and regulations are derived pertaining to the authority of every governmental unit (federal, state, or municipal). For instance the constitution of Federal Republic of Nigeria (F.R.N), 1999 defines the sphere of action and constraints on government by granting certain inalienable rights and obligations to every citizen such as freedom of speech and freedom of movement as well as freedom of association. The Environmental Objectives and Directive of State Policy on the Environment contained in the Constitution of F.R.N,1999 state that, "the state shall protect and improve the environment and safeguard the water, air and land, forest and wildlife of Nigeria" Sec 20 of the Nigeria Constitution (Nigeria 1999). In an effort to develop a framework within which the objectives of protecting and improving the environment can be realized, the constitution allocates certain legislative competencies to each of the three tiers of government. The responsibility for applying the legislation falls to the judiciary. The constitutional obligations are: That everyone in Nigeria has the right to have an Environment that is not harmful to his or her health well being, have the environment protected, for the good of present and future generations, through reasonable laws etc.

Based on the above several agencies have been created at the state level and local Government levels that are involved at least partially in solid waste management. Such agencies include – State waste management board (SWMB), Operation Cleanup, Special Environmental task force, local government environmental department etc. However, there are often no clear roles/functions of the various state and local government agencies defined in relation to solid waste management and also no single agency or committee designated to coordinate their projects and activities. As a matter of fact the government has not been able to develop administrative infrastructure to regulate the management of solid waste and

establish pollution control measures in most large cities and metropolis. These therefore results in the lack of coordination among the state and Local Government agencies. The lack of coordination among the relevant agencies often results in duplication of efforts, wastage of resources, and un-sustainability of overall solid waste management programmes.

7. Solid waste management funding

Funding is one of the most importance requirements for the success of solid waste management. In developed countries such as the United States of America (USA) waste management funding policies are well in place, but in developing countries solid waste management is given very low priority, very limited funds are therefore provided to the solid waste management sector by the government. The waste management agencies are therefore left with options of coping with the little fund raised from the user service charge. The waste disposal service charges collected by the disposal agents is too little to make any meaningful impact on solid waste management and users' ability to pay for the services is very limited by their income, and their willingness to pay for the services which are irregular and ineffective is not high either. More so the end point of the solid waste does not provide financial reward to waste disposal agents hence the only source of finance to the disposal agents is the disposal service charges.

8. Case study

Case studies have been carried out in Nigeria. Results obtained from these case studies have been compared with results obtained by other researcher in and outside Nigeria. The multi-stage, stratified-random sampling techniques were applied in these case studies. The study involved survey and solid waste sampling. In carrying out these surveys and sampling, some major elements that helped to cut across the population using the representative samples were considered. Each study unit chosen was based on some major elements - Type of housing/house, size of household and social economic status for domestic solid waste, type of firm, size of firm and nature of products for commercial solid waste. The case studies presented in the following sections were carried out in Lagos and Benin metropolises in Nigeria.

8.1 Background to study sites

Lagos is a city in Lagos state, Nigeria, undergoing accelerated urbanization with influx of people on a daily basis from other parts of the country and neighbouring countries. According to the 2006 National census figure, Lagos State has a population of 9,013,534. However, based on a U.N study and the State Regional Master Plan, the State is estimated to have above 12 million inhabitants. Out of this population, Lagos metropolitan area is occupied by over 85 percent on an area that is about 37 percent of the land area of Lagos State. The rate of population growth is about 300,000 persons per annum with a population density of about 1,308 persons per square kilometer. In a recent UN study the city of Lagos is expected to hit the 24.5 million-population mark and thus be among the ten most populous cities in the world by the year 2015 (Lagos State Government, 2004).

Management of solid waste did not become a phenomenon in Lagos until the 1970s when due to oil boom Lagos witnessed massive influx of people as a result of industrial growth and urbanization from less developed part of Nigeria and West Africa. Management of solid

waste started in Lagos state with the establishment of Lagos state Refuse Disposal Board in 1977. It was later changed to Lagos state waste disposal board due to added responsibilities of commercial and industrial solid waste collection and drain cleaning. Collection and disposal of scraps and derelict vehicles were added in 1981. Lagos State Waste Management Authority (LAWMA) was established in December 1991 with the responsibility of collection and disposal of municipal waste in the state (Ola, 2006). Since creation LAWMA has been faced with serious problems on the issues of waste management. These include limited budget, inadequate tools and waste data, poor public attitude, etc.

Mushin Local Government is located at the geometrical centre of Lagos metropolis. It is one of the oldest local governments in the state. Mushin is an entirely urban local government Area though its level of urbanization is not as rich as other local governments in the metropolis. Nevertheless, the vibrancy of its population is a sign that given adequate encouragement, the level could still be improved considerably. According to the final figures of the 2006 National Census, Mushin Local Government has a population of 633,009 people. The Local Government area is highly residential and there are no farmlands available for farming.

