

**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
ADDIS ABABA INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CHEMICAL ENGINEERING**

**STUDY OF DOMESTIC SOLID WASTE MANAGEMENT
IN JIMMA TOWN, SOUTHWEST ETHIOPIA**

A thesis Submitted to the school of Graduate studies of Addis Ababa University, in partial fulfillment of the requirements for the Masters of Science in Chemical Engineering.

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Acronyms

AAiT	Addis Ababa Institute of Technology
AAWSSA	Addis Ababa Water Supply and Sewerage Authority
CL	Confidence Level
CSA	Central Statistical Agency
CV	Calorific Value
GHG	Green House Gas
GS	Geological Survey
ISWM	Integrated Solid Waste Management
JU	Jimma University
MSE	Micro and Small Enterprises
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
SW	Solid Waste
UN	United Nation
UNEP	United Nation Environmental Program
VCM	Volatile Compostable Materials
WHO	World Health Organization

Abstract

Improper solid waste management has become a major environmental problem in Jimma town. The town has been experiencing very poor solid waste management system. In-adequate solid waste management in the town has resulted in the accumulation of waste on open lands, in drains and in the residential areas, causing a nuisance and foul-smelling pools, environmental pollution through leachate from piles (water and soil pollution) and burning of waste (air pollution), clogging of drains. This study was, thus, conducted to fill the existing gap.

The study was conducted on randomly selected 120 households that are estimated to represent all classes of income levels; low, middle and high. Daily waste generations from those households were collected and separated into its components; weight and volume of each component were recorded. This has been conducted for nine consecutive days to determine the average daily household waste generation rate and per capital daily generation rate.

The study showed that solid waste generation rate has direct relationship with level of family's income. The findings of this study showed that low, middle and high-income level households generate 0.563kg/HH/day, 0.661kg/HH/day and 0.801kg/HH/day, respectively; and on average, a household generates 0.675kg/HH/day. Similarly, generation per capital per day from low, middle and high-income level was 0.129kg/cap/day, 0.136 kg/cap/day and 0.149kg/cap/day, respectively, and average of 0.140kg/cap/day. The daily, weekly, monthly and yearly solid waste generation rate of Jimma town was estimated to be 22.26, 155.82, 667.8 and 8,124.90 tons respectively. Results of experimental analysis of waste compositions showed high contents of food waste (36.03%) followed by miscellaneous waste (35.67%) and yard waste (17.87%).

The survey analysis also showed that illegal solid waste disposal in open spaces is common practice in the study area and some of the main reasons raised by the respondents were the inappropriate placement and insufficient number of transfer stations and communal containers.

The result of the proximate analysis showed high moisture content and this directly related to the trend of high consumption of fresh vegetables and fruits. And this ultimately lowers the calorific value of the material 3213.36 Btu/lb (7497.84kJ/kg).

CHAPTER ONE

1. Introduction

1.1 Background

The management of solid waste is one of the challenges facing any urban area in the world. An aggregation of human settlements has the potential to produce a large amount of solid waste; the collection, transfer and disposal of that waste has been generally assumed by municipal governments in the developed world. The format varies, however in most urban areas, Garbage is collected either by a government agency or private contractor, and this constitutes a basic and expected government function in the developed world.

Municipal solid waste (MSW) management has become a major issue of concern for many under-developed nations; especially as populations increase. The problem is compounded as many nations continue to urbanize rapidly; 30-50% of populations in many developing countries is urban (Thomas-Hope 1998) and in many African countries the growth rate of urban areas exceeds 4% (Senkoro, 2003).

Urbanization is not necessarily a new phenomenon on the continent of Africa, as shown by urban centers like Addis Ababa and Cairo (Onibokun and Kumuyi, 2003). What is noteworthy about contemporary urbanization in Africa is its fast pace. Although Africa is presently among the least-urbanized regions of the world, it is recording the highest rates of urbanization. For example, Africa and Asia recorded urban growth of 4.9% and 4.2%, respectively, between 1990 and 1992. However, urban growth in Europe and North America in this period was only 0.7% and 1.0%, respectively (United Nations, 1995).

Although developing nations do spend between 20 and 40% of municipal revenues on waste management (Schübeler, 1996; Thomas-Hope, 1998; Bartone, 2000), this is often unable to keep pace with the scope of the problem. In fact, when the governments of African countries were asked by the World Health Organization to prioritize their environmental health concerns, the results revealed that while solid waste was identified as the second most important problem (after water quality), less than 30% of urban populations have access to “proper and regular garbage removal” (Senkoro, 2003).

Solid waste is, therefore, broadly defined as including non-hazardous industrial, commercial and domestic refuse including household organic trash, street sweepings, hospital and institutional garbage, and construction wastes; generally sludge and human waste are regarded as a liquid waste problem outside the scope of MSW. Schübeler (1996) points out that although certain contaminated medical wastes and hazardous industrial wastes are not included by definition, in many nations these are in fact part of the municipal waste stream and “special measures” must be employed to encourage their separation and mitigate their potential harmful effects. Also, the threat of toxic waste being present in industrial garbage often leads to it being treated separately, although this is not always the case. (Akankeng, 2003)

The overall problem of MSW is obviously multi-faceted; many organizations, including the United Nations (UN) and various non-governmental organizations (NGOs) advocate an integrated approach to MSW management by identifying key stakeholders, identifying specific issues which comprise important “stumbling blocks”, and making recommendations based on appropriate technologies, local information, and pressing human and environmental health concerns (UNEP 1996, Thomas-Hope 1998, Senkoro 2003). Within each sector there are various sub-sectors which can and are being dealt with separately by many nations and municipalities, for example the treatment and disposal of potentially dangerous medical wastes by urban health centers.

Like developing countries, in Ethiopia the increase of solid waste generation is resulted from rapid urbanization and population booming (Lemma, 2007). According to Dawit and Alebel (2003) the amount of solid waste in Addis Ababa and other fast growing areas in the country has been increasing over time, largely attributed to rapid population growth rate. The same authors indicated that from the total solid waste released by the population in the City, about 50-60 % was collected and the rest was unattended. Recently the municipality has increased its coverage to about 85 % (AACG-SBPA, 2005).

Jimma like many towns in the country has many sanitary problems of which the bigger one is solid waste. It is very common to see piles of waste on the streets; riverbanks, besides individual houses, available open areas, and market areas. In these areas where generators throw wastes illegally, it is observed that flies and rodents breed and also dogs, goats and sheep scatter the wastes. The poor housing condition of the town is characterized by lack of toilet, kitchen and

proper sanitation. Besides above 70% of the existing houses are owned by the government that makes regular maintenance and renovation impossible. This shows that one of the most important problems of Jimma town is solid waste management. (Lem Ethiopia, 2006)

In-adequate solid waste management in the town has resulted in the accumulation of waste on open lands, in drains and in the residential areas, causing a nuisance and foul-smelling pools, environmental pollution through leachate from piles (water and soil pollution) and burning of waste (air pollution), clogging of drains. This situation is believed to result in poor environmental conditions, which in turn present a formidable threat to health. There is thus a need for improved waste management system of the town. Information on the characteristics, the composition, the volume and weight of waste generated and collected in Jimma town is limited. Very limited surveys and studies have been carried out in early 1980s and mid 1990s by the Department of Environmental Health, Jimma University and in 2008 by Melaku Tegegn.