Benin Metropolis has similar characteristic with Lagos metropolis. It encompasses Benin City the capital City of the ancient Bini kingdom and it is made up of three local Government areas – Oredo, Egor and Ikpoba-Okha local government areas. These local government Areas are located within the three geographical zone of Benin metropolis – the traditional core zone, the transitional zone and the outer zone (Ikelegbe and Ogeah, 2003). The total Population in Benin metropolis is made up of about 1,085,676 persons (National Population Commission, 2006).

Solid waste management is in crisis stage in the Lagos and Benin metropolis and indiscriminate dumping of solid waste around homes, market places and around the street corners has almost become an acceptable life style in the metropolis as solid waste is allowed to lie around without serious consideration even by the government authorities. What is done to solid waste is simply solid waste relocation and not management in the real sense of it as waste is collected from source of generation and dumped on any un-used land by the disposal agents. Worst still the government waste management authorities do not have a complete record of the waste management agents in the metropolis and hand carts are largely patronised by households and small and medium scale enterprises for the disposal of their solid waste.

8.2 Methodology

Mushin local Government Area (LGA) of Lagos metropolis and Oredo LGA of Benin metropolis were selected for the study. The total Population in the metropolises was obtained from the 2006 Population census figure (National Population Commission, NPC, 2006). The population in the metropolises is not defined in terms of social class. The multi-stage stratifies random sampling technique was therefore design and applied for the study. The population was broken down into household unit (a house hold is a group of people living together in a house as a unit). The average household size in Nigeria is 7 (NPC, 1991), (NPC, 2007). Based on NPC submission, the total households was determined. A listing of the houses in the study area was done. A representative sample size was then calculated using a confidence level of 95% and confidence interval (margin of error) of 4%. The minimum number of households in any solid waste survey is 50 per 500 households and a maximum of 250 households in the sampling area (EPA, 1996). Due to the largeness of the

sample size calculated the study was broken down into three sub-surveys each in the two metropolises. 250 households each were further selected from the selected sub-survey area. Each selected household was visited several times. In the first visit, contact was made and participation consent requested. Upon approval, a second visit was made to distribute the questionnaires and moderate size solid waste storage bags. The next visits were made at regular interval to retrieve the questionnaires and collect the solid waste generated over 7 days. Interviews were also conducted during the visits.

8.3 Solid waste generation

As detailed in the methodology, the multi-stage, stratified-random sampling technique was applied. The Mushin LGA and Oredo LGA located at about the geogrphical center of Lagos and Benin metropolis was chosen for the survey. A total weekly average of 2263.2Kg of domestic solid waste was measured in Lagos metropolis within the period of study. Base on these figures a daily generation rate of 0.57kg per person per day (ppd.) was calculated as shown in table 1 for Lagos metropolis. Analysis of the data measured showed that about 47.86% of food waste, 46.47% of rubbish and 4.92% ash were generated. The 46.47% of rubbish was made up of 12.63% of rubber and Plastic materials, 18.16% of other combustible material (paper, cloth, foam, etc.) and 15.685% of non-combustible materials (Metal, glass, ceramics, etc).

S/N	Component of Solid Waste	% of total waste measured	Waste generated Kg– ppd
1	Organic Food waste	47	0.27
2	Combustible waste Rubbish		
	a. Plastic	12.63	0.07
	b. *Others	18.16	0.11
	Non-Combustibles	15.68	0.09
3	Wood Ash	4.92	0.03
	Total		0.54

*Others - This include Paper, Clothes etc

Table 1. Waste generation Data for Lagos metropolis

In addition a total 5373.61Kg of domestic solid waste was measure within the period of study from Oredo LGA. Base on this figure a daily generation rate of 0.425kg per person per day (ppd.) was also calculated as shown in table 2. The results shown in the table revealed that 0.335kg ppd. (78.67%) of food waste, 0.037kg ppd. (8.64%) of plastic and rubber, 0.016kg ppd. (3.66%) of paper, 0.017kg ppd. (4.10% of metal, 0.012kg ppd. (2.82%) glass and 2.10% of other waste is generated in the metropolis.

The value of food waste, the highest from the study in Lagos metropolis consist mainly of vegetables and meal scraps and scraps associated with preparation of food compared favourably with residential waste for some large towns and cities with similar residential characteristics in developing countries such as Gwadalajara, in Mexico with about 52.9% (Gerardo, Et al, 2001) and Nsuka in Enugu state of Nigeria with about 56% (Ogweleka, 2003). In addition when the value obtained in Lagos is compared with the value obtained in Benin metropolis and values obtained by other researchers in some other cities in developing countries such as Guyana in southern America with about 72.8% (Zavodska, A

(2003), Katmandu, Capital City of Nepal with about 70-80% (Alam, Et.al. 2006), and Mumbai in Indian with about 70% (Beukering, Et.al., 1996), (Sashi, 2003) the value is a little lower. The food waste content of residential waste realised from this study is very high because of the heavy dependent on home prepared meals. When compared to the food waste found in the USA of about 11% (USEPA, 2000) the cultural difference stands out (Zavodska, 2003).

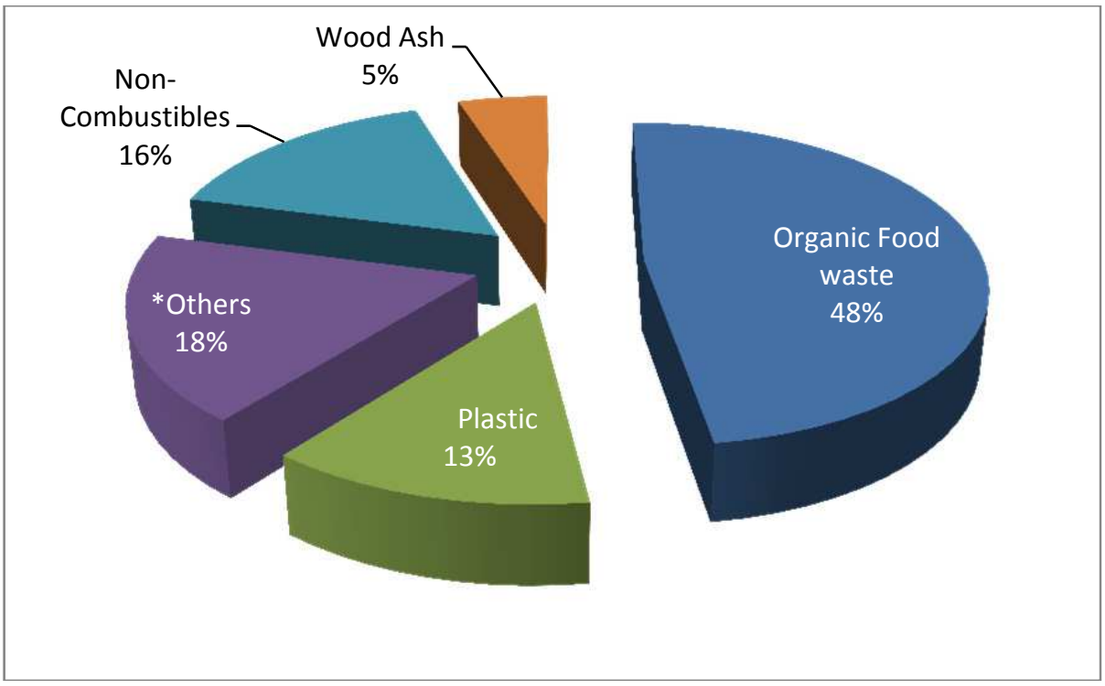

Fig. 2. Waste generation Data for Lagos metropolis

Type of solid waste	Weight (Kg)	% Components
Food waste	0.334	78.59
Plastic/Rubber	0.037	8.65
Paper	0.016	3.67
Metal Waste	0.017	4.11
Glass	0.012	2.83
Unclassified Combustibles	0.003	0.78
Special Waste (Ash)	0.003	0.67
Unclassified Incombustibles(Ceramics)	0.003	0.65
Total Soild Waste Ppd	0.425	

Table 2. Average component of solid waste generated per person per day in Oredo LGA