In the case of characterization, no research has been taken place on the Jimma solid waste, so that such study of domestic solid waste management is required and taken place for further study and well organized management options. Demographic dynamics, socio-economic changes and consumption patterns are the main factors that affect the municipal solid waste generation in general and domestic solid waste in particular, and composition, which in turn affects the waste management system. Therefore, conducting studies on generation rate, characteristics and composition of solid waste at the present demographic and socio-economic conditions is very critical.

1.2 Statement of the Problem

Jimma, as one of rapid urbanizing town, is far from satisfying the infrastructure demand of its inhabitants. Its solid waste management is poor. The section responsible for the waste management of the town is poorly equipped materially, financially, and in terms of human resources to provide the expected service appropriately. One of the major issues that the development strategy should incorporate is the issue of urban environment, which mainly deals with the municipal solid waste characterization.

The total population of Jimma town is estimated to be 159,009 of 79,190 are male and 79,819 are female (CSA, Jimma, 2007) and the city is experiencing rapid urbanization rate. Waste treatment, reduction from its source, recycling of wastes or energy recovery from the wastes are not well exercised. The main activities being done are collection and dumping of wastes at dumping site called *Kofe* which is far 8km from the Jimma town. Rapid urbanization and public service means rapid growth of the wastes, which in turn affects human health and environmental conditions. Moreover, the waste generated in the city simply disposed on the road, play station and waterway area unknowingly or carelessly without characterizing the waste and sorting into hazardous and non-hazardous, recyclable and non-recyclable.

1.3. Objective

The main objective of this thesis is to study domestic solid waste management system and suggest appropriate conversion technology.

The specific objectives of this thesis are to:

- Determine generation rate of solid waste per capital per day
- Characterize the solid waste generated
- Appropriate solid waste management strategies

1.4 Scope of the study

Municipal solid waste management includes all waste streams from various sources such as households, commercials, institutional, non hazardous industrial wastes and street sweeping wastes. It also comprises of all activities including waste generation rate, characterization and composition identification, to waste collection, storage, transfer, waste processing, transportation, and disposal.

Therefore, this study is planned to carry out a study on domestic solid waste quantity, composition and characteristics and finally to recommend the suitable transfer technology of the waste depending on the characteristics results in Jimma town. It is expected that this study will have vital importance in providing significant data which is fundamental to design appropriate solid waste management system or as a step to conduct more systematic study in the town of Jimma with the objectives sated above.

1.5 Significance of the study

- It will be a base line for the further study of solid waste management.
- Characterization of solid waste will pave the way for those interested to compost, recycle or land fill or reprocess the waste generated in the town.
- It will be cooperative to decide appropriate Technology for the Waste conversion.
- It gives values for the control of municipal solid waste management.
- It can be useful whenever there is a need to construct landfill for Jimma town as basic engineering data for the design purpose.
- It enables one to know about the properties and types of waste in the town

CHAPTER TWO

2. Literature Review

2.1 General condition of solid waste

Humans and animals have used the resources of the earth to support life and to dispose of waste. In early times, the disposal of human and other waste did not pose a significant problem, for the population was small and the amount of land available for the assimilation of waste was large. Problems with the disposal of waste can be traced from the time when humans first began to gather together in tribes, villages, and communities and the accumulation of waste become a consequence of life (Tchobanoglous et al, 1993).

2.2 Waste management

Waste management is the collection, transport, processing, recycling or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management is also carried out to recover resources from it. Waste management can involve solid, liquid gaseous or radioactive substances, with different methods and field's expertise for each.

Waste management practices differ for developed and developing nations, for urban and rural areas, and residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generators.

2.3 Source, Composition and Generation of solid waste

Knowledge of the source and types of solid waste, along with data on the composition and rate of generation, is basic to the design and operation of the functional elements associated with the management of solid waste. Sources of solid waste categorized into: residential, commercial, institutional, construction and demolition, municipal services, treatment plant sites, industrial and agricultural.

The municipal solid waste (MSW) is normally assumed to include all community waste with the exception of industrial process and agricultural wastes.

In this regard, in Jimma small scale manufacturing activities are found and produce significant amounts of wastes. Solid waste sources are mainly municipal services in the Jimma town. In the town, the length of asphalted road is very small where street cleaning is under taken by the local community occasionally. From observations, cleaning of the drainage lines is not frequently conducted, and the lines are almost filled with solid wastes most of the time .

2.4 Composition of solid waste

Composition is the term used to describe the individual components that make up a solid waste stream and their relative distribution, usually based on percent by weight (Gerald, 1997). Information on the composition of solid waste is important in evaluating equipment needs, systems, and management programs and plans (Gerald, 1997). Addis Ababa sanitation, beautification and park development agency (AASBPDA), 2004 stated that, the source of solid waste in Addis is assumed 76% from household, 18% from institution and 6% from street sweeping.

According to information found from the municipality of Jimma town, 54%, 30% and 16% of the waste generated from the town is biodegradable, disposable and recyclable respectively. According to Melaku (2008), the food wastes constitute 32.1% of the total household wastes by weight.

2.5 Generation Rate

Human beings can generate a waste in his everyday's activities. This rate of generation will increase from time to time depending on the individual's income and living style. As the living style of individuals change the rate of waste generated per day also changes. Regarding the solid waste generation rate of our capital city Addis Ababa, as mentioned by Fitsum (2008), there is no up-to-date and reliable data. There are few studies undertaken since 1982 by different bodies. Nur consult carried out the first main study in 1982. The result suggested that per capital generation of solid waste was 0.15kg/day/person with a 1% annual growth rate and approximate waste density of 370 kg/m³ (Zerayakob, 2002). Louise Burger international in 1986 carried out

the second study and the result was a rate of 0.20kg/day/person. Louise Burger international also carried out the third available study in 1994 and 1995. According to the 1994 study, the average per capital generation of solid waste was 0.22kg/day/person and the density about 336 kg / m³. The 1994 and 1995 study shows the generation dependency on income levels. Based on the data collected in 1994, generation/capital/day was 0.35kg, 0.28kg, and 0.17kg, for high, medium, low-income groups respectively. The data of 1995 collected shows 0.47kg, 0.236kg, and 0.26kg for high, medium and low respectively (Zerayakob, 2002).

The last available data studied at sub-city level by Yitayal (2005) in his quantity and compositional analysis, he randomly selected 197 households from the Arada sub-city and come up with a result of 116.9, 153 and 162.5 gm/cap/day for low income, middle income, and high income groups with average density of 159.8 Kg/m³.

Developing countries have solid waste management problems different than those found in fully industrialized countries; indeed, the very composition of their waste is different than that of 'developed' nations. Although low-income countries' solid waste generation rates average only 0.4 to 0.6 kg/person/day, as opposed to 0.7 to 1.8 kg/person/day in fully industrialized countries, (Cointreau, 1982) and (Arlosoroff 1982, Blight and Mbande 1996) noted several common differences in the composition of solid waste in developing nations:

- Waste density 2-3 times greater than industrialized nations,
- Moisture content 2-3 times greater,
- Large amount of organic waste (vegetable matter, etc.),
- Large quantities of dust, dirt (street sweepings, etc)
- Smaller particle size on average than in industrialized nations.