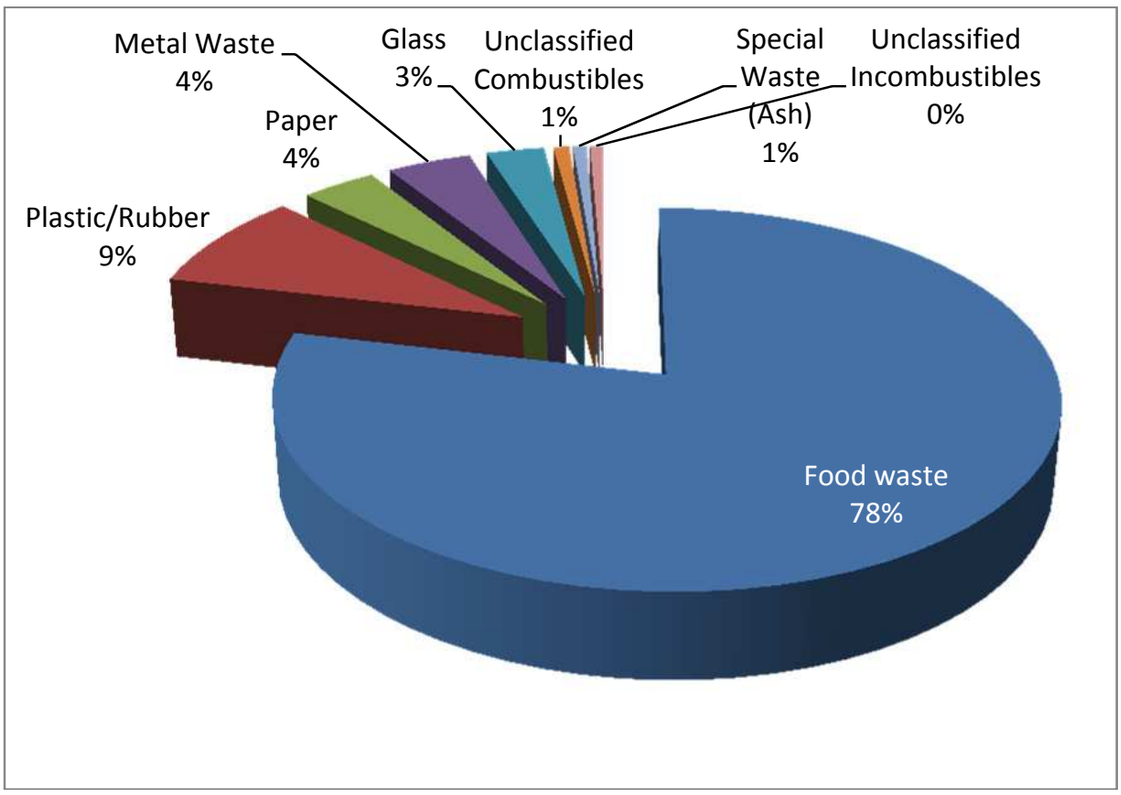

Fig. 3. Average % component of household solid waste generated in Benin metropolis

City	Food waste Percent (%)
Lagos	47
Benin metropolis, Nigeria	78.30
Georgetown, Guyana	72.8
Katmandu, Nepal	70-80
Enugu, Nigeria	56
Gwadalajara, Mexico	52.9
Mumbai, Indian	70
Kano, Nigeria	43
Tianjim, China	58.4
USA	11
Onicha, Nigeria	24-36 (Average 30.67)

Table 3. Food waste in different Countries

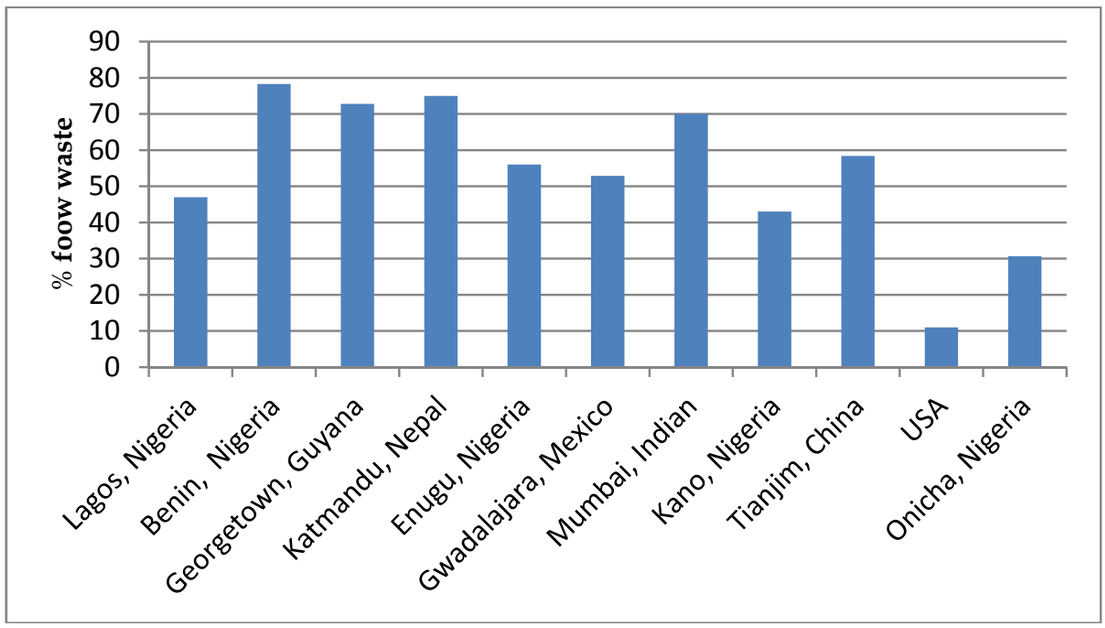

Fig. 4. Food waste in different Countries

In addition a total of 2323.93kg of commercial waste was measured in Benin metropolis and this gave an average of 44.96% of Garbage, 25.43% of plastic waste, 14.27% of paper waste, 3.21% of metal waste, 3.89% of glass, 3.39% and 8.24% of other waste (ceramics, foam, clothes etc) in Benin Metropolis. The percentage of plastics and paper waste are quite high for commercial waste. This can be well understood if we consider the business activities in Benin metropolis which involve sale of products packaged with plastic and paper material and the use material packaged with plastic and paper materials for services. The recent upsurge in the production of table water in Nigeria has brought with it the problem of how to contain the sudden rise in the polythene sachets that are discarded daily after the water has been drunk. Thus, polythene sachets have increased the volume of various waste plastic products requiring attention in Nigeria.

8.4 Solid waste storage and collection

In Lagos and Benin metropolis external waste bins fig. 5 are generally used for storing waste before they were collected for disposal. Small waste bins are also used internally to store the waste before transferring them to the external waste bin for storage for collection by the waste disposal agents. Three private waste disposal agents – Private Sector Participators (PSP) in the solid waste disposal sector were registered in Mushin LGA. Other means of waste disposal are illegal and in some cases punishable. Data shown in table 5 indicates that about 69.09% of household have their waste collected by private solid waste disposal agents for disposal, 5% disposes off their waste by themselves and the 26.36% patronize hand carts in Mushin LGA (see fig. 6). It is imperative to note at this point that hand carts are not registered PSP waste disposal agents and that the areas where hand carts are largely patonised are areas with poor access roads. In addition 51.81% of the household sampled had their solid waste collected for disposal once a week, 22.73% had their waste collected for disposal twice a week and 25.46% had their solid waste collected for disposal twice month. The cart pushers are one of the disposal agents that service the group that had their waste collected for disposal by disposal

agents twice a week. They do not have external temporary solid waste storage bin where solid waste can be store before the disposal agents comes to collect them. Hence when there is delay in the cart pushers turning up to collect the waste, members of the household takes the waste to any piece of unused land or throw then into drainage system. Worst still during the raining season they throw their solid waste into the flood water and the waste eventually find their way into the drainage system as shown in fig.7.

Fig. 5. External bins for storing solid waste before collection by disposal agents

Fig. 6. A hand cart Pusher carrying domestic solid waste for disposal

Fig. 7. Solid waste accumulated in the entrance of a manhole of a drainage system

Number of Household Sampled	Collectors and Disposal agents					Collection Frequency				
	Private agent	Self	Cart Pushers	Local Govt Council	LAWMA	Daily	Once a week	Twice a week	Once in 2 wks	Once a month
110	76	5	29	Nil	Nil	Nil	57	25	28	Nil
Percentage	69.1	4.6	26.4				51.9	22.7	25.5	

Table 4. Household responses on collection of solid waste from their homes for disposal in Lagos metropolis

8.5 Solid waste source segregation

In developing countries solid waste source segregation awareness is very poor. In Lagos and Benin metropolises solid waste source segregation is not practiced by residents and commercial operators. A pilot study carried out in Benin metropolis showed that the residents have poor attitude to solid waste source sorting. The results shown in table 5 indicated that in the week one of the study, 43% of the participants achieved 100% source segregation of biodegradable waste. In weeks 2 and 3 the number of households that achieved 100% source segregation of food waste increased to about 52% and 60%, respective. This was as a result of serious sensitization of the households on the benefits that will be realized from source sorting of solid waste. In this case no personal benefit accrued to the generators, may be in the form of discount on solid waste disposal charges. Thereafter, there was a decline in the numbers of households that achieved 100% segregation of the waste and the participant started asking for what were their benefits from the work and declined on further participation. This implies that for sustainability of the process there must be mutual benefit from the waste for the managers of the solid waste and the generator of the waste.

It is believed that if discounts are granted on disposal service charges, more generators will achieve 100% separation of biodegradables and plastic waste at source as the discount will

represent the benefit of the generator on the segregation exercise. Considering the results from the pilot study on source segregation, two waste bin source segregation of biodegradable waste and other waste (metal, paper, plastics etc) will be much more effective at the start of the system. This will gradually be increased to three waste bins for biodegradable, plastics and other waste with time.

Week	% of households with 100% separation	
	Food waste	Plastic waste
Week 1	43.48	0.00
Week 2	52.17	0.00
Week 3	60.87	34.78
Week 4	50.12	31.45
Week 5	38.10	28.26
Week 6	46.08	28.5

Table 5. Percentage Cooperation of households in each waste Bin in Benin metropolis solid waste management

8.6 Land fill site

Landfill is the common practice in the Benin and Lagos metropolis. Closed mining sites were converted to solid waste dumpsite without preparation for use as solid waste landfill site. There are three approved dump sites in the Lagos metropolis. These land fill sites have weight bridges at the gate house of the site. When vehicles carrying solid waste get to the gate their weights were taken at entry and exit. The difference between their weights on entry and exit were determined and recorded. Table 6 shows the records of weekly average solid waste delivered at the three approved waste dumpsite in the Lagos metropolis in 2006. The table showed that an average of 12,940.15 metric tons of solid waste was delivered at the three approved dumpsite per week. The 2006 national census puts the population of Mushin Local government area at 633,009 people. This population will therefore result to the generation of 360.8 metric tons of solid waste per day and 2525.7 metric tons per week of domestic solid waste alone from the Mushin Local Government. This value is a far cry compare to the total average weekly solid waste (commercial and domestic) of about 1753 metric tons delivered at the approved dump site from Mushin LGA. This therefore explains why solid waste is eventually dumped at illegal waste dump and thrown around in street corners.