These differences from industrialized nations must be recognized both in terms of the additional problems they present as well as the potential opportunities which arise from their waste composition.

Before examining individual problems in MSW management, it is important to understand the political and economic framework in which governments must frequently work in developing

countries. As mentioned above, current figures indicate that some municipal governments spend up to 50% of their revenues on waste-related issues. With increased urbanization, demand for services will undoubtedly increase. Municipal tax and fee revenues, however, are not likely to rise as quickly as the population. This is due to the fact that of the people moving to the city, the majorities are likely to be poor migrants from rural areas in search of employment, unable to contribute significantly to the revenues of the municipality. Although they may demand marginally less services due to their lower level of consumption, they are likely (at least at first) to congregate in the poorer, more densely settled areas, exacerbating the health and sanitation problems posed by these often unplanned communities.

Meeting the financial demands of MSW management will continue to be a problem in the cities of developing countries. In areas where residents are assessed fees for waste removal, the rate of collection can be quite poor (Schübeler 1996). Further, fewer and fewer people will be willing to pay in the face of poor or declining service. Many municipalities may not even be aware of the degree to which revenues are collected, or the true costs of their entire MSW operations. The problems are compounded when revenues from MSW collection are simply rolled into the general treasury, as opposed to returning to waste-related operations. Many municipalities have turned to privatization as a potential solution; certainly the financial picture is cleared somewhat when the entire system is turned over to outside contractors. However, local governments will still be held to account if service declines.

2.6 Solid waste characterization

According to Gerald, 1997 four methods for estimating waste quantities and composition are identified: direct sampling (also referred to as waste stream analysis and waste audits), material flow, surveying waste generators, and literature sources.

Direct sampling: Direct sampling involves sampling, sorting, and weighing materials from the waste stream of a specific generator. This method has been used to estimate the composition of municipal waste streams. Representative sampling methods must be employed to achieve accurate results. When using the direct sampling method, the following questions must be addressed: How will representative samples of waste be obtained; and how many samples should

be selected to achieve the desired level of accuracy in the results? The responses to these questions will influence the cost of conducting the study as well as the usefulness of the data.

Waste stream analysis: Waste stream analysis is another term used for characterizing the waste stream of a specific operation for a designated time period. Waste stream analysis is defined as a method for collecting, sorting, and measuring the amount and type of waste generated by an operation. Results of a waste stream analysis provide data about the amount and type of waste/residues in the waste stream. Data should be collected for a minimum of one week; the length of time depends on how the data are to be used and the accuracy required. The results are averaged to estimate the amount of waste that the facility generates for a period of time.

Waste audit: The basic objectives of a waste audit are similar to a waste stream analysis. A waste audit involves a more detailed assessment of waste. The waste audit assesses not only the output (waste), but also the input, such as food products, packaging materials, office supplies, mail, or any process that results in materials that must be discarded. The detailed and complicated analysis of material flow through an institution will enable the facility to find the amount purchased, used, recycled, and disposed of for different materials. A waste audit can involve all materials or focus on a specific material, such as cardboard or office paper that is generated by a facility or department.

Material flow: The material flow method applies the concept of conservation of mass to track quantities of materials as they move through a defined system or region. The material flow methodology in this instance is based on the production weight data for materials and products. Generation data are the result of making specific adjustments for imports, exports, and diversions to the production data by each material and product category. The method also considers the useful life of products. One of the problems with the material flow approach is that it is difficult to quantify product residues, such as food left in the container and detergent remaining in the package.

Surveying waste: Surveying industrial generators, such as food processors can provide useful data in quantifying waste generation. More accurate data can be obtained if the waste/residues are measured at the disposal site.

Literature sources: Data on waste/residues quantities and composition are available from a variety of sources including public agency documents, engineering reports, trade publications, and professional journals. These data may be helpful in assisting managers in identifying the type of residues/waste generated by a specific industry or activity. However, caution should be exercised when operational decisions are made based on data from the secondary sources. Waste characterization and generation rate studies are recommended for operational uses rather than relying on published data since each study site is unique.

2.7 Solid waste components

2.7.1 Collection and transport

Transport of waste from households, factories, and other generation sites is a growing problem. The rapid urbanization of much of the developing world leaves little time for adequate layout and planning; many of the most rapidly growing parts of cities are at the periphery of existing settlement. Garbage dumps, with their associated disease, odor and frequent fires (in some cases) would ideally be located on suitable land away from the most densely populated areas. These areas are becoming harder to find as population urbanize and municipal traffic increases; the transport of waste becomes longer and more time-consuming, and therefore more expensive and less efficient. Many cities employ neighborhood-level collection points, where households are responsible for transport to the transfer point and the municipal or private enterprise transports the waste from there to the ultimate disposal location. Transport also relies on operational vehicles, and frequent breakdowns coupled with parts shortages can immobilize collection vehicles for extended periods of time. UNEP (1996) estimates that in cities in West Africa, up to 70% of collection/transfer vehicles may be out of action at any one time.

In areas where there exist collection services which remove waste from individual households or streets, often there are no standardized containers used to store waste prior to pickup. Headley (1998) states that in Barbados, there are no containers designated by municipalities or collection companies to “set out” waste for collection; it is up to individual residences to designate some sort of collection container. Frequently, these are plastic barrels or discarded oil drums, however the majority of households simply place grocery bags full of waste on the street to await collection. There may be physical dangers to waste workers in dealing with the former; weather,

animals, and other disturbances prior to collection threaten the integrity of the latter. In an examination of current problems in Kenya, Mungai (1998) agreed that the first step in “sanitary and efficient” waste management must be to ensure that all households use some form of corrosion-resistant container with lids in order to facilitate collection. Lidded containers would exclude most animal pests, reduce the amount of rainfall soaking into garbage and help to reduce trash blowing about on the street.

A major problem is that of development at or on top of landfills; many shantytowns are built from disposed-of waste and in some cases entire neighborhoods are sited on top of existing landfills. For example, the Smoky Mountain dump in Manila, Philippines had as many as 10,000 families living in shacks on or adjacent to the dump site (UNEP 1996). Aside from the obvious health implications, these concentrations of people further complicate transport and unloading procedures and present numerous safety and logistical concerns (Blight and Mbande 1996). UNEP estimates that approximately 100,000 people currently scavenge wastes at dump sites in the Latin American region alone. Further, many people, not only those residing near landfills, make their living from scavenging on solid waste before it enters the municipal waste stream. Street-level waste picking often removes recyclables and other ‘high-value’ waste items from items set out for collection; although these practices serve to reduce the overall quantity entering the waste stream, these practices often scatter waste about, compounding problems for pickup and transfer operators (Pfammatter and Schertenleib 1996). Although it takes only 510 seconds to empty a 45-gallon container of waste into a collection truck, but 1-2 minutes to shovel the equivalent amount of waste (Gage 1998). Any potential change to the waste disposal framework must take into account the urban poor, many of whom may be dependent on waste scavenging for their entire subsistence. In one study at the Bisasar Road landfill in Durban, South Africa, scavenging on waste supported 200 families, “earning” the equivalent of \$15,500 per month, or \$77 per family per month (Johannessen 1999).