In contrast the Benin metropolis had eight approved dump sites. At the time of this study but only two were operational – Iguomo and Uzebu land fill site. There were neither gate houses nor measuring instruments at the sites. Solid waste was dump indiscriminately at the site. However an experiment was carried out to determine the solid waste delivered at these dumpsites during the period of the study. The result from the experiment showed that a daily average of 33.61 metric tons of solid waste was delivered at the Iguomo dump site and 226.40 metric tons of solid waste was delivered at the Uzebu dump site. Table 5 shows the result of the site-specific studies in Benin metropolis and the result revealed that an average of 0.425Kg per person per day is generated from Benin metropolis. The population census put the population in the Benin metropolis at 1085676 people in 2006. This will give a total solid waste

generated from residential site of about 461.41 metric tons per day. When this value is compare with the total of 260.00 metric tons obtained from the experimental determination of solid waste delivered at the dump site, we have a short fall of 201.41 metric tons of solid waste from residential site. It should be noted that solid waste is delivered to the dump site from all the source of solid waste – domestic, commercial and industrial sites in the metropolis. This therefore explains the reason why solid waste also is seen littered all around in the metropolis.

The current method of solid waste management at the landfill site is simple. The waste disposal trucks and other vehicle that deliver waste to the site drive into the dumpsite through the access road and dump their waste. The workers at the site use shovel to manually push the waste from the road and try to spread them as much as their strength can go. This, of course is a Herculean task. Thereafter, scavengers descend on the waste to pickup recyclable materials for sale and, open air incineration without pollution control is also carried out on the waste for volume reduction (see fig. 8)

Environmental health is very important in location of landfill sites. One of the two functional landfill sites in Benin metropolis is located by a stream of water. This of course can cause eutrophication. Hence there is a serious indication of adverse effect on people in the metropolis as the stream is one of the sources of water to the people nearby.

Date/ Period	Abule-Egba (Metric tones)	Soulous (Metric tones)	Olushosun (Metric tones)	Weekly Total (Metric tones)
Week 1	246	1459	8871.6	10,576.6
Week 2	320	1946	9224	11,490
Week 3	690	2051	10608	13,349
Week 4	1354	2058	13541	16,345
Monthly Total	2610	7514	42244.6	51760.6

(Source: LAWMA Solid waste Record)

Table 6. Average Weekly solid waste delivered at the approved dumpsite by the waste management agents in 2006.

Fig. 8.a Open air incineration of solid waste at dump site.

Fig. 8.b Open air incineration and scavenging activities at the dumpsites

Period	Solid waste(Metric tones)
Week 1	1,749
Week 2	1,595
Week 3	1,848
Week 4	1,815
Monthly Total	7,007

(Source: LAWMA Solid waste Record)

Table 7. Average Weekly metric tons of solid waste delivered at the approved dumpsites From Mushin LGA by the waste management agents.

Number of Household Sampled	Collectors and Disposal agents					Collection Frequency				
	Private agent	Self	Cart Pushers	Local Govt Council	LAWMA	Daily	Once a week	Twice a week	Once in 2 wks	Once a month
110	76	5	29	Nil	Nil	Nil	57	25	28	Nil
Percentage	69.10	4.55	26.36				51.81	22.73	25.46	

Table 8. Household responses on collection of solid waste from their homes for disposal

8.7 The solid waste chain in Nigeria

Solid waste management in Lagos and Benin metropolis revealed a serious deviation from the solid waste chain shown in fig. 2. Solid waste was seen in huge heaps in illegal solid

waste dump site, in the open market place, around home and in drainage systems. And this has resulted to serious community environmental health crisis in the metropolis such as water flooding and diseased epidemic. The solid waste chain obtained from the studies is represented in fig.9.

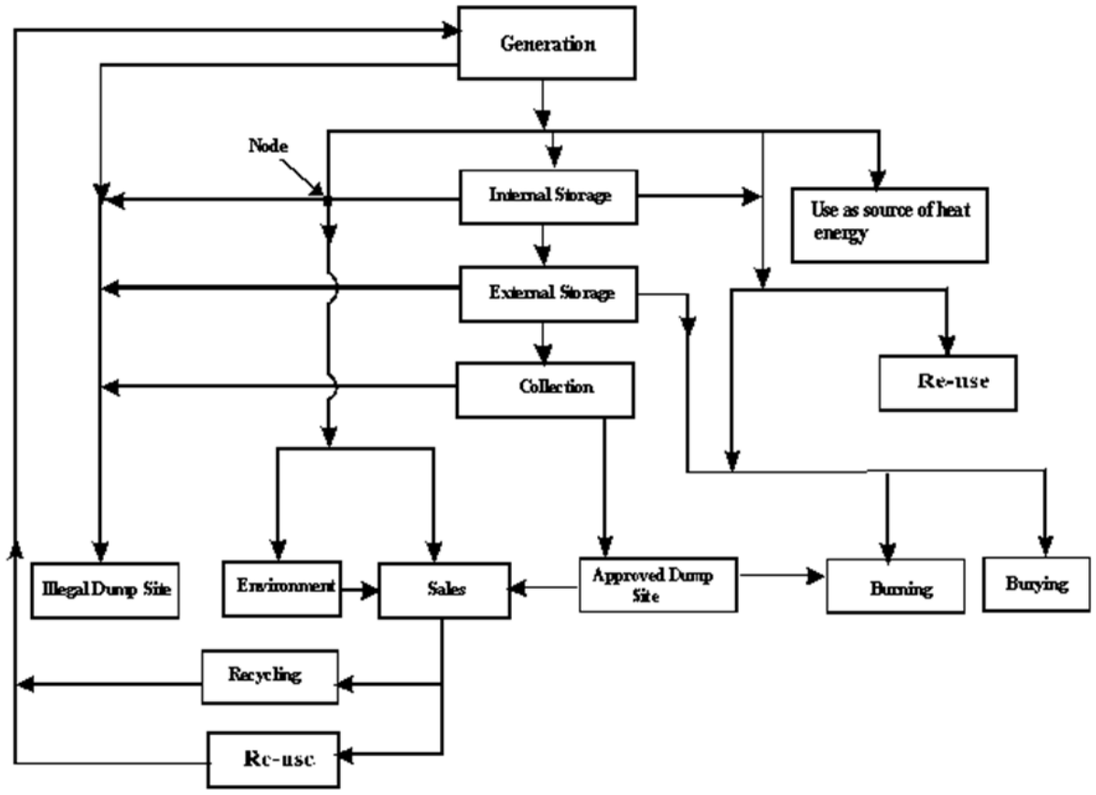

Fig. 9. Solid waste chain in large towns and cities in Nigeria

8.8 Terms in the solid waste chain

8.8.1 Generation

Generation refers to the source of solid waste. In Nigeria municipal solid waste is generally made up of waste generated from domestic and commercial activities.

8.8.2 Internal storage

Internal storage refers to storage of waste within the house or office at source. The study revealed that small waste bin such as perforated bins, small plastic bags, empty paint drums, plastic and metal buckets etc were used for storing waste internally at source. The wastes are usually stored in the internal waste bins until the bins are filled up and then transferred to the external waste bins.

8.8.3 Re-use

In most cases, the generator keeps solid waste items such as bottles and beverage cans for storing liquids (kerosene, cooking oil etc), salt and other food items. In addition other solid waste items such as paint cans, buckets and drums were also kept for storing water in the

home and commercial unit. After a while, the items find their ways back to the waste stream when they become broken or old.

8.8.4 External storage

External storage is the temporary storage of the wastes in bins usually located outside the house for domestic source and outside the premises for commercial source. The types of external waste bins in use in Lagos and Benin metropolis include: Metal and plastic drums, Bins constructed with blocks, Pits, Sacks, etc.

8.8.5 Collection

This refers to the collection of the solid waste from the generators for disposal by the waste disposal agents. The preliminary study showed that solid wastes were left in the external storage bin for a period of one to four week before collection by the disposal agent in Lagos and Benin metropolis.

8.8.6 Environment

Environment in this context means the surroundings of houses and business premises in the metropolis. These include road sides, drainage system, market areas, etc. Large amount of solid waste are thrown and made to lie around the environment in the metropolis.

8.8.7 Illegal dumpsites

These are unauthorized solid waste dumpsites where solid wastes were dumped indiscriminately by residents in the metropolis. Many unused lands are converted to solid waste dumps illegally. In fact, the waste control agencies are unable to enforce the environmental laws and hence resident do whatever they like with their waste including illegal dumping in the metropolis.

8.8.8 Approved dumpsite

These are authorized landfill sites where solid wastes are dumped and managed by the waste management agencies. At the time of this study, there were eight approved dumpsites in the metropolis, but only two were functional due to neglect by the authorities in charge. Hence, there was indiscriminate dumping of solid waste at the site by disposal agents.

8.8.9 Sales

The generators sell some of their solid waste such as waste bottles which buyers use for various purposes such as storage of vegetable oil and other cooking items. Some item were also picked up by scavengers at the illegal dumpsites and external waste bins for sale. Bottles used for packaging medicine were also sold.

8.8.10 Recycling

Recycling is the process of adding value to the waste to make it economically useful. Some recyclable waste such as nylon and plastic/rubber bags were sorted and sent for recycling in the metropolis. Recycling is at low ebb. The facility used for recycling plastic bags installed in the metropolis was not very functional. A study of the recycling facilities showed that the power consumption of the facility is about 225hp of electrical power. This is too high for small and medium scale enterprises (SME). And the system was poorly designed.

8.8.11 Burning

This is the process of setting the waste on fire and allowing it to burn to aches. This study revealed that uncontrolled open burning of solid waste was practiced by generator and waste management agents around houses, business areas and at the dumpsites in the metropolis.