A higher solid waste density also has many implications for the ‘traditional’ methods of collection and disposal; collection and transfer trucks which are able to achieve compression rates of up to 4:1 in industrialized nations may achieve only 1.5:1 in developing countries, and landfill compression technology which averages volume reduction of up to 6:1 in industrial nations may only achieve 2:1 compaction with these increased waste densities (Cointreau, 1982).

Compactor trucks would therefore probably not be useful in many applications; as income level increases and the amount of postconsumer waste such as packaging increases correspondingly, such technologies may be more appropriate. Additionally, the high moisture content and organic composition of wastes in the developing world may lead to problems of increased decomposition rates in areas with high average daily temperatures; high seasonal or year-round rainfall would only compound these problems, presenting additional challenges with insect populations and conditions conducive to disease. To mitigate these problems, much more frequent collection is needed in hot, humid areas to remove organic wastes before they are able to decompose than would be needed in cooler, drier climates. Although daily collection has proven unreliable or unworkable in many cities (Cointreau, 1982), perhaps a twice-weekly collection of organic material (possibly in conjunction with a municipal composting operation), would be sufficient to reduce decomposition.

CHAPTER THREE

3. Materials and Methods

3.1 Description of the study Area-Jimma

This study was conducted at Jimma town, Southwestern Ethiopia, in February 17, 2012 to February 28, 2012. Jimma, which has been founded in the late 1830s, is one of the biggest and dominant political, economical, cultural and historical towns in the southwestern part of the country. Jimma is locally known as the town of Abba Juffar. It is located 354kms far from Addis Ababa on the high way of Mettu - Gambella at an altitude of 1620 m.a.s.l. Geographically, the town is located at 7° 40'N latitude and 36° 60'E longitudes. According to the master plan of the town, the total area of land of the town is 4623 (46.23km²) hectares.

Topographically, the Jimma area is divided in to escarpment and alluvial plains. Elevation with in the town boundary ranges from the lowest 1620 m.a.s.l. of the airfield – Kitto to the highest 2010 m.a.s.l. of Jiren. The mean annual rain fall in the town is 1332.1 mm. The temperature of the town is high at March (30.4°C) where the average at this season is 27.5°C and low at January (8.5°C) where the average is 12.5°C. With mean daily temperature of 19.5°C.(CSA, 2007)

The information on zoning of the town indicates that 25.7% of the total area is covered by residential buildings, 2.65% by commercial activities, 10.6% by social and public services, 2.6% by administrative zone, 15.4% is land reserved for constructions of roads and the proportion of the land left for other infrastructures is about 39.1%.

The population of Jimma town was estimated to be 159,009 (CSA, 2007) with annual population growth rate of 4.9%. The town had 21 kebeles, but recently after restructuring some kebeles were merged and by now the town has 13 administrative kebeles. River Awettu is crossing at the center of the town. Jimma town has more than 27,000 legal registered houses. The total length of its road infrastructure reaches about 379kms, out of which 29km is Asphalt, 56kms gravel and 294km dry weather road. Street cleaning is done only on 16.8kms asphalt road with 20 people.

The main economic activities in the town are commerce (trading & catering services) and small scale manufacturing enterprises. The industries in the town are small- scale and cottage industries like grain mills, oil mills, wood & metal workshops, coffee hullers, hollow block manufacturing, bakeries and pastries, and multipurpose shops. The dominant manufacturing activities that account 70% of the total number of manufacturing enterprise in the town are grain mills and wood works. (Melaku, 2008)

Now the town is being administered by mayor and has a status of zone administration and accountable directly to the Oromia National Regional State. The kebele which was considered in this study is Ginjo Guduru kebeles which is expected to represent all kebeles. Because it is found at the periphery, middle and the center of the town

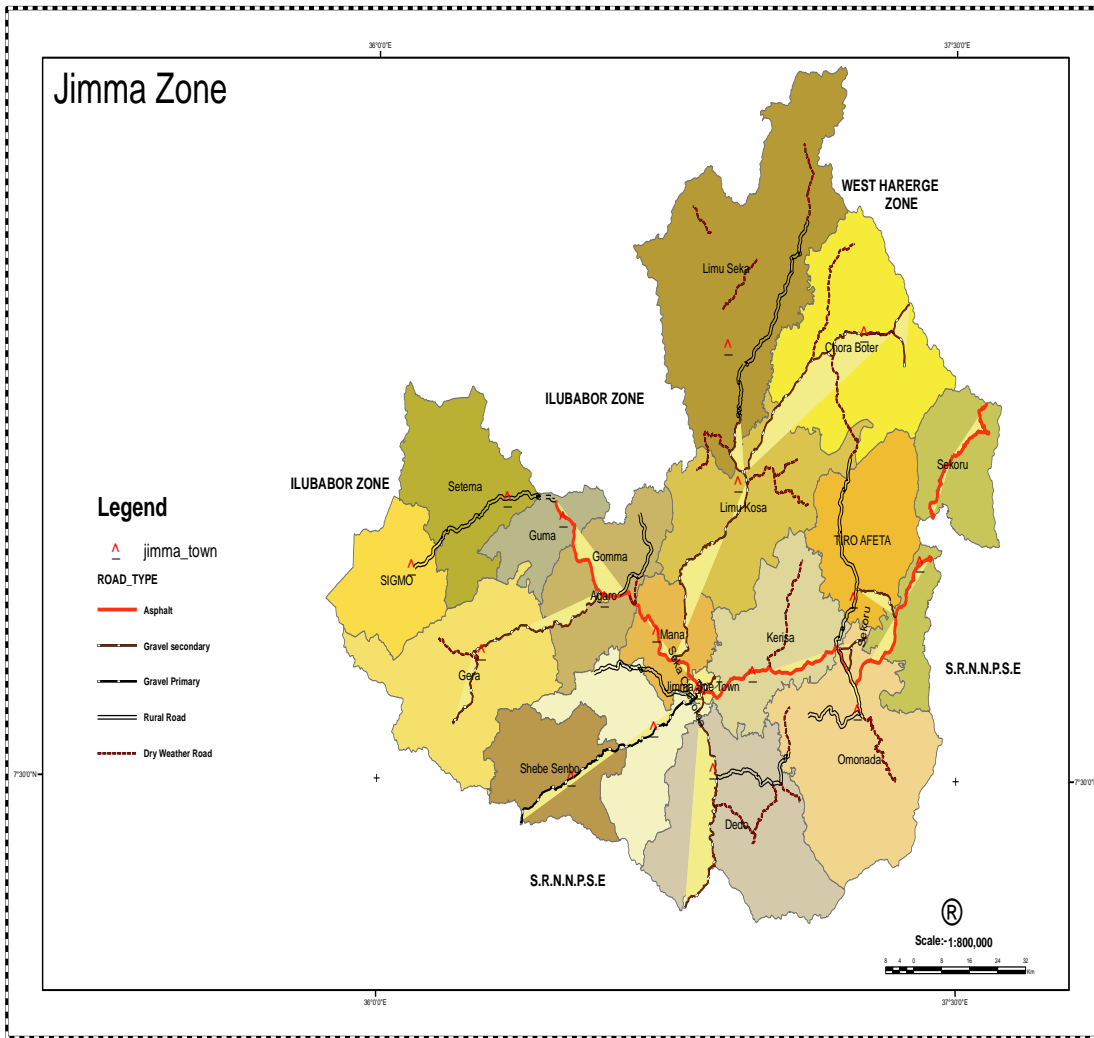


Figure 3-1 Map of the Jimma Zone

3.2 Methods

This study was conducted following the review of relevant literatures, interviews and questioners were prepared and used for data collection, training of groups of data collectors, measurement of collected samples, household daily solid waste generation and waste classification by type, processing of the survey data, analysis of the data and evaluation of findings, assessment of sustainable management options.

3.2.1 Questioner Preparation

The simple and relevant questioners were prepared and organized in simple language for the local communities. The questioners were prepared in English language, as attached in Appendix I, and then translated to Amharic and Afan Oromo for the understandings for the respondents. Then, the selected households filled the questioners before sample collection was started.

3.2.2 Determination of sample size

The number of samples depends primarily on the cost versus its utility. For higher statistical accuracy and confidence level, the number of samples would be more. There are statistical procedures to calculate the number of samples at each confidence level. Usually for solid waste data, the confidence level (C.L) is set at 80% or 90% (UNEP, 2009). To determine the number of households that are going to be analyzed to obtain a reasonable and reliable result a method that was designed based on central limit theorem was used with a 95% confidence interval and a 1% error as a desired reliability. For sample size determination it is possible to use standard deviation of similar study such that a standard deviation of 0.056, which was determined in the Arada sub-city (Yitayal, 2005)

According to the central limit theorem the size of sample determined using the following equation.

$$n = \frac{z^2 \chi \delta^2}{\epsilon^2} \dots\dots\dots 3.1$$

Where Z= value that corresponds to 95% confidence interval and equal to 1.96.

δ = Standard deviation

ϵ = Standard error

Therefore, according to the above formula the number of household that considered in this study was estimated to be: $n = (1.96^2 \times 0.056^2) / (0.01^2) = 120$

3.2.3 Household Identification

In this study 120 households were considered for the collection of samples. These 120 households were selected randomly from the Ginjo guduru kebele which is one of 13 kebeles of the study area in Jimma. This kebele was selected because of its proper place for the study. It is located in the center of the town and also number of activities is taking place here in Ginjo guduru. It is also one of business running area than the others and so that all levels of the residences i.e. high, medium and low incomes individuals are living here.

3.2.4 Data Collection

Before collecting the samples, the plastic bags distributed for each selected households one day before. And the identification number was assigned to each household and corresponding level is given for each and every bag distributed for each household. During distributing the plastic bags all households were informed how and when the sample collectors come back. On the next day early in the morning the collection of samples began. Sample collectors collected all the distributed bags, with solid waste kept in, early morning and brought to the specific place prepared for sorting purpose using hand push cart and horse cart. For the quality of the data the first day waste collected from each household was discarded taking into account that these wastes may not be generated on a daily basis. Right after the second day up to the tenth day (9 days) sample was collected on a daily basis.

Immediately after the waste collection, sorting of waste into different components was made for each household after measuring the total weight and volume of each household wastes. The sorted components then weighted and their volume was determined using different sized wood boxes with a known volume. Finally, the size distribution of the waste was determined using a 25mm and 20mm sized mesh wires and then the weight and volume measurements were done for both sizes.

3.2.5 Proximate Analysis

Proximate analysis is the analysis of wastes to determine moisture content, ash content and fixed carbon.

Moisture content

Moisture content is a very important factor that influences the decisions for converting organic waste into compost and biogas, using solid waste as a fuel, and designing landfills or incineration plants. Currently there are various types of moisture meters available to check the moisture content. However, the traditional test could also be done on certain types of materials. For the specific study, the moisture content was measured by heating the sample at 105°C in an oven until the loss of weight stabilizes. The weight of the sample before and after gives the moisture content. The different fractions of the waste stream shall have their moisture content measured separately. In order to reduce the magnitude of error arising from the moisture change and from decomposition the analysis of the sample was started within two to three hours after collection. Care was also always taken to make the samples well mixed for this purpose each waste component were randomly taken and then chopped to reduce the size and then the well mixed sample finally was taken for laboratory analysis.

Regarding the determination of moisture content a sample from each component of the waste was daily taken to the civil engineering lab, Jimma Institute of Technology, just after the collection and analyzed using oven dry set at 105°C for 24 hours.

The ash content of each component of waste was also determined using the same sample and equipment that was kept at 750°C for three hours by using open crucibles (Techobanaglou et al., 1993). Subtracting moisture content, ash and volatile matter from the initial sample determined fixed carbon.

3.2.6 Ultimate Analysis

Ultimate analysis (elemental analysis) is the analysis of waste to determine percent of C, H, O, N, S and ash. The elemental(C, N and S) analysis of waste components was done at the JIJE Analytical Testing Service Laboratory, Addis Ababa. The analysis involves the determination of sulfur, nitrogen and carbon. The determination of total nitrogen was carried out using the

standard Kjeldhal method where loss on ignition is used for Carbon determination. Regarding the determination of carbon due to the unavailability of analytical equipment and appropriate skill on the part of the analyst in developing countries UNEP, recommends a ‘stop gap’ approach suitable for composting in SWM is an estimation based on a formula developed in 1950s (Adams et al., 1951). The assumption is that for most biological materials the carbon content is between 45 to 60 percent of the volatile solids fraction. Assuming 55 percent is carbon. For the specific case both loss on ignition and stop gap methods were used and the result obtained was approaching each other. The formula for is as follows:

$$\% \text{ Carbon} = (100 - \% \text{Ash})/1.8 \dots\dots\dots 3.2$$

3.2.6.1 Calorific Value

The calorific Value of the sample collected was determined at the Geological survey (GS), Hydrocarbon Laboratory analysis lab using adiabatic bomb calorimeter.

Bomb Calorimeter, in this experiment, was used to determine the heat of combustion/calorific value of a sample. A bomb calorimeter is a sealed container capable of holding several atmospheres of gas pressure. A weighed sample of substance is placed in contact with an ignition wire inside the bomb. The bomb is filled to about 30 atm of pressure with O₂, sealed, and placed in a known amount of water. An electric current is passed through a wire to ignite the mixture. As the combustion takes place, the heat evolved raises the temperature of the calorimeter and its surrounding water, as measured by a thermometer. In order to prevent heat loss from the calorimeter system, some calorimeters are surrounded by a second water bath, whose temperature is continuously adjusted (by the experimenter) to match that of the calorimeter.

3.2.7 Data analysis

For the analysis of the sampled solid waste and survey questionnaire the statistical package for social studies (SPSS.20) and Microsoft excels 2007 were used. In the data analysis the compositions of waste was analyzed and per capital generation rate and per household generation rate were determined.

3.2.8 Ethical Consideration

Official letter was written to Jimma Municipality, Ginjo Gudiru Kebele and concerned bodies to communicate about the research and for required data.

3.2.9 Dissemination and utilization plan of the result

The study findings will be disseminated to scientific community of Addis Ababa University Technology Institute and policy makers. The findings will also communicated to relevant and responsible stockholders including Jimma Municipality.