8.8.12 Burying

Burying is the process of covering the waste in a hole with sand in the ground. Burying of solid waste is wildly practiced in Nigeria. This study revealed that residents dig hole behind their houses to get sand for filling the foundation of their building to damp proof course (DPC) levels during construction. When they move in to live in the houses they bury their solid waste in such holes dug behind their houses during construction.

8.8.13 Use as source of heat energy

Residents of the metropolis burn solid waste to generate heat energy for cooking purpose. For example, some residents in the metropolis go to the wood sawmill industry for collection of wood sawdust which they burn to get heat for cooking their meals. In addition, during the corn season, the boiled corn seller burns the corn curb to get heat for cooking corn for sale.

9. Feasible suggestion for improved solid waste management

1. There is need to pay more attention to the prevention of blocking of water ways. Not only is this an unpleasant sight, it results in flooding of homes, breeding of pathogens and pest. There must be improved litter control in the large town, cities and metropolis. A very good way to promote this is by providing more public waste bins throughout the metropolis and replacing the existing ones when they become old or when they are damaged. If bins are available, then at least people will have the option of using them. Without available waste bins, the only option that the people will have is to throw waste on the ground which is the current practices.
2. It is obvious that funding is a major constraint in solid waste management; hence special attention should be paid to financial planning by the Waste management authorities in the metropolis. The government should create special charges that will be paid by residents and business operators in the metropolis. And these charges should be dedicated to management of solid waste in general in the metropolis. The collection of these charges should be planned is such a way that the difficulties associated with the collection of levies and charges currently will be eliminated.
3. Many officers in charge of solid waste management, particularly at the local and State Waste Management authorities and other agencies handling the issues of waste, have little or no technical background or training in environmental engineering or management. In fact all the problems that the solid waste Management system is faced with are exacerbated by the lack of trained personnel. This includes workers in all ranks, from the administrators to the refuse men. There is no formal training programme and communication is poor. Training for personnel is important. Adequately trained managers, supervisors and foremen in both collection and final disposal site positions are important for a smooth running operation and operational data collection. New policies should be created for the management of solid waste in the metropolis which will indicate the training requirement for various positions in the

solid waste management system and these new policies should be officially implemented by the responsible body

4. Presently, public awareness on solid waste issues is very poor. Public awareness needs to be improved. This can be achieved using various means such as integration of environmental education with emphasis on solid waste into school curricula beginning with primary/elementary school. Other factor that could be applied includes news releases, letters to the editor, news articles, newsletter articles, speeches, guest on the radio and local TV programmes, messages in churches and mosque, notices in church and mosque bulletins. These are plausible and financially feasible methods that can be used for increasing public awareness on solid waste management.
5. Presently, landfill appears to be a method that will continue to be employed, hence funding should therefore be improved for provision of landfill liners. Effort should also be made to obtain liners from foreign sources as donations even if they are not the best ones. This should also apply to leachate and gas collection system even if they are older technology. It is better to have older technology than no technology at all (Zavodska, 2003).
6. Interview with the workers of the solid waste disposal agents indicated that protective gears were not provided for them. Protective gears should be made available for the solid waste collection workers and workers at the landfill sites. Heavy boots and heavy-duty hand gloves should be provided to all as the biggest risk that they are exposed to is stepping onto object that could penetrate their legs and also sharp objects could scratch their hands when picking them up.

10. Conclusion

This has been primarily concerned with the assessment of the status of municipal solid waste with particular reference to Nigeria. The municipal solid waste load assessment in terms of types and quantity generated was carried out in Lagos and Benin metropolises in Nigeria. This is what is termed as characterization of municipal solid waste. This is the case due to the fact that knowing the expected waste load is the first step in any solid waste management design project. The study showed that 0.425kg of solid waste is generated per person per day (ppd) in Benin metropolis and 0.57kg per person per day is generated in Lagos metropolis. The study also showed that over 20% of recyclable solid waste is generated in from domestic source of solid waste in Nigeria. Assessment of the Solid waste management in Lagos and Benin metropolis revealed a serious deviation from the conventional solid waste chain. The landfill situation is in bad state as they were not prepared for sanitary landfill.Considering the results obtained from the study there is need for urgent attention to be paid to the issues of solid waste in Nigeria as it poses serious environmental threat.

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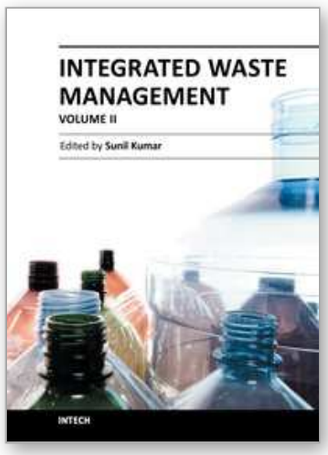

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This book reports mostly on institutional arrangements under policy and legal issues, composting and vermicomposting of solid waste under processing aspects, electrical and electronic waste under industrial waste category, application of GIS and LCA in waste management, and there are also several research papers relating to GHG emission from dumpsites.

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