3.3 Materials and Instruments

During the study time the following listed materials and equipments were used

1. Hand protective plastic gloves;
 - To protect hand from direct contact with dirt.
2. Mouth & Nose Mask;
 - To protect one from bad smells and inhalation of any fumes.
3. Wood boxes (with different types of volumes)
 - For volume measurement
4. Balance scale
 - For weight measurement of collected sample waste
5. A 25 mm and 20 mm wire mesh
 - For particle size determination
6. Plastic sheets
 - To ensure no loss of waste during sorting
7. Different type and color plastic bags
 - For the collection of solid waste from each household
8. Trash bags
 - For handling the collection of plastic bags
9. Audio and Video Cameras
 - For recording capturing pictures of the working process
10. Bomb calorimeter

- For the determination of heating value

11. Digital and non-digital oven

- For proximate analysis (including moisture content, VCM and ash content)

12. Open and closed crucibles

- Used during the determination of ash and VCM(volatile compostable materials)

CHAPTER FOUR

4. Results and Discussions

4.1 Results from the survey

During the study time selected households were conducted for different purpose. From the survey the researcher found out that the communities are living in owned, rented and kebele's house. Table 4.1 shows that the housing ownership of the study area.

Table4-1 House ownership of study area of sample houses

	Frequency	Percent	Valid Percent	Cumulative Percent
Private	66	55.0	55.0	55.0
Rental	28	23.3	23.3	78.3
kebele	26	21.7	21.7	100.0
Total	120	100.0	100.0	

Table 4.1 shows that out of the conducted households 55% , 23.3% and 21.7% are living in private, rental and Kebele's house respectively.

Table 4-2 Income per Month of the respondent

Income level per month	Frequency	Percent	Valid Percent	Cumulative Percent
<500 birr(Low Income)	28	23.3	23.3	23.3
501 - 1000 birr(Medium Income)	26	21.7	21.7	45.0
>1000 birr(High Income)	66	55.0	55.0	100.0
Total	120	100.0	100.0	

According to the data surveyed from the respondents and Table 4.2, three different income levels are found as 66(55%) individuals are in high income level where 26(21.7%) are in medium income following to 28(23.3%) of which are in low income level. These data are from the questioner as per need of the researcher as it was assigned for those whose income is less than Birr 500 are low income and those whose income is between Birr 501 and 100 are medium

income where those whose income is greater than Birr 1000 are high income level. In this study, the researcher concludes that, most of the randomly selected respondents' income is more than Birr 1000. This is due to the additional income they can get from different fruit products and coffee plantation at their compounds. The income level of the household has the correlation with waste generated at the household level which is discussed in Table 4.6.

As per data collected from the respondents, the average level of education of the most respondents of the household varied between 5th grade and college degree. Out of the 120 households surveyed most of the respondents are above grade 12 and some of them are in between of grade 1 to 8. Academic rank of the respondents has negative correlation to the solid waste they generate. Most of the solid waste generated from the study area was from those who are in higher academic level and living in good life standards.

Table 4-3 Energy Availability at household level

Items	Frequency	Percent	Valid Percent	Cumulative Percent
Firewood and cow dung	8	6.7	6.7	6.7
Firewood, cow dung and charcoal	42	35.0	35.0	41.7
Firewood, charcoal, kerosene, electricity	70	58.3	58.3	100.0
Total	120	100.0	100.0	

The researcher found out that, out of the conducted households 58.3% of the total respondents use firewood, charcoal and electricity as an energy source for cooking and making their day to day food. Only 8 (6.7%) households out of 120 respondents use firewood and cow dung as an energy source where 35% of the total respondents use firewood, cow dung and charcoal. In general these figures made the researcher conclude that the as dust/fine particles and ash waste from the household is high.

4.2 Solid waste handling in the study area

Most of the solid waste at the study area is not collected properly because of lack of proper management. Most of the respondents are facing the problem of waste collection and storage before disposal. For the integrated solid waste management, the six stages of the solid management should be addressed. These are collection, storage, transfer, processing waste, transportation and disposal. According to the data from the municipality of the town, the administration allocates only 1% of the total budget for solid waste management which is not highly recommended by the researcher. The following table shows how the respondents collect and keep the solid waste before disposal in temporarily storage tank at their home.

Table 4-4 Temporary storage available at household level

Availability of storage	Frequency	Percent	Valid Percent	Cumulative Percent
Available	102	85.0	85.0	85.0
Not available	18	15.0	15.0	100.0
Total	120	100.0	100.0	

Table 4.4 shows that from the total respondents, 102 households have temporary storage tank where 18 have no temporary storage. Of these storage tanks, plastic bag, plastic dust bin and wood container are used.

Storing the waste at household level before transferring to the transfer station is one of the management options. The above Table 4.4 indicates that 15% of the total respondents have no temporary storage at the household level. This implies that their first choice to through the waste is either on the street or in the nearby open spaces.

From the collected solid wastes, tins, scrap metals and glasses are sorted and sold to the private collectors commonly known as *Kura-lie* for the purpose of recycling and reusing final products before throwing it as a wastes. This contributed that, the actual volume of waste to be disposed of outside the house would be decreased and this reflected in the compositional analysis. The waste consists primarily of organic matter from the kitchen which necessitates frequent disposal because of spoilage but most of the households getting the collection service only once in a week and this revealed in the disposal of some of the waste in the nearby open spaces.

For proper management of solid waste, composting organic matters at household level is highly recommended, but this is not practiced in Jimma as all. From the study findings, only 22.8% of the households compost organic matters at their home. The rest 77.2% are not practiced. The following table shows the practice of composting organic wastes at the households.

Table 4-5 Practice of Composting wastes at household level

	Frequency	Percent	Valid Percent	Cumulative Percent
yes	29	22.8	22.8	22.8
no	91	77.2	77.2	100.0
Total	120	100.0	100.0	

On the other hand incineration of solid waste may be considered as one of the options to reduce the waste generated during disposal, but incineration has its own environmental impact. Most of the households are practicing incineration at the house hold level. From the data gathered about 54.4% of the households incinerate the solid waste.

4.3 Waste generation rate

Waste generation rates are affected by socioeconomic development, degree of industrialization, and climate. Generally, the greater the economic prosperity and the higher percentage of urban population, the greater the amount of solid waste produced.

4.3.1 Per capita generation rate

To calculate overall average per capita generation rate, contributions of households in different income groups (which is discussed in Table 4.2 above) is taken in to account. Because as it was discussed earlier, the mean household generation rate of one income group is different from the other groups.

The total waste generation rate survey of households' of Jimma town is estimated depending on the data collected from the selected households. Results of 120 households were analyzed. The generation rate per day per capita of the conducted area is estimated as total waste collected within nine days divided by total population of the conducted area as shown in table 4.6 below.

Table 4-6 Generation per day per household and per day per capital

Level	Low	Medium	High	Total/average
Total kg	141.9	154.76	475.58	772.24
No. of HH	28	26	66	120
Population	122	126	354	602
kg/HH/day	0.563095	0.661368	0.80064	0.675034
kg/ca/day	0.129235	0.136473	0.149272	0.138326

4.3.2 Total generation rate

Total generation rate per household per day is equal to total weight of sample in nine days divided by the total house hold conducted. This sample size is comparable with that of similar studies conducted at different areas of developing countries. Households are categorized in to three groups depending on their monthly income. It is well known that per capital income level and solid waste generation rates have direct relationship (Wells, 1996). Households that have better life standard use more consumption materials than low-income households do, through which they generate higher wastes.

Therefore, the total generation rate of solid waste which is expressed as the amount of waste (kg) generated by one person on a daily basis will be the total waste collected in nine days divided by total population of the study area in general and it will be 0.140kg/ca/day.

It is known that the total population of the town is about 159,009. Taking this figure into account, the daily, weekly, monthly and yearly solid waste generation rate of Jimma town is estimated to 22.26, 155.82, 667.8 and 8,124.90 tons respectively. There is some variation in figures when it is compared with other studies. For example the annual generation rate of Jimma according to Lem Ethiopia (2005) and Melaku (2008) was 11,897 tons and 9,125 tons respectively. It is highly recommended by the researcher that similar study should be taken place with considerable factors, i.e. season, budget and number of participants.

4.4 Waste characterization

Solid waste streams should be characterized by their sources, by the types of wastes produced, as well as by generation rates and composition. Accurate information in these three areas is

necessary in order to monitor and control existing waste management systems and to make regulatory, financial, and institutional decisions.

Because waste characterization studies are relatively expensive to conduct, the general “rules of thumb” provided in this paper should provide sufficient direction for the purposes of waste management planning.

4.4.1 Waste compositions and moisture contents

The composition of the generated waste which is expressed as the percentage of different components of the generated waste (i.e. green/food waste, plastics, paper, glass, metals and etc), as well as the volume and density of the generate waste are highly required to determine, plan and design waste equipments (sizes of bins, size of rubbish trucks and etc); type of facilities and services (treatment plants, waste landfill sizes, collection and recycling services. The compositions and moisture contents of the waste from the study area are described in the Table 4.7 below.

Table 4-7 Compositional and moisture content analysis

Category	Percent composition by weight (%w/w)	Moisture content (%)
Food waste	36.03	68.7
Yard waste	17.87	62
Plastics	3.35	0.95
Paper	7.08	8.5
Others	35.67	48

As per the Table 4.7, the composition of the food waste is took the larger figure (36.03%) when compared with other waste composition where the next figure is other waste compositions which content ashes, dusts and other fine materials. The percent of the moisture content of the food, waste (68.7%) is also higher as shown in the table above. These figures are somehow related with other literatures for the developing countries (UNEP, 1996). The ash and dirt proportion of the domestic waste of the study area is also high and this is on the face of it due to the use of charcoal and wood as a major source of energy as discussed in earlier in Table 4.3 above. This is

directly related to the poor socio-economic condition of the households to utilize other energy sources like electricity as well as due to the poor housing conditions of the households.

The high moisture content and organic composition of waste may lead to problems of increased decomposition rates in the area because of the high average daily temperature. The high rainfall would only compound these problems, presenting additional challenges with proliferation of insect population and conditions conducive to propagation of diseases. To mitigate these problems, much more frequent collection is needed to remove organic waste before they are able to decompose. Although daily collection has proven unreliable or unworkable in many cities perhaps a twice-weekly collection of organic material would be sufficient to reduce decomposition. (Cointreau, 1982)

4.4.2 Size and Density determination

The particle size distribution analysis shows irregularity in the particle size distribution of the solid waste. Size of the solid waste of the study area is categorized in to three parts as particles with a size larger than 25mm, between 25-20mm and less than 20mm are 58.37%, 10.53%, 31%, respectively. This figures indicated that particle in between 20mm and 25mm size less than those of which is greater than 25mm size. Whereas the bulk density of the solid waste of the study area is estimated to 632.5kg/m³.

4.4.3 Proximate analysis result

According to data obtained from the laboratory experiments, results of proximate analysis of selected samples are given in Table 4.8. The results of ash content show the amount of inorganic substance that would remain after burning.

Table 4-8 Proximate Analysis of the collected sample

Category	Moisture content (%)	VCM	Fixed carbon	Ash content
Food waste	68.7	20	3.8	7.8
Yard waste	62	33	10	2.1
Plastics	0.95	75	2.3	3.3
Paper	8.5	59	7.8	6.2
Others	48	-	-	57.75

In the following Table 4.9 typical proximate analysis data for materials found in residential wastes for developing country is presented. As can be seen from the table below, some of the results differ from the results of the studied area. The researcher thinks that, the variation of the result might have occurred due to the characteristic difference of the materials and accuracies of the data in addition to seasonal variation.

Table 4-9 Typical proximate analysis data for materials found in domestic solid wastes

Category	Moisture content (%)	VCM	Fixed carbon	Ash content
Food waste	70	21.4	3.6	5
Yard waste	60	30	9.5	0.5
Plastics	0.2	95.8	2	2
Paper	10.2	75.9	8.4	5.4
Textile	10	66	17.5	6.5

Source: extracted from Techobanaglou et al., 1993

4.4.4 Ultimate/ elemental analysis results

The results of the ultimate analysis are used to characterize the chemical composition of the organic matter in the solid waste. They are also used to define the proper mix of the waste materials to achieve suitable C: N ratio for biological conversion processes commonly known as compost. Data on the ultimate analysis of the individual waste components are presented in

Table 4-10 Ultimate analysis of domestic solid waste

Waste components	Carbon content	Nitrogen content	C:N ratio
Food waste	51	0.68	51:0.68
Yard waste	54	4.2	54.9:4.2
Paper	52	1.1	52:1.1

The value of the ultimate analysis shows that the carbon content of all the waste components have higher percentage and lower nitrogen percentage compared with the typical value of domestic solid waste. The researcher can conclude that, the variation of lab results of the conducted sample and the ultimate value is due to the accuracy of the sample collected. Accordingly, the sample tested is more suitable for the production of the compost depending on

result recorded. The standard carbon to nitrogen ratio of MSW to be composted is 25-50:1. (Awasthi et al. 2010)

Table 4-11 Typical data on the ultimate analysis of domestic solid waste

Waste components	Carbon content	Nitrogen content
Food waste	48	2.6
Yard waste	47.8	3.4
Paper	43.5	0.3

Source: extracted from Techobanaglous et al., 1993

4.4.5 Calorific Value

The heat value/ calorific value of the samples were determined using adiabatic bomb calorimeter at the GS lab, Addis Ababa. According to the lab result, the total calorific value of the sample analyzed was 3213.36 Btu/lb where a typical value of domestic solid waste has a total heating value of 5000 Btu/lb (Techobanaglous et al., 1993). However, the determined total heating value of the sampled domestic solid waste is less than the results of the typical value. The high proportion of food waste associated with its high moisture content might be the cause for its lower calorific value.

4.5 Appropriate solid waste management strategies

Appropriate SWM is the vital role for the development of a country. Solid waste can be managed in different ways depending on the income level of the country and types of the waste generated also. For the specific study, the food waste and miscellaneous waste is leading. So that as per the results found from the lab, the appropriate solid waste management for Jimma town is composting. In addition to that, as the population of the town is not aware of the waste generation, so that appropriate awareness should be given and charging on the waste generated from the household is another option for the reduction of the solid waste from the source. Therefore the Municipality should follow the above recommended strategies for the proper management of the solid waste generated from the house hold.

CHAPTER FIVE

5. Conclusion and recommendation

5.1 Conclusion

From the study conducted, Jimma town has great environment pollution due to uncontrolled and improper solid waste management. The solid waste simply thrown to the uncontrolled open dump can pollute the river around and decrease the beauty of the town as well.

The study showed that the per capital and per household solid waste generation rate of the town is 0.143 kg/cap/day or an average of 0.775 kg/HH/day respectively. For the total population of the study area 22.74 tones of domestic solid waste is generated from the town in a day. This does not include other municipal solid waste streams.

The proximate analysis results showed that the moisture content of the food waste is 68.7% and yard wastes is 62%. This figure helps the researcher to conclude that, as the moisture content increases the energy value of the waste decreases. So incineration of such waste is not recommended. Rather it is highly recommended that the organic wastes are suitable for the compost to organic fertilizer as the finding results of carbon and nitrogen contents are 51% and 0.68% respectively and nearer to ultimate values. The finding of this paper indicated that 22.7% of the households in the study area are practicing composing household solid wastes at their compounds. This practice should be encouraged at the kebele and town level.

The survey analysis and visual observation show that the placement of communal containers is not appropriate and sufficient and this discourages peoples from disposing into the container. They rather preferred to dispose the waste nearby open areas and play stations.

To have a complete picture on generation rate and characteristics of the solid wastes, similar studies should be conducted on the other waste streams and periodic research is needed to update and modify the data and information regarding household solid waste at the kebele and city level and planning solid waste management accordingly.

5.2 Recommendations

- ❖ Solid waste data is largely unreliable. This research contains one of the most comprehensive compilations of municipal solid waste data in Jimma Town; yet, due to inconsistencies in data recording, definitions, collection methods, and seasonal variations, the data can only be considered approximate, albeit more accurate than most. For planning purposes, however, the data presented in this research should be sufficient.
- ❖ Municipalities should charge for waste management before disposal, and possibly collection, transferring, and transportation based on generation rates.
- ❖ Municipal governments are usually the responsible agency for solid waste collection and disposal, but the magnitude of the problem is well beyond the ability of any municipal government. They need help. In addition to other levels of government, businesses (MSE) and the general community need to be more involved in waste management.
- ❖ The waste components requiring priority attention in Jimma are organics (food waste), yard wastes and papers.
- ❖ The municipality should encourage the community to participate on disposal fees based on the volume or weight of refuse generated in each household. If so the amount of refuse will be reduced.
- ❖ Solid waste reduction at the source is the preferable and crucial means to management system. But this will be done by educating and awarding the primary participants who are households.
- ❖ From the research conducted, the contents of carbon and nitrogen in food waste are 53% and 0.68% respectively. These values vary somewhat from the ultimate values which are 48% and 2.6% for carbon and nitrogen respectively. Even though the values vary, the finding shows that the solid waste at the study area is suitable for compost in general and food wastes in particular. So that composting is the primary conversion technology for the domestic solid waste of Jimma town.
- ❖ In the town there are about 54 containers which serving the communities for the purpose of waste transfer. This means one container serving for about 3000 individuals and not adequate to handle/ accommodate the all wastes generated. So increasing number of the containers is highly recommended.
- ❖ The town administration should think about the management options of the solid waste.

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Annex I: Survey Questioners

A. QUESTIONNAIRE ON SOCIO-ECONOMIC DATA

1. Demographic and social status

Head of household _____

Kebele _____

House No. _____

Age _____ Sex _____ Family size in number _____

Family income /Month

- a) <500
- b) 501-1000
- c) >1000 Birr

Educational Status of the household head _____

2. Housing Conditions

House ownership

- a) Private
- b) Rented
- c) Kebele
- d) Other, specify _____

General Cleanliness of the house (By observation of the interviewer)

- a) Dirty
- b) Fairly Clean
- c) Clean

Energy availability is

- a) Firewood and cow dung _____
- b) Firewood, cow dung and charcoal _____
- c) Firewood, charcoal, kerosene, electricity _____
- d) If others specify _____

3. On-site Solid Waste Handling

How often you clean your house?

- Every day _____
- After two days _____
- After three days _____
- Others, Specify _____

Do you have temporary storage container for generated refuse at home?

Yes _____ No _____

If yes, what is the container type?

- Plastic Dust Bin _____
- Plastic Bag _____
- Paper dust bin _____
- Wooden container _____
- Others, specify _____

Is the container covered with proper cover? Yes _____ No _____

4. Solid Waste Disposal practices

Do you reuse household wastes? Yes _____ No _____

If Yes,

Type of reused wastes _____

Purpose of Reused wastes _____

Do you compost wastes? Yes _____ No _____

If yes, what type of wastes? _____

Do you burn (incinerate) household wastes? Yes _____ No _____

If yes what type of wastes? _____

Where do you incinerate?

- Inside the compound _____
- Outside the compound _____

Do you use open dump as a disposal method? Yes _____ No _____

If yes, where do you dump?

- Inside the compound _____

- Outside the compound _____
- Other specify _____

What type of waste do you dump? _____

How far is the container from your home?

- a) 20-50 meters
- b) 51-100 Meters
- c) 101- 200 Meters
- d) 201-500 Meters
- e) > 500 meters _____

Is there accessible road to the nearest container?

Yes ____ No ____

What means do you use to transport wastes to containers?

- a) By hands
- b) Hand pushed carts
- c) Horse drawn carts
- d) Others specify

Do you dump solid waste in to the river? Yes _____ No _____

If yes, why? _____

Do you sell wastes? Yes _____ No _____

If yes, what type of wastes do you commonly sell?

- a) Plastics
- b) Metals
- c) Papers
- d) Leaves and grasses
- e) Others Specify _____

For whom do you sell wastes?

- a) Korales
- b) Formal recycling centers
- c) Others Specify

Is there any micro and Small Enterprises who collect wastes daily?

Yes _____ No _____

If yes, how often they come and collect the waste?

- a) Per day
- b) Per week
- c) Per two weeks
- d) Other, specify _____

Do you have contractual agreement with Micro and small Enterprises who

Collect and transport wastes to containers? Yes _____ No _____

If yes how much do you pay them monthly? _____ Birr.

Is there anybody who monitors that waste is properly collected and transported to the containers?

Yes _____ No _____

- If yes, who? _____

Is the existing waste management of the municipality satisfactory?

Yes _____ No _____

If no, what measures do you think should be taken to improve? _____
_____.

If you have any suggestion about controlling of household solid waste management of Jimma Town

Annex II: PLATES



Plate 1: Collection of wastes from households by hand push cart



Plate 2: Taking collected samples to transfer area by cart



Plate 3: Collected waste before sorting



Plate 4: Measuring sample waste using scale balance



Plate 5: Sorting of solid waste



Plate 6: Sieving for the purpose of size determination



Plate 7: Measuring moisture contents



Plate 8: Unsafe transfer area



Plate 9: Waste incineration practice



Plate 10: Preparation of sieves for size determination